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WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

June 30, 2020

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MEMORANDUM

SUBJECT: **Prothioconazole:** Draft Ecological Risk Assessment for Registration Review

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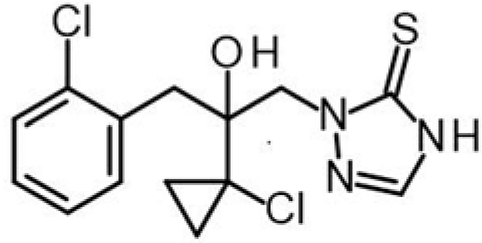
The Environmental Fate and Effects Division (EFED) has completed the draft environmental fate and ecological risk assessment in support of the Registration Review of the prothioconazole (2-(2-(1-chlorocylocpropyl)-3-(2-chlorophenyl)-2-hydroxy-propyl)-2,4-dihydro(1,2,4)-triazol-3-thion; PC Code 113961; CAS No. 178928-70-6).

Draft Ecological Risk Assessment for the Registration Review of Prothioconazole



Prothioconazole; CAS No. 178928-70-6
USEPA PC Code: 113961

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United States Environmental Protection Agency

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1 Executive Summary

1.1 Overview

Prothioconazole is a broad-spectrum, systemic fungicide used as a seed treatment, in chemigation systems, and as an aerial or ground spray with both foliar and soil applications. It is used throughout the U.S. to control (often as a preventative) or suppress some important crop fungal diseases such as anthracnose leaf blight, Ascochyta blight, white mold, frog eye leaf spot, *Rhizoctonia solani*, and Fusarium head blight (scab). Major agricultural uses include corn, wheat, soybeans, sugar beets, dried shelled peas and beans, and peanuts. There is a single non-agricultural use on nursery stock (seeds and seedlings of conifers and hardwoods). There are no registrations for residential use.

This Draft Risk Assessment (DRA) examines the potential ecological risks associated with labeled uses of prothioconazole on non-listed non-target organisms. In 2015, a preliminary Problem Formulation (PF) was conducted on prothioconazole (USEPA, 2015, DP barcocde 427289). As summarized in the PF based on previous risk assessments, potential risks associated with the use of prothioconazole include risks to aquatic invertebrates, aquatic plants and mammals. Based on new data received since the PF was completed, chronic risk to terrestrial invertebrates (bees) has also been identified. This risk assessment assesses all taxa but focuses on those areas of previously identified risk and examines the potential ecological risks to taxa for which additional data have become available. Direct risks to other terrestrial animals and plants and aquatic animals is expected to be low.

Because prothioconazole degrades quickly to other residues in the soil which have equal or greater toxicity to some organisms relative to that of the parent, the Residues of Concern (ROC) include prothioconazole and the major degradates prothioconazole-desthio and prothioconazole S-methyl. A Total Residue (TR) approach is used for the exposure assessment and Estimated Environmental Concentrations (EECs) are compared to the toxicity endpoint of parent prothioconazole or of the most toxic degradate when available. When the most sensitive toxicity endpoint is from exposure to a degradate, the toxicity endpoint (*i.e.*, LC_{50}, NOAEC, LOAEC) is normalized to the molecular weight (MW) of the parent material for ease of comparison. For more information on the ROC see **Section 4**.

1.2 Risk Conclusions Summary

Table 1-1 summarizes risk quotients (RQ) associated with labeled uses of prothioconazole on non-listed organisms at maximum application rates. The new ecological effects data and new fate data result in lower EECs but higher risk estimates for some of the taxa previously identified to be at risk. As with previous assessments, acute and chronic risks to fish (and aquatic-phase amphibians for which freshwater fish serve as surrogates) and birds (and reptiles and terrestrial-phase amphibians for which birds serve as surrogates), and risk to terrestrial plants are not expected to be of concern from the labeled uses of prothioconazole. Although no risk has been identified for terrestrial plants in previous assessments, and no new data have been submitted, there are 16 plant-related incidents associated with prothioconazole in the Incident Data System (IDS) database.

This assessment indicates that the likelihood of adverse effects on freshwater and estuarine/marine aquatic invertebrates in the water column from exposure to prothioconazole (RQs range from <0.01 to 0.22 and 0.04 to 0.40, respectively) is expected to be low. Risk estimates exceed the level of concern (LOC) for aquatic plants and chronic risk to estuarine/marine invertebrates for use on rice. However, there is no reported usage on rice; therefore, those results are separated from the others in **Table 1-1**. Newly submitted data on benthic invertebrates indicate that there may be adverse effects on freshwater and estuarine/marine benthic invertebrates (RQs range from 0.35 to 3.4 and 0.02 to 1.4, respectively) resulting from exposure to prothioconazole ROC from labeled uses. The RQs for non-vascular aquatic plants range from 0.51 to 4.9, based on a new normalized EC_{50} value of 4.8 µg a.i./L.

For mammals, although no new studies have been submitted, the use of MW-normalized toxicity endpoints results in higher RQs than were previously estimated. Chronic dose-based RQs for mammals range from 0.02 to 5.8 and exceed the chronic risk LOC of 1.0 for terrestrial animals.

Newly submitted studies have allowed for the estimation of chronic risk to both larval and adult honey bees (*Apis mellifera*) which serve as surrogates for non-*Apis* bees. Acute risk to bees is not quantified because the results of acute toxicity studies are non-definitive (*i.e*., LD_{50} greater than the highest tested doses for both larval and adult life stages, by both contact and oral exposure). The new toxicity data resulted in chronic RQs of 1.1 – 1.2 for larval honey bees and 0.19 – 0.22 for adult honey bees, with only the larval honey bees exceeding the chronic risk LOC (1.0). Although there are exceedances of the chronic risk LOC for larval bees, the absence of detectable effects in colony-level studies suggests that the effects on individual bees do not translate to adverse effects at the colony level. The chronic RQ value for adult honey bees is based on a study where there was 53 % mortality at the 46.5 µg a.i./bee/day treatment level after 10 days of exposure, resulting in a NOAEL/LOAEL of 26.1/46.5 µg a.i./bee/day. The chronic RQ value for larval honey bees is based on a study where there was a 19% reduction in adult emergence at the LOAEL of 5.2 µg a.i./bee/day after 22 days of exposure, resulting in a NOAEL of 2.0 µg a.i./bee/day. There is one honey bee-related incident in the IDS database. In the reported incident involving hive losses followed the application of prothioconazole end-use product PROSARO™ 421 SC (19.0% prothioconazole) to a crop. The incident had a certainty rating of possible; however, the specific type of crop was not reported nor was the distance from the treated field.

1.3 Environmental Fate and Exposure Summary

The environmental fate database for prothioconazole is complete. While studies submitted previously had high levels of unextracted residues, studies submitted later which used similar extraction methods and then added more exhaustive extractions methods demonstrated that the unextracted residues could be considered bound (thus, unavailable for aquatic exposure) for the purposes of risk assessment.

Prothioconazole is a nonvolatile pesticide that is stable to hydrolysis. It photolyzes slowly in clear, shallow water but dissipates in the environment by microbial degradation in soil, as well as through residues binding to soil and sediment in significant amounts (up to 47-56% of the applied in soil and aquatic systems). Based on laboratory aerobic soil studies, the parent biodegrades quickly to multiple degradates including two major degradates, prothioconazole-desthio (which is also a photodegradate in water) and prothioconazole-S-methyl, both of which are more persistent and possibly more mobile than the parent and are considered ROC in this assessment. While the degradate 1,2,4-triazole is a major degradate in only one of two systems of one aquatic metabolism study (where its maximum in water was 0.8% of the applied in one system and 37.1% in the other), it is not included in the aquatic ROC because it is not a major degradate in the aerobic soil or anaerobic aquatic metabolism studies and is not expected to be of significant exposure concern for aquatic risk assessment. Additionally, 1,2,4-triazole and its conjugates (triazole alanine and triazole acetic acid) are common metabolites to the class of compounds known as the triazole-derivative fungicides (T-D fungicides, conazoles) and in the past have been assessed separately from their parent compounds.

While parent prothioconazole biodegrades with half-lives of several days to several months in aquatic environments, prothioconazole ROC degrade more slowly in aquatic environments, particularly in anaerobic systems where half-lives range from 372 to 1,449 days. Prothioconazole and its degradates are not expected to bioconcentrate significantly in aquatic organisms. In three domestic terrestrial field studies, prothioconazole ROC dissipated more rapidly, with dissipation half-lives (DT_{50}'s) of 2 to 5 days for parent, but with longer DT_{50}'s for the two major degradates (*i.e.*, 85-315 days for prothioconazole-desthio and 21-148 days for prothioconazole S-methyl). While the parent did not leach below 15 cm in any of the studies and prothioconazole-S-methyl was detected below 15 cm only in a single replicate [below the limit of quantification (LOQ)] in one study, prothioconazole-desthio was detected at levels above the LOQ down to 30 cm. This supports the analysis that prothioconazole ROC have the potential to leach to groundwater in some environments. In three aquatic field studies, dissipation half-lives are longer in the sediment for both prothioconazole (77 days) and prothioconazole-desthio (DT_{50}'s of 90-122 days) relative to those in the water phase (DT_{50} of 0.6-4.8 days for parent only and 2.7-9 days for the degradate). The shorter dissipation half-lives in paddy water are likely due to adsorption than to degradation based on the results of lab studies. However, uncertainties in the aquatic field studies (including instability of prothioconazole and some degradates in storage) render the results less than definitive with respect to meaningful dissipation rates in the environment. Recovery of prothioconazole in soil and water ranged from 9.9 to 39.0% after 650-822 days in storage in all three studies.

Surface water modeling is simulated using the Pesticide in Water Calculator (PWC v1.52) for use patterns to terrestrial areas, and the Pesticides in Flooded Applications Model (PFAM; v2.0) for use on cranberries that are grown with intermittently flooded fields. Modeling is conducted for the major uses of prothioconazole using maximum label application rates. Based on modeling, the 1-day (acute) EECs range from 2.7 µg/L for use on bushberries to 26.1 µg/L for use on corn. Similarly, the respective 21-day and 60-day EEC ranges are 2.5-24.7 µg/L and 2.4-21.7 µg/L, indicating that accumulation in the pond does not occur over time. The EECs determined in this assessment are lower than those determined in previous assessments due to the incorporation of additional data (aerobic soil metabolism and anaerobic aquatic metabolism) and because new information provided more certainty that the unextracted residues could be considered bound and are not accounted for in half-life determinations (as they had been in previous assessments).

A search of the limited monitoring data available on the parent and prothioconazole-desthio in surface water and groundwater yielded no detections above the limits of detection (LOD: 0.0029-0.003 µg/L). Data for prothioconazole-S-methyl were not available.

1.4 Ecological Effects Summary

New data have been submitted in support of Registration Review including acute and chronic toxicity studies on fish, aquatic invertebrates, benthic invertebrates, terrestrial invertebrates, birds and aquatic plants for technical grade active ingredient (TGAI) prothioconazole and/or its degradates prothioconazole-S-methyl and prothioconazole-desthio. While some of the data have completed reviews and are used to assess risk in this DRA, other studies that do not impact this assessment based on a preliminary review of the results are still under review and not included here.

Prothioconazole is slightly to moderately toxic to fish (for which freshwater fish serve as surrogates for aquatic-phase amphibians) and freshwater aquatic invertebrates and moderately toxic to estuarine/marine invertebrates on an acute exposure basis; there are effects on aquatic animal survival, growth and reproduction following chronic exposure.

In a static 28-Day emergence test, the freshwater midge *Chironomus riparius,* had a 27% reduction in emergence at the LOAEC of 66 µg S-methyl/L-pore water, resulting in a NOAEC of 5.9 µg S-methyl/L (pore water). In a 28-Day flow-through test, the NOAEC for the estuarine/marine amphipod *Leptocheirus plumulosus* was based on a study with no observed adverse effects up to the highest concentration tested (14.3 µg S-methyl/L-pore water).

Non-vascular aquatic plants (*e.g.*, marine diatom, *Skeletonema costatum.*) are more sensitive to parent prothioconazole and the degradate prothioconazole-desthio than vascular aquatic plants. Additionally, a newly submitted aquatic plant toxicity study indicates that prothioconazole-desthio is approximately four times more toxic to non-vascular aquatic plants than previously estimated.

The compound is no more than slightly toxic to birds (which serve as surrogates for reptiles and terrestrial-phase amphibians) and is practically non-toxic to mammals on an acute oral exposure basis. As with aquatic animals, there were effects on growth in mammals following chronic exposure; however, there were no chronic effects detected in birds up to the highest dietary concentration tested. In a two-generation rat reproduction study with exposure to the degradate prothioconazole-desthio, there was an 8-15% reduction in body weight and a 21-33% reduction in pup viability in both generations.

Although not previously assessed because of insufficient data, there are now data for honey bees. Prothioconazole is practically non-toxic to bees on an acute exposure basis and while the compound did not result in any adverse effects on adult bees up to the highest dietary concentration tested in a chronic toxicity study, bee larvae appeared more sensitive with reductions in larval bee emergence. There were no adverse effects noted in the chronic toxicity test with adult honey bees up to the highest concentration tested (NOAEC = 3.19 µg a.i./bee/day). However, adverse effects were noted in the chronic toxicity study with larval honey bees (*i.e.*, 19% reduction in adult emergence at the LOAEL of 5.2 µg a.i./bee/day). Colony-level studies have also been submitted where bees were exposed to prothioconazole following foliar applications or through feeding the colony a diet of sucrose treated with prothioconazole. None of the colony-level studies resulted in any detectable adverse effects on colony condition [*i.e.*, overall numbers of adults and developing young (brood)].

1.5 Identification of Data Needs

Currently there are no data gaps for environmental fate or ecological effects studies.

Table 1-1. Summary of Risk Quotients (RQ) for Taxonomic Groups from Current Uses of Prothioconazole.

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Freshwater Fish	Acute	<0.01 – 0.02	No	--
	Chronic	0.01 – 0.17	No	--
Estuarine/ Marine Fish	Acute	<0.01	No	--
	Chronic	0.02 – 0.19	No	--
Freshwater Invertebrates (Water-Column Exposure)	Acute	<0.01 – 0.02	No	--
	Chronic	0.02 – 0.26	No	--
Estuarine/ Marine Invertebrates	Acute	0.04 – 0.44	No (except rice, see additional information)	Risk exceeding LOC's for uses on rice only (Acute RQ = 2.3; Chronic RQ = 1.1) at the LOAEC of 128 µg a.i./L there was

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
(Water-Column Exposure)	Chronic	0.04 – 0.41	No (except rice, see additional information)	a 32% reduction in the number of young per female. When based on the LOAEC, the chronic RQ for use on rice is reduced to 0.58. However, while rice is a labeled use, there is no reported usage for rice.
Freshwater Invertebrates (Sediment Exposure)	Acute[2]	<0.02	No	--
	Chronic[2]	0.35 – 3.4	**Yes**	Risk exceeding the chronic LOC for all uses except for ground applications to bushberry and soybean. The EEC does not exceed the LOAEC; therefore, when using the LOAEC (at which there was 24% reduction in adult emergence) instead of the NOAEC, there are no LOC exceedances.
Estuarine/ Marine Invertebrates (Sediment Exposure)	Acute[2]	0.03-0.29	No	--
	Chronic	≤1.4 based on pore water concentrations ≤0.17 based on sediment concentrations	**Yes**	Risk exceeding the chronic risk LOC for use on corn (field or pop) only, based on a study with no effects up to the highest concentration tested. Study was not conducted at high enough concentrations to produce a toxic effect; therefore, there is uncertainty in the calculation of risk.
Mammals	Acute	<0.01 – 0.02	No	--
	Chronic	0.02 – 5.8	**Yes**	Risk exceeding the chronic LOC for small, medium and large mammals foraging on shortgrass, tall grass, broadleaf plants, and arthropods for all uses based on dose-based RQs. There were no LOC exceedances for dietary-based RQs. Calculations based on mean Kenaga values and/or LOAEC values will lower the RQ approximately 35%, but still have exceedances for small mammals foraging on short grass, broadleaf plants and arthropods. Reduction in body weight (8-15%) and pup survival (21-33%) in both F1 and F2 generations. Some dose-based EECs exceed LOAEC.
Birds	Acute	<0.01 – 0.03	No	--
	Chronic	0.01 – 0.28	No	--
Terrestrial Invertebrates[3]	Acute Adult	Not calculated	N/A	No mortality in acute contact or oral studies and test concentrations exceeded predicted EECs.
	Chronic Adult	0.19 – 0.22	No	Chronic adult toxicity test showed 53 and 90% mortality of adult bees at 46.5

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
	Acute Larval	Not calculated	N/A	and 64.3 µg a.i./bee/day treatment groups resulting in NOAEL/LOAEL of 26.1/46.5 µg a.i./bee/day. Chronic larval toxicity test showed 19% reduction in adult emergence at LOAEL of 5.2 µg a.i./bee/day, resulting in NOAEL of 2.0 µg a.i./bee/day. No adverse effects observed in semi-field testing (tunnel and colony-feeding). There is one incident reported involving bees.
	Chronic Larval	1.1 – 1.2	**Yes**	
Aquatic Plants	N/A	Vascular: 0.07 – 0.74 Non-vascular: 0.51 – 5.5	**Yes**	Risk exceeding LOC for vascular species for use on rice only (RQ = 3.9). Risk exceeding LOC for non-vascular species for all modeled uses, except bushberry (RQ for rice = 28). However, while rice is a labeled use, there is no reported usage for rice.
Terrestrial Plants	N/A	N/A	N/A	EC_{25} could not be estimated because <25% effects were observed at the highest tested concentration (EC_{25} >0.272 lbs a.i./A), which is 1.2x higher than the highest application rate currently in use (cotton, 0.222 lbs a.i./A). 16 plant incidents reported (10 with adverse effects to peanuts, other plants affected were wheat, soybean, sorghum, potatoes and corn).

EC_{25}=effect concentration resulting in 25% reduction; EEC=Estimated Environmental Concentration; LOAEC=lowest observed adverse effect concentration; LOAEL=lowest observed adverse effect level; NOAEC=no observed adverse effect level; NOAEL=no observed adverse effect level.

Level of Concern (LOC) Definitions:

- Terrestrial Vertebrates: Acute=0.5; Chronic=1.0
- Terrestrial Invertebrates: Acute=0.4; Chronic=1.0
- Aquatic Animals: Acute=0.5; Chronic=1.0
- Terrestrial and Aquatic Plants: 1.0

[1] Risk quotients (RQs) reflect exposure estimates for parent prothioconazole, prothioconazole-desthio, and prothioconazole S-methyl and maximum application rates allowed on labels.

[2] Based on water-column toxicity data compared to pore-water concentration.

[3] RQs for terrestrial invertebrates are applicable to honey bees (*Apis mellifera*), which are also a surrogate for other species of non-*Apis* bees. Risks to other terrestrial invertebrates (*e.g.*, earthworms, beneficial arthropods) are only characterized when toxicity data are available.

2 Introduction

This Draft Risk Assessment (DRA) examines the potential ecological risks associated with labeled uses of prothioconazole on non-target organisms. Federally listed threatened/endangered species ("listed") are not evaluated in this document. The DRA uses the best available scientific information on the use, environmental fate and transport, and ecological effects of prothioconazole. The general risk assessment methodology is described in the *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs* ("Overview Document"; USEPA, 2004). Additionally, the process is consistent with other guidance produced by the Environmental Fate and Effects Division (EFED) as appropriate. When necessary, risks identified through standard risk assessment methods are further refined using available models and data. This risk assessment incorporates the available exposure and effects data and most current modeling and methodologies.

3 Problem Formulation Update

The purpose of problem formulation is to provide the foundation for the environmental fate and ecological risk assessment being conducted for the labeled uses of prothioconazole. The problem formulation identifies the objectives for the risk assessment and provides a plan for analyzing the data and characterizing the risk. As part of the Registration Review (RR) process, a detailed PF for this DRA was conducted in 2015 (USEPA, 2015*b*, DP barcode 427289) and data gaps were identified for a General Data Call-In (GDCI). The following sections summarize the key points of the PF and discusses key differences between the analysis outlined there and the analysis conducted in this DRA. As summarized in the PF based on previous risk assessments, potential risks associated with the use of prothioconazole include risks to aquatic invertebrates, aquatic plants and mammals. Since the PF was completed, the following data have been submitted:

- Fate and Exposure Data
  - Aerobic soil metabolism study (MRID 50917601)
  - Anaerobic aquatic metabolism study (MRID 50917602)

More specific information on these new data is described in Section 5 and 8.1. The additional data result in updated aquatic modeling input values. Since new information in the studies was also useful in confirming that unextracted residues could be considered bound residues for the purpose of risk assessment, half-lives from previously submitted studies are recalculated to remove unextracted residues as part of the Total Residues (TR) calculations to determine half-life inputs for modeling. The overall effect of the newly determined half-lives on the risk estimation is to decrease the input half-lives in aquatic exposure modeling, thereby reducing EECs in water.

Since the PF was completed, the following ecological effect data have been submitted:

- Ecotoxicity Data
  - Sediment Emergence Test with Freshwater Invertebrate *Chironomus riparius* (MRID 50019201)
  - Early Life Cycle Toxicity Test with Rainbow Trout *Oncorhynchus mykiss* (MRID 50489201)
  - Acute contact and oral toxicity of prothioconazole-desthio (99.5%) to adult honey bees (MRID 50489202)

- Chronic toxicity of prothioconazole SC 480 (39.6% w/w) to adult honey bees (MRID 50489203)
- Acute contact toxicity to the bumble bee (*Bombus terrestris* L.) (MRID 50521801)
- Acute oral toxicity to the bumble bee (MRID 50521802)
- Acute toxicity of prothioconazole-desthio to Sheepshead Minnow (*Cyprinodon variegatus*) (MRID 50633901)
- Acute (single dose) exposure of honey bee to prothioconazole technical (96.7%) (MRID 50633902)
- Chronic (repeated dose) exposure of honey bee larvae to prothioconazole technical (96.7%) (MRID 50633903)
- Toxicity of prothioconazole-desthio (98.3%) to the saltwater diatom (*Skeletonema costatum*) (MRID 50634201)
- Chronic toxicity of prothioconazole SC 480 (41.4% a.i.) to the honey bee adults (MRID 50726802)
- Acute dietary toxicity of prothioconazole-desthio (98.1%) to the canary (*Serinus canaria*) (MRID 50746601)
- Acute toxicity of prothioconazole-S-methyl (99.7%) to the mysid shrimp (*Americamysis bahia*) (MRID 50853501)
- Acute toxicity of prothioconazole-S-methyl (99.6%) to the Eastern oyster (*Crassostrea virginica*) (MRID 50925601)
- Chronic whole sediment toxicity test with freshwater invertebrate midge (*Chironomus dilutus*) (MRID 50973501)
- Chronic whole sediment toxicity test with freshwater invertebrate amphipod (*Hyalella azteca*) (MRID 50969303)
- Chronic whole sediment toxicity test with estuarine/marine invertebrate amphipod (*Leptocheirus plumulosus*) (MRID 50969302)

These new data are described in more detail in the ecological effects characterization section (**Section 6**). Four of the new studies are more sensitive than previously submitted data. These four studies are the acute toxicity data for the Sheepshead Minnow exposed to the degradate prothioconazole-desthio, the chronic toxicity data for the freshwater midge *(C. riparius)* exposed to the degradate prothioconazole-S-methyl, the exposure of the estuarine/marine diatom *(S. costatum)* to prothioconazole-desthio, and chronic larval honey bee exposure to prothioconazole TGAI.

3.1 Mode of Action for Target Pests

Prothioconazole (JAU 6476; 2-[2-(1-chlorocyclopropyl)-3-(2-chloropheny1)-2-hydroxypropyl]-1,2-dihydro-3H-1,2,4-triazole-3-thione) is a broad-spectrum, systemic fungicide belonging to the conazole class of fungicides. As of 2015, it was the sole fungicide in triazolinthiones, which was added in 2012 to the Group 3 of DMI (DeMethylation Inhibitor) fungicides classified by the Fungicide Resistance Action Committee (FRAC). This class of compounds is characterized structurally by inclusion of a nitrogen-containing five-member ring (azole). Conazole fungicides act through disruption of normal fungal cell membrane structure and function primarily through interactions or ergosterol biosynthesis inhibition (EBI), the predominant membrane sterol component (Wolf *et al.* 2006). Prothioconazole's specific mode of action is through the inhibition of demethylation of two precursors of sterols in fungi (lanosterol and 24-methylene dihydrolano-sterol) (Parker *et al*. 2013).

3.2 Label and Use Characterization

3.2.1 Label Summary

Prothioconazole is formulated as a flowable concentrate and applied as a seed treatment, in chemigation systems, and as an aerial or ground spray with both foliar and soil applications. Prothioconazole has been used to control or suppress some important crop diseases such as anthracnose leaf blight on corn, Ascochyta blight on dry beans/peas, white mold on peanuts, frog eye leaf spot on soybeans, *Rhizoctonia solani* on sugar beets, and Fusarium head blight (scab) on wheat. For many registered uses it is initially applied as a preventative, when conditions are favorable for disease, or at the first/early sign of fungal diseases.

General use[1] sites include terrestrial food, nonfood, and nursery as well as indoor/outdoor agricultural use for seed treatment. There are several Special Local Need (FIFRA Section 24c) uses registered for the states of Oregon and Washington. Several uses (*e.g.*, berries, corn) have geographic restrictions preventing the application of specific prothioconazole end-use products to those crops in California and New York. Prothioconazole is used throughout the United States on multiple cereal grains, multiple vegetables (but with no reported field use on most), rice, soybeans, sugar beets, berries, cucurbits, dried shelled peas and beans, and peanuts. There is a non-agricultural use on nursery stock (seeds and seedlings of conifers and hardwoods). Many of the registrations are for full crop groups (although exceptions within groups occur). There are no registrations for residential use. Section **7.1** discusses how the different use patterns are handled in the assessment.

The Biological and Economic Analysis Division (BEAD) prepared a Pesticide Label Use Summary (PLUS) Report summarizing all registered uses of prothioconazole based on actively registered labels in August 2019. The PLUS report was used as the source to summarize representative uses for this DRA. **Table 3-1** and **Table 3-2** summarize information from the PLUS report and product labels.

The maximum single application rate for crops with reported usage[2] is 0.178 lb a.i./A, with up to four applications at that rate for some crops (corn, peanuts). There is a cotton use registered at 0.222 lb ai/A/application (but with no usage reported, per BEAD). The maximum annual rate is 0.781 lb a.i./A (five applications of 0.156 lb a.i./A for conifer/hardwood seedlings).

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[1] Use information reflects use patterns as recommended on registered labels.
[2] Usage information reflects what is actually happening in the field and is typically based on survey data completed by farmers or pesticide applicators.

Although this assessment focuses only on prothioconazole, there are several prothioconazole products containing other active ingredients [*e.g.*, Stratego® 731 and Stratego® YLD (containing 10% prothioconazole and 32.3% trifloxystrobin) and Evergol® Energy (containing 7.18% prothioconazole, 3.59% penflufen plus 5.74% metalaxyl].

The only common restriction on labels was “Do not spray if windspeed is 15 miles per hour or greater.”

Table 3-1. Summary of Selected Maximum Labeled Use Patterns for Foliar and Soil Applications of Prothioconazole.

Use Site/ Location	Form[1]	App Target	App Type	App Equip	App Time	Max Single Rate lbs ai/A	Max # App/yr*	Max Annual Rate lbs ai/A/yr*	MRI (d)	Comments (*e.g.*, geographic/application timing restrictions, pollinator specific language)
Bushberry (Subgroup 13-07B)/Ag	FlC	Foliage/ Plant	Broad	G, C	Post-emergence	0.178	2	0.356	7	none
Low growing berry (Subgroup 13-07H, except strawberry)/ Ag	FlC	Foliage/ Plant	Broad	G, C	Post-emergence	0.156	2	0.313	7	PHI of 45 days for cranberry. Disallowed in CA.
Rapeseed (Subgroup 20A)/Ag	FlC	Foliage/ Plant	Broad	A, G, C	During bloom	0.178	2	0.356	14	May be applied at 20-50% bloom stage. PHI 36 days. Disallowed in CA.
Dried shelled pea and bean (except soybean) subgroup/Ag	FlC	Foliage/ Plant	Broad	A, G, C	Post-emergence	0.178	3	0.534	5	none
		Soil surface	In-furrow	G	At plant or seeding	0.156	(1)			
Cucurbit vegetables/Ag	FlC	Foliage/ Plant	Broad	G, C	Post-emergence	0.178	2	0.534 (total, two foliar plus one soil app	5	none
		Soil surface					1			
Barley/Ag	FlC	Foliage/ Plant	Broad	A, G	Post-emergence	0.178	2	0.293	14	Max number of apps not at max rate (0.115 for second app)
Nursery seedlings of conifers/evergreen/ hardwoods	FlC	Foliage/ Plant	Broad	G	Post-emergence	0.156	(5)	0.781	14	Not for use in forest planting or established woodlands.
Corn/field or pop	FlC	Foliage/ Plant	Broad	A, G, C	Post-emergence	0.178	(4)	0.713	7	none
Cotton	FlC	Soil surface	Broad	G	At emergence	0.222	(1)	0.534	14	A single app at 0.22 lb ai may be applied to soil (by ground spray, in furrow or banded) at crop

Use Site/ Location	Form[1]	App Target	App Type	App Equip	App Time	Max Single Rate lbs ai/A	Max # App/yr*	Max Annual Rate lbs ai/A/yr*	MRI (d)	Comments (*e.g.*, geographic/application timing restrictions, pollinator specific language)
		Foliage/ Plant		A, G, C	Post-emergence	0.178	3			emergence; if high rate is used, then total number of annual app. restricted to 2/yr with the same max annual rate.
Flax	FlC	Foliage/ Plant	Broad	A, G, C	Post-emergence	0.14	1	(0.14)	none	Apply at 20-50% bloom stage. Aerial disallowed in NY.
Garbanzo beans (including chickpeas), lentils	FlC	Foliage/ Plant	Broad	A, G, C	Post-emergence	0.178	3	0.534	10	none
Peanuts	FlC	Foliage/ Plant, Soil	Broad	A, G, C	Post-emergence	0.178	4	0.713	14	Single soil app at planting or seeding or at crop emergence allowed at same max single rate. Max annual rate of 0.713 total for all app Disallowed in CA (all app).
Peas (dried)	FlC	Foliage/ Plant	Broad	A, G, C	Post-emergence	0.178	3	0.534	5	Disallowed in CA.
Rice	FlC	Foliage/ Plant	Broad	A, G	Post-emergence	0.141	1	0.141	none	Disallowed in CA. PHI of 40 days. Do not apply later than 70% panicle emergence.
Oats, Rye, Millet	FlC	Foliage/ Plant	Broad	A, G	Post-emergence	0.178	1	0.178	none	none
Soybean	FlC	Foliage/ Plant	Broad	A, G, C	Post-emergence	0.156	3	0.403	10	Max number of apps not at max rate. Max annual rate and no. of app are for all app types combined. PHI of 21 days. Disallowed in CA.
		Soil	In furrow	G	At plant or seeding					

Use Site/ Location	Form[1]	App Target	App Type	App Equip	App Time	Max Single Rate lbs ai/A	Max # App/yr*	Max Annual Rate lbs ai/A/yr*	MRI (d)	Comments (*e.g.*, geographic/application timing restrictions, pollinator specific language)
Sugar beet	FlC	Foliage/ Plant, Soil	Broad	A, G, C	Post-emergence	0.178	3	0.534	14	Max annual rate and no. of app are for all app types combined.
		Soil	In furrow	G	At plant or seeding					
Wheat/Triticale	FlC	Foliage/ Plant	Broad	A, G	Post-emergence	0.178	2	0.293	14	Max number of apps not at max rate.

[1]App=application; equip=equipment; --=not specified; FlC=flowable concentrate; MRI = Minimum retreatment interval; PHI=preharvest interval; A=aerial; C=chemigation; AB=airblast; G=ground; ai=active ingredient; CC=crop cycle; d=day; ()Values in parenthesis were calculated based on other information provided on the label. These values are not explicitly stated on the label. * Information is provided on an annual basis, unless otherwise specified.

Table 3-2. Summary of Selected Maximum Labeled Use Patterns for Seed Treatment Applications of Prothioconazole.

Crop	Maximum Rate Product per Application (fl. oz./cwt[1])	Maximum Rate Active Ingredient per Application (lb a.i./cwt)	Maximum Rate Active Ingredient per Application (lb a.i./lb seed)	Seeding rate[5] (lb seed/Acre)	Maximum Annual Application Rate (lb a.i./Acre)
Cereal Grains (Barley, Triticale, Wheat, Oats, Rye, Buckwheat and Millet [Pearl and Proso])[2]	1.0	0.0050	0.000050	156	0.0071
Corn (Field, Pop and Sweet)[3]	3.8	0.12	0.0012	33.2	0.034
Alfalfa[2]	3.0	0.015	0.00015	15.0	0.0020
Beans and Peas (dried)[2]	1.0	0.0050	0.000050	163	0.0074
Cotton[3]	0.81	0.025	0.00025	18.9	0.0041
Rice[2]	2.0	0.010	0.00010	129	0.012
Sorghum[2]	2.0	0.010	0.00010	9.1	0.00083
Sugar Beet[2]	1.0	0.0050	0.000050	4.8	0.00022

Crop	Maximum Rate Product per Application (fl. oz./cwt[1])	Maximum Rate Active Ingredient per Application (lb a.i./cwt)	Maximum Rate Active Ingredient per Application (lb a.i./lb seed)	Seeding rate[5] (lb seed/Acre)	Maximum Annual Application Rate (lb a.i./Acre)
Potato[4]	0.31	0.00036	0.0000036	6970	0.024

[1] cwt: centum weight or a hundredweight; equal to 100 pounds.
[2]From label for EverGol® Energy (D507809 and D507880). Mixed in solution at 0.64 lb a.i./Gallon.
[3]From label for Proline® 480 SC (D530919). Mixed in solution at 4 lb a.i./Gallon.
[4]From label for Emesto® Silver (D513372). Mixed in solution at 0.15 lb a.i./Gallon.
[5]From Becker, Jonathan and Ratnayake, Sunil. Acres Planted per Day and Seeding Rates of Crops Grown in the United States. 2011. Biological and Economic Analysis Division (BEAD), Office of Pesticides Programs, United States Environmental Protection Agency.

3.2.2 Usage Summary

Based on BEAD's 2019 Screening Level Usage Analysis (SLUA) for the years 2007-2017 and other information provided by BEAD, more than 399,500 lbs a.i. of prothioconazole are used annually throughout the U.S.; the highest usage is on wheat (220,000 lbs a.i. and 3.6 million acres total for spring plus winter wheat). Corn, soybeans, sugar beets, and peanuts each have annual usages in the range of 45,000-65,000 lbs/yr based on data from 2007-2017. In terms of percent crop treated, sugar beets and wheat are the major uses of prothioconazole, with maximum crop treated values of 40 and 30 percent, respectively, during the survey years. From the standpoint of acres treated, soybeans, corn and wheat comprise the main crops on which prothioconazole is used, with a per-use range of approximately 1.7-3.6 million acres treated annually. Much of the remaining usage is on dry beans/peas, berries (including bushberries and cranberries), and seed treatments. Rice, several vegetables, and cotton had no reported usage in the surveys for the period 2013-2017 (or in limited survey years for some vegetables). Usage has been reported in all geographical areas of the contiguous United States, with reported usage (2013-2017) just on wheat spanning 26 states.

4 Residues of Concern

In this risk assessment, the stressors are those chemicals that may exert adverse effects on non-target organisms. Collectively, the stressors of concern are known as the Residues of Concern (ROC). The ROC usually includes the active ingredient, or parent chemical, and may include one or more degradates that are observed in laboratory or field environmental fate studies. Degradates may be included in, or excluded from, the ROC based on submitted toxicity data, percent formation relative to the application rate of the parent compound, modeled exposure, and structure-activity relationships (SARs). Structure-activity analysis may be qualitative, based on retention of functional groups in the degradate, or they may be quantitative, using programs such as Ecological Structure Activity Relationships (ECOSAR) predictive model[3], the Organization for Economic Cooperation and Development (OECD) Toolbox[4], Assessment Tools for the Evaluation of Risk (ASTER) [5], or others.

As in past ecological risk assessments, the ROC for this assessment includes the parent compound and the two major degradates prothioconazole-desthio and prothioconazole-S-methyl. Each of these compounds formed rapidly and in major amounts (up to 56% and 78% of the applied, respectively) in the laboratory metabolism studies and each is more mobile and persistent than the parent compound, so will be present and an exposure concern in both terrestrial and aquatic environments. Based on empirical data, both terrestrial and aquatic organisms are more sensitive to prothioconazole-desthio than to parent material. There is less

[3] https://www.epa.gov/tsca-screening-tools/ecological-structure-activity-relationships-ecosar-predictive-model
[4] https://www.oecd.org/chemicalsafety/risk-assessment/oecd-qsar-toolbox.htm
[5] https://archive.epa.gov/med/med_archive_03/web/html/aster.html

empirical data available for prothioconazole-S-methyl; however, the data that are available indicate that aquatic organisms are more sensitive to prothioconazole-S-methyl than to parent material, but less sensitive than to prothioconazole-desthio. More information on the two major degradates included as ROC may be found in **Section 5** (Environmental Fate Summary) and in **Section 6** (Ecotoxicity Summary). Additional information on both the major and minor transformation products may be found in USEPA, 2015 (DP Barcode D427289).

The degradate 1,2,4-triazole is not included as a ROC for aquatic exposure. It was a major degradate only in the aqueous photolysis (11.9%) and aerobic aquatic metabolism studies, where in the latter study it was not a major degradate (>10%) until 59 days, and then was a maximum of 41.8% in one system and was only 6% in the second system. In aerobic soil metabolism studies, it was a minor degradate and only detected at <2% of the applied. Based on submitted toxicity data for 1,2,4-triazole, this degradate appears to be (1-3,000 times) less toxic than the parent compound to all taxa. There is similar toxicity observed between the parent compound and 1,2,4-triazole for acute exposures to birds and sub-chronic exposures to mammals (1,2,4-triazole is 1.9 and 1.3x less sensitive than parent, respectively). Therefore, the risk assessment for parent is expected to be protective of exposure to 1,2,4-triazole based on exposure considerations. Additionally, 1,2,4-triazole and its conjugates (triazole alanine and triazole acetic acid) are common metabolites to the class of compounds known as the triazole-derivative fungicides (T-D fungicides, conazoles) and in the past have been assessed separately from their parent compounds.

A Total Residue (TR) approach is used for the exposure assessment and EECs are compared to the toxicity endpoint of parent prothioconazole or of the most toxic degradate when available. When the most sensitive toxicity endpoint is from exposure to a degradate, the toxicity endpoint (*i.e.*, LC_{50}, NOAEC, LOAEC) is normalized to the molecular weight (MW) of the parent material for easy comparison.

5 Environmental Fate Characterization

Table 5-1 summarizes the physical chemical properties of prothioconazole. Prothioconazole is estimated to be of low mobility, but parent compound mobility could not be definitively determined for the parent compound due to instability during the study and low chromatographic column resolution. While the parent compound has a log dissociation constant (pKa) of 6.9 and will be present at approximately half in ionized form and half in neutral form at pH levels of 6.9, the parent has limited exposure potential due to degradation in hours to weeks in aerobic soil and aquatic systems to the major degradates. Prothioconazole's two major degradates have been considered in past assessments to be more mobile than the parent, as sufficient adsorption of residues was observed in the parent study to indicate a potential for limited mobility even though valid mobility coefficients could not be determined. Prothioconazole-desthio is classified as moderately mobile and prothioconazole S-methyl is classified as slightly mobile based on measured organic carbon-normalized distribution coefficients (K_{oc}) values and the FAO classification system (FAO, 2000). Prothioconazole residues may be transported to surface water via spray drift and runoff or to groundwater via leaching. Higher mobility for prothioconazole-desthio relative to the parent is supported by leaching observed in some terrestrial field dissipation studies in which prothioconazole-desthio was measured at up to 45 cm depth in the soil through 307 days while the parent was not detected below 15 cm, although lack of persistence in that soil was likely a factor. While it may be found in both water and sediment, the octanol-water partition coefficient (K_{OW}) and K_{OC} values for the parent compound at common environmental pH values are lower than the values that would trigger the need to conduct a separate sediment exposure assessment (40 CFR Part 158.630); however, the K_{OC} values for prothioconazole S-methyl (a major degradate included in the ROC) indicate a potential for exposure in sediment.[6] Compounds with a log K_{OW} of three and above are generally considered to have the potential to bioconcentrate in aquatic organisms. Based on log K_{OW} values ranging from 0.2 (pH 9) to 2.0 (pH 7), bioconcentration of parent prothioconazole is not a primary concern at common environmental pH levels. In a laboratory bioconcentration study, a concentration plateau was not reached for the parent compound (which did not significantly bioconcentrate) and most residues were depurated by 14 days. In the study, the multiple metabolites, including the two major degradates included in the ROC, did not exhibit a potential for bioaccumulation.

Prothioconazole is classified as non-volatile from water and dry non-adsorbing surfaces (USEPA, 2010a). The estimated log octanol-air partition coefficient (K_{OA}) value is 13.5, but the log K_{ow} is only greater than 2 under acidic conditions (lower than pH 7), so prothioconazole is not likely to accumulate significantly in terrestrial organisms.[7]

Table 5-1. Summary of Physical-Chemical, Sorption, and Bioconcentration Properties of Prothioconazole and Major Degradates.

Parameter	Value[1]	Source/Study Classification/Comment
Molecular Weight (g/mole)	344.26 g/mol (parent) 312.19 (prothioconazole-desthio) 358.28 (prothioconazole S-methyl)	MRID 46246003 Acceptable
Water Solubility Limit at 20°C (mg/L)	5, pH 4 300, pH 8 2000, pH 9	MRID 46246003 Acceptable
Vapor Pressure (Torr; 20°C)	3×10^{-9}	MRID 46246003 Acceptable Limited volatilization. Extrapolated from 70°C measured results.

[6] Sediment data may be required if the soil-water distribution coefficient (K_d) is ≥ 50 L/kg, K_{OC}s are ≥1000 L/kg-organic carbon, or the log K_{OW} is ≥ 3 (40 CFR Part 158.630). Sediment data may also be requested if there may be a toxicity concern.

[7] A recent FIFRA Scientific Advisory Panel (SAP) reported, "Gobas *et al* (2003) concluded that chemicals with a log K_{OA} greater than five can biomagnify in terrestrial food chains if log K_{OW} greater than two and the rate of chemical transformation is low. However, further proof is needed before accepting these limits without reservations" (SAP, 2009). This was also supported by the work of Armitage and Gobas (Armitage and Gobas, 2007).

Henry's Law Constant at 20°C (atm-m^3/mole)	2.96×10^{-10}			MRID 46246003 Acceptable Not expected to volatilize from water or wet surfaces. From estimated VP (see above) and solubility at pH 4.
Log Dissociation Constant (pKa)	6.9			MRID 46246003 Acceptable Weak acid; may exist in ionized from at neutral and alkaline pHs. Approx. half exists as an anion at pH 6.9.
Octanol-water Partition Coefficient (Log K_{ow}) at 25°C (unitless)	pH 4: 3.4 pH7: 2.0 pH9: 0.2			MRID 50917601[N] Acceptable Potential for bioaccumulation only at acidic pH.
Air-water Partition Coefficient (log K_{AW}) (unitless)	log K_{AW} = -10.4			EPIWEB 4.1 (estimated value).[2] non-volatile from water
Octanol-air Partition Coefficient (log K_{OA}) (unitless)	log K_{OA} = 13.5			EPIWEB 4.1 (estimated value).[2]
Soil-Water Distribution Coefficients (Kd in L/kg-soil) Organic Carbon-Normalized Distribution Coefficients (Koc in L/kg-organic carbon)	**Prothioconazole-desthio[2]**			MRID 46246450 Acceptable. Moderately Mobile (FAO classification system); K_{OC} better predictor of sorption based on lower CV.
	Soil/Sediment	**K_d**	**K_{OC}**	
	Loamy sand, 0.79% OC	4.1	523	
	Sandy clay loam, 1.66% OC	8.9	536	
	silt loam, 2.02% OC	12.5	617	
	sand, 2.14% OC	13.4	625	
	Mean	9.7	575	
	CV	43.5%	9.2%	
	Prothioconazole-S-methyl			MRID 46246501 Acceptable. Slightly Mobile (FAO classification system); K_{OC} better predictor of sorption based on lower CV.
	Soil/Sediment	**K_d**	**K_{OC}**	
	Loamy sand, 0.79% OC	15.6	1973	
	Sandy clay loam, 1.66% OC	41.2	2484	
	silt loam, 2.02% OC	56.0	2772	
	sand, 2.14% OC	64.1	2995	
	Mean	44.2	2556	
	CV	48.1%	17.3%	
Fish Bioconcentration Factor (BCF) (L/kg-wet weight fish)	**Species**	**BCF**	**Depuration**	MRIDs 46246034, 46246035 A valid BCF could not be calculated due to lack of a clear accumulation plateau. Prothioconazole and prothioconazole-desthio do not bioaccumulate substantially based on submitted study data for both parent and degradate.
	bluegill sunfish (*Lepomis macrochirus*)	–	91-95% from max level by 14 days	

CV=Coefficient of Variation

[N] Studies submitted since the Problem Formulation was completed are designated with an N associated with the MRID number.

[1]All estimated values were calculated according to "*Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in Problem Formulations for Registration Review, Registration Review Risk*

Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments" (USEPA, 2010a). [2]Parent compound mobility could not be determined due to instability and low column resolution. Very high sorption was estimated for parent (*i.e.*, lower mobility than transformation products); MRID's 46246539, 46246504.

Prothioconazole dissipates in the environment by microbial degradation in soil and by aqueous photolysis, and prothioconazole residues may become bound to soil. It is degraded relatively quickly by aerobic metabolism in soils (half-lives ranged from hours to 23.5 days at 20°C in five soils and were less than or equal to 3 days in four of the soils). Aerobic soil metabolism results indicate that parent prothioconazole is non-persistent to slightly persistent in soil based on the Goring persistence scale (Goring *et al.*, 1975).[8] In soil, prothioconazole biodegrades to multiple degradates including two major degradates, prothioconazole-desthio and prothioconazole-S-methyl, which are more persistent than the parent (*i.e*., moderately persistent to persistent), with half-lives of 116-486 days for prothioconazole ROC, which includes parent plus those two major degradates. While parent prothioconazole biodegrades in aquatic environments with respective half-lives of 4-51 days and 18-110 days in aerobic and anaerobic aquatic systems, the ROC degrade more slowly in aerobic aquatic systems (half-lives of 42-101 days) and are much more persistent in anaerobic aquatic systems (half-lives of 372-1,449 days). In both soil and aquatic systems, prothioconazole forms high levels of bound residues which tended to remain in the soil (up to 56%) or sediment (up to 47%) samples, including in submitted studies which used exhaustive extraction procedures (with multiple extractants of varying dielectric constants) in an attempt to remove additional residues. Prothioconazole is stable to hydrolysis at pH 4-9. In shallow, clear, surface waters it photolyzes slowly (half-life of 9.7 days) but does not photolyze on soil. In water, it photodegrades to prothioconazole-desthio, which is more resistant than the parent is to photolytic degradation (ROC $t_{½}$ = 101 d).

Table 5-2 summarizes representative degradation half-life values from laboratory degradation data for prothioconazole and prothioconazole ROC. These values often are different from the actual time to 50 percent decline of the residues as degradation kinetics were often biphasic with the rate of degradation slowing over time. The representative degradation half-life is designed to provide an estimate of degradation for biphasic degradation curves that will not overestimate degradation when assuming a single first-order decline curve in modeling.

Major transformation products resulting from the environmental degradation of prothioconazole are:

- 2-[2-(1-Chlorocyclopropyl)-3-(2-chlorophenyl)-2-hydroxy-propyl]-1,2-dihydro-3H-1,2,4-triazole (prothioconazole-desthio)

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[8] Goring *et al.* (1975) provides the following persistence scale for aerobic soil metabolism half-lives:

- Non-persistent less than 15 days
- Slightly persistent for 15-45 days
- Moderately persistent for 45-180 days, and
- Persistent for greater than 180 days.

- alpha-1(1-chlorocyclopropyl)-alpha-[(2-chlorophenyl)methyl]-3-(methylthio)-1H-1,2,4-triazole-1-ethanol (prothioconazole-S-methyl)
- 1,2,4-triazole
- prothioconazole-thiazocine
- Carbon dioxide

The identified minor transformation products of prothioconazole include: prothioconazole-sulfonic acid (JAU6726), prothioconazole-triazolinone (WAK7860), prothioconazole-3, 4, 5, and 6-hydroxy-desthio (3, 4, 5, and 6-HO-SXX0665), 2-chlorobenzoic acid, and JAU6476-triazolylketone (WAK4995). A table summarizing the maximum amounts of major degradates formed in different studies and their structures is available in **Appendix A**. As discussed in **Section 4**, past assessments have identified the two major degradates (*i.e*., prothioconazole-desthio and prothioconazole-S-methyl) as ROC for non-target organisms. The discussion here focuses on the identified ROC.

Prothioconazole-desthio is formed quickly and in large amounts (up to 56% of applied) from all degradation processes evaluated and remained present at the end of the laboratory studies at 4-55% of the applied as a result of desulfonation of the parent compound. Prothioconazole-S-methyl is also formed in large amounts from anaerobic aquatic metabolism (78% of applied), and in lesser amounts (up to 15%) from aerobic soil metabolism and aerobic aquatic metabolism and is the result of methylation of the sulfur of prothioconazole parent. Each of these identified major transformation products is expected to form in significant amounts in both the terrestrial and aquatic environments. Available environmental fate data suggest that degradation of the ROC is much slower than that of the parent alone, with ROC representative model input half-live values ranging from 145 to 486 days in aerobic soil systems, 42 to 101 days in aerobic aquatic systems, and 372 to 1,449 days in anaerobic aquatic systems. The ecological risk assessment is being completed for parent prothioconazole and the two major degradates; additionally, the assessment characterizes whether LOCs are exceeded for parent alone for the highest and lowest levels of aquatic exposure modeled (*i.e.*, highest and lowest EECs).

Table 5-2. Summary of Environmental Degradation Data for Prothioconazole Residues of Concern.

Study	System Details	Representative Half-life (days)[1]		Source/Study Classification/Comment
		Parent	ROC[2]	
Abiotic Hydrolysis	pH 4, 7, 9 @ 50°C; pH 5, 7, 9 @ 25°C	Stable	Prothioconazole-desthio: Stable	MRID's 46246505 Acceptable 46246506 Supplemental
Atmospheric Degradation	Hydroxyl Radical	3.4 hours	--	EPIWEB 4.1 (estimated value)
Aqueous Photolysis	pH 7, 25°C, 40°N	9.7 (SFO)	Prothioconazole-desthio: Increasing	MRID 46246507 Supplemental

Study	System Details	Representative Half-life (days)[1]		Source/Study Classification/Comment
		Parent	ROC[2]	
			at study termination (no $t_{1/2}$ calculated) Prothioconazole plus prothioconazole-desthio: 101.9 days	Prothioconazole-S-methyl is not formed by photolysis
Soil Photolysis	Loamy sand, 20°C, pH 6.8, 40°N	Stable	Stable	MRID 46246510 Acceptable Photolysis half-life could not be calculated as parent degraded slightly faster in dark than in irradiated samples. Prothioconazole-desthio was still increasing at study termination.
Aerobic Soil Metabolism	Silt, 20°C, pH 7.1	0.23 (IORE)	145 (DFOP; Slow $t_{1/2}$)	MRID 46246511 Acceptable
	Loamy Sand, 20°C, pH 6.8	3.15 (IORE)	486 (DFOP; Slow $t_{1/2}$)	
	Sandy loam, 20°C, pH 7.2	1.58 (IORE)	177 (SFO)	MRID 46246512 Acceptable
	Silty clay loam, 20°C, pH 5.9	23.5 (IORE)	265 (DFOP; Slow $t_{1/2}$)	
	Silt loam, 20°C, pH 6.8	0.21 (IORE)	116 (DFOP; Slow $t_{1/2}$)	MRID 50917601[N] Acceptable
Aerobic Aquatic Metabolism	Loam, 20°C	51 (DFOP; Slow $t_{1/2}$)	101 (DFOP; Slow $t_{1/2}$)	MRID 46246515, Supplemental
	Loamy sand, 20°C	3.89 (IORE)	41.6 (SFO)	
Anaerobic Aquatic Metabolism	Sandy clay loam, 20°C	110 (SFO)	1449 (SFO)	MRID 46246516, Acceptable
	Silt loam, 20°C	17.7 (IORE)	372 (DFOP; Slow $t_{1/2}$)	MRID 50917602 [N], Acceptable

SFO=single first order; DFOP=double first order in parallel; IORE=indeterminate order (IORE); SFO DT_{50}=single first order half-life; T_{IORE}=the half-life of a SFO model that passes through a hypothetical DT_{90} of the IORE fit; DFOP slow DT_{50}=slow rate half-life of the DFOP fit, --=not available or applicable; SFO-LN=SFO calculated using natural log transformed data

[N] Studies submitted since the Problem Formulation was completed are designated with an N associated with the MRID number.

[1] The value used to estimate a model input value is the calculated SFO DT_{50}, T_{IORE}, or the DFOP slow DT_{50} from the DFOP equation. The model chosen is consistent with that recommended using the, *Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media* (NAFTA, 2012). [2]Residues of Concern include the parent, prothioconazole-desthio, and prothioconazole S-methyl.

A summary of terrestrial field dissipation data is provided in **Table 5-3**. Dissipation half-lives (DT_{50}) in reviewed terrestrial field dissipation studies at three sites in the U.S. range from 2 to 5 days for parent, but are longer for the two major degradates, at 85-315 days for prothioconazole-desthio and 21-148 days for prothioconazole S-methyl. Prothioconazole was not detected below 15 cm in any of the studies. Prothioconazole-desthio was detected at levels above the limit of quantitation (LOQ) down to 30 cm and at levels above the minimum detection limit (MDL) but below the LOQ down to 45 cm in one replicate in the California field study, and at levels below the LOQ at one to two sampling times in the Georgia and New York field studies. Prothioconazole-S-methyl was detected below 15 cm only in a single replicate (below LOQ) in the field study in California. This supports the analysis that prothioconazole ROC have the potential to leach to groundwater in some environments. While field dissipation studies are designed to capture a range of loss processes; laboratory studies are designed to capture loss from one process (*e.g.*, hydrolysis, aerobic metabolism, *etc*.). Thus, the values from laboratory studies are not directly comparable to the values from the field studies; however, it is informative to have some understanding of how the laboratory data compare to the loss rates in the field dissipation studies. The field dissipation studies support the laboratory study results showing that prothioconazole degrades to the two major, more persistent degradates.

In three aquatic field studies (one in CA, two in AR), dissipation half-lives were longer in the sediment for both prothioconazole (77 days) and prothioconazole-desthio (DT_{50}'s of 90-122 days) relative to those in the water phase (DT_{50} of 0.6-4.8 days for parent only and 2.7-9 days for the degradate). The shorter dissipation half-lives in paddy water were likely more due to adsorption than to degradation given the compounds' slower rates of biotic degradation and photodegradation in lab studies. Prothioconazole was detected in sediment below 3 inches at only three sampling intervals but was only present at concentrations below the LOQ (but above the MDL). Prothioconazole-desthio was detected at 3- to 6-inches deep in sediment through 28 days after treatment (DAT) in the Arkansas flooded field and through 60 DAT in the Arkansas flooded and cropped field. Prothioconazole-S-methyl was detected below 3 inches in sediment only, at three sampling intervals in the Arkansas flooded and cropped field. However, uncertainties in the aquatic field studies (including instability of prothioconazole and some degradates in storage) render the results less than definitive with respect to meaningful dissipation rates in the environment. Recovery of prothioconazole in soil and water ranged from 9.9-39.0% after 650-822 days in storage in all three studies.

Table 5-3. Summary of Field Dissipation Data for Prothioconazole and its Major Degradates, Prothioconazole-desthio and Prothioconazole-S-methyl.

System Details	DT_{50} (days)/DT_{90} (days)			Deepest Core in Which (1) Parent, (2) Degradate Found (cm)	Source/Study Classification/ Comment
	Prothiocon-azole	Prothioconazole-desthio	Prothioconazole S-methyl		
Terrestrial Field Dissipation					
CA, sandy loam/loam; pH 8.2, 0.38% OM	2.2/7	84.5/239-307	21.2/63	(1) 15 cm (7 d) (2) 45 cm (through 307 d)	MRID 46246517 Supplemental
GA, sand/sandy loam; pH 6.2, 1.1% OM	4.7/<2	96.3/120-296	41.3/not determined	(1) 15 cm (14 d) (2) 30 cm (7 d)	MRID 46246518 Supplemental

System Details	DT_{50} (days)/DT_{90} (days)			Deepest Core in Which (1) Parent, (2) Degradate Found (cm)	Source/Study Classification/ Comment
	Prothiocon-azole	Prothioconazole-desthio	Prothioconazole S-methyl		
NY, loamy sand; pH 6.4,3.4% OM	3.1/77	315.1/>567	147.5/>422	(1) 15 cm (211 d) (2) 15 cm (through 567 d)	MRID 46246519 Supplemental
Aquatic Field Dissipation					
California, clay	77 days in sediment 1.7 days in paddy water	122 days in sediment 9 days in paddy water	–	–	MRID 46246522 Supplemental
Arkansas, loam	4.8 days in paddy water	121.6 days in sediment 8 days in paddy water	–	–	MRID 46246523 Supplemental
Arkansas - cropped, loam	0.6 days in paddy water	90.0 days in sediment 2.7 days in paddy water	–	–	MRID 46246524 Supplemental

6 Ecotoxicity Summary

Ecological effects data are used to estimate the toxicity of prothioconazole to surrogate species. The ecotoxicity data for prothioconazole and its associated products have been reviewed previously in multiple ecological risk assessments (USEPA, 2010, DP Barcode 378999+; USEPA, 2012, DP Barcode 395296+) and in the PF (USEPA, 2015b, DP Barcode 427289). These data are summarized in Section 6.1 and Section 6.2**.** Additional effect data that were not used in the estimation of toxicity are presented in **Appendix G**. Various studies with terrestrial and aquatic plants, birds, and aquatic animals exposed to either the technical grade active ingredient (TGAI), typical end-use product (TEP) of prothioconazole or one of its degradates (prothioconazole-S-methyl or prothioconazole-desthio) were received since the PF was issued in 2015; the results of these studies are described briefly in this section**.**

A search of the public ECOTOXicology Knowledgebase[9] (ECOTOX) in June 2020 and the EFED ECOTOX refresh report (August 2019), yielded no new data from suitable studies with more sensitive (lower) toxicity endpoints than those previously used in risk assessments[10].

Table 6-1 and **Table 6-2** summarize the most sensitive measured toxicity endpoints available across taxa and ROC. These endpoints are not likely to capture the most sensitive toxicity

[9] https://cfpub.epa.gov/ecotox/

[10] There were some endpoints that were lower in the ECOTOX report; however, the endpoints were not considered reliable for use in risk assessment.

endpoint for a particular taxon but capture the most sensitive endpoint across tested species for each taxon. All studies in this table are classified as acceptable or supplemental. Non-definitive endpoints are designated with a greater than ('>') or less than ('<') value. Values that are based on newly submitted data are designated with an 'N' superscript associated with the master record identification (MRID) number in tables.

6.1 Aquatic Toxicity

The available data indicate that TGAI prothioconazole is moderately toxic to freshwater fish and aquatic-phase amphibians and slightly toxic to estuarine/marine fish on an acute exposure basis. Prothioconazole is moderately toxic to freshwater and estuarine/marine invertebrates on an acute exposure basis.

Available data indicate that prothioconazole-desthio is slightly to moderately toxic to freshwater fish and aquatic-phase amphibians and slightly toxic to estuarine/marine fish on an acute exposure basis. Prothioconazole-desthio is very highly toxic to estuarine/marine invertebrates on an acute exposure basis, but there are no acute data available for freshwater invertebrates exposed to prothioconazole-desthio. Prothioconazole-S-methyl is moderately toxic to freshwater fish and aquatic-phase amphibians and freshwater invertebrates and highly toxic to estuarine/marine invertebrates on an acute exposure basis. There are no acute toxicity data available for estuarine/marine fish exposed to prothioconazole-S-methyl. The TEP is moderately toxic to freshwater fish/aquatic-phase amphibians and freshwater invertebrates on an acute exposure basis. There are no data available for estuarine/marine fish or invertebrates exposed to TEP (**Appendix G**).

Chronic No Observed Adverse Effects Concentrations (NOAECs) are approximately 10-fold more sensitive than the acute lethal concentration to 50% of the organisms tested (*i.e.*, LC_{50}) with one exception. The acute LC_{50} and chronic NOAEC for estuarine/marine invertebrates (*A. bahia*) are approximately equivalent.

Nine new studies examining toxicity to surrogate aquatic species were conducted since the PF. A chronic toxicity study of TGAI prothioconazole (98.3% active ingredient; a.i.) to freshwater fish (*O. mykiss*) was submitted (MRID 50489201), in which there was an 18% reduction in fry survival at the LOAEC (930 µg a.i./L) when compared to the control, resulting in a NOAEC of 490 µg a.i./L. An acute toxicity study of prothioconazole-desthio (98.3% purity) to the estuarine/marine fish (*C. variegatus*; MRID 50633901), resulted in a 96-h LC_{50} of 10,200 µg desthio/L. An acute toxicity study of prothioconazole-S-methyl (99.7% purity) to estuarine/marine invertebrates (*A. bahia*; MRID 50853501) resulted in a 96-h LC_{50} of 520 µg S-methyl/L. Additionally, an acute toxicity study of prothioconazole-S-methyl (99.6%) to the Eastern oyster (*C. virginica*; MRID 50925601) resulted in an 50% inhibition concentration (IC_{50}) of >520 µg S-methyl/L. Data on a marine diatom *S. costatum* exposed to prothioconazole-desthio resulted in a 96-hour EC_{50} of 4.81 µg desthio/L (MRID 50634201).

Four new toxicity studies with benthic invertebrates have also been submitted since the previous risk assessments and PF. In a 28-day spiked water test for the freshwater midge *(C. riparius)* exposed to prothioconazole-S-methyl (98.9% purity), the NOAEC/ LOAEC based on reduced emergence (24% reduction at the LOAEC) were 5.9/66 µg S-methyl/L pore water (MRID 50019201). In a 41-day life cycle spiked sediment test for the freshwater midge *(C. dilutus)* exposed to prothioconazole TGAI, the NOAEC/ LOAEC were 65/ >65 µg a.i./L pore water due to no observed effects at the highest concentration tested (MRID 50973501). In a 42-day life cycle spiked sediment toxicity test of prothioconazole TGAI with the freshwater amphipod *H. azteca*, the NOAEC/LOAEC were 1,080/>1,080 µg a.i./L pore water due to no observed effects at the highest concentration tested (MRID 50969303). In a 28-day life cycle spiked sediment toxicity test with the estuarine/marine amphipod *Leptocheirus plumulosus* exposed to prothioconazole TGAI, the NOAEC/LOAEC were 15,100/>15,100 µg a.i./L (corresponding to 14/>14 µg S-methyl/L) pore water due to no effects observed at the highest concentration tested (MRID 50969302). In the three life cycle studies with benthic invertebrates (*C. dilutus, H. azteca and L. plumulosus*), concentrations were measured for the parent material as well as the two degradates. The toxicity endpoints from the *C. riparius* and *L. plumulosus* studies were used to evaluate chronic risk to freshwater and estuarine/marine benthic invertebrates exposed in sediment, respectively. The endpoints for both studies were based on the measured concentrations of prothioconazole-S-methyl.

Only four of the newly submitted aquatic exposure studies were used in estimating RQ values. The acute exposure of the estuarine/marine Sheepshead Minnow to prothioconazole-desthio, the 28-day exposure of the freshwater benthic invertebrate *C. riparius* to prothioconazole-S-methyl and the exposure of the marine diatom *S. costatum* to prothioconazole-desthio resulted in slightly lower (more sensitive) toxicity endpoints than were used in previous assessments. The sediment exposure to the estuarine/marine amphipod *L. plumulosus* had not been previously assessed.

Typically, risk quotient (RQ) values are based on the toxicity of the parent compound. However, available fate data indicate that the parent quickly degrades to the two main degradates (*i.e.*, prothioconazole-desthio and prothioconazole-S-methyl), which are more persistent. Because of this, it is assumed that exposure to the degradates would be more likely to occur than to the parent material and that RQ values based on these more sensitive endpoints would be protective for the parent as empirical toxicity data indicate that the assessed organisms are often more sensitive to one of the two degradates than to the parent compound. Therefore, the toxicity endpoints selected for risk estimation (**Table 6-1** and **Table 6-2**) are based primarily on the most toxic degradate where that endpoint is normalized to the molecular weight of the parent so that the endpoints can be compared to the EEC for ROC, which are expressed in terms of parent. There is one exception, and that is for the acute exposure to the freshwater invertebrate. The acute exposure to freshwater invertebrates occurs over a 48-hour period. The shorter exposure time could mean that the organisms were more likely exposed to the parent chemical and the empirical data show that the organisms are more sensitive to the parent than the degradates. **Appendix G** lists additional endpoints that were not used in the risk estimation calculations.

Table 6-1. Aquatic Toxicity Endpoints Selected for Risk Estimation for Prothioconazole, Prothioconazole-desthio, and Prothioconazole-S-methyl.

Study Type	Test Substance (% a.i. or purity)	Test Species	Toxicity Value in µg a.i./L[1] (normalized value)	MRID or ECOTOX No./ Classification	Comments
Freshwater Fish (Surrogates for Vertebrates)					
Acute	S-methyl (98.6% purity)	Rainbow Trout (*Oncorhynchus mykiss*)	96-hour LC_{50} = 1,780 [1,709]	46246021 Acceptable	moderately toxic
Chronic	-Desthio (96.4% purity)	Fathead Minnow *(Pimephales promelas)*	30-weeks NOAEC = 148 [163] LOAEC = 296 [326]	46246033 Supplemental	reduction in survival (14%) and spawning frequency (100%) and increase in growth deformities (46% affected) at LOAEC
Estuarine/Marine Fish (Surrogates for Vertebrates)					
Acute	-Desthio (98.3% purity)	Sheepshead Minnow (*Cyprinodon variegatus*)	96-h LC_{50} = 10,200 [11,220]	50633901[N] Acceptable	slightly toxic
Chronic			NOAEC = 145	N/A	Based on acute to chronic ratio (ACR) of freshwater fish: 77.0[2]
Freshwater Invertebrates (Water-Column Exposure)					
Acute	TGAI (98.4% a.i.)	Water Flea (*Daphnia magna*)	48-h LC_{50} = 1,200	46246009 Acceptable	moderately toxic
Chronic	-Desthio (96.5% purity)	Water Flea (*Daphnia magna*)	3-weeks NOAEC = 103 [113] LOAEC = 206 [227]	46246029 Acceptable	14% reduction in number of offspring/surviving adult at LOAEC
Estuarine/Marine Invertebrates (Water-Column Exposure)					
Acute	-Desthio (96.5% purity)	Mysid Shrimp (*Americamysis bahia*)	96-h LC_{50} = 60 [66]	46246017 Acceptable	Very highly toxic
Chronic	-Desthio (97.0% purity)	Mysid Shrimp (*Americamysis bahia*)	29-days NOAEC = 64 [70] LOAEC = 128 [141]	46246030 Acceptable	32% reduction in number of young/female at LOAEC
Mollusks (Based on Water Column Exposure)					
Acute Shell Depositi on	S-methyl (99.6% purity)	Eastern Oyster (*Crassostrea virginica*)	96-h IC_{50} >520 [>499]	50925601[N] Supplemental	Highly toxic
Freshwater Invertebrate (Sediment Exposure)					

Study Type	Test Substance (% a.i. or purity)	Test Species	Toxicity Value in µg a.i./L[1] (normalized value)	MRID or ECOTOX No./ Classification	Comments
Chronic	S-methyl (98.9% purity)	Midge (*Chironomus riparius*)	28-d Pore water: NOAEC = 5.9 [5.7] LOAEC = 66 [63] Overlying water: NOAEC = 28 [27] LOAEC = 280 [269]	50019201[N] Supplemental	Emergence adversely affected at two highest concentrations (24 and 93%↓, respectively); analytical in low, mid and high conc. only in overlying water and pore water; not measured in sediment
Estuarine/ Marine Invertebrates (Sediment Exposure)					
Chronic	TGAI[3] (98.10% a.i.)	Amphipod (*Leptocheirus plumulosus*)	28-day OC-normalized sediment: NOAEC = 68,400 [65,664] µg a.i./kg_{OC} LOAEC >68,400 [>65,664] µg a.i./kg_{OC} Pore water: NOAEC = 14.3 [13.7] µg a.i./L LOAEC >14.3 [>13.7] µg a.i./L	50969302[N] Acceptable	Organic carbon content in sediment = 0.36%; no effect study up to highest concentration
Aquatic Plants and Algae					
Vascular	-Desthio (97.0% purity)	Duckweed (*Lemna gibba*)	7-day EC_{50} = 35 [39] NOAEC = 5.8 [6.4] LOAEC = 14 [16]	46246104 Acceptable	26% reduction in frond number at LOAEC
Non-vascular	-Desthio (98.3% purity)	Marine Diatom (*Skeletonema costatum*)	96-hour EC_{50} = 4.8 [5.3] NOAEC = 1.3 [1.5] LOAEC = 2.8 [3.1]	50634201[N] Acceptable	26% reduction in yield at the LOAEC

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient

[N] Studies submitted since the preliminary Problem Formulation was completed are designated with an N associated with the MRID number but are not necessarily used to estimate risk.

>Greater than values designate non-definitive endpoints where no effects were observed at the highest level tested, or effects did not reach 50% at the highest concentration tested (USEPA, 2011).

[1] Molecular weight (MW) normalization: A conversion was made from the metabolite to the parent on a MW basis. The toxicity endpoint of the metabolite (*e.g.*, LC_{50} or NOAEC/LOAEC) was multiplied by the ratio of the MW of the parent divided by the MW of the metabolite. The MW of prothioconazole is 344.25 g/mol; the MW of prothioconazole-desthio is 312.19 g/mol and the MW of prothioconazole-S-methyl is 358.28 g/mol. The ratio of parent and -desthio is 1.10 and the ratio of parent and -S-methyl is 0.96. The toxicity value reported in the data evaluation record (DER) is reported first, followed by the MW converted value in [brackets].

[2] Acute to chronic ratio (ACR) calculated based on freshwater fish studies (MRIDs 46246026 and 46246033). Acute value 11,400 µg desthio/L divided by chronic value 148 µg desthio/L = 77.0. Therefore, the acute endpoint from the estuarine/marine study 10,200 µg desthio/L was divided by 77.0 to obtain the ACR chronic toxicity value for estuarine/marine fish.

[3] Concentrations of the parent and both major degradates were measured. Results presented above are based on the measured concentrations of the degradate prothioconazole-S-methyl normalized to the molecular weight of the parent material.

6.2 Terrestrial Toxicity

The available data indicate that prothioconazole TGAI is practically non- toxic to birds (and reptiles and terrestrial-phase amphibians for which birds serve as surrogates) and mammals on an acute oral exposure basis and practically non-toxic to birds, reptiles and terrestrial-phase amphibians on a sub-acute dietary exposure basis. Prothioconazole is practically non-toxic to young adult honey bees and adult bumble bees on an acute contact exposure basis (**Appendix G**); prothioconazole TGAI is also practically non-toxic to adult honey and bumble bees on an acute oral exposure basis.

Available data indicate that prothioconazole-desthio is practically non-toxic to birds, reptiles, terrestrial-phase amphibians, and mammals on an acute oral exposure basis and slightly toxic to birds, reptiles and terrestrial-phase amphibians on a sub-acute dietary exposure basis. Prothioconazole-desthio is practically non-toxic to adult honey bees on an acute contact and oral exposure basis. There are no acute or chronic toxicity data available for birds, mammals or bees exposed to prothioconazole-S-methyl. Based on available data on select TEP, the formulated end-use product is practically non-toxic to honey bees on an acute contact and oral exposure basis (**Appendix G**). **Table 6-2** provides a listing of the endpoints used to estimate risk to terrestrial organisms.

In a 20-week reproductive toxicity study on the mallard duck (*Anas platyrhynchos*) exposed to prothioconazole-desthio, the NOAEC/LOAEC are 449/>449 mg a.i./kg-diet, based on no effects observed at the highest concentration tested relative to controls. Available chronic data for the mallard duck exposed to the parent compound is 4.4 times less sensitive than data from the exposure to prothioconazole-desthio.

Laboratory rats (*Rattus norvegicus*) fed diets containing prothioconazole-desthio (640 mg a.i./kg-diet) during a two-generation study, had a decrease in viability of pups (21-33% reduction) and body weight (8-15% reduction) relative to controls. Available chronic data for rats exposed to the parent compound are 10 times less sensitive than data from the exposure to prothioconazole-desthio.

Chronic exposure of adult bees to the TEP Prothioconazole™ SC 480 (39.6% a.i.) did not result in any adverse effects up to the highest dose tested (NOAEL=3.19 µg a.i./bee/day). A second chronic exposure of adult bees to the TEP Prothioconazole™ SC 480 (41.4% a.i.) indicated 53 and 90% adult mortality in 46.5 and 64.3 µg a.i./bee/day treatment groups, respectively, resulting in a NOAEC/LOAEC of 26.1/46.5 µg a.i./bee/day, respectively. The second chronic adult study was used to estimate risk in this assessment since it provides bounded toxicity endpoints, even though the first study provided a lower NOAEL. Chronic exposure of honey bee larvae to technical grade prothioconazole resulted in a NOAEL of 2.0 µg ai/bee/day based on 19% reduction in adult emergence at the LOAEL of 5.2 µg ai/bee/day. Three semi-field colony-level studies (*i.e.*, two tunnel- and one colony-feeding) with honey bees showed no statistically significant effects on bees at the highest rates tested in the studies. These colony-level studies have not completed review; however, taken at face value, they indicate that the two semi-field (tunnel) studies were conducted at rates up to 199.2 and 205.43 g/ha, respectively, which is equivalent to application rates of 0.178 and 0.187 and are protective of the application rates evaluated in this assessment where the compounds were applied to phacelia in full bloom while bees were actively foraging. Additionally, the colony-feeding study exposed bees to a liquid diet 470 mg/L for 24 hrs; this concentration is roughly 16x higher than the EEC in nectar based on Bee-REX (29.4 mg/L) and there were no adverse effects on the colony.

As reported in the 2010 Environmental Risk Assessment (USEPA, 2010*c*), Tier I plant studies were conducted with 10 species of plants exposed to 0.272 lbs a.i./A, which is greater than the highest single application rate of 0.178 lbs a.i./A used in previous assessments. With the exception of cucumbers, effects did not exceed 25% inhibition, and the endpoint (*i.e*., the 25% inhibition concentration; EC_{25}) used to calculate standard risk quotients was not available. For cucumbers, there was a greater than 25% effect on shoot length and dry weight in the seedling emergence study. Although effects in cucumbers did not exceed 25% in the vegetative vigor study, the percent inhibition for this species was generally among the highest of the agricultural plants tested. Based on the results of the Tier I study, a Tier II study for cucumber was required. In the Tier II study, no effects exceeded a 25% inhibition compared to the control for cucumbers for the highest test concentration of 0.272 lbs a.i./A. However, there were significant effects on both shoot height and dry weight with the lowest NOAEC associated with shoot height. The NOAEC for shoot height is equivalent to an application rate of 0.03 lbs a.i./A while the EC_{25} is greater than 0.272 lbs a.i./A.

No new studies have been submitted for mammals or terrestrial plants, and one new study submitted for birds (*i.e.*, canaries) was less sensitive than the studies used in previous assessments. Therefore, the estimated risks to terrestrial vertebrates and plants (detailed in the 2010 and 2016 ERAs) has not changed.

Table 6-2. Terrestrial Toxicity Endpoints Selected for Risk Estimation for Prothioconazole.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value[1,2] [normalized value]	MRID or ECOTOX No./ Classification	Comments
Birds (Surrogates for Terrestrial Amphibians and Reptiles)					
Acute Oral	TGAI (98.4% a.i.)	Northern Bobwhite Quail (*Colinus virginianus*)	14-day LD_{50} >2,000 mg a.i./kg-bw	46246036 Acceptable	Practically non-toxic
Sub-acute dietary	-Desthio (96.8% purity)	Northern Bobwhite Quail (*Colinus virginianus*)	8-days LC_{50} = 4,252 [4,677] mg a.i./kg-diet	46246039 Acceptable	Slightly toxic
Chronic	-Desthio (96.4% purity)	Mallard (*Anas platyrhynchos*)	20-weeks NOAEC = 449 [494] mg a.i./kg-diet LOAEC >449 [>494]	46246045 Supplemental	No treatment-related effects.
Mammals					

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value[1,2] [normalized value]	MRID or ECOTOX No./ Classification	Comments
Acute Oral	-Desthio (93.70% purity)	Norway Rat (*Rattus norvegicus*)	14-day LD_{50} = 2,806 [3,087] mg a.i./kg-bw	46246231 Acceptable	Practically non-toxic
Chronic (2-generation reproduction)	-Desthio (93.0% purity)	Norway Rat (*Rattus norvegicus*)	44 weeks NOAEC/NOAEL = 160 [176] mg a.i./kg-diet/9.5-11 [10.5-12] mg a.i./kg bw/day LOAEC/LOAEL =640 [704] /40-60 [44-51]	46246333 Acceptable	F1: 10-15% reduction in body weight and 21% reduction in Day 4 viability; F2: 8-12% reduction in body weight and 33% reduction in viability
Terrestrial Invertebrates					
Acute contact (adult)	TGAI (98.6% a.i.)	Honey bee (*Apis mellifera L.*)	48-hour LD_{50} >200 µg a.i./bee	46246048 Acceptable	Practically non-toxic
Acute oral (adult)	-Desthio (99.5% purity)		48-hour LD_{50} >106.5 [>117] µg a.i./bee	50489202[N] Acceptable	Practically non-toxic
Chronic oral (adult)	Prothioconazole™ SC 480 (39.6% a.i.)		10-day NOAEL = 3.19 µg a.i./bee/day	50489203[N] Acceptable	No effects up to the highest concentration tested
Acute oral (larval)	TGAI (96.7% a.i.)		7-day LD_{50} >58 µg a.i./larvae	50633902[N] Acceptable	16.7% mortality at highest concentration tested
Chronic oral (adult)	Prothioconazole™ SC 480 (41.4% a.i.)		10-day NOAEL = 26.1 µg a.i./bee/day LOAEL = 46.5 µg a.i./bee/day	50726802[N] Supplemental	53 and 90% adult mortality in 46.5 and 64.3 µg ai/bee/day treatment groups, respectively. Food consumption reduced 14-63% in all treatment groups
Chronic oral (larval)	TGAI (96.7% a.i.)		22-day NOAEL = 2.0 µg a.i./bee/day LOAEL = 5.2 µg a.i./bee/day	50633903[N] Acceptable	19% reduction in adult emergence at the LOAEL
Semi-field study (tunnel)	Prothioconazole™ EC 250 G	Honey bee (*Apis mellifera L.*)	31-day NOAEC =199.2 g a.s./ha	50489204[N] Under review	No effect study
Semi-field study (tunnel)	Prothioconazole™ EC 250 G	Honey bee (*Apis mellifera L.*)	17-day NOAEC =205.43 g a.s./ha	50521803[N] Under review	No effect study

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value[1,2] [normalized value]	MRID or ECOTOX No./ Classification	Comments
Semi-field study (colony-feeding)	SC™ 480 G (40.9% w/w)	Honey bee (*Apis mellifera L.*)	21-day NOAEL = 470 mg/L diet	50489205[N] Under review	No effect study
Terrestrial and Wetland Plants					
Seedling Emergence (Tier I)	TEP 41% a.i.	Buckwheat, Corn, Onion, Ryegrass, Wheat, Cucumber, Soybean, Sunflower, Tomato and Turnip	Most sensitive monocot: none EC_{25} >0.272 lb a.i./A NOAEC = 0.272 lb a.i./A Most sensitive dicot: cucumber EC_{25} <0.272 lb a.i./A NOAEC <0.272 lb a.i./A][3]	46246050 Acceptable	21-d duration; 31% inhibition of dry weight for cucumber
Seedling Emergence (Tier II)	TEP 41% a.i.	Cucumber	EC_{25} >0.272 lb a.i./A NOEC = 0.03 lb a.i./A	46246050 Acceptable	21-d duration; 16% reduction in dry weight at highest concentration tested
Vegetative Vigor	TEP 41% a.i.	Buckwheat, Corn, Onion, Ryegrass, Wheat, Cucumber, Soybean, Sunflower, Tomato and Turnip	Most sensitive monocot: none EC_{25} >0.272 lb a.i./A NOAEC = 0.272 lb a.i./A Most sensitive dicot: none EC_{25} >0.272 lb a.i./A NOAEC = 0.272 lb a.i./A	46246049 Acceptable	21-d duration; no significant effects

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient

[N] Studies submitted since the Problem Formulation was completed are designated with an N associated with the MRID number but was not necessarily used to estimate risk.

[1] NOAEC and LOAEC are reported in the same units.

[2] Molecular weight (MW) conversion (normalization): A conversion was made from the metabolite to the parent on a MW basis. The toxicity endpoint of the metabolite (*e.g.*, LC/LD_{50} or NOAEC/LOAEC) was multiplied by the ratio of the MW of the parent divided by the MW of the metabolite. The MW of prothioconazole is 344.25 g/mol; the MW of prothioconazole-desthio is 312.19 g/mol and the MW of prothioconazole-S-methyl is 358.28 g/mol. The ratio of parent and -desthio is 1.10 and the ratio of parent and -S-methyl is 0.96. The toxicity value reported in the data evaluation record (DER) is reported first, followed by the MW converted value in [brackets].

>Greater than values designate non-definitive endpoints where no effects were observed at the highest level tested, or effects did not reach 50% at the highest concentration tested (USEPA, 2011).

< Less than values designate non-definitive endpoints where growth, reproductive, and/or mortality effects are observed at the lowest tested concentration.

[3]The seedling emergence study with dicots (cucumbers) was repeated and it was determined that it was not as sensitive as suggested by the Tier I study.

6.3 Incident Data

The Incident Data System (IDS) provides information on the available ecological pesticide incidents, including those that have been aggregately reported to the EPA that reported since registration to when the database was searched on April 2020. **Table 6-3** provides a listing of the available incident data. These are also discussed in more detail in the risk assessment sections below.

A preliminary review of the Incident Data System (IDS) indicated a total of 20 ecological incidents (occurring between 2009-2016) associated with the use of prothioconazole; however, this total includes incidents classified as 'unlikely.' Only 17 incidents with a certainty category of 'possible' are summarized in **Table 6-3.** Sixteen incidents involved terrestrial plants (*i.e.*, potato, peanut, soybean, corn, wheat and sorghum), and one incident involved terrestrial organisms (*i.e*., honey bees). Of the 17 reported incidents, 6 of the incidents were considered to reflect registered uses at the time of the incident, the legality of use was undetermined in 8 of the incidents and 3 of the incidents were considered to reflect a misuse of the product at the time of the incident.

There are 16 plant incidents associated with prothioconazole in the IDS database. The reported incidents occurred between 2009 and 2016 and impacted anywhere from 7 acres to a total of 525 acres of plants (*i.e.,* potato, peanut, soybean, corn, wheat and sorghum).

There is one reported incident in the IDS database involving honey bees. In the reported incident, hive losses followed the application of PROSARO™ 421 SC (19.0% prothioconazole) to a crop. The specific type of crop was not reported, nor was the distance from the treated field.

Pesticide registrants report certain types of incidents to the Agency as aggregate counts of incidents occurring per product quarter. Ecological incidents reported in aggregate reports include those categorized as 'minor fish and wildlife' (W-B), 'minor plant' (P-B), and 'other non-target' (ONT) incidents. 'Other non-target' incidents include reports of adverse effects to insects and other terrestrial invertebrates. No incidents have been reported to the Agency in aggregated incident reports for prothioconazole.

Table 6-3. Prothioconazole Incidents from the Incident Data System (IDS).

Incident Number	Year	State	Product and Additional Active Ingredients	Legality	Certainty Index	Use Site	Species	Magnitude/Other Notes
Plant								
I023082-051	2011	IL	Stratego® YLD (also contains trifloxystrobin)	Undetermined	Possible	Soybean	Corn	47.6% of treated field
I023082-034	2011	IA	Stratego® YLD (also contains trifloxystrobin)	Misuse	Possible	Corn		100% of 70 acres
I024295-045	2012	IL	Prosaro® 421 SC (also contains tebuconazole)	Registered	Possible	Sorghum	Grain	100% of 64 acres
I028066-022	2015	VA	Provost® 433 SC (also contains tebuconazole)	Undetermined	Possible	Peanut	Peanut	150 crops
I022286-036	2010	GA		Undetermined	Possible			40 acres
I022392-027	2010	GA		Undetermined	Possible			50% of 460 acres
I023302-038	2011	GA		Registered	Possible			525 acres
I023554-008	2011	FL		Undetermined	Possible			56% of 450 acres
I023302-031	2011	GA		Registered	Possible			100% of treated field
I023302-030	2011	GA		Registered	Possible			100% of 100 acres
I023302-029	2011	GA		Registered	Possible			210 acres
I024925-047	2012	GA	Proline® 480 SC	Registered	Possible			100% of 7 acres
I025344-022	2013	ND	Emesto® Silver (also contains penflufen)	Undetermined	Possible	Agricultural area	Potato	100% of 120 acres
I028066-001	2015	MI	Stratego® YLD (also contains trifloxystrobin)	Undetermined	Possible	Soybean	Soybean	29 acres
I021485-021	2009	MN	Proline® 480 SC	Misuse	Possible	Agricultural area		500 acres
I024431-042	2012	ND	Prosaro® 421 SC (also contains tebuconazole)	Misuse	Possible	Wheat, spring	Wheat, spring	100% of 400 acres
Bees								
I029416-00002	2016	N/R	Prosaro® 421 SC (also contains tebuconazole)	Undetermined	Possible	N/R	Honey Bee	4 hives

N/R = not reported

7 Analysis Plan

7.1 Overall Process

This assessment uses a weight of evidence approach that relies heavily, but not exclusively, on a risk quotient (RQ) method. The RQs are calculated by dividing an estimate environmental concentration (EEC) by a toxicity endpoint (*i.*e., EEC/toxicity endpoint). This is a way to determine if an estimated concentration is expected to be above or below the concentration associated with the toxicity endpoint. The RQs are compared to regulatory levels of concern (LOCs). The LOCs for non-listed species are meant to be protective of community-level effects. For terrestrial and aquatic vertebrates, the acute risk LOC is 0.5 while the chronic risk LOC is 1.0. For aquatic invertebrates, the acute risk LOC is 0.5 while the chronic risk LOC is 1.0. For bees, the acute risk LOC is 0.4 while the chronic risk LOC is 1.0. For terrestrial and aquatic plants, the LOC is 1.0. In addition to RQs, other available data (*e.g.*, incident data) can be used to help understand the potential risks associated with the use of the pesticide.

Representative use patterns were selected for the risk assessment to present the range of potential risk and to provide an understanding of potential risk for unique use patterns.

7.2 Modeling

Various models are used to calculate aquatic and terrestrial EECs (see **Table 7-1).** The specific models used in this assessment for aquatic and terrestrial taxa are discussed further below in Sections **8** and **9**, respectively.

The aquatic exposure modeling conducted for this assessment focuses on the main uses of prothioconazole that are expected to have the most significant impact on the risk assessment. The main uses include those associated with the highest average annual pounds applied and/or highest average annual total acres treated. Based on information provided by BEAD in the PLUS report, the 2019 Screening Level Usage Analysis, aquatic exposure modeling was conducted for the following major uses (as listed in **Tables 3.2.1** and **3.2.2**.): sugar beets, wheat, soybeans, corn, peanuts and dry peas/beans. Other individual uses modeled for which magnitude of usage information was not available or was unclear (*i.e*., not specifically reported by crop) include berries (low-growing bush, including cranberries), and nursery seedlings (evergreen, conifer, softwood). Other uses were not modeled for aquatic exposure due to information from BEAD that indicated either low or non-existent usage, so would not be expected to make a significant impact on the ecological risk (*e.g.*, rapeseed, cucurbit vegetables, beets, leafy vegetables, brassica vegetables, rice, cotton). For the remaining registered uses (other than seed treatments), there are uses modeled which may serve as surrogates in terms of estimating risk (*e.g.*, wheat for all other cereal grains). For seed treatment, only the seed treatment use associated with the highest equivalent field rate (in lb/a) was examined for aquatic exposure using preliminary modeling. As no exceedances occurred for aquatic risk based on seed treatment, further modeling was not conducted, and risk was not presented quantitatively in this document.

Table 7-1. List of the Models Used to Assess Risk.

Environment	Taxa of Concern	Exposure Media	Exposure Pathway	Model(s) or Pathway
Aquatic	Vertebrates/ Invertebrates (including sediment dwelling)	Surface water and sediment [1]	Runoff and spray drift to water and sediment	PWC version 1.52[2] PFAM version 2.0[3]
	Aquatic Plants (vascular and nonvascular)			
Terrestrial	Vertebrate	Dietary items	- Dietary residues from liquid sprays (includes residues on foliage, seeds/pods, arthropods, and soil) - Non specified exposure pathway (*e.g.*, LD_{50}/ft^2) - Ingestion of seeds - Ingestion of granules Ingestion of Seeds	T-REX (version 1.5.2[4]) -Kenaga nomogram (for liquid foliar sprays) - LD_{50}/ft^2 index - ingestion of treated seeds calculations - ingestion of granules calculations Refinements for Treated Seed (USEPA, 2016)
	Plants	Spray drift/runoff	Runoff and spray drift to plants	TERRPLANT (version 1.2.2)
	Bees and other terrestrial invertebrates	Contact Dietary items	Spray contact and ingestion of residues in/on dietary items as a result of direct application	BeeREX (version 1.0)
All Environments	All	Movement through air to aquatic and terrestrial media	Spray drift	AgDRIFT™ (version 2.1.1) Spray drift

[1] Sediment analysis is recommended when the soil-water distribution coefficient (K_d) ≥50-L/kg-soil; the log K_{OW}≥3; or the K_{OC} ≥ 1000 L/kg-organic carbon. Analysis of risk in sediment from exposure in pore water may also occur if aquatic invertebrates are particularly sensitive, as it is expected that RQs will exceed LOCs even if the sediment is not the primary exposure media.

[2] The Pesticide in Water Calculator (PWC) is a Graphic User Interface (GUI) that estimates pesticide concentration in water using the Pesticide Root Zone Model (PRZM) and the Variable Volume Water Model (VVWM). PRZM-VVWM.

[3] Pesticides in Flooded Applications Model (PFAM) is used to simulate EECs when pesticides are applied to flooded or intermittently flooded areas.

[4] The Terrestrial Residue Exposure (T-REX) Model is used to estimate pesticide concentration on avian and mammalian food items. For liquid applications to bare soil, arthropod and seed residues estimated from the Kenaga nomogram are possible dietary exposure routes on the field and foliar residues estimate exposure adjacent to the field and that may occur with spray drift.

8 Aquatic Organisms Risk Assessment

8.1 Aquatic Exposure Assessment

8.1.1 Modeling

Surface water aquatic modeling was simulated using the Pesticide in Water Calculator (PWC version 1.52) for use patterns to terrestrial areas, and the Pesticides in Flooded Applications Model (PFAM; version 2.0 dated September 27, 2016) for use on cranberries that are grown with intermittently flooded fields. Chemical input parameters used in modeling are presented in **Table 8-1** and were calculated for ROC using a Total Residue (TR) approach based on information described in **Section 5.** Modeling was also conducted for parent alone only for two selected major uses for the purpose of comparison. Input parameters specific to the application scenarios are specified in **Table 8-2** based on the use information described in **Section 3.2.** Input parameters were selected in accordance with EFED's guidance documents (USEPA, 2009; USEPA, 2010b; USEPA, 2012a; USEPA, 2012b; USEPA, 2013a; USEPA, 2013b; USEPA, 2014a; USEPA, 2014b; USEPA, 2019; USEPA and Health Canada, 2012; USEPA and Health Canada, 2013). See **Section 7.2** of the analysis plan for an explanation of which uses were simulated in aquatic modeling. Dates for the first day of application for simulated use patterns were based on scenario emergence dates and on label instructions for use as a preventative foliar spray and for use once early disease symptoms are visible (see **Table 8-2**). Thus, for most of the uses modeled, an initial application date of 14 days post-emergence was used in simulation modeling, as in previous assessments.

The uses on agricultural crops allow for ground, aerial, and chemigation applications. For selected agricultural crop uses, preliminary modeling was conducted to generate EECs for broadcast aerial and ground spray applications. Based on the results of preliminary modeling of selected major uses (presented only for beans in **Table 8-3**), which indicates that aerial application resulted in higher EECs than ground applications, only aerial application is used for definitive modeling of EECs for all remaining uses for which aerial use is not restricted on the labels. Modeling is conducted using a batch processing input file with available scenarios including nonstandard scenarios when available (see **Appendix E**), particularly for uses with the highest usage based on the SLUA report (*i.e.*, for beans, sugar beets, and wheat) for which a limited number of standard scenarios were available. Since the previous ecological risk assessment was completed, new aerobic soil metabolism and anaerobic aquatic metabolism data were submitted. Based on the submitted studies, it was also determined that unextracted residues still remained bound after exhaustive extraction (*i.e.*, using multiple solvents with various dielectric constants) and could therefore be considered bound residues, so they are no longer incorporated into half-life estimates to account for the uncertainty in whether they could potentially be available for exposure, as was done in previous assessments. The new data and recalculated half-life input values are incorporated into the risk assessment and result in some changes in the aquatic modeling inputs. The model inputs for prothioconazole half-lives decreased with the newly available data and information on unextracted residues because the newly available data and the recalculated half-lives from previously submitted metabolism studies result in lower representative half-life inputs than previously calculated values. The input value for aerobic soil metabolism dropped from 1052 to 340 days for ROC (TR in the table below), while the aerobic aquatic metabolism half-life dropped from 385 to 163 days for ROC. The half-life input for anaerobic aquatic metabolism is now 2,573 days for ROC while in the past it was entered as "0" for stable (*i.e.*, no metabolism occurring). An additional change from previous assessments is that it is now recommended that the daily average value be used to calculate acute risk quotients for aquatic organisms rather than the peak value used in previous risk assessments (USEPA, 2017).

Modeling was conducted using the Total Residue (TR) approach to account for the ROC (*i.e.*, the parent and the two major degradates). This assessment is not focusing on risk from exposure to parent alone since there are toxicological concerns and data for the degradates in the ROC, and because the parent often rapidly degrades to the major degradates in soil; however, input values for parent only for selected major uses are included in **Table 8-1** for comparison, and parent only EECs were determined for two selected major uses (*i.e.*, corn, bushberry) to represent higher and lower bounds of parent EECs. The soil mobility (K_{oc} value) of the more mobile degradate (*i.e.*, prothioconazole-desthio) is used for modeling, as there is no value available for parent and that degradate is expected to be present as a major residue of prothioconazole in both the soil and aquatic environments.

Table 8-1. Aquatic Modeling Input Parameters for Chemical Tab for Prothioconazole and Prothioconazole Residues of Concern (Designated with TR).

Parameter (units)	Value (s)	Source	Comments
K_{OC} (mL/g)	575	MRID 46246450	Average of 4 values for prothioconazole-desthio, the more mobile degradate. The coefficient of variation was 9.2% for K_{OC} and 43% for K_d. Parent K_{oc} is not available.
Water Column Metabolism Half-life (days) at 20°C	163 TR 100.2 parent	MRID 46246515	Represents the 90 percent upper confidence bound on the mean of 2 representative half-life values from aerobic aquatic metabolism studies.
Benthic Metabolism Half-life (days) at 20°C	2573 TR 205.9 parent	MRIDs 46246516 50917602	Represents the 90 percent upper confidence bound on the mean of 2 representative half-life values from anaerobic aquatic metabolism studies.
Aqueous Photolysis Half-life (days)@ pH 7	101.9 TR 9.7 parent at 40°N	MRID 46246507	Single measured values for parent and parent plus prothioconazole-desthio (prothioconazole-S-methyl not present).
Hydrolysis Half-life (days)	0	MRIDs 46246505 46246506	No significant degradation observed at 25°C or 50°C for parent or prothioconazole-desthio.

Parameter (units)	Value (s)	Source	Comments
Soil Half-life (days) at 20°C	340.1 TR 13.3 parent	MRIDs 46246511 46246512 50917601	Represents the 90 percent upper confidence bound on the mean of 5 representative half-life values from aerobic soil metabolism studies.
Foliar Half-life (days)	–	–	No Data
Molecular Weight (g/mol)	344.26	MRID 46246003	–
Vapor Pressure (Torr) at 25°C	3×10^{-9}	MRID 46246003	Vapor pressure for parent
Solubility in Water (mg/L)	300	MRID 46246003	20°C and pH 8, measured value for parent
Heat of Henry (J/mol)	49,844	–	Calculated from EPIWEB 4.1
Henry Reference Temperature (°C)	25	–	–

[1] Other input parameters for the applications tab are shown in **Table 8-2**

Pesticide in Water Calculator scenarios are used to specify soil, climatic, and agronomic inputs in the Pesticide Root Zone Model (PRZM) and are intended to result in high-end water concentrations associated with a particular crop and pesticide within a geographic region. Each PWC scenario is specific to a vulnerable area where the crop is commonly grown. Soil and agronomic data specific to the location are built into the scenario, and a specific climatic weather station providing 30 years of daily weather values is associated with the location. **Table 8-2** identifies the use sites associated with each PRZM or PFAM scenario. Nonstandard PWC scenarios are described in **Appendix E**. Metadata for the PFAM scenarios is presented in **Appendix B.**

Currently approved standard PRZM crop scenarios were used in modeling when available. Low-growing berries include both berries grown on the ground (*e.g.*, strawberries) and berries grown on shrubs (*e.g.*, blackberries). The crop group registration (Subgroup 13-07H) for prothioconazole excludes strawberries, so the ORberriesOP scenario represents that subgroup as well as the bushberries use (Subgroup 13-07B) which has a slightly higher application rate (used in modeling); results are reported only for the higher rate (*i.e.*, bushberries use) which is protective of both uses. The ORberriesOP scenario was developed for the organophosphate (OP) cumulative assessment and although prothioconazole is not an OP, the OP berry scenario is the only scenario available for this type of crop. The Pesticide Flooded Application Model (PFAM) was also used to model cranberries as a representative crop for the low-growing berries (Subgroup 13-07H). For both wheat and sugar beets, which are two of the major crops on which prothioconazole is used, OP scenarios were used in addition to the standard modeling scenarios, as only a single standard scenario was available for each of those uses. For a third major use (*i.e.*, dried shelled pea and beans), available standard scenarios were utilized in addition to scenarios developed to support the N-methyl carbamate (NMC) risk assessments. This was done to provide modeling results for additional geographic areas of the U.S., including Illinois, since data provided by BEAD indicate that prothioconazole is used on beans in that state.

Unlike EFED's standard crop scenarios, the OP-cumulative scenarios were not developed specifically to represent high-end exposure (*i.e*., vulnerable) sites. Instead, these scenarios were developed by first identifying areas of high combined use of the entire OP class of chemicals that coincided with drinking water intakes that draw from surface water sources. Within these high OP-use areas, major crop uses were identified, and scenarios were developed to represent high runoff-prone soils known to support the crops in these areas. In some instances, these scenarios may represent the major growing area for a particular crop. In other instances, the major crop area may be elsewhere, and the scenario in the high OP-use area may represent a "fringe" area of the crop in question. It has not been determined how the vulnerability of a crop scenario developed for the OP cumulative assessment compares to a standard scenario developed for the same crop; therefore, the OP scenarios may represent either greater or lesser vulnerability than standard scenarios. Because the OP scenarios focused on areas that coincided with drinking water intakes, their suitability as high-end vulnerable scenarios for ecological exposure assessments is less certain. There is additional discussion on non-standard scenarios in **Appendix E.**

The 1-day (acute) EECs range from 2.7 µg/L for bushberries to 26.1 µg/L for corn. Similarly, the respective 21-day and 60-day ranges were 2.5-24.7 µg/L and 2.4-21.7 µg/L. The EECs determined in this assessment are lower than those determined in previous assessments due to the incorporation of additional data and because new information provided more certainty that the unextracted residues could be considered bound and were not accounted for in half-life determinations (as they had been in previous assessments). Acute EECs in previous assessments for the major uses (wheat, corn, soybeans, sugar beets) were in the range of 17-44 µg/L; whereas, in this assessment acute EECs are 26 µg/L for corn and range from 6 to 13 µg/L for those other four major uses. For the use with the highest acute EEC for prothioconazole ROC (*i.e*., corn at 26 µg/L), the acute EEC for parent only is about 50% of that (*i.e*., 12.9 µg/L). For the use with the lowest EEC for prothioconazole ROC (*i.e*., bushberries at 2.7 µg/L), the parent only acute EEC is about 78% of that (*i.e*., 2.1 µg/L). Example output files from PWC and PFAM are presented in **Appendix B**.

Table 8-2. Pesticide in Water Calculator (PWC) and Pesticide Flooded Application Model (PFAM) Input Parameters Specific to Selected Use Patterns for Prothioconazole (Applications Tab and Crop/land Tab).

Use Site	PWC Scenario/PFAM[1]	Date of Initial App.	App. Rate in lbs a.i./A (kg a.i./ha)	# App. per Year	Max Annual App in lbs a.i./A	App. Interval (days)	App Method	Application Efficiency/ Spray Drift Fraction
Bushberry (Subgroup 13-07B)/Ag	ORberriesOP	4/15	0.178 (0.199)	2	0.356	7	Above crop	0.99/0.062

Use Site	PWC Scenario/PFAM[1]	Date of Initial App.	App. Rate in lbs a.i./A (kg a.i./ha)	# App. per Year	Max Annual App in lbs a.i./A	App. Interval (days)	App Method	Application Efficiency/ Spray Drift Fraction
Low growing berry (Subgroup 13-07H, except strawberry) /Ag (Cranberry)	MA_cranberry_WinterFlood (PFAM) OR_cranberry_NoFlood (PFAM) OR_cranberry_winterFlood (PFAM) WI_Cranberry_winterflood (PFAM)	7/1	0.156 (0.175)	2	0.313	7	Ground	–
Dried shelled pea and bean (except soybean) subgroup/ Dried peas/ Ag	MIbeansSTD ORsnbeansSTD ILbeansNMC WAbeansNMC	14 days post-emergence	0.178 (0.199)	3	0.534	5	Above crop	0.95/0.125 0.99/0.062
Nursery seedlings of conifers/evergreen /softwood	CAnursery STD_V2 FLnursery STD_V2 MInurserySTD_V2 NJnursery STD_V2 ORnursery STD_V2 TNnursery STD_V2	14 days post-emergence	0.156 (0.175)	(5)	0.781	14	Above crop	0.99/0.062
Corn/field or pop	IAcornstd ILcornSTD INcornStd KScornStd MNcornStd MScornSTD NCcornESTD NEcornStd OHcornSTD PAcornSTD	14 days post-emergence	0.178 (0.199)	(4)	0.713	7	Above crop	0.95/0.125 0.99/0.062
Peanuts	NCpeanutSTD	5/30	0.178 (0.199)	4	0.713	14	Above crop	0.95/0.125 0.99/0.062

Use Site	PWC Scenario/PFAM[1]	Date of Initial App.	App. Rate in lbs a.i./A (kg a.i./ha)	# App. per Year	Max Annual App in lbs a.i./A	App. Interval (days)	App Method	Application Efficiency/ Spray Drift Fraction
Soybean	MSsoybeanSTD	At planting (7 days pre-emergence)	0.156 (0.175) 1st, 2nd app. & 0.094 (0.105) 3rd app.	3	0.403	10	Below crop Above crop (2nd, 3rd app)	0.99/0.062 0.95/0.125
Sugar beet	MNsugarbeetSTD CAsugarbeet_WirrigOP	14 days post-emergence	0.178 (0.199)	3	0.534	14	Above crop	0.95/0.125 0.99/0.062
Wheat/Triticale/Barley	NDwheatSTD ORwheatOP TXwheatOP	14 days post-emergence	0.178 (0.199)	2	0.293	14	Above crop	0.95/0.125 0.99/0.062

[1]All scenarios are PWC scenarios unless marked as PFAM scenarios.

Table 8-3. Surface Water Estimated Environmental Concentrations (EECs) for Prothioconazole Residues of Concern (unless noted) Estimated Using Pesticide in Water Calculator (PWC) version 1.52 and Pesticides in Flooded Applications Model (PFAM).

Use	PWC Scenario	Annual App Rate lbs a.i./A, App type	1-in-10 year mean EEC						
			Water Column (µg/L)			Pore-Water (µg/L)		Bulk Sediment (µg/kg-organic carbon)[1]	
			1-day	21-day	60-day	1-day	21-day	1-day	21-day
Bushberry (Subgroup 13-07B)/Ag	ORberriesOP	0.356, ground	**2.7**	**2.5**	**2.4**	2.0	2.0	1170	1170
Bushberry (**Parent Only**)	ORberriesOP	0.356, ground	2.1	1.3	1.1	0.78	0.78	456	456
Low growing berry (Subgroup 13-07H, except strawberry) /Ag (**Cranberry[2]**)	MA_cranberry_WinterFlood (PFAM)	0.313	24.6	23.4	21.8	–	–	–	–
	OR_cranberry_NoFlood (PFAM)		4.29	0.380	0.133	–	–	–	–
	OR_cranberry_winter Flood (PFAM)		17.0	16.2	15.5	–	–	–	–
	WI_Cranberry_winterflood (PFAM)		**29.1**	**28.6**	**26.6**	–	–	–	–
Dried shelled pea and bean (except soybean) subgroup/ Dried peas/ Ag	MIbeansSTD	0.534, ground	12.4	11.7	10.6	9.9	9.9	5792	5792
	ORsnbeansSTD		11.5	11.3	11	10.4	10.3	6084	6026
	ILbeansNMC		14.9	13.7	12.5	11.3	11.3	6611	6611
	WAbeansNMC		3.7	3.4	3.1	2.7	2.7	1580	1580
	MIbeansSTD	0.534, aerial	14.8	13.9	12.7	11.6	11.6	6786	6786
	ORsnbeansSTD		12.8	12.6	12.4	11.9	11.8	6962	6903
	ILbeansNMC		**16.7**	**15.4**	**14.2**	**12.8**	**12.7**	7488	7430
	WAbeansNMC		6.7	6.1	5.5	4.8	4.8	2808	2808
Nursery seedlings of conifers/evergreen/soft wood	CAnursery STD_V2	0.781, ground	5.4	5.2	5.1	4.3	4.3	2516	2516
	FLnursery STD_V2		9.6	9.0	8.3	6.6	6.6	3861	3861
	MInurserySTD_V2		10.3	9.9	9.6	8.9	8.9	5207	5207
	NJnursery STD_V2		**13.5**	**12.7**	**11.7**	**9.9**	**9.9**	5792	5792
	ORnursery STD_V2		6.9	6.6	6.3	5.6	5.6	3276	3276
	TNnursery STD_V2		10.5	9.8	9.1	7.3	7.3	4271	4271
	IAcornstd	0.713, aerial	16.3	15.4	13.5	11.4	11.4	6669	6669

Use	PWC Scenario	Annual App Rate lbs a.i./A, App type	1-in-10 year mean EEC						
			Water Column (µg/L)			Pore-Water (µg/L)		Bulk Sediment (µg/kg-organic carbon)[1]	
			1-day	21-day	60-day	1-day	21-day	1-day	21-day
Corn/field or pop	ILcornSTD		20.9	19.3	17.2	15.0	15.0	8775	8775
	INcornStd		16	14.6	13.5	11.5	11.5	6728	6728
	KScornStd		**26.1**	**24.7**	**21.7**	**19.1**	**19.1**	11174	11174
	MNcornStd		20.1	18.9	17.2	15.8	15.7	9243	9185
	MScornSTD		21.0	19.4	17.6	14.7	14.7	8600	8600
	NCcornESTD		13.5	12.6	11.6	9.9	9.9	5792	5792
	NEcornStd		22.0	20.1	18.4	17.0	17.0	9945	9945
	OHcornSTD		17.6	16.8	15.8	13.6	13.6	7956	7956
	PAcornSTD		17.0	16.4	15.1	12.8	12.8	7488	7488
Corn (**Parent Only**)	KScornStd	0.713, aerial	12.9	11.2	9.5	5.9	5.8	3452	3393
Peanuts	NCpeanutSTD	0.713, aerial	**13.1**	**12.2**	**10.6**	8.9	8.8	5207	5148
Soybean	MSsoybeanSTD	0.403, ground and aerial	**6.2**	**5.8**	**5.2**	4.4	4.4	2574	2574
Sugar beet	MNsugarbeetSTD	0.534, aerial	**11.9**	**11.3**	**10.7**	**9.9**	**9.8**	5792	5733
	CAsugarbeet_WirrigOP		5.6	5.2	4.7	4.0	3.9	2340	2282
Wheat/Triticale/Barley	NDwheatSTD	0.293, aerial	**8.7**	**8.1**	**7.5**	**7.0**	**7.0**	4095	4095
	ORwheatOP		6.1	5.9	5.7	5.5	5.5	3218	3218
	TXwheatOP		7.3	7.2	6.4	5.1	4.8	2984	2808

Maximum EECs for each registered use are shown in bold.

[1] The benthic conversion factor is 23.4 and the fraction organic carbon (foc) is 0.04 in the EPA pond. Benthic numbers were not provided for the PFAM cranberry modeling because the EECs provided reflect soil pore-water concentrations because the applications are made when the field is not flooded. These concentrations are not appropriate to calculate RQs with using the available toxicity data.

[2]Cranberry was modeled as a representative use for this crop sub-group using the PFAM model. All other crops in this sub-group can be expected to have lower EECs than those determined for cranberry.

8.1.2 Monitoring

The following databases and sources were searched for monitoring information on prothioconazole and its major degradate prothioconazole-desthio in March 2020:

- Water Quality Portal[11] (USEPA *et al.*); and,
- California Environmental Data Exchange Network[12] (CEDEN) (State Water Resources Control Board, 2015).

In the Water Quality Portal dataset, there were no reported detections (0%) of the prothioconazole degradate prothioconazole-desthio out of 484 surface water samples and four groundwater samples analyzed for prothioconazole-desthio with the maximum detection of 0.003 µg/L. Samples in the database represented surface water sample collections in California, Maryland, New Jersey, New York, Pennsylvania, and Wisconsin; and groundwater sample collections in West Virginia. Additionally, there were no reported detections of parent prothioconazole in groundwater samples collected in West Virginia and analyzed for prothioconazole with the maximum detection of 0.0029 µg/L. It is unknown whether samples were collected in areas where prothioconazole is used. There were no results for prothioconazole or prothioconazole-desthio monitoring reported in CEDEN.

Groundwater and surface water are connected; where groundwater may feed surface water or surface water may move into groundwater. Both groundwater and surface water monitoring are important in understanding the potential for exposure in the aquatic environment. In most cases, residues observed in groundwater are expected to be diluted when moving into and interacting with surface water; however, there are cases where groundwater may be the dominant source of a surface water body during dry periods.

Most studies were not specifically targeted at prothioconazole use areas and the frequency of sample collection in all studies was not adequate to ensure the capture of peak concentrations. Monitoring data are useful in that they provide some information on the occurrence of prothioconazole residues in the environment under existing usage conditions. However, the absence of detections from non-targeted monitoring cannot be used as a line of evidence to indicate exposure is not likely to occur because it is often conducted in areas where the pesticide is not used. Additionally, modeling results are not expected to be similar to monitoring results as monitoring does not reflect the modeled conceptual model and the sampling frequency and duration does not reflect what is simulated in modeling. However, monitoring data are a useful line of evidence to explore whether exposure in the environment is occurring at the levels of the modeled EECs and whether monitoring shows that exposure is occurring at levels that are higher than toxicity endpoints. For non-targeted monitoring data, if exceedances are not occurring this is not evidence that exceedances will not occur with usage;

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[11] https://www.waterqualitydata.us/
[12] http://www.ceden.org/

however, if there are exceedances, it confirms that exposure occurred in the environment at levels where effects are expected to occur.

8.2 Aquatic Organism Risk Characterization

8.2.1 Aquatic Vertebrates

The available data indicate that TGAI prothioconazole is moderately toxic to freshwater fish and slightly toxic to estuarine/marine fish on an acute exposure basis. Available data indicate that prothioconazole-desthio is slightly to moderately toxic to freshwater fish and slightly toxic to estuarine/marine fish on an acute exposure basis. Prothioconazole-S-methyl and selected TEP are moderately toxic to freshwater fish; however, there are no acute toxicity data available for estuarine/marine fish exposed to prothioconazole-S-methyl or TEP. Chronic NOAEC values are approximately 10-fold more sensitive than the acute LC_{50} values for freshwater fish. A chronic toxicity study with prothioconazole-desthio and freshwater fish had a significant reduction in survival, spawning frequency and an increase in growth deformities at the LOAEC of 296 µg desthio/L, resulting in a NOAEC of 148 µg desthio/L (MRID 46246033). There are no chronic toxicity data available for estuarine/marine fish; therefore, an acute-to-chronic ratio (ACR) was calculated based on freshwater fish studies (MRIDs 46246026 and 46246033). The acute LC_{50} value (11,400 µg desthio/L) was divided by the chronic NOAEC value (148 µg desthio/L) to obtain an ACR of 77.0. The acute LC_{50} value from the estuarine/marine study (10,200 µg desthio/L) was then divided by 77.0 to obtain the ACR chronic toxicity value (*i.e.*, NOAEC=132 µg desthio/L) for estuarine/marine fish.

In the newly submitted acute toxicity test with the estuarine/marine vertebrates (Sheepshead Minnow) exposed to prothioconazole-desthio there was 100% mortality at the highest concentration tested (14,900 µg desthio/L) with no other mortality observed in any other tested concentration (MRID 50633901). However, sub-lethal effects were noted in the 7,030 µg desthio/L treatment group, which included fish on the bottom of the tank, labored respiration and dark coloration. The resulting LC_{50} was 10,200 µg desthio/L.

There are no acute risk LOC exceedances (LOC = 0.5) for freshwater or estuarine/marine aquatic vertebrate species. The acute RQs for uses with aerial or ground applications of prothioconazole (ROC) are ≤0.02 and in intermittently flooded fields (cranberry bog) is 0.02. Additionally, there are no chronic risk LOC exceedances for freshwater aquatic vertebrates for any ground or aerial application based on maximum application rates (RQs: ≤0.15) (**Table 8-4**). For applications in an intermittently flooded field (cranberry bog) and based on maximum rates, the freshwater vertebrate chronic RQ is 0.17. and the estuarine/marine vertebrate RQ is 0.19 Since there are no acute or chronic risk LOC exceedances, no further refinements are required.

Table 8-4. Acute and Chronic Vertebrate Risk Quotients for Non-listed Species.

Use Sites, application equip	1-in-10 Yr EEC (µg/L)		Risk Quotient			
			Freshwater		Estuarine/Marine	
	Daily Mean	60-day Mean	Acute[1,2]	Chronic[2,3]	Acute[1,2]	Chronic[4]
			LC_{50} = 1,709 µg a.i./L	NOAEC = 163 µg a.i./L	LC_{50} = 11,220 µg a.i./L	NOAEC = 145 µg a.i./L
Bushberry-GRD	2.7	2.4	<0.01	0.01	<0.01	0.02
Dried shelled pea and bean-AER	17	14	0.01	0.09	<0.01	0.10
Nursery seedlings of conifers/ evergreens/ softwood-GRD	14	12	0.01	0.07	<0.01	0.08
Corn (field/pop/sweet) -AER	26	22	0.02	0.13	<0.01	0.15
Peanuts-AER	13	11	0.01	0.07	<0.01	0.07
Soybean-GRD	6.2	5.2	<0.01	0.03	<0.01	0.04
Sugar beet-AER	12	11	0.01	0.07	<0.01	0.07
Wheat/Triticale/ Barley-AER	8.7	7.5	0.01	0.05	<0.01	0.05
Cranberry	29	27	0.02	0.17	<0.01	0.19

None of the values exceed the acute risk level of concern (LOC) of 0.5 for non-listed species or the chronic risk LOC of 1.0. The toxicity endpoints listed in the table are those used to calculate the risk quotient (RQ).
GRD = ground application; AER = aerial application.
[1] The estimated environmental concentrations (EECs) used to calculate these RQs are based on the 1-in-10-year daily average value from **Table 8-3.**
[2] Endpoint values from exposure to prothioconazole-desthio or prothioconazole-S-methyl have been normalized to the parent molecular weight (see **Table 6-1**).
[3] The EECs used to calculate chronic RQs are based on the 1-in-10-year 60-day average value from **Table 8-3**.
[4] Calculated using an acute-to-chronic ratio (ACR) of 77 from the freshwater fish studies.

Therefore, based on the available data, the risk to fish from the use of prothioconazole from aerial or ground applications or in an intermittently flooded field (cranberry bog), using maximum application rates for all uses is expected to be low. Since freshwater fish serve as surrogates for aquatic-phase amphibians, risk estimates for freshwater fish extend to this other taxon as well.

8.2.2 Aquatic Invertebrates

Prothioconazole is moderately toxic to freshwater and estuarine/marine invertebrates on an acute exposure basis. Prothioconazole-desthio is very highly toxic to estuarine/marine invertebrates on an acute exposure basis, but there are no acute toxicity data available for freshwater invertebrates exposed to prothioconazole-desthio. Prothioconazole-S-methyl is moderately toxic to freshwater invertebrates and highly toxic to estuarine/marine invertebrates on an acute exposure basis. The TEP is moderately toxic to freshwater invertebrates on an acute exposure basis; however, there are no data available for estuarine/marine invertebrates exposed to TEP. Chronic exposure of freshwater invertebrates exposed to prothioconazole-desthio resulted in a NOAEC of 103 µg desthio/L (LOAEC of 206 µg desthio/L) while exposure of estuarine/marine invertebrates to the same degradate resulted in a NOAEC of 64 µg desthio/L (LOAEC of 128 µg desthio/L). There are no acute or chronic risk LOC exceedances (0.5 or 1.0, respectively) for freshwater aquatic invertebrates based on ROC for any use using aerial or ground applications or for applications in intermittently flooded fields (cranberry). The acute RQs for freshwater invertebrates and for uses with aerial or ground applications of prothioconazole ROC are ≤0.02 and in intermittently flooded fields (cranberry) are ≤0.02. The chronic RQs for freshwater invertebrates and for uses with aerial or ground applications of prothioconazole ROC are ≤0.22 and in intermittently flooded fields (cranberry) are ≤0.26.

On the basis of ROC, estuarine/marine invertebrate RQs exceed the acute and chronic risk LOCs for use on rice (not summarized in **Table 8-5)**, in a flooded field, based on maximum application rates (acute RQ = 2.3; chronic RQ = 1.1). However, while the use of prothioconazole on rice is allowed on the label, there is no reported usage for rice. For ground and aerial applications based on maximum application rates, RQs for estuarine/marine invertebrates do not exceed the acute or chronic risk LOCs for any registered use (acute RQs range from 0.04 to 0.44; chronic RQs range from 0.04 to 0.41).

Table 8-5. Acute and Chronic Aquatic Invertebrate (Exposed in the Water-Column) Risk Quotients.

Use Sites[4]	1-in-10 Yr EEC (µg/L)		Risk Quotient			
			Freshwater		Estuarine/Marine	
	Daily Mean	21-day Mean	Acute[1]	Chronic[2,3]	Acute[1,2]	Chronic[2,3]
			LC_{50} = 1,200 µg a.i./L	NOAEC = 113 µg a.i./L	LC_{50} = 66 µg a.i./L	NOAEC = 70 µg a.i./L
Bushberry-GRD	2.7	2.5	<0.01	0.02	0.04	0.04
Dried shelled pea and bean-AER	17	15	0.01	0.13	0.26	0.21
Nursery seedlings of conifers/evergreens/softwood-GRD	14	13	0.01	0.12	0.21	0.18
Corn (field, pop or sweet)-AER	26	25	0.02	0.22	0.40	0.36
Peanuts-AER	13	12	0.01	0.11	0.20	0.17
Soybean-GRD	6.2	5.8	0.01	0.05	0.09	0.08
Sugar beet-AER	12	11	0.01	0.10	0.18	0.16
Wheat/Triticale /Barley-AER	8.7	8.1	0.01	0.07	0.13	0.12
Cranberries (grown in bogs)	29	29	0.02	0.26	0.44	0.41

The toxicity endpoints listed in the table are those used to calculate the risk quotient (RQ).
GRD = ground application; AER = aerial application.
[1] The estimated environmental concentrations (EECs) used to calculate this RQ are based on the 1-in-10-year daily average value from **Table 8-3**.

[2] Toxicity endpoint values from exposure to prothioconazole-desthio or prothioconazole-S-methyl have been normalized to the parent molecular weight (see **Table 6-1**).
[3] The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average value from **Table 8-3**.
4 All modeling was simulated with the PWC, except for applications to intermittently flooded cranberry bogs. These EECs were calculated using PFAM.

Therefore, based on the available data, the risk to aquatic invertebrates from registered uses of prothioconazole is expected to be low.

8.2.3 Benthic Invertebrates

Sediment toxicity testing is not required of all chemicals; however, it is required for those chemicals with a Log K_{ow} ≥3, K_{oc} ≥1,000 and/or a K_d ≥50 (40 CFR Part 158). The soil mobility (K_{OC} value) of one of the major degradates (prothioconazole-S-methyl, K_{OC} = 2,556 mL) exceeds the threshold that would trigger testing for benthic invertebrates (≥1,000 mL/g). The K_{OC} for the parent is not available and the degradate (prothioconazole-desthio) has a K_{OC} of 575 mL/g_{oc}. Neither the parent material nor the two major degradates trigger the requirement for testing of benthic invertebrates based on Log K_{OW} or K_d.

Four new chronic sediment toxicity tests with benthic invertebrates were submitted since the PF. A static test with the freshwater midge (*C. riparius*) indicated that emergence was reduced by 24% resulting in a NOAEC/LOAEC in the pore water of 5.9/66 µg S-methyl/L, respectively.

Three life cycle spiked sediment toxicity studies with benthic invertebrates (*i.e.*, the freshwater midge (*C. dilutus*), the freshwater amphipod (*H. azteca*) and the estuarine/marine amphipod (*L. plumulosus*)) are available. All three studies were conducted with TGAI prothioconazole. Since the spiked *C. riparius* is more sensitive of the freshwater benthic invertebrates, it is used to calculate the freshwater benthic invertebrate RQ. The NOAEC of 15,100 µg a.i./L (corresponding to 14 µg S-methyl/L) for *L. plumulosus* study is used to estimate the estuarine/marine benthic invertebrate RQ.

For freshwater benthic invertebrates, based on EECs calculated using the 1-in-10 year 21-day average pore water concentration and the NOAEC based on measured toxicity in pore water, the risk quotients (RQs) range from 0.35 – 3.4. There are chronic risk LOC exceedances for aerial applications to dried, shelled peas and beans, corn (field/pop/sweet), peanuts, sugar beets and cereal grains (wheat/triticale/barley) and ground applications to nursery seedlings (conifers, evergreens and softwoods). When using the LOAEC value (66 µg S-methyl/L, where there was a 24% reduction in emergence) from the midge study instead of the NOAEC value, there are no chronic risk LOC exceedances for freshwater benthic invertebrates (RQs range from 0.03 to 0.30) (see **Appendix F**.).

For estuarine/marine species, RQs were calculated using the 1-in-10 year 21-day average pore water concentration and the NOAEC based on the measured toxicity in pore water, but also on the 1-in-10-year 21-day average organic-carbon normalized bulk sediment concentration and the measured organic-carbon normalized bulk-sediment NOAEC from the sediment toxicity test. In pore water, the RQs range from 0.15 to 1.4, with a chronic risk LOC exceedance for aerial application to corn (field/pop/sweet) only. In sediment, the RQs range from 0.02 to 0.17, with no chronic risk LOC exceedances for any use.

Table 8-6. Aquatic Benthic Invertebrate (Exposed in Sediment) Risk Quotients for Non-listed Species.

Use Site	1-in-10 Yr EEC Pore Water (µg/L)/ OC Normalized Bulk Sediment ($\mu g/kg_{OC}$)[2]			Risk Quotients				
				Freshwater		Estuarine/marine		
				Acute	Chronic	Acute	Chronic[7]	
	Daily Mean	21-day Mean (PW)	21-day Mean (BS)	LC_{50} = 1,200 µg a.i./L[1]	NOAEC = 5.7 µg a.i./L[2,3,4]	LC_{50} = 66 µg a.i./L[1]	NOAEC = 13.7 µg a.i./L[2,4,5,6]	NOAEC = 65,664 µg a.i./kg_{OC}[4,6]
Bushberry-GRD	2.0	2.0	1170	<0.01	0.35	0.03	0.15	0.02
Dried shelled pea and bean-AER	13	13	7430	0.01	**2.2**	0.19	0.93	0.11
Nursery seedlings of conifers/evergreens/softwood-GRD	9.9	9.9	5792	0.01	**1.7**	0.15	0.72	0.09
Corn (field, pop or sweet)-AER	19	19	11,174	0.02	**3.4**	0.29	**1.4**	0.17
Peanuts-AER	8.9	8.8	5,148	0.01	**1.5**	0.13	0.64	0.08
Soybean-GRD	4.4	4.4	2,574	<0.01	0.77	0.07	0.32	0.04
Sugar beet-AER	9.9	9.8	5,733	0.01	**1.7**	0.15	0.72	0.09
Wheat/Triticale/Barley-AER	7.0	7.0	4,095	0.01	**1.2**	0.11	0.51	0.06

Bolded values exceed the chronic risk level of concern (LOC) of 1.0 for non-listed species. The toxicity endpoints listed in the table are those used to calculate the risk quotient (RQ).

PW = pore water; BS = organic carbon-normalized bulk sediment concentration; GRD = ground application; AER = aerial application.

[1] The estimated environmental concentrations (EECs) used to calculate this RQ are based on the 1-in-10 year daily average pore water value. Since there is no acute toxicity available with benthic invertebrates, the toxicity results for invertebrates exposed in the water column were compared to the pore water EECs.

[2] The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average pore water value.

[3] The 28-day test with *Chironomus riparius* (MRID 50019201) analytically confirmed concentrations of prothioconazole-S-methyl in overlying water and pore water but did not measure concentrations in the bulk sediment; therefore, an RQ normalized for organic carbon content in the sediment could not be calculated.

[4] Endpoint values from exposure to prothioconazole-S-methyl have been normalized to the parent prothioconazole molecular weight (see **Table 6-1**).

[5] The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average organic carbon normalized bulk sediment value (*i.e.*, the bulk sediment EECs are divided by 0.04 to account for the 4% organic carbon content of the sediment for the EPA pond).

[6] The 28-day spiked sediment life-cycle toxicity test with *Leptocheirus plumulosus* (MRID 50969302) analytically confirmed concentrations of prothioconazole, prothioconazole-desthio and prothioconazole-S-methyl in overlying water, pore water and sediment. The risk quotients above are based on prothioconazole-S-methyl concentrations in pore water and organic-carbon normalized bulk sediment concentrations.

[7] The RQs are less than or equal to the values reported above based on a study with no adverse effects observed up to the highest concentration tested.

Therefore, based on the available data, risk to aquatic benthic invertebrates is possible from the use of prothioconazole, for all uses except for ground application to bushberry and soybean.

8.2.4 Aquatic Plants

In the available study with vascular aquatic plant species, the most sensitive measurement endpoint is reduced frond number. Specifically, in a 7-d toxicity test with duckweed (*Lemna gibba*; MRID 46246104), exposed to prothioconazole-desthio, the EC_{50} is 35 µg desthio/L and the NOAEC/LOAEC are 5.8/14 µg desthio/L, respectively.

A new study with non-vascular plant *S. costatum* exposed to prothioconazole-desthio was submitted since the PF. After 96 hours, the most sensitive endpoint was reduced yield, with an IC_{50}/NOAEC of 4.81/1.33 µg desthio/L, respectively. This study is more sensitive than the previous *S. costatum* study that had an EC_{50} of 20.1 µg a.i./L (conducted with prothioconazole TGAI – MRID 46246110).

On the basis of ROC (parent plus prothioconazole-desthio and prothioconazole-S-methyl), non-vascular plant RQs exceed the LOC of 1.0 for risk to plants for all prothioconazole uses based on maximum application rates except for ground application to bushberry (RQ = 0.51). RQs for non-vascular plants range from 1.2 to 5.5 [see **Table 8-7**]. The RQ values for vascular aquatic plants exceed the LOC of 1.0 for use on rice (RQ = 3.9) based on the maximum application rate allowed on the label. While prothioconazole is registered for use on rice, there is currently no reported usage of prothioconazole on rice and no other uses exceeded the LOC for vascular plants.

Table 8-7. Aquatic Vascular and Non-vascular Plant Risk Quotients for Non-listed Species.

Use Sites	1-in-10 Year Daily Mean EEC (µg/L)	Risk Quotients[1]	
		Vascular	Non-vascular
		IC_{50} = 39 µg a.i./L[2]	IC_{50} = 5.3 µg a.i./L[2]
Bushberry-GRD	2.7	0.07	0.51
Dried shelled peas and beans - AER	17	0.44	**3.2**
Nursery seedlings of conifers/evergreens/softwoods – GRD	14	0.36	**2.6**
Corn (field/pop/sweet) – AER	26	0.67	**4.9**
Peanuts – AER	13	0.33	**2.5**
Soybean – GRD	6.2	0.16	**1.2**
Sugar beet – AER	12	0.31	**2.3**
Wheat/Triticale/Barley – AER	8.7	0.22	**1.6**
Cranberry grown in bogs	29	0.74	**5.5**

Bolded values exceed the Level of Concern (LOC) of 1 for risk to aquatic plants. The EC_{50} values listed in the table are those used to calculate the risk quotient (RQ). GRD = ground application; AER = aerial application

[1] The Estimated Environmental Concentrations (EECs) used to calculate these RQs are based on the 1-in-10-year 1-day average value.
RQ=1-day average EEC/EC_{50}.
The EC_{50} value for vascular plants is from MRID 46246104 based on reduction in frond number; EC_{50} for non-vascular plants is from MRID 50634201 based on reduction in yield.
[2]Endpoint values from exposure to prothioconazole-desthio have been normalized to the parent molecular weight.

Therefore, based on the available data, risk to non-vascular aquatic plants is expected for all evaluated uses of prothioconazole except for use on bushberry. It can be assumed that the likelihood of adverse effects on aquatic vascular plants is low but possible for rice, although there is no reported usage on rice.

9 Terrestrial Vertebrates Risk Assessment

9.1 Terrestrial Vertebrate Exposure Assessment

Terrestrial wildlife exposure estimates are calculated for birds and mammals by emphasizing the dietary exposure pathway. Prothioconazole is applied through aerial and ground application methods, which includes sprayers and chemigation, as well as through seed treatments. Therefore, potential dietary exposure for terrestrial wildlife in this assessment is based on consumption of prothioconazole residues on food items following spray (foliar or soil) applications, and from possible dietary ingestion of prothioconazole residues on treated seeds. The EECs for birds (which are surrogates for reptiles and terrestrial-phase amphibians) and mammals from consumption of dietary items on the treated field were calculated using T-REX v.1.5.2. Since prothioconazole has a Log K_{OW} of 2.0 (at a pH of 7), and bioconcentration studies with prothioconazole TGAI (MRID 46246034) and prothioconazole-desthio (MRID 46246035) demonstrated that prothioconazole does not accumulate in fish, terrestrial wildlife is not likely to be exposed to prothioconazole through ingestion of residues in aquatic organisms that serve as prey; therefore, exposure through this pathway is not evaluated.

9.1.1 Dietary Items on the Treated Field (for Foliar Applications)

Potential dietary exposure for terrestrial wildlife in this assessment is based on consumption of prothioconazole residues on food items following spray (foliar or soil) applications, and from possible dietary ingestion of prothioconazole residues on treated seeds. The EECs for birds and mammals from consumption of dietary items on the treated field were calculated using T-REX v.1.5.2. For the foliar uses, EECs are based on application rates, number of applications, and intervals presented in **Table 3-1**.

Most use sites have multiple applications per year. In order to characterize the range of RQs for terrestrial vertebrates (*i.e.*, present high and low estimates of likely environmental exposure and resulting ecological risk), the following use scenarios were used for T-REX modeling:

- bushberry (2x 0.178 lbs a.i./A);
- nursery seedlings of conifers, evergreens and softwoods (5x 0.156 lbs a.i./A);
- corn, field and pop (4x 0.178 lbs a.i./A);
- dried, shelled peas and beans (3x 0.178 lbs a.i./A);
- low growing berries (2x 0.156 lbs a.i./A);
- peanuts (4x 0.178 lbs a.i./A);
- soybean (3x 0.156 lbs a.i./A);
- sugar beet (3x 0.178 lbs a.i./A);
- wheat, which also covered rapeseed, triticale and barley (2x 0.178 lbs a.i./A); and,
- flax (1x 0.140 lbs a.i./A).

There is also a labeled use for cotton (1x 0.222 lbs a.i./A), which represents the highest single application rate and a use on rice (1x 0.141 lbs a.i./A), which represents one of the lower single application rates; however, neither cotton nor rice have reported usage.

For foliar uses of prothioconazole, EECs are based on application rates, number of applications, and intervals presented in **Table 3-1.** Data are not available to estimate a foliar dissipation half-life; therefore, the default foliar dissipation half-life (*i.e*., 35-days), as well as the default Mineau scaling factor (*i.e*., 1.15), were also used in T-REX.

Upper-bound Kenaga nomogram values are used to derive EECs for prothioconazole exposures to terrestrial mammals and birds on the field of application based on a 1-year time period for foliar applications. Consideration is given to different types of feeding strategies for mammal and birds, including herbivores, insectivores and granivores. Dose-based exposures are estimated for three weight classes of birds (*i.e*., 20 g, 100 g, and 1,000 g) and three weight classes of mammals (*i.e*., 15 g, 35 g, and 1,000 g). A summary of the EECs for the high and low application rates is found in **Table 9-1**. The EECs on terrestrial food items for birds and mammals range from 4.4 to 140 mg a.i./ kg-diet based on upper-bound Kenaga values. Dose-based EECs, adjusted for body weight, range from 0.28 to 160 mg a.i./kg-body weight (bw) for birds and 0.15 to 134 mg a.i./ kg-bw for mammals. A summary of EECs for other modeled uses is found in **Appendix E.** An example of the T-REX output is presented in **Appendix C.**

Table 9-1. Summary of Dietary (mg a.i./kg-diet) and Dose-based Estimated Environmental Concentrations (EECs; mg a.i./kg-bw) as Food Residues for Birds, Reptiles, Terrestrial-Phase Amphibians and Mammals from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Upper-Bound Kenaga)

Food Type	Dietary-Based EEC (mg/kg-diet)	Dose-Based EEC (mg/kg-body weight)					
		Birds, Reptiles and Terrestrial Phase Amphibians			Mammals		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Low Growing Berries (0.156lb a.i./acre, 2x, 7-day interval)							
Short grass	70	80	45	20	67	46	11
Tall grass	32	37	21	9.3	31	21	4.9
Broadleaf plants/small insects	39	45	26	11	38	26	6.0
Fruits/pods/seeds (dietary only)	4.4	5.0	2.8	1.3	4.2	2.9	0.67
Arthropods	27	31	18	8.0	26	18	4.2
Seeds (granivore)[1]	N/A	1.1	0.63	0.28	0.93	0.64	0.15
Corn (0.178 lbs ai/A, 4x, 7-day interval)							
Short grass	140	160	91	41	134	93	21
Tall grass	64	73	42	19	61	42	9.8
Broadleaf plants/small insects	79	90	51	23	75	52	12
Fruits/pods/seeds (dietary only)	8.8	10	5.7	2.6	8.4	5.8	1.3
Arthropods	55	63	36	16	52	36	8.4
Seeds (granivore)[1]	N/A	2.2	1.3	0.57	1.9	1.3	0.30

[1] Seeds presented separately for dose – based EECs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

Application rates (in terms of lbs a.i/A, mg a.i./seed and fl oz a.i./cwt) are presented in **Table 3-2** (use table)**,** and resulting EECs from prothioconazole-treated seeds are provided in **Table 9-2** (below)**.** Results include Nagy dose-based values (*i.e.*, mg/kg-bw) and available mass of active ingredient per unit area (*i.e.*, mg a.i/ft^2). Seed treatment exposure estimates are based not only on lb a.i./A allowed but how many seeds are planted on a given acre. Fewer number of seeds sown per acre may increase dietary exposure due to more a.i. per unit of dietary item (the seed) available up to a maximum allowable poundage per acre. Seeding rates for cotton and soybean are based on the values used in T-REX v 1.5.2 and represent national maximum values.

Table 9-2. Avian and Mammalian Dose-Based Estimated Environmental Concentrations (EECs) and mg a.i./ft^2 EECs for Prothioconazole Seed Treatment Uses

Crop	Seeding Rate (lbs/A)	Animal Size	Maximum Application Rate (lbs ai/A)	Maximum Seed Application Rate (mg ai/kg seed)	Avian Nagy Dose (mg ai/kg-bw/day)	Mammalian Nagy Dose (mg ai/kg-bw/day)	Available AI (mg ai/ft^2)
Cereal Grains[1]	156 (Wheat)	Small	0.0071	46	12	9.7	0.07
		Medium			6.6	6.7	
		Large			2.9	1.6	
Corn[2]	33.2	Small	0.034	1022	259	217	0.35
		Medium			147	150	
		Large			66	35	
Alfalfa	15.0	Small	0.0020	137	35	29	0.02
		Medium			20	20	
		Large			8.8	4.6	
Beans and Peas (dried)	163	Small	0.0074	46	12	9.7	0.08
		Medium			6.6	6.7	
		Large			2.9	1.6	
Cotton	18.9	Small	0.0041	216	55	46	0.04
		Medium			31	32	
		Large			14	7.3	
Rice	129	Small	0.012	91	23	19	0.12
		Medium			13	13	
		Large			5.9	3.1	
Sorghum	9.1	Small	0.00083	91	23	19	0.01
		Medium			13	13	
		Large			5.9	3.1	
Sugar Beet	4.8	Small	0.00022	46	12	9.7	0.00
		Medium			6.6	6.7	
		Large			2.9	1.6	
Potato	6970	Small	0.024	3.4	0.86	0.72	0.25

Crop	Seeding Rate (lbs/A)	Animal Size	Maximum Application Rate (lbs ai/A)	Maximum Seed Application Rate (mg ai/kg seed)	Avian Nagy Dose (mg ai/kg-bw/day)	Mammalian Nagy Dose (mg ai/kg-bw/day)	Available AI (mg ai/ft²)
		Medium			0.49	0.50	
		Large			0.22	0.12	

[1] Barley, Triticale, Wheat, Oats, Rye, Buckwheat and Millet (Pearl and Proso)
[2] Field, Pop and Sweet

9.2 Terrestrial Vertebrate Risk Characterization

9.2.1 Birds, Reptiles, and Amphibians (Applications to Fields)

Prothioconazole is classified as practically non-toxic to birds on an acute oral basis (LD_{50}: >2,000 mg a.i./kg-bw) and on a sub-acute dietary exposure basis. However, in the submitted avian acute and sub-acute toxicity studies, sub-lethal effects including decreased food consumption and reduction in body weight were observed. The degradate prothioconazole-desthio is classified as practically non-toxic on an acute oral basis and slightly toxic on a sub-acute dietary exposure basis (LC_{50}: 4,252 mg desthio/kg-diet). Following chronic exposure to prothioconazole-desthio, the NOAEC was 449 mg a.i./kg-diet, the highest concentration tested, based on a study with no observed treatment-related effects.

With respect to mammals, prothioconazole is practically non-toxic on an acute oral exposure basis. The degradate prothioconazole-desthio is also practically non-toxic on an acute oral basis (LD_{50}: 2,806 mg desthio/kg-bw), while chronic exposure resulted in a NOAEC of 160 mg desthio/kg-diet (equivalent to a NOAEL = 9.5-11 mg desthio/kg-bw/day) based on a study with 8-15% reduction in body weight and 21-33% reduction in reduction in pup viability at the LOAEC of 640 mg desthio/kg-diet (equivalent to 40-60 mg desthio/kg-bw/day).

The RQ values are generated based on the upper-bound EECs discussed (see **Table 9-1**) above and toxicity values contained in **Table 6-2** and reproduced above. Acute dose-based RQs are not calculated because only non-definitive acute oral toxicity endpoints are available. For acute dietary-based exposure, avian RQ values range from <0.01 to 0.03 based on upper-bound Kenaga exposure values. Following chronic dietary-based exposure, avian RQ values range from 0.01 to 0.28. Acute and chronic dietary-based RQ values are calculated for prothioconazole use on corn (0.178 lbs a.i./A, 4 applications, 7-day application interval) and low growing berries (0.156 lbs a.i./A, 2 applications, 7-day application interval) and are provided in **Table 9-3**. The RQ values for other prothioconazole uses (bushberry, soybean, nursery seedlings, dried, shelled peas and beans, peanuts, sugar beet and cereal grains) are also calculated and are listed in **Appendix E**. Consistent with past assessments, there are no exceedances of either acute or chronic risk LOCs for birds. Since birds serve as surrogates for reptiles and terrestrial-phase amphibians, risk estimates for birds extend to these other taxa as well. RQs for seed treatments are characterized in **Section 9.2.3**. While there are no acute or chronic risk LOC exceedances for birds based on labeled aerial or ground applications of prothioconazole, there is chronic risk

LOC exceedance for birds for seed treatment of corn. There are no reported incidents involving birds in the IDS database.

Table 9-3. Acute and Chronic Risk Quotient (RQ) values for Birds, Reptiles, and Terrestrial-Phase Amphibians from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Upper-Bound Kenaga).

Use	Food Type	Acute Dietary-Based RQ LC_{50} = 4,677 mg a.i./kg-diet[1]	Chronic Dietary RQ NOAEC = 494 mg a.i./kg-diet[1]
Corn (0.178 lbs a.i./A, 4x, 7-day interval)	Short grass	0.03	0.28
	Tall grass	0.01	0.13
	Broadleaf plants	0.02	0.16
	Fruits/pods/seeds	<0.01	0.02
	Arthropods	0.01	0.11
Low-Growing Berries (0.156 lbs a.i./A, 2x, 7-day interval)	Short grass	0.02	0.14
	Tall grass	0.01	0.06
	Broadleaf plants	0.01	0.08
	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.06

No RQs exceed the acute risk to non-listed species level of concern LOC of 0.5 or the chronic risk LOC of 1.0. The toxicity endpoints listed in the table are those used to calculate the risk quotient (RQ).

[1]Toxicity values from exposure to prothioconazole-desthio have been normalized to the parent molecular weight (see **Table 6-2**).

9.2.2 Mammals (Applications to Fields)

Table 9-4 lists acute dose-based mammalian RQs for use on corn and low growing berries. The RQs for acute dietary-based exposure to mammals are not quantifiable as the available acute mammalian toxicity data (MRID 46246231) do not report endpoints relative to dietary concentrations. For acute dose-based exposures for mammals, RQs for all uses and all size classes range from <0.01 to 0.02 based on upper-bound Kenaga values. Acute dose-based RQ values for other prothioconazole uses (bushberry, soybean, nursery seedlings, dried, shelled peas and beans, peanuts, sugar beet and cereal grains) were also calculated and are listed in **Appendix E**. There are no exceedances of the acute risk LOC (0.5) for any modeled uses.

Table 9-4. Acute Dose-Based Risk Quotient (RQ) Values for Mammals from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Upper-Bound Kenaga).

Food Type	Acute Dose-Based RQ LD_{50} = 3,087 mg/kg-bw[2]		
	Small (15 g)	Medium (35 g)	Large (1000 g)
Corn (0.178 lbs ai/A, 4x, 7-day interval)			
Herbivores/Insectivores			
Short grass	0.02	0.02	0.01
Tall grass	0.01	0.01	<0.01
Broadleaf plants	0.01	0.01	0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	0.01	0.01	<0.01
Granivores			

Food Type	Acute Dose-Based RQ LD_{50} = 3,087 mg/kg-bw[2]		
	Small (15 g)	Medium (35 g)	Large (1000 g)
Seeds[1]	<0.01	<0.01	<0.01
Low-Growing Berries (0.156 lb ai/A, 2x, 7-day interval)			
Herbivores/Insectivores			
Short grass	0.01	0.01	<0.01
Tall grass	<0.01	<0.01	<0.01
Broadleaf plants	0.01	<0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	<0.01	<0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01

RQs did not exceed acute risk to non-listed species LOC of 0.5. The toxicity endpoints listed in the table are those used to calculate the risk quotient (RQ).
[1] Seeds presented separately for dose – based estimated environmental concentrations (EECs) due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.
[2] Toxicity values from exposure to prothioconazole-desthio have been normalized to the parent molecular weight (see **Table 6-2**).

Table 9-5 lists chronic dose-based and chronic dietary-based RQs for use of prothioconazole on corn and low growing berries. Chronic dose-based RQs range from 0.04-5.8, 0.03-5.0, and 0.02-2.7, respectively for small, medium, and large mammals based on upper-bound Kenaga values. Chronic dietary-based RQs range between 0.02 and 0.80 and are below the chronic risk LOC (1.0); however, dose-based RQs exceed the chronic risk LOC (1.0) for all uses and size classes of mammals foraging on short grass, tall grass, broadleaf plants and arthropods. Chronic dose-based RQ values for other prothioconazole uses (bushberry, soybean, nursery seedlings, dried, shelled peas and beans, peanuts, sugar beet and cereal grains) were also calculated and are listed in **Appendix E**.

Additional characterization of potential risk to mammals was conducted using mean Kenaga values. In doing so, mean Kenaga values are roughly 35% lower than upper-bound Kenaga values for mammals; however, there are still chronic risk LOC exceedances for small and medium-sized mammals foraging on short grass and arthropods and small-sized mammals foraging on broadleaf plants (see **Appendix E**). A comparison was also made for the chronic mammalian endpoint using the LOAEC value of 640 mg a.i./kg-diet, corresponding to 40-46 mg a.i./kg-bw/day (where there was a 8-15% reduction in body weight and a 21-33% reduction in pup viability) instead of the NOAEC value. This comparison showed a reduction in the upper-bound Kenaga values (approximately 70%); however, there are still LOC exceedances for small and medium-sized mammals foraging on short grasses (see **Appendix E**). There were no reported incidents involving mammals in the IDS database.

Table 9-5. Chronic Risk Quotient (RQ) values for Mammals from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Upper-Bound Kenaga).

Food Type	Chronic Dose-Based RQ NOAEL = 10.5 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet[1]
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Corn (0.178 lbs ai/A, 4x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**5.8**	**5.0**	**2.7**	0.80
Tall grass	**2.7**	**2.3**	**1.2**	0.37
Broadleaf plants	**3.3**	**2.8**	**1.5**	0.45
Fruits/pods/seeds	0.36	0.31	0.17	0.05
Arthropods	**2.3**	**1.9**	**1.0**	0.31
Granivores				
Seeds[2]	0.08	0.07	0.04	N/A
Low Growing Berries (0.156 lb ai/A, 2x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**2.9**	**2.5**	**1.3**	0.40
Tall grass	**1.3**	**1.1**	0.61	0.18
Broadleaf plants	**1.6**	**1.4**	0.75	0.22
Fruits/pods/seeds	0.18	0.16	0.08	0.02
Arthropods	**1.1**	0.97	0.52	0.16
Granivores				
Seeds[2]	0.04	0.03	0.02	N/A

Bolded values exceed the chronic risk LOC of 1.0. The toxicity endpoints listed in the table are those used to calculate the risk quotient (RQ).

[1] Toxicity values from exposure to prothioconazole-desthio have been normalized to the parent molecular weight (see **Table 6-2**).

[2] Seeds presented separately for dose – based RQs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

It is useful to know how far from the edge of the field prothioconazole spray drift exposure could result in risk to mammals (*i.e.*, "distance of effect"). AgDRIFT™ (version 2.1.1) was used to determine potential risk to mammals from spray drift exposure to prothioconazole off the site of application. The terrestrial spray drift distance was determined using Tier I ground and terrestrial point deposition estimates. Assuming a high boom height, the American Society of Agricultural Engineers (ASAE) Very Fine to Fine droplet size distribution and a 90th data percentile, distance from the edge of a treated field where spray drift could result in RQs greater than LOCs is 16 ft for mammals. Assuming ASAE Fine to Medium/Coarse droplet size, distance from the edge of the treated field where spray drift could result in RQs greater than LOCs is 3 ft for mammals (**Table 9-6**). The terrestrial spray drift distance was also determined using Tier I aerial and terrestrial point deposition estimates. Assuming ASAE Very Fine to Fine droplet size distribution and a 90th data percentile, distance from the edge of a treated field where spray drift could result in RQs greater than LOCs is 154 ft for mammals. Assuming ASAE Fine to Medium/Coarse droplet size, distance from the edge of a treated field where spray drift could result in RQs greater than LOCs is 26 ft for mammals.

Table 9-6. Summary of Distances from the Edge of Treated Field to Which Risk Quotient (RQ) Values Exceed the Chronic Risk Level of Concern (LOC) for Mammals from Ground and Aerial Applications of Prothioconazole.

Use Site	Target Fraction of Applied (LOC/RQ)	Off-field Distance (ft)	Model Parameters
Corn (0.178 lbs a.i./A) ground application	0.172	16	Tier I, high boom height, very fine to fine droplet size
		3	Tier I, high boom height, fine to medium/coarse droplet size
Corn (0.178 lbs a.i./A) aerial application		154	Tier I, very fine to fine droplet size
		26	Tier I, fine to medium/coarse droplet size

9.2.3 Birds and Mammals (Seed Treatments)

For assessing acute risk related to treated seeds for avian and mammalian species, a dose-based RQ[1] is calculated, where the exposure metric is an estimated ingested dose (mg a.i./kg-bw) based on the pesticide concentration on the treated seed and the allometric food ingestion rate[2]. An area-based RQ[3], analogous to an LD_{50} ft^{-2} is also calculated based on the mass of active ingredient per unit area (square foot). This method simply compares the amount of pesticide expected to be present in a square foot to the acute LD_{50} and does not include any specific estimation of pesticide ingested doses. Chronic risks are estimated using a "diet based" approach by comparing the concentration of pesticide on the treated seed divided by the chronic diet-based NOAEC. Additionally, an underlying assumption of the model is that at least 10% of seeds will remain on the soil surface, assuming some potential for exposure by birds and mammals to treated seeds. **Table 9-7** shows RQs for birds and mammals exposed to prothioconazole-treated seed. The RQ values for acute dose-based exposure to birds could not be calculated due to lack of definitive data (no effects were observed at the highest concentration tested). On a chronic exposure basis, RQs exceed the chronic risk LOC (1.0) for birds consuming treated corn seed (RQ = 2.1); however, there is uncertainty with this risk as well, since there were no effects observed at the highest concentration tested.

For mammals, dose-based RQs do not exceed the acute risk LOC for any size class (RQs range from 0.00 to 0.03). On a chronic exposure basis, RQs exceed the chronic risk LOC for all size classes of mammals consuming treated corn and cotton seed and for small- and medium-sized mammals consuming treated alfalfa seed (RQs range from 1.0 to 10).

[1] RQ = [(Seed Application Rate (mg a.i./kg-seed) * daily food intake (g/day) * 0.001 kg/g) / body weight of animal (kg)] / Adjusted (bw) Toxicity Endpoint (LD_{50})
[2] Assumes 100% of the diet is composed of treated seeds and does not presently account for the probability of consuming a treated seed which may be reduced with soil incorporation of seeds.
[3] RQ = [(Application Rate (lbs a.i./A) * 1,000,000 mg/kg) / (43,560 ft2 * 2.2 lb/kg)] / Adjusted LD50)

Table 9-7. Acute Dose-Based, LD_{50}/ft^2 based and Chronic dose-based Risk Quotients (RQs) for Birds and Mammals Exposed to Prothioconazole-Treated Seed.

Crop	Risk Quotients					
	Avian (LD_{50} >2,000 mg a.i./kg-bw, NOAEC = 494 mg a.i./kg-diet)		Mammalian (LD_{50} = 3,087 mg a.i./kg-bw, NOAEC = 176 mg a.i./kg-diet)			
	Animal Size	Chronic	Animal Size	Acute Dose-Based	Acute LD_{50}/ft^2	Chronic
Cereal Grains[1]	20 g	0.09	15 g	<0.01	<0.01	0.46
	100 g		35 g			0.39
	1000 g		1000 g			0.21
Corn[2]	20 g	**2.1**[3]	15 g	0.03	<0.01	**10**
	100 g		35 g	0.03		**8.9**
	1000 g		1000 g	0.01		**4.8**
Alfalfa	20 g	0.28	15 g	<0.01	<0.01	**1.4**
	100 g		35 g			**1.2**
	1000 g		1000 g			0.63
Dried Beans and Peas	20 g	0.09	15 g	<0.01	<0.01	0.46
	100 g		35 g			0.39
	1000 g		1000 g			0.21
Cotton	20 g	0.44	15 g	0.01	<0.01	**2.2**
	100 g		35 g	0.01		**1.9**
	1000 g		1000 g	<0.01		**1.0**
Rice	20 g	0.18	15 g	<0.01	<0.01	0.92
	100 g		35 g			0.79
	1000 g		1000 g			0.42
Sorghum	20 g	0.18	15 g	<0.01	<0.01	0.92
	100 g		35 g			0.79
	1000 g		1000 g			0.42
Sugar Beet	20 g	0.09	15 g	<0.01	<0.01	0.46
	100 g		35 g			0.39
	1000 g		1000 g			0.21
Potato	20 g	0.01	15 g	<0.01	<0.01	0.03
	100 g		35 g			0.03
	1000 g		1000 g			0.02

Bold values exceed acute LOC (0.5) and chronic LOC (1.0).
Chronic RQs are the same for all size classes since body weight toxicity endpoints are not scaled for avian species.
LD_{50}/ft^2 is the amount of pesticide estimated to kill 50% of exposed animals in each square foot of applied area.
[1] Barley, Triticale, Wheat, Oats, Rye, Buckwheat and Millet (Pearl and Proso).
[2] Field, Pop and Sweet.

[3] There is uncertainty with this RQ since it is based on a study with no observed adverse effects at the highest tested concentration.

According to EFED's Refinements for Risk Assessment of Pesticide Treated Seeds – Interim Guidance (derived from Benkman and Pulliam 1988[4]), the maximum size seed that an average 20-g bird will consume is 60 mg, and the maximum size seed a 100-g bird will consume is 120 mg. Based on an average weight of one corn seed (≤ 270 mg), it is likely too large to be consumed by smaller-sized birds. If the most sensitive toxicity estimates for birds are reflective of the sensitivity of passerines alone, according to USEPA (2015) there are 117 common species of birds associated with agricultural fields or their adjacent edge habitats and 89 (76%) of those species are passerines.

While there is some uncertainty with using size of seed as a limiting factor for consumption by all passerine species based on toxicity data from a waterfowl species, EFED considers this approach reasonable for foraging birds. Based on the large size of the seed, there is some uncertainty with the degree to which larger bird species would consume seed corn. Further analysis of the estimated number of seeds to reach the chronic risk LOC for non-listed species indicates that birds of any size class would need to consume 1.6 to 6.4 times their daily diet to be exposed to potentially toxic levels of prothioconazole (**Table 9-8**). As the home range for each size class is larger than the foraged area of concern, there is potential for risk to all size classes of birds consuming treated corn seed.

Table 9-8. Number of Seeds Required to Reach the Chronic Risk Level of Concern (LOC) for Non-listed Species (LOC = 1.0), % Diet, and Associated Foraging Parameters for Bird Size Classes

Bird Size	Seed (weight in g)	# Seeds to Reach LOC	% Diet seeds to reach LOC[1]	Foraging Area of Concern (ha)	% Home Range [2]
Small (20 g)	Corn (0.270 g)	31	163	0.0221	1.5
Medium (100 g)		153	286	0.111	1.3
Large (1000 g)		1,527	638	1.11	0.97

Assuming 100% of diet is treated seed.
[2] Standard range size assumptions are as follows: small birds – 1.4 ha; medium birds – 8.7 ha; and, large birds – 114.5 ha.

The risk estimation from seed treatment uses identified chronic dietary-based risk to birds of all size classes from corn use scenarios based on the sensitivity of Mallard duck, a waterfowl species. There are notable uncertainties related to chronic risks from corn seed treatments, considering how many seeds an organism would have to consume to elicit the toxicological effects as well the unlikely consumption of the large seed by small and medium-sized birds. Based on the NOAEC (494 mg ai/kg diet), the quantity of corn seed that would need to be consumed to exceed the chronic risk LOC represent 163-638% of the bird's likely foraging diet.

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[4] Benkman, C.W. and H.R. Pulliam. 1988. Comparative Feeding Ecology of North American Sparrows and Finches. Ecology. 69: 1195—1199.

Chronic RQs are calculated for mammals using a "dose-based" approach in which the ingested dose of pesticide is divided by the dose-based NOAEL. While there are no RQs exceeding the acute risk LOC for non-listed mammalian species (RQ≥0.5) under any use scenario, there are dietary-based RQ exceedances of the chronic risk LOC (RQ≥1) for use on corn, cotton and alfalfa. For mammalian risk due to seed treatments, RQs exceed the chronic risk LOC for mammals through consumption of treated corn and cotton seeds by all size classes and treated alfalfa seeds by small and medium-sized mammals. As the home range for each size class is larger than the foraged area of concern, there is potential for risk to all size classes of mammals consuming treated corn, cotton and alfalfa seed (**Table 9-9**). Analysis of the estimated number of corn seeds that would need to be consumed to reach the chronic risk LOC for non-listed species suggests that small-sized mammals would need to consume a large portion of their diets solely as treated seed (69%) to exceed the chronic risk LOC for non-listed species; whereas, 100% of a medium-sized mammal's diet would have to be treated seed to exceed the chronic risk LOC. Large mammals consuming treated corn seed and all sizes of mammals consuming treated cotton and alfalfa seed would have to consume 2-20 times more than their daily diet to exceed the chronic risk LOC for non-listed mammals. Overall, analysis of seed treatment risks to mammals suggests that LOC exceedances may occur only for small mammals consuming corn seeds, for which the amount of seed required to exceed the chronic risk LOC represent a large (69%) portion of their diets, but a small portion of their home ranges (4%).

Table 9-9. Number of Treated Seeds Required to Reach the Chronic Risk Level of Concern (LOC) for Non-listed Species (LOC = 1.0), Percent Diet, and Associated Foraging Parameters for Mammal Size Classes.

Mammal Size	Seed (weight in g)	# Seeds to Reach LOC	% Diet seeds to reach LOC[1]	Foraging Area of Concern (ha)	Home Range (ha)
Small (15 g)	Corn (0.270 g)	8	69	0.006	0.15
Medium (35 g)		19	100	0.014	0.38
Large (1000 g)		544	433	0.394	16.00
Small (15 g)	Cotton (0.101 g)	102	324	0.049	0.15
Medium (35 g)		237	467	0.113	0.38
Large (1000 g)		6,769	2,014	3.22	16.00
Small (15 g)	Alfalfa (0.00213g)	3,300	221	0.042	0.15
Medium (35 g)		7,700	320	0.098	0.38
Large (1000 g)		220,000	1,380	2.79	16.00

[1] Assuming 100% of diet is treated seed.

Therefore, based on the available data, the likelihood of adverse effects to birds is low; however, there is a likelihood of direct adverse effects to mammals from chronic exposure to prothioconazole as a result of registered prothioconazole uses both through foliar application and by consumption of treated seed.

10 Terrestrial Invertebrate Risk Assessment

10.1 Bee Exposure Assessment

The crops to which prothioconazole is applied is listed in **Table 10-1** along with the United States Department of Agriculture (USDA) pollinator attractive data (USDA, 2018) to identify which crops may represent direct exposure to pollinators on the field. Off-field assessments are conducted for foliar sprays regardless of whether the crop is attractive or not.

Table 10-1. Summary of Information on the Attractiveness of Registered Use Patterns for Prothioconazole to Bees

Crop Name	Honey Bee Attractive?[1,2]	Bumble Bee Attractive?[1,2]	Solitary Bee Attractive?[1,2]	Acreage in the U.S.	Notes
Rapeseed (*Brassica napus*)	Yes (nectar & pollen)[2]	Yes[1]	Yes[2]	1,700	Managed bees needed for hybrid seed production
Peas (*Pisum arvense*)	Y (nectar & pollen)[1]	Yes[1]	Yes[1]	797,000	Does not require bee pollination; does not use managed pollinators
Beans (*Phaseolus* spp.)	Y (nectar & pollen)[1]	Yes[1]	N/AV	77,200	Acreage is for snap beans; does not require bee pollination; does not require managed pollinators
Cucurbit (*Cucurbita* spp.)	Yes (nectar & pollen)[1]	Yes[2]	Yes[1]	91,700	Acreage is for pumpkins and squash; requires bee pollination; uses managed pollinators
Barley (*Hordeum* spp.)	-	-	-	3,000,000	Wind pollinated
Corn (*Zea mays*)	Yes (pollen)[1]	Yes[1]	Yes[1]	87,668,000	Wind pollenated but can be visited during pollen shedding
Cotton (*Gossypium* spp.)	Yes (nectar)[1]	Yes[1]	Yes[1]	7,664,400	Does not require bee pollination; does not use managed pollinators; used by some beekeepers for honey production
Garbanzo Beans (*Cicer arietinum*)	Yes (nectar[2] & pollen[1])	Yes[1]	Yes[1]	213,600	Self-pollinated
Peanuts (*Arachis hypogaea*)	Yes (pollen)[1]	Yes[1]	Yes[1]	1,042,000	N/AV
Rice (*Oryza sativa*)	N/AV	N/AV	N/AV	2,468,000	Wind pollinated
Oats (*Avena sativa*)	N/AV	N/AV	N/AV	1,030,000	Wind pollinated

Crop Name	Honey Bee Attractive?[1,2]	Bumble Bee Attractive?[1,2]	Solitary Bee Attractive?[1,2]	Acreage in the U.S.	Notes
Soybean (*Glycine soja*)	Y (nectar & pollen)[1]	Yes[1]	Yes[1]	75,869,000	Does not require bee pollination; does not use managed pollinators
Sugar Beet (*Beta vulgaris*)	Yes (nectar)[1]	N/AV	Yes[1]	1,154,200	A small percentage of acreage is grown for breeding
Wheat (*Triticum* spp.)	--	--	--	45,157,000	Does not require bee pollination; does not use managed pollinators

[1] attractiveness rating is a single "+", denoting a use pattern is opportunistically attractive to bees.
[2] attractiveness rating is a double "++" denoting a use pattern is attractive in all cases
N/AV = crop-specific data are unavailable.

10.2 Bee Tier I Exposure Estimates

Contact and dietary exposure are estimated separately using different approaches specific for different application methods. The Bee-REX model (Version 1.0) calculates default (*i.e.*, high end, yet reasonably conservative) EECs for contact and dietary routes of exposure for foliar, soil, and seed treatment applications. See **Appendix C** for a sample output from BeeREX for prothioconazole. Additional information on bee-related exposure estimates, and the calculation of risk estimates in BeeRex can be found in the *Guidance for Assessing Risk to Bees* (USEPA *et al.*, 2014).

In cases where the Tier I RQs (*i.e.*, RQ values based on Bee-REX generated exposure estimates) exceed the acute and chronic risk LOCs of 0.4 and 1.0, respectively, estimates of exposure may be refined using measured pesticide concentrations in pollen and nectar of treated crops (provided measured residue data are available), and further calculated for other castes of bees using their food consumption rates as summarized in the White Paper to support the Scientific Advisory Panel (SAP) on the pollinator risk assessment process (USEPA, 2012c).

10.3 Bee Risk Characterization (Tier I)

Eleven new bee toxicity tests (*i.e.*, 9 honey bee and 2 bumble bee) were submitted since the PF and 2016 risk assessment were completed (**Appendix G**). Risk to adult and larva honey bees on an acute contact or oral exposure basis was not assessed since the available toxicity data indicate no significant mortality or notable sub-lethal effects up to the highest doses tested for both honey bees and bumble bees, resulting in LD_{50} values of greater than the highest concentrations tested (**Table 6-2 and Appendix G**). The RQ values are not typically calculated with non-definitive toxicity values.

The chronic larval toxicity study (MRID 50633902) with exposure to prothioconazole TGAI (96.7% a.i.) resulted in NOAEL/LOAEL values of 2.0/5.2 µg a.i./bee/day, respectively, based on 19% reduction in adult emergence at the LOAEL. The chronic adult toxicity study (MRID

50489203) with exposure to TEP (Prothioconazole™ SC 480; 39.6% a.i.) resulted in a NOAEL/LOAEL of 3.19/>3.19 µg a.i./bee/day based on no significant observed effects at the highest doses tested. A second chronic adult toxicity study (MRID 50726802) was also reviewed since the first study did not test high enough to produce a LOAEL. In the second study, adult honey bees were exposed to TEP (Prothioconazole™ SC 480, 41.4% a.i.). After 10 days, there was 53% mortality of adult bees in the 46.5 µg a.i./bee/day treatment group, which resulted in a NOAEL of 26.1 µg a.i./bee/day and a LOAEL of 46.5 µg a.i./bee/day. The second chronic adult study was used for calculation of risk.

10.3.1 Tier I Risk Estimation

On-Field Risk

Since an exposure potential of bees is identified for all foliar applications to agricultural crops both on and off the treated field, the next step in the risk assessment process is to conduct a Tier 1 risk assessment. By design, the Tier 1 assessment begins with (high-end) model-generated (foliar and soil treatments) or default (seed treatments) estimates of exposure via contact and oral routes. For contact exposure, only the adult (forager and drones) life stage is considered since this is the relevant life stage for honey bees (*i.e.*, since other bees are in-hive, the presumption is that they would not be subject to contact exposure). Furthermore, toxicity testing protocols have only been developed for acute exposures. Effects are defined by laboratory exposures to groups of individual bees (which serve as surrogates for solitary non-*Apis* bees and individual social non-*Apis* bees).

Based on the two chronic toxicity studies, RQs generated for use on corn (0.178 lbs a.i./A) and low-growing berries (0.156 lbs a.i./A) exceed the chronic risk LOC of 1 for larval honey bees (RQs range from 1.1 to 1.2) but are below the chronic risk LOC for adult worker honey bees foraging for nectar (RQs range from 0.19 to 0.22) (See **Table 10-2**).

10.3.2 Tier I Risk Estimation (Oral Exposure)

Table 10-2. Tier 1 Oral Risk Quotients (RQs) for Adult Nectar Forager and Larval Worker Honey Bees (*Apis mellifera*) from BeeRex (ver. 1.0).

Use Pattern	Max. Single Appl. Rate	Bee Caste/Task	Oral Dose (µg a.i./bee)	Acute Oral RQ[1]	Chronic Oral RQ[2,3]
Corn	0.178 lb a.i./A	Adult nectar forager	5.7	N/A	0.22
		Larval worker	2.4		**1.2**
Low Growing Berry	0.156 lb a.i./A	Adult nectar forager	5.0	N/A	0.19
		Larval worker	2.1		**1.1**

[1] The available acute contact and oral toxicity tests with larval and adult honey bees exposed to TGAI prothioconazole and the degradate prothioconazole-desthio are not reliable enough to be used quantitatively for risk estimation since they showed no effect up to the highest tested concentrations. The LD_{50} values ranged from >58 to >214.32 µg/bee.

[2] **Bolded** RQ value exceeds (or potentially exceeds) the chronic risk Level of Concern (LOC) of 1.0.
[3] Based on a honey bee larval 22-day chronic NOAEL of 2.0 µg a.i./bee/day (MRID 50633903) and a 10-day chronic adult NOAEC of 26.1 µg a.i./bee/day (MRID 50726802).

Off-Field Risk
In addition to bees foraging on the treated field, bees may also be foraging in fields adjacent to the treated fields.

It is useful to know how far from the edge of the field prothioconazole spray drift exposure could result in risk to bees (*i.e.*, "distance of effect"). AgDRIFT™ (version 2.1.1) is used to determine potential risk to bees from spray drift exposure to prothioconazole off the site of application. The terrestrial spray drift distance was determined using Tier I ground and aerial applications and terrestrial point deposition estimates. Assuming a high boom height (ground applications), the American Society of Agricultural Engineers (ASAE) Very Fine to Fine droplet size distribution and a 90th data percentile, distance from the edge of a treated field where spray drift could result in chronic RQs greater than LOCs is 3 ft for larval bees. Assuming ASAE fine to medium/ coarse droplet size, distance from the edge of the treated field where spray drift could result in RQs greater than LOCs is also 3 ft for larval bees (**Table 10-3**). For aerial applications, ASAE Very Fine to Fine droplet size distribution or ASAE Fine to Medium/Coarse droplet size distribution and a 90th data percentile, distance from the edge of a treated field where spray drift could result in RQs greater than LOCs is 0 ft for larval bees (**Table 10-3**).

Table 10-3. Summary of Distances from the Edge of Treated Field to Which Risk Quotient (RQ) Values Exceed the Chronic Risk Level of Concern (LOC) for Larval Bees from Ground and Aerial Applications of Prothioconazole.

Use Site	Life Stage	Target Fraction of Applied (LOC/RQ)	Off-field Distance (ft)	Model Parameters
Corn (0.178 lbs a.i./A) ground application	Larva	0.833	3	Tier I, high boom height, very fine to fine droplet size
			3	Tier I, high boom height, fine to medium/coarse droplet size
Corn (0.178 lbs a.i./A) aerial application			0	Tier I, very fine to fine droplet size
			0	Tier I, fine to medium/coarse droplet size

10.4 Bee Risk Characterization (Tier II)

Three semi-field (two tunnel- and one colony-feeding) colony-level studies were submitted since the PF. The studies are still being reviewed; however, when taken at face value, they indicate that there were no statistically significant effects on honey bee colonies at the highest rates tested in the studies. In a semi-field tunnel study (MRID 50489204), TEP was applied at a mean rate of 199.2 g a.s./ha (equivalent to 0.178 lbs/A) in 4 replicates/treatment to *Phacelia tanacetifolia* at full bloom while bees were actively foraging. Colonies (~8,400 bees) remained in the tunnel (100 m^2) for 7 days and were then tracked up to 23 days after application (*i.e*., one complete brood cycle). Fenoxycarb (an insect growth regulator) was used as the reference toxicant. Colony condition and brood indices appeared to be unaffected; however, the brood termination rate in controls versus prothioconazole-treated bees was 30.57 and 46.6, respectively, but were not statistically different.

In a second semi-field tunnel study (MRID 50521803), TEP was applied at a nominal rate of 205.43 g a.s./ha (equivalent to 0.183 lbs/A) in 3 replicates/treatment to *P. tanacetifolia* at full bloom while bees were actively foraging. Colonies (~6,000 bees) remained in the tunnel (50 m^2) for 7 days and then were tracked for 17 day after treatment (not a complete brood cycle). Dimethoate was used as the reference toxicant. The second study stopped tracking brood development before completion of a brood cycle due to 2/3 of the prothioconazole-treated colonies shutting down brood production. The study authors attributed the cessation of brood production to a combination of inadequate food supply and the test bees preparing to overwinter.

In a colony-feeding study (MRID 50489205) TEP was fed at a rate of up to 470 mg a.s./L. Three replicate colonies per treatment ranged from 10 – 15,000 free-foraging bees. Fenoxycarb was used as a reference toxicant along with negative controls. Each colony was fed one time with 1-L of treated or untreated sugar solution, which was generally consumed by 24.5 hours although it took 46 hours for the fenoxycarb-treated colonies to consume their diet. While adult bee mortality was <9 bees/colony/day in the prothioconazole-treated colonies, there were roughly 21 dead bees/colony/day in the control replicates, which was similar to that for the fenoxycarb-treated colonies. Colonies were monitored for a total of 21 days after feeding (*i.e.*, a complete brood cycle). Brood mortality was low in the prothioconazole-treated colonies (7%) compared to the negative control (59%) and fenoxycarb-treated colonies (87%).

The two tunnel studies were conducted at rates of up to 199.2 and 205.43 g/ha, respectively, this is roughly equivalent to an application rate of 0.178 and 0.183 lbs/A, which are protective of the application rates under review in this assessment, but is approximately 18% lower than the maximum application rate of 0.22 lbs a.i./A allowed for use on cotton (cotton currently has no reported usage). Additionally, the colony-feeding study exposed bees to 470 mg/L which is roughly 26x higher than the estimated concentration in nectar based on BeeRex (17-20 mg/L) and there were no adverse effects on the colony.

Therefore, based on the available data, there were direct adverse effects to individual larval honey bees from chronic exposure to prothioconazole as a result of registered prothioconazole uses; however, chronic risk to adult bees is expected to be low. While a laboratory chronic exposure of honey bees to TEP indicated 53% mortality of adult bees exposed at a treatment level of 46.5 µg a.i./bee/day, and there is an incident report associated with the use of prothioconazole in which four colonies were reported as lost, preliminary review of colony-level studies does not suggest adverse effects to bee colonies when bees were either exposed while actively foraging or treated directly in the diet.

11 Terrestrial Plant Risk Assessment

Tier I plant studies were conducted with 10 species of plants exposed to 0.272 lbs a.i./A, which is greater than the maximum single foliar application rate of 0.178 lbs a.i./A. With the exception of cucumbers, effects did not exceed 25% inhibition. For cucumber plants, there was a greater than 25% effect on shoot length and dry weight in the seedling emergence study (MRID 46246050). Although effects in cucumbers did not exceed 25% in the vegetative vigor study (MRID 46246049), the percent inhibition for this species was generally among the highest. Based on the results of the Tier I study, a Tier II study for cucumber was required. In the Tier II seedling emergence study, no effects exceeded a 25% inhibition compared to control for cucumbers for the highest test concentration of 0.272 lbs a.i./A.

There were less than 25% adverse effects noted in the available terrestrial plant studies conducted at an application rate of 0.272 lb a.i./acre. This rate is higher than the maximum single application rate allowed for foliar uses of prothioconazole; therefore, all of the RQs for terrestrial plants are below the LOC for risk to terrestrial plants (*i.e*., the RQs are all <1). As noted earlier, there are 16 plant incidents associated with prothioconazole in the IDS database. Since prothioconazole is a fungicide, some of the reported plant incidents may have occurred if prothioconazole was not effective at treating the fungus it was applied to treat, but it is difficult to determine if this is the case based on the information provided in the incident reports. The reported incidents occurred between 2009 and 2016 and impacted anywhere from 7 acres to a total of 525 acres of plants (*i.e.,* potato, peanut, soybean, corn, wheat and sorghum).

Therefore, based on the available data, the risk to terrestrial plants from the use of prothioconazole is expected to be low; however, there is uncertainty as there are reported incidents.

12 Conclusions

Prothioconazole is being assessed as part of Registration Review. The ROC for this assessment include the parent compound and the two major degradates prothioconazole-desthio and prothioconazole-S-methyl. Residues of prothioconazole may move off-site via spray drift, leaching and runoff (**Table 12-1**).

Prothioconazole dissipates in the environment by microbial degradation in soil and by aqueous photolysis, and prothioconazole residues may become bound to soil in significant amounts. It is degraded relatively quickly by aerobic metabolism in soils (half-life range of hours to 23.5 days at 20^{o}C). In soil, prothioconazole biodegrades to multiple degradates including two major degradates, prothioconazole-desthio and prothioconazole-S-methyl, which are more persistent than the parent, with TR half-lives of 116-486 days for prothioconazole ROC. While parent prothioconazole biodegrades in aquatic environments (half-lives of 4-110 days), the ROC degrade more slowly in aerobic aquatic systems (TR half-lives of 42-101 days) and are much more persistent than parent in anaerobic aquatic systems (half-lives of 372-1,449 days).

Prothioconazole is stable to hydrolysis but will photolyze slowly in shallow, clear, surface waters (half-life of 9.7 days). In water, it photodegrades to prothioconazole-desthio, which is more resistant than the parent is to photolytic degradation (ROC $t_{1/2}$ = 101 d). Prothioconazole does not photolyze on soil based on available data. Prothioconazole is estimated to be of low mobility, but mobility could not be definitively determined for the parent compound because data were inadequate to calculate adsorption coefficients. Prothioconazole-desthio is classified as moderately mobile and prothioconazole S-methyl is classified as slightly mobile based on measured K_{oc} values.

In general, prothioconazole is slightly to moderately toxic to fish (for which freshwater fish serve as surrogates for aquatic-phase amphibians) and freshwater aquatic invertebrates and moderately toxic to estuarine/marine invertebrates on an acute exposure basis; there are effects on aquatic animal survival, growth and reproduction following chronic exposure. Non-vascular aquatic plants are more sensitive to prothioconazole than vascular aquatic plants.

The compound is no more than slightly toxic to birds (which serve as surrogates for reptiles and terrestrial-phase amphibians) and is practically non-toxic to mammals on an acute exposure basis. As with aquatic animals, there were effects on growth in mammals following chronic exposure; however, there were no chronic effects detected in birds up to the highest dietary concentration tested. Prothioconazole is also practically non-toxic to bees on an acute exposure basis, while reductions in larval and adult bee emergence were noted in chronic toxicity studies.

Given the uses of prothioconazole and the chemical's environmental fate properties, there is a likelihood of exposure of prothioconazole ROC to non-target terrestrial and/or aquatic organisms. When used in accordance with the label, such exposure may result in adverse effects upon the survival, growth, and reproduction of non-target terrestrial and aquatic organisms. Consistent with previous risk assessments (USEPA, 2010), there is a potential for direct adverse effects to freshwater and estuarine/marine benthic invertebrates, mammals, terrestrial invertebrates (larval bees), and aquatic (non-vascular) plants from exposure to prothioconazole ROC as a result of registered uses. A more in-depth summary of the risk conclusions is available in the Executive Summary, **Section 1**.

While previous assessments identified chronic risk to aquatic (estuarine/marine) invertebrates in the water column, this assessment indicates that the likelihood of adverse effects on these taxa in the water column from exposure to prothioconazole ROC is expected to be low. However, newly submitted data on benthic invertebrates indicate that there may be adverse effects on freshwater and estuarine/marine benthic invertebrates resulting from exposure to prothioconazole ROC from labeled uses.

As with previous assessments, acute and chronic risks to fish (and aquatic-phase amphibians for which freshwater fish serve as surrogates), birds (and reptiles and terrestrial-phase amphibians for which birds serve as surrogates), and terrestrial plants are not expected to be of concern from the labeled uses of prothioconazole. However, there was chronic risk LOC exceedance for birds consuming treated seed (corn only).

Although no risk has been identified for terrestrial plants in previous assessments, and no new data have been submitted, there are 16 plant incidents associated with prothioconazole in the IDS database. While some of the reported plant incidents may have occurred if prothioconazole was not effective at treating the fungus it was applied to treat, such information is not provided in the incident reports.

Table 12-1. Potential Environmental Fate Concerns Identified for Prothioconazole.

Bioconcentration/ Bioaccumulation[1]	Groundwater Contamination	Sediment	Persistence[2]	Residues of Concern	Volatilization
No, log K_{ow}<3	Yes	Yes, for prothioconazole-s-methyl	Non-persistent to slightly persistent	Parent, prothioconazole-desthio, prothioconazole-S-methyl	No

[1] Based on K_{ow} Based Aquatic Bioaccumulation Model (KABAM) for chemicals with a log K_{ow} >3.
[2] Persistence classification for parent compound only, consistent with Goring *et al* (1975) applied to aerobic soil metabolism studies. Degradates and ROC show persistence in soil.

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46246046	2050900 2050895-memo	Schmitzer, S. (2004) Effects of JAU 6476 SC 480 (Acute Contact and Oral) on Honey Bees (*Apis mellifera* L.) in the Laboratory. Project Number: 18351035. Unpublished study prepared by Institut fuer Biologische Analytik und Consulting IBACON GmbH. 31 p.
46246048	2050901 2050895-memo	Wilhelmy, H. (1999) JAU 6476 a.i.: Acute Effects on the Honeybee *Apis mellifera*. Project Number: IBA64051, 990222BN. Unpublished study prepared by Dr. U. Noack-Laboratorium fuer Angewandte Biologie. 32 p.
6246131	2050906	Hendel, B. (2000) Influence of JAU6476 (tech.) on Developmental and Emergence of Larvae of *Chironomus riparius* in a Water-Sediment System. Project Number: E/4161775/1, HDB/CH42. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 53 p.
46246132	2050905	Hendel, B. (2000) Influence of SXX 0665 (tech.) on Development and Emergence of Larvae of *Chironomus riparius* in a Water-Sediment System. Project Number: E/4161808/8, HDB/CH43. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 53 p. Prothioconazole – Desthio metabolite
46246132	2050905 2050895	Hendel, B. (2000) Influence of **SXX 0665** (tech.) on Development and Emergence of Larvae of *Chironomus riparius* in a Water-Sediment System. Project Number: E/4161808/8, HDB/CH43. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 53 p. Desthio metabolite
46246013	2051017	Sayers, L. (2004) JAU 6476-**Desthio** - Acute Toxicity to Crayfish (*Promcambarus clarkii*) Under Static-Renewal Conditions: Amended Final Report. Project Number: 13798/6147, EBJAY004, J6880601. Unpublished study prepared by Springborn Smithers Laboratories. 49 p. Desthio metabolite
46246015	2050958	Kendall, T.; Nixon, W. (2001) Analytical Method Verification for the Determination of JAU-6476 in Saltwater. Project Number: 149C/115, J6112401, 110957. Unpublished study prepared by Wildlife International, Ltd. 30 p.
46246041	DER not located	Martin, K.; Nixon, W. (2001) Analytical Method Verification for the Determination of Desthio JAU 6476 in Avian Diet. Project Number: 149C/113, J6111901, 99/B/203. Unpublished study prepared by Wildlife International, Ltd. 30 p.
46246118	DER not located	Nienstedt, K. (2002) Reproduction Toxicity Test Exposing *Folsomia candida* (Collembola) to JAU6476 Technical. Project Number: 1022/028/641. Unpublished study prepared by Springborn Laboratories (Europe) Ag. 34 p
46246119	DER not located	Moser, T.; Rombke, J. (2001) Acute and Reproduction Toxicity of JAU6476-**Desthio** to the Collembolan Species *Folsomia candida* According to the ISO Guideline 11267 "Soil Quality-Inhibition of Reproduction of Collembola (*Folsomia candida*) by Soil Pollutants" (1999). Project Number: P1CR. Unpublished study prepared by ECT Oekotoxikologie Gmbh. 28 p. Desthio metabolite
46246120		Nienstedt, K. (2001) Reproduction Toxicity Test Exposing *Folsomia candida* (Collembola) to JAU6476-Desthio. Project Number: 1022/020/641. Unpublished study prepared by Springborn Laboratories (Europe) Ag. 36 p. Desthio metabolite

46246121	Moser, T.; Scheffczyk, A. (2001) Acute and Reproduction Toxicity of JAU6476-S-Methyl to the Collembolan Species *Folsomia candida* According to the ISO Guideline 11267 "Soil Quality-Inhibition of Reproduction of Collembola (*Folsomia candida*) by Soil Pollutants" (1999). Project Number: P35CR. Unpublished study prepared by ECT Oekotoxikologie Gmbh. 24 p.
46246122	Meisner, P. (2000) Acute Toxicity of JAU6476 (tech.) to Earthworms (*Eisenia fetida*). Project Number: E/3101769/7, MPE/RG326/00. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 22 p.
46246123	Meisner, P. (2000) Acute Toxicity of JAU6476 EC 250 to Earthworms (*Eisenia fetida*). Project Number: E/3101795/6, MPE/RG331/00. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 18 p.
46246124	Lechelt-Kunze, C. (2003) Prothioconazole (JAU 6476) SC 480: Acute Toxicity to Earthworms (*Eisenia fetida*) Tested in Artificial Soil with 10% Peat. Project Number: E/3102600/2, LKC/RG/A/16/03. Unpublished study prepared by Bayer Ag, Institute of Product Info. 23 p.
46246125	Meisner, P. (2000) Acute Toxicity of JAU6476-Desthio to Earthworms (*Eisenia fetida*). Project Number: E/3101844/1, MPE/RG338/00. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 20 p. Desthio metabolite
46246126	Heimbach, F. (2000) Acute Toxicity of JAU6476-S-Methyl to Earthworms (*Eisenia fetida*). Project Number: E/3101743/9, HBF/RG321. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 19 p.
46246127	Meisner, P. (2000) Influence of JAU6476-EC 250 on the Reproduction of Earthworms (*Eisenia fetida*). Project Number: E/3121753/2, MPE/RG325. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 27 p.
46246128	Meisner, P. (2000) Influence of JAU6476-Desthio on the Reproduction of Earthworms (*Eisenia fetida*). Project Number: E/3121799/2, MPE/RG322/00. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 24 p. Desthio metabolite
46246129	Heimbach, F. (2000) Influence of JAU6476-S-Methyl on the Reproduction of Earthworms (*Eisenia fetida*). Project Number: E/3121713/8, HBF/RG317. Unpublished study prepared by Bayer Ag Institut fuer Ruckstands-Analytik. 24 p.
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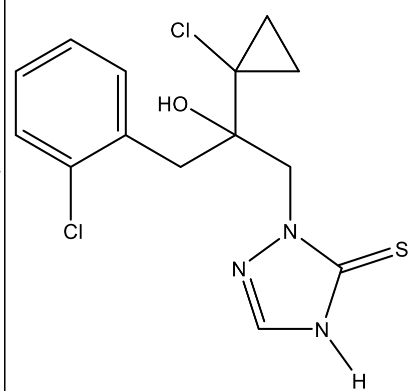
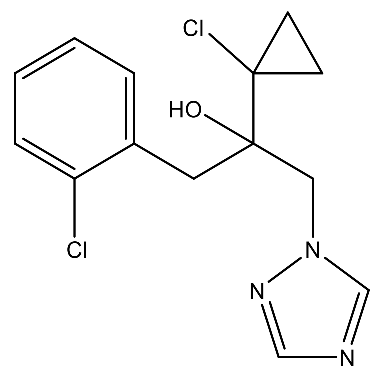
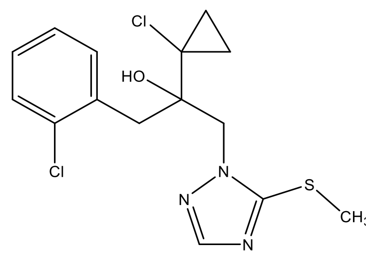
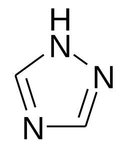
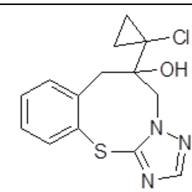
Appendix A. ROCKS table

Table A1. Chemical Names and Structures of Prothioconazole and Its Major Transformation Products

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (day)
PARENT COMPOUND						
Prothioconazole	**IUPAC:** (RS)-2-[2-(1-chlorocyclopropyl)-3-(2-chlorophenyl)-2-hydroxypropyl]-2,4-dihydro-1,2,4-triazole-3-thione **CAS:** 2-[2-(1-Chlorocyclopropyl)-3-(2-chlorophenyl)-2-hydroxypropyl]-2,4-dihydro-3H-1,2,4-triazole-3-thione **CAS No.:** 178928-70-6 **Formula:** $C_{14}H_{15}Cl_2N_3OS$ **MW:** 344.25 g/mol **SMILES:** ClC1=CC=CC=C1CC(CN2N=CN([H])C2=S)(O)C3(Cl)CC3		Aerobic soil	46246511		2.0-5.9% (365)
				46246512		3.1-10.5% (120)
				50917601		4.8% (120)
			Soil photolysis	46246510		18.8% irr/19% dark (15)
			Aqueous photolysis	46246507		not detected (18)
			Hydrolysis	46246505		93.3-99.9% (7)
			Aerobic aquatic	46246515		3.3-9.5% (121)
			Anaerobic aquatic	46246516		1.4% (360)
				50917602		8.9% (100)
			Field studies-Terrestrial	46246517		ND (14)
				46246518		ND (28)
				46246519		10.6 ug/kg (14 d)
			Field studies - Aquatic	46246522 46246523 46246524		CA: 14.8 ug/kg sediment (364); 0.42 ug/L paddy water (14) AK:12.2 ug/kg sediment (0); 0.3 ug/L paddy water (7)
MAJOR (>10% of Applied Radioactivity) TRANSFORMATION PRODUCTS						
Prothioconazole-desthio:			Aerobic soil	46246511	46.5-49.4% (7) 38.4-41.2% (90)	6.1-6.3% (365) 21.9-23.7% (365)
				46246512	41.3% (3 d)	42.3% (120)

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (day)
	IUPAC: 2-(1-chlorocyclopropyl)-1-(2-chlorophenyl)-3-(1H-1,2,4-triazol-1-yl)propan-2-ol **CAS No.:** 120983-64-4 **Formula:** $C_{14}H_{15}Cl_2N_3O$ **MW:** 312.19 g/mol **SMILES:** ClC1=CC=CC=C1CC(CN2N=CN=C2)(O)C3(Cl)CC3				20.9% (7 d)	18.5% (120)
				50917601	53.6% (1 d)	25.2% (120 d)
			Soil photolysis	46246510	38.5% light/ 25.4% dark (7)	38.1% light/ 29.4% dark (15)
			Aqueous photolysis	46246507	54.8-55.7% (11)	53.2-54.8% (18)
			Hydrolysis	46246505	5.2% (168 hr)	5.2% (168 hr)
			Aerobic aquatic	46246515	54.6% (7)	8.2-11.1% (121)
			Anaerobic aquatic	46246516	parent+desthio 95.2% (0)	1.4% (360 d)
				50917602	16.7% (9 d)	4.2% (100 d)
			Field studies-Terrestrial	46246517	191.0 ug/kg soil (3)	ND-2.2 ug/kg soil (553 d)
				46246518	82.0 ug/kg (0)	ND-3.0 ug/kg (421-532)
				46246519	221.0 ug/kg (58)	82.5 ug/kg (567)
			Field studies - Aquatic	46246522 46246523 46246524	CA: 32.7 ug/kg sediment (14); 50.3 ug/L paddy water (3) AK: 63.2 ug/kg sediment (3) 109.8 ug/L paddy water (0)	CA: 20.4 ug/kg sediment (364); 0.69 ug/L paddy water (60) AK:4.4 ug/kg sediment (365); 0.8 ug/L paddy water (60)

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (day)
S-Methyl prothioconazole	**IUPAC:** 2-(1-chlorocyclopropyl)-1-(2-chlorophenyl)-3-(5-(methylthio)-1H-1,2,4-triazol-1-yl)propan-2-ol **CAS No.:** 178928-71-7 **Formula:** $C_{15}H_{17}Cl_2N_3OS$ **MW:** 358.28 g/mol **SMILES:** ClC1=CC=CC=C1CC(O)(CN2N=CN=C2SC)C3(Cl)CC3		Aerobic soil	46246511	11.3-12.8% (1) 13.7-14.6% (7)	2.8-3.1% (365 d) 7.1-7.6% (365 d)
				46246512	3.8-5.5% (1-7 d)	1.5-1.7% (7d)
				50917601	53.6% (1 d)	25.2% (120 d)
			Soil photolysis	46246510		
			Aqueous photolysis	46246507		
			Hydrolysis	46246505		
			Aerobic aquatic	46246515	12.7% (7)	1.9-3.1% (121)
			Anaerobic aquatic	46246516	78.2% (240)	76.1% (360)
				50917602	49.0% (100 d)	49.0% (100 d)
			Field studies-Terrestrial	46246517	14.2 ug/kg (3)	1.9 ug/kg (63)
				46246518	10.1 ug/kg (7)	ND-1.3 ug/kg (120-141)
				46246519	46.9 ug/kg (7)	4.0 ug/kg (567)
			Field studies - Aquatic	46246522 46246523 46246524	CA: 10.0 ug/kg sediment (122); 0.23 ug/L paddy water (3) AK: 16.7 ug/kg sediment (14); 3.0 ug/L paddy water (1)	CA: 5.3 ug/kg sediment (364); 0.02 ug/L paddy water (2) AK: ND sediment (365); 0.1 ug/L paddy water (7-14)
1,2,4-triazole	IUPAC name: Not reported. CAS name: 1-H-1,2,4-triazole. CAS No.: Not reported.		Aerobic soil	46246511 46246512 50917601	nd - <2.0% (120, 272, & 365)	nd - <2% (365)
			Aqueous photolysis	46246507	11.9% (18)	11.9% (18)

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (day)
			Aerobic aquatic	46246515	4.6-6.1% (121; sediment) 0.8-37.2% (121; water) 6.1-41.8% (121; total system)	4.6-6.1% (121; sediment) nd-37.2% (121; water) 6.1-41.8% (121; total system)
			Field studies - Terrestrial	46246517	7.3 ug/kg soil (29)	1.3 ug/kg soil (553)
				46246518	4.9 ug/kg soil (120)	ND-4.5 ug/kg soil (532)
				46246519	3.3 ug/kg soil (422)	ND-3.1 ug/kg soil (567)
			Field studies - Aquatic	46246522 46246523 46246524	CA: 3.3 ug/kg sediment (273-364); 0.13 ug/L paddy water (7) AK: 2.9 ug/kg sediment (270); 0.5 ug/L paddy water (1)	CA: 3.3 ug/kg sediment 364); 0.3 ug/L paddy water (3) AK: 2.9 ug/kg sediment (365); 0.3 ug/L paddy water (3)
Prothioconazole-thiazocine			Aq photolysis	46246507	14.1% (5 d; phenyl label) 9.5% (11 d; triazole label)	8.4% (18) 9.1% (18)

ND= means “not detected”. AR means “applied radioactivity”. MW means “molecular weight”. LOQ means “limit of quantitation”. Bolded values are laboratory study values >10%AR.

Appendix B. Example Aquatic Modeling Output and Input Batch Files

Below is an example output summary file from a single PWC modeling simulation.

Aerial Application to Corn – Example Output file
Summary of Water Modeling of Prothioconazole ROC and the USEPA Standard Pond
Estimated Environmental Concentrations for prothioconazoleTR are presented in Table 1 for the USEPA standard pond with the KSCornStd field scenario. A graphical presentation of the year-to-year peaks is presented in Figure 1. These values were generated with the Pesticide Water Calculator (PWC), Version 1.52. Critical input values for the model are summarized in Tables 2 and 3. This model estimates that about 4.3% of prothioconazoleTR applied to the field eventually reaches the water body. The main mechanism of transport from the field to the water body is by runoff (69.1% of the total transport), followed by spray drift (28.9%) and erosion (1.96%). In the water body, pesticide dissipates with an effective water column half-life of 218.1 days. (This value does not include dissipation by transport to the benthic region; it includes only processes that result in removal of pesticide from the complete system.) The main source of dissipation in the water column is metabolism (effective average half-life = 222.2 days) followed by photolysis (11873.3 days) and volatilization (1.043204E+08 days).
In the benthic region, pesticide dissipation is negligible (3507.2 days). The main source of dissipation in the benthic region is metabolism (effective average half-life = 3507.2 days). The vast majority of the pesticide in the benthic region (98.42%) is sorbed to sediment rather than in the pore water.

Table B1. Estimated Environmental Concentrations (ppb) for prothioconazoleTR.

1-day Avg (1-in-10 yr)	26.1
4-day Avg (1-in-10 yr)	25.7
21-day Avg (1-in-10 yr)	24.7
60-day Avg (1-in-10 yr)	21.7
365-day Avg (1-in-10 yr)	16.1
Entire Simulation Mean	12.7

Table B2. Summary of Model Inputs for prothioconazoleTR.

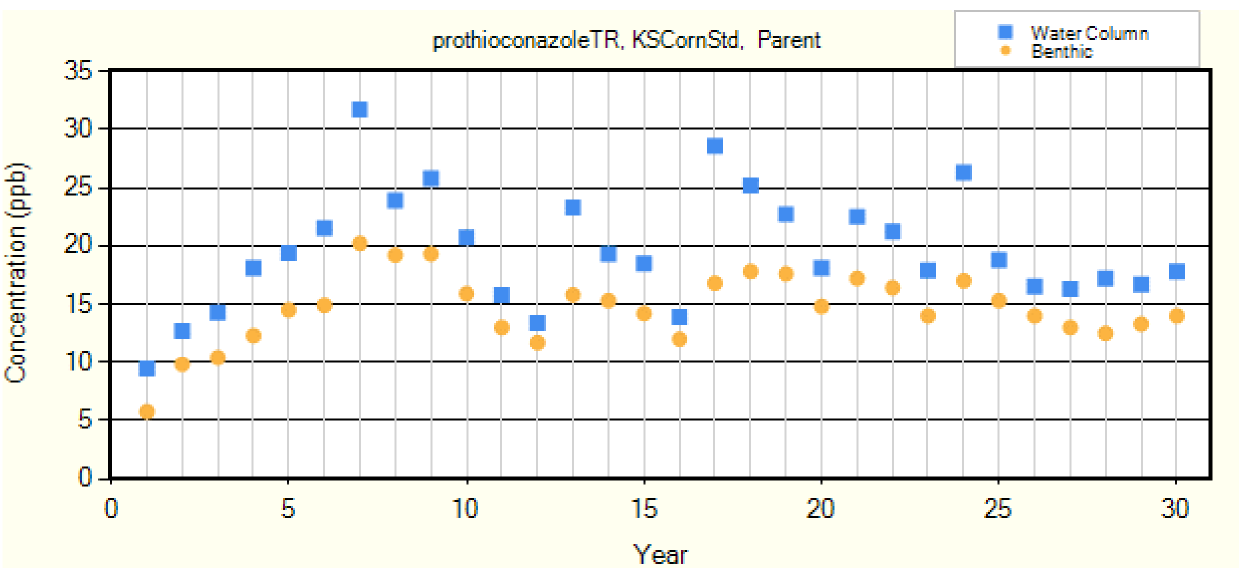
Scenario	KSCornStd
Cropped Area Fraction	1
Koc (ml/g)	575
Water Half-Life (days) @ 20 °C	163
Benthic Half-Life (days) @ 20 °C	2573
Photolysis Half-Life (days) @ 40 °Lat	101.9

Hydrolysis Half-Life (days)	0
Soil Half-Life (days) @ 20 °C	340.1
Foliar Half-Life (days)	0
Molecular Weight	344.3
Vapor Pressure (torr)	3E-9
Solubility (mg/l)	300
Henry's Constant	1.85E-10

Table B3. Application Schedule for prothioconazoleTR.

Date (Days Since Emergence)	Type	Amount (kg/ha)	Eff.	Drift
14	Above Crop (Foliar)	0.199	0.95	0.125
21	Above Crop (Foliar)	0.199	0.95	0.125
28	Above Crop (Foliar)	0.199	0.95	0.125
35	Above Crop (Foliar)	0.199	0.95	0.125

Figure B1. Yearly Peak Concentrations



<u>Example Output Files from PFAM Modeling (WIcranberries)</u>

Pesticide in Flooded Applications (PFAM)
Version 2
6/22/2020 6:45:46 PM
******* Summary of Paddy Concentration Rankings ********

****
************** Analysis for Parent ************
Max released concentration (ppb) = 0.305E+04
Index for max concentration = 8235

1-in-10 Year Return Concentrations:
********* WATER COLUMN CONCENTRATION (ug/L) ************
Water Column Peak = 29.1
Water Column 1-day Avg = 29.1
Water Column 4-day Avg = 29.0
Water Column 21-day Avg = 28.6
Water Column 60-day Avg = 26.6
Water Column 90-day Avg = 22.1
Water Column 365-day Avg = 5.84

****** BENTHIC PORE WATER (ug/L) Concentration *********
Benthic Pore Water Peak = 102.
Benthic Pore Water 4-day Avg = 102.
Benthic Pore Water 21-day Avg = 98.3
Benthic Pore Water 60-day Avg = 89.3
Benthic Pore Water 90-day Avg = 81.8
Benthic Pore Water 365-day Avg = 50.3

***** BENTHIC TOTAL CONCENTRATION (Mass/Dry Mass) ******
Benthic Total Conc. Peak = 625.
Benthic Total Conc. 4-day Avg = 623.
Benthic Total Conc. 21-day Avg = 601.
Benthic Total Conc. 60-day Avg = 547.
Benthic Total Conc. 90-day Avg = 500.
Benthic Total Conc. 365-day Avg = 308.

Pesticide in Flooded Applications (PFAM)
Version 2
6/22/2020 6:45:46 PM
Paddy Information
****
Sediment_Conversion_Factor= 6.12037037037037
(ug/L aqueous to ug / kg dry mass)
****
Effective compartment halflives averaged over simulation duration:

----Chemical 1
Washout halflife = Infinity

Aerobic halflife = 3833.33583089610
Hydrolysis halflife = 403427851.102242
Photolysis halflife = 234661.191510631
Volatilization halflife = 2054323335.07746
Leakage halflife(water col) = Infinity
Benthic Metabolism halflife = 636.881156314185
Benthic Hydrolysis halflife = 6654264955.34834

Metadata for Pesticides in Flooded Applications Model (PFAM) Scenarios

Table B4. Summary of Model Inputs for the Crop Tab and Physical Tab.

Parameter	Value	Source/Reference
Crop Tab		
Zero height reference	5/1 (MA)[A] 4/15 (OR)[B] 5/1 (WI)[C]	Since cranberry is a perennial crop, early spring leafing of cranberry was assumed based on Crop Group 13 document prepared by Health Effects Division (USEPA, 2006). Values are set to keep the canopy coverage term working correctly for this perennial crop scenario.[D]
Days from zero height to full height	1 (MA, OR, WI)	Values are set to keep the canopy coverage term working correctly for perennial crop scenario.
Days from Zero Height to Removal	167 (MA) 183 (OR) 167 (WI)	Values are set as harvest dates to keep the canopy coverage term working correctly for this perennial scenario. As a perennial crop, the vines are not removed from the field after harvest. The removal date corresponding to these days is October 15th.
Maximum Fractional Areal Coverage of Foliage	1.0	Assumed 100% coverage.
Physical Tab		
Meteorological files	w14765 (MA) w24221 (OR) w14920 (WI)	Meteorological data available at EPA models web site (SAMSON data). Stations selected are the closest station to the intended scenario: Providence, RI (w14765), Eugene, OR (w24221), and La Crosse, WI (14920).
Latitude	41.6° (MA) 44.7° (OR) 43.8° (WI)	Corresponds to latitude of meteorological station.
Area of application (m^2)	1	This input (except 0) does not have an impact on the concentration estimated inside the cranberry bog and for the ecological risk assessment. No drinking water scenario was developed.
Weir leakage (m/d)	0	PFAM default
Benthic leakage (m/d)	0	PFAM default
Mass transfer coefficient (m/s)	1×10^{-8}	PFAM default
Reference depth (m)	0.458	Depth of as weir height, per PFAM guidance.
Benthic depth (m)	0.05	PFAM default
Benthic porosity	0.50	PFAM default
Dry bulk density (g/cm^3)	1.35	Average bulk density ranges from 1.0 to 1.7 (g/cm^3) (Davenport and DeMoranville, 1993).

Parameter	Value	Source/Reference
FOC Water column on SS	0.04	PFAM default
FOC benthic	0.01	PFAM default
SS (mg/L)	30	PFAM default
Water column DOC (mg/L)	5.0	PFAM default
Chlorophyll, CHL (mg/L)	0.005	PFAM default
DFAC	1.19	PFAM default
Q10	2	PFAM default

[A] (MA) MA_Cranberry Winter Flood.PFS
[B] (OR) OR_Cranberry_No Flood.PFS, and OR_Cranberry_Winter Flood. PFS
[C] (WI) WI_Cranberry_Winter Flood.PFS
[D] Plant growth is based on linear increase in areal coverage of the plant from the zero-height reference date to the date of removal (harvest). In this version of PFAM, plant canopy only functions to shield the water body from light and thereby reduces photolysis.

Table B5. Summary of Model Inputs for the Applications Tab.

Parameter	Value	Comment, Source
Applications Tab		
Apply Pesticide on Specific Days or Apply Pesticide Over a Distribution of Days	Varies	User specified date for aquatic exposure assessment.
Month, Day	XX/XX XX/XX	Dependent on pesticide, pre- emergence vs post-emergence, pre-flood or post-flood label recommendations.
Mass Applied (kg/ha)	X.XX X.XX	Dependent on label rate.
Slow Release (1/day)	0	This parameter is used if the formulation slowly releases the pesticide over time. A "0" indicates instant release.
Drift Factor	0	Assumed 100% efficiency.

Table B6. Summary of Model Inputs for the Flood Tab (Winter Flood (MA_Cranberry_Winter Flood. PFS; Applicable for MA, OR, and WI).

Parameter	Value	Comment, Source
Floods Tab		
Reference Date	December 15	Generally, winter flooding is a common practice for cranberry production, although it is not required in Oregon (Williams *et al.*, 2019)).
Gradual or Sharp Transition	Sharp	This parameter simulates the release of water from the flooded field.[A]
Number of Events	5	Number of events needed to capture flooding and releases over an entire year and simulate the holding period.

Fill Level		Weir		Min. Level		Turn over		Turn over assumed negligible for cranberry.
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0[B]	0.305[C]	0	0.458[D]	0	0.305	0	0	Cranberry field remains flooded during winter (12/15)
90	0	90	0	90	0	90	0	Drain field 90 days after winter flood (3/15)
304	0.305	304	0.458	304	0.305	304	0	Flooded for harvest (10/15)
307	0	307	0	307	0	307	0	Post-harvest release of flood (10/18)[E]
365	0.305	365	0.458	365	0.305	365	0	Flood field for winter (12/15)

[A] Use sharp transitions unless specific information is available to change to gradual. This would also require a scenario modification to change the number of events so that flooding does not occur during the dry season.
[B] Reference Date: Initial date for winter flood (e.g., 12/15).
[C] Winter flood level. The winter flood begins as early as December 1 and is drained sometime between mid-February and mid-March (Averill et al., 2008).
[D] Arbitrary weir height was set at higher level than flood level to maintain flooding condition inside cranberry bog.
[E] Generally, harvest water is moved from bog to bog and is held for two to five days to allow settling of particles and nutrients before release of the water to adjacent receiving waters (Averill et al., 2008).

Table B7. Summary of Model Inputs for the Flood Tab (OR_Cranberry_No Flood.PFS; Applicable in OR only).

Parameter				Value				Comment
Floods Tab								
Reference Date				January 1				No winter flooding for cranberry production applicable in the Pacific Northwest cranberry production.
Gradual or Sharp Transition				Sharp				This parameter simulates the release of water from the rice paddy on a specific day.
Number of Events				4				Number of events needed to capture flooding and releases over an entire year and simulate the flood harvest.
Fill Level		Weir		Min. Level		Turn over		Turn over assumed negligible for cranberry.
Days	(m)	Days	(m)	Days	(m)	Days	d^{-1}	
0	0	0	0	0	0	0	0	No winter flood reference date (1/1)
287	0.305	287	0.458	287	0.305	287	0	Flooded for harvest (10/15)
290	0	290	0	290	0	290	0	Post-harvest release of flood (10/18)
365	0	365	0	365	0	365	0	Remain dry in winter

Appendix C. Example Outputs for Terrestrial Modeling

Upper-Bound Kenaga Residues For RQ Calculation

Chemical Name:	Prothioconazole	
Use	crop	
Formulation	0	
Application Rate	0.178	lbs a.i./acre
Half-life	35	days
Application Interval	7	days
Maximum # Apps./Year	4	
Length of Simulation	1	year
Variable application rates?	no	

Endpoints			
Avian	Bobwhite quail	LD50 (mg/kg-bw)	0.00
	Bobwhite quail	LC50 (mg/kg-diet)	4677.00
	Bobwhite quail	NOAEL(mg/kg-bw)	0.00
	Mallard duck	NOAEC (mg/kg-diet)	494.00
Mammals		LD50 (mg/kg-bw)	3087.00
		LC50 (mg/kg-diet)	0.00
		NOAEL (mg/kg-bw)	10.50
		NOAEC (mg/kg-diet)	176.00

Dietary-based EECs (ppm)	**Kenaga Values**
Short Grass	140.47
Tall Grass	64.38
Broadleaf plants	79.01
Fruits/pods/seeds	8.78
Arthropods	55.02

Avian Results

Avian Class	Body Weight (g)	Ingestion (Fdry) (g bw/day)	Ingestion (Fwet) (g/day)	% body wgt consumed	FI (kg-diet/day)
Small	20	5	23	114	2.28E-02
Mid	100	13	65	65	6.49E-02
Large	1000	58	291	29	2.91E-01
	20	5	5	25	5.06E-03
Granivores	100	13	14	14	1.44E-02
	1000	58	65	6	6.46E-02

Avian Body Weight (g)	Adjusted LD50 (mg/kg-bw)
20	0.00
100	0.00
1000	0.00

Dose-based EECs (mg/kg-bw)	Avian Classes and Body Weights (grams)		
	small 20	mid 100	large 1000
Short Grass	159.98	91.23	40.84
Tall Grass	73.32	41.81	18.72
Broadleaf plants	89.99	51.32	22.97
Fruits/pods	10.00	5.70	2.55
Arthropods	62.66	35.73	16.00
Seeds	2.22	1.27	0.57

Dose-based RQs (Dose-based EEC/adjusted LD50)	Avian Acute RQs Size Class (grams)		
	20	100	1000
Short Grass	#DIV/0!	#DIV/0!	#DIV/0!
Tall Grass	#DIV/0!	#DIV/0!	#DIV/0!
Broadleaf plants	#DIV/0!	#DIV/0!	#DIV/0!
Fruits/pods	#DIV/0!	#DIV/0!	#DIV/0!
Arthropods	#DIV/0!	#DIV/0!	#DIV/0!
Seeds	#DIV/0!	#DIV/0!	#DIV/0!

Dietary-based RQs (Dietary-based EEC/LC50 or NOAEC)	RQs	
	Acute	Chronic
Short Grass	0.03	0.28
Tall Grass	0.01	0.13

Broadleaf plants	0.02	0.16
Fruits/pods/seeds	0.00	0.02
Arthropods	0.01	0.11

Mammalian Results

Mammalian Class	Body Weight	Ingestion (Fdry) (g bwt/day)	Ingestion (Fwet) (g/day)	% body wgt consumed	FI (kg-diet/day)
Herbivores/ insectivores	15	3	14	95	1.43E-02
	35	5	23	66	2.31E-02
	1000	31	153	15	1.53E-01
Grainvores	15	3	3	21	3.18E-03
	35	5	5	15	5.13E-03
	1000	31	34	3	3.40E-02

Mammalian Class	Body Weight	Adjusted LD50	Adjusted NOAEL
Herbivores/ insectivores	15	6784.70	23.08
	35	5489.55	18.67
	1000	2374.40	8.08
Granivores	15	6784.70	23.08
	35	5489.55	18.67
	1000	2374.40	8.08

Dose-Based EECs (mg/kg-bw)	Mammalian Classes and Body weight (grams)		
	15	35	1000
Short Grass	133.93	92.56	21.46
Tall Grass	61.38	42.42	9.84
Broadleaf plants	75.33	52.07	12.07
Fruits/pods	8.37	5.79	1.34
Arthropods	52.46	36.25	8.41
Seeds	1.86	1.29	0.30

Dose-based RQs (Dose-based EEC/LD50 or NOAEL)	Small mammal 15 grams		Medium mammal 35 grams		Large mammal 1000 grams	
	Acute	Chronic	Acute	Chronic	Acute	Chronic
Short Grass	0.02	5.80	0.02	4.96	0.01	2.66
Tall Grass	0.01	2.66	0.01	2.27	0.00	1.22
Broadleaf plants	0.01	3.26	0.01	2.79	0.01	1.49
Fruits/pods	0.00	0.36	0.00	0.31	0.00	0.17
Arthropods	0.01	2.27	0.01	1.94	0.00	1.04
Seeds	0.00	0.08	0.00	0.07	0.00	0.04

	Mammal RQs

Dietary-based RQs (Dietary-based EEC/LC50 or NOAEC)	Acute	Chronic
Short Grass	#DIV/0!	0.80
Tall Grass	#DIV/0!	0.37
Broadleaf plants	#DIV/0!	0.45
Fruits/pods/seeds	#DIV/0!	0.05
Arthropods	#DIV/0!	0.31

Example Output from BeeREX (ver 1.0)

Table C1. User inputs (related to exposure)

Description	Value
Application rate	0.156
Units of app rate	lb a.i./A
Application method	foliar spray
Are empirical residue data available?	no

Table C2. Toxicity data

Description	Value (µg a.i./bee)
Adult contact LD50	
Adult oral LD50	
Adult oral NOAEL	26.1
Larval LD50	
Larval NOAEL	2

Table C3. Estimated concentrations in pollen and nectar

Application method	EECs (mg a.i./kg)	EECs (µg a.i./mg)
foliar spray	17.16	0.01716
soil application	NA	NA
seed treatment	NA	NA
tree trunk	NA	NA

Table C4. 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	Chronic RQ
Larval	Worker	1	1.9	0	0	0.00032604	#DIV/0!	0.000163
		2	9.4	0	0	0.00161304	#DIV/0!	0.000807
		3	19	0	0	0.0032604	#DIV/0!	0.00163
		4	0	60	1.8	1.060488	#DIV/0!	0.530244
		5	0	120	3.6	2.120976	#DIV/0!	1.060488
	Drone	6+	0	130	3.6	2.292576	#DIV/0!	1.146288
	Queen	1	1.9	0	0	0.00032604	#DIV/0!	0.000163
		2	9.4	0	0	0.00161304	#DIV/0!	0.000807
		3	23	0	0	0.0039468	#DIV/0!	0.001973
		4+	141	0	0	0.0241956	#DIV/0!	0.012098
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	1.143714	#DIV/0!	0.04382
	Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	2.567136	#DIV/0!	0.098358
	Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	1.058772	#DIV/0!	0.040566
	Worker (foraging for pollen)	>18	0	43.5	0.041	0.74716356	#DIV/0!	0.028627
	Worker (foraging for nectar)	>18	0	292	0.041	5.01142356	#DIV/0!	0.192009
	Worker (maintenance of hive in winter)	0-90	0	29	2	0.53196	#DIV/0!	0.020382
	Drone	>10	0	235	0.0002	4.032603432	#DIV/0!	0.154506
	Queen (laying 1500 eggs/day)	Entire life stage	525	0	0	0.09009	#DIV/0!	0.003452

Table C5. Results (highest RQs)

Exposure	Adults	Larvae
Acute contact	#DIV/0!	NA
Acute dietary	#DIV/0!	#DIV/0!
Chronic dietary	0.19	1.06

Appendix D. Non-Standard PWC Crop Scenarios

Standard scenarios were developed with the intention of representing high end exposure (i.e., vulnerable) sites. Non-standard scenarios have been developed to address specific issues, such as refinements of assessments for endangered species, or for a specific class of chemicals. These are not necessarily vulnerable locations or major crop growing areas for the particular crop. Below is a list and description of non-standard scenarios used in this assessment.

Organophosphates (OPs) - The scenarios ending in OP were developed to support the organophosphate risk assessments. These scenarios were not developed specifically to represent high-end exposure (i.e., vulnerable) sites. Instead, these scenarios were developed by first identifying areas of high combined use of the entire OP class of chemicals which coincided with drinking water intakes that draw from surface water sources. Within these high OP-use areas, major crop uses were identified, and scenarios developed to represent high runoff-prone soils known to support the crops in these areas. In some instances, these scenarios may represent the major growing area for a particular crop. In other instances, the major crop area may be elsewhere, and the scenario in the high OP-use area may represent a "fringe" area of the crop in question. It has not been determined how the vulnerability of a crop scenario developed for the OP cumulative assessment compares to a standard scenario developed for the same crop; therefore, the OP scenarios may represent either greater or lesser vulnerability than standard scenarios. Because the OP scenarios focus on areas coinciding with drinking water intakes, their suitability as high-end vulnerable scenarios for ecological exposure assessments is less certain. The ORwheatOP, TXwheatOP, ORberriesOP, and CAsugarbeet_WirrigOP scenarios were used with the appropriate crop groups in this assessment.

N-methyl carbamate (NMC) - The scenarios ending in NMC were developed to support the N-methyl carbamate risk assessments. These scenarios were developed by first identifying areas of high combined use of the entire NMC class of chemicals that coincided with drinking water intakes that draw from surface water sources. Within these high NMC-use areas, major crop uses were identified, and scenarios developed to represent high runoff-prone soils known to support the crops in these areas. In some instances, these scenarios may represent the major growing area for a particular crop. In other instances, the major crop area may be elsewhere, and the scenario in the high NMC-use area may represent a "fringe" area of the crop in question. It has not been determined how the vulnerability of a crop scenario developed for the NMC assessments compare to a standard scenario developed for the same crop; therefore, the NMC scenarios may represent either greater or lesser vulnerability than standard scenarios. Because the NMC scenarios focused on areas that coincided with drinking water intakes, their suitability as high-end vulnerable scenarios for ecological exposure assessments is less certain. The ILbeansNMC and WAbeansNMC scenarios were used with the appropriate crop groups in this assessment.

Appendix E. Additional Tables for Terrestrial Vertebrate Exposure Assessment

Table E-1. Summary of Dietary (mg a.i./kg-diet) and Dose-based EECs (mg a.i./kg-bw) as Food Residues for Birds, Reptiles, Terrestrial-Phase Amphibians and Mammals from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Upper-Bound Kenaga)

Food Type	Dietary-Based EEC (mg/kg-diet)	Dose-Based EEC (mg/kg-body weight)					
		Birds, Reptiles and Terrestrial Phase Amphibians			Mammals		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Bushberry (0.178 lbs a.i/A, 2x, 7-day interval)							
Short grass	80	91	52	23	76	53	12
Tall grass	37	42	24	11	35	24	5.6
Broadleaf plants/small insects	45	51	29	13	43	30	6.9
Fruits/pods/seeds (dietary only)	5.0	5.7	3.2	1.5	4.8	3.3	0.76
Arthropods	31	36	20	9.1	30	21	4.8
Seeds (granivore)[1]	N/A	1.3	0.72	0.32	1.1	0.73	0.17
Soybean (0.156 + 0.156 + 0.094 lb ai/A, 10-day interval)							
Short grass	78	89	51	23	75	52	12
Tall grass	36	41	23	11	34	24	5.5
Broadleaf plants/small insects	44	50	29	13	42	29	6.7
Fruits/pods/seeds (dietary only)	4.9	5.6	3.2	1.4	4.7	3.2	0.75
Arthropods	31	35	20	8.9	29	20	4.7
Seeds (granivore)[1]	N/A	1.2	0.71	0.32	1.0	0.72	0.17
Nursery Seedlings (0.156 lbs a.i./A, 5x, 14-day interval)							
Short grass	116	132	75	34	111	76	18
Tall grass	53	61	35	15	51	35	8.1
Broadleaf plants/small insects	65	74	42	19	62	43	10
Fruits/pods/seeds (dietary only)	7.3	8.3	4.7	2.1	6.9	4.8	1.1
Arthropods	45	52	30	13	43	30	6.9
Seeds (granivore)[1]	N/A	1.8	1.1	0.47	1.5	1.1	0.25
Dried, Shelled Peas and Beans (0.178 lb a.i./A, 3x, 5-day interval)							
Short grass	116	133	76	34	111	77	18
Tall grass	53	61	35	16	51	35	8.2
Broadleaf plants/small insects	66	75	43	19	62	43	10
Fruits/pods/seeds (dietary only)	7.3	8.3	4.7	2.1	6.9	4.8	1.1

Food Type	Dietary-Based EEC (mg/kg-diet)	Dose-Based EEC (mg/kg-body weight)					
		Birds, Reptiles and Terrestrial Phase Amphibians			Mammals		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Arthropods	46	52	30	13	43	30	7.0
Seeds (granivore)[1]	N/A	1.8	1.1	0.47	1.5	1.1	0.25
Peanuts (0.178 lb a.i./A, 4x, 14-day interval)							
Short grass	118	135	77	34	113	78	18
Tall grass	54	62	35	16	52	36	8.3
Broadleaf plants/small insects	67	76	43	19	63	44	10
Fruits/pods/seeds (dietary only)	7.4	8.4	4.8	2.2	7.1	4.9	1.1
Arthropods	46	53	30	13	44	31	7.1
Seeds (granivore)[1]	N/A	1.9	1.1	0.48	1.6	1.1	0.25
Sugar beet (0.178 lbs ai/A, 3x, 14-day interval)							
Short grass	100	113	65	29	95	66	15
Tall grass	46	52	30	13	44	30	7.0
Broadleaf plants/small insects	56	64	36	16	53	37	8.6
Fruits/pods/seeds (dietary only)	6.2	7.1	4.0	1.8	5.9	4.1	0.95
Arthropods	39	44	25	11	37	26	6.0
Seeds (granivore)[1]	N/A	1.6	0.90	0.40	1.3	0.91	0.21
Wheat (0.178 lbs a.i./A, 2x, 14-day interval)							
Short grass	75	86	49	22	72	49	11
Tall grass	34	39	22	10	33	23	5.3
Broadleaf plants/small insects	42	48	27	12	40	28	6.5
Fruits/pods/seeds (dietary only)	4.7	5.4	3.1	1.4	4.5	3.1	0.72
Arthropods	29	34	19	8.6	28	19	4.5
Seeds (granivore)[1]	N/A	1.2	0.68	0.30	0.99	0.69	0.16

[1] Seeds presented separately for dose – based EECs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

Table E-2. Acute and Chronic RQ values for Birds, Reptiles, and Terrestrial-Phase Amphibians from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Upper-Bound Kenaga)

Use	Food Type	Acute Dietary-Based RQ LC_{50} = 4,677 mg a.i./kg-diet	Chronic Dietary RQ NOAEC = 494 mg a.i./kg-diet
Bushberry (0.178 lbs a.i/A, 2x, 7-day interval)	Short grass	0.02	0.16
	Tall grass	0.01	0.07
	Broadleaf plants	0.01	0.09
	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.06
Corn (0.178 lbs a.i./A, 4x, 7-day interval)	Short grass	0.03	0.28
	Tall grass	0.01	0.13
	Broadleaf plants	0.02	0.16
	Fruits/pods/seeds	<0.01	0.02
	Arthropods	0.01	0.11
Low Growing Berries (0.156 lbs a.i./A, 2x, 7-day interval)	Short grass	0.01	0.14
	Tall grass	0.01	0.06
	Broadleaf plants	0.01	0.08
	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.06
Soybean (0.156 lbs a.i./A, 3x, 10-day interval)	Short grass	0.02	0.16
	Tall grass	0.01	0.07
	Broadleaf plants	0.01	0.09
	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.06
Nursery Seedlings [Conifers, Evergreens, Softwoods] (0.156 lbs a.i./A, 5x, 14-day interval)	Short grass	0.02	0.23
	Tall grass	0.01	0.11
	Broadleaf plants	0.01	0.13
	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.09
Dried, Shelled, Peas and Beans (0.178 lbs a.i./A, 3x, 5-day interval)	Short grass	0.02	0.24
	Tall grass	0.01	0.11
	Broadleaf plants	0.01	0.13
	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.09
Peanuts 0.178 lbs a.i./A, 4x, 14-day interval)	Short grass	0.03	0.24
	Tall grass	0.01	0.11
	Broadleaf plants	0.01	0.13
	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.09
Sugar Beet (0.178 lbs a.i./A, 3x, 14-day interval)	Short grass	0.02	0.20
	Tall grass	0.01	0.09
	Broadleaf plants	0.01	0.11
	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.08
Cereal Grains [Barley, Wheat, Triticale, Oats, Rye,	Short grass	0.02	0.15
	Tall grass	0.01	0.07
	Broadleaf plants	0.01	0.09

Use	Food Type	Acute Dietary-Based RQ LC_{50} = 4,677 mg a.i./kg-diet	Chronic Dietary RQ NOAEC = 494 mg a.i./kg-diet
Buckwheat and Millet {Pearl and Proso}] (0.178 lbs a.i./A, 2x, 14-day interval)	Fruits/pods/seeds	<0.01	0.01
	Arthropods	0.01	0.06

Bolded values exceed the LOC for acute risk to non-listed species of 0.5 or the chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

Table E-3. Acute Risk Quotient (RQ) Values for Mammals from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Upper-Bound Kenaga)

Food Type	Acute Dose-Based RQ LD_{50} = 3,087 mg/kg-bw		
	Small (15 g)	Medium (35 g)	Large (1000 g)
Bushberry (0.178 lb a.i./acre, 2x, 7-day interval)			
Herbivores/Insectivores			
Short grass	0.01	0.01	0.01
Tall grass	0.01	<0.01	<0.01
Broadleaf plants	0.01	0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	<0.01	<0.01	<0.01
Granivores			

Food Type	Acute Dose-Based RQ LD_{50} = 3,087 mg/kg-bw		
	Small (15 g)	Medium (35 g)	Large (1000 g)
Seeds[1]	<0.01	<0.01	<0.01
Corn (0.178 lbs ai/A, 4x, 7-day interval)			
Herbivores/Insectivores			
Short grass	0.02	0.02	0.01
Tall grass	0.01	0.01	<0.01
Broadleaf plants	0.01	0.01	0.01
Fruits/pods/seeds	<0.01	<0.00	<0.01
Arthropods	0.01	0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01
Low Growing Berries (0.156 lb ai/A, 2x, 7-day interval)			
Herbivores/Insectivores			
Short grass	0.01	0.01	<0.01
Tall grass	<0.01	<0.01	<0.01
Broadleaf plants	0.01	<0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	<0.01	<0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01
Soybean (0.156 + 0.156 + 0.094 lb ai/A, 10-day interval)			
Herbivores/Insectivores			
Short grass	0.01	0.01	0.01
Tall grass	0.01	<0.01	<0.01
Broadleaf plants	0.01	0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	<0.01	<0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01
Nursery Seedlings (0.156 lbs a.i./A, 5x, 14-day interval)			
Herbivores/Insectivores			
Short grass	0.02	0.01	0.01
Tall grass	0.01	0.01	<0.01
Broadleaf plants	0.01	0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	0.01	0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01
Dried, Shelled Peas and Beans (0.178 lb a.i./A, 3x, 5-day interval)			
Herbivores/Insectivores			
Short grass	0.02	0.01	0.01
Tall grass	0.01	0.01	<0.01
Broadleaf plants	0.01	0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	0.01	0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01

Food Type	Acute Dose-Based RQ LD50 = 3,087 mg/kg-bw		
	Small (15 g)	Medium (35 g)	Large (1000 g)
Peanuts (0.178 lb a.i./A, 4x, 14-day interval)			
Herbivores/Insectivores			
Short grass	0.02	0.01	0.01
Tall grass	0.01	0.01	<0.01
Broadleaf plants	0.01	0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	0.01	0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01
Sugar beet (0.178 lbs ai/A, 3x, 14-day interval)			
Herbivores/Insectivores			
Short grass	0.01	0.01	0.01
Tall grass	0.01	0.01	<0.01
Broadleaf plants	0.01	0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	0.01	<0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01
Wheat (0.178 lbs a.i./A, 2x, 14-day interval)			
Herbivores/Insectivores			
Short grass	0.01	0.01	<0.01
Tall grass	<0.01	<0.01	<0.01
Broadleaf plants	0.01	0.01	<0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	<0.01	<0.01	<0.01
Granivores			
Seeds[1]	<0.01	<0.01	<0.01

Bolded values exceed the LOC for acute risk to non-listed species of 0.5. The endpoints listed in the table are the endpoint used to calculate the RQ.

[1] Seeds presented separately for dose – based EECs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

Table E-4. Chronic Risk Quotient (RQ) values for Mammals from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Upper-Bound Kenaga)

Food Type	Chronic Dose-Based RQ NOAEL = 10.5 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Bushberry (0.178 lb a.i./acre, 2x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**3.3**	**2.8**	**1.5**	0.45
Tall grass	**1.5**	**1.3**	0.69	0.21
Broadleaf plants	**1.9**	**1.6**	0.85	0.26
Fruits/pods/seeds	0.21	0.18	0.09	0.03
Arthropods	**1.3**	**1.1**	0.59	0.18

Food Type	Chronic Dose-Based RQ NOAEL = 10.5 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Granivores				
Seeds[2]	0.05	0.04	0.02	N/A
Corn (0.178 lbs ai/A, 4x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**5.8**	**5.0**	**2.7**	0.80
Tall grass	**2.7**	**2.3**	**1.2**	0.37
Broadleaf plants	**3.3**	**2.8**	**1.5**	0.45
Fruits/pods/seeds	0.36	0.31	0.17	0.05
Arthropods	**2.3**	**1.9**	**1.0**	0.31
Granivores				
Seeds[2]	0.08	0.07	0.04	N/A
Low Growing Berries (0.156 lb ai/A, 2x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**2.9**	**2.5**	**1.3**	0.40
Tall grass	**1.3**	**1.1**	0.61	0.18
Broadleaf plants	**1.6**	**1.4**	0.75	0.22
Fruits/pods/seeds	0.18	0.15	0.08	0.02
Arthropods	**1.1**	0.97	0.52	0.16
Granivores				
Seeds[2]	0.04	0.03	0.02	N/A
Soybean (0.156 + 0.156 + 0.094 lb ai/A, 10-day interval)				
Herbivores/Insectivores				
Short grass	**3.2**	**2.8**	**1.5**	0.45
Tall grass	**1.5**	**1.3**	0.68	0.20
Broadleaf plants	**1.8**	**1.6**	0.83	0.25
Fruits/pods/seeds	0.20	0.17	0.09	0.03
Arthropods	**1.3**	**1.1**	0.58	0.17
Granivores				
Seeds[2]	0.05	0.04	0.02	N/A
Nursery Seedlings (0.156 lbs a.i./A, 5x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**4.8**	**4.1**	**2.2**	0.66
Tall grass	**2.2**	**1.9**	**1.0**	0.30
Broadleaf plants	**2.7**	**2.3**	**1.2**	0.37
Fruits/pods/seeds	0.30	0.26	0.14	0.04
Arthropods	**1.9**	**1.6**	0.86	0.26
Granivores				
Seeds[2]	0.07	0.06	0.03	N/A
Dried, Shelled Peas and Beans (0.178 lb a.i./A, 3x, 5-day interval)				
Herbivores/Insectivores				
Short grass	**4.8**	**4.1**	**2.2**	0.66
Tall grass	**2.2**	**1.9**	**1.0**	0.30
Broadleaf plants	**2.7**	**2.3**	**1.2**	0.37
Fruits/pods/seeds	0.30	0.26	0.14	0.04
Arthropods	**1.9**	**1.6**	0.86	0.26
Granivores				

Food Type	Chronic Dose-Based RQ NOAEL = 10.5 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Seeds[2]	0.07	0.06	0.03	N/A
Peanuts (0.178 lb a.i./A, 4x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**4.9**	**4.2**	**2.2**	0.67
Tall grass	**2.2**	**1.9**	**1.0**	0.31
Broadleaf plants	**2.8**	**2.4**	**1.3**	0.38
Fruits/pods/seeds	0.31	0.26	0.14	0.04
Arthropods	**1.9**	**1.6**	0.88	0.26
Granivores				
Seeds[2]	0.07	0.06	0.03	N/A
Sugar beet (0.178 lbs ai/A, 3x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**4.1**	**3.5**	**1.9**	0.57
Tall grass	**1.9**	**1.6**	0.86	0.26
Broadleaf plants	**2.3**	**2.0**	**1.1**	0.32
Fruits/pods/seeds	0.26	0.22	0.12	0.04
Arthropods	**1.6**	**1.4**	0.74	0.22
Granivores				
Seeds[2]	0.06	0.05	0.03	N/A
Wheat (0.178 lbs a.i./A, 2x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**3.1**	**2.7**	**1.4**	0.43
Tall grass	**1.4**	**1.2**	0.65	0.20
Broadleaf plants	**1.8**	**1.5**	0.80	0.24
Fruits/pods/seeds	0.19	0.17	0.09	0.03
Arthropods	**1.2**	**1.0**	0.56	0.17
Granivores				
Seeds[2]	0.04	0.04	0.02	N/A

Bolded values exceed the LOC for chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.
[1] Seeds presented separately for dose – based RQs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

Table E-5. Chronic Risk Quotient (RQ) values for Mammals from Labeled Uses of Prothioconazole (T-REX v. 1.5.2, Mean Kenaga)

Food Type	Chronic Dose-Based RQ NOAEL = 10.5 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Bushberry (0.178 lb a.i./acre, 2x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**1.2**	**1.0**	0.54	0.16
Tall grass	0.50	0.42	0.23	0.07
Broadleaf plants	0.62	0.53	0.28	0.09
Fruits/pods/seeds	0.10	0.08	0.04	0.01

Food Type	Chronic Dose-Based RQ NOAEL = 10.5 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Arthropods	0.89	0.76	0.41	0.12
Granivores				
Seeds[2]	0.02	0.02	0.01	N/A
Corn (0.178 lbs ai/A, 4x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**2.1**	**1.8**	0.94	0.28
Tall grass	0.87	0.74	0.40	0.12
Broadleaf plants	**1.1**	0.93	0.50	0.15
Fruits/pods/seeds	0.17	0.14	0.08	0.02
Arthropods	**1.6**	**1.3**	0.72	0.22
Granivores				
Seeds[2]	0.04	0.03	0.02	N/A
Low Growing Berries (0.156 lb ai/A, 2x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**1.0**	0.88	0.47	0.14
Tall grass	0.43	0.37	0.20	0.06
Broadleaf plants	0.54	0.46	0.25	0.07
Fruits/pods/seeds	0.08	0.07	0.04	0.01
Arthropods	0.78	0.67	0.36	0.11
Granivores				
Seeds[2]	0.02	0.02	0.01	N/A
Soybean (0.156 + 0.156 + 0.094 lb ai/A, 10-day interval)				
Herbivores/Insectivores				
Short grass	**1.2**	0.98	0.53	0.16
Tall grass	0.49	0.42	0.22	0.07
Broadleaf plants	0.61	0.52	0.28	0.08
Fruits/pods/seeds	0.09	0.08	0.04	0.01
Arthropods	0.88	0.75	0.40	0.12
Granivores				
Seeds[2]	0.02	0.02	0.01	N/A
Nursery Seedlings (0.156 lbs a.i./A, 5x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**1.7**	**1.5**	0.78	0.23
Tall grass	0.72	0.61	0.33	0.10
Broadleaf plants	0.90	0.77	0.41	0.12
Fruits/pods/seeds	0.14	0.12	0.06	0.02
Arthropods	**1.3**	**1.1**	0.59	0.18
Granivores				
Seeds[2]	0.03	0.03	0.01	N/A
Dried, Shelled Peas and Beans (0.178 lb a.i./A, 3x, 5-day interval)				
Herbivores/Insectivores				
Short grass	**1.7**	**1.5**	0.78	0.23
Tall grass	0.72	0.62	0.33	0.10
Broadleaf plants	0.90	0.77	0.41	0.12
Fruits/pods/seeds	0.14	0.12	0.06	0.02
Arthropods	**1.3**	**1.1**	0.60	0.18

Food Type	Chronic Dose-Based RQ NOAEL = 10.5 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Granivores				
Seeds[2]	0.03	0.03	0.01	N/A
Peanuts (0.178 lb a.i./A, 4x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**1.7**	**1.5**	0.79	0.24
Tall grass	0.73	0.63	0.34	0.10
Broadleaf plants	0.92	0.78	0.42	0.13
Fruits/pods/seeds	0.14	0.12	0.07	0.02
Arthropods	**1.3**	**1.1**	0.61	0.18
Granivores				
Seeds[2]	0.03	0.03	0.01	N/A
Sugar beet (0.178 lbs ai/A, 3x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**1.5**	**1.3**	0.67	0.20
Tall grass	0.62	0.53	0.28	0.08
Broadleaf plants	0.77	0.66	0.35	0.11
Fruits/pods/seeds	0.12	0.10	0.05	0.02
Arthropods	**1.1**	0.95	0.51	0.15
Granivores				
Seeds[2]	0.03	0.02	0.01	N/A
Wheat (0.178 lbs a.i./A, 2x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**1.1**	0.94	0.50	0.15
Tall grass	0.47	0.40	0.21	0.06
Broadleaf plants	0.58	0.50	0.27	0.08
Fruits/pods/seeds	0.09	0.08	0.04	0.01
Arthropods	0.84	0.72	0.38	0.12
Granivores				
Seeds[2]	0.02	0.02	0.01	N/A

Bolded values exceed the LOC for chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

[1] Seeds presented separately for dose – based RQs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

Table E-6. Chronic Risk Quotient (RQ) values for Mammals from Labeled Uses of Prothioconazole Based on the LOAEL (T-REX v. 1.5.2, Upper-Bound Kenaga)

Food Type	Chronic Dose-Based RQ LOAEL = 44 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Bushberry (0.178 lb a.i./acre, 2x, 7-day interval)				
Herbivores/Insectivores				
Short grass	0.79	0.67	0.36	0.11
Tall grass	0.36	0.31	0.17	0.05
Broadleaf plants	0.44	0.38	0.20	0.06

Food Type	Chronic Dose-Based RQ LOAEL = 44 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Fruits/pods/seeds	0.05	0.04	0.02	0.01
Arthropods	0.31	0.26	0.14	0.04
Granivores				
Seeds[2]	0.01	0.01	0.01	N/A
Corn (0.178 lbs ai/A, 4x, 7-day interval)				
Herbivores/Insectivores				
Short grass	**1.4**	**1.2**	0.63	0.20
Tall grass	0.63	0.54	0.29	0.09
Broadleaf plants	0.78	0.67	0.36	0.11
Fruits/pods/seeds	0.09	0.07	0.04	0.01
Arthropods	0.54	0.46	0.25	0.08
Granivores				
Seeds[2]	0.02	0.02	0.01	N/A
Low Growing Berries (0.156 lb ai/A, 2x, 7-day interval)				
Herbivores/Insectivores				
Short grass	0.69	0.59	0.32	0.10
Tall grass	0.32	0.27	0.14	0.05
Broadleaf plants	0.39	0.33	0.18	0.06
Fruits/pods/seeds	0.04	0.04	0.02	0.01
Arthropods	0.27	0.23	0.12	0.04
Granivores				
Seeds[2]	0.01	0.01	<0.01	N/A
Soybean (0.156 + 0.156 + 0.094 lb ai/A, 10-day interval)				
Herbivores/Insectivores				
Short grass	0.77	0.66	0.35	0.11
Tall grass	0.35	0.30	0.16	0.05
Broadleaf plants	0.44	0.37	0.20	0.06
Fruits/pods/seeds	0.05	0.04	0.02	0.01
Arthropods	0.30	0.26	0.14	0.04
Granivores				
Seeds[2]	0.01	0.01	<0.01	N/A
Nursery Seedlings (0.156 lbs a.i./A, 5x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**1.1**	0.98	0.52	0.16
Tall grass	0.52	0.45	0.24	0.08
Broadleaf plants	0.64	0.55	0.29	0.09
Fruits/pods/seeds	0.07	0.06	0.03	0.01
Arthropods	0.45	0.38	0.21	0.06
Granivores				
Seeds[2]	0.02	0.01	0.01	N/A
Dried, Shelled Peas and Beans (0.178 lb a.i./A, 3x, 5-day interval)				
Herbivores/Insectivores				
Short grass	**1.2**	0.98	0.53	0.17
Tall grass	0.53	0.45	0.24	0.08
Broadleaf plants	0.65	0.55	0.30	0.09
Fruits/pods/seeds	0.07	0.06	0.03	0.01

Food Type	Chronic Dose-Based RQ LOAEL = 44 mg/kg-bw[1]			Chronic Dietary-Based RQ NOAEC = 176 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1,000 g)	
Arthropods	0.45	0.38	0.21	0.06
Granivores				
Seeds[2]	0.02	0.01	0.01	N/A
Peanuts (0.178 lb a.i./A, 4x, 14-day interval)				
Herbivores/Insectivores				
Short grass	**1.2**	**1.0**	0.53	0.17
Tall grass	0.53	0.46	0.24	0.08
Broadleaf plants	0.66	0.56	0.30	0.09
Fruits/pods/seeds	0.07	0.06	0.03	0.01
Arthropods	0.46	0.39	0.21	0.07
Granivores				
Seeds[2]	0.02	0.01	0.01	N/A
Sugar beet (0.178 lbs ai/A, 3x, 14-day interval)				
Herbivores/Insectivores				
Short grass	0.98	0.84	0.45	0.14
Tall grass	0.45	0.38	0.21	0.06
Broadleaf plants	0.55	0.47	0.25	0.08
Fruits/pods/seeds	0.06	0.05	0.03	0.01
Arthropods	0.38	0.33	0.18	0.06
Granivores				
Seeds[2]	0.01	0.01	0.01	N/A
Wheat (0.178 lbs a.i./A, 2x, 14-day interval)				
Herbivores/Insectivores				
Short grass	0.74	0.63	0.34	0.11
Tall grass	0.34	0.29	0.16	0.05
Broadleaf plants	0.42	0.36	0.19	0.06
Fruits/pods/seeds	0.05	0.04	0.02	0.01
Arthropods	0.29	0.25	0.13	0.04
Granivores				
Seeds[2]	0.01	0.01	<0.01	N/A

Bolded values exceed the LOC for chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

[1] Seeds presented separately for dose – based RQs due to difference in food intake of granivores compared with herbivores and insectivores. This difference reflects the difference in the assumed mass fraction of water in their diets.

Appendix F. Additional Tables for Aquatic Benthic Invertebrate Exposure Assessment

Table F-1. Aquatic Invertebrate (Exposed in Sediment) Risk Quotients for Non-listed Species Based on LOAEC Value.

Use Site	1-in-10 Yr EEC Pore Water (µg/L)/ Bulk Sediment (µg/kg$_{OC}$)[2]			Risk Quotients Freshwater Chronic
	Daily Mean	21-day Mean (PW)	21-day Mean (BS)	LOAEC = 63 µg a.i./L[1,2,3]
Bushberry-GRD	2.0	2.0	1170	0.03
Dried shelled pea and bean-AER	13	13	7430	0.20
Nursery seedlings of conifers/evergreens/softwood-GRD	9.9	9.9	5792	0.16
Corn (field, pop or sweet)-AER	19	19	11,174	0.30
Peanuts-AER	8.9	8.8	5,148	0.14
Soybean-GRD	4.4	4.4	2,574	0.07
Sugar beet-AER	9.9	9.8	5,733	0.16
Wheat/Triticale/Barley-AER	7.0	7.0	4,095	0.11

Bolded values exceed the LOC for chronic risk to non-listed species of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

PW = pore water; BS = bulk sediment; GRD = ground application; AER = aerial application.

[1] The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average pore water value.

[2] The 28-day test with *Chironomus riparius* (MRID 50019201) analytically confirmed concentrations of prothioconazole-S-methyl in overlying water and pore water but did not measure concentrations in the bulk sediment; therefore, a risk quotient normalized for organic carbon content in the sediment could not be calculated.

[3] Endpoint values from exposure to prothioconazole-S-methyl have been normalized to the parent molecular weight (see **Table 6-1**).

Appendix G. Available Aquatic and Terrestrial Endpoints for Prothioconazole, Prothioconazole-desthio and Prothioconazole-S-methyl

Based on the available data, prothioconazole is slightly to moderately toxic to fish (for which freshwater fish serve as surrogates for aquatic-phase amphibians) and freshwater aquatic invertebrates and moderately toxic to estuarine/marine invertebrates on an acute exposure basis; there are effects on aquatic animal survival, growth and reproduction following chronic exposure (**Table G-1**). The compound is no more than slightly toxic to birds (which serve as surrogates for reptiles and terrestrial-phase amphibians) and is practically non-toxic to mammals on an acute exposure basis (**Table G-2**). Similar to aquatic animals, there were effects on growth in mammals following chronic exposure; however, there were no chronic effects detected in birds up to the highest dietary concentration tested. Prothioconazole is also practically non-toxic to bees on an acute exposure basis and while the compound did not result in any adverse effects on adult bees up to the highest dietary concentration tested in a chronic toxicity study, bee larvae appeared more sensitive with reductions in larval bee emergence. Non-vascular aquatic plants are more sensitive to prothioconazole than vascular aquatic plants.

In a 96-h acute toxicity study, the estuarine/marine Sheepshead Minnow (*Cyprinodon variegatus*) were exposed to the prothioconazole degradate prothioconazole-desthio (98.3% purity) at nominal concentrations of 0 (negative control and solvent [dimethylformamide; DMF; 100 µL/L] control), 0.938, 1.88, 3.75, 7.50, and 15.0 mg ai/L under static-renewal conditions (MRID 50633901). Mean-measured concentrations reported by the study author were <0.05 (<limit of quantification [LOQ], controls), 0.915, 1.78, 3.59, 7.03, and 14.9 mg ai/L. Mortality and sublethal effects were recorded daily. After 96 hours of exposure, no mortality was observed in any prothioconazole-desthio treatment or control group apart from highest treatment (*i.e.*, the mean-measured 14.9 mg ai/L), where there was 100% mortality. The 96-hour LC_{50} value is 10.2 (95% CI: 7.03 to 14.9) mg ai/L. Sublethal effects were noted in the mean-measured 7.03 (at the hour 24 observation interval) and 14.9 mg ai/L treatment levels (afte4 4 hrs); effects included fish on bottom of the tank, labored respiration, and dark coloration. By 24 hours, all fish were dead in the 14.9 mg ai/L treatment level.

In a 96-h acute toxicity study, Eastern oysters (*Crassostrea virginica*) were exposed to the prothioconazole degradate prothioconazole-s-methyl (99.6% purity) at nominal concentrations of 0 (negative and solvent [dimethylformamide; DMF; 100 µL/L] controls), 0.063, 0.13, 0.25, 0.50, and 1.0 mg ai/L under flow-through conditions (MRID 50925601). Mean-measured concentrations reported by the study author were <0.010 (<MDL, controls), 0.055, 0.096, 0.18, 0.25, and 0.52 mg ai/L. Mortality and sublethal effects were recorded daily. After 96 hours of exposure, no mortality or sublethal effects were observed in any prothioconazole-s-methyl treatment or control group. Shell growth averaged 1.9 mm and 2.1 mm for the negative and solvent controls, respectively, as compared to growth ranging from 1.4 to 2.2 mm in the groups exposed to the test material. Shell growth inhibition ranged from -16 to 26% as compared to the negative control. The 96-hour IC_{50} value for inhibition of shell growth was determined to be

greater than the highest concentration >0.52 mg ai/L based on the mean-measured concentrations.

In a 28-day emergence study, midges *(Chironomus riparius)* were exposed to the prothioconazole-degradate: prothioconazole-S-methyl (98.9% purity) at nominal concentrations of 0 (negative and solvent [dimethylformamide; DMF; 100 µg/L] controls), 1.0, 10, 100, 1,000 and 10,000 µg S-methyl/L under static conditions (MRID 50019201). Time-weighted average (TWA) concentrations calculated by the reviewer were 0.48, 2.8, 28, 280 and 3,084 µg S-methyl/L in the overlying water and 0.41, 0.66, 5.9, 66 and 793 µg S-methyl/L in the pore water. Observations of emergence of males and females was recorded daily from Day 14 until the end of the test (Day 28). Development rate and percent emergence were adversely affected by exposure to prothioconazole-S-methyl in the 66 and 793 µg S-methyl/L (pore water) treatment groups (development rate: 8 and 19%, respectively; percent emergence: 27 and 93%, respectively compared to the negative control group). The 28-Day NOAEC value for percent emergence was 5.9 µg S-methyl/L and the LOAEC value was 66 µg S-methyl/L.

In a 28-day whole sediment toxicity study of the marine amphipod (*Leptocheirus plumulosus*), sediment was treated with technical grade prothioconazole (98.10% active ingredient, a.i.) at nominal sediment concentrations of 6.25, 12.5, 25, 50 and 100 mg ai/kg (MRID 50973501). Time-weighted average (TWA) concentrations of prothioconazole in the sediment were 2.26, 4.55, 8.51, 18.6 and 36.4 mg ai/kg, respectively. The TWA organic carbon (OC; 0.36% OC) normalized bulk sediment concentrations were 0.628, 1.26, 2.36, 5.15 and 10.1 g ai/kg_{oc}, respectively and the TWA pore water concentrations were 1.14, 1.94, 3.33, 7.94 and 15.1 mg ai/L, respectively. The study design included a negative control and solvent control (acetone, 10 mL/kg-evaporated out of the sediment prior to organism exposure). The study also reported measurements of two major degradates of prothioconazole (*i.e*., prothioconazole-S-methyl and prothioconazole-desthio) in the pore water, bulk sediment and OC normalized bulk sediment. After 28 days, there was a statistically significant difference between the negative and solvent (acetone) control for number of young produced per female where there was a 27% reduction in the solvent control relative to the negative control. Therefore, statistical comparisons for all of the study endpoints were conducted relative to the solvent control. No statistically significant adverse effects were detected for survival, growth, or reproduction of *Leptocheirus* in any of the prothioconazole-treated sediment concentrations tested. In terms of parent prothioconazole, the NOAEC for all endpoints is 15.1 mg ai/L pore water (corresponding to 36.4 mg ai/kg bulk sediment and 10.1 g ai/kg_{oc} normalized sediment). The LOAEC for all endpoints is >15.1 mg ai/L pore water (corresponding to >36.4 mg ai/kg bulk sediment and >10.1 g ai/kg_{oc} normalized sediment). When expressed in terms of the degradates, the NOAEC is 0.392 mg desthio/L and 0.0143 mg S-methyl/L of pore water.

In a 96-hour toxicity study, cultures of saltwater diatom, *Skeletonema costatum* were exposed to the prothioconazole degradate prothioconazole-desthio (98.3% purity) at nominal concentrations of 0 (negative and solvent controls), 1.56, 3.13, 6.25, 12.5, 25.0, 50.0, and 100 µg ai/L under static conditions (MRID 50634201). Measured concentrations of prothioconazole-desthio decreased over the course of the study. The reviewer based the results of the test on time-weighted average (TWA) concentrations in order to be conservatively representative of the entire exposure period; TWA concentrations were <0.02 (<LOQ, controls), 1.33, 2.81, 5.52, 12.0, 24.8, 50.6 and 99.1 µg ai/L. The percent growth inhibition in the treated algal cultures relative to the negative control ranged from -4.3 to 94%. In a 96-hour toxicity test, prothioconazole-desthio-related effects were detected for yield, growth rate and area under the growth curve (AUC). The overall NOAEC, LOAEC and IC_{50} values for yield (the most sensitive measurement endpoint) were 1.33, 2.81 and 4.81 µg ai/L, respectively. No cell abnormalities were observed in the control or any of the treatment groups.

Young adult honey bees, *Apis mellifera* L., were exposed to the prothioconazole degradate prothioconazole-desthio (BCS-AA53879; 99.5%) for 48 hours in both oral and contact toxicity tests (MRID 50489202). The nominal limit dose for the acute oral toxicity test was 100.0 µg ai/bee, corresponding to an actual intake dose of 106.5 µg ai/bee. The nominal limit dose for the acute contact toxicity test was 100.0 µg ai/bee. By 48 hours in the oral toxicity test, mortality was 0, 0, and 8% in the negative control, solvent (4% acetone and 1% Tween 80) control, and 106.5 µg ai/bee treatment groups, respectively. No bees in any of the control or treatment groups exhibited signs of sub-lethal effects throughout the duration of the study. By 48 hours in the contact toxicity test, mortality was 0, 6, and 0% in the negative control, solvent (acetone) control, and 100.0 µg ai/bee treatment groups, respectively. No bees in any of the control or prothioconazole-desthio treatment groups showed signs of sub-lethal effects throughout the duration of the study. The LD_{50} value for the <u>oral toxicity test</u> was >106.5 µg ai/bee. The LD_{50} value for the <u>contact test</u> was >100.0 µg ai/bee. As a result, prothioconazole-desthio is categorized as practically nontoxic to honey bees on both an acute contact and oral exposure basis.

Young adult worker honey bees, *Apis mellifera* L., were exposed to prothioconazole formulated end-use product Prothioconazole SC 480 (ai: 39.6% w/w active ingredient; ai) for 10 days in a feeding study at nominal dietary concentration of 100 mg ai/kg diet and a nominal actual intake dietary dose of 3.80 µg ai/bee/day (MRID 50489203). The measured actual intake dietary dose was 3.19 µg ai/bee/day and the measured dietary concentration was 83.9 mg ai/kg diet. Because the prothioconazole was a formulation, the measured diet concentration and actual intake dietary dose based on the formulation were 212 mg formulation/kg diet and 8.05 µg formulation/bee/day, respectively. After the 10-day exposure period, mortality was 3 and 5% in the negative control and measured 83.9 mg ai/kg diet treatment groups, respectively. Mortality in bees exposed to the reference item (dimethoate) averaged 100%. One bee was observed to be affected (reduced coordination) in the 83.9 mg ai/kg diet treatment group on Day 6. No other sub-lethal effects were observed in the negative control or 83.9 mg ai/kg diet treatment groups throughout the duration of the study period. Food consumption averaged 41.2 and 38.0 mg/bee/day in the negative control and 83.9 mg ai/kg diet treatment groups, respectively. The 10-day NOAEC and LC_{50} were 83.9 and >83.9 mg ai/kg diet, respectively, corresponding to 10-day NOAEL and LD_{50} of 3.19 and >3.19 µg ai/bee/day, respectively.

Individual synchronized honey bee (*Apis mellifera* L.) larvae (first instar, L1) were exposed *in vitro* to one application of technical grade prothioconazole (96.7% active ingredient; ai) diluted in larval diet (MRID 50633902). The toxicity of the prothioconazole was determined at the nominal dietary concentrations of 92.0, 185, 369, 738 and 1,476 mg ai/kg representing nominal doses of 3.128, 6.26, 12.5, 25 and 50 µg ai/larva. Mean-measured diet concentrations were 78.1, 174, 368, 711 and 1,700 mg ai/kg and measured doses were 2.7, 5.9, 12.5, 24 and 58 µg ai/larva. Additionally, honey bee larvae were treated with dimethoate as a positive reference toxicant at a dose of 8.8 µg dimethoate/larva. Untreated diet served as a negative control and untreated diet with 1.0% (v/v) acetone was used as a solvent control. After 72 hours of exposure, mortality was a maximum of 17% in the prothioconazole treatments and was not statistically different from the negative control. No behavioral abnormalities were observed in any of the prothioconazole treatment or control group larvae. Based on these results, following acute exposure of honey bee larvae to technical grade prothioconazole the NOAEL and 72-hr LD_{50} are 58 and >58 µg ai/larva, respectively, and the 72-hr NOAEC and LC_{50} are 1,700 and >1,700 mg ai/kg diet, respectively.

Young adult worker honey bees, *Apis mellifera* L., were exposed to the prothioconazole formulated end-use product Prothioconazole SC 480 G (41.4% active ingredient, ai) for 10 days in a feeding study at nominal dietary concentrations of 257, 513, 1,026, 2,053 and 4,105 mg ai/kg diet corresponding to nominal doses of 8.78, 15.2, 23.9, 40.8 and 58.0 µg ai/bee/day (MRID 50726802). The measured dietary concentrations and measured doses based on the purity of the test substance and the average recovery of the prothioconazole during analytical verification were 261, 556, 1,120, 2,349 and 4,557 mg ai/kg diet and 8.95, 16.4, 26.1, 46.5, 46.5 and 64.3 µg ai/bee/day, respectively. Because the test material was a formulated end-use product, the measured dietary concentrations and measured doses based on the formulation were 629, 1,343, 2,705, 5,674 and 11,007 mg formulation/kg diet and 21.6, 39.6, 63.0, 112 and 155 µg formulation/bee/day, respectively. At the end of the 10-day exposure period, mortality was 3, 3, 0, 3, 3, 53, and 90% in the negative control, solvent [0.1% (w/v) xanthan] control, and measured 261, 556, 1,120, 2,349, and 4,557 mg ai/kg diet treatment groups, respectively. Mortality in bees exposed to the reference toxicant (dimethoate) averaged 100%. One bee was observed to be affected (uncoordinated movements) in the 4,557 mg ai/kg diet treatment group on Days 1, 2, 5, and 6. No other sub-lethal effects were observed in any of the control or prothioconazole treatment groups throughout the duration of the study. Food consumption averaged 39.7, 33.8, 34.2, 29.6, 23.3, 19.9, and 14.5 mg/bee/day in the negative control, solvent control, and measured 261, 556, 1,120, 2,349, and 4,557 mg ai/kg diet treatment groups, respectively. The 10-day NOAEC and LC_{50} are 1,120 and 2,300 mg ai/kg diet, respectively, corresponding to a NOAEL and LD_{50} of 26.1 and 43.4 µg ai/bee/day, respectively. In terms of formulation, the NOAEC and LC_{50} values are 2,705 and 5,556 mg form/kg diet, respectively. The 10-day food consumption NOAEC and IC_{50} are <261 and 2,130 mg ai/kg diet, respectively, corresponding to a NOAEL and ID_{50} of <8.95 and 40.8 µg ai/bee/day, respectively when treatment groups are compared to the negative control. In terms of food consumption, the study does not establish a definitive NOAEC as all prothioconazole treatment levels are significantly different from the negative control. However, when the treatment levels are compared to the solvent control, the 10-day food consumption NOAEC and IC_{50} are 261 and 3,026 mg ai/kg diet respectively, corresponding to a NOAEL and ID_{50} of 8.95 and 51.8 µg ai/bee/day, respectively.

Individual honey bee (*Apis mellifera*) larvae (first instar) were exposed *in vitro* to technical grade prothioconazole (96.7% active ingredient; a.i.) at nominal concentrations of 4, 10, 25, 63 and 159 mg a.i./kg-diet, corresponding to nominal dietary doses of 0.16, 0.40, 1.0, 2.5 and 6.3 µg a.i./larva/day, respectively (MRID 50633903). Mean-measured dietary concentrations dietary dose concentrations were 3.1, 8.3, 21, 52 and 133 mg a.i./kg-diet, corresponding to measured daily dietary doses of 0.12, 0.33, 0.82, 2.0 and 5.2 µg a.i./larva/day, respectively. Mortality during the larval phase was assessed daily from Day 3 to Day 8. Mortality during the pupation phase was assessed on Day 15. The adult emergence rate was assessed on Day 22. The presence of uneaten food was qualitatively recorded on Day 8. On Day 8, larval mortality was 0% in the negative and solvent (0.5% v/v acetone) controls compared to mortality ranging from 0 to 8% in the prothioconazole treatment groups. Day 15 mortality averaged 8 and 11% in the negative and solvent controls, respectively, while mortality in the groups exposed to prothioconazole ranged from 3 to 17%. On Day 22, adult emergence averaged 86 and 81% in the negative and solvent controls, respectively, as compared to emergence ranging from 69 to 86% in the exposed groups. On Day 8, uneaten food was observed in the highest prothioconazole treatment (5.2 µg ai/larva/day) group and in the dimethoate reference toxicant group. Mortality in the dimethoate treatment (nominal concentration of 48.0 mg ai/kg diet), averaged 83% by Day 8. There was no statistically significant effect on larval or pupal mortality in this experiment. However, there was a significant ($p<0.05$) reduction in adult bee emergence in the highest prothioconazole test level. The NOAEC and EC_{50} are 52 and >133 mg ai/kg diet, respectively. The NOAEL and ED_{50} are 2.0 and >5.2 µg ai/larva/day, respectively based on a 19% reduction in adult emergence relative to the negative control at the LOAEL of 5.2 µg ai/larva/day.

Table G-1. Available Aquatic Toxicity Endpoints for Prothioconazole, its Degradates and Typical End-Use Products.

Study Type	Test Substance	Test Species	Toxicity Value in µg a.i./L Unless Noted	MRID/Accession No. & Classification	Comments
Freshwater Fish (Surrogates for Vertebrates)					
Acute	-Desthio	*Pimephales promelas* (Fathead Minnow)	96-hr LC_{50} = 11,400	46246026 Acceptable	96-h duration; slightly toxic
	TGAI (98.4% a.i.)	*Oncorhynchus mykiss* (Rainbow Trout)	96-hr LC_{50} = 1,830	46246018 Acceptable	96-h duration; moderately toxic
	TEP (41.4% purity)		96-hr LC_{50} = 1,690	46246019 Acceptable	96-h duration; moderately toxic
	S-methyl (98.6% purity)		96-hr LC_{50} = 1,780	46246021 Acceptable	96-h duration; moderately toxic
	-Desthio		96-hr LC_{50} = 5,940	46246020 Acceptable	96-h duration; moderately toxic

Study Type	Test Substance	Test Species	Toxicity Value in µg a.i./L Unless Noted	MRID/Accession No. & Classification	Comments
	1,2,4-Triazole		96-hr LC_{50} = 498 mg/L (2483 mg prothioconazole equivalents/L)	48474301 Acceptable	96-h duration; practically non-toxic
	TGAI	*Lepomis macrochirus* (Bluegill)	96-hr LC_{50} = 4,590	46246022 Acceptable	96-h duration; moderately toxic
	TEP		96-hr LC_{50} = 5,530	46246023 Acceptable	96-h duration; moderately toxic
	TGAI	*Cyprinus carpio* (Common Carp)	96-hr LC_{50} = 6,420	46246025 Supplemental	96-h duration; moderately toxic
Chronic Early Life Stage	TGAI	*Oncorhynchus mykiss* (Rainbow Trout)	NOAEC = 490 LOAEC = 930	50489201[N] Acceptable	91-d duration; reduced fry survival (18% ↓@ LOEC), morphological/behavioral effects also observed
Chronic Full Life-cycle	-Desthio (96.4% purity)	*Pimephales promelas* (Fathead Minnow)	NOAEC = 148 LOAEC =296	46246033 Supplemental	30-w duration; significant effect in survival, spawning frequency, growth deformities
Biocon-centration	TGAI	*Lepomis macrochirus* (Bluegill)	Does not bioaccumulate in fish	46246034 Supplemental	
	-Desthio		Does not bioaccumulate in fish	46246035 Acceptable	
Estuarine/Marine Fish (Surrogates for Vertebrates)					
Acute	*TGAI*	*Cyprinodon variegatus* (Sheepshead Minnow)	LC_{50} >10,300	46246027 Acceptable	96-h duration; slightly toxic
	-Desthio (98.3% purity)		LC_{50} = 10,200 NOEC = 3,590	50633901[N] Acceptable	96-h duration; slightly toxic
Freshwater Invertebrates (Based on Water Column Exposure)					
Acute	TGAI (98.4% a.i.)	*Daphnia magna* (Water Flea)	EC_{50} = 1,200	46246009 Acceptable	48-h duration; moderately toxic

Study Type	Test Substance	Test Species	Toxicity Value in µg a.i./L Unless Noted	MRID/Accession No. & Classification	Comments
	TEP		EC_{50} = 4,100	46246010 Supplemental	48-h duration; moderately toxic
	S-methyl		EC_{50} = 2,700	46246012 Acceptable	48-h duration; moderately toxic
	1,2,4-Triazole		EC_{50} >98.1 mg/L (>489 mg prothioconazole equivalents/L)	48453206 Acceptable	48-h duration; practically non-toxic
Chronic	TGAI		NOAEC = 560 LOAEC = 1000	46246028 Acceptable	21-day duration; reproduction and growth, most sensitive endpoints
	-Desthio (96.5% purity)		NOAEC = 103 LOAEC = 206	46246029 Acceptable	21-day duration; significant difference in offspring production
Freshwater Invertebrates (Based on Sediment Exposure)					
Chronic	TGAI	*Chironomus riparius* (Midge)	NOAEC = 9,140 (pore water) LOAEC >9,140	46246131 Supplemental	28-day duration; no effect; analytical in 3 of 7 treatment levels in OW and PW only; results based on nominal. Reported solubility 7000 µg/L.
	S-methyl (98.9% purity)		NOAEC = 5.9 (pore water)	50019201[N] supplemental	28-d duration (OECD 219); emergence adversely affected at four highest concentrations (23, 6.4, 24 and 93%↓, respectively); analytical in low, mid and high conc. only; not measured in sediment
	-Desthio		NOAEC = 640 (pore water) LOAEC = 1200	47626901 Supplemental	28-day duration; most sensitive endpoint = emergence
	TGAI	*Chironomus dilutus* (midge)	NOAEC = 64.5 (pore water) LOAEC >64.5	50973501[N] Acceptable	NOAEC in sediment adjusted for %OC = 400 mg a.i./kg_{OC}; no effect study
		Hyalella azteca (amphipod)	NOAEC = 1,080 (pore water) LOAEC >1,080	50969303[N] Acceptable	NOAEC in sediment adjusted for %OC = 4,200 mg a.i./kg_{OC}; no effect study
Estuarine/Marine Invertebrates (Based on Water Column Exposure)					
Acute	TGAI	*Americamysis bahia*	LC_{50} = 2,400	46246016 Acceptable	96-h duration; moderately toxic

Study Type	Test Substance	Test Species	Toxicity Value in µg a.i./L Unless Noted	MRID/Accession No. & Classification	Comments
	-Desthio (96.5% purity)	(Mysid shrimp)	LC_{50} = 60	46246017 Acceptable	96-h duration; very highly toxic
	S-methyl		LC_{50} = 520	50853501[N] Acceptable	96-h duration; highly toxic
Chronic	-Desthio (97.0% purity)		NOAEC = 64 LOAEC = 128	46246030 Acceptable	29-d duration; most sensitive endpoint = reproduction (33%↓ at LOAEC)
Estuarine/Marine Invertebrates (Based on Water Column Exposure)					
Chronic	TGAI (98.10% a.i.)	*Leptocheirus plumulosus* (amphipod)	NOAEC = 15,100 µg a.i./L (pore water) LOAEC >15,100 µg a.i./L	50969302[N] Acceptable	NOAEC in sediment adjusted for 0.36%OC = 10,100 mg a.i./kg_{OC}; no effect study
Mollusks (Based on Water Column Exposure)					
Acute Shell Deposition	TGAI	*Crassostrea virginica* (Eastern oyster)	IC_{50} = 3,000	46246014 Acceptable	96-h duration; moderately toxic
	S-methyl (99.6% purity)		IC_{50} = >520	50925601[N] Supplemental	96-h duration; Highly toxic
Aquatic Plants and Algae					
Vascular	TGAI	*Lemna gibba* (duckweed)	EC_{50} =74 NOAEC = 3.34 LOAEC =10.4	46246101 Acceptable	7-d duration; most sensitive endpoint = frond number
	TEP		EC_{50} = 66 NOAEC = 7.5 LOAEC = 28.8	46246102 Acceptable	7-d duration; most sensitive endpoint = frond number
	-Desthio (97.0% purity)		EC_{50} = 35 NOAEC = 5.8 LOAEC =14	46246104 Acceptable	7-d duration; most sensitive endpoint = frond number (14, 52 and 73% ↓at 14.3, 35.6 and 89.8 µg/L)
Non-Vascular	TGAI	*Anabaena flos-aquae* (blue-green algae)	EC_{50} = 3,550 NOAEC = 820 LOAEC = 2,970	46246103 Acceptable	96-hour duration; most sensitive endpoint = cell density and growth rate
	TGAI	*Navicula pelliculosa* (freshwater diatom)	96-h EC_{50} = 163.8 EC_{05} = 42.0	46246109 Acceptable	96-hour duration; most sensitive endpoint = biomass
	-Desthio	*Scenedesmus subspicatus* (green algae)	EC_{50} = 74 EC_{05} = 11 NOAEC = Not determined (<10)	46246108 Acceptable	96-h duration; most sensitive endpoint = cell density
	TGAI	*Pseudokirchneriella subcapitata* (green algae)	EC_{50} = 880 NOAEC = 371	46246105 Acceptable	96-h duration; most sensitive endpoint = cell density
	S-methyl		EC_{50} = 2,690 NOAEC <1,030 LOEC = 1,030	46246107 Supplemental	96-h duration; most sensitive endpoint = cell density

Study Type	Test Substance	Test Species	Toxicity Value in µg a.i./L Unless Noted	MRID/Accession No. & Classification	Comments
	TEP		EC_{50} = 1,100 NOAEC = 480	46246106 Acceptable	96-h duration; most sensitive endpoint = cell density
	1,2,4-Triazole		EC_{50} = 14,000 (69.8 mg prothioconazole equivalents/L)	45880401 Acceptable	96-h duration; most sensitive endpoint = biomass
	TGAI	*Skeletonema costatum* (marine diatom)	EC_{50} = 20.1 NOAEC = 7.3 LOAEC = 17.5	46246110 Acceptable	120-hour duration; most sensitive endpoint = biomass
	-Desthio (98.3% purity)		EC_{50} = 4.81 NOAEC = 1.33	50634201[N] Acceptable	96-h duration; most sensitive endpoint = yield (cell density)

† Non-definitive study endpoint; cannot be used to calculate RQs for risk estimation.

Table G-2. Available Terrestrial Toxicity Endpoints for Prothioconazole, its Degradates and Typical End-Use Products.

Study Type	Test Substance	Test Species	Toxicity Value	MRID/Accession No. & Classification	Comments
Birds (Surrogates for Terrestrial-phase Amphibians and Reptiles)					
Acute Oral	TGAI	*Serinus canaria* (Canary)	LD_{50} >2,000 mg a.i./kg-bw	48024801 Supplemental	14-d duration; practically non-toxic
	TGAI (98.4% a.i.)	*Colinus virginianus* (Northern Bobwhite Quail)	LD_{50} >2,000 mg a.i./kg-bw	46246036 Acceptable	14-d duration; practically non-toxic
	-Desthio		LD_{50} >2,000 mg /kg-bw	46246037 Acceptable	14-d duration; practically non-toxic
	1,2,4-Triazole		LD_{50} = 770 mg/kg-bw (3,839 mg prothioconazole equivalents/kg-bw)	49380701 Acceptable	14-d duration; practically non-toxic – slightly toxic
Sub-acute Dietary	TGAI	*Anas platyrhynchos (mallard duck)*	LC_{50} >5,567 mg a.i./ kg-diet	46246040 Acceptable	5-d duration; practically non-toxic
	TGAI	*Colinus virginianus* (Northern Bobwhite Quail)	LC_{50} >4,983 mg a.i./kg-diet†	46246038 Acceptable	5-d duration; practically non-toxic
	-Desthio (96.8% purity)	*Colinus virginianus* (Northern Bobwhite Quail)	LC_{50} = 4,252 mg/ kg-diet	46246039 Acceptable	8-day duration; slightly toxic
	-Desthio	*Serinus canaria* (Canary)	LC_{50} >4,414 mg/kg-diet NOAEC = 1,108 mg/kg-diet	50746601[N] Supplemental	8-d duration; reduction in feed consumption and body weight; slightly toxic

Study Type	Test Substance	Test Species	Toxicity Value	MRID/Accession No. & Classification	Comments
Reproductive Toxicity	TGAI	*Anas platyrhynchos (mallard duck)*	NOAEC = 1,978 mg a.i./kg-diet LOAEC >1,978 mg ai/kg-diet	46246044 Acceptable	
	-Desthio (96.4% purity)	*Anas platyrhynchos (mallard duck)*	NOAEC = 449 mg/kg-diet LOAEC >449 mg/kg-diet	46246045 Supplemental	No effects, Issues with degradation of the test substance
	TGAI	*Colinus virginianus* (Northern Bobwhite Quail)	NOAEC = 982 mg a.i./kg-diet LOAEC >982 mg a.i./kg-diet	46246042 Acceptable	
Mammals					
Acute Oral	TGAI	*Rattus norvegicus* (Norway Rat)	LD$_{50}$ >6,200 mg/kg-bw	46246230 Acceptable	14-d duration; practically non-toxic
	-Desthio (93.70% purity)		LD$_{50}$ = 2,806 mg/kg	46246231 Acceptable	14-d duration; practically non-toxic
2-Generation Reproduction Toxicity	TGAI	*Rattus norvegicus* (Norway Rat)	NOAEL=100 mg a.i./kg/day LOAEC=750 mg a.i./kg/day	46246334 Acceptable	Decreased number and duration of estrus cycles
	-Desthio (93.0% purity)		NOAEC/NOAEL = 160 mg/kg-diet/9.5-11 mg/kg bw/day LOAEC/LOAEL = 640 /40-46	46246333 Acceptable	F1: 10-15% reduction in body weight and 21% reduction in Day 4 viability; F2: 8-12% reduction in body weight and 33% reduction in viability
	1,2,4-Triazole		NOAEL <250 mg/kg/day LOAEC ≤ 250 mg/kg/day (≤ 1,246 mg prothioconazole equivalents/kg-diet)	464670304 Acceptable	Most sensitive effects were decreased body weight and decreased body weight gain in the parents and in the offspring.
Terrestrial Invertebrates					
Acute Adult Contact	TGAI (98.6% a.i.)	*Apis mellifera* (Honey bee)	LD$_{50}$ >200 µg a.i./bee	46246048 Acceptable	48-h duration; practically non-toxic
	TEP		LD$_{50}$ >200 µg a.i./bee	46246046 Acceptable	48-h duration; practically non-toxic
	-Desthio		LD$_{50}$ >100 µg a.i./bee	50489202[N] Acceptable	48-h duration; practically non-toxic
	TGAI	*Bombus terrestris L. (Bumble Bee)*	NOAEC >100 µg a.i./bee	50521801[N] Supplemental	48-h duration; practically non-toxic

Study Type	Test Substance	Test Species	Toxicity Value	MRID/Accession No. & Classification	Comments
Acute Adult Oral	TGAI	*Apis mellifera* (Honey bee)	LD_{50} >71 µg a.i./bee	46246048 Supplemental	48-h duration; practically non-toxic
	TEP		LD_{50} >232 µg a.i./bee	46246046 Acceptable	48-h duration; practically non-toxic
	-Desthio (99.5% purity)		LD_{50} >106.5 µg a.i./bee	50489202[N] Acceptable	48-h duration; practically non-toxic
	TGAI	*Bombus terrestris L. (Bumble Bee)*	LD_{50} >214.32 µg a.s./bee NOAEC ≥214.32	50521802[N] Supplemental	48-h duration; practically non-toxic
Larvae Single exposure (diet)	TGAI (96.7% a.i.)	*Apis mellifera* (Honey bee)	LC_{50} >1,476 mg a.i./kg-diet	50633902[N] Acceptable	7-d duration; 16.7% mortality in 1476 mg/kg-diet group on Day 7
Chronic Larva Repeated exposure	TGAI (96.7% a.i.)	*Apis mellifera* (Honey bee)	NOAEL = 2.0 µg ai/bee/day LOAEL = 5.2 µg ai/bee/day	50633903[N] Acceptable	22-d duration; 19% reduction in adult emergence at the LOAEL
Chronic Adult Oral	Prothioconazole SC 480 (39.6% a.i.)	*Apis mellifera* (Honey bee)	NOEC = 83.9 mg ai/kg-diet NOEDD = 3.19 µg a.i./bee/day	50489203[N] Acceptable	10-day duration; no effects
Chronic Adult Feeding	Prothioconazole SC 480 (41.4% a.i.)		LD_{50} = 43.4 µg a.i./bee/day NOAEL = 26.1 µg ai/bee/day LOAEL = 46.5 µg ai/bee/day	50726802[N] Supplemental	10-d duration; 53 and 90% adult mortality in 46.5 and 64.3 µg ai/bee/day treatment groups, respectively. Food consumption reduced 14-63% in all treatment groups
Semi-field (tunnel)	Prothioconazole EC 250 G		NOAEL = >187.5 g a.s./ha	50489204[N] Under review	31-d duration; no effects
			NOAEL = >205.43 g a.i./ha	50521803[N] Under review	17-d duration; no effects
Semi-field (colony-feeding)	SC 480 G (40.9% w/w)		NOAEL = 470 ppm	50489205[N] Under review	21-d duration; no effect
Terrestrial Plants					
Tier 1 Vegetative Vigor	TEP (41% a.i.)	Buckwheat, Corn, Onion, Ryegrass, Wheat, Cucumber, Soybean, Sunflower, Tomato, Turnip	Most sensitive monocot and dicot: none EC_{25} = >0.272 lb a.i./A NOAEC = 0.272 lb a.i./A	46246049 Acceptable	21-d duration; no significant effects

Study Type	Test Substance	Test Species	Toxicity Value	MRID/Accession No. & Classification	Comments
Tier 1 Seedling Emergence	TEP (41% a.i.)	Buckwheat, Corn, Onion, Ryegrass, Wheat, Cucumber, Soybean, Sunflower, Tomato, Turnip	**Most sensitive monocot: none** EC_{25} = >0.272 lb a.i./A NOAEC = 0.272 lb a.i./A **Most sensitive dicot: cucumber** EC_{25} = <0.272 lb a.i./A NOEC = <0.272 lb a.i./A]	46246050 Acceptable	21-d duration; 31% inhibition of dry weight for cucumber
Tier 2 Seedling Emergence	TEP (41% a.i.)	Cucumber	EC_{25} >0.272 lb a.i./A NOEC = 0.03 lb a.i./A	46246050 Acceptable	16% reduction in dry weight at highest concentration tested

† Non-definitive study endpoint; cannot be used to calculate RQs for risk estimation.

Appendix H. Endocrine Disruptor Screening Program (EDSP)

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 the Draft Ecological Risk Assessment for Registration Review, 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), prothioconazole 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[1] 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. Prothioconazole is not on List 1. 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[2].

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