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OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

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MEMORANDUM

SUBJECT: **Thiram, Ferbam, Ziram:** Draft Ecological Risk Assessment (DRA) for Registration Review

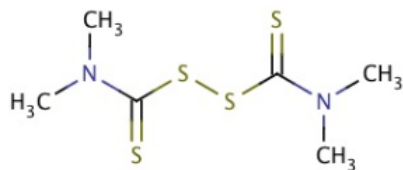
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The Environmental Fate and Effects Division (EFED) has completed the draft environmental fate and ecological risk assessment in support of the Registration Review of the carbamate fungicides thiram, ferbam, and ziram.

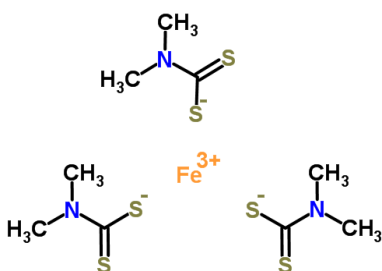
Draft Ecological Risk Assessment for the Registration Review of Thiram, Ferbam, and Ziram



Thiram

PC Code:079801

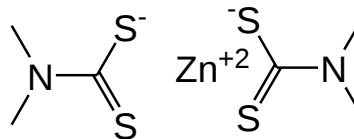
CAS No.: 137-26-8



Ferbam

PC Code:034801

CAS No.: 14484-64-1



Ziram

PC Code:034805

CAS No.: 137-30-4

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1 Executive Summary

1.1 Overview

This Draft Risk Assessment (DRA) examines the potential ecological risks associated with labeled agricultural and/or non-agricultural (i.e., turf, ornamentals, conifers) uses of thiram (PC 079801), ferbam (PC 034801), and ziram (PC 034805) on non-listed non-target organisms. Taxa included in this assessment include mammals, birds, amphibians, reptiles, pollinators, fish, aquatic invertebrates, and aquatic and terrestrial plants. Risks from registered uses of each of these three pesticides are assessed together in the same document. This is because thiram is a primary degradate of both ferbam and ziram. All three are dimethyldithiocarbamate fungicides that are non-systemic and act by concomitant inhibition of spore germination and mycelial growth through multi-site interference of enzyme processes associated with respiration. The three chemicals are assessed as follows:

- Thiram only: registered uses of thiram (parent only);
- Ferbam → Thiram (exposure assessed mainly as thiram given rapid transformation of ferbam to thiram, with some characterization as ferbam): registered uses of ferbam, with thiram as the major degradate; and
- Ziram → Thiram + Ziram (exposure assessed as Total Residues): registered uses of ziram, with thiram as the major degradate. The breakdown is not as rapid as for ferbam and so both compounds are considered.

A separate DRA has been conducted for antimicrobial uses of ziram as material preservatives in paper coatings, adhesives, dried films (wall and ceiling textures, wallpaper paste, wallboard, joint compounds, spackles, wood fillers, caulks and sealants), mold-resistant paper and paperboard, and paints (USEPA, 2020).

1.2 Risk Conclusions Summary

The risk drivers for this assessment are mammals and birds (also reptiles and terrestrial-phase amphibians, for which birds are considered surrogates), especially from chronic exposure (based on significant effects to growth, reproduction, and survival up to 56%) but also including acute exposure, to all three compounds assessed (with RQs [risk quotients] up to 2200 for thiram, 710 for ferbam, and 1200 for ziram uses), and pollinators (with RQs for honey bees up to 8700 for thiram, 2800 for ferbam, and 3200 for ziram uses). Aquatic animals are also at potential risk. Neither terrestrial or aquatic plants are at risk.

1.3 Environmental Fate and Exposure Summary

Thiram, ferbam, and ziram all are transformed by hydrolysis and biodegradation and appear to have low bioaccumulation potential. Ferbam is a short-lived chemical that degrades rapidly (in minutes) via hydrolysis, photolysis and aerobic soil metabolism to thiram, the major degradate of ferbam. Thiram was the major degradate in all degradation studies. Ferbam is unstable

under hydrolytic and aerobic conditions, therefore, there is very little potential for ferbam itself to impact either surface water or groundwater due to its rapid degradation rate.

Considering thiram's vapor pressure (1.72×10^{-5} mm Hg), water solubility (16.5 mg/L), and Henry's law constant (3.30×10^{-7} atm.m³/mole), volatilization should not be a concern. Similarly, for ziram's vapor pressure (1.35×10^{-7} mm Hg), water solubility (0.97 mg/L), and Henry's law constant (5.6×10^{-8} atm.m³/mole), volatilization should not be a concern.

Based on FAO (Food and Agricultural Organization)¹ mobility classification, thiram is from slightly mobile to hardly mobile ($K_{oc} = 2245$ to $24,526$ mL/g_{OC} in 4 soils) and ziram is from moderately mobile to slightly mobile ($K_{oc} = 314$ to 3732 mL/g_{OC} in 4 soils). Due to this mobility and rapid hydrolysis degradation rate, the ground water impacts are minimal. However, both thiram and ziram have a potential to reach surface water through runoff via erosion or spray drift.

Generally, ziram degrades rapidly via hydrolysis and photodegradation. Degradation is somewhat slower in aerobic soil and slower in anaerobic soil and water. Half-lives are generally from a few days to a few weeks in soil and water; field studies show some residues may persist for months after application. Thiram degrades by similar pathways as ziram, but hydrolysis, aerobic metabolism, and anaerobic metabolism tend to be slower than for ziram.

1.4 Ecological Effects Summary

The datasets for thiram and ziram were largely complete. While certain studies for ferbam were not available, due to ferbam's rapid breakdown to thiram, toxicity data with thiram were considered sufficient for assessing both ferbam and thiram uses. Therefore, most of the ferbam endpoints used in the assessment are from its degradate, thiram, adjusted to ferbam equivalents.

For mammals, ziram is the most toxic (moderately toxic), and ferbam the least toxic (practically non-toxic), of the three with thiram categorized as slightly toxic based on acute dosing studies. The three chemicals are practically non-toxic to moderately toxic on an acute basis to the avian species tested, although for mammals and birds calculated exposure levels were in many cases above effects levels for survival, growth, and reproduction.

¹ FAO. 2000. Appendix 2. Parameters of pesticides that influence processes in the soil. In FAO Information Division Editorial Group (Ed.), Pesticide Disposal Series 8. Assessing Soil Contamination. A Reference Manual. Rome: Food & Agriculture Organization of the United Nations (FAO). (Accessed July 10, 2009).

A full suite of honey bee data were available for thiram, but only acute contact data for ferbam. For ziram, toxicity data were available with adult bees, but not for larval bees due to stability problems with ziram in the larval food matrix, so the thiram data are used to assess risk to larva from ziram exposure. Similarly, for ferbam, thiram data were used for risk assessment. On an acute contact and oral basis, all three chemicals are practically non-toxic to the adult honey bee. However, a single-dose larval study with thiram (MRID 50940001) showed thiram to be highly toxic to bee larvae.

Thiram, ferbam, and ziram are highly toxic to very highly toxic to fish and aquatic invertebrates, on an acute exposure basis to the most sensitive species for which information is available. Some uncertainty is acknowledged due to stability and test substance verification issues with many of the studies. However, studies were available with adequate test substance verification, including radio-labeled studies, to build sound conclusions from aquatic risk calculations.

1.5 Identification of Data Needs

The datasets for thiram and ziram were relatively complete (ferbam was assessed using thiram data due to rapid transformation). The largest uncertainty identified was that exposure estimates were unclear for many of the aquatic studies. However, in some cases radio-labeled studies were available to add certainty and characterize the range of potential risk.

Chronic toxicity data for sediment (benthic) invertebrates were not available. Sediment toxicity studies were not requested in the respective problem formulations. Even though the Koc for both thiram (Koc of 2245 to 24,526 mL/g_{OC}) and ziram (Koc of 314 to 3732 mL/g_{OC}, **Table 5-1** and **Table 5-4**) were above 1000 mL/g_{OC}, triggering sediment assessment, the problem formulations concluded that thiram and ziram are not expected to accumulate in sediment. However, based on the 40 CFR Part 158 data needs, the fate properties of thiram would trigger the need for chronic sediment toxicity data (aquatic metabolism has a half-life of more than ten days as shown in Section 8.2.2). Potential chronic risk to benthic invertebrates were evaluated using water-column invertebrate toxicity data as surrogates and potential chronic risk was identified. Some uncertainty is acknowledged as to whether benthic aquatic invertebrates may need further evaluation using sediment-based toxicity data given the complex fate characteristics of the chemicals. However, because potential chronic risk based on sediment pore water exposure and surrogate toxicity data was identified, (**Section 8.2.2**) (**Section 5**) a chronic spiked-sediment study with thiram (using either an amphipod or chironomid) could help to determine if added risk may also come from exposure to contaminated sediment.

For pollinators, thiram, ferbam, and ziram are dimethyldithiocarbamate fungicides that are not systemically translocated in plants. Thiram is a primary degradate of both ferbam and ziram. All three active ingredients are currently registered on a variety of bee-attractive crops and crops that require managed pollination (except for thiram, where only the peach use has managed pollination). A full suite of Tier I honey bee data are available for thiram, but only acute contact data are available for ferbam, and only adult (acute and chronic) data are available for ziram. On an acute contact exposure basis (oral also for thiram and ziram), all three chemicals are

practically non-toxic to adult honey bees. However, an acute larval toxicity study with thiram indicates that the compound is highly toxic to bee larvae on an acute exposure basis; this applies to all three chemicals due to thiram's occurrence as a breakdown product of the others. Moreover, because ferbam breaks down rapidly to thiram (in minutes), thiram data are largely used for risk assessment of ferbam. For ziram, toxicity data (both acute and chronic) are available for adult bees, but not for larval bees due to stability problems with ziram in the larval food matrix. Information submitted in a waiver request substantiated the difficulties and provided preliminary data indicating that thiram is more toxic than ziram to larvae (MRID 50940401); therefore, EFED recommended granting the waiver and used thiram data to assess ziram risk to bee larvae (DP Barcode: 454570+).

Based on the maximum labeled application rates for thiram, ferbam, and ziram, RQ values for larval honey bees range up to 8,740 (which represent thiram uses) and exceed the chronic risk LOC (LOC = 1). These LOC exceedances are based on a thiram NOAEL (0.0254 ug ai/larvae/day) above which there was a 20% reduction in adult emergence at the LOAEL (0.0757 ug ai/larvae/day). RQ values would also exceed the chronic risk LOC had values been based on the LOAEL. Also, 22-day short-term small-scale colony feeding studies (Tier II) are available for thiram and ziram which showed significant (52% and 23%, respective) effects to reproduction (increases in brood termination rates) at application rates of less than 2 lbs/A. Other Tier II colony-level studies are available for thiram though they did not show effects on adult or pupal survival or colony condition up to 2 lb/A, which is below the maximum application rates ranging from 5.2 to 16.3 lb/A for the three chemicals. Oral exposure to adult bees can occur when products are applied during bloom, which applies to thiram use on peaches and strawberries, most ferbam uses, and ziram use on pears and pecans. Because thiram, ferbam, and ziram are non-systemic, exposure via nectar or pollen is only anticipated to occur through direct spray drift (and for larvae, from spray-drift exposed nectar or pollen brought back to the hive), and not uptake by the plant from runoff or movement from exposed soil to the plant. Although there are limited effects observed in the Tier I studies with adult bees and there are no ecological incidents reported with bees, there are chronic risks of concern for larvae based on both laboratory and some colony-level studies. Given that all three chemicals have uses that are pollinator-attractive, submission of higher-tier exposure (residue) and effects data (*e.g.*, semi-field) are recommended for thiram, ziram, and ferbam. For higher tier studies, exposures should encompass the maximum application rates currently registered and for the effects data should be conducted for sufficient duration to evaluate effects through multiple brood cycles.

Risk Summary Tables for Agricultural and Non-Agricultural Uses

Table 1-1. Summary of Risk Quotients for Taxonomic Groups from Current Uses of Thiram

Taxa	Exposure Duration	Risk Quotient (RQ) Range ¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Freshwater Fish	Acute	Foliar: 0.2 – 1.0 Seed: ¹ <0.01 – 0.04	Yes	Risk exceeding the LOC for residential and ornamental uses, but not lowest foliar use on peach or strawberry. One fish-kill incident involved thiram where millions of fish over 50 miles were killed as a result of an intentional misuse. The causality was “highly probable” for thiram, but this was not associated with a registered use.
	Chronic	Foliar: 2.2 – 6.3 Seed: <0.01 – 0.21	Yes	All foliar uses exceed the LOC. Based on significant effects to spawning (69.5%), egg production (76.0%), and survival (24%) for the fathead minnow.
Estuarine/ Marine Fish	Acute	Foliar: 0.02 – 0.08 Seed: <0.01	No	--
	Chronic	Foliar: 2.0 – 7.9 Seed: <0.01 – 0.25	Yes	Based on significant effects on growth (4.6%-12%) for the sheepshead minnow.
Freshwater Invertebrates (Water-Column Exposure)	Acute	Foliar: 0.04 – 0.20 Seed: <0.01 – 0.01	No ²	Risk not exceeding LOC. However, due to LOC exceedances with estuarine/ marine invertebrate data and the toxicity data variability (discussed in the document), some uncertainty is acknowledged as to whether sensitive freshwater invertebrates may be at risk.
	Chronic	Foliar: 0.18 – 0.80 Seed: <0.01 – 0.03	Yes ²	Risk not exceeding LOC. However, due to a mesocosm study that showed 20% growth effects to a rotifer at 1 µg thiram a.i./L compared with chronic exposure estimates of 4-16 µg thiram a.i./L (within estimated EECs), sensitive taxa were determined to potentially be at risk. Additionally, due to LOC exceedances with estuarine/ marine invertebrate data and the toxicity data variability that is discussed in the document, it is acknowledged that freshwater invertebrates may be at risk, based on alternative lines of evidence.
Estuarine/ Marine Invertebrates (Water-Column Exposure)	Acute	Foliar: 0.12 – 3.9 Seed: <0.01 – 0.01	Yes	Risk exceeding LOC for all foliar uses.
	Chronic	Foliar: 3.6 – 16 Seed: 0.01 – 0.51	Yes	Based on use of an acute-to-chronic ratio from daphnid data with a mysid acute endpoint; the daphnid chronic endpoints was based on significant growth effects (19%) in the water flea.
Freshwater Invertebrates (Sediment Exposure) ³	Acute	Foliar: 0.01-0.02 Seed: <0.01	No	Pore water exposure is expected to range from 5 to 51% of highest day-one water column concentrations, and therefore, benthic organisms would be expected to be at lower risk than pelagic invertebrates from acute (day-one) exposure.

Taxa	Exposure Duration	Risk Quotient (RQ) Range ¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
	Chronic	Foliar: 0.06 – 23 Seed: <0.01 – 0.0 1	Yes	Pore water exposure is expected to range from 24 to 200% of 21-day water column concentrations and therefore, benthic organisms could be expected to be at greater risk (up to twice as great) than pelagic invertebrates from chronic exposures to pore water (assuming they are equally or more sensitive than water-column organisms).
Estuarine/Marine Invertebrates (Sediment Exposure) ³	Acute	Foliar: 0.11 – 0.44 Seed: <0.01 – 0.02	No	Same comments as for freshwater.
	Chronic	Foliar: 1.2 – 4.6 Seed: <0.01 – 0.21	Yes	Same comments as for freshwater
Mammals	Acute	Foliar: <0.01 – 2.5 Seed: <0.01 – 0.9	Yes	Risk exceeding LOC for highest uses. For lowest application rates (peach), there were no exceedances. Based on mean exposure estimates, only exceedances were for small and medium sized mammals consuming exposed grass and arthropod . As few as 90 lima beans or 460 onion seeds treated with thiram may be toxic to small mammals.
	Chronic	Foliar: 0.9 – 2200 Seed: 5.7 – 823	Yes	Risk exceeding LOC for all uses, for most food items and size classes, and remains when based on mean exposure values and lowest-effect concentration. Based on significant reductions in growth in a 2-generation study (effects to both F1 and F2 generations) in the rat. For a single app. at the lowest rate (peach), dietary exposure estimates remained above the lowest-effect level for 67 days. As few as 1 of most seeds (represented by lima bean, pea, rape seed, and onion seeds) treated with thiram may exceed chronic risk concerns for small mammals.
Birds	Acute	Foliar: <0.01 – 31 Seed: <0.01 – 12	Yes	Risk exceeding LOC for all uses. For lowest application rates (peach), not all food items and size classes exceeded, and none exceeded based on mean exposure. As few as 12 lima bean or 59 onion seeds treated with thiram may be toxic to small birds.
	Chronic	Foliar: 4.1 – 1100 Seed: 27 – 1780	Yes	Based on significant effects to reproduction (ranging from 11-46%) and survival (56%) in the mallard duck. For a single app. at the lowest rate (peach), dietary exposure estimates remained above the lowest-effect level for 88 days. As few as 1 of most seeds (represented by lima bean, pea, rape seed, and onion seeds) treated with thiram may exceed chronic risk concerns for small birds.

Taxa	Exposure Duration	Risk Quotient (RQ) Range ¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Terrestrial Invertebrates ⁴	Acute Adult	Contact: 0.1 – 0.6 Oral RQs not calculated but non-definitive endpoint compared with exposure estimate did not exclude risk	Yes	No mortality in acute oral studies. Contact data showed marginal risk only with the highest application rate (Residential). For oral acute risk, even though there was not mortality, the exposure estimates are up to 5 times the range covered by the toxicity estimate.
	Chronic Adult	RQs not calculated but non-definitive endpoint compared with exposure estimate did not exclude risk	Yes ²	No mortality in the 10-day adult oral study. However, the exposure estimates are up to 121 times the range covered by the toxicity estimate. Brood feeding study (22-day) showed significant (52%) increase in egg termination, but no effects to mortality or larval development. Tunnel study (26-day) showed no effects to survival, development or brood parameters at 2.5 lb a.i./acre.
	Acute Larval	128 – 793	Yes	
	Chronic Larval	1410 – 8740	Yes	Based on significant (20%) reduction in emergence. The brood feeding study and tunnel studies (above under adults) showed no effects to larvae, but effects to reproduction.
Aquatic Plants	N/A	Foliar: <0.01 – 0.3 Seed: <0.01 – 0.01	No	Risk not exceeding LOC for non-vascular or vascular aquatic plants for any use.
Terrestrial Plants	N/A	RQs Not calculated but non-definitive endpoints compared with exposure estimates were <1	No	Risk screening suggests no LOC exceedances for monocot or dicot plants for any use.

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

Plants: 1.0

¹ RQs reflect exposure estimates for parent and maximum application rates allowed on labels. Note that for thiram, RQs for foliar and seed-treatment uses are given separately for aquatic risk and for dietary risk to terrestrial vertebrates.

² Italicized Yes or No indicates that due to uncertainty the LOC exceedance call is not clearly Yes or No.

³ Based on water-column toxicity data compared to pore-water concentration.

⁴ RQs for terrestrial invertebrates are applicable to honey bees, which are also a surrogate for other species of bees. Risks to other terrestrial invertebrates (e.g., earthworms, beneficial arthropods) are only characterized when toxicity data are available.

Table 1-2. Summary of Risk Quotients for Taxonomic Groups from Current Uses of Ferbam

Taxa	Exposure Duration	Risk Quotient (RQ) Range¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Freshwater Fish	Acute	0.01 – 0.38	No	One fish-kill incident involved thiram where millions of fish over 50 miles were killed as a result of an intentional misuse. The causality was “highly probable” for thiram, but this was not associated with a registered use.
	Chronic	0.03 – 2.9	Yes	Risk exceeding the LOC for all uses except the cranberry (non-flooded) use. Based on significant effects to spawning (69.5%), egg production (76.0%), and survival (24%) for the fathead minnow.
Estuarine/ Marine Fish	Acute	<0.01 – 0.03	No	--
	Chronic	0.04 – 3.5	Yes	Based on significant effects on growth (4.6%-12%) for the sheepshead minnow.
Freshwater Invertebrates (Water-Column Exposure)	Acute	<0.01 – 0.08	<i>No</i> ²	However, due to LOC exceedances with estuarine/ marine invertebrate data and the toxicity data variability (discussed in the document), it is acknowledged that sensitive freshwater invertebrates may also be at risk.
	Chronic	<0.01 – 0.23	<i>Yes</i> ²	Due to a mesocosm study with thiram that showed 20% growth effects to a rotifer at 1 µg thiram a.i./L compared with chronic exposure estimates of 2-6 µg thiram a.i./L from ferbam uses, sensitive taxa may be at risk. Additionally, due to LOC exceedances with estuarine/ marine invertebrate data and the toxicity data variability that is discussed in the document, it is acknowledged that freshwater invertebrates may also be at risk.
Estuarine/ Marine Invertebrates (Water-Column Exposure)	Acute	<0.01 – 1.4	Yes	Risk exceeding LOC for all uses, with the exception of the cranberry use based on PFAM (Pesticides in Flooded Application Model) exposure estimates.
	Chronic	0.05 – 5.1	Yes	Risk exceeding LOC for all uses, with the exception of the cranberry use based on PFAM exposure estimates. Based on use of an acute-to-chronic ratio from daphnid data with a mysid acute endpoint; the daphnid chronic endpoints was based on significant growth effects (19%) in the water flea.

Taxa	Exposure Duration	Risk Quotient (RQ) Range ¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Freshwater Invertebrates (Sediment Exposure) ³	Acute	<0.01 – 0.87	Yes	Pore water exposure (other than for cranberry) is expected to range from 5 to 51% of highest day-one water column concentrations, and therefore, benthic organisms would be expected to be at lower risk than pelagic invertebrates from acute (day-one) exposure for most uses. For the cranberry use pore water concentrations are estimated to be 138 to 500x greater than the day-one water column concentrations
	Chronic	0.05 – 7.3	Yes	Pore water exposure is expected to range from 24 to 200% of 21-day water column concentrations and therefore, benthic organisms could be expected to be at greater risk (up to twice as great) than pelagic invertebrates from chronic exposures to pore water for most uses. For the cranberry use pore water concentrations are estimated to be 940 to 2700x greater than the day-one water column concentrations.
Estuarine/Marine Invertebrates (Sediment Exposure) ³	Acute	0.09 – 17	Yes	Same comments as for freshwater.
	Chronic	0.96 – 150	Yes	Same comments as for freshwater
Mammals	Acute	<0.01 – 0.8	Yes	Risk only exceeding LOC for highest application rates (citrus) and only for small and medium sized mammalian grass consumers. No exceedances based on mean exposure values.
	Chronic	0.9 – 710	Yes	Risk exceeding LOC for all uses, for most food items and size classes, and remains when based on mean exposure values and lowest-effect concentration. Based on significant reductions in growth in a 2-generation study (effects to both F1 and F2 generations) in the rat. For a single app. at the lowest rate (mango), dietary exposure estimates remained above the lowest-effect level for 66 days.
Birds	Acute	<0.01 – 10	Yes	Risk exceeding LOC for all uses. For lowest application rates (mango), not all food items and size classes exceeded, and not exceeded based on mean exposure.
	Chronic	4.1 – 340	Yes	Based on significant effects to reproduction (ranging from 11-46%) and survival (56%) in the mallard duck. For a single app. at the lowest rate (mango), dietary exposure estimates remained above the lowest-effect level for 87 days.

Taxa	Exposure Duration	Risk Quotient (RQ) Range ¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Terrestrial Invertebrates ⁴	Acute Adult	Contact: 0.1 – 0.2 Oral RQs not calculated but non-definitive endpoint compared with exposure estimate did not exclude risk	Yes ²	No mortality in acute oral studies. Contact data showed no risk concerns. Using a lower (non-definitive) ferbam toxicity endpoint suggested some potential for contact risk if ferbam is more toxic than thiram on immediate contact, but this is not known. For oral acute risk, even though there was no mortality, the exposure estimates are up to 1.6 times the range covered by the toxicity estimate.
	Chronic Adult	RQs not calculated but non-definitive endpoint compared with exposure estimate did not exclude risk	Yes	No mortality in the 10-day adult oral study. However, the exposure estimates are up to 39 times the range covered by the toxicity estimate. Thiram brood feeding study (22-day) showed significant (52%) increase in egg termination, but no effects to mortality or larval development. Thiram tunnel study (26-day) showed no effects to survival, development or brood parameters at 2.5 lb a.i./acre.
	Acute Larval	126 – 252	Yes	
	Chronic Larval	1390 – 2780	Yes	Based on significant (20%) reduction in emergence. The thiram brood feeding study and tunnel studies (above under adults) showed no effects to larvae, but effects to reproduction.
Aquatic Plants	N/A	<0.01 – 0.1	No	Risk not exceeding LOC for non-vascular or vascular aquatic plants for any use.
Terrestrial Plants	N/A	RQs Not calculated but non-definitive endpoints compared with exposure estimates were <1	No	Risk screening not suggesting LOC exceedances for monocot or dicot plants for any use.

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

Plants: 1.0

¹ RQs reflect exposure estimates for parent and degradate thiram and maximum application rates allowed on labels.

² Italicized Yes or No indicates that due to uncertainty the LOC exceedance call is not clearly Yes or No.

³ Based on water-column toxicity data compared to pore-water concentration.

⁴ RQs for terrestrial invertebrates are applicable to honey bees, which are also a surrogate for other species of bees. Risks to other terrestrial invertebrates (*e.g.*, earthworms, beneficial arthropods) are only characterized when toxicity data are available.

Table 1-3. Summary of Risk Quotients for Taxonomic Groups from Current Uses of Ziram

Taxa	Exposure Duration	Risk Quotient (RQ) Range ¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Freshwater Fish	Acute	0.15 – 1.3	Yes	Risk exceeding the LOC for apple/pear, conifer, filbert and nectarine/peach uses. One fish-kill incident involved thiram where millions of fish over 50 miles were killed as a result of an intentional misuse. The causality was “highly probable” for thiram, but this was not associated with a registered use.
	Chronic	0.65 – 6.8	Yes	Risk exceeding the LOC for most uses except the ones with the lowest application rates (e.g., grapes, blueberries, cherries, tomatoes, trees, and pecans). Based on significant effects to spawning (69.5%), egg production (76.0%), and survival (24%) for the fathead minnow.
Estuarine/ Marine Fish	Acute	0.01 – 0.10	No	--
	Chronic	0.70 – 7.4	Yes	Based on significant effects on growth (4.6%-12%) for the sheepshead minnow.
Freshwater Invertebrates (Water-Column Exposure)	Acute	0.17 – 1.5	Yes	Risk exceeded LOC for Apple/Pear, Conifer, Filbert, and Peach uses based on highest scenarios.
	Chronic	0.10 – 0.59	Yes ²	Due to a mesocosm study with thiram that showed 20% growth effects to a rotifer at 1 µg thiram a.i./L compared with chronic exposure estimates of 1-8 µg thiram a.i./L from ziram uses, sensitive taxa may be at risk. Additionally, due to LOC exceedances with estuarine/ marine invertebrate data and the toxicity data variability that is discussed in the document, it is acknowledged that freshwater invertebrates may also be at risk.
Estuarine/ Marine Invertebrates (Water-Column Exposure)	Acute	0.11 – 5.1	Yes	Risk exceeding LOC for all uses.
	Chronic	1.9 – 11	Yes	Risk exceeding LOC for all uses. Based on use of an acute-to-chronic ratio from daphnid data with a mysid acute endpoint; the daphnid chronic endpoints was based on significant growth effects (19%) in the water flea.
Freshwater Invertebrates (Sediment Exposure) ³	Acute	0.01 – 0.17	No	Pore water exposure is expected to range from 5 to 51% of highest day-one water column concentrations, and therefore, benthic organisms would be expected to be at lower risk than pelagic invertebrates from acute (day-one) exposure.
	Chronic	0.02 – 0.28	No	Pore water exposure is expected to range from 24 to 200% of 21-day water column concentrations and therefore, benthic organisms could be expected to be at greater risk (up to twice as great) than pelagic invertebrates from chronic exposures to pore water.

Taxa	Exposure Duration	Risk Quotient (RQ) Range ¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Estuarine/Marine Invertebrates (Sediment Exposure) ³	Acute	0.05 – 0.58	Yes	Same comments as for freshwater.
	Chronic	0.44 – 5	Yes	Same comments as for freshwater
Mammals	Acute	0.01 – 13	Yes	Risk exceeding LOC for all uses for many food items and size classes. For lowest application rates (grapes), there were no exceedances when risk based on mean exposure estimates.
	Chronic	0.7 – 1200	Yes	Risk exceeding LOC for all uses, for most food items and size classes, and remains when based on mean exposure values and lowest-effect concentration. Based on significant reductions in growth in a 2-generation study (effects to both F1 and F2 generations) in the rat. For a single app. at the lowest rate (grape), dietary exposure estimates remained above the lowest-effect level for 62 days.
Birds	Acute	0.08 – 130	Yes	Risk exceeding LOC for all uses. Even for lowest application rates (grapes), most food items and size classes exceeded, and still exceeded based on mean exposure.
	Chronic	3.8 – 660	Yes	Based on significant effects to reproduction (ranging from 11-46%) and survival (56%) in the mallard duck. For a single app. at the lowest rate (grape), dietary exposure estimates remained above the lowest-effect level for 83 days
Terrestrial Invertebrates ⁴	Acute Adult	Contact: <0.01 – 0.2 Oral RQs not calculated but non-definitive endpoint compared with exposure estimate did not exclude risk	Yes ²	No mortality in acute oral studies. Contact data showed no risk concerns. Using a lower (non-definitive) ferbam toxicity endpoint suggested some potential for contact risk if ziram is more toxic than thiram on immediate contact, but this is not known. For oral acute risk, even though there was not mortality, the exposure estimates are up to 2.3 times the range covered by the toxicity estimate.
	Chronic Adult	0.1 – 49.8	Yes	Based on significant (16.7%) mortality. Lowest single application rate (Flowering plants) did not cause exceedance. Ziram brood feeding study (22-day) showed significant (23%) increase in egg termination rate at 1.36 lb a.i./acre, Ziram tunnel study (26-day) showed no effects to survival, development, or brood parameters at 2.03 lb a.i./acre.
	Acute Larval	0.6 – 287	Yes	

Taxa	Exposure Duration	Risk Quotient (RQ) Range ¹	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
	Chronic Larval	6.4 – 3200	Yes	Based on significant (20%) reduction in emergence. The ziram brood feeding study and tunnel studies (above under adults) showed no effects to larvae, but effects to reproduction.
Aquatic Plants	N/A	0.01 – 0.8	No	Risk not exceeding LOC for non-vascular or vascular aquatic plants for any use.
Terrestrial Plants	N/A	RQs Not calculated but non-definitive endpoints compared with exposure estimates were <1	No	Risk screening not suggesting LOC exceedances for monocot or dicot plants for any use. One plant incident involved ziram plus another fungicide in which 40 acres of apricots were damaged by residue (decreasing yield), with a certainty of “possible” for ziram causality.

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

Plants: 1.0

¹ RQs reflect exposure estimates for parent and degradate thiram and maximum application rates allowed on labels.

² Italicized Yes or No indicates that due to uncertainty the LOC exceedance call is not clearly Yes or No.

³ Based on water-column toxicity data compared to pore-water concentration.

⁴ RQs for terrestrial invertebrates are applicable to honey bees, which are also a surrogate for other species of bees. Risks to other terrestrial invertebrates (*e.g.*, earthworms, beneficial arthropods) are only characterized when toxicity data are available.

For antimicrobial uses of ziram, no terrestrial risks are expected due to negligible exposure. A screening-level aquatic risk assessment for the paint use found risks to not be of concern for freshwater invertebrates and aquatic plants, but risks were of concern for freshwater fish. Additionally, risk was assumed for estuarine/marine fish and invertebrates due to similar toxicity to freshwater fish. Risks to aquatic organisms from other antimicrobial use sites were negligible due to a lack of exposure potential. For more details see the Antimicrobials Division DRA (USEPA, 2020).

2 Introduction

This Draft Risk Assessment (DRA) examines the potential ecological risks associated with labeled agricultural and/or non-agricultural (*i.e.*, turf, ornamentals, conifers) uses of thiram (PC 079801), ferbam (PC 034801), and ziram (PC 034805) on non-listed 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 these chemicals. 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, 2004a). 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.

Because ferbam and ziram degrade quickly (ferbam degrades much more quickly than ziram) to thiram, the three fungicides are being assessed together.

A separate DRA has been conducted for antimicrobial uses of ziram as material preservatives in paper coatings, adhesives, dried films (wall and ceiling textures, wallpaper paste, wallboard, joint compounds, spackles, wood fillers, caulks and sealants), mold-resistant paper and paperboard, and paints (USEPA, 2020, DP 458893, September 24, 2020).

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 the fungicides thiram, ferbam, and ziram. 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, detailed Problem Formulations (USEPA, 2015a and USEPA, 2015b; DP Barcodes 427810, 427924, and 427965) for this DRA were published to the docket in October of 2015. The three fungicides are being assessed together because, while thiram is a registered fungicide, ferbam and ziram also rapidly degrade to the more persistent thiram. Therefore, in addition to having registered uses, thiram is also the major degradate of concern for ferbam and ziram, all of which are dimethyldithiocarbamate fungicides. The following sections summarize the key points of the Problem Formulations and discuss any updates. Although ziram's problem formulation was written separately, the three chemicals are assessed together to reduce redundancy.

Since the problem formulations were written, two waiver requests were addressed for thiram and two for ziram. One thiram request (DP Barcode: 444667; dated January 25, 2018) presented difficulties in passerine toxicity testing due to regurgitation. Rather than recommending a waiver, EFED suggested options of switching species or using a dietary study format. Both options were employed, and the data was submitted (MRID 50835201). The other waiver request for thiram (DP Barcode: 449074; dated October 23, 2018) was for a waiver of the acute larval honey bee study, based on use of data from a 22-day larval study. However, preliminary calculations suggested a need for the data to clarify risk at the expected exposure range so EFED did not recommend a waiver. An acceptable single-dose study was then submitted (MRID 5094001) to address the acute larval honey bee study requirement. For ziram, a 2017 request (DP Barcode: 441186; dated August 28, 2017) was to waive honey bee larval Tier I (acute and chronic) studies by using Tier II screening data from a brood feeding study (MRID 50294108) and a brood development study (MRID 50294104). The data was not determined to be sufficient and the waiver not recommended. Email exchanges during late 2018 alerted EFED that the registrant was having difficulty with ziram stability in royal jelly,

which was followed by a second waiver request (DP Barcode: 454570+; MRID 50940401,) asking that honey bee larval acute and chronic toxicity studies be waived based on difficulties with ziram stability in royal jelly and on preliminary data indicating that thiram is more toxic than ziram to larvae. Based on this information and the rapid degradation from ziram to thiram, EFED recommended granting the waiver and thiram data are used to assess toxicity to bee larvae in this assessment.

The thiram and ziram Reregistration Eligibility Decisions (REDs) were completed in 2004 and the ferbam RED in 2005. All three REDs concluded that there were risks concern for aquatic organisms. The thiram and ferbam REDs concluded risk of chronic adverse effects to birds, and mammals. Acute risks to birds and mammals were considered unlikely due to thiram's use as a wildlife repellent for mammals; ziram was also previously registered as a rabbit repellent. The ziram RED concluded that there was risk of adverse effects to birds and mammals, but avian chronic risk could not be assessed due to a lack of toxicity data. Newly submitted data will be incorporated into the registration review risk assessment. New uses were assessed for ziram use on filberts in 2017 (USEPA, 2017) found similar exposure using updated aquatic modeling tools and reached the same conclusions as previous assessments.

Several ecotoxicity studies for thiram and ziram were submitted to the Agency since the problem formulations were published, chiefly chronic aquatic data, plant toxicity data, and bee toxicity data. These new data listed below:

- Ecotoxicity Data with thiram:
 - Canary dietary acute mortality and feed aversion test (MRID 50835201, acceptable);
 - Saltwater fish early life-stage study (MRID 51049801, acceptable);
 - Non-vascular aquatic plant toxicity studies with cyanobacteria, and two diatom species (MRIDs 50792001, 50792002, and 50792003, all acceptable);
 - Terrestrial plant studies (50330201 and 50835301, both acceptable);
 - Several honey bee studies (all acceptable or supplemental/quantitative):
 - adult acute and oral contact toxicity (MRID 50273401),
 - adult chronic toxicity (MRID 50273402),
 - brood feeding test (MRID 50273403),
 - larval acute (MRID 50940001),
 - semi-field brood study (tunnel study) (MRID 50273404 and 50273405), and
 - larval chronic toxicity (MRID 50669901).
- Ecotoxicity Data with ziram:
 - Zebra finch passerine dietary acute mortality study (MRID 50939501, supplemental/quantitative);
 - Non-vascular aquatic plant toxicity studies with cyanobacteria, and two diatom species (MRIDs 50814402 and 50814403 were acceptable or supplemental/quantitative, but MRID 50814401, the freshwater diatom study, was determined to be qualitative due to exposure uncertainties. However, enough information was available to determine that it was not the most sensitive species);
 - Several honey bee studies (all acceptable or supplemental/quantitative):

- adult acute and oral contact toxicity (MRID 50294101),
- adult chronic toxicity (MRID 50294102),
- brood feeding test (MRID 50294103), and
- semi-field brood study (tunnel study) (MRID 50294104 and 50294105).

These new data are described in more detail in the effects characterization (**Section 6**) and in **Appendix D**. The results are incorporated into this assessment. The subacute dietary toxicity data for the canary and zebra finch were not clearly more sensitive than previously submitted data, though the additional information did help to reduce uncertainties.

3.1 Mode of Action for Target Pests

Thiram (tetramethyl thiuram disulfide), ferbam (ferric dimethyldithiocarbamate), and ziram (zinc-bis(dimethyldithiocarbamate) are dimethyldithiocarbamate fungicides; ziram is also an antimicrobial chemical. Dimethyldithiocarbamate fungicides are non-systemic and act by concomitant inhibition of spore germination and mycelial growth through multi-site interference of enzyme processes associated with respiration. Thiram is also considered an animal repellent, as it creates a taste aversion to deter feeding by rabbits, deer, and rodents. Ziram was also formerly registered as a rabbit repellent.

3.2 Label and Use Characterization

3.2.1 Label and Use Characterization of Thiram

Based on the Pesticide Label Use Summary (PLUS) report (file: 079801 Thiram PLUS - Maximum Use Scenario Report.xlsx), thiram can be used as (1) agricultural indoor, (2) agricultural outdoor, and (3) residential/recreational/institutional /retail (outdoor).

- (1) The agricultural indoor use is on seed treatment. The available formulations include D (dust), FIC (flowable concentrate), DF (dry flowable), EC (emulsifiable concentrate), and RTU (liquid-ready to use). The highest application rate is for coniferous/evergreen/softwood with a rate of 0.021 lb ai/lb seed.
- (2) The agricultural outdoor use sites are described in **Table 3-1**. The available formulations include FIC (flowable concentrate), DF (dry flowable), and SC/L (soluble concentrate/liquid).
- (3) The residential/ recreational/ institutional/ retail (outdoor) is on grass/turf: golf course: tees and greens. The available formulations include FIC (flowable concentrate) and DF (dry flowable). The application method is ground-boom spray at post-emergence. The highest rate is 16.33 lb ai/ac up to 4 applications per year with a 7-day treatment interval.

Table 3-1. Maximum Use Patterns for Current Uses of Thiram

Use	Max Single App. Rate (lbs a.i./A)	Max # of App. per Year	Min Retreatment Interval (days)	Max Annual App. Rate (lbs a.i./A)	Application Methods
Agricultural Indoor (seed treatment)					
Alfalfa, barley, beans, beets, broccoli, Brussels sprouts, buckwheat, cabbage, canola, carrot, castor bean, cauliflower, celery, Swiss chard, chicory, clover, collards, coniferous/evergreen/softwood, coriander, field corn, sweet corn, cowpeas, cucumber, eggplant, endive, flax, grass grown for forage or seed, kale, kohlrabi, lentils, lettuce, melons, millet, mustard, oats, okra, onion, ornamentals, peanuts, peas, pepper, pumpkin, radish, rice, rye, safflower, sesame, small seeded legumes, sorghum, soybeans, spinach, squash, sugar beets, sunflower, tomato, triticale, turnip, vegetables, vetch, wheat.					
The highest application rate is for coniferous/evergreen/softwood with a rate of 0.021 lb ai/lb seed. Followed by onion with a rate of 0.0125 lb ai/lb seed, all others with rates are all less than 0.003 lb ai/lb seed.					
Agricultural Outdoor					
Ornamentals ¹	4.36	NS	NS	NS	Hand-held spray wand & brush-on
Shrubs/Bushes/Vines ¹	4.36				
Tree ¹	4.36				
Peach ²	2.63	5	3	13.1	Aerial & ground spray
Strawberry ³	3.30	5	10	NS	
Residential/ Recreational/ Institutional/ Retail (outdoor)					
Grass/turf: golf course: tees and greens ⁴	16.33	3	7	47	Ground-boom spray

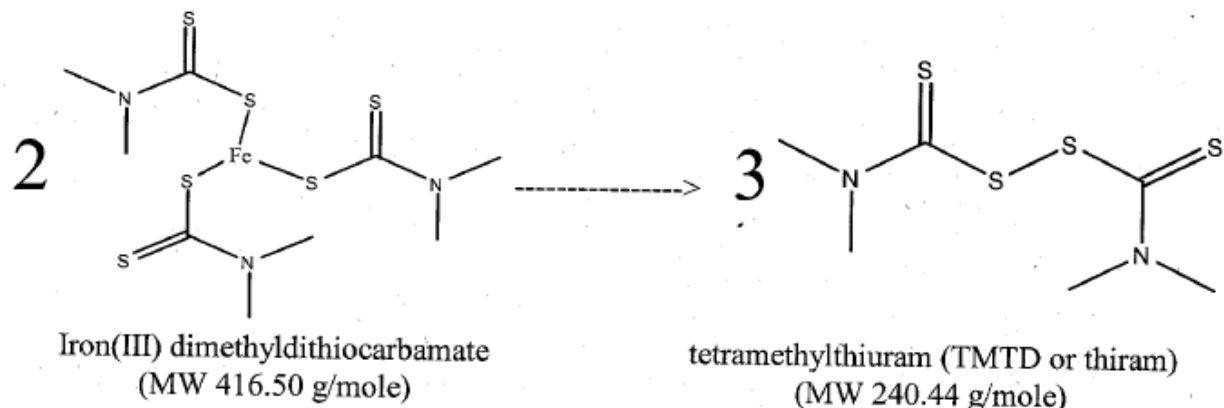
¹applied during winter season (October thru March), ²applied during dormant, bloom, post bloom

³applied during bloom, and ⁴applied during post-emergence. NS = non specified

3.2.2 Label and Use Characterization of Ferbam

Based on the PLUS report (file: 034801 Ferbam PLUS - Maximum Use Scenario Report.xlsx), ferbam use sites are for agricultural outdoor only, the only available formulation is dry flowable (DF). The mango use is the only one without any geographic restrictions, all other uses are not allowed in the state of California. Also, mango use is the only one allowed for airblast spray. The timing of applications for most uses are during bloom, only nectarine and peach are during the dormant period. Summaries of the maximum use pattern for ferbam are provided in **Table 3-2**.

According to the problem formation (USEPA, 2015a), ferbam degrades rapidly into thiram. For modeling purposes, the application rates of ferbam are being converted to a thiram basis. Theoretically, for every two ferbam molecules, three thiram molecules could potentially be formed, as shown below:



Therefore, the application rate of ferbam is calculated as:

$$\# \text{ lb/ac (ferbam)} \div 2 \div 416.5 \times 3 \times 240.44 = 0.866 \# \text{ lb/ac (thiram)}$$

Table 3-2. Maximum Use Patterns for Current Uses of Ferbam (expressed as Thiram equivalents, assuming 0.866 lb/A thiram per 1.0 lb/A ferbam)

Use	Max Single App. Rate (lbs a.i./A)		Max App. Rate per Year (lbs a.i./A)		Max # of App. per Year	Min Retreatment Interval (days)	Application Methods
	ferbam	as thiram	ferbam	as thiram			
Apple	3.50	3.031	10.5	9.092	3	7	Chemigation & ground spray
Citrus	6.00	5.196	18	15.587	3	7	
Cranberry*	4.64	4.018	23.2	20.090	5	7	
Peach	3.42	2.961	10.26	8.884	3	7	
Nectarine	3.42	2.961	10.26	8.884	3	7	
Pear	3.50	3.031	10.5	9.092	3	7	Airblast spray
Mango	2.99	2.589	29.9	25.891	10	10	

* The cranberry use also allows spot treatment; however, this use would expect a lesser amount used than the chemigation or the ground spray on the whole field.

3.2.3 Label and Use Characterization of Ziram

Based on the PLUS report (file: 034805 Ziram PLUS - Maximum Use Scenario Report.xlsx), the ziram uses are summarized in **Table 3-3**. For agricultural uses, ziram is applied as a foliar spray via aerial and ground application methods. The two labeled Section 3 end-use products are Ziram Granuflo and Ziram 76DF Fungicide, both are 76% a.i. water dispersible granule formulations.

Table 3-3. Maximum Use Patterns for Current Uses of Ziram

Use	Single Max Application Rate (lb/ac)	Max Application Rate per Year	Min Application Retreatment Interval (days)	Max # of Applications Per Year	Application Methods, Timing
Almond	6.08	24.32	NS	NS	A/G, before, during, post bloom
Apricot	6.08	24.40	NS	4	A/G, before, during, post bloom
Apple	4.56	32.22	NS	7	G, before bloom, post petal fall
Blueberry	3.04	15.20	7	NS	A/G, before, during, post bloom
Cherry	4.56	18.39	NS	4	A/G, before, during post bloom
Coniferous/ Evergreen/ Softwood (non-food)	6.08	NS	3	NS	G, post emergence
Filbert (Hazelnut)	6.08	22.8	14	5	A/G, before, during, post bloom
Flowering plants, Shrubs/Bushes/ Vines	0.0152	NS	3	NS	G, all site
Grapes	3.04	21.28	7		G, before bloom
Nectarine Peach	7.60	45.60	NS	6	A/G, dormant
Pear	4.56	32.22	NS	7	A/G, before, during bloom, prior to harvest
Pecan	6.08	36.63	21	6	G, before, during bloom
Tomato	3.04	18.01	7	NS	G, post emergence
Tree	6.08	NS	NS	NS	G, dormant

A/G = aerial/ground applications

Additionally, ziram is used as an antimicrobial pesticide with use sites as a material preservative in paper coatings, adhesives, dried films (wall and ceiling textures, wallpaper paste, wallboard, joint compounds, spackles, wood fillers, caulks and sealants), mold-resistant paper and paperboard, and paints (USEPA, 2020).

3.2.4 Usage Summary

A SLUA (Screening Level Usage Analysis) was performed by BEAD based on the data sources from USDA-NASS (United States Department of Agriculture's National Agricultural Statistics Service), Private Pesticide Market Research, and California Department of Pesticide Regulation

(DPR) Pesticide Use Reporting (PUR) database. The SLUA results are presented below in **Table 3-4** to **Table 3-6**.

Thiram

Table 3-4. Screening Level Estimates of Agricultural Uses of Thiram (079801)
Sorted Alphabetically. Reporting Years: 2007-2016 (Date: 17 December 2018)

	Crop	Annual Average Lbs. A.I. Applied	Percent Crop Treated	
			Average	Maximum
1	Broccoli *	<500	NC	NC
2	Cotton (seed treatment**)	10,000	5	25
3	Peaches	1,000	<1	<2.5
4	Peanuts (seed treatment**)	2,000	<2.5	<2.5
5	Soybeans (seed treatment**)	60,000	<2.5	5
6	Strawberries	50,000	20	30
7	Sugar Beets (seed treatment**)	<500	<2.5	<2.5
8	Sweet Corn (seed treatment**)	<500	<1	<2.5
9	Wheat, Spring (seed treatment**)	4,000	<1	<2.5
10	Wheat, Winter (seed treatment**)	10,000	<1	<2.5

All numbers are rounded to one significant digit, except those over 1 million, which are rounded to two significant digits.

<500: less than 500 pounds of active ingredients.

<2.5: less than 2.5 percent of crop is treated.

<1: less than 1 percent of crop is treated.

**** seed treatment usage is not surveyed beyond 2014**

NC: not calculated, only pounds AI available.

Ferbam

Table 3-5. Screening Level Estimates of Agricultural Uses of Ferbam (034801)
Sorted Alphabetically. Reporting Years: 2007-2017 (Date: 12 December 2018)

	Crop	Annual Average Lbs. A.I. Applied	Percent Crop Treated	
			Average	Maximum
1	Apples	2,000	<1	<2.5
2	Cherries	7,700	<2.5	<2.5
3	Grapefruit	10,000	<2.5	5
4	Oranges	40,000	<2.5	10
5	Peaches	40,000	<1	<2.5

All numbers are rounded to one significant digit, except those over 1 million, which are rounded to two significant digits.

<500: less than 500 pounds of active ingredients.

<2.5: less than 2.5 percent of crop is treated.

<1: less than 1 percent of crop is treated.

Ziram

**Table 3-6. Screening Level Estimates of Agricultural Uses of Ziram (034805)
Sorted Alphabetically. Reporting Years: 2007-2016 (Date: 18 December 2018)**

Crop		Annual Average Lbs. A.I. Applied	Percent Crop Treated	
			Average	Maximum
1	Almonds	600,000	10	30
2	Apples	300,000	15	20
3	Apricots	20,000	30	60
4	Blueberries	80,000	30	40
5	Cherries	30,000	5	15
6	Grapes, Raisin	20,000	5	10
7	Grapes, Table	50,000	15	40
8	Grapes, Wine	40,000	<2.5	10
9	Nectarines *	100,000	NC	NC
10	Peaches	200,000	30	40
11	Pears	60,000	10	30
12	Pecans	20,000	<2.5	<2.5
13	Plums/Prunes	10,000	<2.5	5
14	Strawberries	1,000	<2.5	5

All numbers are rounded to one significant digit, except those over 1 million, which are rounded to two significant digits.

<500: less than 500 pounds of active ingredients.

<2.5: less than 2.5 percent of crop is treated.

<1: less than 1 percent of crop is treated.

* Based on CalPUR data only (80% or more of U.S. acres grown are in California)

NC: not calculated, only pounds AI available.

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 ECOSAR (ECOLOGICAL Structure-activity Relationship model), the OECD (Organization for Economic Cooperation and Development) Toolbox, ASTER (Assessment Tools for the evaluation of Risk), or others.

The major degradates of thiram, Carbonyl Sulfide (COS), Carbon Disulfide (CS₂), and Carbon Dioxide (CO₂), are volatile compounds and are not expected to persist in water or soil. CS₂ may cause respiratory distress to wildlife in the immediate area if it is inhaled.²

For both ferbam and thiram, thiram is the stressor of concern for the ecological assessments. For ziram, the parent ziram and its major degradate thiram are the stressors of concern for ecological risk assessments. Thiram is the only major degradate of ziram expected to maintain the toxicity of the parent compound. Available toxicity data for the three compounds were compared in **Sections 6.1** and **6.2** (also see **Table 6-4** and **Table 6-8**). Stability issues with the compounds in various exposure media and analytical verification difficulties made direct comparisons difficult. The three chemicals generally showed similar toxicity to aquatic organisms. Ziram, and possibly ferbam, appear to be more toxic than thiram on an acute basis to terrestrial vertebrates, with rat data showing ziram to be as much as eight to nine times more toxic than thiram to the rat on an acute basis. Chronic toxicity endpoints for terrestrial vertebrates tended to be similar, which was likely due to chronic exposures tending to be dominated by thiram as the chemical species. Terrestrial invertebrate data and plant data did not allow for toxicity comparisons of the three chemicals to those taxa due to non-definitive endpoints.

For all non-inhalation exposure and risk assessment, the three chemicals are assessed as follows:

- Thiram only: registered uses of thiram (parent only);
- Ferbam → Thiram (assessed mainly as thiram, with some characterization as ferbam): registered uses of ferbam, with thiram as the major degradate; and
- Ziram → Thiram + Ziram (Total Residues, TR): registered uses of ziram, with thiram as the major degradate.

Because of ferbam's rapid degradation to thiram, it is assessed as thiram. Ziram degradation to thiram is not as fast and therefore, both compounds are assessed.

5 Environmental Fate Summary

Thiram

Table 5-1 summarizes the physical-chemical data for thiram. Considering thiram's vapor pressure (1.72×10^{-5} mm Hg) and Henry's law constant (3.30×10^{-7} atm.m³/mole), volatilization should not be a concern. Thiram's mobility class is from slightly mobile to hardly mobile ($K_{oc} = 2245$ to $24,526$ mL/goc in 4 soils), therefore, leaching to groundwater should be minimal. However, thiram has a potential to reach surface water through runoff via erosion or spray drift.

² See <http://www.epa.gov/ttnatw01/hlthef/carbondi.html#ref1> and <http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=474&tid=84> for additional information on carbon disulfide.

Table 5-1. Physical/Chemical Properties of Thiram

Parameter (units)	Value	Source
Molecular mass (molecular formula)	240.43 g/mol (C ₆ H ₁₂ N ₂ S ₄)	(Calculated)
Vapor pressure (25°C)	1.72 x 10 ⁻⁵ mm Hg	USEPA, 2004a
Aqueous solubility (20°C)	16.5 mg/L	PPDB ¹
Henry's Law Constant (20°C)	3.30 x 10 ⁻⁷ atm.m ³ /mole	(Calculated)
Log octanol-to-water partition coefficient (log K _{ow})	1.73	PPDB
Organic Carbon-Normalized Distribution Coefficients (K _{oc}) (mL/g _{oc})	Soil	K_{oc}
	Sandy loam	2245
	loamy sand	24526
	silt loam	6359
	loam	12899
MRID 43787501		

¹ Pesticide Properties DataBase (<https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm>)

Table 5-2 summarizes the degradation half-life values for thiram. Thiram is moderately persistent and is degraded by a combination of abiotic and biotic processes in soil and water to produce volatile degradates including carbonyl sulfide (COS), carbon disulfide (CS₂), and carbon dioxide (CO₂). Hydrolysis, photodegradation, and aerobic soil metabolism are the main degradation processes for thiram. Observed half-lives are generally less than 22 days under the expected use conditions and environmentally relevant pHs. When exposed to sunlight, thiram is expected to degrade within approximately 0.3 days via photolysis. Thiram degrades via pH dependent hydrolysis with a half-life of 3.5 days at pH 7, and a half-life of approximately 2 months at pH 5. Thiram degrades via microbial metabolism in soil and water, with half-lives of approximately 2.85 days in soil and 22 days in water under aerobic conditions. Thiram is more persistent under anaerobic aquatic metabolism conditions with a half-life of approximately 43 days.

There are two terrestrial field dissipation studies available. In one study conducted in California, thiram (Spotrete™ 75 WDG), broadcast applied eight times as a spray at a nominal application rate of 10.3 lbs a.i./A/application, dissipated with half-lives of 14 and 27 days for bare-ground and turf plots of sandy loam soil (pH 8.2 to 9.6), respectively. Thiram was not detected below the 6- to 12-inch depth. In the other study conducted in North Carolina, Thiram (Spotrete® 75WDG), broadcast applied eight times as a spray at a nominal application rate of 10.3 lbs a.i./A/application, dissipated with half-lives of 36 and 62 days on a bare ground plot of sand soil (pH 4.1 to 4.7) and a turf plot of loamy sand soil (pH 4.4 to 4.5), respectively. Thiram was not detected below the 6- to 12-inch depth.

Table 5-2. Environmental Fate Parameters of Thiram

Parameter	Value	Source
Hydrolysis $t_{1/2}$ (days) (25°C)	pH 5: 68.5 days, pH 7: 3.5 days, pH 9: 6.9 hours	MRID 41840601
Aqueous photolysis half-life (days) (pH 5 buffer, 25°C)	7.2 hour (0.3 days)	MRID 45651201
Soil photolysis $t_{1/2}$ (25°C)	17.3 hours, 43.2 hours (dark controls)	MRID 45724501
Aerobic soil metabolism $t_{1/2}$ (25°C)	2.85 days (IORE)	MRID 43734901
Aerobic aquatic metabolism $t_{1/2}$ (25°C)	18.2 days (pond water) (IORE) 21.5 days (river water) (IORE)	MRID 45243401
Anaerobic aquatic metabolism $t_{1/2}$ (25°C)	43.1 days	MRID 43628501
Terrestrial field dissipation half-lives	California - 14 days (bare ground) 27 days (turfed sandy loam)	MRID 44724501
	North Carolina - 36 days (bare ground) 62 days (turfed sandy loam)	MRID 44724502

*IORE=indeterminate order (IORE).

Ferbam

Table 5-3 summarizes the physical-chemical and environmental fate for ferbam. Ferbam degrades in minutes via hydrolysis, photolysis and aerobic soil metabolism to form thiram, the major degradate of ferbam in all degradation studies. Ferbam hydrolyzed with half-lives of less than 12.1 minutes at pH 5 to 9. In aqueous photolysis, soil photolysis, and aerobic soil metabolism studies, ferbam degraded too quickly to allow for the measurement of the degradation rate. Thiram was the major degradate in all degradation studies. Ferbam is unstable under hydrolytic and aerobic conditions, therefore, there is little potential for ferbam to leach into groundwater due to its rapid degradation rate.

Table 5-3. Chemical Properties and Environmental Fate Parameters of Ferbam

Parameter	Value	Source
Selected Physical/Chemical Parameters		
Molecular mass (molecular formula)	416.49 g/mol (C ₉ H ₁₈ FeN ₃ S ₆)	(Calculated)
Vapor pressure (25°C)	1.54 x 10 ⁻⁸ mm Hg	MRID 00262064
Aqueous solubility (20°C)	130 mg/L	PPDB ¹
Henry's Law Constant (20°C)	6.49 x 10 ⁻¹¹ atm.m ³ /mole	PPDB
Log octanol-to-water partition coefficient (log K _{ow})	-1.6	MRID 40600608
Persistence		
Hydrolysis half-life (25°C)	pH 5: 12 min, pH 7: 8 min, pH 9: <0.2 min	MRID 44071801
Aqueous photolysis T _½ (25°C)	<1 hr	MRID 43999801
Soil photolysis T _½ (25°C)	<1 hr	MRID 45742501
Aerobic soil metabolism T _½ (25°C)	<1 hr	MRID 44368901
Anaerobic soil metabolism T _½ (25°C)	NA	NA
Aerobic aquatic metabolism T _½ (25°C)	NA	NA
Anaerobic aquatic metabolism T _½ (25°C)	NA	NA
Mobility		
Mobility in Soils	NA	NA
Field Dissipation		
Terrestrial field dissipation half-life; leaching depth	NA	NA

¹ Pesticide Properties DataBase (<https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm>)

NA: Not Available

Ziram

Table 5-4 summarizes the physical-chemical data for ziram. Considering ziram's vapor pressure (1.35 x 10⁻⁷ mm Hg), water solubility (0.97 mg/L), and Henry's law constant (5.6 x 10⁻⁸ atm.m³/mole), volatilization should not be a concern. Ziram's mobility class is from moderately mobile to slightly mobile based on K_{oc} values from 314 mL/g_{oc} to 3732 mL/g_{oc} in 4 soils.

Table 5-4. Physical/Chemical Properties of Ziram

Parameter (units)	Value	Source
Molecular mass (molecular formula)	305.8 g/mol (C ₆ H ₁₂ N ₂ S ₄ Zn)	(Calculated)
Vapor pressure (25°C)	1.35 x 10 ⁻⁷ mm Hg	PPDB ¹
Aqueous solubility (20°C)	0.97 mg/L	PPDB
Henry's Law Constant (20°C)	5.6 x 10 ⁻⁸ atm-m ³ /mole	(Calculated)
Log octanol-to-water partition coefficient (log K _{ow})	1.65	PPDB
Mobility in Soils – K _{oc} (mL/g _{oc})	Soil	K_{oc}
	Sandy loam	314
	sand	1232
	silt loam	759
	clay	3732
MRID 43873501		

¹ Pesticide Properties DataBase (<https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm>)

Table 5-5 summarizes the degradation half-life values for ziram. Ziram degrades rapidly via hydrolysis and photodegradation. Hydrolysis of ziram is pH dependent, with hydrolytic decomposition being faster at the lower pH values. The calculated half-lives were 0.173, 17.7, and 151 hours (~6 days) at pH 5, 7, and 9, respectively. In aqueous photolytic conditions, ziram degraded with a half-life of 0.43 days. In soil photolysis, ziram degraded with a half-life of 0.3 days.

In three aerobic soil metabolism studies, ziram dissipated with half-life values from 3.5 to 5.3 days. In an anaerobic soil metabolism study, ziram was applied to an aerobic sandy loam soil and had an observed a half-life of 14.1 days.

In terrestrial dissipation studies, ziram (Ziram 76DF®) dissipation appeared to be biphasic, with faster degradation after initial application, followed by a slower degradation until the end of the study. Data for aquatic field dissipation and bioaccumulation are not available for ziram, however, a rapid hydrolysis of ziram at pH 7 and a log K_{ow} of 1.65 suggest that ziram would not persist long enough in water to cause bioaccumulation in aquatic species.

Table 5-5. Environmental Fate Parameters of Ziram

Parameter	Value	Source
Hydrolysis T _½ (25°C)	(pH 5) 0.07, (pH 7) 0.74, (pH 9) 6.3 days	MRID 43866701
Aqueous photolysis T _½ (pH 5 buffer, 25°C)	0.43 days	MRID 44097701
Soil photolysis T _½ (25°C)	0.3 days	MRID 43642501
Aerobic soil metabolism T _½ (25°C)	3.5, 4.4, 4.9, 5.3 days	MRIDs 43985801, 46622302, 47005202
Anaerobic soil metabolism T _½ (25°C)	14.1 days	MRID 44228402
Aerobic aquatic metabolism T _½ (25°C)	River 0.3 days, Pond 0.2 days	MRID 46045903

5.1 Transformation Products

Ferbam degrades rapidly via hydrolysis, photodegradation, and aerobic soil metabolism. It has a very short half-life, ranging from too low to assess to 31 minutes under abiotic and biotic (natural) degradative processes. Rapid degradative processes of ferbam suggest that the chemical would not persist in the environment. The major transformation product is tetramethylthiuram disulfide (TMTD, also commonly known as thiram), which is moderately persistent in soil or water.

Degradates of thiram include dimethyldithiocarbamate anion (DTC), COS, CS₂, and CO₂. There are no major (≥10%) non-volatile degradates.

Thiram is the major degradate of ziram. The other major degradate observed was 1,1-dimethylurea. Ferbam, thiram, and ziram degradates are detailed in **Appendix A**.

6 Ecotoxicity Summary

Ecological effects data are used to estimate the toxicity of each active ingredient and major degradate to surrogate species. The ecotoxicity data for thiram, ferbam, and ziram and their associated products have been reviewed previously in problem formulation documents for Registration Review (USEPA, 2015a and USEPA, 2015b) and for thiram and ziram, in the California red-legged frog assessment (USEPA, 2008). Comprehensive lists of available toxicity data from supplemental and acceptable studies are found below in **Appendix C**. New data reviewed since the problem formulations are denoted in the tables in **Appendix C** by an “N” superscript in the MRID column. Those new study reviews are summarized in **Appendix C**.

A search of the public Ecotoxicology database (ECOTOX) was made on December 26, 2018, and again on May 28, 2020, using CAS Numbers 137-26-8 (thiram), 14484-64-1 (ferbam) and 137-

30-4 (ziram). Those searches yielded no new data from suitable studies with more sensitive (lower) toxicity endpoints than those previously used in risk assessments³. Additional information can be found in **Appendix C**.

The most sensitive measured toxicity endpoints available across taxa are summarized for each of the three active ingredients separately in **Appendix C, Section C-1 (Tables C-1-1 through C-1-6)**, followed by a comprehensive list of studies and description of new studies in **Section C-2** (aquatic studies) and **Section C-3** (terrestrial studies). In the following sections (**Section 6.1** and **Section 6.2**), the endpoints that are used in risk calculations are presented. Because risk is calculated for thiram, and then for ferbam or ziram plus thiram as the major break-down product for each, the aquatic (**Section 6.1**) and terrestrial (**Section 6.2**) toxicity sections contain two tables each presenting the endpoints used in risk calculations for:

- thiram toxicity data (data used in evaluating risk from registered uses of thiram and ferbam, which is the same data due to rapid degradation of ferbam to thiram), **Table 6-1** and **Table 6-5**; and
- ziram plus thiram (data used in evaluating risk from registered uses of ziram with thiram as the degradate), **Table 6-3** and **Table 6-7**.

The datasets for thiram and ziram were largely complete, but the dataset for ferbam was incomplete and, therefore, most of the ferbam endpoints used in the assessment are from its degradate, thiram. These are also adjusted to ferbam equivalents (feq) using the molecular weight ratio (416.49/240.43 g/mol). Due to ferbam's rapid breakdown to thiram, toxicity data with thiram were considered sufficient for both ferbam and thiram uses (USEPA, 2015a), and additional toxicity data with ferbam were not requested in the problem formulation. Some ferbam toxicity data were available and where the ferbam study had a more sensitive endpoint, this was used.

For ziram, the endpoints presented in **Table 6-3** and **Table 6-7** are the most sensitive from either ziram or thiram data, and if thiram, data were converted to ziram equivalents (zeq) using the molecular weight ratio (305.8/240.43 g/mol).

These endpoints are not likely to capture the most sensitive toxicity endpoint for a taxon but capture the most sensitive endpoint across tested species for each taxon. All studies presented in these sections (**Tables 6-1 through 6-4**) are classified as acceptable or supplemental and are quantitatively usable for risk calculations unless otherwise noted for use in risk characterization. Non-definitive endpoints are designated with a greater than or less than value (USEPA, 2011a). Values that are based on newly submitted data are designated with an N footnote associated with the MRID number in tables.

³ There were some endpoints that were lower in the ECOTOX report; however, the endpoints were not considered reliable for use in risk assessment.

6.1 Aquatic Toxicity

Notable issues with aquatic toxicity data included:

- For ferbam, the breakdown to thiram is so rapid that (as discussed above), the dataset used consisted mainly of thiram data.
- For ziram, low test substance stability in water was thought to be responsible, at least in part, for a wide range of intra-species LC₅₀s (particularly in fish). Some older data points were reconsidered, and the data points selected for risk calculations were those in which exposure was quantified with some certainty, often from radio-labelled studies.
- For thiram, test substance stability in saltwater was particularly low. For estuarine/marine invertebrate data, some ziram endpoints were used as surrogates for thiram based on similar modes of action and chemical class. This is not to be confused with the use of thiram toxicity data as the degradate of ferbam and ziram, but in this case, the ziram data had better exposure confirmation.
- Even with these careful considerations, the data variability (noise) resulted in at least one case (mysid shrimp ziram data) where the acute endpoint appeared to be slightly lower than the chronic endpoint, which is theoretically not plausible in concept. In that case, an acute-to-chronic ratio from another invertebrate taxa was used to calculate a theoretical chronic endpoint.

Due to these issues, risk was characterized to include ranges for considerations in the risk picture.

Fish

The available data indicate that thiram (**Table 6-1**, also see **Table C-1-1** in **Appendix C**), ferbam (**Table 6-2**, also see **Table C-1-2**), and ziram (**Table 6-3**, also see **Table C-1-3**) TGAIs (technical grade active ingredients) are very highly toxic to freshwater fish and highly toxic to estuarine/marine fish on an acute exposure basis to the most sensitive species for which information is available. The full range of available data (4-5 species for each chemical) are presented and discussed in **Appendix C, Tables C-2-1 to C-2-4**. No clear difference was observed between cold-water and warm-water species.

For thiram, the most sensitive species was the Harlequin fish (*Rasbora heteromorpha*) with an LC₅₀ of 7 µg thiram a.i./L from a formulation study. This is included only for spray drift characterization due to possible adjuvant effects. The most sensitive fish from a study with technical a.i. (and that was quantitatively usable) was the bluegill (*Lepomis macrochirus*), a warm-water fish, with a LC₅₀ of 42 µg thiram a.i./L. The rainbow trout (*Oncorhynchus mykiss*), a cold-water fish, was slightly less sensitive, though close, with LC₅₀s ranging from 46 to 382 µg thiram a.i./L. For ferbam, the 96-hr LC₅₀ values for three species of freshwater fish (bluegill, fathead minnow, *Pimephales promelas*, and carp, *Cyprinus carpio*) ranged from 90 (for the carp) to 3600 µg feq/L (for the bluegill). The thiram bluegill endpoint was more sensitive and used for ferbam risk calculations. For ziram, the data had much variability (as mentioned above and discussed in **Appendix C**), and the thiram bluegill data were also determined to be the most

sensitive usable endpoint for ziram risk calculations. In all cases, when thiram data are used for risk calculations for ferbam or ziram, the endpoint is adjusted by respective molecular weights.

Estuarine/marine fish were generally less sensitive to the three chemicals on an acute basis than freshwater fish, although the dataset was smaller with one study each for thiram and ferbam and two for ziram. See **Tables C-2-1** and **C-2-3** in **Appendix C** for more details. The sheepshead minnow (*Cyprinodon variegatus*; MRID 42514401) LC₅₀ of 540 µg thiram a.i./L (also 970 µg feq/L and 690 µg zeq/L) was considered highly toxic and was the most sensitive acute endpoint for use in risk calculations for all three chemicals.

Chronic and sub-chronic fish toxicity data (no-observed and lowest-observed effects concentrations, or NOAEC/LOAECs) were available for thiram and ziram, but not ferbam. For freshwater fish exposed to thiram in a fish life-cycle study, the fathead minnow (MRID 47824101) had significant (p<0.05) reductions in spawning frequency (69.5%), egg production (76.0%), and 4-week survival (24%) at the LOAEC (2.2 µg thiram a.i./L, NOAEC was 1.1 µg thiram a.i./L) also, time to hatch was delayed by up to 2 days. This endpoint was determined to be the most sensitive freshwater fish chronic endpoint for use in ferbam and ziram calculations, as well.

For estuarine/marine fish, the sheepshead minnow (MRID 51049801) exposed to thiram had significant (p<0.05) 4.6% and 12% reductions, relative to controls, in length and dry weight from exposure to 2.0 µg thiram a.i./L (NOAEC was 0.93 µg thiram a.i./L) from a 28-day early life-stage study. This endpoint was determined to be the most sensitive estuarine/marine fish chronic endpoint for use in ferbam and ziram calculations, as well.

Aquatic Invertebrates

The available data indicate that thiram (**Table 6-1**, also see **Table C-1-1** in **Appendix C**), ferbam (**Table 6-2**, also see **Table C-1-2**), and ziram (**Table 6-3**, also see **Table C-1-3**) TGAs are highly toxic to very highly toxic to freshwater and estuarine/marine invertebrates on an acute exposure basis to the most sensitive species for which information is available. The only exception for which data are available is the pink shrimp (*Penaeus duorarum*; slight to moderate toxicity). The full range of available acute data (2-3 species for each chemical) are presented and discussed in **Appendix C, Tables C-2-5** and **C-2-7**.

For thiram, the most sensitive freshwater invertebrate species was the water flea (*Daphnia magna*) with an LC₅₀ of 210 µg thiram/L (MRID 00164662). This endpoint was also used for ferbam risk calculations. For ziram, the most sensitive endpoint was also with the water flea with an LC₅₀ of 48 µg ziram a.i. (zeq)/L (MRID 42386305). For thiram, the most sensitive estuarine/marine invertebrate species was the mysid shrimp (*Americamysis bahia*) with an LC₅₀ of 3.4 µg thiram a.i./L (MRID 42488302), but the study had problems with test substance recovery/stability. Therefore, the ziram mysid study (MRID 43781603), even though a surrogate chemical, was determined to be a better candidate for risk calculations, with a thiram equivalent adjusted LC₅₀ of 11 µg thiram a.i./L (14 µg ziram a.i. (zeq)/L), which was also used for

ferbam risk calculations. Since much of the ziram toxicity would have likely been attributable to thiram, the test measurements were much better, and the endpoint is actually in a similar range to the thiram one above (3.4 thiram $\mu\text{g a.i./L}$), this endpoint seemed to be the most sound based on the troubles encountered in testing thiram in saltwater.

Chronic aquatic invertebrate toxicity data were available for all three chemicals, with ziram being the only one of the chemicals with both freshwater and estuarine/marine endpoints available. Chronic endpoints (NOAECs) were approximately one order-of-magnitude (ten-fold) more sensitive than the acute LC_{50} s with the exceptions of the pink shrimp which was less sensitive than other tested species (see **Appendix C**) and of the ziram endpoint (discussed below). For thiram, the freshwater water flea (MRID 47495001) had significant ($p < 0.05$) 19% reduction in dry weight at the LOAEC (40 $\mu\text{g a.i./L}$). *Daphnia* from the 40 and 81 $\mu\text{g a.i./L}$ levels demonstrated treatment-related signs of toxicity, including lethargy, pale coloration, and/or small size. Mortality was 100% at the highest treatment level (81 $\mu\text{g a.i./L}$). This endpoint was also the most sensitive freshwater invertebrate chronic endpoint for use in ferbam and ziram risk calculations.

No estuarine/marine invertebrate chronic data were available with thiram. Conversely, for ferbam, only estuarine/marine data were available; the mysid shrimp had significant ($p < 0.05$) 2.7% reduction in F0 body length followed by a dose-dependent pattern (MRID 47784401). The 2.7% reduction at the lowest concentration (1.2 $\mu\text{g feq/L}$) was statistically significant but it is unclear whether the reduction is biologically significant, especially since there was a 5% increase in dry weight at that treatment level. This study is described in more detail in **Appendix C**. Even with a non-definitive endpoint, a new study would not be anticipated to provide meaningful information and so is not needed.

For ziram, the mysid shrimp had significant ($p < 0.05$) 38.0% and 11.1% respective reductions in young/reproductive day and dry weight at 27 $\mu\text{g ziram a.i. [zeq]/L}$ (NOAEC of 16 $\mu\text{g ziram a.i. [zeq]/L}$, MRID 46893103), followed by dose-dependent patterns with respective reductions of 83.3% and 30.2% at the next higher concentration (65 $\mu\text{g ziram a.i. [zeq]/L}$) at 27 $\mu\text{g ziram a.i. [zeq]/L}$ (NOAEC of 16 $\mu\text{g zeq/L}$). The complexities of analytical verification seen in the toxicity dataset for these three chemicals is likely the reason that the ziram acute and chronic endpoints do not appear to line up plausibly, with the acute endpoint (LC_{50} of 14 $\mu\text{g ziram a.i. [zeq]/L}$, MRID 43781603) being slightly below the chronic endpoint (16 $\mu\text{g ziram a.i. [zeq]/L}$, MRID 46893103). For example, (also see **Appendix C**) with MRID 46893103, analytical variability was over 20%; however, the radio-labeled verification was sufficient. MRID 43781603, the study with the higher endpoint, was also a radio-labeled study. One difference in the studies that may help explain the difference is that MRID 43781603 had only 6 daily turn-overs (more time to convert to thiram), while MRID 46893103 had thirteen daily turn-overs, and therefore should have had a higher ziram/thiram ratio which was less toxic. This demonstrates the complexity of this toxicity picture and the noise in the dataset may be due to varying ratios of parent to thiram degradate, but this is not entirely certain. Therefore, the ranges are characterized.

Both studies were determined to be good studies, yet a no-effects concentration cannot theoretically be higher than a 50% mortality concentration. Because it is not known which toxicity estimate better reflects expected bioavailability and effects in real-world conditions, the most conservative assumption is used in risk calculations with the acute endpoint used and an acute-to-chronic ratio (ACR) from the daphnid thiram toxicity data was used to calculate a theoretical chronic endpoint for the mysid. This was determined to be the best and most sensitive estimate for use in calculating risk for all three chemicals.

The thiram freshwater water flea ACR of 11 was used for estimating chronic toxicity to the mysid (210/20 µg thiram a.i./L, MRIDs 00164662 and 47495001). Applying this to the ziram mysid acute data (MRID 43781603) yields a chronic toxicity estimate of NOAEC = 1.0 µg thiram a.i./L (11 , 11 = 1.0). This calculated endpoint is also close to the non-definitive ferbam mysid chronic endpoint (<0.69 µg thiram equivalents/L when adjusted for molecular weights by multiplying by 240.43/416.49), and to the thiram LC₅₀ estimate of 3.4 µg thiram a.i./L (MRID 42488302). For ziram, another ACR of 5.3 (206/39 µg zeq/L, MRIDs 47405701 and 46823301) is available with the water flea in which both studies had radio-labeled exposure estimates, but the thiram ACR is slightly more conservative and is used here. Therefore, despite the noise, this endpoint is supported by multiple lines of evidence in the concentration range around 1.0 µg thiram a.i./L.

Sediment toxicity studies were not requested in the respective problem formulations. Even though the Koc for both thiram (Koc of 2245 to 24,526 mL/g_{OC}) and ziram (Koc of 314 to 3732 mL/g_{OC}, **Table 5-1** and **Table 5-4**) were above 1000 mL/g_{OC}, triggering sediment assessment, the problem formulations concluded that thiram and ziram are not expected to accumulate in sediment. For ferbam, the problem formulation states that thiram toxicity data are sufficient to assess ferbam uses. The ziram problem formulation also states that ziram is associated with water in the presence of sediment. Without toxicity data for benthic invertebrates from spiked-sediment exposure, toxicity is therefore assumed to be similar to that of water column invertebrates in the risk assessment and risk was assessed based on pore water exposure.

For aquatic plants, toxicity comparisons between ziram and thiram were not conclusive. While ziram appears to be more toxic to aquatic vascular (duckweed) and non-vascular (green algae) plants, this was not always clear because some thiram data were based on formulation studies, and where this was the case, those thiram endpoints were assumed to be thiram-specific and were not used for ferbam or ziram calculations.

The most sensitive aquatic toxicity endpoints for thiram for use in risk calculations are presented in **Table 6-1**. For ferbam and ziram, a total residues (TR) approach is used in the risk assessment, due to rapid breakdown, in which the more sensitive endpoint of either parent or the thiram degradate was chosen for use. **Table 6-2** and **Table 6-3** contains the most sensitive aquatic toxicity values for ferbam and ziram, respectively, and are based on parent or thiram endpoints depending on which is more sensitive.

Table 6-4 shows a direct comparison of toxicities of the three chemicals. The most sensitive endpoints for ferbam and ziram are converted to thiram equivalents and compared with the most sensitive thiram endpoints. More complete information for the endpoints presented here can be found in **Appendix C, Tables C-1-1, C-1-2, and C-1-3**. Considering the noise in the toxicity data discussed above, in general the three chemicals show similar toxicity to fish and aquatic invertebrates, or at least do not clearly show that one is more toxic. One possible exception shown in **Table 6-4** is that the bluegill was an order-of-magnitude more sensitive to thiram than ziram on an acute basis, but the fathead minnow only slightly more sensitive on a chronic basis and the sheepshead minnow showed similar sensitivity to all three chemicals on an acute basis and was possibly more sensitive to thiram than ziram on a chronic basis. Conversely, the daphnid was slightly more sensitive to ziram than thiram on an acute basis but similarly sensitive on a chronic basis. With the difficulties with thiram stability in saltwater, and wide range of endpoints for ferbam and ziram, no clear difference in sensitivity was supported for estuarine/marine invertebrates. Thiram showed some indication of being less toxic to aquatic plants than ziram, but ferbam data were not available for comparison. Overall, the three compounds appear to be similarly toxic to aquatic animals and no clear distinctions were seen, though ziram may be slightly more toxic than thiram to aquatic plants.

Table 6-1. Aquatic Toxicity Endpoints Selected for Risk Estimation of Thiram

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in µg thiram a.i./L	MRID or ECOTOX No./ Classification	Comments
Freshwater Fish (Surrogates for Vertebrates)					
Acute	Thiram TGAI (98.7%)	Bluegill sunfish (<i>Lepomis macrochirus</i>)	96-hr LC ₅₀ = 42	TN 996 Acceptable	Very highly toxic. Study from the U.S. Agricultural Research Service Lab. Raw data used to check statistics.
	Thiram TEP (80%)	Harlequin Fish (<i>Rasbora heteromorpha</i>)	96-hr LC ₅₀ = 7	05020144 Supplemental (Quantitative)	Very highly toxic. Not fully acceptable due to protocol deviations and information gaps. TEP study is only used for risk characterization of thiram spray drift.
Chronic (Full lifecycle)	Thiram TGAI (98.7%)	Fathead Minnow (<i>Pimephales promelas</i>) (Reproduction and survival)	210-d NOAEC = 1.1 LOAEC = 2.2 (Reproduction and survival)	47824101 Acceptable	Based on significant (p<0.05) reductions in spawning frequency (69.5%), egg production (76.0%), and 4-week survival (24%); also, time to hatch was affected.
Estuarine/Marine Fish (Surrogates for Vertebrates)					
Acute	Thiram TGAI (98.3%)	Sheepshead Minnow (<i>Cyprinodon variegatus</i>)	96-hr LC ₅₀ = 540	42514401 Acceptable	Highly toxic.
Chronic	Thiram TGAI (97.08%)	Sheepshead Minnow (<i>C. variegatus</i>)	34-day NOAEC = 0.93 LOAEC = 2.0 (Length and dry wt.)	51049801 ^N Acceptable	Based on significant (p<0.05) 4.6% and 12% reductions in length and dry weight.
Freshwater Invertebrates (Water-Column Exposure)					
Acute	Thiram TGAI (98.0%)	Water Flea (<i>Daphnia magna</i>)	48-hr EC ₅₀ = 210	00164662 Acceptable	Highly toxic.
Chronic	Thiram TGAI (98.7%)	Water Flea (<i>D. magna</i>)	21-d NOAEC = 20 LOAEC = 40 (Dry wt.)	47495001 Acceptable	Based on significant (p<0.05) 19% reduction in dry weight.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in µg thiram a.i./L	MRID or ECOTOX No./ Classification	Comments
Estuarine/Marine Invertebrates (Water-Column Exposure)					
Acute	Ziram TGAi (98.0%) surrogate for thiram toxicity	Mysid Shrimp (<i>Americamysis bahia</i>)	96-hr LC ₅₀ = 11	43781603 Acceptable	Very highly toxic. The ziram study is used as a surrogate for thiram toxicity. ¹
Acute (Shell Deposition)	Ziram TGAi (98.0%) surrogate for thiram toxicity	Eastern Oyster (<i>Crassostrea virginica</i>)	96-hr EC ₅₀ = 61	43781602 Acceptable	Very highly toxic. The ziram study is used as a surrogate for thiram toxicity. ¹
Chronic	Ziram TGAi (98.0%) surrogate for thiram toxicity	Mysid Shrimp (<i>Americamysis bahia</i>)	Calculated NOAEC using ACR of 11: 1.0	43781603 Acceptable (MRIDs used in ACR: 00164662, 47495001)	Ziram acute endpoint (as surrogate) with thiram daphnid ACR. ^{1,2}
Aquatic Plants and Algae					
Vascular	Thiram TGAi (98.7%)	Duckweed (<i>Lemna gibba</i>)	7-d IC ₅₀ = 1600 (Frond number)	45441202 Acceptable	Based on reduction in frond number.
Non-vascular	Thiram TGAi (99.0%)	Green Algae (<i>Pseudokirchneriella subcapitata</i>)	5-d IC ₅₀ = 140 (Biomass)	44086101, 44086001 Acceptable	Based on biomass reduction.
	Thiram TEP (71.0%)	Freshwater Diatom (<i>Navicula pelliculosa</i>)	4-d IC ₅₀ = 0.58 (Yield)	50792001 ^N Acceptable	Based on reduced yield. Most sensitive non-vascular endpoint but is from a thiram TEP study and is only used for risk characterization of thiram spray drift.

TGAi=Technical Grade Active Ingredient; TEP= Typical end-use product; NC = not calculated; a.i.=active ingredient; hr = hour, d = day; NOAEC and LOAEC = no- and lowest-observed adverse effects concentration; LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

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

>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.

¹ The ziram mysid and oyster acute studies (MRIDs 43781603 and 43781602) are radio-labeled studies with good recoveries. Because of uncertainties in the thiram mysid and oyster studies (MRIDs 42488302 and 42488301, stability and recoveries made exposure uncertain), ziram saltwater invertebrate acute studies are being used as toxicity surrogates, especially because much of the toxicity would likely have been from thiram and since the compounds have similar modes of action.

²Calculations of ACR as follows: 210/20 (from thiram freshwater invertebrate endpoints) = 11. Mysid ziram endpoint (used as surrogate): 11/11 = 1.0 µg thiram a.i./L).

Table 6-2. Aquatic Toxicity Endpoints Selected for Risk Estimation of Ferbam

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value as $\mu\text{g freq/L}^1$	MRID or ECOTOX No./ Classification	Comments
Freshwater Fish (Surrogates for Vertebrates)					
Acute	Thiram TGA1 (98.7%)	Bluegill sunfish (<i>Lepomis macrochirus</i>)	96-hr LC_{50} = 73	TN 996 Acceptable	Very highly toxic. Study from the U.S. Agricultural Research Service Lab. Raw data used to check statistics.
Chronic (Full lifecycle)	Thiram TGA1 (98.7%)	Fathead Minnow (<i>Pimephales promelas</i>) (Reproduction and survival)	210-d NOAEC = 1.9 LOAEC = 3.8 (Reproduction and survival)	47824101 Acceptable	Based on significant ($p < 0.05$) reductions in spawning frequency (69.5%), egg production (76.0%), and 4-week survival (24%); also, time to hatch was affected.
Estuarine/Marine Fish (Surrogates for Vertebrates)					
Acute	Thiram TGA1 (98.3%)	Sheepshead Minnow (<i>Cyprinodon variegatus</i>)	96-hr LC_{50} = 940	42514401 Acceptable	Highly toxic.
Chronic	Thiram TGA1 (97.08%)	Sheepshead Minnow (<i>C. variegatus</i>)	34-day NOAEC = 1.6 LOAEC = 3.5 (Length and dry wt.)	51049801 ^N Acceptable	Based on significant ($p < 0.05$) 4.6% and 12% reductions in length and dry weight.
Freshwater Invertebrates (Water-Column Exposure)					
Acute	Thiram TGA1 (98.0%)	Water Flea (<i>Daphnia magna</i>)	48-hr EC_{50} = 360	00164662 Acceptable	Highly toxic.
Chronic	Thiram TGA1 (98.7%)	Water Flea (<i>D. magna</i>)	21-d NOAEC = 35 LOAEC = 69 (Dry wt.)	47495001 Acceptable	Based on significant ($p < 0.05$) 19% reduction in dry weight.
Estuarine/Marine Invertebrates (Water-Column Exposure)					
Acute	Ziram TGA1 (98.0%) surrogate for thiram toxicity	Mysid Shrimp (<i>Americamysis bahia</i>)	96-hr LC_{50} = 19	43781603 Acceptable	Very highly toxic. The ziram study is used as a surrogate for thiram toxicity. ²

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value as µg feq/L ¹	MRID or ECOTOX No./ Classification	Comments
Acute (Shell Deposition)	Ziram TGAI (98.0%) surrogate for thiram toxicity	Eastern Oyster (<i>Crassostrea virginica</i>)	96-hr EC ₅₀ = 105	43781602 Acceptable	Very highly toxic. The ziram study is used as a surrogate for thiram toxicity. ²
Chronic	Ziram TGAI (98.0%) surrogate for thiram toxicity	Mysid Shrimp (<i>Americamysis bahia</i>)	Calculated NOAEC using ACR of 11: 1.7	43781603 Acceptable (MRIDs used in ACR: 00164662, 47495001)	Ziram acute endpoint (as surrogate) with thiram daphnid ACR. ^{2,3}
Aquatic Plants and Algae					
Vascular	Thiram TGAI (98.7%)	Duckweed (<i>Lemna gibba</i>)	7-d IC ₅₀ = 2800 (FronD number)	45441202 Acceptable	Based on reduction in frond number.
Non-vascular	Thiram TGAI (99.0%)	Green Algae (<i>Pseudokirchneriella subcapitata</i>)	5-d IC ₅₀ = 240 (Biomass)	44086101, 44086001 Acceptable	Based on biomass reduction.

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; NC = not calculated; a.i.=active ingredient; feq = ferbam equivalents, hr = hour, d = day; NOAEC and LOAEC = no- and lowest-observed adverse effects concentration; LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

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

¹ All endpoints are reported as ferbam equivalents (feq). For studies conducted with thiram, reported thiram toxicity endpoint was converted to feq by multiplying by the ratio of molecular weights (416.49/240.43). The mysid study with ziram was converted to thiram in the above table.

² The ziram mysid and oyster acute studies (MRIDs 43781603 and 43781602) are radio-labeled studies with good recoveries. Because of uncertainties in the thiram mysid and oyster studies (MRIDs 42488302 and 42488301, stability and recoveries made exposure uncertain), ziram saltwater invertebrate acute studies are being used as toxicity surrogates, especially because much of the toxicity would likely have been from thiram and since the compounds have similar modes of action.

³ Calculations of ACR as follows: 210/20 (from thiram freshwater invertebrate endpoints) = 11. Mysid ziram endpoint (used as surrogate): 19/11 = 1.7 µg feq/L).

Table 6-3. Aquatic Toxicity Endpoints Selected for Risk Estimation of Ziram

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in $\mu\text{g zeq/L}^1$	MRID or ECOTOX No./ Classification	Comments
Freshwater Fish (Surrogates for Vertebrates)					
Acute	Thiram TGA1 (98.7%)	Bluegill sunfish (<i>Lepomis macrochirus</i>)	96-hr LC_{50} = 53	TN 996 Acceptable	Very highly toxic. Study from the U.S. Agricultural Research Service Lab. Raw data used to check statistics.
Chronic (Full lifecycle)	Thiram TGA1 (98.7%)	Fathead Minnow (<i>P. promelas</i>)	210-d NOAEC = 1.4 LOAEC = 2.8 (Reproduction and survival)	47824101 Acceptable	Based on significant ($p < 0.05$) reductions in spawning frequency (69.5%), egg production (76.0%), and 4-week survival (24%); also, time to hatch observationally determined to be affected.
Estuarine/Marine Fish (Surrogates for Vertebrates)					
Acute	Thiram TGA1 (98.3%)	Sheepshead Minnow (<i>Cyprinodon variegatus</i>)	96-hr LC_{50} = 690	42514401 Acceptable	Highly toxic. Had 90-96% analytical recovery.
Chronic	Thiram TGA1 (97.08%)	Sheepshead Minnow (<i>C. variegatus</i>)	34-d NOAEC = 1.2 LOAEC = 2.5 (Length and dry weight)	51049801 ^N Acceptable	Based on significant ($p < 0.05$) 4.6% and 12% reductions in length and dry weight.
Freshwater Invertebrates (Water-Column Exposure)					
Acute	Ziram TGA1 (98.9%)	Water Flea (<i>Daphnia magna</i>)	48-hr EC_{50} = 48	42386305 Acceptable	Very highly toxic. Problems with ziram recovery in low treatments but had enough treatment levels to only use ones around the LC_{50} with very good recoveries. Not Radio-labeled.
Chronic	Thiram TGA1 (98.7%)	Water Flea (<i>D. magna</i>)	21-d NOAEC = 25 LOAEC = 51 (Dry weight)	47495001 Acceptable	Based on significant ($p < 0.05$) 19% reduction in dry weight.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in $\mu\text{g zeq/L}^1$	MRID or ECOTOX No./ Classification	Comments
Estuarine/Marine Invertebrates (Water-Column Exposure)					
Acute	Ziram TGAi (98.0%)	Mysid Shrimp (<i>Americamysis bahia</i>)	96-hr $\text{LC}_{50} = 14$	43781603 Acceptable	Very highly toxic. This is a radio-labeled study with good recoveries.
Acute (Shell Deposition)	Ziram TGAi (98.0%)	Eastern Oyster (<i>Crassostrea virginica</i>)	96-hr $\text{EC}_{50} = 77$	43781602 Acceptable	Very highly toxic. Not radio-labeled study.
Chronic	Ziram TGAi (98.0%)	Mysid Shrimp (<i>A. bahia</i>)	Calculated NOAEC using ACR of 11: 1.3	43781603 Acceptable (MRIDs used in ACR: 00164662, 47495001)	Ziram acute endpoint with thiram daphnid ACR. ²
Aquatic Plants and Algae					
Vascular	Ziram TGAi (98.2%)	Duckweed (<i>Lemna gibba</i>)	7-d $\text{IC}_{50} = 370$ (Biomass)	46823302 Acceptable	Based on biomass inhibition.
Non-vascular	Ziram TGAi (98.0%)	Green Algae (<i>Pseudokirchneriella subcapitata</i>)	120-hr $\text{IC}_{50} = 67$ (Biomass)	43833901 Acceptable	Based on biomass inhibition.
	Ziram TEP (71.0%)	Freshwater Cyanobacterium (<i>Anabaena flos-aquae</i>)	96-hr $\text{IC}_{50} = 2.4$ (Yield)	50814403 ^N Acceptable	Based on yield inhibition. Most sensitive non-vascular endpoint but is from a TEP study and is included for spray drift characterization. A thiram TEP endpoint is more sensitive but not applicable.

TGAi=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient; zeq = ziram equivalents, hr = hour, d = day; NOAEC and LOAEC = no- and lowest-observed adverse effects concentration; LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

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

>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.

¹ All endpoints are reported as ziram equivalents (zeq). For studies conducted with thiram, reported thiram toxicity endpoint was converted to zeq by multiplying by the ratio of molecular weights (305.8/240.43).

² Calculations of ACR as follows: 210/20 (from thiram freshwater invertebrate endpoints) = 11. Mysid ziram endpoint: 14/11 = 1.3 $\mu\text{g zeq/L}$.

Table 6-4. Comparison of Most Sensitive Aquatic Toxicity Endpoints for Thiram, Ferbam, and Ziram TGAs Expressed as Thiram Equivalents

Study Type	Test Species	Toxicity Value				MRID or ECOTOX No.
		Endpoint	µg thiram a.i./L	Conv. from µg Feq/L to µg thiram eq./L ¹	Conv. from µg Zeq/L to µg thiram eq./L ²	
Freshwater Fish (Surrogates for Vertebrates)						
Acute	<u>Thiram</u> : Bluegill sunfish (<i>Lepomis macrochirus</i>) <u>Ferbam</u> : Carp (<i>Cyprinus carpio</i>) <u>Ziram</u> : Bluegill sunfish (<i>L. macrochirus</i>)	96-hr LC ₅₀ 48-hr LC ₅₀ 96-hr LC ₅₀	42	52	448	TN 996 05001997 47307901
Chronic (Full lifecycle)	<u>Thiram</u> : Fathead minnow (<i>Pimephales promelas</i>) <u>Ferbam</u> : No Data <u>Ziram</u> : Fathead minnow (<i>P. promelas</i>)	210-d NOAEC -- 275-d NOAEC	1.1	--	19	47824101 -- 47435501
Estuarine/Marine Fish (Surrogates for Vertebrates)						
Acute	<u>Thiram</u> : Sheepshead Minnow (<i>Cyprinodon variegatus</i>) <u>Ferbam</u> : Longnose killifish (<i>Fundulus similis</i>) <u>Ziram</u> : Sheepshead Minnow (<i>C. variegatus</i>)	96-hr LC ₅₀	540	462	660	42514401 40228401 43781601
Chronic	<u>Thiram</u> : Sheepshead Minnow (<i>C. variegatus</i>) <u>Ferbam</u> : No Data <u>Ziram</u> : Sheepshead Minnow (<i>C. variegatus</i>)	34-d NOAEC	0.93	--	21	51049801 -- 46856401
Freshwater Invertebrates (Water-Column Exposure)						
Acute	<u>Thiram</u> : Water Flea (<i>Daphnia magna</i>) <u>Ferbam</u> : No Data <u>Ziram</u> : Water Flea (<i>D. magna</i>)	48-hr EC ₅₀	210	--	38	00164662 -- 42386305/ 47405701
Chronic	<u>Thiram</u> : Water Flea (<i>D. magna</i>) <u>Ferbam</u> : No Data <u>Ziram</u> : Water Flea (<i>D. magna</i>)	21-d NOAEC	20	--	31	47495001 -- 46823301
Estuarine/Marine Invertebrates (Water-Column Exposure)						
Acute	<u>Thiram</u> : Mysid Shrimp (<i>Americamysis bahia</i>) <u>Ferbam</u> : Pink Shrimp (<i>Penaeus duorarum</i>) <u>Ziram</u> : Mysid Shrimp (<i>A. bahia</i>)	96-hr LC ₅₀ 48-hr LC ₅₀ 96-hr LC ₅₀	3.36	(>23000)	11-110	42488302 40228401 43781603/ 47405702

Study Type	Test Species	Toxicity Value				MRID or ECOTOX No.
		Endpoint	µg thiram a.i./L	Conv. from µg Feq/L to µg thiram eq./L ¹	Conv. from µg Zeq/L to µg thiram eq./L ²	
Acute (Larval development)	<u>Thiram</u> : Pacific Oyster (<i>Crassostrea gigas</i>) <u>Ferbam</u> : Eastern Oyster (<i>C. virginica</i>) <u>Ziram</u> : Pacific Oyster (<i>C. gigas</i>)	48-hr EC ₅₀ 96-hr LC ₅₀ 96-hr LC ₅₀	4.7	30	61	42488301 40228401 43781602
Chronic	<u>Thiram</u> : No Data <u>Ferbam and Ziram</u> : Mysid Shrimp (<i>A. bahia</i>)	-- 28-d NOAEC 27-d NOAEC	--	<0.69	13	-- 47784401 46893103
Aquatic Plants and Algae						
Vascular	<u>Thiram</u> : Duckweed (<i>Lemna gibba</i>) <u>Ferbam</u> : No Data <u>Ziram</u> : Duckweed (<i>L. gibba</i>)	7-d IC ₅₀	1600	--	291	45441202 -- 46823302
Non-vascular	<u>Thiram</u> : Green Algae (<i>Pseudo-kirchneriella subcapitata</i>) <u>Ferbam</u> : No Data <u>Ziram</u> : Green Algae (<i>P. subcapitata</i>)	120-hr IC ₅₀	140	--	53	44086101, 44086001 -- 43833901

Feq = Ferbam equivalents (see footnote¹ below); Zeq = Ziram equivalents (see footnote² below); a.i.=active ingredient; hr = hour, d = day, wk = week; NOAEC and LOAEC = no- and lowest-observed adverse effects concentration; LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

>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.

¹Thiram equivalents calculated from ferbam a.i. data using molecular wt. ratio (240.43/416.49).

²Thiram equivalents calculated from ziram a.i. data using molecular wt. ratio (240.43/305.8).

6.2 Terrestrial Toxicity

The available data indicate that thiram (**Table 6-5**, also see **Table C-1-4** in **Appendix C**), ferbam (**Table 6-6**, also see **Table C-1-5**), and ziram (**Table 6-7**, also see **Table C-1-6**) TGAs are slightly toxic to moderately toxic to birds and mammals on an acute exposure basis to the most sensitive species for which information is available.

The full range of available bird data (2-7 species for each chemical) is presented in **Appendix C**, **Tables C-3-1** to **C-3-3**. No clear difference was observed between passerine species vs. other species tested, with one possible exception that in ziram dietary acute studies, the zebra finch (*Taeniopygia guttata*, a passerine) was more sensitive than the bobwhite quail (*Colinus virginianus*) or mallard duck (*Anas platyrhynchos*) with an LC₅₀ of 594 mg zeq/kg-diet (MRID 50939501) compared with LC₅₀s of >5200 to 5160 mg zeq/kg-diet (MRIDs 42386301 and

42386302). However, at least a portion of the zebra finch toxicity may have been due to starvation, rather than inherent ziram toxicity. The zebra finch study was originally planned to be an oral dose study (OCSPP 850.2100) but due to regurgitation in the range finding study was modified to be a dietary study (OCSPP 850.2200) with dietary-based sub-acute endpoints calculated. The dietary-based endpoint was more sensitive than those for the mallard and bobwhite. In the definitive dietary study food avoidance especially in the higher treatments was evident, with <1g/bird/day consumed in the three highest treatments. Therefore, some mortality may have been due to starvation; this could not be determined from the study report, and so uncertainty is acknowledged due to the possibility that not all mortality in the finch study was from frank toxicity but may have also been due to severe food avoidance. Nonetheless, the finch endpoint is used for ziram dietary acute risk calculations.

For thiram and ferbam acute risk calculations, a ring-neck pheasant (*Phasianus colchicus*) LD₅₀ of 673 mg thiram a.i./kg-bw (MRID 00160000) was the most sensitive endpoint for both chemicals. This was from a thiram study. Bobwhite quail sub-acute dietary LC_{50s} of 3950 mg thiram a.i./kg-diet (MRID 00022293) and 2940 mg ferbam a.i.(feq)/kg-diet (MRID 00106146) were the most sensitive dietary endpoints from thiram and ferbam studies, respectively. As with the aquatic endpoints, when thiram endpoints are used for ferbam or ziram risk calculations, they are molecular weight adjusted to equivalents of those compounds.

Chronic (also including sub-chronic) avian toxicity data were available for thiram and ziram, but not ferbam. The NOAECs for thiram and ziram were generally one to two orders-of-magnitude more sensitive than the acute dietary LC_{50s}.

A thiram chronic study with the mallard was available in which NOAEC and LOAEC of 9.6 and 39.7 mg thiram a.i./kg-diet were determined based on significant (p<0.05) reductions in eggs set (35%), viable embryos (46%), live 3-week embryos (46%), normal hatchlings (56%), 14-d survivors (56%), eggs set/eggs laid (11%), normal hatchlings/live 3-week embryos (22%), normal hatchlings/eggs laid (26%). This was the most sensitive avian chronic endpoint for use in risk calculations for all three chemicals.

Although there is a range of toxicity data for the rat (*Rattus norvegicus*) based on studies used in the past and those that are more recent (**Appendix C, Tables C-3-4 to C-3-6**), a full range of data for mammals is not included here but endpoints are selected in coordination with the Health Effects Division. The summary of most-sensitive mammalian endpoints for each chemical are found in **Appendix C, Tables C-1-4 through C-1-5**, as with the bird data). In general, ziram was the most toxic (moderately toxic), and ferbam the least toxic (practically non-toxic), of the three with thiram categorized as slightly toxic based on acute dosing studies. Similarly, inhalation studies were available for all three chemicals, with ziram being the most toxic and ferbam the least. For acute risk calculations, the thiram rat (*Rattus norvegicus*) LD₅₀ of 1800 mg thiram a.i./kg-bw (MRID 00153548) was the most sensitive endpoint for all three chemicals.

Chronic, two-generation studies were available for thiram and ziram but not ferbam. Laboratory rats fed diets containing thiram (NOAEC/ LOAEC of 20/ 60 mg thiram a.i./kg-diet; corresponding to dose-based NOAEL/ LOAEL of 2/ 5 mg thiram a.i./kg-bw/day, MRID 42095901) had a decreased body weight of the F1 and F2 generations. Rats fed diets containing ziram (dose-based NOAEL/ LOAEL of 14.8/ 37.5 mg zeq/kg-bw/day, MRID 43935801) had significant reductions in F0 and F1 generation body weights, body-weight gains, and food consumption. Although ziram was more toxic on an acute basis, thiram was more toxic on a chronic basis, and so thiram data were used to assess chronic risk for all three chemicals.

A full suite of honey bee data were available for thiram, but only acute contact data for ferbam. For ziram, toxicity data were available with adult bees, but not for larval bees due to stability problems with ziram in the larval food matrix, so the thiram data are used to assess risk to larva from ziram exposure. The two compounds had similar toxicity to honey bee adults, and while it is unclear if that holds true for larvae, the rapid breakdown of ziram to thiram suggests that evaluating ziram exposure to larvae using thiram toxicity data is a reasonable approach. Similarly, for ferbam, thiram data are used for risk assessment. The single acute contact datapoint with ferbam was non-definitive (>) and did not provide a good comparison of ferbam and thiram toxicity to the honey bee given the disparity of tested doses. On an acute contact and oral basis, all three chemicals are practically non-toxic to the adult honey bee, although ferbam data were only for contact exposure (see **Appendix C, Tables C-1-4** through **C-1-5** for the most sensitive endpoints, and **Tables C-3-7a** and **C-3-7b** for more detail on all available honey bee studies). However, a single-dose larval study with thiram (MRID 50940001) showed thiram to be highly toxic to larva with an LD₅₀ of 0.28 µg thiram a.i./larva (dietary concentration of 8.2 mg a.i./kg-diet). Other studies available for thiram included a 10-day adult chronic toxicity study (MRID 50273402) with a NOAEL/ LOAEL of 4.32/ >4.32 µg a.i./bee (120/ >120 mg a.i./kg-diet) based on no effects to mortality or food consumption; and a 22-day larval chronic study (MRID 50669901) with a NOAEL/ LOAEL of 0.0254/ 0.0757 µg a.i./larvae/day (0.661/ 1.97 mg a.i./kg-diet) based on significant (p<0.05) 20% reductions in survival and emergence. For ziram, a 10-day adult chronic toxicity study (MRID 50294102) had a NOAEL/ LOAEL of 4.9/ 8.5 µg zeq/bee/day based on significant (p<0.05) 16.7% mortality.

For thiram, Tier II studies submitted included a 22-day honey bee brood feeding study (single day exposure; MRID 50273403) and a 26-day (7-day exposure) semi-field brood study (tunnel study; MRID 50273404 and 50273405). The 22-day brood feeding study showed a significant (p<0.05) 51.8% increase in termination rate of eggs at dietary exposure to 3180 mg a.i./kg-diet (NOAEL <3180 mg a.i./kg-diet; LOAEL ≤3180 mg a.i./kg-diet), with no effects to mortality, larval development, or behavior at that exposure. The 26-day tunnel study showed no effects to survival, development, or brood parameters (NOAEL≥2.5 lb a.i./acre).

For ziram, Tier II studies were submitted. These included a 22-day honey bee brood feeding study (single day of exposure; MRID 50294103) and a 26-day (7-day exposure) semi-field brood study (tunnel study; MRID 50294104 and 50294105). The 22-day brood feeding study showed significant (p<0.05) 22.6% increase in termination rate of eggs at dietary exposure to 2300 mg a.i./L-diet (2300 ppm or mg a.i./kg-diet assuming the weight of water for the sugar solution)

and equivalent to 1.36 lb a.i./acre. The 26-day tunnel study showed no effects to survival, development, or brood parameters (NOAEL $\geq$ 2.03 lb a.i./acre).

The available data for terrestrial plants exposed to formulated products of either thiram (71.0% a.i.) or ziram (76.6% a.i.), indicate that neither thiram nor ziram cause measurable effects to seedling emergence or growth from exposure to seeds in treated soils, or to plant growth and survival from direct exposure to foliage, at application rates equivalent to 4.1-4.6 lbs thiram a.i./A and 6.0-6.1lbs zeq/A. In the thiram studies (MRIDs 50835301 and 50830201), sugarbeet had significant ($p<0.05$) 32% reduction in survival and emergence and cabbage had significant ($p<0.05$) 16% reduction in dry weight in the Tier I part of each respective study, but then in Tier II of both studies had no significant effects. No ferbam terrestrial plant data were available.

The most sensitive terrestrial toxicity endpoints for thiram for use in risk calculations are presented in **Table 6-5**. For ferbam and ziram, as explained above, a TR approach was used due to rapid breakdown, in which the more sensitive endpoint of either parent or the thiram degradate was chosen for use. Due to generally higher toxicity and a more complete dataset, the thiram endpoints are largely used for ferbam risk calculations, with the exception of a ferbam bobwhite dietary acute endpoint which was more sensitive than the thiram one, and is used for ferbam risk calculation, and a ferbam honey bee acute contact endpoint which was non-definitive and is included for ferbam characterization in case ferbam may be more toxic to bees on an acute basis (**Table 6-6**). **Table 6-7** contains the most sensitive terrestrial toxicity values for ferbam and ziram, respectively, which are based on parent or thiram endpoints depending on which was more sensitive.

Table 6-8 shows a direct comparison of toxicities of the three chemicals as much as available data allows. The most sensitive endpoints for ferbam and ziram are converted to thiram equivalents and compared with the most sensitive thiram endpoints. More complete information for the endpoints presented here can be found in **Appendix C, Tables C-1-4, C-1-5, and C-1-6**. Toxicity data with birds and mammals (**Table 6-8**) suggest that on an acute basis, ziram may be more toxic than thiram although it is not clear whether the difference in sensitivities are due to the chemical or species differences, especially with birds because the species differed for both acute oral (ring-neck pheasant vs. bobwhite) and passerine dietary (canary vs. zebra finch) data. However, the rat was also more sensitive to ziram on an acute oral basis (with ziram being approximately 8 times more toxic) but was slightly less sensitive to ziram than thiram on a chronic basis, which may be expected since chronic exposures depend more on ziram breaking down to thiram. For terrestrial invertebrates (using honey bee data) and plants, the endpoints were generally non-definitive and thus impossible to compare. For ferbam, acute and chronic bird data and chronic rat data show it to be at least as toxic as thiram, and possibly more toxic, though less toxic to the rat on an acute basis. Overall, the three compounds appear to be similarly toxic, although there is some suggestion that ziram, and possibly thiram, are more toxic to terrestrial vertebrates on an acute exposure basis.

Table 6-5. Terrestrial Toxicity Endpoints Selected for Risk Estimation for Thiram

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ expressed as thiram a.i.	MRID or ECOTOX No./ Classification	Comments
Birds (Surrogates for Terrestrial Amphibians and Reptiles)					
Acute Oral	Thiram TGA1 (99.0%)	Ring-neck Pheasant (<i>Phasianus colchicus</i>)	14-d (single dose) LD ₅₀ = 673 mg a.i./kg-bw	00160000 Supplemental/ Quantitative	Slightly toxic. Supplemental due to non-standard species and lack of raw data.
	Thiram TGA1 (% unknown)	Passerine: Red-wing Blackbird (<i>Agelaius phoeniceus</i>)	(Single dose) LD ₅₀ >100 mg a.i./kg-bw ²	00073683, 00020560 Supplemental/ Quantitative	Included for characterization. Supplemental due to non-standard species and lack of raw data.
Sub-acute Dietary	Thiram TGA1 (95.0%)	Bobwhite Quail (<i>Colinus virginianus</i>)	LC ₅₀ = 3950 mg a.i./kg-diet ²	00022293 Acceptable	Slightly toxic.
Chronic	Thiram TGA1 (98.7%)	Mallard Duck (<i>Anas platyrhynchos</i>)	23-wk NOAEC = 9.6 LOAEC = 39.7 mg a.i./kg-diet (Reproduction and survival)	45441201 Acceptable	Based on significant (p<0.05) reductions in eggs set (35%), viable embryos (46%), live 3-week embryos (46%), normal hatchlings (56%), 14-d survivors (56%), eggs set/eggs laid (11%), normal hatchlings/live 3-week embryos (22%), normal hatchlings/eggs laid (26%).
Mammals					
Acute Oral	Thiram TGA1 (99.0%)	Laboratory Rat (<i>Rattus norvegicus</i>)	LD ₅₀ = 1800 mg/kg-bw	00153548 Acceptable	Slightly toxic.
Chronic (2-generation reproduction)	Thiram TGA1 (100%)	Laboratory Rat (<i>R. norvegicus</i>)	NOAEL = 2 LOAEL = 5 mg a.i./kg-bw/day (F1 & F2 body weight)	42095901 Acceptable	Significant reductions in F1 and F2 body weight (NOAEC/ LOAEC: 20 and 60 mg a.i./kg-diet; 35 and 100 mg feq/kg-diet)
Terrestrial Invertebrates					
Acute contact (adult)	Thiram TGA1 (% unknown)	Honey Bee (<i>Apis mellifera</i> L.)	48-hr LD ₅₀ = 73.7 µg a.i./bee	00036935 Acceptable	Practically non-toxic.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ expressed as thiram a.i.	MRID or ECOTOX No./ Classification	Comments
Acute oral (adult)	Thiram TGAI 98.8% a.i.	Honey Bee (<i>A. mellifera</i>)	48-hr LD ₅₀ >106 µg a.i./bee	50273401 ^N Acceptable	Practically non-toxic
Chronic oral (adult)	Thiram TGAI (98.8%).	Honey Bee (<i>A. mellifera</i>)	10-d NOAEL ≥4.32 LOAEL >4.32 µg a.i./bee/day (No effect)	50273402 ^N Supplemental/ Quantitative	Based on no significant effects to mortality or food consumption. The results are nominal, but dose was adjusted for food consumption and purity and are quantitatively usable.
Acute oral (larval)	Thiram TGAI (98.08%).	Honey Bee (<i>A. mellifera</i>)	7-d (single dose) LD ₅₀ = 0.28 µg a.i./larvae	50940001 ^N Acceptable	Highly toxic.
Chronic oral (larval)	Thiram TGAI (98.2%)	Honey Bee (<i>A. mellifera</i>)	22-d NOAEL = 0.0254 LOAEL = 0.0757 µg a.i./larvae/day (Emergence)	50669901 ^N Acceptable	Based on significant (p<0.05) 20% reduction in emergence (NOAEC/LOAEC = 0.661/1.97 mg a.i./kg-diet).
Semi-field study	Thiram TEP (79.6%)	Honey Bee (<i>A. mellifera</i>)	22-d (1-d exposure) NOAEC <3,180,000 µg a.i./L NOAEL <3180 mg a.i./kg-diet (Egg termination rate)	50273403 ^N Supplemental/ Quantitative	Based on significant (p<0.05) 51.8% increase in termination rate of eggs. No effects were found in mortality, larval development, or behavior at 3180 mg a.i./kg-diet. Information (e.g., analytical confirmation and nectar quantities) was insufficient for a fully acceptable colony feeding study.
Semi-field study	Thiram TEP (79.6%)	Honey Bee (<i>A. mellifera</i>)	26-d (7-d exposure) NOAEL ≥2.5 lb a.i./acre (No effects)	50273404 ^N and 50273405 ^N Supplemental/ Quantitative	Based on no effects to survival, development, or brood parameters. Information (e.g., analytical confirmation) provided insufficient for a fully acceptable study (also low replication).

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ expressed as thiram a.i.	MRID or ECOTOX No./ Classification	Comments
Terrestrial and Wetland Plants					
Seedling Emergence	Thiram TEP (71.0%)	Various species (Monocots tested: corn, oat, onion, ryegrass; Dicots tested: bean, cabbage, cucumber, soybean, sugarbeet, tomato)	21-d Monocots (All Spp., Tier I): IC ₂₅ >4.6 lb a.i./acre (No effects) Dicots (Sugarbeet, Tier II): IC ₂₅ >4.1 lb a.i./acre (Emergence)	50835301 ^N Acceptable	Sugarbeet had significant (p<0.05) 32% reduction in survival and emergence in the Tier I part of the study, but then in Tier II had no significant effects. Endpoints based on measured amounts.
Vegetative Vigor	Thiram TEP (71.0%)	Various species (Monocots tested: corn, oat, onion, ryegrass; Dicots tested: bean, cabbage, cucumber, soybean, sugarbeet, tomato)	21-d Monocots (All Spp., Tier I): IC ₂₅ >4.6 lb a.i./acre (No effects) Dicots (Cabbage, Tier II): IC ₂₅ >4.1 lb a.i./acre (Dry wt.)	50830201 ^N Acceptable	Cabbage had significant (p<0.05) 16% reduction in dry weight in the Tier I part of the study, but then in Tier II had no significant effects. Endpoints based on measured amounts

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.

>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.

¹ NOAEC and LOAEC are reported in the same units.

² An acceptable dietary acute study with a passerine is also available, 50835201^N, but is less sensitive than the quail study. It has an LC₅₀ of >4240 mg a.i./kg-diet and an EC₅₀ for food consumption of >4240 mg a.i./kg-diet. Therefore, the uncertainty of the lower acute oral blackbird endpoint is greatly lessened but kept in the table for characterization.

Table 6-6. Terrestrial Toxicity Endpoints Selected for Risk Estimation for Ferbam

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ expressed as feq ¹	MRID or ECOTOX No./ Classification	Comments
Birds (Surrogates for Terrestrial Amphibians and Reptiles)					
Acute Oral	Thiram TGA1 (99.0%)	Ring-neck Pheasant (<i>Phasianus colchicus</i>)	14-d (single dose) LD ₅₀ = 1170 mg feq/kg-bw	00160000 Supplemental/ Quantitative	Slightly toxic. Supplemental due to non-standard species and lack of raw data.
	Thiram TGA1 (% unknown)	Passerine: Red-wing Blackbird (<i>Agelaius phoeniceus</i>)	(Single dose) LD ₅₀ >170 mg feq/kg-bw ²	00073683, 00020560 Supplemental/ Quantitative	Included for characterization. Supplemental due to non-standard species and lack of raw data.
Sub-acute dietary	Ferbam TGA1 (% unknown)	Bobwhite Quail (<i>Colinus virginianus</i>)	LC ₅₀ = 2940 mg feq/kg-diet ³ (Slightly toxic)	00106146 Supplemental/ Quantitative	Slightly toxic. Information insufficient (lack of raw data) for full acceptability. Used for ferbam.
Chronic	Thiram TGA1 (98.7%)	Mallard Duck (<i>Anas platyrhynchos</i>)	23-wk NOAEC = 17 LOAEC = 68.8 mg feq/kg-diet (Reproduction and survival)	45441201 Acceptable	Based on significant (p<0.05) reductions in eggs set (35%), viable embryos (46%), live 3-week embryos (46%), normal hatchlings (56%), 14-d survivors (56%), eggs set/eggs laid (11%), normal hatchlings/live 3-week embryos (22%), normal hatchlings/eggs laid (26%).
Mammals					
Acute Oral	Thiram TGA1 (99.0%)	Laboratory Rat (<i>Rattus norvegicus</i>)	LD ₅₀ = 3100 mg feq/kg-bw	00153548 Acceptable	Slightly toxic.
Chronic (2-generation reproduction)	Thiram TGA1 (100%)	Laboratory Rat (<i>R. norvegicus</i>)	NOAEL = 3 LOAEL = 9 mg feq/kg-bw/day (F1 & F2 body weight)	42095901 Acceptable	Significant reductions in F1 and F2 body weight (NOAEC/ LOAEC: 20 and 60 mg a.i./kg-diet; 35 and 100 mg feq/kg-diet)
Terrestrial Invertebrates					
Acute contact (adult)	Ferbam TEP (% unknown)	Honey bee (<i>Apis mellifera</i> L.)	48-hr LD ₅₀ ->12.1 µg feq/bee ³	00036935 Acceptable	Practically nontoxic. Included for ferbam characterization.
	Thiram TGA1 (% unknown)	Honey Bee (<i>Apis mellifera</i> L.)	48-hr LD ₅₀ = 128 µg feq/bee	00036935 Acceptable	Practically non-toxic.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ expressed as feq ¹	MRID or ECOTOX No./ Classification	Comments
Acute oral (adult)	Thiram TGAI 98.8% a.i.	Honey Bee (<i>A. mellifera</i>)	48-hr LD ₅₀ >184 µg feq/bee	50273401 ^N Acceptable	Practically non-toxic
Chronic oral (adult)	Thiram TGAI (98.8%).	Honey Bee (<i>A. mellifera</i>)	10-d NOAEL ≥7.48) LOAEL >7.48 µg feq/bee/day (No effect)	50273402 ^N Supplemental/ Quantitative	Based on no significant effects to mortality or food consumption. The results are nominal, but dose was adjusted for food consumption and purity and are quantitatively usable.
Acute oral (larval)	Thiram TGAI (98.08%).	Honey Bee (<i>A. mellifera</i>)	7-d (single dose) LD ₅₀ = 0.49 µg feq/larvae	50940001 ^N Acceptable	Highly toxic.
Chronic oral (larval)	Thiram TGAI (98.2%)	Honey Bee (<i>A. mellifera</i>)	22-d NOAEL = 0.0440 LOAEL = 0.131 µg feq/larvae/day (Emergence)	50669901 ^N Acceptable	Based on significant (p<0.05) 20% reduction in emergence (NOAEC/ LOAEC = 1.15/3.41 mgfeq/kg-diet).
Semi-field study	Thiram TEP (79.6%)	Honey Bee (<i>A. mellifera</i>)	22-d (1-d exposure) NOAEC <5,510,000 µg feq/L NOAEL <5510 mg feq/kg-diet (Egg termination rate)	50273403 ^N Supplemental/ Quantitative	Based on significant (p<0.05) 51.8% increase in termination rate of eggs. No effects were found in mortality, larval development, or behavior at exposure, also 3180 mg a.i./kg-diet. Information (e.g., analytical confirmation and nectar quantities) was insufficient for a fully acceptable colony feeding study.
Semi-field study	Thiram TEP (79.6%)	Honey Bee (<i>A. mellifera</i>)	26-d (7-d exposure) NOAEL ≥4.3 lb feq/acre (No effects)	50273404 ^N and 50273405 ^N Supplemental/ Quantitative	Based on no effects to survival, development, or brood parameters. Information (e.g., analytical confirmation) provided insufficient for a fully acceptable study (also low replication).

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ expressed as feq ¹	MRID or ECOTOX No./ Classification	Comments
Terrestrial and Wetland Plants					
Seedling Emergence	Thiram TEP (71.0%)	Various species (Monocots tested: corn, oat, onion, ryegrass; Dicots tested: bean, cabbage, cucumber, soybean, sugarbeet, tomato)	21-d Monocots (All Spp., Tier I): IC ₂₅ >8.0 lb feq/acre (No effects) Dicots (Sugarbeet, Tier II): IC ₂₅ >7.1 lb feq/acre (Emergence)	50835301 ^N Acceptable	Sugarbeet had significant (p<0.05) 32% reduction in survival and emergence in the Tier I part of the study, but then in Tier II had no significant effects. Endpoints based on measured amounts.
Vegetative Vigor	Thiram TEP (71.0%)	Various species (Monocots tested: corn, oat, onion, ryegrass; Dicots tested: bean, cabbage, cucumber, soybean, sugarbeet, tomato)	21-d Monocots (All Spp., Tier I): IC ₂₅ >8.0 lb feq/acre (No effects) Dicots (Cabbage, Tier II): IC ₂₅ >7.1 lb feq/acre (Dry wt.)	50830201 ^N Acceptable	Cabbage had significant (p<0.05) 16% reduction in dry weight in the Tier I part of the study, but then in Tier II had no significant effects. Endpoints based on measured amounts

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

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

>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.

¹ NOAEC and LOAEC are reported in the same units. All endpoints are reported as ferbam equivalents (feq). For studies conducted with thiram, reported thiram toxicity endpoint was converted to feq by multiplying by the ratio of molecular weights (416.49/240.43).

² An acceptable dietary acute study with a passerine is also available, 50835201^N, but is less sensitive than the quail study. It has an LC₅₀ of >4240 mg a.i./kg-diet and an EC₅₀ for food consumption of >4240 mg a.i./kg-diet. Therefore, the uncertainty of the lower acute oral blackbird endpoint is greatly lessened but kept in the table for characterization.

³Two studies available for ferbam were more sensitive than thiram studies and it is not clear whether the higher toxicity is due to ferbam toxicity or to thiram toxicity and the endpoint variability is within the range of thiram toxicity variability. In the case of honey bee contact, ferbam could potentially be more toxic, but this was impossible to tell because the study was non-definitive and tested doses below the those tested in the thiram study. In these cases, thiram endpoints were calculated from the ferbam data and the data were included for ferbam risk characterization.

Table 6-7. Terrestrial Toxicity Endpoints Selected for Risk Estimation for Ziram and Degradate, Thiram

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ (expressed as zeq) ²	MRID or ECOTOX No./ Classification	Comments
Birds (Surrogates for Terrestrial Amphibians and Reptiles)					
Acute Oral	Ziram TGAI (98.5%)	Bobwhite quail (<i>Colinus virginianus</i>)	14-d (single dose) LD ₅₀ = 97 mg zeq/kg-bw	41725701 Acceptable	Moderately toxic.
Sub-acute dietary	Ziram TGAI (93.6%)	Zebra Finch (<i>T. guttata</i>)	8-d LC ₅₀ = 594 (417 to 797) mg zeq/kg-diet	50939501 ^N Supplemental (Quantitative)	Moderately toxic. As described above, food avoidance occurred and so some mortality could have been due to starvation. The dietary endpoint is quantitatively usable. ⁴
Chronic	Thiram TGAI (98.7%)	Mallard duck (<i>Anas platyrhynchos</i>)	23-wk NOAEC = 12 LOAEC = 50.5 (mg/kg-diet) (Reproduction and survival)	45441201 Acceptable	Based on significant (p<0.05) reductions in eggs set (35%), viable embryos (46%), live 3-week embryos (46%), normal hatchlings (56%), 14-d survivors (56%), eggs set/eggs laid (11%), normal hatchlings/live 3-week embryos (22%), normal hatchlings/eggs laid (26%).
Mammals					
Acute Oral	Ziram TGAI (98.5%)	Laboratory rat (<i>Rattus norvegicus</i>)	LD ₅₀ = 267 mg zeq/kg-bw	41340401 Acceptable	Moderately toxic. LD ₅₀ for females; for combined sexes the LD ₅₀ is 320 mg zeq/kg-bw.
Chronic (2-generation reproduction)	Thiram TGAI (100%)	Laboratory rat (<i>R. norvegicus</i>)	NOAEL = 3 LOAEL = 6 (mg/kg-bw/day) (F0 and F1 weight)	42095901 Acceptable	Based on decreased body weight of the F1 and F2 generations (NOAEC/ LOAEC: 25 and 76 mg zeq/kg-diet).
Terrestrial Invertebrates					
Acute contact (adult)	Thiram TGAI (% unknown)	Honey bee (<i>Apis mellifera</i> L.)	48-hr LD ₅₀ = 93.8 (µg zeq/bee)	00036935 Acceptable	Practically nontoxic.
Acute oral (adult)	Ziram TGAI (98.7%)	Honey bee (<i>A. mellifera</i>)	48-hr LD ₅₀ >105 µg zeq/bee	50294101 Acceptable	Practically nontoxic.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ (expressed as zeq) ²	MRID or ECOTOX No./ Classification	Comments
Chronic oral (adult)	Ziram TEP (76.5%)	Honey bee (<i>A. mellifera</i>)	10-d NOAEL = 4.9 LOAEL = 8.5 µg zeq/bee/day (Mortality)	50294102 ^N Supplemental/ Quantitative	Based on significant (p<0.05) 16.7% mortality. The results are nominal, but dose was adjusted for food consumption and purity.
Acute oral (larval)	Thiram TGAi (98.08%).	Honey bee (<i>A. mellifera</i>)	7-d (single dose) LD ₅₀ = 0.36 (µg/larvae)	50940001 ^N Acceptable	Highly toxic.
Chronic oral (larval)	Thiram TGAi (98.2%)	Honey bee (<i>A. mellifera</i>)	22-d NOAEL = 0.0323 LOAEL = 0.0963 (µg/larvae/day) (Emergence)	50669901 ^N Acceptable	Based on significant (p<0.05) 20% reduction in emergence.
Foliage Residue	No data available				
Semi-field study	Ziram TEP (76.7%)	Honey bee (<i>A. mellifera</i>)	22-d (1-d exposure) NOAEC <2,300,000 µg a.i./L -diet (sugar soln.) (Egg termination rate)	50294103 ^N Supplemental/ Quantitative	Based on significantly (p<0.05) higher (22.6%) mean termination rates of eggs. Information provided was insufficient (eg., analytical verification) for a fully acceptable study.
Semi-field study	Ziram TEP (76.5%) and TGAi (98.2%)	Honey bee (<i>A. mellifera</i>)	26-d (7-d exposure) NOAEL = 2.03 lb zeq/acre (No effects)	50294104 ^N and 50294105 ^N Supplemental/ Quantitative	Based on no effects to survival, development, or brood parameters. Information provided was insufficient (eg., analytical verification) for a fully acceptable study.
Terrestrial and Wetland Plants					
Seedling Emergence	Ziram TEP (76.6%)	Various species	Monocots (Most Sensitive Species not identified): IC ₂₅ >6.0 lb zeq/acre; NOAEC ≥6.0 lb zeq/acre (No effects) Dicots (Soybean): IC ₂₅ >6.0 lb zeq/acre; NOAEC <6.0 lb zeq/acre (Height)	46893101 Acceptable	

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹ (expressed as zeq) ²	MRID or ECOTOX No./ Classification	Comments
Vegetative Vigor	Ziram TEP (76.6%)	Various species	Monocots (Ryegrass): IC ₂₅ >6.1 lb zeq/acre; NOAEC <6.1 lb zeq/acre (Dry weight) Dicots (Tomato): IC ₂₅ >6.1 lb zeq/acre; NOAEC <6.1 lb zeq/acre (Dry weight)	46893102 Acceptable	

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.

>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.

¹ NOAEC and LOAEC are reported in the same units.

² All endpoints are reported as ziram equivalents (zeq). For studies conducted with thiram, reported thiram toxicity endpoint was converted to zeq by multiplying by the ratio of molecular weights (305.8/240.43).

³ The range finding study for this was initially designed as a dose-based study (OCSPP 850.2100). However, due to regurgitation, a dietary-based study (OCSPP 850.2200) was undertaken. This is consistent with EFED recommendations for passerines. In the definitive dietary study food avoidance was evident and because of this avoidance, calculating a dose from the consumed food did not follow the increasing gradient of exposure of the dietary concentrations. Therefore, the actual endpoint has uncertainties but can be used quantitatively as a dietary-based and a dose-based endpoint to calculate and characterize risk. Due to multiple uncertainties, the study is classified as Supplemental. The dose-based endpoint is calculated as mg a.i./kg-bw/day and is a conservative screening estimate of the dose-based LD50 due to multiple days of dosing which were conservatively attributed to a single (daily) dose.

⁴ Finches in the study also had significant reductions in body weight for the 649 and 1233 mg ai/kg diet treatment groups. During the exposure period, the study author found significant reductions in food consumption for all treatment groups. During the post-exposure period, a significant increase in food consumption was noted in the 317 mg ai/kg diet treatment group. Finches also exhibited clinical signs of toxicity including piloerection, wing drop, hyperactivity, asthenia, and lethargy were observed. Gross necropsies found birds were emaciated and had black material in the gastrointestinal tract. Several birds had feathers on the abdomen and surrounding vent that were coated in dark red-brown feces while other birds had black material in the lungs. Gross necropsies of several surviving birds revealed no remarkable findings.

Table 6-8. Comparison of Most Sensitive Terrestrial Toxicity Endpoints for Thiram, Ferbam, and Ziram Expressed as Thiram Equivalents

Study Type	Test Species	Toxicity Value ¹				MRID or ECOTOX No.
		Endpoint (units) (chronic effect)	As thiram a.i.	Conv. from ferbam equivalents to thiram eq. ¹	Conv. from ziram equivalents to µg thiram eq. ²	
Birds (Surrogates for Terrestrial Amphibians and Reptiles)						
Acute Oral	Thiram: Ring-neck Pheasant (<i>Phasianus colchicus</i>) Ferbam: No Data Ziram: Bobwhite quail (<i>Colinus virginianus</i>)	14-d (single dose) LD ₅₀ (mg/kg-bw)	673	--	76	00160000 -- 41725701
Sub-acute dietary	Thiram and Ferbam: Bobwhite quail (<i>Colinus virginianus</i>) Ziram: Only passerine data below	~ 8-d LC ₅₀ (mg/kg-diet) ²	3950	1700	--	00022293 00106146 --
	Passerine: Thiram: Canary (<i>Serinus canaria</i>) Ferbam: No Data Ziram: Zebra Finch (<i>Taeniopygia guttata</i>)	8-d LC ₅₀ (mg/kg-diet) ²	>4240	--	467	50835201 -- 50939501
Chronic	Thiram: Mallard duck (<i>Anas platy-rhynchos</i>) Ferbam: No Data Ziram: Mallard duck (<i>A. platy-rhynchos</i>)	20-23-wk NOAEC (mg/kg-diet)	9.6	0.23	12	45441201 -- 47286501
Mammals						
Acute Oral	Thiram, Ferbam, and Ziram: Laboratory rat (<i>Rattus norvegicus</i>)	LD ₅₀ (mg/kg-bw)	1800	>2900	210	00153548 40561501 41340401
Chronic (2-generation repro-duction)		NOAEL (mg/kg-bw/day)	2	0.23	12	42095901 41508101 43935801
Terrestrial Invertebrates						
Acute contact (adult)	Thiram and Ziram (Ferbam contact study was TEP and not included here): Honey bee (<i>Apis mellifera</i> L.)	48-hr LD ₅₀ (µg/bee)	73.7	--	>160	00036935 -- 41667901
Acute oral (adult)		48-hr LD ₅₀ (µg/bee)	>106	--	>83	50273401 -- 50294101
Chronic oral (adult)		10-d NOAEL (µg/bee/day)	≥4.32	--	3.9	50273402 -- 50294102

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient; hr = hour, d = day, wk = week; NOAEC(L) and LOAEC(L) = no- and lowest-observed adverse effects concentration (or level); LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group. >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.

¹Thiram equivalents calculated from ferbam a.i. data using molecular wt. ratio (240.43/416.49).

²Thiram equivalents calculated from ziram a.i. data using molecular wt. ratio (240.43/305.8).

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 June 30, 2020. **Table 6-9** provides a listing of the available incident data with a likelihood index of Possible or better. These are also discussed in more detail in the risk assessment sections below.

The respective problem formulations describe two incidents for thiram (one fish and one bird incident) and one (plant damage) incident for ziram. The thiram fish incident, I025285-001, occurred in Indiana in 1999, when 4.6 million fish over 50 miles were killed as a result of an intentional misuse involving discharge into a river. This incident was attributed to thiram exposure with “highly probable” certainty. Because this does not involve a registered use, it does not provide evidence for non-target species effects but does show the potential for toxicity to aquatic organisms at high exposure levels. A bird incident, I005754-012, was considered unlikely to have been caused by thiram exposure, and therefore is not used to support risk conclusions. An additional incident was found for thiram, I026798-00014, involving a bee kill, but several other pesticides (including: carbaryl, carbathiin, clothianidin, difenoconazole, fludioxonil, metalaxyl, and thiamethoxam) were involved and thiram certainty was determined to be “unlikely,” and so was not included in the table. For ziram, one terrestrial plant incident in California attributed to ziram with “possible” certainty. Incident I013563-012 occurred in 1999 when a registered agricultural use of ziram was applied to apricots, along with the fungicide fenbuconazole. Forty acres of apricots were damaged by visible residue, resulting in a loss of yield.

Based on information in IDS, no aggregate incidents involving wildlife, plants, or other non-target (category associated with bee incidents) were reported by registrants for thiram or ferbam, while one plant incident was reported involving ziram (**Table 6-10**).

EPA's changes in the registrant reporting requirements for incidents in 1998 may account for a reduced number of non-aggregated reported incidents. Registrants are now only required to submit detailed information on "major" fish, wildlife, and plant incidents. Minor fish, wildlife, and plant incidents, as well as all other non-target incidents, are generally reported aggregately.

Table 6-9. Thiram and Ziram 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
Thiram Incidents								
Fish								
I025285-001	1999	IN	Unknown	Misuse (Intentional)	Highly Probable	Discharge into river	Fish	4.6 million fish over 50 miles killed
Ferbam Incidents								
None found								
Ziram Incidents								
Plant								
I013563-012	1999	CA	Ziram: also involved fungicide, fenbuconazole	Registered use (6 lb/acre)	Possible	Aerial spray to apricots	Apricots	40 acres damaged; visible residue on fruit resulting in loss of yield

Table 6-10. Thiram, Ferbam, and Ziram Aggregate Incidents from the Incident Data System (IDS)

Taxa	Number of Incidents ¹		
	Thiram ²	Ferbam	Ziram
Vertebrate Wildlife (W-B)	0	0	0
Plant (P-B)	0	0	1
Non-vertebrate (ONT)	0	0	0

¹ Aggregate incidents are only reported as a count-based measure.

² For thiram, there were 76 domestic animal incidents, but no wildlife, plant, or other non-target (often bee) incidents in the aggregate database.

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. 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 an effect 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 acute and chronic risks to vertebrates, the LOCs are 0.5 and 1.0, respectively, and for plants, the LOC is 1.0. The acute and chronic risk LOCs for bees are 0.4 and 1.0, respectively. 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.

7.2 Modeling

Various models are used to calculate aquatic and terrestrial EECs (see **Table 7-1**). The specific models used in this assessment are discussed further below.

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 pore water ¹	Runoff and spray drift to water and sediment pore water (spiked- sediment toxicity information not available) ¹ Thiram cranberry use does not have direct application to flood water.	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 (<i>e.g.</i> , LD50/ft ²) - 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 Refinements for Treated Seed (USEPA, 2016a)
	Plants	Spray drift/runoff	Runoff and spray drift to plants	TERRPLANT version 1.2.2

Environment	Taxa of Concern	Exposure Media	Exposure Pathway	Model(s) or Pathway
	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 $\log K_{ow} \geq 3$; or the $K_{oc} \geq 1000$ 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. For this assessment, even though the K_{oc} for both thiram (K_{oc} of 2245 to 24,526 mL/g_{oc}) and ziram (K_{oc} of 314 to 3732 mL/g_{oc}, **Table 5-1** and **Table 5-4**) were above 1000 mL/g_{oc}, triggering sediment assessment, the problem formulations concluded that thiram and ziram are not expected to accumulate in sediment. The ziram problem formulation also states that ziram is associated with water in the presence of sediment. Therefore, without spiked-sediment toxicity information, peak/24-hour and 21-day pore water exposure to benthic invertebrates were assessed using water column toxicity data (USEPA, 2014).

² The Pesticide in Water Calculator (PWC) is a Graphical 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.

8 Aquatic Organisms Risk Assessment

8.1 Aquatic Exposure Assessment

8.1.1 Modeling

8.1.1.1 Thiram

Pesticide in Water Calculator (PWC) scenarios are used to specify soil, climatic, and agronomic inputs in 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 8-1** identifies the use sites associated with each PWC scenario. BEAD provided the application dates simulated and reviewed the use

patterns simulated. The corresponding PWC scenarios, the first application dates and application efficiencies and spray drift amounts are summarized in **Table 8-2**.

Table 8-1. PWC Input Parameters for Thiram

Parameter	Value	Source (MRID)
Physical/Chemical Parameters		
Molecular mass (molecular formula)	240.43 g/mol (C ₆ H ₁₂ N ₂ S ₄)	Calculated
Vapor pressure (25°C)	1.72 x 10 ⁻⁵ mm Hg	PPDB ¹ USEPA, 2004a
Aqueous solubility (25°C)	16.5 mg/L (pH 7)	
Henry's Law Constant (25°C)	3.30 x 10 ⁻⁷ atm.m ³ /mole	Calculated
Persistence		
Hydrolysis half-life (25°C)	3.5 days (pH 7)	MRID 41840601
Aqueous photolysis half-life (25°C)	7.2 hours (0.3 days)	MRID 45651201
Aerobic soil metabolism half-life (25°C)	8.55 days (2.85 days x 3)	MRID 43734901
Aerobic aquatic metabolism half-life (20°C)	24.93 days (Upper 90% confidence bound on the mean of 21.5 days, 18.2 days)	MRID 45243401
Anaerobic aquatic metabolism half-life (25°C)	129.3 days (43.1 days x 3)	MRID 43628501
Mobility		
Organic carbon partition coefficients (K _{oc})	11507 (mean of 2245, 6359, 12899, 24526 L/kg _{oc})	MRID 43787501

¹ Pesticide Properties DataBase (<https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm>)

For thiram uses, as shown in **Table 3-1**, in addition to agricultural outdoor uses, there are also many agricultural indoor (seed treatment) uses. For seed treatment, the highest application rates per quantity of seeds are for coniferous/evergreen/softwood with a rate of 0.021 lb ai/lb seed, followed by onion with a rate of 0.0125 lb ai/lb seed. All other application rates per quantity of seeds are all less than 0.003 lb ai/lb seed. Considering the modeling purpose, the application rate per quantity of seeds information needs to be expressed as lb ai/ac. To convert lb ai/lb seed to lb ai/ac, the PLUS report (USEPA, 2019a) application rates per quantity of seeds need to be multiplied by the seeding rate in lb seed/acre. Since the seeding rate for coniferous/evergreen/softwood is 5 lb seed/ac,⁴ the highest application rate per acre will be onion use with a seeding rate of 110 lb seed/acre. The top three application rates per acre are onion (1.375 lb ai/ac), succulent beans – snap (0.4487 lb ai/ac), and small seeded legumes – Lima beans (0.4297 lb ai/ac). However, there are two reasons that onion is expected to have the highest exposure values of all the seed treatments. First, the onion rate is about 3 times of the next high rate for succulent beans. Second, the seeding depth for onion is shallow at ¼ inches. The shallower the seeding depth, the more pesticide is available to runoff.

⁴ Seeding rate if from an April 23, 2020 email correspondence from the Biological and Economic Analysis Division to the EFED ipconazole team as referenced in USEPA (2020b).

Table 8-2. PWC scenarios, the first application date, and application mode for Thiram

Use Site	PWC Scenario	1 st Application Date	Application Method, Efficiency and Off-Target Spray Drift
Ornamentals Shrubs/ bushes/ vines	CAnurserySTD	01/16	Ground Application 99% efficiency 6.2% Drift
	FLnurserySTD	01/16	
	MLnurserySTD	01/16	
	NJnurserySTD	01/16	
	ORnurserySTD	01/16	
	TNnurserySTD	04/01	
Tree	ORXmastreeSTD	01/16	
	CAForestryRLF	01/16	
Peach	Cafruit_WirrigSTD (a)	02/16	Aerial, 95% efficiency, 12.5% drift
	(ground)	02/16	Ground Application
	GApeachesSTD (a)	03/01	Aerial, 95% efficiency, 12.5% drift
	(ground)	03/01	Ground Application
Strawberry	CAstrawberry-noplasticRLF (a)	02/16	Aerial, 95% efficiency, 12.5% drift
	(ground)	02/16	Ground Application
	FLstrawberry wirrigSTD (a)	11/16	Aerial, 95% efficiency, 12.5% drift
	(ground)	11/16	Ground Application 99% efficiency 6.2% Drift
Grass/turf: golf course: tees and greens	CATurfRLF	02/16	
	FLturfSTD	03/16	
	PAturfSTD	04/16	
	TurfBSS	02/16	
Seed Treatment			
Onion	CAonion_WirrigSTD	15 days Before emergence	Seed planting at The seeding depth (Onion – ¼ inch; Snap beans – ½ inch; Lima beans – 1 inch) 100% efficiency 0% drift
	GAonionSTD		
	WAonionNMC		
Bean, succulent (snap)	IlbeansNMC		
	WAbearsNMC		
Small seeded legumes (lima beans)	IlbeansNMC		

Table 8-3. Aquatic EECs for Thiram Uses

1-in-10 years Estimated Environmental Concentration (µg/L)						
Uses	PWC Scenario	1-day	21-day	60-day	Pore Water Peak	Pore Water 21-day
Ornamentals; Shrubs/Bushes / Vines; Tree	CAnurserySTD_V2	21.1	5.86	3.26	3.08	2.89
	FLnurserySTD_V2	11.4	4.14	1.94	1.22	1.15
	MIlurserySTD_V2	11.6	4.54	2.10	1.39	1.33
	NJnurserySTD_V2	12.1	4.97	2.54	1.72	1.63
	ORnurserySTD_V2	12.2	4.54	2.10	1.43	1.36
	TNnurserySTD_V2	12.9	5.01	2.32	1.70	1.60
	ORXmasTreeSTD	11.7	4.53	2.05	1.38	1.31
	CAForestryRLF	19.2	6.27	3.24	2.91	2.76
Peach	CAfruit_WirrigSTD (A)	15.1	7.42	3.74	2.49	2.35
	CAfruit_WirrigSTD (G)	7.60	3.75	1.90	1.27	1.20
	GAPeachesSTD (A)	19.2	8.01	4.15	2.87	2.70
	GAPeachesSTD (G)	12.9	4.49	2.35	1.68	1.58
Strawberry	CAstrawberry-noplasticRLF_V2 (A)	18.4	6.56	4.82	3.08	2.91
	CAstrawberry-noplasticRLF_V2 (G)	10.0	3.71	2.64	1.68	1.59
	FLstrawberry_WirrigSTD (A)	17.5	6.30	4.58	2.94	2.70
	FLstrawberry_WirrigSTD (G)	9.08	3.55	2.46	1.60	1.49
Residential/ Recreational/ Institutional/ Retail Turf	CATurfRLF	42.3	15.7	6.97	4.70	4.44
	FLturfSTD	41.7	15.5	6.98	4.68	4.39
	PATurfSTD	42.2	16.0	7.30	4.89	4.61
	TurfBSS	42.0	15.7	6.89	4.64	4.37
Seed Treatment						
Onion	CAonion_WirrigSTD	0.122	0.022	0.00957	0.00722	0.0068
	GAonion_WirrigSTD	1.55	0.511	0.233	0.227	0.207
	WAonionNMC	0.00459	0.000661	0.000287	0.000233	0.000218
Succulent Beans	IlbeansNMC	0.343	0.0801	0.0383	0.0358	0.0331
	WAbbeansNMC	0.00295	0.000416	0.000179	0.00016	0.000172
Small Seeded Legumes	IlbeansNMC	0.0987	0.0228	0.0108	0.00978	0.00906

Maximum EECs are shown in **bold**.

All PWC modeled aquatic EECs are presented in **Table 8-3**. The highest EECs are 42.3 µg/L, 16.0 µg/L, and 7.30 µg/L, respectively for 1-in-10 year one-day average, 1-in-10 year 21-day average and 1-in-10 year 60-day average for application to turf. This is to be expected, as the application rates are more than three time higher than the next highest application rate for use on peaches. The 1-in-10 year 1-day average water column EECs are in the range from 7.60 µg/L to 42.3 µg/L. The range for 1-in-10 year 21-day average EECs is from 3.55 µg/L to 16.0 µg/L, and for 60-day average, the range is from 1.90 µg/L to 7.30 µg/L.

For the seed treatment uses, the Georgia onion scenario based on 0.0125 lb ai/lb seed with 110 lb seed/ac at the seeding depth of 0.25 inches, PWC predicted the onion EECs of 1.55 µg/L, 0.511 µg/L, and 0.233 µg/L, respectively for 1-in-10 year one-day average, 1-in-10 year 21-day average and 1-in-10 year 60-day average. IlbeansNMC scenario was used for both succulent bean and small seeded legumes, the two application rates are close with about 4% difference. The 3-fold increase in EECs are mainly due to the different seeding depth: ½ inch vs. 1 inch.

8.1.1.2 Ferbam

Due to the rapid transformation of ferbam to thiram, the modeling input parameters for thiram were used. The PWC chemical input parameters are same as in **Table 8-1**.

All the modeling scenarios and the application information including application rate, timing, efficiency and spray drift percentage are presented in **Table 8-4**.

Table 8-4. PWC Modeling Scenarios for Ferbam Uses

Use Site	PWC Scenario	1 st Application Date*	Application Method, Efficiency and Off-Target Spray Drift
Apple	NCappleSTD	04/01	Ground Spray 99% Efficiency 6.6% Drift
	ORappleSTD	04/01	
	PAappleSTD_v2	04/01	
Citrus	CAcitrus_WirrigSTD	01/16	
	FLcitrusSTD	01/16	
Cranberry	ORberriesOP	06/01	
Peach Nectarine	CAfruit_WirrigSTD	01/16	
	GApeachsSTD	02/01	
Pear	CAfruit_WirrigSTD	02/01	
	GApeachsSTD	03/16	
Mango	CAfruit_WirrigSTD	01/01	Airblast 99% Efficiency, 4.8% Drift
	GApeachsSTD	01/01	

*1st/Initial Application Date Recommended by BEAD

All PWC modeled aquatic EECs are presented in **Table 8-5**. Among all modeling scenarios, the 1-in-10 year 1-day average water column EECs are in the range from 6.25 µg/L to 15.80 µg/L. The range for 1-in-10 year 21-day average EECs is from 2.33 µg/L to 6.09 µg/L, and for 60-day average, the range is from 1.52 µg/L to 3.21 µg/L.

Table 8-5. Aquatic EECs for Ferbam Uses (expressed in thiram equivalents)

1-in-10 years Estimated Environmental Concentration (µg/L)						
Uses	PWC Scenario	1-day	21-day	60-day	Pore Water Peak	Pore Water 21-day
Apple	NCappleSTD	9.79	3.59	1.72	1.13	1.07
	ORappleSTD	8.90	3.36	1.52	1.03	0.97
	PAappleSTD_V2	9.18	3.61	1.65	1.21	1.14
Citrus	CAcitrus_WirrigSTD	15.3	5.65	2.76	1.74	1.65
	FLcitrusSTD	15.2	6.09	3.07	2.11	1.97
Cranberry	ORberriesOP	12.2	4.85	3.21	2.13	2.00
Peach Nectarine	CAfruit_WirrigSTD	8.90	3.33	1.57	1.00	0.96
	GAPeachesSTD	14.9	5.10	2.33	1.70	1.61
Pear	CAfruit_WirrigSTD	8.96	3.56	1.60	1.08	1.02
	GAPeachesSTD	10.4	3.94	1.83	1.29	1.22
Mango	CAfruit_WirrigSTD	6.25	2.33	2.00	1.44	1.39
	GAPeachesSTD	15.8	4.53	3.01	2.07	2.03

Maximum EECs are shown in **bold**.

PFAM for cranberry use

PFAM was developed specifically for regulatory applications to estimate exposure for pesticides used in flooded agriculture such as rice paddies and cranberry bogs. The model considers the environmental fate properties of pesticides and allows for specification of common management practices that are associated with flooded agriculture such as scheduled water releases and refills. It estimates both acute and chronic concentrations over different durations, allows for defining different receiving water bodies, and allows for more flexibility in refinement of assessments when needed.

PFAM was used to estimate EECs for ferbam use on cranberries in the flood water released from a bog. The PFAM model simulates application of the pesticide to a wet or dry field and degradation in soil and/or water. If the pesticide is applied to dry soil, water may then be introduced into the field and movement of the pesticide may occur from soil into the water.

After flooding, water may be held in a holding system, recirculated to other areas of the cranberry production facility, or released to adjacent waterbodies (canals, rivers, streams, lakes, or bays) external to the cranberry fields. Potential exposure was evaluated for residues in cranberry bog water (*i.e.*, flood water in the treated cranberry field). The cranberry bog water estimates are post-application residues in flood water introduced into the treated cranberry field.

Release water EECs were calculated based on 30-years of simulated results with two flooding events per year for cranberries (*i.e.*, winter flooding and flooding during harvest). The same chemical inputs used in PWC are also applicable for PFAM. The PFAM applications tab and scenario input parameters are shown in **Table 8-6**.

Table 8-6. PFAM applications tab and scenario for Ferbam Uses

Parameter	Input Value and Unit	Source/Comments
Scenario	MA_Cranberry-Winter Flood STD.PFA OR_Cranberry-Winter Flood STD.PFA OR_Cranberry-No Flood STD.PFA WI_Cranberry-Winter Flood STD.PFA	Interim cranberry scenarios
Maximum application rate	5 x 4.018 lb ai/A (4.5 kg ai/HA)	Application rate to cranberries
Application Dates	1 st date of application: June 1 (5 applications at 7 days apart)	Ground applications
Heat of Henry	37395 J/Mol	From EPI - HENRYWIN
Slow Release (1/day)	0	Applied as an EC. Slow release is not expected to occur.
Drift Factor	Not applicable	Not applicable

The PFAM modeling results are presented in **Table 8-7**. For estimated environmental concentrations (EECs), the 1-in-10 year daily average concentrations are in the range of 0.32 µg/L to 1.33 µg/L; 21-day average concentrations are in the range of 0.046 µg/L to 0.154 µg/L; and 60-day average concentrations are in the range from 0.030 µg/L to 0.112 µg/L.

Table 8-7. Cranberry EECs with PFAM Modeling for Ferbam (Expressed as Thiram Equivalents)

Use	PWC Scenario	1-in-10 year EEC (µg/L)				
		Water Paddy Values			Pore Water	
		1-day	21-day	60-day	1-day	21-day
Cranberry Five applications @ 4.018 lb/ac (4.5 kg/HA)	MA_Cranberry-Winter Flood STD.PFA	0.320	0.0461	0.0383	160	126
	OR_Cranberry-Winter Flood STD.PFA	1.33	0.154	0.112	183	145
	OR_Cranberry-No Flood STD.PFA	0.836	0.0864	0.0302	183	145
	WI_Cranberry-Winter Flood STD.PFA	0.319	0.0589	0.0507	158	124

8.1.1.3 Ziram

Table 8-8 identifies PWC chemical input parameters for ziram using the Total Residues (TR) approach. The corresponding PWC scenarios, the first application dates and application efficiencies and spray drift amounts are summarized in **Table 8-9**. For selecting the half-life value for abiotic reactions used in the TR approach, the longer half-life value between ziram and thiram is used. For biotic (metabolism) reactions, the half-life values are generated based

on the sum of ziram and thiram residues. For mobility, the lower Koc value from ziram and thiram is used.

Table 8-8. PWC Input Parameters for Ziram Total Residues Approach

Parameter	Value	Source (MRID)
Physical/Chemical Parameters		
Molecular mass (molecular formula)	305.8 g/mol (C ₆ H ₁₂ N ₂ S ₄ Zn)	Calculated
Vapor pressure (25°C)	1.35 x 10 ⁻⁷ Torr	PPDB ¹
Aqueous solubility (25°C)	0.97 mg/L (pH 7)	
Persistence		
Hydrolysis half-life (25°C)	3.5 days (pH 7)	MRID 41840601 (Thiram)
Aqueous photolysis half-life (25°C)	0.43 days	MRID 44097701
Aerobic soil metabolism half-life (25°C)	2.47 days (Upper 90% confidence bound on the mean of 0.513*, 0.933*, 2.19, 2.78 days)	MRID 47005202
Aerobic aquatic metabolism half-life (20°C)	0.713 days (Upper 90% confidence bound on the mean of 0.497, 0.603 days)	MRID 46045903
Anaerobic aquatic metabolism half-life (25°C)	52.8 days (17.6 days x 3)	MRID 44228402 (anaerobic soil)
Mobility		
Organic carbon partition coefficients (K _{oc})	1509 (mean of 3732, 1232, 759, and 314 L/kg _{oc}) – ziram	MRID 43873501

*corrected for temperature at 25°C

¹ Pesticide Properties DataBase (<https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm>)

Table 8-9. PWC Scenarios and the Related Application Information for Ziram Uses

Use	PWC scenario	# of Applications, Rate, Retreatment Interval, 1st Application date	Application Methods, Timing
Almond	CAalmond_WirrigSTD	4 @ 6.08 – 7 days April 1	A/G, before, during, post bloom
Apricot	Cafruit_WirrigSTD	4 @ 6.08 – 7 days April 1	A/G, before, during, post bloom
Apple	NCappleSTD ORappleSTD PAappleSTD_v2.std	7 @ 4.56 – 7 days April 10	G, before bloom, post petal fall
Blueberry	Orberries	5 @ 3.04 – 7 days April 1	A/G, before, during, post bloom
Cherry	MIcherriesSTD	4 @ 4.56 – 7 days April 1	A/G, before, during, post bloom
Coniferous/Evergreen/Softwood (non-food)	CAnurseySTD FLnurseySTD MINurseySTD NJnurseySTD ORNurseySTD TNnumserystd	4 @ 6.08 – 3 days April 1	G, post emergence
Filbert (Hazelnut)	ORfilbertSTD	5 @ 6.08 – 14 days March 1	A/G, before, during, post bloom
Grapes	Cagrapes_WirrigSTD CAWineGrapesRLF_V2 NYgrapesSTD	3 @ 3.04 – 7 days April 1	G, before bloom
Nectarine Peach	Cafruit_WirrigSTD	6 @ 7.60 – 7 days February 21	A/G, dormant
Pear	Cafruit_WirrigSTD	7 @ 4.56 – 7 days March 1	A/G, before, during bloom, prior to harvest
Pecan	GApecansSTD	6 @ 6.08 – 21 days April 24	G, before, during bloom
Tomato	CAtomato_wirrigSTD FLtomatoSTD_v2 PAtomatoSTD	6 @ 3.04 – 7 days March 1	G, post emergence
Tree	CAForestryRLF ORXmaxTreeSTD	3 @ 6.08 – 7 days April 1	G, dormant

All PWC modeled aquatic EECs are presented in **Table 8-10**. Among all modeling scenarios, the 1-in-10 year 1-day average water column EECs are in the range from 8.03 µg/L to 70.7 µg/L. The range for 1-in-10 year 21-day average EECs is from 2.48 µg/L to 14.7 µg/L, and for 60-day average, the range is from 0.905 µg/L to 9.55 µg/L.

Table 8-10. Aquatic EECs for Ziram Uses

1-in-10 years Estimated Environmental Concentration (µg/L)						
Uses	PWC Scenario	1-day	21-day	60-day	Pore Water Peak	Pore Water 21-day
Almond	CAalmond_WirrigSTD	16.7	5.29	2.49	1.87	1.66
	CAalmond_WirrigSTD*	33.2	10.5	4.97	3.72	3.29
Apricot	Cafruit_WirrigSTD	16.3	4.97	2.38	1.73	1.56
	Cafruit_WirrigSTD*	32.6	10	4.66	3.48	3.06
Apple	NCappleSTD	70.7	9.53	5.47	6.75	5.69
	ORappleSTD	13.9	4.4	3.46	2.33	2.15
	PAappleSTD_v2	17.3	4.89	4.01	4.71	4.13
Blueberry	OrberriesOP	8.59	2.95	1.74	1.41	1.25
	OrberriesOP*	17.2	5.94	3.5	2.54	2.26
Cherry	MIcherriesSTD	16.9	6.52	2.96	3.38	3.17
	MIcherriesSTD*	30.5	11.9	5.64	5.25	4.83
Coniferous/ Evergreen/ Softwood (non-food)	CAnurserySTD_V2	21.4	6.54	2.62	4.97	4.12
	FLnurserySTD_V2	30.7	6.14	2.18	2.67	2.18
	MIlternSTD_V2	26.1	10.4	3.78	3.65	3.27
	NJnurserySTD_V2	67.2	14.7	5.32	5.94	5.36
	ORnurserySTD_V2	20.9	7.71	2.76	2.35	2.09
	TNnurserySTD_V2	44.9	9.42	3.37	3.8	3.26
Filbert (Hazelnut)	ORfilbertsSTD	17.6	4.41	3.53	2.26	2.11
	ORfilbertsSTD*	66.4	11.9	7.15	4.95	4.38
Grapes	Cagrapes_WirrigSTD	8.03	2.48	0.905	0.708	0.617
	CAWineGrapesRLF_V2	8.43	2.63	0.944	0.976	0.837
	NYgrapesSTD	10.3	3.99	1.47	2.45	2.16
Nectarine Peach	Cafruit_WirrigSTD	23.2	7.23	4.84	3.21	2.94
	Cafruit_WirrigSTD*	43.5	13.8	9.55	6.28	5.69
Pear	Cafruit_WirrigSTD	14.3	4.26	3.23	2.04	1.88
	Cafruit_WirrigSTD*	25.8	8.14	6.37	3.95	3.59
Pecan	GApecansSTD	22.7	2.5	1.68	2.38	1.89
Tomato	CAtomato_wirrigSTD	9.51	2.89	1.91	1.27	1.15
	FLtomatoSTD_v2	23.1	3.3	1.83	1.28	1.12
	PAtomatoSTD.	18.1	5.37	3.28	3.8	3.66
Tree	ORXmastreeSTD	17	5.83	2.1	1.67	1.48
	CAForestryRLF	26.4	7.39	3.13	8.17	7.03

*For aerial application, maximum EECs are shown in **bold**.

8.1.2 Monitoring

Two data sources, Water Quality Portal (WQP; USEPA *et al.*)⁵ and the California Environmental Data Exchange Network (CEDEN) (State Water Resources Control Board, 2015)⁶, were checked on June 4, 2020. Neither had monitoring data for ferbam. Only CEDEN had monitoring data for thiram. For ziram, both the WQP and CEDEN databases held monitoring data.

The thiram monitoring data in CEDEN consisted of 16 surface water grab samples collected in 2007. All were less than the detection limit of 0.1 µg/L.

For ziram, the WQP provided groundwater, surface water, and sediment monitoring data. The groundwater data consisted of 12 samples from the EPA Region 10 superfund program sampled in 1989 (all less than the detection limit of 8 µg/L) and 23 “vapor” samples from the Arizona Department of Environmental Quality sampled in 1994 (all less than the detection limits which are recorded as varying from 0.005 µg/L to 0.005 mg/L). Fifteen surface water and 14 sediment samples came from the “Big Valley Band of Pomo Indians of the Big Valley Rancheria, California.” All were less than the detection limits, which varied from 0.4 to 5 µg/L for surface water and 0.5 to 1 mg/kg for sediment. The WQP also contained eight CEDEN surface water samples. However, since the CEDEN query yielded a more complete set of ziram samples collected by this organization, these CEDEN samples in the WQP were not considered further.

The ziram samples retrieved from the CEDEN database contained 32 surface water samples collected between 2017 to 2019 in California. There are 2 detections (1.3 and 1.0 µg/L) for a detection rate of 6.25%. The method detection limit was 1 µg/L for all samples.

8.2 Aquatic Organism Risk Characterization

Potential exposure of aquatic life to thiram, ferbam, and ziram was assessed for the combination of runoff, spray drift and erosion. Parent-only exposure was considered for thiram. For ferbam and ziram, thiram was also considered as a residue of concern of each, with ferbam being assessed as thiram due to ferbam’s rapid breakdown, and ziram being assessed as both ziram and thiram using a TR approach, as discussed in **Section 4**. The EECs for use scenarios were based on application rates, number of applications, and intervals, presented in **Table 3-1**, **Table 3-2**, and

⁵ <https://www.waterqualitydata.us/>

⁶ <http://www.ceden.org/>

Table 3-3. For thiram seed treatment uses, aquatic estimated environmental concentrations from runoff were estimated from application rate to seeds and converted to lbs/acre. using seeding rates from TREX (see **Section 8.1.1.1** and **Appendix D**). For other uses, RQ values were calculated for estimating acute and chronic risk to fish and aquatic invertebrates, as well as risks to aquatic plants. In this assessment, risk estimates for fish also apply to aquatic-phase amphibians, for which fish serve as surrogates.

8.2.1 Aquatic Vertebrates

Thiram, ferbam, and ziram are highly toxic to very highly toxic to fish and aquatic invertebrates on an acute exposure basis to the most sensitive species for which information is available, and the most sensitive outcomes from the chronic toxicity studies included reduced survival, reproduction, and growth. For all three chemicals, the chronic fish endpoints used in assessing risk were based on thiram studies showing significant ($p < 0.05$) reductions in spawning frequency (69.5%), egg production (76.0%), and 4-week survival (24%); also, the time to hatch was affected for the fathead minnow (*Pimephales promelas*; MRID 47824101), and significant ($p < 0.05$) 4.6% and 12% reductions in length and dry weight for the sheepshead minnow (*Cyprinodon variegatus*; MRID 42514401).

For all three chemicals and all uses (**Table 8-11**, **Table 8-12**, and **Table 8-13**), with the exception of the ferbam cranberry use, the chronic LOC was exceeded for freshwater and estuarine/marine fish with RQ ranges of 1.7 to 6.6 and 2.2 to 7.9 for thiram foliar uses (no exceedances for thiram seed-treatment uses), 1.4 to 2.9 and 1.6 to 3.5 for ferbam uses, and 0.65 to 6.8 and 0.70 to 7.4 for ziram uses. The acute LOC was exceeded for uses with the highest application rates for thiram and ziram, but not for ferbam uses. For thiram, the residential and ornamental use had acute LOC exceedances for freshwater fish with RQs ranging from 0.28 to 1.0 (no exceedances for thiram seed-treatment uses). For ziram, all uses except tomato, blueberry and grapes uses had acute freshwater LOC exceedances with RQs ranging from 0.31 to 1.3.

Uncertainties in the datasets for fish and aquatic invertebrates were described above in **Section 6.1**. This is thought to be due largely to instability of the compounds in water, especially ziram, leading to high variability in calculated toxicity endpoints and uncertainties as to the exposure levels in the studies. For thiram, a fish LC_{50} of 7 $\mu\text{g a.i./L}$ (harlequin fish, MRID 05020144) was available, but this was determined to be from a formulated product (80% a.i.) and is only used here for spray drift assessment below. Also, a ziram endpoint of 9.7 (LC_{50} of 9.7 $\mu\text{g ziram a.i./L}$, MRID 42386303) was determined to not be a quantitatively usable toxicity estimate due to stability and analytical problems which made the exposure uncertain. Similarly, for ziram a lower LC_{50} of 8 $\mu\text{g zeq/L}$ was available, but this also was determined to not be quantitatively usable, but an open literature study which stated that the endpoints were preliminary and did not contain enough information to ensure that the actual exposure concentration was confirmed. Several studies were also available with good recoveries (including some radio-labelled studies), as explained above, and these were used for risk calculation. However, the uncertain lower endpoints are used for characterization. Preliminary risk estimates show that if

these more sensitive endpoints were used, all registered uses for thiram, ferbam, and ziram would exceed the acute LOC with risk estimates of 6, 2.3, and 6.9 times over the LOC, respectively, with the exception of the ferbam cranberry use. Also, if the lower estimates were used with available ACRs to estimate a lower chronic endpoint, the risk estimates would exceed the LOC by estimates in the hundreds for some uses. Therefore, there is some uncertainty as to the extent of potential risk when acute risk estimates are within 2x-6x below the LOC, and where risk is identified, the potential risks may be greater than indicated by the RQs, thus increasing confidence in the risk call.

Table 8-11. Acute and Chronic Vertebrate Risk Quotients for Non-listed Aquatic Species exposed to Thiram

Uses PWC Scenario	1-in-10 Yr EEC (µg/L)		Risk Quotient			
	Daily Mean	60-day Mean	Freshwater		Estuarine/Marine	
			Acute ¹	Chronic ²	Acute ¹	Chronic ²
			LC ₅₀ = 42 µg a.i./L	NOAEC = 1.1 µg a.i./L	LC ₅₀ = 540 µg a.i./L	NOAEC = 0.93 µg a.i./L
Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)						
CATurfRLF	42.3	6.97	1.0	6.3	0.08	7.5
PATurfSTD	42.2	7.30	1.0	6.6	0.08	7.9
FLturfSTD	41.7	6.98	0.99	6.4	0.08	7.5
Ornamentals; Shrubs/Bushes/ Vines; Trees; 4.36 lb/acre x 3 apps (7-day interval)						
CAnurserySTD_V2	21.1	3.26	0.50	3.0	0.04	3.5
ORXmasTreeSTD	11.7	2.05	0.28	1.9	0.02	2.2
Peach; 2.63 lb/acre x 5 apps (3-day interval)						
GAPeachesSTD (A)	19.2	4.15	0.46	3.8	0.04	4.5
CAfruit_WirrigSTD (G)	7.6	1.90	0.18	1.7	0.01	2.0
Strawberry; 4.36 lb/acre x 5 apps (10-day interval)						
CAStrawberry-noplasticRLF_V2 (A)	18.4	4.82	0.44	4.4	0.03	5.2
FLstrawberry_WirrigSD (G)	9.08	2.46	0.22	2.2	0.02	2.7
Seed Treatments:						
Onion 1.375 lb/acre						
GAOnion_WirrigSTD	1.55	0.233	0.04	0.21	<0.01	0.25
WAonionNMC	0.00459	0.000287	<0.01	<0.01	<0.01	<0.01
Succulent Beans 0.4487 lb/acre						
IlbeansNMC	0.343	0.0383	0.01	0.03	<0.01	0.04
WAbeansNMC	0.00295	0.000179	<0.01	<0.01	<0.01	<0.01
Small Seeded Legumes 0.4297 lb/acre						
IlbeansNMC	0.0987	0.0108	<0.01	<0.01	<0.01	0.01

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.

¹ The EECs used to calculate these RQs are based on the 1-in-10-year peak 1-day average value from **Table 8-3**. Endpoints used were: Bluegill LC₅₀ = 42 µg thiram a.i./L (TN 996); and Sheepshead LC₅₀ = 540 µg thiram a.i./L (MRID 42514401).

² The EECs used to calculate these RQs are based on the 1-in-10-year 60-day average value from **Table 8-3**. Endpoints used were: Fathead minnow NOAEC of 1.1 µg thiram a.i./L (MRID 47824101, based on 70% reduction in spawning, 67% reduction in egg production, and 24% mortality); and Sheepshead minnow NOAEC of 0.93 µg thiram a.i./L (MRID 51049801 based on significant 5% reduction in length and 12% reduction in dry weight).

Table 8-12. Acute and Chronic Vertebrate Risk Quotients for Non-listed Aquatic Species exposed to Ferbam and Degradate, Thiram (Amounts Expressed as Thiram a.i. and also as Ferbam Equivalents, Feq)

Uses PWC Scenario	1-in-10 Yr EEC (µg thiram a.i./L)		Risk Quotient			
			Freshwater Endpoints Expressed as both µg thiram a.i./L (and µg feq/L)		Estuarine/Marine Endpoints Expressed as both µg thiram a.i./L (and µg feq/L)	
	Daily Mean	60-day Mean	Acute ¹	Chronic ²	Acute ¹	Chronic ²
			LC ₅₀ = 42 µg (73 µgfeq)/L	NOAEC = 1.1 µg (1.9 µgfeq)/L	LC ₅₀ = 540 µg (940 µg feq)/L	NOAEC = 0.93 µg (1.6 µg feq)/L
Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre) x 10 apps (10-day interval)						
GAPeachesSTD	15.8	3.01	0.38	2.7	0.03	3.2
CAfruit_WirrigSTD	6.25	2.00	0.15	1.8	0.01	2.2
Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)						
CACitrus_WirrigSTD	15.3	2.76	0.36	2.5	0.03	3.0
FLcitrusSTD	15.2	3.07	0.36	2.8	0.03	3.3
Peach and Nectarine: 2.96 lb thiram a.i./acre (3.42 lb feq/acre) x 3 apps (7-day interval)						
GAPeachesSTD	14.9	2.33	0.35	2.1	0.03	2.5
CAfruit_WirrigSTD	8.9	1.57	0.21	1.4	0.02	1.7
Pear: 3.03 lb thiram a.i./acre (3.50 lb feq/acre) x 3 apps (7-day interval)						
GAPeachesSTD	10.4	1.83	0.25	1.7	0.02	2.0
CAfruit_WirrigSTD	8.96	1.60	0.21	1.5	0.02	1.7
Apple: 3.03 lb thiram a.i./acre (3.50 lb feq/acre) x 3 apps (7-day interval)						
NCappleSTD	9.79	1.72	0.23	1.6	0.02	1.9
ORappleSTD	8.90	1.52	0.21	1.4	0.02	1.6
Cranberry: 4.02 lb thiram a.i./acre (4.64 lb feq/acre) x 5 apps (7-day interval) (PWC Calculations)						
ORberriesOP	12.2	3.21	0.29	2.9	0.02	3.5
Cranberry: 4.02 lb thiram a.i./acre (4.64 lb feq/acre) x 5 apps (7-day interval) (PFAM Calculations)						
OR_Cranberry- Winter Flood STD.PFA	1.33	0.112	0.03	0.10	<0.01	0.12
WI_Cranberry-Winter Flood STD.PFA	0.319	0.0507	0.01	0.05	<0.01	0.05
PFAM: OR_Cranberry- Winter Flood STD.PFA	1.33	0.112	0.03	0.10	<0.01	0.12
PFAM: MA_Cranberry- Winter Flood STD.PFA	0.32	0.0383	0.01	0.03	<0.01	0.04

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.

¹ The EECs used to calculate this RQ are based on the 1-in-10-year peak 1-day average value from **Table 8-5** and **Table 8-7**. Endpoints used were: Bluegill LC₅₀ = 73 µg feq/L (TN 996); and Sheepshead LC₅₀ = 940 µg feq./L (MRID 42514401).

² The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average value from **Table 8-5** and **Table 8-7**. Endpoints used were: Fathead minnow NOAEC of 1.9 µg feq/L (MRID 47824101, based on 70% reduction in spawning, 67% reduction in egg production, and 24% mortality); and Sheepshead minnow NOAEC of 1.6 µg feq/L (MRID 51049801 based on significant 5% reduction in length and 12% reduction in dry weight).

Table 8-13. Acute and Chronic Vertebrate Risk Quotients for Non-listed Aquatic Species exposed to Ziram and Degradate, Thiram (Amounts Expressed as Ziram Equivalents, Zeq)

Uses PWC Scenario	1-in-10 Yr EEC (µg/L)		Risk Quotient			
	Daily Mean	60- day Mean	Freshwater		Estuarine/Marine	
			Acute ¹	Chronic ²	Acute ¹	Chronic ²
			LC ₅₀ = 53 µg zeq/L	NOAEC = 1.4 µg zeq/L	LC ₅₀ = 690 µg zeq/L	NOAEC = 1.3 µg zeq/L
Apple/ Pear: 4.56 lb/acre x 7 apps (7-day interval)						
NCappleSTD	70.7	5.47	1.3	3.9	0.10	4.2
ORappleSTD	13.9	3.46	0.26	2.5	0.02	2.7
Conif./ Evergr./ Softwood: 6.08 lb/acre x 4 apps (3-day interval)						
NNurserySTD_V2	67.2	5.32	1.3	3.8	0.10	4.1
ORNurserySTD_V2	20.9	2.76	0.39	2.0	0.03	2.1
Filbert: 6.08 lb/acre x 5 apps (14-day interval)						
ORfilbertsSTD (aerial)	66.4	7.15	1.3	5.1	0.10	5.5
ORfilbertsSTD	17.6	3.53	0.33	2.5	0.03	2.7
Nectarine/ Peach: 7.60 lb/acre x 6 apps (7-day interval)						
Cafruit_WirrigSTD (aerial)	43.5	9.55	0.82	6.8	0.06	7.4
Cafruit_WirrigSTD	23.2	4.84	0.44	3.5	0.03	3.7
Pecan: 6.08 lb/acre x 6 apps (21-day interval)						
GApecansSTD	22.7	1.68	0.43	1.2	0.03	1.3
Almond/ Apricot: 6.08 lb/acre x 4 apps (7-day interval)						
CAalmond_WirrigSTD (aerial)	33.2	4.97	0.82	6.8	0.06	7.4
Cafruit_WirrigSTD	16.3	2.38	0.31	1.7	0.02	1.8
Tree: 6.08 lb/acre x 3 apps (7-day interval)						
CAForestryRLF	26.4	3.13	0.50	2.2	0.04	2.4
ORXmastreeSTD	17	2.1	0.32	1.5	0.02	1.6
Cherry: 4.56 lb/acre x 4 apps (7-day interval)						
MIcherriesSTD (aerial)	30.5	5.64	0.58	4.0	0.04	4.3
MIcherriesSTD	16.9	2.96	0.32	2.1	0.02	2.3
Tomato: 3.04 lb/acre x 6 apps (7-day interval)						
FLtomatoSTD_v2	23.1	1.83	0.44	1.3	0.03	1.4
CAtomato_wirrigSTD	9.51	1.91	0.18	1.4	0.01	1.5
Blueberry: 3.04 lb/acre x 5 apps (7-day interval)						
OrberriesOP (aerial)	17.2	3.5	0.32	2.5	0.02	2.7
OrberriesOP	8.59	1.74	0.16	1.2	0.01	1.3
Grapes: 3.04 lb/acre x 3 apps (7-day interval)						
NYgrapesSTD	10.3	1.47	0.19	1.1	0.01	1.1
Cagrapes_WirrigSTD	8.03	0.905	0.15	0.65	0.01	0.70

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.

¹ The EECs used to calculate these RQs are based on the 1-in-10-year peak 1-day average value from **Table 8-10**. Endpoints used were: Bluegill LC₅₀ = 53 µg zeq/L (TN 996); and Sheepshead LC₅₀ = 690 µg zeq/L (MRID 42514401).

² The EECs used to calculate these RQs are based on the 1-in-10-year 60-day average value from **Table 8-10**. Endpoints used were: Fathead minnow NOAEC of 1.4 µg feq/L (MRID 47824101, based on 70% reduction in spawning, 67% reduction in egg production, and 24% mortality); and Sheepshead minnow NOAEC of 1.2 µg zeq/L (MRID 51049801 based on significant 5% reduction in length and 12% reduction in dry weight).

Therefore, based on the available data, chronic risk to fish is expected from all registered uses of thiram, ferbam, and ziram, with the exception of the ferbam cranberry use and the ziram

pecan, tomato, and grapes uses. Acute risk to fish is also expected from registered uses with the highest application rates for thiram and ziram, but not for ferbam uses.

Available fish formulation toxicity data with thiram (with the harlequin fish, *Rasbora heteromorpha*, MRID 05020144) is used to characterize spray-drift distances that may cause toxicity to fish. Formulation toxicity data is not typically used for runoff, but only for spray-drift and direct water applications because the components of the formulation may not behave the same way in environmental runoff as the active ingredient. Using the highest and lowest thiram application rates of 16.33 and 2.63 lb a.i./acre (**Table 8-14**, also see **Appendix G**):

Highest Application Rate (Residential Use, 16.33 lb a.i./acre):

- With high boom and fine droplets, 200 feet of spray-drift distance would be needed for the concentration to be as low as the formulation LC₅₀; and >200 feet would be needed to remove the presumption of acute risk; and
- With low boom and medium to coarse droplets, 4 feet would be needed to be below the fish TEP LC₅₀ (remove the presumption of acute risk).

Lowest Application Rate (Peach Use, 2.63 lb a.i./acre):

- With high boom and fine droplets, 7 feet of spray-drift distance would be needed to remove the presumption of acute risk to fish;
- With low boom and medium to coarse droplets, 0 feet would be needed to be below the fish TEP LC₅₀ (remove the presumption of acute risk).

Table 8-14. Spray-drift Distances to Concentrations Compared with Formulation Toxicity Endpoints

Acute Endpoint, LC ₅₀ , µg thiram a.i./L ¹	Distance from Application Site, feet	Concentration, µg Thiram a.i. [Bold if Above Endpoint]	
		Low Boom/ Medium to Coarse Droplets	Low Boom/ Fine Droplets
Thiram Highest Single Application Rate for Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre			
LC ₅₀ = 7	0	10.0	56.4
	4	6.2 (Below the LC ₅₀)	43.8
	100	2.5	11.9
	200	1.8	7.1 (At the LC ₅₀)
	300	1.4	4.9 (Below the LC ₅₀)
	500	0.9	2.8
	1000 (990; model doesn't allow 1000)	0.5	1.1
Thiram Lowes Single Application Rate for Peaches; 2.63 lb/acre			
LC ₅₀ = 7	0	1.6 (Below the LC ₅₀)	9.0
	7	0.9	6.2 (Below the LC ₅₀)
	100	0.4	2.0

Concentrations above the LC₅₀ of 7 µg thiram a.i./L are shown in **Bold** with highlight.

¹Acute endpoint for harlequin fish from MRID 5020144.

8.2.2 Aquatic Invertebrates

In contrast to the fish data, freshwater invertebrates had less sensitive acute endpoints than estuarine/marine invertebrates for use as representative data for risk calculations. However, as described above in **Sections 6.1** and **8.2.1**, much variability was seen in the toxicity datasets, which may be due in large part to the stability of the test substances, especially for ziram. Therefore, it is unclear whether differences in risk calculations (**Table 8-15**, **Table 8-16**, and **Table 8-17**) for freshwater vs. estuarine/ marine fish and aquatic invertebrates are true differences in toxicological sensitivity or generally signify noise in the data.

For all three chemicals, the freshwater chronic invertebrate endpoint used in assessing risk was based on a thiram study showing significant ($p < 0.05$) 19% reduction in dry weight for the water flea (*Daphnia magna*; MRID 47495001). For estuarine/marine invertebrates, the chronic endpoint was calculated using a daphnid ACR of 11 (210/20; MRIDs 00164662 and 47495001) with mysid (*Americamysis bahia*) acute data.

For estuarine/marine invertebrates, acute risk LOC (0.5) and the chronic risk LOC (1) were exceeded for all uses, except the ferbam cranberry use and thiram seed-treatment uses, with acute and chronic RQs of 0.12 to 3.9 and 3.6 to 16 for thiram foliar uses, < 0.01 to 0.14 and 0.01 to 0.51 for thiram seed-treatment uses, 0.10 to 1.4 and 3.4 to 6.1 for ferbam uses, and 0.12 to 5.1 and 1.9 to 11 for ziram uses, respectively. RQs for mollusks were lower than those for crustaceans.

For freshwater invertebrates, the acute and chronic risk LOCs were not exceeded for thiram or ferbam uses. For ziram uses the acute risk LOC was exceeded for ziram highest application rates for apples, pears, filberts, nectarines, peaches, cherries, trees, and conifers/evergreens/softwoods, and within those for only the highest scenarios, with acute RQs ranging from 0.21-1.5 for those uses. All other uses (as well as chronic estimates for those uses) had freshwater acute and chronic RQs of < 0.01 -0.2 and < 0.01 -0.8 for thiram; < 0.01 -0.08 and < 0.01 -0.3 for ferbam; and 0.18-0.48 and 0.10-0.55 for ziram.

Table 8-15. Acute and Chronic Risk Quotients for Non-listed Aquatic Invertebrate Species (Water-Column Exposure) Exposed to Thiram

Use Sites	1-in-10 Yr EEC (µg/L)		Risk Quotient				
			Freshwater		Estuarine/Marine		
	Daily Mean	21-day Mean	Acute ¹	Chronic ²	Acute ¹		Chronic ²
			LC ₅₀ = 210 µg a.i./L	NOAEC = 20 µg a.i./L	Crustacean LC ₅₀ = 11 µg a.i./L	Mollusc EC ₅₀ = 61 µg a.i./L	NOAEC = 1.0 µg a.i./L
Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)							
CATurfRLF	42.3	15.7	0.20	0.79	3.9	0.69	16
PATurfSTD	42.2	16	0.20	0.80	3.8	0.69	16
FLturfSTD	41.7	15.5	0.20	0.78	3.8	0.68	16
Ornamentals; Shrubs/Bushes/ Vines; Trees; 4.36 lb/acre x 3 apps (7-day interval)							
CAnurserySTD_V2	21.1	5.86	0.10	0.29	1.9	0.35	5.9
ORXmasTreeSTD	11.7	4.53	0.06	0.23	1.2	0.19	4.5
Peach; 2.63 lb/acre x 5 apps (3-day interval)							
GAPeachesSTD (A)	19.2	8.01	0.09	0.40	1.9	0.31	8.0
CAfruit_WirrigSTD (G)	7.6	3.75	0.04	0.19	0.69	0.12	3.8
Strawberry; 4.36 lb/acre x 5 apps (10-day interval)							
CAStrawberry-noplasticRLF_V2 (A)	18.4	6.56	0.09	0.33	1.7	0.30	6.6
FLstrawberry_WirrigSTD (G)	9.08	3.55	0.04	0.18	0.83	0.15	3.6
Seed Treatments:							
Onion (Highest Rate) 1.375 lb/acre							
GAOnion_WirrigSTD	1.55	0.511	0.01	0.03	0.14	0.01	0.51
WAonionNMC	0.00459	0.000661	<0.01	<0.01	<0.01	<0.01	<0.01
Succulent Beans 0.4487 lb/acre							
IlbeansNMC	0.343	0.0801	<0.01	<0.01	0.03	<0.01	0.08
WAbearsNMC	0.00295	0.000416	<0.01	<0.01	<0.01	<0.01	0.04
Small Seeded Legumes 0.4297 lb/acre							
IlbeansNMC	0.0987	0.0228	<0.01	<0.01	0.01	<0.01	0.02

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.

¹ The EECs used to calculate this RQ are based on the 1-in-10-year peak 1-day average value from **Table 8-3**. Endpoints used were: Daphnid (water flea) LC₅₀ = 210 µg thiram a.i./L (MRID 00164662); Mysid LC₅₀ = 11 µg thiram equivalents/L (MRID 43781603); Eastern oyster EC₅₀ = 61 µg thiram a.i./L (MRID 43781602).

² The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average value from **Table 8-3**. Endpoints used were: Daphnid (water flea) NOAEC of 20 µg thiram a.i./L (MRID 47495001, based on 19% reduction in dry weight); and Mysid NOAEC of 1.0 µg thiram equivalents/L (a calculated endpoint based on the mysid acute value and daphnid ACR, see **Table 6-1**).

Table 8-16. Acute and Chronic Risk Quotients for Non-listed Aquatic Invertebrate Species (Water-Column Exposure) Exposed to Ferbam and Degradate, Thiram (Expressed as Thiram a.i. and Ferbam Equivalents, Feq)

Use Sites	1-in-10 Yr EEC (µg thiram a.i./L)		Risk Quotients				
			Freshwater Endpoints Expressed as both µg thiram a.i./L (and µg feq/L)		Estuarine/Marine Endpoints Expressed as both µg thiram a.i./L (and µg feq/L)		
	Daily Mean	21-day Mean	Acute ¹	Chronic ²	Acute ¹		Chronic ²
			LC ₅₀ = 210 µg (360 µg feq)/L	NOAEC = 20 µg (35 µg feq)/L	Crustacean LC ₅₀ = 11 µg (19 µg feq)/L	Mollusc EC ₅₀ = 77 µg (105 µgfeq)/L	NOAEC = 1.0 µg (1.7 µfeq)/L
Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre) x 10 apps (10-day interval)							
GAPeachesSTD	15.8	4.53	0.08	0.23	1.4	0.26	4.5
CAfruit_WirrigSTD	6.25	2.33	0.03	0.12	0.57	0.10	2.3
Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)							
CACitrus_WirrigSTD	15.3	5.65	0.07	0.28	1.4	0.25	5.7
FLcitrusSTD	15.2	6.09	0.07	0.30	1.4	0.25	6.1
Peach and Nectarine: 2.96 lb thiram a.i./acre (3.42 lb feq/acre) x 3 apps (7-day interval)							
GAPeachesSTD	14.9	5.10	0.07	0.26	1.4	0.24	5.1
CAfruit_WirrigSTD	8.90	3.33	0.04	0.17	0.81	0.15	3.3
Pear: 3.03 lb thiram a.i./acre (3.50 lb feq/acre) x 3 apps (7-day interval)							
GAPeachesSTD	10.4	3.94	0.05	0.20	0.95	0.17	3.9
CAfruit_WirrigSTD	8.96	3.56	0.04	0.18	0.81	0.15	3.6
Apple: 3.03 lb thiram a.i./acre (3.50 lb feq/acre) x 3 apps (7-day interval)							
NCappleSTD	9.79	3.59	0.05	0.18	0.89	0.16	3.6
ORappleSTD	8.90	3.36	0.04	0.17	0.81	0.15	3.4
Cranberry: 4.02 lb thiram a.i./acre (4.64 lb feq/acre) x 5 apps (7-day interval) (PWC Calculations)							
ORberriesOP	12.2	4.85	0.06	0.24	1.1	0.20	4.9
Cranberry: 4.02 lb thiram a.i./acre (4.64 lb feq/acre) x 5 apps (7-day interval) (PFAM Calculations)							
OR_Cranberry- Winter Flood STD.PFA	1.33	0.154	0.01	0.01	0.12	0.02	0.15
WI_Cranberry- Winter Flood STD.PFA	0.319	0.0589	<0.01	<0.01	0.03	0.01	0.06
PFAM: OR_Cranberry- Winter Flood STD.PFA	1.33	0.154	0.01	0.01	0.12	0.02	0.15
PFAM: MA_Cranberry- Winter Flood STD.PFA	0.32	0.0461	<0.01	<0.01	0.03	0.01	0.05

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.

¹ The EECs used to calculate this RQ are based on the 1-in-10-year peak 1-day average value from **Table 8-5** and **Table 8-7**. Endpoints used were: Daphnid (water flea) LC₅₀ = 360 µg feq/L (MRID 00164662); Mysid LC₅₀ = 19 µg feq/L (MRID 43781603); Eastern oyster EC₅₀ = 105 µg feq/L (MRID 43781602).

² The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average value from **Table 8-5** and **Table 8-7**. Endpoints used were: Daphnid (water flea) NOAEC of 35µg feq/L (MRID 47495001, based on 19% reduction in dry weight); and Mysid NOAEC of 1.7 µg feq/L (a calculated endpoint based on the mysid acute value and daphnid ACR, see **Table 6-2**).

Table 8-17. Acute and Chronic Risk Quotients for Non-listed Aquatic Invertebrate Species (Water-Column Exposure) Exposed to Ziram and Degradate, Thiram (Expressed as Ziram Equivalents, zeq)

Use Sites	1-in-10 Yr EEC (µg/L)						
	Daily Mean	21-day Mean	Freshwater		Estuarine/Marine		
			Acute ¹	Chronic ²	Acute ¹		Chronic ²
			LC ₅₀ = 48 µg zeq/L	NOAEC = 25 µg zeq/L	Crustacean LC ₅₀ = 14 µg zeq/L	Mollusc EC ₅₀ = 77 µg zeq/L	NOAEC = 1.3 µg zeq/L
Apple/ Pear: 4.56 lb/acre x 7 apps (7-day interval)							
NCappleSTD	70.7	9.53	1.5	0.38	5.1	0.92	7.3
ORappleSTD	13.9	4.4	0.29	0.18	0.99	0.18	3.4
Conif./ Evergr./ Softwood: 6.08 lb/acre x 4 apps (3-day interval)							
NJnurserySTD_V2	67.2	14.7	1.4	0.59	4.8	0.87	11
ORnurserySTD_V2	20.9	7.71	0.44	0.31	1.5	0.27	5.9
Filbert: 6.08 lb/acre x 5 apps (14-day interval)							
ORfilbertsSTD (aerial)	66.4	11.9	1.4	0.48	4.7	0.86	9.2
ORfilbertsSTD	17.6	4.41	0.37	0.18	1.3	0.23	3.4
Nectarine/ Peach: 7.60 lb/acre x 6 apps (7-day interval)							
Cafruit_WirrigSTD (aerial)	43.5	13.8	0.91	0.55	3.1	0.56	11
Cafruit_WirrigSTD	23.2	7.23	0.48	0.29	1.7	0.30	5.6
Pecan: 6.08 lb/acre x 6 apps (21-day interval)							
GApecansSTD	22.7	2.5	0.47	0.10	1.6	0.29	1.9
Almond/ Apricot: 6.08 lb/acre x 4 apps (7-day interval)							
CAalmond_WirrigSTD (aerial)	33.2	10.5	0.69	0.42	2.4	0.43	8.1
Cafruit_WirrigSTD	16.3	4.97	0.34	0.20	1.2	0.21	3.8
Tree: 6.08 lb/acre x 3 apps (7-day interval)							
CAForestryRLF	26.4	7.39	0.55	0.30	1.9	0.34	5.7
ORXmastreeSTD	17	5.83	0.35	0.23	1.2	0.22	4.5
Cherry: 4.56 lb/acre x 4 apps (7-day interval)							
MIcherriesSTD (aerial)	30.5	11.9	0.64	0.48	2.2	0.40	9.2
MIcherriesSTD	16.9	6.52	0.35	0.26	1.2	0.22	5.0
Tomato: 3.04 lb/acre x 6 apps (7-day interval)							
FLtomatoSTD_v2	23.1	3.3	0.48	0.13	1.7	0.30	2.5
CAtomato_wirrigSTD	9.51	2.89	0.20	0.12	0.68	0.12	2.2
Blueberry: 3.04 lb/acre x 5 apps (7-day interval)							
OrberriesOP (aerial)	17.2	5.94	0.36	0.24	1.2	0.22	4.6
OrberriesOP	8.59	2.95	0.18	0.12	0.61	0.11	2.3
Grapes: 3.04 lb/acre x 3 apps (7-day interval)							
NYgrapesSTD	10.3	3.99	0.21	0.16	0.74	0.13	3.1
Cagrapes_WirrigSTD	8.03	2.48	0.17	0.10	0.57	0.10	1.9

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.

¹ The EECs used to calculate this RQ are based on the 1-in-10-year peak 1-day average value from **Table 8-10**.

Endpoints used were: Daphnid (water flea) LC₅₀ = 48 µg zeq/L (MRID 42386305); Mysid LC₅₀ = 14 µg zeq/L (MRID 43781603); Eastern oyster EC₅₀ = 77 µg thiram a.i./L (MRID 43781602).

² The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average value from **Table 8-10**.

Endpoints used were: Daphnid (water flea) NOAEC of 25 µg zeq/L (MRID 47495001, based on 19% reduction in dry weight); and Mysid NOAEC of 1.4 µg zeq/L (a calculated endpoint based on the mysid acute value and daphnid ACR, see **Table 6-3**).

As described in the respective problem formulations (USEPA, 2015a and USEPA, 2015b), toxicity from spiked-sediment exposure was not assessed because the compounds have been described as not being expected to accumulate in the sediment. However, with K_{oc} s that are greater than 1000 for thiram and ziram in some soils (see **Table 5-1** and **Table 5-4**), risk associated with sediment pore water exposure was assessed and a qualitative discussion is made below comparing pore water with overlying water concentrations. For benthic invertebrates, acute risk LOC (0.5) was not exceeded for thiram uses. The benthic invertebrate acute risk LOC was also not exceeded for ferbam uses except cranberry, or ziram uses except the highest scenario (California forestry scenario for the tree use, RQ of 0.58) with freshwater and estuarine/marine acute RQs ranging from <0.01 to 0.02 and <0.01 to 0.44 for thiram, <0.01 to 0.01 and 0.09 to 0.19 for ferbam (for cranberry use the ranges were 0.75 to 0.87 and 14 to 17), and 0.01 to 0.17 and 0.05 to 0.58 for ziram. The chronic risk LOC (1) was exceeded for most foliar uses for estuarine marine organisms, but not for freshwater organisms, except that the freshwater chronic LOC was also exceeded for the ferbam cranberry use (RQ up to 7.3), with freshwater and estuarine/marine chronic RQs of 0.06 to 23 and 1.2 to 4.6 for thiram foliar uses, <0.01 to 0.01 and <0.01 to 0.21 for the thiram seed-treatment uses, 0.05 to 0.10 and 0.96 to 2.0 (6.2 to 7.3 and 120 to 150 for the cranberry use) for ferbam, and 0.02 to 0.28 and 0.44 to 5.0 for ziram (**Table 8-18**).

Table 8-18. Aquatic Invertebrate (Exposed in Sediment) Risk Quotients for Non-listed Species

Use Site	1-in-10 Yr EEC Pore Water (µg/L)1		Risk Quotients			
			Freshwater		Estuarine/marine	
	Daily Mean	21-day Mean	Acute	Chronic	Acute	Chronic
			LC/EC50: 210 µg a.i./L, 360 µg feq/L 48 µg zeq/L 2	NOAEC: 20 µg a.i./L 35 µg feq/L 25 µg zeq/L 3	LC/EC50: 11 µg a.i./L 19 µg feq/L 14 µg zeq/L 2	NOAEC: 1.0 µg a.i./L 1.7 µg feq/L 1.4 µg zeq/L 3
Thiram Registered Uses with Concentrations Expressed as µg thiram a.i./L:						
Highest Foliar Scenario: Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)						
PA turfSTD	4.89	4.61	0.02	0.23	0.44	4.6
Lowest Foliar Scenario: Ornamentals; Shrubs/Bushes/ Vines; Trees; 4.36 lb/acre x 3 apps (7-day interval)						
FLnurserySTD_V2	1.22	1.15	0.01	0.06	0.11	1.2
Highest Seed Treatment Scenario:						
Onion (High Rate) GAOnion_WirrigSTD	0.227	0.207	<0.01	0.01	0.02	0.21
Lowest Seed Treatment Scenario:						
Onion (Low Rate) WAOnionNMC	0.0000356	0.0000333	<0.01	<0.01	<0.01	<0.01
Ferbam Registered Uses with Concentrations Expressed as µg thiram a.i./L (and ferbam µg feq/L):						
Highest PWC Scenario (except cranberry): Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)						
FLcitrusSTD	2.11 (3.66)	1.97 (3.41)	0.01	0.10	0.19	2.0
Lowest Scenario: Peach and Nectarine: 2.96 lb thiram a.i./acre (3.42 lb feq/acre) x 3 apps (7-day interval)						
CAfruit_WirrigSTD	1.00 (1.73)	0.96 (1.66)	<0.01	0.05	0.09	0.96
Highest and Lowest PFAM Scenario: Cranberry: 4.02 lb thiram a.i./acre (4.64 lb feq/acre) x 5 apps (7-day interval) (PFAM Calculations)						
OR_Cranberry-Winter Flood STD.PFA	183 (317)	145 (251)	0.87	7.3	17	150
WI_Cranberry-Winter Flood STD.PFA	158 (274)	124 (215)	0.75	6.2	14	120
Ziram Registered Uses Expressed as µg ziram a.i. (zeq)/L:						
Highest Scenario: Tree: 6.08 lb/acre x 3 apps (7-day interval)						
CAForestryRLF	8.17	7.03	0.17	0.28	0.58	5.0
Lowest Scenario: Grapes: 3.04 lb/acre x 3 apps (7-day interval)						
Cagrapes_WirrigSTD	0.708	0.617	0.01	0.02	0.05	0.44

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.

¹ The EECs used to calculate this RQ are based on the 1-in-10-year peak/1-day average value and 21-day average value from **Table 8-3**, **Table 8-5**, **Table 8-7**, and **Table 8-10**; for ferbam, the EECs are also converted to ferbam equivalents (feq) using the molecular weight conversion.

² Measured water-column LC₅₀ from the most sensitive water-column toxicity tests. Endpoints used were: Daphnid (water flea) LC₅₀ = 210 µg thiram a.i./L (also 360 µg feq/L, MRID 00164662); and Mysid LC₅₀ = 11 µg thiram equivalents/L (also 19 µg feq/L and 14 µg zeq/L, MRID 43781603). The same daphnid study was used for thiram and ferbam acute RQ calculations, and the same mysid study for all three chemicals. For ziram, a different acute endpoint was used: Daphnid (water flea) LC₅₀ = 48 µg zeq/L (MRID 42386305).

³ Chronic endpoints used were from the most sensitive water-column toxicity tests: Daphnid (water flea) NOAEC of 20 µg thiram a.i./L (also 35 µg feq/L and 25 µg zeq/L, MRID 47495001, based on 19% reduction in dry weight); and Mysid NOAEC of 1.0 µg thiram equivalents/L (also 1.7 µg feq/L and 1.4 µg zeq/L); this is a calculated endpoint based on the mysid acute value and daphnid ACR (see **Table 6-1**). The same daphnid study and mysid chronic studies were used for RQ calculations for all three chemicals.

Looking at the pore water concentrations, for most uses of thiram, ferbam, and ziram, the pore water concentrations range from 5 to 51% of highest day-one water column concentrations, and 24 to 200% of 21-day water column concentrations (see **Table 8-3**, **Table 8-5**, and **Table 8-10**). Therefore, assuming equal toxicity compared to water-column organisms, benthic organisms would be expected to be at lower risk (5-51% lower) than pelagic invertebrates from acute (day-one) exposure but to greater risk (up to 200% greater, or twice as great) from chronic exposures to pore water. This applies to all uses except cranberry, where pore water concentrations are calculated using different modeling software to assess both high bush and flooded cranberries. Therefore, the results were very different, showing flooded pore water concentrations of 138 to 500x greater in pore water than the day-one water column concentrations and 940 to 2700x greater at 21-days (**Table 8-7**). The cranberry EECs calculated using the PWC, however, were much lower than for other uses, but the calculations using PFAM were up to 62x higher than the highest EEC calculated for the other uses on day-one and up to 430x higher than the highest EEC calculated for other uses at 21-days. Therefore, potential risk to benthic invertebrates may occur from all registered uses of thiram, ferbam, and ziram, based on pore water exposure estimates.

For further characterization, a field study with thiram is available where effects of spray drift were simulated in a freshwater ecosystem (MRID 46249304). This study was intended to simulate the potential impact of Thiram 80 WG (a water dispersible formulation containing 81.2% of the active ingredient Thiram) contamination via spray drift from agricultural applications on a freshwater ecosystem under field conditions. A spray application method was used to simulate the entry of the test material into a water body by direct over-spray or spray drift. Four applications of seven treatment levels were made at 7-day intervals with identical application rates; therefore, exposure, although intermittent, had a similar exposure duration to the 21- to 27-day exposures used in the daphnid and mysid chronic studies presented in **Appendix C**. The highest test concentration selected was intended to result in substantial acute adverse effects on at least some of the mesocosm taxa. The lower test concentrations were intended to permit the estimation of toxicant effects thresholds for the different taxa. The mesocosm study design included three replicate mesocosm ponds for the negative control group and one replicate mesocosm pond per treatment group. Seven treatment levels were used with nominal Thiram 80 WG formulation treatment concentrations ranging from 1.25 to 1250 µg formulation (Thiram 80 WG)/L, which corresponded to 1.0 to 1000 µg thiram a.i./L nominal concentrations. The study was classified as supplemental because only five of the seven treatment levels were analytically verified and because this study was non-guideline. The overall short duration of the study (less than 1 year for the in-life portion of the study) did not allow for the comparison of the treated community structure compared to the structure from untreated or post-treatment years.

In this study the following conclusions were found:

- NOAEC/ LOAEC were $\leq 1.0/ 1.0 \mu\text{g thiram a.i./L}$ (the lowest concentration tested) based on effects to zooplankton community similarity;
- NOAEC/ LOAEC were $2.1/ 11.5 \mu\text{g thiram a.i./L}$ based on significant reduction in invertebrate taxa abundance; zooplankton community diversity (based on ShannonWeaver Index) and evenness were not significantly affected during the treatment period; NOAEC/ LOAEC were $32/ 107 \mu\text{g thiram a.i./L}$ based on effects to macrozoobenthic community similarity and population reductions for aquatic snails (*Gyraulus albus*) and leeches (*Helobdella stagnalis*);
- NOAEC/ LOAEC were $32/ >32 \mu\text{g thiram a.i./L}$ based on no effects to emergent insect community; and
- NOAEC/LOAEC were $107/320 \mu\text{g thiram a.i./L}$ based on significant reduction in phytoplankton taxa abundance, diversity, evenness, and similarity.

Because the zooplankton communities were the most sensitive, more detail of the variety of measurements is included here (additional details are found in **Appendix C**). Results described here stipulate whether the treatment level was nominal or measured. Because recoveries were good, the nominal treatment levels are close to measured levels for the (5 of 7) treatment levels measured. In general, the zooplankton community was dominated by Crustacea and Rotatoria species. The dominant cladocerans *Daphnia pulex* and *Daphnia magna* population densities were significantly reduced following the first treatment application at the two highest treatment levels, 320 and 1000 $\mu\text{g a.i./L}$ (nominal). Consequently, the NOAEC for *Daphnia pulex* and *Daphnia magna* during the treatment period was 107 $\mu\text{g a.i./L}$ (measured). Thiram applications had slight to strong effects on copepod nauplii during the treatment period at treatment levels of 32 to 1000 $\mu\text{g a.i./L}$ (nominal). Consequently, the NOAEC value for all copepod nauplii was determined to be 11.5 $\mu\text{g a.i./L}$ (measured). Population densities of the rotifer, *Keratella quadrata*, were significantly reduced by treatment at the 11.5 through 1000 $\mu\text{g a.i./L}$ treatment levels (measured and nominal, respectively). Consequently, the NOAEC for *Keratella quadrata* was 2.1 $\mu\text{g a.i./L}$ (measured). The population densities of *Brachionus urceolaris/variabilis* were significantly reduced during the treatment period at the nominal 32 through 1000 $\mu\text{g a.i./L}$ treatment levels (nominal). Consequently, the NOAEC for *Brachionus urceolaris/variabilis* was concluded to be 11.5 $\mu\text{g a.i./L}$ (measured). The growth rates of the rotifer, *Hexarthra mira/intermedia*, were significantly reduced at all treatment levels. However, this was based on the reported EC₂₀ and EC₅₀ values (1.3 and 7.6 $\mu\text{g Thiram 80 WG formulation/L}$, respectively), the lowest of which corresponds with the 1.0 $\mu\text{g thiram a.i./L}$ treatment level (measured). Consequently, the NOAEC for *Hexarthra mira/intermedia* was $<1.0 \mu\text{g a.i./L}$ (measured), i.e. less than the lowest treatment concentration tested. Therefore, the data show a variety of effects endpoints for zooplankton species and communities ranging from NOAEC of <1.0 (based on 20% effect on rotifer growth) to 107 $\mu\text{g a.i./L}$ (based on significant reduction in daphnid population densities for two species; both NOAECs were measured).

These findings showing effects in the range of 1 to 100 $\mu\text{g thiram a.i./L}$, which can be compared with chronic NOAEC used for freshwater risk assessment (20 $\mu\text{g thiram a.i./L}$) and the estimated exposure concentrations (ranging from 8 to 42 $\mu\text{g thiram a.i./L}$ for acute exposures and 4 to 16

µg thiram a.i./L for chronic exposures) and suggest that freshwater invertebrates may be affected by thiram uses. Because available toxicity information may not capture the sensitivities of the most vulnerable taxa or life stages, the difference between freshwater and estuarine/marine species may not be as important as the range of sensitivities among taxa.

8.2.3 Aquatic Plants:

Thiram, ferbam, and ziram registered uses do not exceed the LOC (1) for aquatic plants except for the two highest scenarios for ziram. Thiram foliar uses had RQs of <0.01-0.03 for vascular and 0.05-0.3 for non-vascular plants and thiram seed-treatment uses had RQs of <0.01 for vascular and <0.01-0.01 for non-vascular plants (**Table 8-19**). Ferbam uses had RQs of <0.01-0.01 for vascular and <0.01-0.11 for non-vascular plants (**Table 8-20**). Ziram uses had RQs of 0.02 to 0.19 for vascular and 0.12-1.1 for non-vascular plants with exceedances in the highest scenarios for apples/pears and conifers/evergreens/softwoods (**Table 8-21**).

Table 8-19. Aquatic Plant Risk Quotients for Non-listed Species exposed to Thiram

Use Sites	1-in-10 Year Daily Mean EEC (µg/L)	Risk Quotients ¹	
		Vascular	Non-vascular
		IC ₅₀ = 1600 µg a.i./L	IC ₅₀ = 140 µg a.i./L (TGAI)
Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)			
CATurfRLF	42.3	0.03	0.30
PAturfSTD	42.2	0.03	0.30
FLturfSTD	41.7	0.03	0.30
Ornamentals; Shrubs/Bushes/ Vines; Trees; 4.36 lb/acre x 3 apps (7-day interval)			
CAnurserySTD_V2	21.1	0.01	0.15
ORXmasTreeSTD	11.7	0.01	0.08
Peach; 2.63 lb/acre x 5 apps (3-day interval)			
GAPeachesSTD (A)	19.2	0.01	0.14
CAfruit_WirrigSTD (G)	7.60	<0.01	0.05
Strawberry; 4.36 lb/acre x 5 apps (10-day interval)			
CAStrawberry-noplasticRLF_V2 (A)	18.4	0.01	0.13
FLstrawberry_WirrigSTD (G)	9.08	0.01	0.06
Seed Treatments:			
Onion (Highest Rate) 1.375 lb/acre			
GAOnion_WirrigSTD	1.55	<0.01	0.01
WAonionNMC	0.00459	<0.01	<0.01
Succulent Beans 0.4487 lb/acre			
ILbeansNMC	0.343	<0.01	<0.01
WAbearsNMC	0.00295	<0.01	<0.01

Bolded values exceed the LOC for non-listed plants, which is 1. The endpoints listed in the table are used to calculate the RQ.

¹ The EECs used to calculate this RQ are based on the 1-in-10-year peak 1-day average value from **Table 8-3**. Endpoints used were: Duckweed IC₅₀ = 1600 µg thiram a.i./L (MRID 45441202); and green algae IC₅₀ = 140 µg thiram a.i./L (MRID 44086101, 44086001).

Table 8-20. Aquatic Plant Risk Quotients for Non-listed Species exposed to Ferbam and Degradate, Thiram (Amounts Expressed as Both Thiram a.i. and as Ferbam Equivalents)

Use Sites	1-in-10 Year Daily Mean EEC (µg thiram a.i./L)	Risk Quotients ¹	
		Vascular	Non-vascular
		IC ₅₀ = 1600 µg thiram a.i. (2800 µg feq)/L	IC ₅₀ = 140 µg thiram a.i. (240 µg feq)/L
Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre) x 10 apps (10-day interval)			
GAPeachesSTD	15.8	0.01	0.11
CAfruit_WirrigSTD	6.25	<0.01	0.04
Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)			
CACitrus_WirrigSTD	15.3	0.01	0.11
FLcitrusSTD	15.2	0.01	0.11
Peach and Nectarine: 2.96 lb thiram a.i./acre (3.42 lb feq/acre) x 3 apps (7-day interval)			
GAPeachesSTD	14.9	0.01	0.11
CAfruit_WirrigSTD	8.90	0.01	0.06
Pear: 3.03 lb thiram a.i./acre (3.50 lb feq/acre) x 3 apps (7-day interval)			
GAPeachesSTD	10.4	0.01	0.07
CAfruit_WirrigSTD	8.96	0.01	0.06
Apple: 3.03 lb thiram a.i./acre (3.50 lb feq/acre) x 3 apps (7-day interval)			
NCappleSTD	9.79	0.01	0.07
ORappleSTD	8.90	0.01	0.06
Cranberry: 4.02 lb thiram a.i./acre (4.64 lb feq/acre) x 5 apps (7-day interval) (PWC Calculations)			
ORberriesOP	12.2	0.01	0.09
Cranberry: 4.02 lb thiram a.i./acre (4.64 lb feq/acre) x 5 apps (7-day interval) (PFAM Calculations)			
OR_Cranberry- Winter Flood STD.PFA	1.33	<0.01	0.01
WI_Cranberry- Winter Flood STD.PFA	0.319	<0.01	<0.01
PFAM: OR_Cranberry- Winter Flood STD.PFA	1.33	<0.01	0.01
PFAM: MA_Cranberry- Winter Flood STD.PFA	0.320	<0.01	<0.01

Bolded values exceed the LOC for non-listed plants, which is 1. The endpoints listed in the table are used to calculate the RQ.

¹ The EECs used to calculate this RQ are based on the 1-in-10-year peak 1-day average value from **Table 8-5** and **Table 8-7**. Endpoints used were: Duckweed IC₅₀ = 2800 µg feq/L (MRID 45441202); and green algae IC₅₀ = 240 µg feq/L (MRID 44086101, 44086001).

Table 8-21. Aquatic Plant Risk Quotients for Non-listed Species exposed to Ziram and Degradate, Thiram (Amounts Expressed as Ziram Equivalents, zeq)

Use Sites	1-in-10 Year Daily Mean EEC (µg zeq/L)	Risk Quotients ¹	
		Vascular	Non-vascular
		IC ₅₀ = 370 µg zeq/L	IC ₅₀ = 67 µg zeq/L
Apple/ Pear: 4.56 lb/acre x 7 apps (7-day interval)			
NCappleSTD	70.7	0.19	1.1
ORappleSTD	13.9	0.04	0.21
Conif./ Evergr./ Softwood: 6.08 lb/acre x 4 apps (3-day interval)			
NJnurserySTD_V2	67.2	0.18	1.0
ORNurserySTD_V2	20.9	0.06	0.31
Filbert: 6.08 lb/acre x 5 apps (14-day interval)			
ORfilbertsSTD (aerial)	66.4	0.18	0.99
ORfilbertsSTD	17.6	0.05	0.26
Nectarine/ Peach: 7.60 lb/acre x 6 apps (7-day interval)			
Cafruit_WirrigSTD (aerial)	43.5	0.12	0.65
Cafruit_WirrigSTD	23.2	0.06	0.35
Pecan: 6.08 lb/acre x 6 apps (21-day interval)			
GApecansSTD	22.7	0.06	0.34
Almond/ Apricot: 6.08 lb/acre x 4 apps (7-day interval)			
CAalmond_WirrigSTD (aerial)	33.2	0.09	0.50
Cafruit_WirrigSTD	16.3	0.04	0.24
Tree: 6.08 lb/acre x 3 apps (7-day interval)			
CAForestryRLF	26.4	0.07	0.39
ORXmastreeSTD	17	0.05	0.25
Cherry: 4.56 lb/acre x 4 apps (7-day interval)			
MIcherriesSTD (aerial)	30.5	0.08	0.46
MIcherriesSTD	16.9	0.05	0.25
Tomato: 3.04 lb/acre x 6 apps (7-day interval)			
FLtomatoSTD_v2	23.1	0.06	0.34
CAtomato_wirrigSTD	9.51	0.03	0.14
Blueberry: 3.04 lb/acre x 5 apps (7-day interval)			
OrberriesOP (aerial)	17.2	0.05	0.26
OrberriesOP	8.59	0.02	0.13
Grapes: 3.04 lb/acre x 3 apps (7-day interval)			
NYgrapesSTD	10.3	0.03	0.15
Cagrapes_WirrigSTD	8.03	0.02	0.12

Bolded values exceed the LOC for non-listed plants, which is 1. The endpoints listed in the table are used to calculate the RQ.

¹ The EECs used to calculate this RQ are based on the 1-in-10-year peak 1-day average value from **Table 8-10**. Endpoints used were: Duckweed IC₅₀ = 370 µg ziram a.i./L (MRID 46823302); and green algae IC₅₀ = 67 µg ziram a.i./L (MRID 43833901).

Therefore, based on the available data, the risk to aquatic plants from the use of thiram is expected to be low. Although formulation data are available for ziram, with cyanobacteria (*Anabaena flos-aquae*), it was not used to calculate spray-drift distances because there were no LOC exceedances.

A field study with thiram is available where effects of spray drift were simulated in a freshwater ecosystem (MRID 46249304). This study concluded that the NOAEC/LOAEC were 100/320 µg thiram a.i./L based on significant reduction in phytoplankton taxa abundance, diversity, evenness, and similarity. This finding is consistent with the risk assessment findings presented here, where low risk was found and the exposure estimates (EECs) were below this level (9-42 µg thiram a.i./L).

9 Terrestrial Vertebrates Risk Assessment

9.1 Terrestrial Vertebrate Exposure Assessment

Terrestrial wildlife exposure estimates are typically calculated for birds and mammals by emphasizing the dietary exposure pathway. Thiram, ferbam, and ziram are applied through ground application methods, which includes sprayers. Thiram peach and strawberry uses also allow aerial applications, and thiram has many seed treatment uses (alfalfa, barley, beans, beets, broccoli, brussels sprouts, buckwheat, cabbage, canola, carrot, castor bean, cauliflower, celery, swiss chard, chicory, clover, collards, coniferous/evergreen/softwood, coriander, field corn, sweet corn, cowpeas, cucumber, eggplant, endive, flax, grass grown for forage or seed, kale, kohlrabi, lentils, lettuce, melons, millet, mustard, oats, okra, onion, ornamentals, peanuts, peas, pepper, pumpkin, radish, rice, rye, safflower, sesame, small seeded legumes, sorghum, soybeans, spinach, squash, sugar beets, sunflower, tomato, triticale, turnip, vegetables, vetch, wheat). Therefore, potential dietary exposure for terrestrial wildlife in this assessment is based on consumption of thiram, ferbam, and ziram residues on food items following foliar spray applications, and from possible dietary ingestion of thiram residues on treated seeds. Terrestrial wildlife may also be exposed through ingestion of residues in aquatic organisms for chemicals with high log K_{OWS} (4-8), but this pathway did not apply to these chemicals due to lower Log K_{OWS} and was not evaluated.

9.1.1 Dietary Items on the Treated Field

Potential dietary exposure for terrestrial wildlife in this assessment is based on consumption of thiram, ferbam, and ziram residues on food items following foliar spray applications, and from possible dietary ingestion of thiram residues on treated seeds. EECs for birds⁷ 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**, **Table 3-2**, and

⁷ Birds are also used as a proxy for reptiles and terrestrial-phase amphibians.

Table 3-3. The default 35-day foliar dissipation half-life was used in T-REX model because no foliar dissipation data were available.

Upper-bound Kenaga nomogram values are used to derive EECs for thiram, ferbam, and ziram (also thiram as a degradate of ferbam and ziram, and in the case of ferbam, all analyses were done as thiram equivalents) exposures to terrestrial mammals and birds on the field of application based on a 1-year time period. Mean Kenaga values are also used for characterization (roughly one third of upper-bound estimates). Consideration is given to different types of feeding strategies for mammals and birds, including herbivores, insectivores and granivores. Dose-based exposures are estimated for three weight classes of birds (20 g, 100 g, and 1,000 g) and three weight classes of mammals (15 g, 35 g, and 1,000 g). EECs on terrestrial food items range from 39 to 10,000 mg thiram a.i./kg-diet for thiram uses, 39 to 3300 mg thiram a.i./kg-diet for ferbam uses, and 46 to 8000 mg zeq/kg-diet for ziram uses, based on upper bound Kenaga values. Dose base EECs, adjusted for body weight, range from 2.5 to 12,000 mg thiram a.i./kg-bw for birds and 1.3 to 9800 mg thiram a.i./kg-bw for mammals from thiram uses; from 2.5 to 3700 mg thiram a.i./kg-bw for birds and 1.3 to 3100 mg thiram a.i./kg-bw for mammals from ferbam uses; and from 2.9 to 9100 mg zeq/kg-bw for birds and 1.5 to 7600 mg zeq/kg-bw for mammals from ziram uses. A summary of EECs are found in **Table 9-1**, **Table 9-2**, and **Table 9-3**. In general, the highest and lowest application rates are presented, as well as the lowest single application rate. However, in some cases, a lower application rate had a higher number of applications, and so several application rates were used to calculate EECs. Although only the highest and lowest were actually used to calculate risk quotients, the EECs in the tables below help to show the comparative ranges.

Table 9-1. 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 Thiram (T-REX v. 1.5.2, Upper Bound Kenaga)

Food Type	Dietary-Based EEC (mg a.i./kg-diet)	Dose-Based EEC (mg a.i./kg-body weight)					
		Birds			Mammals		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Residential/ Recreational/ Institutional/ Retail; 16.33 lb a.i./acre x 3 apps (7-day interval)							
Short grass	10301	11732	6690	2995	9821	6788	1574
Tall grass	4721	5377	3066	1373	4502	3111	721
Broadleaf plants/small insects	5794	6599	3763	1685	5525	3818	885
Fruits/pods/seeds (dietary only)	644	733	418	187	614	424	98
Arthropods	4035	4595	2620	1173	3847	2659	616
Seeds (granivore) ¹	--	163	93	41.6	136	94	21.9
Strawberry; 4.36 lb a.i./acre x 5 apps (10-day interval)							
Short grass	3661	4169	2377	1064	3490	2412	559
Tall grass	1678	1911	1090	488	1600	1106	256
Broadleaf plants/small insects	2059	2345	1337	599	1963	1357	315
Fruits/pods/seeds (dietary only)	229	261	149	67	218	151	35
Arthropods	1434	1633	931	417	1367	945	219
Seeds (granivore) ¹	--	58	33.0	14.8	48	34	7.8
Peach; 2.63 lb a.i./acre (lowest single application rate)							
Short grass	631	719	410	184	602	416	96
Tall grass	289	329	188	84	276	191	44
Broadleaf plants/small insects	355	404	231	103	339	234	54
Fruits/pods/seeds (dietary only)	39	45	26	11	38	26	6
Arthropods	247	282	161	72	236	163	38
Seeds (granivore) ¹	--	10	5.7	2.5	8.4	5.8	1.3

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 9-2. 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 Ferbam and Degradate, Thiram (T-REX v. 1.5.2, Upper Bound Kenaga; expressed as thiram a.i.)

Food Type	Dietary-Based EEC (mg a.i./kg-diet)	Dose-Based EEC (mg a.i./kg-body weight)					
		Birds			Mammals		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)							
Short grass	3280	3736	2130	954	3127	2162	501
Tall grass	1503	1712	976	437	1433	991	230
Broadleaf plants/small insects	1845	2101	1198	537	1759	1216	282
Fruits/pods/seeds (dietary only)	205	233	133	60	195	135	31
Arthropods	1285	1463	834	374	1225	847	196
Seeds (granivore) ¹	--	52	30	13.2	43	30	7.0
Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre) x 10 apps (10-day interval)							
Short grass	2982	3397	1937	867	2843	1965	456
Tall grass	1367	1557	888	397	1303	901	209
Broadleaf plants/small insects	1678	1911	1089	488	1599	1105	256
Fruits/pods/seeds (dietary only)	186	212	121	54	178	123	28
Arthropods	1168	1330	759	340	1114	770	178
Seeds (granivore) ¹	--	47	27	12.0	39	27	6.3
Apple: 3.03 lb thiram a.i./acre (3.50 lb feq/acre) x 3 apps (7-day interval)							
Short grass	1911	2177	1241	556	1822	1259	292
Tall grass	876	998	569	255	835	577	134
Broadleaf plants/small insects	1075	1224	698	313	1025	708	164
Fruits/pods/seeds (dietary only)	119	136	78	35	114	79	18
Arthropods	749	853	486	218	714	493	114
Seeds (granivore) ¹	--	30	17	7.7	25	17	4.1
Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre; lowest single application rate)							
Short grass	622	708	404	181	593	410	95
Tall grass	285	324	185	83	272	188	44
Broadleaf plants/small insects	350	398	227	102	333	230	53
Fruits/pods/seeds (dietary only)	39	44	25	11	37	26	6
Arthropods	243	277	158	71	232	160	37
Seeds (granivore) ¹	--	10	6	2.5	8	6	1.3

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 9-3. Summary of Dietary (mg zeq/kg-diet) and Dose-based EECs (mg zeq/kg-bw) as Food Residues for Birds, Reptiles, Terrestrial-Phase Amphibians and Mammals from Labeled Uses of Ziram and Degradate, Thiram (T-REX v. 1.5.2, Upper Bound Kenaga)

Food Type	Dietary-Based EEC (mg zeq/kg-diet)	Dose-Based EEC (mg zeq/kg-body weight)					
		Birds			Mammals		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Nectarine/ Peach: 7.60 lb zeq/acre x 6 apps (7-day interval)							
Short grass	7957	9062	5168	2314	7587	5243	1216
Tall grass	3647	4154	2369	1060	3477	2403	557
Broadleaf plants/small insects	4476	5098	2907	1301	4267	2949	684
Fruits/pods/seeds (dietary only)	497	566	323	145	474	328	76
Arthropods	3117	3549	2024	906	2971	2054	476
Seeds (granivore) ¹	--	126	72	32	105	73	17
Grapes: 3.04 lb zeq/acre x 3 apps (7-day interval)							
Short grass	1918	2184	1245	558	1828	1264	293
Tall grass	879	1001	571	256	838	579	134
Broadleaf plants/small insects	1079	1229	701	314	1028	711	165
Fruits/pods/seeds (dietary only)	120	137	78	35	114	79	18
Arthropods	751	855	488	218	716	495	115
Seeds (granivore) ¹	--	30	17	7.7	25	18	4.1
Grapes: 3.04 lb zeq/acre (lowest single application rate)							
Short grass	730	831	474	212	696	481	111
Tall grass	334	381	217	97	319	220	51
Broadleaf plants/small insects	410	467	267	119	391	270	63
Fruits/pods/seeds (dietary only)	46	52	30	13	43	30	7
Arthropods	286	325	186	83	272	188	44
Seeds (granivore) ¹	--	12	6.6	2.9	10	6.7	1.5

ZeQ = ziram equivalents (where thiram data are used have been mol. wt. adjusted).

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.

9.2 Terrestrial Vertebrate Risk Characterization

Foliar Uses

RQ values are generated based on the upper bound EECs discussed above and toxicity values contained in **Table 6-5** and **Table 6-7**. For acute/chronic exposures for birds, dietary based RQs were based on 50% mortality for acute risk and for chronic risk on studies with thiram showing significant ($p < 0.05$) reductions in eggs set (35%), viable embryos (46%), live 3-week embryos (46%), normal hatchlings (56%), 14-d survivors (56%), eggs set/eggs laid (11%), normal hatchlings/live 3-week embryos (22%), normal hatchlings/eggs laid (26%) in the mallard duck (*Anas platyrhynchos*; MRID 45441201) for avian risk and on significant reductions in F1 and F2 body weight in the rat (*Rattus norvegicus*; MRID 42095901).

For birds, both acute (0.5) and chronic (1) LOCs were exceeded for all uses based on upper-bound exposure estimates, with respective acute and chronic RQs ranging from <0.01 to 31 and 4.1 to 1100 for thiram uses, <0.01 to 10 and 4.1 to 340 for ferbam uses, and 0.08 to 130 and 3.8 to 660 for ziram uses (**Table 9-4**). Based on mean exposure estimates (roughly one third of upper-bound estimates) and LOAELs (lowest effect levels), rather than NOAELs (no-effect levels), LOCs were still exceeded, but with lower RQs: respective acute and chronic RQs ranging from <0.01 to 11 and 0.5 to 92 for thiram uses, <0.01 to 3.5 and 0.05 to 29 for ferbam uses, and 0.01 to 46 and 0.4 to 56 for ziram uses (**Table 9-5**).

For mammals, the lowest single application rates for thiram and ferbam fall below the acute LOCs, but the highest rates still have exceedances for some feeding groups (dietary items) with RQs ranging from <0.01 to 2.5 for thiram uses, <0.01 to 0.8 for ferbam uses, and 0.01 to 13 for ziram uses (**Table 9-6**). Considering mean exposure estimates, acute RQs fall below the LOC for all three chemicals based on a single application at the lowest application rates, and for all ferbam uses, but still exceed the LOCs for some feeding groups for the highest application rates for thiram (RQs from 0.01 to 0.9) and ziram (RQs from <0.01 to 4.6; **Table 9-7**).

Chronic risk was much higher than acute risk for mammals (**Table 9-8**). The chronic LOC (1) was exceeded for all uses whether using dose-based or dietary-based estimates and for all size classes and most feeding groups (food item categories) with RQs ranging from 0.9 to 2200 for thiram uses, 0.9 to 710 for ferbam uses, and 0.7 to 1200 for ziram uses. Considering mean exposure estimates did not change the risk picture very much except to reduce the RQs with maximum RQs remaining as high as 320 for thiram uses, 180 for ferbam uses, and 200 for ziram uses (**Table 9-9**).

Table 9-4. Acute and Chronic RQ values for Birds, Reptiles, and Terrestrial-Phase Amphibians from Labeled Uses of Thiram, Ferbam, and Ziram (T-REX v. 1.5.2, Upper Bound Kenaga)

Food Type	Acute Dose-Based RQ LD ₅₀ = 673 mg thiram a.i./kg-bw; ¹ 97 mg zeq/kg-bw			Acute Dietary- Based RQ LC ₅₀ = 3950 mg thiram a.i./kg- diet; 594 mg zeq/kg-diet	Chronic Dietary RQ NOAEC = 9.6 mg thiram a.i./kg- diet; 12 mg zeq/kg-diet
	Small (20 g)	Medium (100 g)	Large (1000 g)		
Thiram Registered Uses					
Thiram Highest Rate: Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)					
Short grass	31	14	4.5	2.6	1100
Tall grass	14	6.4	2.0	1.2	490
Broadleaf plants	18	7.9	2.5	1.5	600
Fruits/pods/seeds	2.0	0.88	0.28	0.16	67
Arthropods	12	5.5	1.7	1.0	420
Seeds (granivore) ²	0.44	0.20	0.06	0.16	67
Thiram Lowest Single App. Rate: Peach; 2.63 lb/acre (single application)					
Short grass	1.9	0.86	0.27	0.16	66
Tall grass	0.88	0.39	0.12	0.07	30
Broadleaf plants	1.1	0.48	0.15	0.09	37
Fruits/pods/seeds	0.12	0.05	0.02	0.01	4.1
Arthropods	0.75	0.34	0.11	0.06	26
Seeds (granivore) ²	0.03	0.01	0.00	0.01	4.1
Ferbam Registered Uses (plus Thiram Degradate)					
Ferbam Highest Rate: Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)					
Short grass	10	4.5	1.4	2.2	340
Tall grass	4.6	2.0	0.65	1.0	160
Broadleaf plants	5.6	2.5	0.80	1.3	190
Fruits/pods/seeds	0.62	0.28	0.09	0.14	21
Arthropods	3.9	1.8	0.56	0.87	130
Seeds (granivore) ²	0.14	0.06	0.02	0.14	21
Ferbam Lowest Single App. Rate: Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre; single application)					
Short grass	1.9	0.85	0.27	0.42	65
Tall grass	0.87	0.39	0.12	0.19	30
Broadleaf plants	1.1	0.48	0.15	0.24	36
Fruits/pods/seeds	0.12	0.05	0.02	0.03	4.1
Arthropods	0.74	0.33	0.11	0.17	25
Seeds (granivore) ²	0.03	0.01	<0.01	0.03	4.1
Ziram Registered Uses (plus Thiram Degradate)					
Ziram Highest Rate: Nectarine/ Peach: 7.60 lb zeq/acre x 6 apps (7-day interval)					
Short grass	130	58	18	13	660
Tall grass	59	27	8	6.1	300
Broadleaf plants	73	33	10	7.5	370
Fruits/pods/seeds	8.1	3.6	1.2	0.84	41
Arthropods	51	23	7.2	5.2	260
Seeds (granivore) ²	1.8	0.81	0.26	0.84	41
Ziram Lowest Single App. Rate: Grapes: 3.04 lb zeq/acre (single application)					
Short grass	12	5.3	1.7	1.2	61
Tall grass	5.4	2.4	0.77	0.56	28
Broadleaf plants	6.7	3.0	0.95	0.69	34

Food Type	Acute Dose-Based RQ LD ₅₀ = 673 mg thiram a.i./kg-bw; ¹ 97 mg zeq/kg-bw			Acute Dietary- Based RQ LC ₅₀ = 3950 mg thiram a.i./kg- diet; 594 mg zeq/kg-diet	Chronic Dietary RQ NOAEC = 9.6 mg thiram a.i./kg- diet; 12 mg zeq/kg-diet
	Small (20 g)	Medium (100 g)	Large (1000 g)		
Fruits/pods/seeds	0.74	0.33	0.11	0.08	3.8
Arthropods	4.7	2.1	0.66	0.48	24
Seeds (granivore) ²	0.17	0.07	0.02	0.08	3.8

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.

¹ In assessing risk using the ring-neck pheasant LD₅₀ (673 mg a.i./kg-bw), the weight of the ring-neck pheasant was not provided in the study. The test birds were 3-4 months old and were estimated to weigh 1000g. Information from the “Pheasant Facts” website (<https://pheasantsforever.org>) showed that weight of males (roosters) averaged 2 to 3 pounds while their female (hen) counterparts average 2 pounds (2 pounds = 907g). Also, the “All About Birds” website (https://www.allaboutbirds.org/guide/Ring-necked_Pheasant/id) said adults weigh 17.6-105.8 oz (500-3000 g). This website said that by 16 weeks of age the birds reach adult body size (<https://www.pheasantsforever.org/BlogLanding/Blogs/Field-Notes/How-Old-Are-Those-Pheasant-Chicks.aspx?feed=articles>). So using a 2 lb estimate (900g) for females and a 2.5 lb estimate for males (1100g) to include both females and males. Since the sex distribution was not provided, assumed half of each, so an average weight of 1000g was used in TREX.

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.

Table 9-5. Acute and Chronic RQ values for Birds, Reptiles, and Terrestrial-Phase Amphibians from Labeled Uses of Thiram, Ferbam, and Ziram (T-REX v. 1.5.2, Mean Kenaga Exposures and Lowest-Obs. Effects Level)

Food Type	Acute Dose-Based RQ LD ₅₀ = 673 mg thiram a.i./kg-bw; ¹ 97 mg zeq/kg-bw			Acute Dietary- Based RQ LC ₅₀ = 3950 mg thiram a.i./kg- diet; 594 mg zeq/kg-diet	Chronic Dietary RQ LOAEC = 39.7 mg thiram a.i./kg- diet; 50.5 mg zeq/kg-diet
	Small (20 g)	Medium (100 g)	Large (1000 g)		
Thiram Registered Uses					
Thiram Highest Rate: Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)					
Short grass	11	5.0	1.6	0.92	92
Tall grass	4.7	2.1	0.67	0.39	39
Broadleaf plants	5.9	2.6	0.83	0.49	49
Fruits/pods/seeds	0.91	0.41	0.13	0.08	7.6
Arthropods	8.5	3.8	1.2	0.71	70
Seeds (granivore) ²	0.20	0.09	0.03	0.08	7.6
Thiram Lowest Single App. Rate: Peach; 2.63 lb/acre (single application)					
Short grass	0.68	0.30	0.10	0.06	5.6
Tall grass	0.29	0.13	0.04	0.02	2.4
Broadleaf plants	0.36	0.16	0.05	0.03	3.0
Fruits/pods/seeds	0.06	0.03	0.01	0.00	0.46
Arthropods	0.52	0.23	0.07	0.04	4.3
Seeds (granivore) ²	0.01	0.01	0.00	0.00	0.46
Ferbam Registered Uses (plus Thiram Degradate)					
Ferbam Highest Rate: Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)					
Short grass	3.5	1.6	0.50	0.79	29
Tall grass	1.5	0.67	0.21	0.33	12
Broadleaf plants	1.9	0.84	0.27	0.42	15
Fruits/pods/seeds	0.29	0.13	0.04	0.07	2.4
Arthropods	2.7	1.2	0.38	0.60	22
Seeds (granivore) ²	0.06	0.03	0.01	0.07	2.4
Ferbam Lowest Single App. Rate: Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre; single application)					
Short grass	0.67	0.30	0.10	0.15	5.6
Tall grass	0.28	0.13	0.04	0.06	2.4
Broadleaf plants	0.35	0.16	0.05	0.08	2.9
Fruits/pods/seeds	0.06	0.02	0.01	0.01	0.46
Arthropods	0.51	0.23	0.07	0.11	4.2
Seeds (granivore) ²	0.01	0.01	0.00	0.01	0.46
Ziram Registered Uses (plus Thiram Degradate)					
Ziram Highest Rate: Nectarine/ Peach: 7.60 lb zeq/acre x 6 apps (7-day interval)					
Short grass	46	21	6.5	4.7	56
Tall grass	19	8.7	2.8	2.0	24
Broadleaf plants	24	11	3.5	2.5	30
Fruits/pods/seeds	3.8	1.7	0.54	0.39	4.6
Arthropods	35	16	5.0	3.6	43
Seeds (granivore) ²	0.84	0.38	0.12	0.39	4.6
Ziram Lowest Single App. Rate: Grapes: 3.04 lb zeq/acre (single application)					
Short grass	4.2	1.9	0.60	0.44	5.1
Tall grass	1.8	0.80	0.25	0.18	2.2

Food Type	Acute Dose-Based RQ LD ₅₀ = 673 mg thiram a.i./kg-bw; ¹ 97 mg zeq/kg-bw			Acute Dietary- Based RQ LC ₅₀ = 3950 mg thiram a.i./kg- diet; 594 mg zeq/kg-diet	Chronic Dietary RQ LOAEC = 39.7 mg thiram a.i./kg- diet; 50.5 mg zeq/kg-diet
	Small (20 g)	Medium (100 g)	Large (1000 g)		
Broadleaf plants	2.2	1.0	0.32	0.23	2.7
Fruits/pods/seeds	0.35	0.16	0.05	0.04	0.42
Arthropods	3.2	1.4	0.46	0.33	3.9
Seeds (granivore) ²	0.08	0.03	0.01	0.04	0.42

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.

¹ In assessing risk using the ring-neck pheasant LD₅₀ (673 mg a.i./kg-bw), the weight of the ring-neck pheasant was not provided in the study. The test birds were 3-4 months old and were estimated to weigh 1000g. Information from the “Pheasant Facts” website (<https://pheasantsforever.org>) showed that weight of males (roosters) averaged 2 to 3 pounds while their female (hen) counterparts average 2 pounds (2 pounds = 907g). Also, the “All About Birds” website (https://www.allaboutbirds.org/guide/Ring-necked_Pheasant/id) said adults weigh 17.6-105.8 oz (500-3000 g). This website said that by 16 weeks of age the birds reach adult body size (<https://www.pheasantsforever.org/BlogLanding/Blogs/Field-Notes/How-Old-Are-Those-Pheasant-Chicks.aspx?feed=articles>). So, using a 2 lb estimate (900g) for females and a 2.5 lb estimate for males (1100g) to include both females and males. Since the sex distribution was not provided, assumed half of each, so an average weight of 1000g was used in TREX.

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.

Table 9-6. Acute RQ values for Mammals from Labeled Uses of Ferbam and Degradate, Thiram (T-REX v. 1.5.2, Upper Bound Kenaga)

Food Type	Acute Dose-Based RQ LD ₅₀ = 1800 mg thiram a.i./kg-bw; 267 mg zeq/kg-bw			Acute Dietary-Based RQ {No Data}
	Small (15 g)	Medium (35 g)	Large (1000 g)	
Thiram Registered Uses				
Thiram Highest Rate: Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)				
Short grass	2.5	2.1	1.1	--
Tall grass	1.1	0.97	0.52	--
Broadleaf plants	1.4	1.2	0.64	--
Fruits/pods/seeds	0.16	0.13	0.07	--
Arthropods	0.97	0.83	0.45	--
Seeds (granivore) ¹	0.03	0.03	0.02	--
Thiram Lowest Single App. Rate: Peach; 2.63 lb/acre (single application)				
Short grass	0.15	0.13	0.07	--
Tall grass	0.07	0.06	0.03	--
Broadleaf plants	0.09	0.07	0.04	--
Fruits/pods/seeds	0.01	0.01	<0.01	--
Arthropods	0.06	0.05	0.03	--
Seeds (granivore) ¹	<0.01	<0.01	<0.01	--
Ferbam Registered Uses (plus Thiram Degradate)				
Ferbam Highest Rate: Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)				
Short grass	0.79	0.68	0.36	--
Tall grass	0.36	0.31	0.17	--
Broadleaf plants	0.44	0.38	0.20	--
Fruits/pods/seeds	0.05	0.04	0.02	--
Arthropods	0.31	0.26	0.14	--
Seeds (granivore) ¹	0.01	0.01	0.01	--
Ferbam Lowest Single App. Rate: Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre; single application)				
Short grass	0.15	0.13	0.07	--
Tall grass	0.07	0.06	0.03	--
Broadleaf plants	0.08	0.07	0.04	--
Fruits/pods/seeds	0.01	0.01	<0.01	--
Arthropods	0.06	0.05	0.03	--
Seeds (granivore) ¹	<0.01	<0.01	<0.01	--
Ziram Registered Uses (plus Thiram Degradate)				
Ziram Highest Rate: Nectarine/ Peach: 7.60 lb zeq/acre x 6 apps (7-day interval)				
Short grass	13	11	5.9	--
Tall grass	5.9	5.1	2.7	--
Broadleaf plants	7.3	6.2	3.3	--
Fruits/pods/seeds	0.81	0.69	0.37	--
Arthropods	5.1	4.3	2.3	--
Seeds (granivore) ¹	0.18	0.15	0.08	--
Ziram Lowest Single App. Rate: Grapes: 3.04 lb zeq/acre (single application)				
Short grass	1.2	1.0	0.54	--
Tall grass	0.54	0.46	0.25	--
Broadleaf plants	0.67	0.57	0.31	--
Fruits/pods/seeds	0.07	0.06	0.03	--
Arthropods	0.46	0.40	0.21	--
Seeds (granivore) ¹	0.02	0.01	0.01	--

Bolded values exceed the LOC for acute risk to non-listed species of 0.5. Endpoints were used to calculate RQs.

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 diets.

Table 9-7. Acute RQ values for Mammals from Labeled Uses of Ferbam and Degradate, Thiram (T-REX v. 1.5.2, Mean Kenaga Exposure)

Food Type	Acute Dose-Based RQ LD ₅₀ = 1800 mg thiram a.i./kg-bw; 267 mg zeq/kg-bw			Acute Dietary-Based RQ {No Data}
	Small (15 g)	Medium (35 g)	Large (1000 g)	
Thiram Registered Uses				
Thiram Highest Rate: Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)				
Short grass	0.88	0.75	0.40	--
Tall grass	0.37	0.32	0.17	--
Broadleaf plants	0.47	0.40	0.21	--
Fruits/pods/seeds	0.07	0.06	0.03	--
Arthropods	0.67	0.57	0.31	--
Seeds (granivore) ¹	0.02	0.01	0.01	--
Ferbam Registered Uses (plus Thiram Degradate)				
Ferbam Highest Rate: Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)				
Short grass	0.28	0.24	0.13	--
Tall grass	0.12	0.10	0.05	--
Broadleaf plants	0.15	0.13	0.07	--
Fruits/pods/seeds	0.02	0.02	0.01	--
Arthropods	0.21	0.18	0.10	--
Seeds (granivore) ¹	0.01	0.00	0.00	--
Ziram Registered Uses (plus Thiram Degradate)				
Ziram Highest Rate: Nectarine/ Peach: 7.60 lb zeq/acre x 6 apps (7-day interval)				
Short grass	4.6	3.9	2.1	--
Tall grass	1.9	1.7	0.89	--
Broadleaf plants	2.4	2.1	1.1	--
Fruits/pods/seeds	0.38	0.32	0.17	--
Arthropods	3.5	3.0	1.6	--
Seeds (granivore) ¹	0.08	0.07	0.04	--
Ziram Lowest Single App. Rate: Grapes: 3.04 lb zeq/acre (single application)				
Short grass	0.42	0.36	0.19	--
Tall grass	0.18	0.15	0.08	--
Broadleaf plants	0.22	0.19	0.10	--
Fruits/pods/seeds	0.03	0.03	0.02	--
Arthropods	0.32	0.27	0.15	--
Seeds (granivore) ¹	0.01	0.01	0.00	--

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 9-8. Chronic RQ values for Mammals from Labeled Uses of Ziram and Degradate, Thiram (T-REX v. 1.5.2, Upper Bound Kenaga)

Food Type	Chronic Dose-Based RQ NOAEL = 2.0 mg thiram a.i./kg/day-bw; 3.0 mg zeq/kg/day-bw			Chronic Dietary RQ NOAEC = 20 mg thiram a.i./kg-diet; 25 mg zeq/kg-diet
	Small (15 g)	Medium (35 g)	Large (1000 g)	
Thiram Registered Uses				
Thiram Highest Rate: Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)				
Short grass	2200	1900	1000	520
Tall grass	1000	880	470	240
Broadleaf plants	1300	1100	580	290
Fruits/pods/seeds	140	120	64	32
Arthropods	880	75	400	200
Seeds (granivore) ¹	31	27	14	32
Thiram Lowest Single App. Rate: Peach; 2.63 lb/acre (single application)				
Short grass	140	120	63	32
Tall grass	63	54	29	14
Broadleaf plants	77	66	35	18
Fruits/pods/seeds	8.6	7.3	3.9	2.0
Arthropods	54	46	25	12
Seeds (granivore) ¹	1.9	1.6	0.87	2.0
Ferbam Registered Uses (plus Thiram Degradate)				
Ferbam Highest Rate: Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)				
Short grass	710	610	330	160
Tall grass	330	280	150	75
Broadleaf plants	400	340	180	92
Fruits/pods/seeds	44	38	20	10
Arthropods	280	240	130	64
Seeds (granivore) ¹	9.9	8.4	4.5	10
Ferbam Lowest Single App. Rate: Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre; single application)				
Short grass	130	120	62	31
Tall grass	62	53	28	14
Broadleaf plants	76	65	35	17
Fruits/pods/seeds	8.4	7.2	3.9	1.9
Arthropods	53	45	24	12
Seeds (granivore) ¹	1.9	1.6	0.86	1.9
Ziram Registered Uses (plus Thiram Degradate)				
Ziram Highest Rate: Nectarine/ Peach: 7.60 lb zeq/acre x 6 apps (7-day interval)				
Short grass	1200	980	530	320
Tall grass	530	450	240	150
Broadleaf plants	650	550	300	180
Fruits/pods/seeds	72	61	33	20
Arthropods	450	390	210	130
Seeds (granivore) ¹	16	14	7.3	20
Ziram Lowest Single App. Rate: Grapes: 3.04 lb zeq/acre (single application)				
Short grass	110	90	48	29
Tall grass	48	41	22	13
Broadleaf plants	59	51	27	16
Fruits/pods/seeds	6.6	5.6	3.0	1.8
Arthropods	41	35	19	11

Food Type	Chronic Dose-Based RQ NOAEL = 2.0 mg thiram a.i./kg/day-bw; 3.0 mg zeq/kg/day-bw			Chronic Dietary RQ NOAEC = 20 mg thiram a.i./kg-diet; 25 mg zeq/kg-diet
	Small (15 g)	Medium (35 g)	Large (1000 g)	
Seeds (granivore) ¹	1.5	1.3	0.67	1.8

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 9-9. Chronic RQ values for Mammals from Labeled Uses of Ziram and Degradate, Thiram (T-REX v. 1.5.2, Mean Kenaga Exposures and Lowest-Obs. Effects Level)

Food Type	Chronic Dose-Based RQ LOAEL = 5.0 mg thiram a.i./kg/day-bw; 6.0 mg zeq/kg/day-bw			Chronic Dietary RQ LOAEC = 60 mg thiram a.i./kg-diet; 76 mg zeq/kg-diet
	Small (15 g)	Medium (35 g)	Large (1000 g)	
Thiram Registered Uses				
Thiram Highest Rate: Residential/ Recreational/ Institutional/ Retail; 16.33 lb/acre x 3 apps (7-day interval)				
Short grass	320	270	140	61
Tall grass	130	110	61	26
Broadleaf plants	170	140	77	32
Fruits/pods/seeds	26	22	12	5.0
Arthropods	240	210	110	47
Seeds (granivore) ¹	5.8	5.0	2.7	5.0
Thiram Lowest Single App. Rate: Peach; 2.63 lb/acre (single application)				
Short grass	19	17	8.9	3.7
Tall grass	8.2	7.0	3.8	1.6
Broadleaf plants	10	8.8	4.7	2.0
Fruits/pods/seeds	1.6	1.4	0.73	0.31
Arthropods	15	13	6.8	2.9
Seeds (granivore) ¹	0.35	0.30	0.16	0.31
Ferbam Registered Uses (plus Thiram Degradate)				
Ferbam Highest Rate: Citrus: 5.20 lb thiram a.i./acre (6.00 lb feq/acre) x 3 apps (7-day interval)				
Short grass	100	86	46	19
Tall grass	43	36	20	8.2
Broadleaf plants	53	46	24	10
Fruits/pods/seeds	8.3	7.1	3.8	1.6
Arthropods	77	66	35	15
Seeds (granivore) ¹	1.8	1.6	0.84	1.6
Ferbam Lowest Single App. Rate: Mango: 2.59 lb thiram a.i./acre (2.99 lb feq/acre; single application)				
Short grass	19	16	8.8	3.7
Tall grass	8.1	6.9	3.7	1.6
Broadleaf plants	10	8.6	4.6	1.9
Fruits/pods/seeds	1.6	1.3	0.72	0.30
Arthropods	15	12	6.7	2.8
Seeds (granivore) ¹	0.35	0.30	0.16	0.30
Ziram Registered Uses (plus Thiram Degradate)				
Ziram Highest Rate: Nectarine/ Peach: 7.60 lb zeq/acre x 6 apps (7-day interval)				
Short grass	200	170	93	37
Tall grass	86	74	40	16
Broadleaf plants	110	92	49	20
Fruits/pods/seeds	17	14.	7.7	3.1
Arthropods	160	130	71	28
Seeds (granivore) ¹	3.7	3.2	1.7	3.1
Ziram Lowest Single App. Rate: Grapes: 3.04 lb zeq/acre (single application)				
Short grass	19	16	8.6	3.4
Tall grass	7.9	6.8	3.6	1.4
Broadleaf plants	10	8.5	4.5	1.8
Fruits/pods/seeds	1.5	1.3	0.70	0.28
Arthropods	14	12	6.5	2.6

Food Type	Chronic Dose-Based RQ LOAEL = 5.0 mg thiram a.i./kg/day-bw; 6.0 mg zeq/kg/day-bw			Chronic Dietary RQ LOAEC = 60 mg thiram a.i./kg-diet; 76 mg zeq/kg-diet
	Small (15 g)	Medium (35 g)	Large (1000 g)	
Seeds (granivore) ¹	0.34	0.29	0.16	0.28

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.

For chronic dietary RQ exceedances, the number of days that the LOAEL is exceeded based on mean Kenega exposure values and a single application at the lowest application rate are:

- Thiram peach use single application: 88 days for birds (to below LOAEC 39.7 mg thiram a.i./kg-diet); 67 days for mammals (60 mg thiram a.i./kg-diet)
- Ferbam mango use single application: 87 days for bird (39.7 mg thiram a.i./kg-diet); 66 days for mammals (60 mg thiram a.i./kg-diet)
- Ziram grape use single application: 83 days for birds (50.5 mg zeq/kg-diet); 62 days for mammals (76 mg zeq/kg-diet).

Additionally, for chronic dietary risk, the inverse of the chronic RQ is an indication of what fraction of the diet would need to be obtained from the treated field in order to exceed the NOAEL. Applying this to the highest and lowest EECs, the fractions (expressed as percentages) of the diet that would need to be obtained from the treated field to exceed the NOAEC for birds would be from 0.09% to 24% for thiram uses, from 0.29% to 24% for ferbam uses, and from 0.15% to 26% for ziram uses. Likewise, for mammals, the percentages of the diet that would need to be obtained from the treated field to exceed the NOAEC for mammals would be from 0.19% to 50% for thiram uses, from 0.63% to 53% for ferbam uses, and from 3.4% to 56% for ziram uses.

Thiram Seed Treatment Uses

Characterization of the risk posed by seed treatments followed the methodology of USEPA, 2016a with the following modifications: a) calculation of the number of seeds to reach an acute threshold of concern was modified to reflect the LOC (0.5), b) foraging time equations were modified to reflect the equations originally presented in Benkman and Pulliam (1988) with modifications to accurately represent passerine consumption rates for known dietary items (*e.g.* removal of chipping sparrow data that gave unrealistically large foraging times for known seed dietary items under the original equations) and c) minimum and maximum bounds around the foraging area and foraging time of concern were used, replacing the previous mean estimates.

For thiram seed treatments, the maximum application rates range from 0.000288 (for triticale) to 0.021 lbs a.i./lb seed for coniferous/evergreen/softwood (**Table 3-1**). The maximum and minimum application rates for each type of seed (in lb a.i./lb seed; from February 26, 2019 PLUS report from BEAD) are presented in **Table D-2-1** in **Appendix D (Section D-2)**. The seeding

rates from TREX (found in the model's Seed Treatments sheet) were used to calculate the application rates in lb a.i./acre for those seed types that had seeding rate information available ($\text{lb a.i./lb seed} \times \text{lb seed/acre} = \text{lb a.i./acre}$). The maximum rates in lbs a.i./acre are ranked in **Table D-2-2** (also in **Appendix D, Section D-2**). Because seeding rates vary due to geography and seasonal conditions, rates based on highest application of a.i. per pound of seeds do not match the same ranking order of rates based on highest application of a.i. per acre. **Figure 9-1** shows a graphic of the relationship between maximum application rate in lb a.i./acre with the seeding rate in lb seed/acre. Although some trend may be noted, the highest onion rate seems to be an outlier when compared with the other rates. Therefore, while rates for aquatic risk assessment were grouped by lb a.i./acre estimates, they are grouped by lb a.i./lb seeds for terrestrial assessment because, although both rates would affect terrestrial exposure, the dietary items for terrestrial vertebrates may be more dependent on the lb a.i./lb seed as it is assumed that birds and mammals are consuming individual seeds that are available for consumption as opposed to exposure via leaching from the seed and eventual runoff into the aquatic system.

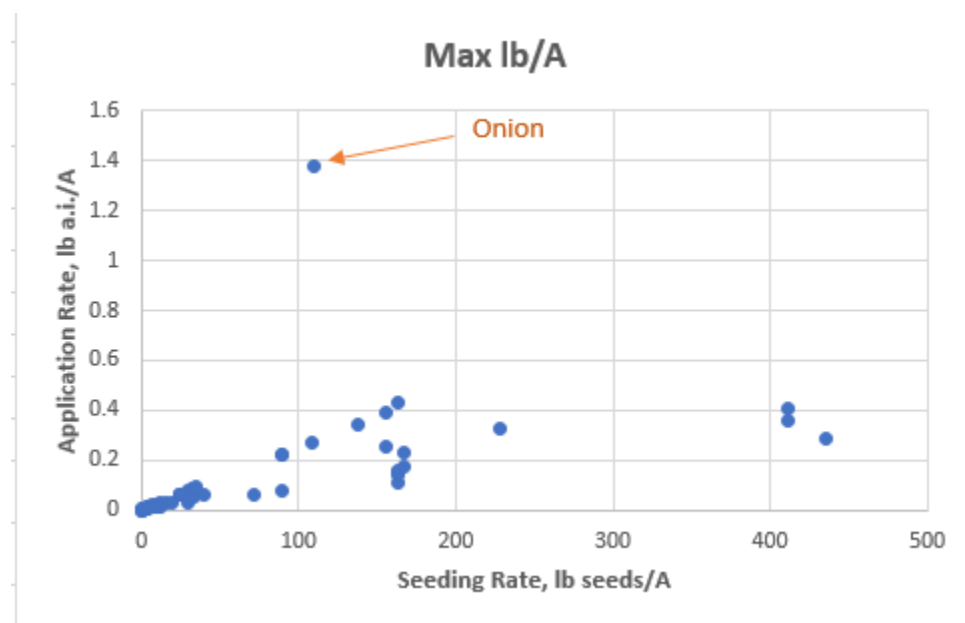


Figure 9-1: Chart of Maximum Application Rates Plotted Against Seeding Rates

Data from **Table D-2-2** in **Appendix D** showing seeding rate compared with application rate with the highest rate for Onion appearing to be an outlier (A is used to represent acre in the chart).

Thiram seed treatments are grouped here as follows for the terrestrial vertebrate assessment:

- **Highest rates - greater than 0.002 lb a.i./lb seed (0.00201 to 0.021 lbs a.i./lb seed)** (the group had a.i. per acre rates up to 1.375 lb a.i./A). The group included: Barley, Beets, Broccoli, Brussels sprouts, Cabbage, Canola/ Rape, Carrot, Cauliflower, Celery, Swiss chard, Collards, Coniferous/Evergreen/Softwood (non-food), Eggplant, Endive, Flowering plants, Grass/ Turf, Kale, Kohlrabi, Lettuce, Millet, Mustard, Non-flowering plants, Oats, Onion, Pepper, Radish, Rye, Safflower, Small-seeded legumes, Sorghum, Spinach, Sugar beet, Sunflower, Turnip, Triticale, and Wheat. Two representative seeds were assessed in this group, the one with the highest lb a.i./lb seed rate (conifer at

0.021 lb a.i./lb seed, no seeding rate was available to calculate lb a.i./A) and the one with the highest lb a.i./A rate (onion at 0.0125 lb a.i./lb seed, 1.375 lb a.i./A):

- Conifer (assessed by product Thiram SC [44% a.i.] at 64 oz/cwt [hundred pounds of seeds] which corresponds with this rate): coniferous/ evergreen/ softwood;
- Onion assessed at maximum rate 0.0125 lb a.i./lb seed (assessing by product Pro-Gro [44% a.i.] at 2.5 lb/cwt which corresponded with this rate, converted to 38 oz/cwt using the TREX default product density of 8.33 lb/gal).
- **Intermediate rates – from >0.001 to 0.002 lb a.i./lb seed (0.00103 to 0.002 lb a.i./lb seed)** (up to 0.45 lb a.i./A). The group included: Alfalfa, Barley, Beans/ Succulent (Lima), Canola/ Rape, Castor bean, Chicory, Clover, Coriander, Corn (Field and Sweet), Cotton, Cucumber, Eggplant, Flax, Grass/ Turf, Melons (Cantaloupe and Water), Millet, Oats, Okra, Onion, Parsley, Peanuts, Pumpkin, Rice, Rye, Safflower, Sorghum, Soybeans, Squash, Tomato, Triticale, Vetch, and Wheat. Three representative seeds were assessed in this group, the one with the highest lb a.i./lb seed rate (canola/rape with a rate of 0.002 lb a.i./lb seeds), the one with the highest lb a.i./A rate (unspecified peas with a rate of 0.404 lbs a.i./A based on a rate of 0.000984 lb a.i./lb seed), and one with the lowest lb a.i./lb seed rate (with the exception of cotton which has a slightly lower rate but was not chosen as the representative due to lack of palatability; Lima beans, based on a rate of 0.00103 lb a.i./lb seed):
 - Canola/Rape assessed at 0.002 lb a.i./lb seed (assessed by products Flowsan Seed Treatment [44.04%] at 6.4 fl oz/cwt which corresponded with this rate);
 - Peas (unspecified) assessed at 0.000984 lb a.i./lb seed (assessing by product Thiram SC [44% a.i.] at 3 fl oz/cwt which corresponded with this rate);
 - Lima beans assessed at 0.00103 lb a.i./lb seed (assessing by product Thiram Granulfo [75% a.i.] at 2.2 fl oz/cwt which corresponded with this rate).
- **Lowest rates - up to 0.001 lb a.i./lb seed (0.000288 to 0.000984 lb a.i./lb seed)** (as low as 0.03 lb a.i./A) – One representative seed was assessed in this group based on the lowest application rate. Triticale was assessed at 0.000288 lb a.i./lb seed (assessed by product Vitaflow 280 which corresponded with this rate, at 3 fl oz/cwt of a 13.25% product). The group included: Barley, Beans (General, Dry-type, Succulent-Lima and Snap), Corn (Field and Sweet), Cotton, Cowpeas, Flax, Grass/ Turf, Lentils, Millet, Oats (General and Silage), Peanuts, Peas (Dry and Unspecified), Rice, Safflower, Sesame, Sorghum, Soybeans, Sunflower, Triticale, Wheat.

Note that some seeds have a wide range of rates and so are listed in more than one rate group above; for example, onion rates range from 0.00188 to 0.0125 lb a.i./lb seed. For both aquatic and terrestrial exposure, the highest rates were modeled based on lb ai/lb seed and maximum seeding rate but recognizing that seeding rates vary due to geography and seasonal conditions. Rather than assess all rates, a high rate, two intermediate rates, and a low rate were assessed. For treated seeds, the label did not list the application rates in terms of lb a.i./A, but in terms of lb a.i./lb seed. It also listed the fluid ounce (fl oz) of each product allowed per 100 lbs of seeds (cwt). Because the T-REX modeling input value is in terms of fl oz/cwt, the product information was used in this assessment that was listed on the label with each maximum rate in terms of lb a.i./lb seeds, but the uses were grouped by lb a.i./lb seeds for grouping purposes.

Corresponding exposure estimates for birds and mammals is shown in **Table 9-10**. 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./ft²). Seed treatment exposure estimates are based not only on lb a.i./A allowed per acre 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 are based on the values used in T-REX v 1.5.2 and represent national maximum values.

Table 9-10. Avian and Mammalian Dose-Based EECs and mg a.i./ft² EECs for Thiram Seed Uses

Crop	Animal Size	Maximum Application Rate	Maximum Application Rate	Maximum Seed Application Rate	Avian Nagy Dose	Mammalian Nagy Dose	Available AI
		(lbs a.i./lb seed)	(lbs a.i./A)	(mg a.i./kg seed)	(mg a.i./kg-bw/day)	(mg a.i./kg-bw/day)	(mg a.i./ft ²)
Coniferous/ evergreen/ softwood ¹	Small	0.021 (assessed at 64 oz/cwt of 44% product)	0.46	18,300	4640	3880	4.78
	Medium				2640	2680	
	Large				1180	622	
Onion	Small	0.0125 (assessed at 38 oz/cwt of 50% product)	1.36	12,400	3130	2620	14.2
	Medium				1780	1810	
	Large				799	420	
Canola/ Rape	Small	0.002 (assessed at 6.4 oz/cwt of 44.04% product)	0.02	1830	464	389	0.16
	Medium				265	269	
	Large				119	62.3	
Peas (unspecified)	Small	0.00984 (assessed at 3 oz/cwt of 44% product)	0.35	859	217	182	3.68
	Medium				124	126	
	Large				55.6	29.2	
Lima beans	Small	0.00103 (assessed at 2.2 oz/cwt of 75% product)	0.11	1070	272	228	1.17
	Medium				155	157	
	Large				69.4	36.5	
Triticale	Small	0.000288 (assessed at 3 oz/cwt of a 13.25% product)	0.03	259	65.5	54.8	0.29
	Medium				37.3	37.9	
	Large				16.7	8.78	

¹ Based on a mean seeding rate of 1,180,000 seeds/acre (range of 1,045,440 to 1,306,800 seeds/acre for Forest seedlings (USEPA, 2011b).

Table 9-11 below shows the calculated RQs for birds and mammals exposed to thiram on treated seed. For all bird size classes, acute dose-based RQs exceed the LOC (0.5) for the conifer and onion uses for all size classes (RQs range from 1.8 to 12 and 1.2 to 8.4, respectively) and for only the smallest to medium size classes for uses with intermediate application rates (represented by canola/rape with RQs ranging from 0.2 to 1.2, peas with RQs ranging from 0.1 to 0.6 and lima beans with RQs range from 0.1 to 0.7). No exceedances were found for the lowest use rate for triticale (RQs 0.02 to 0.17). On an LD₅₀/ft² basis, RQs exceed the LOC for small birds consuming conifer and onion seeds (RQs of 0.6 and 1.9, respectively); RQs do not exceed the LOC for medium or large birds for any of the uses. On a chronic basis, RQs exceed the LOC (1.0) for birds consuming all assessed seeds (RQs range from 27 to 1910).

For mammals, acute dose-based RQs exceed the LOC for small and medium mammals for the highest application rates represented by conifer and onion uses (RQs range from 0.8 to 1.0, and 0.6 to 0.7, respectively). No acute exceedances were found for the low and intermediate rates. On an LD₅₀/ft² basis, no RQs exceed the LOC. On a chronic basis, RQs exceed the LOC for all size classes consuming all assessed seeds (RQs range from 5.7 to 883).

Table 9-11. Acute Dose-Based, LD₅₀/ft² based and Chronic dose-based RQs for Birds and Mammals Exposed to Thiram Treated Seed

Crop	Risk Quotients							
	Avian (LD ₅₀ = 673 mg a.i./kg-bw, NOAEC = 9.6 mg a.i./kg-diet)				Mammalian (LD ₅₀ = 1800 mg a.i./kg-bw, NOAEL = 2.0 mg a.i./kg-bw)			
	Animal Size	Acute Dose-Based	Acute LD ₅₀ /ft ²	Chronic	Animal Size	Acute Dose-Based	Acute LD ₅₀ /ft ²	Chronic
Conifers Etc.	20 g	12.4	0.64	1910	15 g	0.98	0.08	883
	100 g	5.55	0.10		35 g	0.84	0.04	755
	1000 g	1.76	0.01		1000 g	0.45	<0.01	404
Onion	20 g	8.36	1.90	1290	15 g	0.66	0.24	596
	100 g	3.75	0.30		35 g	0.57	0.13	509
	1000 g	1.19	0.02		1000 g	0.30	0.01	273
Canola/ Rape	20 g	1.24	0.02	191	15 g	0.10	<0.01	88.4
	100 g	0.56	<0.01		35 g	0.08	<0.01	75.5
	1000 g	0.18	<0.01		1000 g	0.04	<0.01	40.5
Peas (unspecified)	20 g	0.58	0.49	89.5	15 g	0.05	0.06	41.4
	100 g	0.26	0.08		35 g	0.04	0.03	35.4
	1000 g	0.08	0.01		1000 g	0.02	<0.01	19.0
Lima beans	20 g	0.73	0.16	112	15 g	0.06	0.02	51.8
	100 g	0.33	0.02		35 g	0.05	0.01	44.2
	1000 g	0.10	<0.01		1000 g	0.03	<0.01	23.7
Triticale	20 g	0.17	0.04	27.0	15 g	0.01	<0.01	12.5

Crop	Risk Quotients							
	Avian (LD ₅₀ = 673 mg a.i./kg-bw, NOAEC = 9.6 mg a.i./kg-diet)				Mammalian (LD ₅₀ = 1800 mg a.i./kg-bw, NOAEL = 2.0 mg a.i./kg-bw)			
	Animal Size	Acute Dose-Based	Acute LD ₅₀ /ft ²	Chronic	Animal Size	Acute Dose-Based	Acute LD ₅₀ /ft ²	Chronic
	100 g	0.08	0.01		35 g	0.01	<0.01	10.7
	1000 g	0.02	<0.01		1000 g	0.01	<0.01	5.71

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. LD₅₀/ft² is the amount of pesticide estimated to kill 50% of exposed animals in each square foot of applied area.

¹ A mean seeding rate of 1,180,000 seeds/acre (range of 1,045,440 to 1,306,800 seeds/acre) for Forest seedlings (USEPA, 2011b). Forestry seedlings was not an option in TREX and so Perennial Grass Hay or Pasture was used as the scenario as a rough screening (2 to 25 lb/ acre). This may underestimate the actual rate but was a mid-range selection.

Information was not available in the PLUS report to link the lb. a.i./lb seed with lb a.i./acre maximum application rates, so these were estimated using TREX. The BEAD seeding rate document (USEPA, 2011b) provided a mean seeding rate of 1,180,000 seeds/acre (range of 1,045,440 to 1,306,800 seeds/acre for Forest seedlings. Seeding rates on the other uses assessed were automatically adjusted in TREX. The pasture scenario was used to screen for the conifer use but it was not clear how well it represented forestry seeding rates. A 1990 emergency exemption assessment (USEPA, 1990) equated the onion rate (also given as 2.5 lbs product /100 lb seed) with 1 oz. thiram a.i./ acre (based on an onion seeding rate of 5 lb seed/ acre; this would equate to (0.0125 lb a.i./lb seed * 5 lb seed/ acre = 0.0625 lb a.i./acre). For onion, a maximum application rate of 0.0125 lbs a.i./ lb seed in TREX was estimated to have a rate of 1.36 lb a.i./A.

Using the modifications for seed treatments (USEPA, 2016a) mentioned above, the number of seeds and foraging area to reach an acute threshold of concern (LOC of 0.5) was estimated (**Table 9-12**). These modifications were not available for calculating conifer seeds in TREX and therefore the highest group was assessed by onion only. The following estimates were made:

- **For the group with highest per acre seed treatment rates** (represented by onions), 59-6,800 and 460-14,000 seeds (or 82-420,000 and 640-860,000 feet of foraging area) would be needed to reach acute risk levels of concern for birds and mammals, respectively, depending on size class, while 1-11 and 1-31 seeds (or 1.4-61 and 1.4-43 feet of foraging area) would be needed to reach the chronic levels of concern for birds and mammals, respectively.
- **For the intermediate seed treatment rates** (represented by canola/rape, peas, and lima beans), 12-9840 and 92-169,000 seeds (or 282-492,000 and 867-1,010,000 feet of foraging area) would be needed to reach acute risk levels of concern for birds and mammals, respectively, depending on size class, while 1-15 and 1-45 seeds (or 6-125 and 6-375 feet of foraging area) would be needed to reach the chronic levels of concern for birds and mammals, respectively.

- **For the lowest seed treatment rate** (represented by triticale), the estimates were not calculated by the model used due to seed-specific estimate difficulties. However, one rate (109 lb seed/A) was available in TREX and so this single rate was used in the modification to assess triticale). At this rate, 371-33,4000 and 2900-68,700 seeds would be needed (or up to 1,300,000,000 and 2,700,000,000 feet of foraging area) would be needed to reach the acute risk levels of concern for birds and mammals, respectively, depending on the size class. For chronic risk, 1-52 and 7-153 seeds (or up to 2,080,000 and 6,110,000 feet of foraging area) would be needed to reach levels of concern for birds and mammals, respectively. Also, the rate of a.i. applied to the triticale seeds is approximately 1% of the application rate to onions, and therefore, it may be roughly estimated that 100 times the amounts given above for onions would be needed to reach levels of concern for this use.

Table 9-12. Acute Dose-Based, Number of Seeds or Minimum Foraging Area Needed to Exceed the LOC for Birds and Mammals Exposed to Thiram Treated Seeds¹

Crop Rate, Product	Unit of Concern	Number of Seeds					
		Avian (LD ₅₀ = 673 mg a.i./kg-bw, NOAEC = 9.6 mg a.i./kg-diet)			Mammalian (LD ₅₀ = 1800 mg a.i./kg-bw, NOAEL = 2.0 mg a.i./kg-bw)		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Acute Risk							
Onion 38 oz/cwt, Pro-Gro (50% a.i.) ²	Min # Seeds	59	370	5,300	460	880	11,000
	Max # Seeds	76	480	6,800	600	1,100	14,000
	Min Forage Area (ft ²)	82	520	7,300	640	1,200	15,000
	Max Forage Area (ft ²)	4,600	30,000	420,000	37,000	70,000	860,000
Canola/ Rape 6.4 fl oz/cwt, Flowsan (44.04%) ³	Min # Seeds	48	307	4,340	382	722	8,920
	Max # Seeds	48	307	4,340	382	722	8,920
	Min Forage Area (ft ²)	282	1,810	25,500	2,250	4,250	52,500
	Max Forage Area (ft ²)	480	3,070	43,400	3820	7,220	89,200
Peas (unspecified) 3 fl oz/cwt, Thiram SC (44%) ⁴	Min # Seeds	109	696	9,840	867	1,640	20,200
	Max # Seeds	109	696	9,840	867	1,640	20,200
	Min Forage Area (ft ²)	908	5,800	82,000	7,230	13,600	169,000
	Max Forage Area (ft ²)	5,450	34,800	492,000	43,400	81,900	1,010,000

Crop Rate, Product	Unit of Concern	Number of Seeds					
		Avian (LD ₅₀ = 673 mg a.i./kg-bw, NOAEC = 9.6 mg a.i./kg-diet)			Mammalian (LD ₅₀ = 1800 mg a.i./kg-bw, NOAEL = 2.0 mg a.i./kg-bw)		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Lima beans 2.2 oz/cwt, Thiram Granuflo (75% a.i.) ⁵	Min # Seeds	12	74	1,000	92	170	2,100
	Max # Seeds	12	74	1,000	92	170	2,100
	Min Forage Area (ft ²)	NC	NC	47,000	4,200	7,900	98,000
	Max Forage Area (ft ²)	NC	NC	160,000	14,000	26,000	320,000
Triticale 3 oz/cwt, Vitaflow 280 (13.25% a.i.) ⁶	Est. # Seeds	371	2,360	33,400	2,940	5,560	68,700
	Est. Forage Area (ft ²)	1.5E07	9.4E07	1.3E09	1.2E08	2.2E08	2.7E09
Chronic Risk							
Onion 38 oz/cwt, ProGro (50% a.i.) ²	Min # Seeds	1	1	8	1	2	24
	Max # Seeds	1	1	11	1	3	31
	Min Forage Area (ft ²)	1.4	1.4	11	1.4	2.8	33
	Max Forage Area (ft ²)	61	61	15	1.4	4.2	43
Canola/ Rape 6.4 fl oz/cwt, Flowsan (44.04%) ³	Min # Seeds	1	1	7	1	2	20
	Max # Seeds	1	1	7	1	2	20
	Min Forage Area (ft ²)	5.88	5.88	41.2	5.88	11.8	118
	Max Forage Area (ft ²)	10.0	10.0	41.2	5.88	11.8	118
Peas (unspecified) 3 fl oz/cwt, Thiram SC (44%) ⁴	Min # Seeds	1	2	15	2	4	45
	Max # Seeds	1	2	15	2	4	45
	Min Forage Area (ft ²)	8.33	16.7	125	16.7	33.3	375
	Max Forage Area (ft ²)	50.0	100	125	16.7	33.3	375
Lima beans 2.2 oz/cwt,	Min # Seeds	1	1	2	1	1	5

Crop Rate, Product	Unit of Concern	Number of Seeds					
		Avian (LD ₅₀ = 673 mg a.i./kg-bw, NOAEC = 9.6 mg a.i./kg-diet)			Mammalian (LD ₅₀ = 1800 mg a.i./kg-bw, NOAEL = 2.0 mg a.i./kg-bw)		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Thiram Granuflo (75% a.i.) ⁵	Max # Seeds	1	1	2	1	1	5
	Min Forage Area (ft ²)	NC	NC	92	46	46	230
	Max Forage Area (ft ²)	NC	NC	92	46	46	230
Triticale 3 oz/cwt, Vitaflow 280 (13.25% a.i.) ⁶	Est. # Seeds	1	5	52	7	12	153
	Est. Forage Area (ft ²)	40,000	200,000	2,080,000	280,000	480,000	6,110,000

cwt = hundred pounds of seeds; NC: could not calculated with current tools (in the case of lima beans, seed size was too big).

¹ Seed treatment modifications used to calculate number of seeds and foraging area were not available for conifer and triticale seeds. For conifers, did not have the seed weight information.

² For Pro-Gro, 2.5 lb/cwt was converted to 38 oz/cwt using the TREX default product density of 8.33 lb/gal.

³ For Flowsan a density of 1.16-1.26 is given at 20°C as a “Typical Value, Units” but without the units specified. This is assumed to be in g/mL

(https://productcatalog.eastman.com/tds/ProdDatasheet.aspx?product=71103806&pn=Flowsan+FS#_ga=2.160856501.94708636.1600883637-828947389.1600883637). This (mean of 1.21 g/mL) equates to 10.1 lb/gal and was used for calculations.

⁴ For Thiram SC, used density of 4.2 lbs a.i./gal (from a label with 44% a.i.; calculated product density as: 4.2-lbs a.i./gal, 0.44 lbs a.i./lbs product = 9.5 lbs product/gal).

⁵ For Thiram Granuflo label did not have density information and MSDS said specific gravity not available. TREX User Guide says, “The density of the product is ...usually ...found on the product label. If the density is unknown, the default value of 8.33 lbs/gallon will be used by the model. One label for Granuflo T said that the density is ~0.60 g/m, which is 5.01 lb/gal, and so this was used for product density since it is likely closer than the default even though it is for Granuflo T, rather than Granuflo.

⁶ For Vitaflow 280 label (13.25%) says contains 1.23 lb thiram/gal. Calculated product density as: 1.23 lbs a.i./gal, 0.1325 lbs a.i./lbs product = 9.3 lbs product/gal. Also, for triticale, information on the seeding rate and number of seeds/lb was not available in the modification draft. The seeding rate (109 seeds/acre) was obtained from the TREX model and seed weight information (11,000 to 13,500 seeds/lb seeds) was obtained from an Riverdale Agricultural Service, Muscoda, WI (<http://www.riverdaleagservice.com/index.cfm?show=10&mid=30>).

An important factor in determining the extent to which birds, mammals, reptiles, or terrestrial-phase amphibians would be affected by exposure to thiram, ferbam, or ziram is the palatability aspect. Waivers on bird toxicity data have been requested based on the supposition that animals will avoid consuming thiram (USEPA, 1991). Food avoidance has been documented, in the open literature (e.g., E77673, thiram avoidance in the house sparrow) as well as submitted studies. This has been reviewed in EFED’s Re-registration assessment (USEPA, 2004b) and summarized in the thiram/ferbam problem formulation (USEPA, 2015a), as follows. Feeding choice studies with bobwhite quail and mallard ducks have demonstrated that while birds prefer untreated feed to feed treated with thiram, they will still consume the treated feed in quantities shown to cause adverse reproductive effects (MRIDs 43612505, 43612506). Also, multiple field studies have demonstrated that granivorous birds will consume seeds treated with thiram. Dhinsa *et al.* (1991) demonstrated that thiram did not effectively repel the common house crow from eating planted sunflower seeds treated with thiram. The study compared bird consumption of seeds in plots of untreated sunflower seeds to plots of thiram

treated sunflower seeds. The results showed no significant difference between seed consumption between the untreated and treated plots. Furthermore, a Danish study found that more than half of the daily energy intake of pink-footed geese (*Anser brachyrhynchus*) could be obtained from foraging in newly-sown fields. Also based on observations in fields sown with thiram-treated peas, the study predicted that individuals consumed enough pesticide to elicit effects on reproduction in less than an hour (Madsen, 1996). Additionally, the European union risk assessment (Appendum to Monogram, November 2, 2002; Page 9-3) for thiram references a study which demonstrates that thiram may not serve as an effective avian repellent. The study results showed that when wheat seeds treated with 600 ppm of thiram were broadcasted on the ground at initial densities of 100 seeds/m², 49 to 32% of the seeds were consumed within three days and were completely devoured them within seven days.

It is not entirely known how much food avoidance or acceptance will vary among taxa. For example, the proportion of the diet consisting of short grass consumed by small birds and mammals is often discussed because these food items typically are associated with the highest RQs. Whether consumption rates will be lower when grass is tainted with thiram, ferbam, or ziram is not quantified, but it is likely that it would be reduced if other non-tainted food items are available that are a natural part of the diet. Data is available indicating that reptiles (for which birds serve as surrogates in the risk assessment) do commonly eat grasses, legumes, and other plant materials (Dierner, 1986; Kilimstra and Newsome, 1960; Mushinsky *et al.*, 2003). The current approach is to provide an upper bound of potential exposure because at least a portion of the diet is expected to come from the dietary categories (*e.g.*, a small bird may not only eat short grass, but short grass may be part of its diet and there will be times when a large portion of the diet could come from short grass). Additionally, short grass residues can be considered a surrogate for dietary items that organisms do consume that have a similar surface area to volume ratio as that of short grass.

No bird or mammalian incidents to date have been attributed to thiram. However, without a targeted monitoring program in place, this does not provide enough evidence to conclude that no incidents have occurred.

Therefore, based on the available data, including exceedances based on even mean residue estimates and even when measured against LOAEC endpoints, the risk to birds and/or mammals (also reptiles and terrestrial-phase amphibians) is expected to be high from all uses of thiram, ferbam, and ziram.

10 Terrestrial Invertebrate Risk Assessment

The honey bee (*A. mellifera*) or other non-*Apis* bee species for which data are often submitted (*e.g.* the bumble bee [*Bombus spp.*]), may not be adequate surrogates for terrestrial invertebrates other than bees. However, due to broader concerns regarding potential pesticide adverse impacts to managed pollinators such as the honey bee, the only terrestrial invertebrate taxa for which data are required under the 850 guidelines is the honey bee. The assessment

here focuses on exposure to bees from contact and dietary exposure to thiram, ferbam, and ziram. Due to the lack of systemic uptake by plants expected for these chemicals, dietary uptake via pollen is expected to be limited.

10.1 Bee Exposure Assessment

Crops and other uses to which thiram, ferbam, and ziram are applied are listed in **Table 10-1** (USDA, 2018) along with the United States Department of Agriculture (USDA) pollinator attractive data to identify which uses, especially 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. Bees (both Apis and non-Apis) may be exposed on the field through all outdoor uses of thiram, ferbam, and ziram, including:

- Thiram Outdoor Uses: Grass/ Turf/ Golf course tees and greens, Ornamentals, Shrubs/Bushes/Vines, Trees, Peach, and Strawberry;
- Ferbam Outdoor Uses: Apple, Citrus, Cranberry, Peach, Nectarine, Pear, and Mango;
- Ziram Outdoor Uses: Almond, Apricot, Apple, Blueberry, Cherry, Coniferous/Evergreen/Softwood (non-food), Filberts (Hazelnuts), Flowering plants, Shrubs/ Bushes/ Vines, Grapes, Nectarine, Peach, Pear, Pecan, Tomato, and Tree.

Additionally, a list of seed treatment crops for thiram includes: alfalfa, barley, beans, beets, broccoli, Brussels sprouts, buckwheat, cabbage, canola, carrot, castor bean, cauliflower, celery, Swiss chard, chicory, clover, collards, coniferous/evergreen/softwood, coriander, field corn, sweet corn, cowpeas, cucumber, eggplant, endive, flax, grass grown for forage or seed, kale, kohlrabi, lentils, lettuce, melons, millet, mustard, oats, okra, onion, ornamentals, peanuts, peas, pepper, pumpkin, radish, rice, rye, safflower, sesame, small seeded legumes, sorghum, soybeans, spinach, squash, sugar beets, sunflower, tomato, triticale, turnip, vegetables, vetch, wheat. These were not assessed for pollinator exposure since thiram is not systemic in plants.

Table 10-1. Summary of Information on the Attractiveness of Registered Use Patterns for Thiram, Ferbam, and Ziram 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
Thiram Registered Uses:					
Ornamentals; Shrubs/Bushes/Vines; Tree (applied during winter)	Not Available, Grouping not in Database,	Not Available, Grouping not in Database	Not Available, Grouping not in Database	N/AV	Winter application should reduce exposure, except in tropical areas. However, if exposure occurs, although the listing was not specified in the database, other sources document attractiveness of bees to various ornamentals and trees.
Grass/turf: golf course: tees and greens Represented by Grasses for forage Including inter alia: bent, redbtop, fiorin grass (<i>Agrostis</i> spp.); bluegrass (<i>Poa</i> spp.); Columbus grass (<i>Sorghum alnum</i>); fescue (<i>Festuca</i> spp.); Napier, elephant grass (<i>Pennisetum purpureum</i>); orchard grass (<i>Dactylis glomerata</i>); Rhodes grass (<i>Chloris gayana</i>); <i>Phleum</i> , <i>Agropyron</i> , <i>Elymus</i> , <i>Phalaris</i> , <i>Koeleria</i> , <i>Stipa</i> , <i>Danthonia</i> , <i>Deschampsia</i> , <i>Bromus</i> , <i>Trisetum</i> , <i>Calamagrostis</i> , <i>Carex</i> and <i>Juncus</i>]	Y (pollen) ¹	No or Unknown	No or Unknown	N/AV (35,300,000 for grasses for forage)	Does not require bee pollination. Wind pollinated, source of pollen only when no other forage sources are available. Note: Golf courses not commonly associated with blooming weeds which may also be bee attractive and managed turf is mowed so the grass does not bloom. In the neonicotinoid assessment (for example. see USEPA, 2016b) residential turf was assessed as attractive based primarily on the assumed presence of blooming weeds, while sod farms and golf courses were not. So, the attractiveness notations are intended for residential uses in which blooming occurs.
Peaches (<i>Prunus persica</i> ; <i>Amygdalus persica</i> ; <i>Persica laevis</i>)	Y (nectar & pollen) ¹	Yes ¹	Yes ¹ <i>Osmia</i>	113,000	Requires bee pollination and uses managed pollinators.
Strawberries (<i>Fragaria</i> spp.)	Y (nectar & pollen) ¹	Yes ¹	Yes ¹ <i>Andrena</i> , Halictids, <i>Osmia</i>	58,200	Not essential, but some growers add supplemental hives to compliment wind pollination.
Ferbam Registered Residential Uses:					
Apples (<i>Malus pumila</i> ; <i>M. sylvestris</i> ; <i>M. communis</i> ; <i>Pyrus malus</i>)	Y (nectar ¹ & pollen ²)	Yes ¹	Yes ² <i>Andrena</i> , <i>Anthidium</i> , <i>Halictus</i> , <i>Osmia</i> , <i>Anthophora</i> , <i>Habropoda</i>	328,000	Requires bee pollination and uses managed pollinators.

Crop Name	Honey Bee Attractive? ^{1,2}	Bumble Bee Attractive? ^{1, 2}	Solitary Bee Attractive? ^{1, 2}	Acreage in the U.S.	Notes
Citrus: Evaluated using Oranges [Based on: Common, sweet orange (<i>Citrus sinensis</i>); bitter orange (<i>C. aurantium</i>)]; Grapefruit (<i>Citrus maxima</i> ; <i>C. grandis</i> ; <i>C. paradisi</i>); Mandarin, Tangerine (<i>Citrus reticulata</i>); Clementine, Satsuma (<i>C. unshiu</i>); and Lemons (<i>Citrus limon</i>)	Y (nectar & pollen) ²	Yes ¹ Lemons (N/AV)	Yes ¹ Except: for grapefruits N/AV; for oranges, tangerines, and mandarins: <i>Andrena</i> , <i>Xylocopa</i>	613,000 (oranges) 73,300 (grapefruit, no pomelos) 55,000 (lemons) 52,100 (Tangerines and Mandarins)	Variable among orange cultivars; honey bees brought to groves for orange blossom honey. Both oranges and lemons do not require bee pollination.
Cranberry (American cranberry, <i>Vaccinium macrocarpon</i>)	Y (nectar & pollen) ¹	Yes ²	Yes ² <i>Andrena</i> , <i>Agapostemon</i> , <i>Melitta</i> , <i>Megachile</i>	40,300	Requires bee pollination and uses managed pollinators.
Peaches/ Nectarines (<i>Prunus persica</i> ; <i>Amygdalus persica</i> ; <i>Persica laevis</i>)	Y (nectar & pollen) ¹	Yes ¹	Yes ¹ <i>Osmia</i>	113,000	Requires bee pollination and uses managed pollinators.
Pears (<i>Pyrus communis</i>)	Y (nectar & pollen) ¹	Yes ¹	Yes ¹ <i>Osmia</i> , <i>Andrena</i>	54,400	Requires bee pollination and uses managed pollinators.
Mango Date not available; Evaluated using related plant, Cashew (PR, Anacardiaceae)	Y (nectar & pollen) ¹	N/AV	N/AV	N/AV	Requires bee pollination but does not use managed pollinators.
Ziram Registered Residential Uses:					
Almonds (<i>Prunus amygdalus</i> ; <i>P. communis</i> ; <i>Amygdalus communis</i>)	Y (nectar ¹ & pollen ²)	Yes ¹	Yes ¹ <i>Osmia</i>	780,000	Requires bee pollination; uses managed pollinators. Ziram labels allow use on almonds before, during, and post bloom (Table 3-3).
Apricot (<i>Prunus armeniaca</i>)	Y (nectar & pollen) ²	Yes ²	Yes ¹ <i>Osmia</i>	12,200	Requires bee pollination; uses managed pollinators.
Apples (<i>Malus pumila</i> ; <i>M. sylvestris</i> ; <i>M. communis</i> ; <i>Pyrus malus</i>)	Y (nectar ¹ & pollen ²)	Yes ¹	Yes ² <i>Andrena</i> , <i>Anthidium</i> , <i>Halictus</i> , <i>Osmia</i> , <i>Anthophora</i> , <i>Habropoda</i>	328,000	Requires bee pollination and uses managed pollinators.
Blueberry (fruits of the genus <i>Vaccinium</i>)	Y (nectar & pollen) ¹	Yes ²	Yes ² <i>Andrena</i> , <i>Colletes</i> , <i>Osmia</i> , <i>Anthophora</i> , <i>Xylocopa</i>	77,700	Requires bee pollination; uses managed pollinators. Acreage is only for cultivated blueberries; <i>Apis</i> M. and Megachilidae used in commercial pollination.

Crop Name	Honey Bee Attractive? ^{1,2}	Bumble Bee Attractive? ^{1, 2}	Solitary Bee Attractive? ^{1, 2}	Acreage in the U.S.	Notes
Cherries [Mazzard, sweet cherry (<i>Prunus avium</i> ; <i>Cerasus avium</i>); hard-fleshed cherry (var. <i>duracina</i>); heart cherry (var. <i>juliana</i>)]	Y (nectar ¹ & pollen ²)	Yes ¹	Yes ² <i>Osmia</i>	86,800 (Sweet) 36,500 (Tart)	Requires bee pollination; uses managed pollinators.
Coniferous/ Evergreen/ Softwood (non-food; applied post emergence); also, Tree (applied when dormant)	Not Available, Grouping not in Database, or Uncertainty	Not Available, Grouping not in Database, or Uncertainty	Not Available, Grouping not in Database, or Uncertainty	N/AV	Because conifers are non-flowering plants, they are assumed to not be attractive. However, that assumption cannot be made for flowering evergreens.
Hazelnuts, with shell (filberts, <i>Corylus avellana</i>)	Y (pollen) ¹	No	No	29,000	Does not require bee pollination.
Flowering plants, Shrubs/ Bushes/ Vines – the “Flowering Plants Category is very broad and therefore, can include plants that are not attractive, but here is represented by a plant with maximum attractiveness, the Sunflower (<i>Helianthus annuus</i>)	Y (nectar & pollen) ²	Yes ²	Yes ² <i>Halictus</i> , <i>Dieunomia</i> , <i>Megachile</i> , <i>Melissodes</i> , <i>Svastra</i> , <i>Xylocopa</i> (possibly others due to broad category of plants)	1, 470,000 (sunflower as representative; but not really applicable due to broad category)	Some flowering plants require bee pollination and use managed pollinators; others do not.
Grapes (<i>Vitis vinifera</i>)	Y (pollen) ¹	No	No	962,000	Wind pollinated.
Peaches/ Nectarines (applied when dormant) (<i>Prunus persica</i> ; <i>Amygdalus persica</i> ; <i>Persica laevis</i>)	Y (nectar & pollen) ¹	Yes ¹	Yes ¹ <i>Osmia</i>	113,000	Requires bee pollination and uses managed pollinators. However, applied during dormancy.
Pears (<i>Pyrus communis</i>)	Y (nectar & pollen) ¹	Yes ¹	Yes ¹ <i>Osmia</i> , <i>Andrena</i>	54,400	Requires bee pollination and uses managed pollinators.
Pecans (Juglandaceae)	No	No	No	N/AV	Wind pollinated.
Tomatoes (<i>Lycopersicon esculentum</i>)	No	Yes ¹	Yes ¹	93,600 (fresh) 277,000 (processing)	Requires bee pollination and uses 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

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 D** for a sample output from BeeREX for thiram. In the case of thiram seed treatments, because thiram is not considered systemic, and thus, not taken up by plants into pollen or nectar, this route of exposure was not assessed for bees. 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 exceed the LOC, discussed below, 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, 2012). This is automatic in Bee-REX; consumption rates are reported in Bee-REX Table 4 (see **Appendix D**).

10.3 Bee Risk Characterization (Tier I)

10.3.1 Tier I Risk Estimation (Contact Exposure)

On-Field Risk

An exposure potential of bees is identified for all foliar uses both on and off the treated field, with the possible exceptions of thiram use on ornamentals/shrubs/bushes/vines/trees largely because applications are made during winter, and partly because the use is not specific enough to determine attractiveness, and ziram's use on pecans (because they are determined to be not attractive) and on other trees for the same reasons as for thiram's use on trees (not specific enough to determine attractiveness and applied when dormant). 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).

On the basis of acute contact exposure to adult honey bees, RQs range from 0.1 to 0.6 for thiram uses, 0.09 to 0.19 for ferbam uses (based on thiram toxicity data), and <0.01 to 0.22 for ziram uses (all ziram uses were below the LOC). Based on this analysis, RQs generated for the thiram grass/turf/golf course uses exceed the LOC (0.4). A summary of acute contact RQs for

adult honey bees are provided in **Table 10-2**. Also, for ferbam, an additional characterization is provided. RQs were calculated using a definitive thiram endpoint, but also an acute contact study with ferbam had an a non-definitive LD₅₀ of >6.05 µg thiram a.i./bee (>12.1 ug feq/bee; MRID 00036935). Based on this endpoint, a risk ratio (exposure to toxicity ratio) is also included in the table (consistent with guidance in USEPA, 2011a). The risk ratio is not a definitive RQ and is shown in italics and brackets to distinguish it from an RQ. It is used here to characterize the uncertainty of whether ferbam could be more toxic and have potentially higher RQs based on the non-definitive endpoint. In the study, 10% mortality occurred when bees were exposed to 6.05 µg thiram a.i./bee (12.1 ug feq/bee). In general, the assumption in this assessment is that with ferbam's rapid conversion to thiram, that all risk is from thiram, but there is some acknowledged uncertainty as to whether ferbam might cause contact toxicity to bees before converting to thiram in the range of 12 to 128 ug feq/bee; 128 ug feq/bee corresponds to the thiram LD₅₀ of 73.7 ug thiram a.i./bee, where the risk falls below the LOC. The bracketed ratios show that risk (ratios of 0.6 to 1.2) would be calculated over the LOC of 0.4, but since it is known that this level corresponds to 10% mortality, rather than 50%, the risk is likely low, but uncertainty is acknowledged and risk may depend on the actual dose-response slope for ferbam, which is not known.

Table 10-2. Tier 1 Adult, Acute Contact Risk Quotients for Honey Bees Foraging on Plants Treated with Thiram, Ferbam, or Ziram from BeeRex (ver. 1.0)

Use Pattern	Bee Attractiveness	Max. Single Application Rate	Dose (µg a.i./bee per 1 lb a.i./A) ¹	Contact Dose (µg a.i. or zeq/bee) ¹	Acute RQ [Risk Ratio] ²
Thiram					
Grass/Turf/ Golf Course	Y (nectar & pollen)	16.3 lb a.i./A	2.7	44.1	0.60
Ornamentals Etc.	Not Available	4.36 lb a.i./A	2.7	11.8	0.16
Strawberry	Y (nectar & pollen)	3.30 lb a.i./A	2.7	8.91	0.12
Peach	Y (nectar & pollen)	2.63 lb a.i./A	2.7	7.10	0.10
Ferbam					
Citrus	Y (nectar & pollen)	5.20 lb a.i. (6.00 lb feq)/A	2.7	14.0	0.19 [<1.2]
Cranberry	Y (nectar & pollen)	4.02 lb a.i. (4.64 lb feq)/A	2.7	10.9	0.15 [<0.90]
Apple/ Pear	Y (nectar & pollen)	3.03 lb a.i. (3.50 lb feq)/A	2.7	8.18	0.11 [<0.68]
Peach/ Nectarine	Y (nectar & pollen)	2.96 lb a.i. (3.42 lb feq)/A	2.7	7.99	0.11 [<0.66]
Mango	Y (nectar & pollen)	2.59 lb a.i. (2.99 lb feq)/A	2.7	6.99	0.09 [<0.58]
Ziram					
Peach/ Nectarine	Y (nectar & pollen)	7.60 lb zeq/A	2.7	20.5	0.22

Use Pattern	Bee Attractiveness	Max. Single Application Rate	Dose (μg a.i./bee per 1 lb a.i./A) ¹	Contact Dose (μg a.i. or zeq/bee) ¹	Acute RQ [Risk Ratio] ²
Almond/ Apricot	Y (nectar & pollen)	6.08 lb zeq/A	2.7	16.4	0.18
Conifer, Tree, Etc.	Not Available				
Filbert	Y (pollen)				
Apple/ Cherry/ Pear	Y (nectar & pollen)	4.56 lb zeq/A	2.7	12.3	0.13
Blueberry	Y (nectar & pollen)	3.04 lb zeq/A	2.7	8.2	0.09
Grape	Y (pollen)				
Tomato	Y for bumble and solitary bees				
Flowering plants, Shrubs/ Bushes/ Vines	Y (nectar & pollen) for some; varies	0.0152 lb zeq/A	2.7	0.04	<0.01

a.i. = active ingredient; A = acre; feq = ferbam equivalents, zeq = ziram equivalents.

¹ Source: USEPA, PMRA, and CDPR, 2014. Guidance for Assessing Pesticide Risks to Bees. Contact dose: (app. rate * dose per pound which is 2.7 by definition) App. Rate in lb/A*2.7 = Dose in μg a.i./bee. For thiram and ferbam, the a.i. is in thiram a.i., for ziram, it is in ziram equivalents (zeq) because thiram toxicity is also considered for both ferbam and ziram as the degradate.

² Based on a 48-h acute contact LD₅₀ of 73.7 μg thiram a.i./bee for thiram and ferbam (MRID 00036935) and 93.8 μg zeq/bee for naled (MRID 00036935), and 0.56 μg zeq/bee for ziram (MRID 00036935). Also included in brackets is a risk ratio (an exposure:toxicity ratio) for ferbam based on a non-definitive LD₅₀ of >6.05 μg thiram a.i./bee, corresponding to >12.1 μg feq/bee; MRID 00036935). The risk ratio is not a definitive RQ and is shown in italics and brackets to distinguish it from an RQ. It is used here to characterize the uncertainty of whether ferbam could be more toxic and have potentially higher based on the non-definitive endpoint.

10.3.2 Tier I Risk Estimation (Oral Exposure)

On-Field Risk

For oral exposure, the Tier 1 assessment considers just the caste of bees with the greatest oral exposure (foraging adults and 5-day old worker larvae). Actually, larval drones had slightly higher RQs than 5-day old worker larvae but are not as prevalent in the hive and so worker larvae are highlighted in this assessment. If risks are identified, then other factors are considered for refining the Tier 1 risk estimates. These factors include other castes of bees and available information on residues in pollen and nectar which is deemed applicable to the crops of interest.

On the basis of acute oral exposure to larval worker honey bees, RQs range from 128 to 793 for thiram uses, 126 to 252 for ferbam uses, and 0.57 to 287 for ziram uses. On the basis of chronic oral exposure to larval worker honey bees, RQs range from 1410 to 8740 for thiram uses, 1390 to 2780 for ferbam uses, and 6.4 to 3200 for ziram uses. On the basis of chronic oral exposure

to adult nectar-foragers, RQs range from 0.10 to 49.8 for ziram uses. A summary of these oral RQs is provided in **Table 10-3**.

Neither acute or chronic RQs could be calculated for adult bees due to non-definitive acute and chronic endpoints for thiram and ferbam, and acute adult RQs could not be calculated for ziram due to a non-definitive acute endpoint. In these cases, a risk ratio (the ratio of exposure to toxicity, assuming non-definitive dose as the toxicity estimate) is shown in italics and parenthesis in **Table 10-3** to distinguish it from an RQ and used here for screening. For thiram and ferbam, the ratios are based on a 48-h acute oral LD₅₀ of >73.7 µg thiram a.i./bee for adults (MRID 00036935) and 10-d NOAEL of >4.32 µg a.i./bee/day for larvae (MRID 50273402), based on no effects to mortality. For ziram, the adult acute ratios are based on a 48-h acute oral LD₅₀ of >105 µg zeq/bee for adults (MRID 50294101), based on no mortality at that treatment level. In these cases, the estimate is only capable of showing where risk cannot be discounted due to lack of toxicity data at the exposure estimate and is not an acknowledgement of calculated risk. Using these ratio estimates, on the basis of acute oral exposure to adult nectar-foragers ratios range from <0.80 to <4.95 for thiram uses, from <0.78 to <1.58 for ferbam uses, and <0.01 to <2.33 for ziram uses, and on the basis of chronic oral exposure to adult nectar-foragers, ratios range from <19.6 to <121 for thiram uses, and <19.3 to <38.7 for ferbam uses.

For larval worker honey bees, acute RQs range from 128 to 793 for thiram uses, 126 to 252 for ferbam uses, and 0.57 to 287 for ziram use and chronic RQs range from 1410 to 8740 for thiram uses, 1390 to 2780 for ferbam uses, and 6.4 to 3200 for ziram uses. For adult nectar-foragers, chronic RQs range from 0.10 to 49.8 for ziram uses. For adult nectar-foragers, with the exception of the lowest application rate for ziram (0.0152 lb zeq/acre for flowering plants, shrubs, bushes, and vines), risk could not be discounted for all uses of thiram, ferbam, and ziram, even though mortality was not seen in adult oral toxicity tests at treatment levels up to approximately 100 µg a.i./bee oral dose (which is the usual highest dose to determine that the compound is practically non-toxic) risk could not be discounted due to the high exposure potential that exceeds this exposure level.

Table 10-3. Tier 1 Oral Risk Quotients for Adult Nectar Forager and Larval Worker Honey Bees from BeeRex (ver. 1.0)

Use Pattern	Max. Single Appl. Rate	Bee Caste/Task	Unit Dose (μg a.i./bee per 1 lb a.i./A)	Oral Dose (μg a.i./bee)	Acute Oral RQ ^{1,2}	Chronic Oral RQ ^{1,3}
Thiram						
Grass/Turf/ Golf Course	16.3 lb a.i./A	Adult nectar forager	32.1 ⁴	525	(<i><4.95</i>)	(<i><121</i>)
		Larval workers (5-d old)	13.6 ⁴	222	793	8740
Peach	2.63 lb a.i./A	Adult nectar forager	32.1	84.5	(<i><0.80</i>)	(<i><19.6</i>)
		Larval workers (5-d old)	13.6	35.8	128	1410
Ferbam						
Citrus	5.20 lb a.i. (6.00 lb feq)/A	Adult nectar forager	32.1	167	(<i><1.58</i>)	(<i><38.7</i>)
		Larval workers (5-d old)	13.6	70.7	252	2780
Mango	2.59 lb a.i. (2.99 lb feq)/A	Adult nectar forager	32.1	83.2	(<i><0.78</i>)	(<i><19.3</i>)
		Larval workers (5-d old)	13.6	35.2	126	1390
Ziram						
Peach/ Nectarine	7.60 lb zeq/A	Adult nectar forager	32.1	244	(<i><2.33</i>)	49.8
		Larval workers (5-d old)	13.6	103	287	3200
Flowering plants, Shrubs/ Bushes/ Vines	0.0152 lb zeq/A	Adult nectar forager	32.1	0.488	(<i><0.01</i>)	0.10
		Larval workers (5-d old)	13.6	0.207	0.57	6.40

a.i. = active ingredient; A = acre; feq = ferbam equivalents, zeq = ziram equivalents, d = day.

Bolded RQ value exceeds (or potentially exceeds) the acute risk LOC of 0.4 or chronic LOC of 1.0.

¹ Risk Quotients (RQs) could not be calculated for adult bees due to non-definitive acute and chronic endpoints for thiram and ferbam, and acute adult RQs could not be calculated for ziram due to a non-definitive acute endpoint. In these cases, a risk ratio (of exposure to toxicity, assuming non-definitive dose as tox. estimate) is shown in italics and parenthesis to distinguish it from an RQ and used here for screening. For thiram and ferbam, the ratios are based on a 48-h acute oral LD₅₀ of >73.7 μg thiram a.i./bee for adults (MRID 00036935) and 10-d NOAEL of >4.32 μg a.i./bee/day for larvae (MRID 50273402), based on no effects to mortality. For ziram, the adult acute ratios are based on a 48-h acute oral LD₅₀ of >105 μg zeq/bee for adults (MRID 50294101).

² Acute larval RQs for all three chemicals are based on a 7-day (single dose) LD₅₀ of 0.28 μg thiram a.i./larvae, also expressed as 0.36 μg zeq/larvae (MRID 50940001).

³ Based on a 10-d chronic NOAEL of 4.9 μg zeq/bee/d for adults (MRID 50294102) for ziram (thiram and ferbam are discussed in the first footnote) and a 22-d chronic NOAEL of 0.0254 μg thiram a.i./bee/d for larvae and 0.0323 μg zeq/bee/d (MRID 50669901), which is based on significant ($p < 0.05$) 20% reduction in emergence.

⁴ Source: USEPA, PMRA, and CDPR, 2014. Guidance for Assessing Pesticide Risks to Bees. Oral dose: (app. rate * dose per pound) 0.94 * 32.1 = 30.2; 0.94 * 13.6 = 12.8.

Off-Field Risk

In addition to bees foraging on the treated field, bees may also be foraging in fields adjacent to the treated fields. AgDrift™ analysis showed that distances to remove the presumption of risk from ground spray applications for the bee castes at highest risk (*i.e.*, adult nectar foragers and 5-day old larval workers which are used in place of drones, as discussed above) were:

Thiram Uses:

- <1 to 33 feet for acute risk and 7 to 279 feet for chronic risk for adult nectar foragers independent of droplet size or boom height; and,
- 165 to >1000 feet for acute and chronic risk for larval workers.

Ferbam Uses:

- 4 to 14 feet for acute risk and 7 to 99 feet for chronic risk for adult nectar foragers independent of droplet size or boom height; and,
- 857 to >1000 feet for acute and chronic risk for larval workers.

Ziram Uses:

- 4 to 17 feet for acute risk and 4 to 125 feet for chronic risk for adult nectar foragers independent of droplet size or boom height; and,
- 430 to >1000 feet for acute and chronic risk for larval workers.

Coarse droplet size (and low boom) reduced the distance for adults, compared to fine droplets (and high boom), but was not as effective for larvae because the risk was greater and for most scenarios, even 1000 feet was insufficient to reduce the presumption of risk to below the LOC (**Table 10-4**, also see **Appendix E**).

Table 10-4. AgDrift™ Tier 1 Distances to Remove the Presumption of Oral Risk to Adult Nectar Foragers and Larval 5-Day Old Worker Honey Bees (*Apis mellifera*).

Use Pattern	Max. Single Appl. Rate	Bee Caste/ Task	Fraction of Application Rate That Would Remove the Presumption of Risk ¹		Ground or Aerial (only Peach) Application: Estimated Distance from Edge of Field, feet			
					Fine Droplet Size ² / High Boom		Coarse Droplet Size ² / Low Boom	
			Acute	Chronic	Acute	Chronic	Acute	Chronic
Thiram								
Grass/Turf/ Golf Course	16.3 lb a.i./A	Adult nectar forager	0.081	0.0083	33	279	7	43
		Larval workers (5-d old)	0.00050	0.00011	>1000	>1000	>1000	>1000
Peach (Ground Application)	2.63 lb a.i./A	Adult nectar forager	0.50	0.051	7	50	4	7
		Larval workers (5-d old)	0.0031	0.00071	594	>1000	165	867
Peach (Aerial Application)	2.63 lb a.i./A	Adult nectar forager	0.50	0.051	<1	181	<1	76
		Larval workers (5-d old)	0.0031	0.00071	>1000	>1000	>1000	>1000
Ferbam								
Citrus	5.20 lb a.i. (6.00 lb feq)/A	Adult nectar forager	0.25	0.026	14	99	4	14
		Larval workers (5-d old)	0.0016	0.00036	922	>1000	368	>1000
Mango	2.59 lb a.i. (2.99 lb feq)/A	Adult nectar forager	0.51	0.052	7	50	4	7
		Larval workers (5-d old)	0.0032	0.00072	581	>1000	158	857
Ziram								
Peach/ Nectarine	7.60 lb zeq/A	Adult nectar forager	0.17	0.020	17	125	4	17
		Larval workers (5-d old)	0.0014	0.00031	>1000	>1000	430	>1000
Flowering plants, Shrubs/ Bushes/ Vines	0.0152 lb zeq/A	Larval workers (5-d old)	0.70	0.16	4	20	4	4

¹This is the fraction of the highest calculated caste RQ from **Table 10-3** that would equal the chronic LOC of 1.0 for pollinators.

²Based on a tier 1 ground-spray scenario with high boom application, ASAE very fine to fine drop spectrum and 90th percentile exposure. For peach only (strawberry also has an aerial application of thiram but not all uses displayed here), also based on a tier 1 aerial-spray scenario with ASAE very fine to fine drop spectrum and 90th percentile exposure.

³Based on a tier 1 ground-spray scenarios with low boom application, ASAE medium/coarse drop spectrum and 90th percentile exposure. For peach only (strawberry also has an aerial application of thiram), also based on a tier 1 aerial-spray scenario with ASAE course to very coarse drop spectrum and 90th percentile exposure.

At the proposed application rates, the acute risk picture for adult contact risk is only triggered at the highest application rate for thiram (golf courses, turf, etc.), and possibly for ferbam due

to a non-definitive study, but this was based on only 10% mortality and is not the risk driver. Also the potential risk to adult bees from oral toxicity could not be discounted because even though the toxicity studies did not show toxicity when tested up to approximately 100 µg a.i./bee, this did not cover the estimated exposure levels and so risk could not be precluded, but this is also not the risk driver. The risk driver is risk to bee larvae, and this is based on 50% mortality for acute risk and on significant ($p < 0.05$) 20% reduced emergence for chronic risk.

10.4 Bee Risk Characterization (Tier II)

Tier II studies examine colony-level responses and provide data on both adult bees and the brood. By examining brood development, these studies provide insight on how well the queen bee is functioning. In some studies, data is collected to allow for the calculation of brood indices (*i.e.*, brood index, brood termination index, and brood compensation index), which provide insight into whether the queen is responding to dead or dying brood by replacing losses. Because of the logistics involved in higher tier studies, they do not tend to have many replicates (normally 3-4), and so the ability of such tests to finely discriminate effects can be limited. Also, these studies should minimally be conducted at the maximum single application rate for a given pesticide, but this is not always the case, and some studies may either include other rates in addition to the maximum single application rate, or will include single rates lower than the maximum single application rate.

For thiram, Tier II studies submitted included a 22-day honey bee brood feeding study (1-day of exposure; MRID 50273403) and a 26-day (7-day exposure) semi-field brood study (tunnel study) (MRID 50273404 and 50273405), both Tier II studies with a thiram TEP (71.0% thiram a.i.). The 22-day brood feeding study showed significant ($p < 0.05$) 51.8% increase in termination rate of eggs at dietary exposure to 3180 mg a.i./kg-diet (NOAEL < 3180 mg a.i./kg-diet; LOAEL ≤ 3180 mg a.i./kg-diet), with no effects to mortality, larval development, or behavior at that exposure. The 26-day tunnel study showed no effects to survival, development, or brood parameters (NOAEL ≥ 2.5 lb a.i./acre).

To put this into context, BeeRex predicts 110 mg/kg in pollen/nectar per 1 lb a.i./A. Thus, dividing the 3,180 mg a.i./kg in feeding solution by 110 mg/kg/lb ai/A = 29 lb ai/A, which is a very high rate compared with the tunnel study which tested only 2.5 lb ai/A, which is lower than most of the registered application rates (and only 1 application). Therefore, the tunnel study seems to only address the lowest application rates and only tracked bees through one brood cycle, while two brood cycles are preferred. Conversely, comparing the 3180 mg a.i./kg-diet concentration with the dietary concentrations in the chronic adult and larval toxicity studies, the respective dietary treatment ranges were much lower, from 15-120 mg a.i./kg-diet (nominal concentrations, MRID 50273402) with the NOAEL of 4.3 µg ai/bee/day corresponding to 120 mg a.i./kg-diet for the adult study and 0.072-5.31 mg a.i./kg-diet (measured concentrations, MRID 50669901) with the NOAEL of 0.03 µg/larvae/day corresponding to 0.219 mg a.i./kg-diet. Also, the dietary concentrations in the acute larval study ranged from 0.59 to 16 mg a.i./kg-diet (mean measured, MRID 50940001) and showed that the LD₅₀ was calculated to be between dietary ranges of 2.6 and 7.4 mg a.i./kg-diet. Therefore, the effects seen in the

brood feeding study were at higher dietary concentrations than those used in the chronic toxicity studies and also concentrations resulting in 50% mortality to larvae.

For ziram, Tier II studies were submitted using a ziram TEP (76.5% ziram a.i.). These included a 22-day honey bee brood feeding study (1-day of exposure; MRID 50294103) and a 26-day (7-day exposure) semi-field brood study (tunnel study) (MRID 50294104 and 50291405), both Tier II studies. The 22-day brood feeding study showed significant ($p < 0.05$) 22.6% increase in termination rate of eggs at dietary exposure to 2300 mg a.i./L-diet (2300 ppm or mg a.i./kg-diet assuming the weight of water for the sugar solution) and equivalent to 1.36 lb a.i./acre. The 26-day tunnel study showed no effects to survival, development, or brood parameters ($\text{NOAEL} \geq 2.03 \text{ lb a.i./acre}$). Similar to the above discussion of the thiram studies, to put this into context, dividing the 2300 mg a.i./kg in feeding solution by $110 \text{ mg/kg/lb ai/A} = 21 \text{ lb ai/A}$, which is also a very high rate compared with the tunnel study test level of only 1.4 lb ai/A, which is lower than most of the registered application rates. Therefore, the tunnel study tested lower than the lowest application rates but the brood feeding study tested higher than the highest application rates. Similar to the thiram discussion above, comparing the 2300 mg a.i./kg-diet concentration in the brood study with the dietary concentrations in the ziram chronic adult study (Tier I), the dietary treatment range was lower in the chronic adult study, with the NOAEL of 4.9 ug ai/bee/day corresponding to 173 mg a.i./kg-diet and a LOAEL (based on 17% mortality) of 8.5 ug ai/bee/day corresponding to 300 mg a.i./kg-diet. The Tier I and Tier II findings are not obviously contradictory and show closer agreement than the thiram comparison above even though the effect concentration was approximately 8X lower than the dietary concentration in the brood feeding study. However, the Tier II studies provide conflicting conclusions regarding risk at lower application rates (*i.e.* below 2.6 lb a.i./A, the lowest application rate for thiram and ferbam – but not lower than the lowest rate for ziram, which is 0.015 lb a.i./A), but overall potential risks, particularly at application rates above this, cannot be precluded.

10.5 Bee Risk Characterization – Additional Lines of Evidence

As previously mentioned (**Section 3.1**), dimethyldithiocarbamate fungicides, such as thiram, ferbam, and ziram, are non-systemic. Therefore, exposure via nectar or pollen is only anticipated to occur through direct spray drift and not uptake by the plant from runoff or movement from exposed soil to the plant.

11 Terrestrial Plant Risk Assessment

There were no adverse effects noted in the available terrestrial plant studies conducted at an application rates of 4.1-4.6 lb thiram a.i./acre for thiram and ferbam assessment, and 6.0-6.1 lb eq/acre for ziram assessment. These rates are lower than the maximum single application rate allowed for flowable uses of the three chemicals. Additionally, there was one reported plant incident involving ziram plus another fungicide, in which 40 acres of apricots were damaged by residue (decreasing yield), with a certainty of “possible” for ziram causality. Therefore, even

with no effects in the plant toxicity studies, the non-definitive endpoints were used to screen for risk.

11.1 Terrestrial Plant Exposure Assessment

EECs for terrestrial plants are calculated using TERRPLANT v.1.2.2. Exposure is estimated for a single application evaluating exposure via spray drift and runoff. In the RQ table, the runoff RQs for dryland and semi-aquatic areas are relying upon the summation of the exposure from drift and runoff. Additionally, the spray drift RQs rely only on the spray drift estimated exposure. It is important to note that for spray drift, the TERRPLANT exposure estimate corresponds to an equivalent AgDrift estimated deposition for fine-medium droplets at approximately 200 feet from the edge of the treated field. For runoff, there are a few assumptions regarding the ratio of treated area to receiving non-target area that have an impact on the exposure estimation. In a dry area adjacent to the treatment area, exposure is estimated as sheet runoff. Sheet runoff is the amount of pesticide in water that runs off of the soil surface of a target area of land that is equal in size to the non-target area (1:1 ratio of areas). This differs for semi-aquatic areas, where runoff exposure is estimated as channel runoff. Channel runoff is the amount of pesticide that runs off of a target area 10 times the size of the non-target area (10:1 ratio of areas).

Exposures from runoff and spray drift are compared to measures of survival and growth (e.g., effects to seedling emergence and vegetative vigor) to develop RQ values. Resulting upper-bound exposure estimates to terrestrial and semi-aquatic (wetland) plants adjacent to the treated field are in **Table 11-1**. EECs are based on the maximum single application rate for terrestrial uses, solubility, and spray drift fraction. The EECs represent residues from off-site exposure via spray drift and/or run-off to non-target plants found near application sites.

Table 11-1. TerrPlant Calculated EECs for Terrestrial and Semi-Aquatic Plants near Thiram, Ferbam, and Ziram Terrestrial Use Areas

Use Site	Single Max. Application Rate (lb a.i./A)	EECs (lb a.i./A) ¹					
		Ground ²			Aerial ³		
		Dry Areas (Total)	Semi- Aquatic Areas (Total)	Spray Drift	Dry Areas (Total)	Semi- Aquatic Areas (Total)	Spray Drift
Thiram							
Grass/Turf/ Golf Course	16.3 lb a.i./A	0.152	0.836	0.076	--	--	--
Strawberry	3.03 lb a.i./A	0.231	0.825	0.165	0.099	0.693	0.033
Ferbam							
Citrus	5.20 lb a.i. (6.00 lb feq)/A	0.312	2.65	0.052	--	--	--
Ziram							
Peach/ Nectarine	7.60 lb zeq/A	0.152	0.836	0.076	--	--	--

¹ Based on a runoff fraction of 0.02 for thiram, 0.05 for ferbam, and 0.01 for ziram (based on respective solubility limits of 16.5, 130, and 0.97 ppm).

² Based on a drift fraction of 1% (*i.e.*, 0.01).

³ Based on a drift fraction of 5% (*i.e.*, 0.05).

11.2 Terrestrial Plant Risk Characterization

Based on non-definitive (no effects) endpoints used for screening using a risk ratio (exposure: toxicity no-effects estimate) and the EECs calculated using TerrPlant (see above), no potential LOC exceedances were found (see **Table 11-2**).

Table 11-2. Terrestrial Plant Risk Ratios (Used as Screening for Risk Quotients, RQs, but using Non-Definitive Endpoints) – Non-listed Species

Type of Plant	Ground Spray Ratios ¹			Aerial Spray Ratios ¹		
	Dry Areas	Semi-Aquatic Areas	Spray Drift Only	Dry Areas	Semi-Aquatic Areas	Spray Drift Only
Thiram						
Turf, Etc.						
Monocot	<0.11	<0.75	<0.1	--	--	--
Dicot	<0.12	<0.84	<0.1	--	--	--
Strawberry.						
Monocot	<0.1	<0.15	<0.1	<0.1	<0.18	<0.1
Dicot	<0.1	<0.17	<0.1	<0.1	<0.20	<0.1
Ferbam						
Turf, Etc.						
Monocot	<0.1	<0.58	<0.1	--	--	--
Dicot	<0.1	<0.65	<0.1	--	--	--
Ziram						
Turf, Etc.						
Monocot	<0.1	<0.14	<0.1	--	--	--
Dicot	<0.1	<0.14	<0.1	--	--	--

Bolded Ratios that exceed the LOC of 1.0 would suggest potential risk, but none did at highest application rates.

¹Endpoints used were all non-definitive (> greater than) values and therefore RQs were not calculated. Risk ratios (similar to RQs) were calculated by dividing exposure by toxicity estimates. The toxicity endpoints used were as follows: For thiram and ferbam, Monocots: Seedline emergence IC₂₅ >4.6 lb thiram a.i./acre (also >8.0 lb feq/acre; MRID 50835301) and vegetative vigor IC₂₅ >4.6 lb thiram a.i./acre (also >8.0 lb feq/acre; MRID 50830201); Dicots: Seedline emergence IC₂₅ >4.1 lb thiram a.i./acre (also >7.1 lb feq/acre; MRID 50835301) and vegetative vigor IC₂₅ >4.6 lb thiram a.i./acre (also >7.1 lb feq/acre; MRID 50830201). For ziram: Monocots and Dicots: Seedline emergence IC₂₅ >6.0 lb ziram a.i./acre (MRID 46893101) and vegetative vigor IC₂₅ >6.1 lb ziram a.i./acre (MRID 46893102).

Therefore, based on the available data, the risk to terrestrial plants from the use of thiram, ferbam, and ziram, is expected to be low.

12 Conclusions

Given the uses of thiram, ferbam, and ziram, and their environmental fate properties, there is a likelihood of exposure of their residues of concern 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, there is a potential for direct adverse effects to mammals, birds, terrestrial invertebrates, fish and aquatic invertebrates from exposure to thiram, ferbam (and degradate, thiram), and ziram (and degradate, thiram) as a result of each chemical's respective registered uses. A more in-depth summary of the risk conclusions is available in the **Executive Summary Section 1**.

13 Literature Cited

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14 Referenced MRIDs

Thiram

71-1 Avian Single Dose Oral Toxicity

MRID	Citation Reference
3308	Mastalski, K. (1970) Report to Uniroyal Chemical, Division of Uniroyal, Inc.: Acute Oral Toxicity Study on Vitavax Seed Protectant with Thiram in Bobwhite Quail: IBT No. J8584. (Unpublished study received May 8, 1972 under 2F1191; prepared by Industrial Bio-Test Laboratories, Inc., submitted by Uniroyal Chemical, Bethany, Conn.; CDL:091003-C)
98168	Hamrick, W.J. (1967) The Effects of Arasan-endrin Treated Pine Seed on Bobwhite Quail, Gray Squirrel and Turkey. Master's thesis. (Unpublished study received Jul 1, 1964 under 2935-352; submitted by W.A. Cleary Corp., Somerset, N.J.; CDL:235183-A)
99594	Grolleau, G. (1965) Toxicity of Seed-dressing Products for Partridge and Pheasant. (Unpublished study received Nov 22, 1978 under 42567-1; prepared by Centre National de Recherches Zoo- techniques, France, submitted by La Quinoleine S.A., c/o Registration Consulting Assoc., Pacifica, CA; CDL:237443-E)
160000	Hudson, R.; Tucker, R.; Haegele, M. (1984) Handbook of toxicity of pesticides to wildlife: Second edition. US Fish and Wildlife Service: Resource Publication 153. 91 p.
20560 or 73683	Schafer, E.W. (1972) The acute oral toxicity of 369 pesticidal, pharmaceutical and other chemicals to wild birds. Toxicology and Applied Pharmacology 21(?):315-330. (Also in unpublished submission received Apr 25, 1978 under 476-2180; submitted by Stauffer Chemical Co., Richmond, Calif.; CDL:233577-C)

71-2 Avian Dietary Toxicity (850.2200)

MRID	Citation Reference
143824	Egberts, J.; Roos, J.; Beijer, H. (1972) The toxicity of TMTD in japanese quail, an experimental study. TNO Nieuws 27(10):594- 598.
43612505	Beavers, J.; Haberlein, D.; Grimes, J. et al. (1995) Thiram Technical: A Palatability/Repellancy Study with the Mallard (Anas platyrhynchos) Under Multiple Choice Conditions: Lab Project Number: 357/106: CHR17. Unpublished study prepared by Wildlife International Ltd. 183 p.
43612506	Beavers, J.; Haberlein, D.; Grimes, J. et al. (1995) Thiram Technical: A Palatability/Repellancy Study with the Northern Bobwhite (Colinus virginianus) Under Multiple Choice Conditions: Lab Project Number: 357/105: CHR17. Unpublished study prepared by Wildlife International Ltd. 184 p.
22293	Hill, E.F.; Heath, R.G.; Spann, J.W.; et al. (1975) Lethal Dietary Toxicities of Environmental Pollutants to Birds: Special Scientific Report--Wildlife No. 191. (U.S. Dept. of the Interior, Fish and Wildlife Service, Patuxent Wildlife Research Center; unpublished report)

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71-4 Avian Reproduction

MRID	Citation Reference
43612501	Beavers, J.; Chafey, K.; Mitchell, L. et al. (1995) Thiram Technical: A Reproduction Study with the Mallard: Lab Project Number: 357/104: CHR24. Unpublished study prepared by Wildlife International Ltd. 278 p.
43612502	Beavers, J.; Chafey, K.; Mitchell, L. et al. (1995) Thiram Technical: A One Generation Reproduction Study with the Northern Bobwhite (<i>Colinus virginianus</i>): Amended: Lab Project Number: 357/103: CHR24. Unpublished study prepared by Wildlife International Ltd. 250 p.
43612503	Beavers, J.; Trumbull, S.; Grimes, J. et al. (1995) Thiram Technical: A Pilot Reproduction Study with the Mallard (<i>Anas platyrhynchos</i>): Lab Project Number: 357/102: CHR17. Unpublished study prepared by Wildlife International Ltd. 220 p.
43612504	Beavers, J.; Trumbull, S.; Grimes, J. et al. (1995) Thiram Technical: A Pilot Reproduction Study with the Northern Bobwhite (<i>Colinus virginianus</i>): Lab Project Number: 357/101: CHR17. Unpublished study prepared by Wildlife International Ltd. 217 p.
45441201	Gallagher, S.; Martin, K.; Beavers, J. (2001) Thiram Technical: A Reproduction Study with the Mallard: Final Report: Lab Project Number: 357-107. Unpublished study prepared by Wildlife International, Ltd. 143 p.

71-3 Toxicity to Wild Mammals

MRID	Citation Reference
40022008	Hornshaw, T.; Ringer, R.; Aulerich, R.; et al. (1983) Determination of LC50 for Compound 1080, o-Cresol, Thiram , and Aroclor 1254 in Mink and/or Ferrets. Unpublished study prepared by Michigan State Univ., Dept. of Animal Sciences. 23 p.

71-4 Avian Reproduction

40016989	Hornshaw, T.; Ringer, R. (1983) Effects of Compound 1080, o-cresol, and Thiram on the Reproductive Performance of Mink and/or Ferrets. Unpublished study prepared by Michigan State Univ., Dept. of Animal Science. 12 p.
43612501	Beavers, J.; Chafey, K.; Mitchell, L. et al. (1995) Thiram Technical: A Reproduction Study with the Mallard: Lab Project Number: 357/104: CHR24. Unpublished study prepared by Wildlife International Ltd. 278 p.
43612502	Beavers, J.; Chafey, K.; Mitchell, L. et al. (1995) Thiram Technical: A One Generation Reproduction Study with the Northern Bobwhite (<i>Colinus virginianus</i>): Amended: Lab Project Number: 357/103: CHR24. Unpublished study prepared by Wildlife International Ltd. 250 p.

43612503	Beavers, J.; Trumbull, S.; Grimes, J. et al. (1995) Thiram Technical: A Pilot Reproduction Study with the Mallard (<i>Anas platyrhynchos</i>): Lab Project Number: 357/102: CHR17. Unpublished study prepared by Wildlife International Ltd. 220 p.
43612504	Beavers, J.; Trumbull, S.; Grimes, J. et al. (1995) Thiram Technical: A Pilot Reproduction Study with the Northern Bobwhite (<i>Colinus virginianus</i>): Lab Project Number: 357/101: CHR17. Unpublished study prepared by Wildlife International Ltd. 217 p.
45441201	Gallagher, S.; Martin, K.; Beavers, J. (2001) Thiram Technical: A Reproduction Study with the Mallard: Final Report: Lab Project Number: 357-107. Unpublished study prepared by Wildlife International, Ltd. 143 p.

71-5 Simulated or Actual Field Testing

MRID	Citation Reference
40022008	Hornshaw, T.; Ringer, R.; Aulerich, R.; et al. (1983) Determination of LC50 for Compound 1080, o-Cresol, Thiram, and Aroclor 1254 in Mink and/or Ferrets. Unpublished study prepared by Michigan State Univ., Dept. of Animal Sciences. 23 p.

72-1 Acute Toxicity to Freshwater Fish

MRID	Citation Reference
21610 or 2923	Mastri, C. (1970) Report to Uniroyal Chemical, Division of Uniroyal, Inc.: Four-Day Fish Toxicity Study on Three Samples of Vitavax Seed Protectants: IBT No. A8585. (Unpublished study received Feb 18, 1972 under 400-81; prepared by Industrial Bio-Test Laboratories, Inc., submitted by Uniroyal Chemical, Beth- any, Conn.; CDL:003261-D)
5020144	Tooby, T.E., Hursey, and Alabaster. 1975. The acute toxicity of 102 pesticides and miscellaneous substances to fish (Harlequin fish). Chemistry and Industry (21): 523-526.
90293	McCann, J.A. (1972) ?Tersan 75: Rainbow trout. Test No. 463. (U.S. Agricultural Research Service, Pesticides Regulation Div., Animal Biology Laboratory, Fish Toxicity Laboratory; unpublished study; CDL:130512-A) 75% ai test material
90294	McCann, J.A. (1972) ?Tersan 75: Bluegill sunfish. Test No. 446. (U.S. Agricultural Research Service, Pesticides Regulation Div., Animal Biology Laboratory, Fish Toxicity Laboratory; unpublished study; CDL:130513-A)
90428	McCann, J.A. (1968) ?Niagara Niacide M Fungicide: Bluegill sunfish: Test No. 114. (U.S. Agricultural Research Service, Pesticides Regulation Div., Animal Biology Laboratory; unpublished study; CDL:130271-A)
98156	Eibert, J., Jr. (1966) Toxicity Study of Kromad to Young Bluegill Fish: S.A. No. R-1364. (Unpublished study received Apr 14, 1966 under 372-24; prepared by Scientific Associates, Inc., submitted by Mallinckrodt, Inc., St. Louis, Mo.; CDL:226534-A)
46249301	Peither, A. (2000) Acute Toxicity of Thiram Technical to Rainbow Trout (<i>Oncorhynchus mykiss</i>) in a 96-Hour Static Test. Project Number: 775552. Unpublished study prepared by VJP Consulting, Inc. and RCC Ltd. 46 p.

46249303	Memmert, U. (2001) Sublethal Effects of Thiram 80 WG to Rainbow Trout (<i>Oncorhynchus mykiss</i>) After a Fourfold Application to a Water-Sediment System. Project Number: 8043363. Unpublished study prepared by RCC Umweltchemie Ag. 60 p.
TN 996	McCann, J.A. (1968: Bluegill (<i>Lepomis macrochirus</i>) : Test No. 996. (U.S. Agricultural Research Service, Pesticides Regulation Div., Animal Biology Laboratory; With 99 % technical
TN 1001	McCann, J.A. ,1976. Rainbow trout Test No. 1001. (U.S. Agricultural Research Service, Pesticides Regulation Div., Animal Biology Laboratory; With 99 % technical

72-2 Acute Toxicity to Freshwater Invertebrates

MRID	Citation Reference
84745	Cheah, M.L.; Avault, J.W., Jr.; Graves, J.B. (1978) Some Effects of Thirteen Rice Pesticides on Crawfish <i>Procambarus clarkii</i> and <i>P. acutus acutus</i> . (Unpublished paper presented at the 4th international symposium of the International Association of Astacology; Aug 28-31, 1978, Thonon les Bains, France; unpublished study received Oct 8, 1981 under 476-2107; prepared by Louisiana State Univ., Dept. of Entomology and Fisheries Section, submitted by Stauffer Chemical Co., Richmond, Calif.; CDL:246020-L)
98159	Roberts, S.; Wineholt, R.L. (1976) Static 96-hour Toxicity Study of TNL to Daphnids: Laboratory No. 6E-3283. (Unpublished study received Nov 24, 1976 under 15382-14; prepared by Cannon Laboratories, Inc., submitted by Kalo Laboratories, Inc., Kansas City, Mo.; CDL:226989-H)
147098	Espeldooren, A. (1981) [Toxicity Test with Thiram in 25 <i>Daphnia magna</i>]. Unpublished translation of study prepared by UCB. 4 p.
154264	Van Leeuwen, C. (1985) The Toxicological Consequences of the Use of Dialkylidithiocarbamates for Some Softwater Organisms. Unpublished translation of journal article with related data prepared by RIZA Ecotoxicology Laboratory. 14 p.
164662	Husson, R. (1986) Letter sent to J. Rockwell dated Sept 17, 1986: [Data requested to complete review of 48 hour LC50 study on <i>Daphnia magna</i> : thiram]. Prepared by UCB Societe Anonyme. 3 p.

72-3 Acute Toxicity to Estuarine/Marine Organisms

MRID	Citation Reference
3074	Heitmuller, T. (1975) Acute Toxicity of Vitavax to Pink Shrimp (?~ <i>Penaeus duorarum</i> ?~) and Fiddler Crabs (?~ <i>Uca pugilator</i> ?~). (Unpublished study received May 16, 1975 under 400-116; prepared by Bionomics--EG&G, Inc., submitted by Uniroyal Chemical, Bethany, Conn.; CDL:165048-A)
42488301	Thompson, R.; Croudace, C.; Grinell, A. (1992) Thiram: Acute Toxicity to Larvae of the Pacific Oyster (<i>Crassostrea gigas</i>): Lab Project Number: W199/C: BL4547/B. Unpublished study prepared by Imperial Chemical Industries PLC. 20 p.

42488302	Thompson, R.; Croudace, C.; Grinell, A. (1992) Thiram: Acute Toxicity to Mysid Shrimp (<i>Mysidopsis bahia</i>): Lab Project Number: W199/D: BL4562/B. Unpublished study prepared by Imperial Chemical Industries PLC. 19 p.
42514401	Croudace, C.; Caunter, J.; Johnson, P. (1992) Thiram: Acute Toxicity to Sheepshead Minnow (<i>Cyprinodon variegatus</i>): Lab Project Number: W199/B. Unpublished study prepared by Imperial Chemical Industries PLC. 22 p.

122-2 and 123-2 Aquatic plant growth

MRID	Citation Reference
42646001	Douglas, M. (1993) Thiram: Algal Growth Inhibition (<i>Selenastrum capricornutum</i>): Lab Project Number: UCB 442/921255. Unpublished study prepared by Huntingdon Research Centre Ltd. 30 p.
44086101	Coates, M. (1996) Thiram: Algal Growth Inhibition: Addendum to MRID 426460-01: Lab Project Number: UCB 442/960953: UCB 442/921255. Unpublished study prepared by Huntingdon Life Sciences, Ltd. 10 p.
45441202	Sutherland, C.; Kendall, T.; Krueger, H. (2001) Thiram Technical: A 7-Day Toxicity Test with Duckweed (<i>Lemna gibba</i> G3): Final Report: Lab Project Number: 357A-101. Unpublished study prepared by Wildlife International. Ltd. 79 p. {OPPTS 850.4400}
50792001	Softcheck, K.A. 2019. Thiram- 96-Hour Toxicity Test with the Freshwater Diatom, <i>Navicula pelliculosa</i> . Unpublished study performed by Smithers Viscient, Wareham, Massachusetts. Smithers Viscient Study No. 14130.6101. Study sponsored and submitted by the Thiram Task Force comprised of Taminco, BVBA, Ghent, Belgium and MacDermid Agricultural Solutions, Inc., Waterbury, Connecticut. Study initiated August 30, 2017 and completed February 13, 2019
50792002	Softcheck, K.A. 2019. Thiram- 96-Hour Toxicity Test with the Marine Diatom, <i>Skeletonema costatum</i> . Unpublished study performed by Smithers Viscient, Wareham, Massachusetts. Smithers Viscient Study No. 14130.6102. Study sponsored and submitted by the Thiram Task Force comprised of Taminco, BVBA, Ghent, Belgium and MacDermid Agricultural Solutions, Inc., Waterbury, Connecticut. Study initiated August 30, 2017 and completed February 14, 2019.
50792003	Softcheck, K.A. 2019. Thiram- 96-Hour Toxicity Test with the Freshwater Cyanobacterium, <i>Anabaena flos-aquae</i> . Unpublished study performed by Smithers Viscient, Wareham, Massachusetts. Smithers Viscient Study No. 14130.6103. Study sponsored and submitted by the Thiram Task Force comprised of Taminco, BVBA, Ghent, Belgium and MacDermid Agricultural Solutions, Inc., Waterbury, Connecticut. Study initiated August 30, 2017 and completed February 19, 2019.

141-1 Toxicity to Honey bee – Tier I Toxicity Studies and Tier II Brood Studies

MRID	Citation Reference
36935	Atkins, E.L.; Greywood, E.A.; Macdonald, R.L. (1975) Toxicity of Pesticides and Other Agricultural Chemicals to Honey Bees: Laboratory Studies. By University of

	California, Dept. of Entomology. ? UC, Cooperative Extension. (Leaflet 2287; published study.)
1999	Atkins, L., Jr.; Anderson, L.D. (1967) Toxicity of Pesticides and Other Agricultural Chemicals to Honey Bees: Laboratory Studies. (Unpublished study received Jan 30, 1969 under 9G0802; prepared by Univ. of California--Riverside, Dept. of Entomology, submitted by Hercules, Inc., Agricultural Chemicals, Wilmington, Del.; CDL:093111-D)
5001322	King, C.C. (1959) The effects of fungicides. Gleanings in Bee Culture 87:678-681.
5003399	Citation not located in OPPIN
50273401	Kling, A. 2010. Thiram technical – Acute Oral and Contact Toxicity to the Honeybee <i>Apis mellifera</i> L. in the Laboratory. Unpublished study performed by Eurofins Agrosience Services, Niefern-Öschelbronn, Germany. Laboratory Report ID: S10-02445. Study sponsored by Taminco BVBA, Gent, Belgium. Study completed July 9, 2010.
50273402	Vergé, E. 2014. Thiram Technical: Assessment of Chronic Effects to the Honeybee, <i>Apis mellifera</i> L., in a 10 Day Continuous Laboratory Feeding Test. Unpublished study performed by Eurofins Agrosience Services, Niefern-Öschelbronn, Germany. Laboratory Report ID: S13-00482. Study sponsored by Taminco BVBA, Gent, Belgium and Chemtura Europe Ltd., Langley, Sough, UK. Study completed January 16, 2014.
50273403	Tänzler, V. 2013. Study on the effects of Thiram 80WG on honey bee brood (<i>Apis mellifera</i> L.) – Brood feeding test. Unpublished study performed by Institut für Biologische Analytik und Consulting, Rossdorf, Germany. Laboratory Report ID: 71251031. Study sponsored by Taminco BVBA, Gent, Belgium. Study completed March 15, 2013.
50273404 and 50273405	Hecht-Rost, S. and C. Claben. 2015. Semi-field brood study to evaluate potential effects of Thiram 80WG on the brood development of honeybees (<i>Apis mellifera</i> L.) and Final Analytical Phase Report (RIF-CON Report No. R13057). Unpublished study performed by RIFCON GmbH, Hirschberg, Germany and Huntingdon Life Sciences, Eye Research Centre, Suffolk, UK. Laboratory Report ID: R13057. Study sponsored by Taminco BVBA, Gent, Belgium. Study portions completed March 3 and 19, 2015.
50669901	Colli, M. 2017. S Effects of Thiram Technical to Honeybees (<i>Apis mellifera</i> L.) Larval Toxicity Test, Repeated Exposure. Unpublished study performed by Biotechnologie BT S.r.l. Laboratory Report ID: R BT065/17. Study sponsored by Taminco BVBA, Gent, Belgium, a subsidiary of Eastman Chemical Company. Study completed December 27, 2017.
50940001	Picard, C.R. 2019. Thiram: Honey Bee (<i>Apis mellifera</i>) Larval Toxicity Test, Single Exposure. Unpublished study performed by Smithers Viscient, Wareham, Massachusetts. Laboratory Report ID: 14130.6119. Study sponsored and submitted by the Thiram Task Force. Study completed August 30, 2019

141-2 Acute Toxicity to Beneficial Insects

MRID	Citation Reference
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59461 Colburn, R.; Asquith, D. (19??) Tolerance of *Stethorus punctum* adults and larvae to various pesticides. *Journal of Economic Entomology* 66:961-962.
(Also In unpublished submission received Aug 19, 1976 under 8340-EX-3; submitted by American Hoechst Corp., Somerville, N.J.; CDL:095253-AL)

5016293 Citation not located in OPPIN

5017841 Citation not located in OPPIN

142-3 Simulated or Actual Field Testing

MRID	Citation Reference
105372	Alexandrescu, S.; Serban, M. (1966) Toxicitatea unor insecticide fata de albine, determinata in laborator si camp. (Toxicity to bees of some insecticides, as determined by laboratory and field tests). <i>An. Inst. Cercet. Prol. Plant, Inst. Cent. Cercet. Agr. IV</i> :411-417. (Rumanian text; also In unpublished submission received Nov 1, 1970 under unknown admin. no.; submitted by Hercules, Inc., Agricultural Chemicals, Wilmington, DE; CDL: 005103-AN)
105560	Wojtowski, F.; Hess, E.; Wiolkaniec, Z. (1969) Toxicity of more important pesticides to honey bees. <i>Biul. Inst. Ochr. Rosi. 44</i> : 249-261. Taken from: [Source unknown]. (Abstract 2935q; also In unpublished submission received Sep 17, 1975 under 1F1118; submitted by Hercules, Inc., Wilmington, DE; CDL:094610-AS)

850.1300 and 850.1350 Daphnid and Mysid chronic toxicity tests

MRID	Citation Reference
46249303	Memmert, U. (2001) Sublethal Effects of Thiram 80 WG to Rainbow Trout (<i>Oncorhynchus mykiss</i>) After a Fourfold Application to a Water-Sediment System. Project Number: 8043363. Unpublished study prepared by RCC Umweltchemie Ag. 60 p. 28 day exposure test- not really an early life test
47495001	Krueger, H.; Kendall, T. (2008) (Carbon 14)-Thiram: A Flow-Through Life-Cycle Toxicity Test with the Cladoceran (<i>Daphnia magna</i>): Final Report. Project Number: 657A/101. Unpublished study prepared by Wildlife International, Ltd. 59 p.

850.1400 Fish early-life stage toxicity test

MRID	Citation Reference
47495002	Krueger, H.; Kendall, T. (2008) (Carbon 14)-Thiram: An Early Life-Stage Toxicity Test with the Fathead Minnow (<i>Pimephales promelas</i>): Final Report. Project Number: 657A/102. Unpublished study prepared by Wildlife International, Ltd. 70 p.
51049801	Marini, J.P. 2020. Thiram – Early Life-Stage Toxicity Test with Sheepshead Minnow, <i>Cyprinodon variegatus</i> . Unpublished study performed by Smithers, Wareham, Massachusetts. Laboratory Project No. 14130.6104. Study sponsored by Thiram Task Force, comprised of Taminco, BVBA, Ghent, Belgium, and Macdermid Agricultural Solutions, Inc., Waterbury, Connecticut. Study initiated August 10, 2017 and completed January 10, 2020.

850.1500 Fish life cycle toxicity

MRID	Citation Reference
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47824101 Krueger, H.; Kendall, T. (2009) (Carbon 14)-Thiram: A Flow-Through Life-Cycle Toxicity Test with the Fathead Minnow (*Pimephales promelas*): Final Report. Project Number: 657A/103. Unpublished study prepared by Wildlife International, Ltd. 144 p.

850.4100 and 850.4225 Terrestrial plant toxicity, Tier I and Tier II (seeding emergence)

MRID	Citation Reference
50835301	Marchessault, N.S. 2019. Thiram – Seedling Emergence Test. Unpublished study performed by Smithers Viscient, Wareham, Massachusetts. Laboratory Study No.: 14130.6106. Study sponsored by Thiram Task Force: Taminco, BVBA, Ghent, Belgium, and MacDermid Agricultural Solutions, Inc., Waterbury Connecticut. Study completion on April 5, 2019

850.4150 and 850.4250 Terrestrial plant toxicity, Tier I and Tier II (vegetative vigor)

MRID	Citation Reference
50830201	Marchessault, N.S. 2019. Thiram – Vegetative Vigor Test. Unpublished study performed by Smithers Viscient, Wareham, Massachusetts. Laboratory Study No.: 14130.6107. Study sponsored by Taminco, BVBA, Ghent, Belgium. Study completed April 4, 2019.

Non-Guideline Studies

MRID	Citation Reference
4905	Hildreth, A.C.; Brown, G.B. (1955) Repellents to Protect Trees and Shrubs from Damage by Rabbits. By U.S. Agricultural Research Service. Washington, D.C.: U.S. Dept. of Agriculture. (Technical bulletin no. 1134; available from: Superintendent of Documents, U.S. Government Printing Office, Washington, DC; also ?~In~unpublished submission received Dec 13, 1973 under 779-29; submitted by Faesy & Besthoff, Inc., Edgewater, N.J.; CDL: 022733-B)
143852	Olson, D.; Christensen, G. (1980) Effects of water pollutants and other chemicals on fish acetylcholinesterase (in vitro). Environmental Research 21:327-335.
5001322	King, C.C. (1959) The effects of fungicides. Gleanings in Bee Culture 87:678-681.
45534701	Lamb, IV, J.; Hentz, K.; Matthews, S.; et al. (2001) Analysis of Common Mechanisms of Toxicity for Ethylenebisdithiocarbamates and Other Dithiocarbamates. Unpublished study prepared by BBL Sciences. 111 p.
46249303	Memmert, U. (2001) Sublethal Effects of Thiram 80 WG to Rainbow Trout (<i>Oncorhynchus mykiss</i>) After a Fourfold Application to a Water-Sediment System. Project Number: 8043363. Unpublished study prepared by RCC Umweltchemie Ag. 60 p. 28-42 day study
46249304	Memmert, U. (2000) Ecological Effects of Thiram 80 WG in A Freshwater Mesocosm Study. Project Number: 733454. Unpublished study prepared by RCC Ltd. and Aachen Univ. of Technology. 319 p.
48033008	Kojima, H.; Katsura, E.; Takeuchi, S.; et al. (2004) Screening for Estrogen and Androgen Receptor Activities in 200 Pesticides by In Vitro Reporter Gene Assays Using Chinese Hamster Ovary Cells. Environmental Health Perspectives 112(5): 524-531.

48033010 Nishihara, T.; Nishikawa, J.; Kanayama, T.; et al. (2000) Estrogenic Activities of 517 Chemicals by Yeast Two-Hybrid Assay. *Journal of Health Science* 46(4): 282-298.

48033013 Roncaglioni, A.; Piclin, N.; Pintore, M.; et al. (2008) Binary Classification Models for Endocrine Disrupter Effects Mediated Through the Estrogen Receptor. *SAR and QSAR in Environmental Research* 19(7-8): 679-733.

161-1 Hydrolysis

MRID	Citation Reference
142855	Lemal, R.; Boel, C.; Debondues, M. (1984) Ziram: Rate of Hydrolysis as a Function of pH. Unpublished study prepared by UCB, Drogenbos Laboratory. 6 p.
154985	Korotkova, O. (1976) Razlozhenie fungitsidov--proizvodnykh ditio- karbaminovoy kisloty (obzor literatury) [Decomposition of such fungicides as derivatives of dithiocarbamic acid (literature re- view)]. <i>Khim. Sel'sk. Khoz.</i> 12(11):869-874, 1974. Abstracted in <i>Pest. Abs.</i> 76-0215.
40497301	Daly, D.; Cranor, W. (1987) Determination of Hydrolysis Rate with ¹⁴ C-Ziram: Final Report #33363. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 573 p.
43866701	Kim-Kang, H. (1995) Hydrolysis of (carbon 14)-Ziram in Water at pH 5, 6, and 9: Lab Project Number: XBL 94071: PRT00213: IDC433102. Unpublished study prepared by Xenobiotic Labs, Inc. and NPC Inc. 272 p.

161-2 Photodegradation-water

MRID	Citation Reference
153198	Carpenter, M. (1985) Determination of Photodegradation of Ziram in Aqueous Solution: Report 33369. Unpublished study prepared by Analytical Bio-Chemistry Labs., Inc. 53 p.
154985	Korotkova, O. (1976) Razlozhenie fungitsidov--proizvodnykh ditio- karbaminovoy kisloty (obzor literatury) [Decomposition of such fungicides as derivatives of dithiocarbamic acid (literature re- view)]. <i>Khim. Sel'sk. Khoz.</i> 12(11):869-874, 1974. Abstracted in <i>Pest. Abs.</i> 76-0215.
44097701	Kim-Kang, H. (1996) Aqueous Photolysis of (carbon 14)-Ziram: Lab Project Number: XBL94073: RPT00223: IDC 433102. Unpublished study prepared by XenoBiotic Labs, Inc. 245 p.

161-3 Photodegradation-soil

MRID	Citation Reference
153199	Carpenter, M. (1985) Determination of Photodegradation of Ziram on the Surface of Soil: Report 33370. Unpublished study prepared by Analytical Bio-Chemistry Labs., 60 p.
154985	Korotkova, O. (1976) Razlozhenie fungitsidov--proizvodnykh ditio- karbaminovoy kisloty (obzor literatury) [Decomposition of such fungicides as derivatives of dithiocarbamic acid (literature re- view)]. <i>Khim. Sel'sk. Khoz.</i> 12(11):869-874, 1974. Abstracted in <i>Pest. Abs.</i> 76-0215.

44228401 Reynolds, J. (1997) Photolysis of (carbon 14) Ziram on Soil: (Final Report): Lab Project Number: 96001: RPT00296: XBL 96001. Unpublished study prepared by XenoBiotic Laboratories, Inc. 179 p.

162-1 Aerobic soil metabolism

MRID	Citation Reference
40061601	Cranor, W. (1987) Aerobic Soil Metabolism Study with [Carbon 14]- Ziram: Final Report #33366. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 85 p.
43985801	Kim-Kang, H. (1996) Aerobic Soil Metabolism of (carbon 14)- Ziram: Lab Project Number: XBL 94072: RPT00225. Unpublished study prepared by XenoBiotic Labs, Inc. 180 p.
47005202	Reibach, P. (2006) (Carbon 14)-Ziram Fungicide Soil Metabolism. Project Number: KP/2006/44. Unpublished study prepared by Cerexagri, Inc. 11 p.
46622302	Mamouni, A. and Piccirillo, V. (2001) Degradation Rate of (Carbon 14)-Ziram in Three Soils Incubated Under Aerobic Conditions. Project Number: 785744. Unpublished study prepared by RCC Umweltchemie Ag. 90 p.

162-2 Anaerobic soil metabolism

MRID	Citation Reference
40061602	Cranor, W. (1987) Anaerobic Soil Metabolism Study with [Carbon 14]- Ziram: Final Report #33367. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 70 p.
44228402	Reynolds, J.; Smalley, J. (1997) Anaerobic Soil Metabolism of (carbon 14) Ziram: (Final Report): Lab Project Number: XBL96002: RPT00297: XBL 96002. Unpublished study prepared by XenoBiotic Laboratories, Inc. 111 p.

Aerobic Aquatic Metabolism

MRID	Citation Reference
46045903	Vokl, S. (2001) (Carbon 14)-Ziram: Route and Rate of Degradation in Aerobic Aquatic Systems. Project Number: 744693. Unpublished study prepared by RCC Umweltchemie Ag. 109 p.

163-1 Leach/adsorption/desorption

MRID	Citation Reference
151488	Warren, J. (1985) Leaching Characteristics of Aged Ziram: ABC Re- port #33364. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 28 p.
153205	Analytical Bio-Chemistry Labs., Inc. (1985) Soil/Sediment Adsorption/ Desorption: [Ziram]: Rev. ABC Protocol #M-8007: Study No. 33368. Unpublished study. 13 p.
153206	Analytical Bio-Chemistry Labs., Inc. (1985) Leaching Characteristics in Soil: ABC Protocol #M-8102: Study No. 33365. Unpublished study. 14 p.

5001190 Helling, C.S.; Dennison, D.G.; Kaufman, D.D. (1974) Fungicide movement in soils. *Phytopathology* 64(8):1091-1100.

43873501 Spare, W. (1995) Adsorption/Desorption of (carbon 14)-Ziram: Lab Project Number: 2526: IDC 433102: 94072. Unpublished study prepared by Agrisearch Inc. 162 p.

164-1 Terrestrial field dissipation

MRID	Citation Reference
40061603	Selman, F. (1987) Ziram Soil Dissipation Study: ABC Preliminary Report #35028. Unpublished study prepared by Analytical Bio- Chemistry Laboratories, Inc. in cooperation with Morse Laboratories, Inc. 112 p.
40061604	Selman, F. (1987) Ziram Soil Dissipation Study: ABC Preliminary Report #35029. Unpublished study prepared by Analytical Bio- Chemistry Laboratories, Inc. in cooperation with Morse Laboratories, Inc. 109 p.
44548301	Novak, R.; Binari, L. (1998) Terrestrial Field Dissipation of Ziram 76 DF Fungicide in North Carolina: Final Report: Lab Project Number: F96-7204: GR96255: 96-0030. Unpublished study prepared by Grayson Research, Ltd., EN-CAS Analytical Laboratories, and NPC, Inc. 428 p.
44548302	Novak, R.; Binari, L. (1998) Terrestrial Field Dissipation of Ziram 76 DF Fungicide in California: Final Report: Lab Project Number: F96-7203: R319601: ML96-0606-ZTF. Unpublished study prepared by Research for Hire, Morse Laboratories, Inc., and NPC, Inc. 401 p.
46545601	Reibach, P. (2005) Terrestrial Field Dissipation of Ziram. Project Number: KP/2005/13. Unpublished study prepared by Cerexagri, Inc. 20 p.
ACC 259584	Warren, J. 1985. ABC # 33368

Non-Guideline Study

MRID	Citation Reference
146901 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Soil/Sediment Adsorption-Desorption": [Protocol only--Protocol #M-8007]. Un- published study. 9 p.
146902 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Leaching Characteristics of Soil Incorporated Test Material following Aerobic Aging": [Protocol only--Protocol #M-8406]. Unpublished study. 15 p.
146903 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Leaching Characteristics in Soil": [Protocol only--Protocol #M-8102]. Unpublished study. 9 p.
146904 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Determination of Hydrolysis Rate": [Protocol only--Protocol #M-8201]. Unpublished study. 9 p.
146905 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Determination of Photolysis Rate": [Protocol only--Protocol #M-8301]. Unpublished study. 9 p.
146906 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Determination of Photolysis Rate on the Surface of Soil": [Protocol only--Protocol #M-8304]. Unpublished study. 12 p.

146907 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Aerobic Soil Metabolism": [Protocol only--Protocol #M-8001]. Unpublished study. 13 p.
146908 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Anaerobic Soil Metabolism": [Protocol only--Protocol #M-8002]. Unpublished study. 13 p.
154984	Klisenko, M.; Vekshtein, M. (1971) Kinetics of the hydrolysis of metal complexes of dialkyldithiocarbamic and ethylenebisdithio- carbamic acids in their dependence on the pH of the medium, and identification of their transformation products. J. Gen. Chem. of the U.S.S.R. 41(5):1125-1130.
40497300	Penwalt Corp. (1988) Submission of Hydrolysis Rate in Response to Groundwater Data Call-in for Ziram. Transmittal of 1 study.
N.A.	1990 Fate Database Oneliner Report Protocol for Terrestrial Field Dissipation study 1986
ACC 258212	Lemal, R. 1984. Ziram Determination of Octanol Water partition coefficient 1990 Fate Data Summary Lab Audit for Soil Dissipation Study

Ferbam

71-2 Avian Dietary Toxicity

MRID	Citation Reference
106146	Fink, R.; Reno, F. (1973) Final Report: Eight-day Dietary LC50-- Bobwhite Quail: Ferbam : Project No. 104-172. (Unpublished study received Jun 11, 1973 under 279-388; prepared by Environ- mental Sciences Corp., submitted by FMC Corp., Philadelphia, PA; CDL:008720-A)
106148	Fink, R.; Reno, F. (1973) Final Report: Eight-day Dietary LC50-- Mallard Ducks: Ferbam : Project No. 104-173. (Unpublished study received Jul 11, 1973 under unknown admin. no.; prepared by Environmental Sciences Corp., submitted by FMC Corp., Philadelphia, PA; CDL:130715-A)
44593301	Hill, E.; Camardese, M. (1986) Lethal dietary toxicities of environmental contaminants and pesticides to coturnix. Fish and Wildlife Technical Report 2:1-147.

72-1 Acute Toxicity to Freshwater Fish

MRID	Citation Reference
5014941	Pickering, Q.H.; Henderson, C. (1966) The acute toxicity of some pesticides to fish. Ohio Journal of Science 66(5):508-513.

81-1 Acute oral toxicity in rats

MRID	Citation Reference
26174	Jasper, R.L. (1964) (Scotts Haze: Toxicity to Rats). (U.S. Pharmacology Laboratory, unpublished report.)
34304	Food Research Laboratories, Incorporated (1954) Acute Oral Toxicity of Vancide F-956: Laboratory No. 68713. (Unpublished study received Jan 26, 1956 under 279-1017; submitted by FMC Corp., Philadelphia, Pa.; CDL:002277-E)
83232	Hodge, H.C.; Maynard, E.A.; Downs, W.; et al. (1952) Acute and short-term oral toxicity tests of ferric dimethyldithiocarbamate (ferbam) and zinc dimethyldithiocarbamate (ziram). Journal of the American Pharmaceutical Association, Scientific Ed. XLI(12): 662-665. (Also In unpublished submission received Dec 25, 1962 under PP0393; submitted by E.I. du Pont de Nemours & Co., Inc., Wilmington, Del.; CDL:090425-B)
90638	Foulger, J.H.; Zapp, J.A., Jr. (1949) Letter sent to Justus C. Ward dated Apr 5, 1949 ?Toxicity of Fermate on rats and guinea pigs . (Unpublished study received Apr 6, 1949 under unknown admin. no.; prepared by Haskell Laboratory of Industrial Toxicology, submitted by ?; CDL:110198-A)
143817	Lee, C.; Russell, J.; Minor, J. (1978) Oral toxicity of ferric di- methyl dithiocarbamate (ferbam) and tetramethylthiuram disulfide (thiram) in rodents. Journal of Toxicology and Environmental Health 4:93-106.
40561401	Reijnders, J. (1987) Evaluation of the Acute Oral Toxicity of Ferbam 76 percent WDG in the Rat: Laboratory Project ID NOTOX 0741/936. Unpublished study prepared by NOTOX C. V., Netherlands. 12 p.
40561501	Reijnders, J. (1987) Evaluation of the Acute Oral Toxicity of Ferbam Technical in the Rat: Laboratory Project ID NOTOX 0740/930. Unpublished study prepared by NOTOX C. V., Netherlands. 11 p.
92038007	Ritter, D. (1990) John W. Kennedy Consultants, Inc. Phase 3 Summary of MRID 40561401. Evaluation of the Acute Oral Toxicity of Ferbam 76 % WDG in the Rat: Study # NOTOX 0741/936. Prepared by NOTOX C.V. 6 p.
92038008	Ritter, D. (1990) John W. Kennedy Consultants, Inc. Phase 3 Summary of MRID 40561501. Evaluation of the Acute Oral Toxicity of FERBAM TECHNICAL in the Rat: Report No. NOTOX/0740/930. Prepared by NOTOX C.V. 6 p.

850.1350 Mysid chronic toxicity test

MRID	Citation Reference
47784401	Gallagher, S.; Claude, M.; Kendall, T.; et al. (2009) (Carbon 14)-Ferbam: A Flow-Through Life-Cycle Toxicity Test with the Salt Water Mysid (Americamysis bahia): Final Report. Project Number: 657A/104. Unpublished study prepared by Wildlife International, Ltd. 70 p.

161-1 Hydrolysis

MRID	Citation Reference
40088201	Warren, J. (1987) Determination of the Hydrolysis Rate of [Carbon 14]-Ferbam: ABC Preliminary Report #34375. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 248 p.
44071801	Nixon, W.; Atkins, R. (1996) Hydrolysis of (carbon-14) Ferbam in Aqueous Buffered Solutions of pH 5, 7 and 9: Lab Project Number: 990: 1898: 95044. Unpublished study prepared by PTRL East, Inc. 150 p.

161-2 Photodegradation-water

MRID	Citation Reference
40088202	Warren, J. (1986) Determination of the Photolysis Rate of [Carbon 14]-Ferbam: ABC Preliminary Report #34373. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 230 p.
43999801	Nixon, W. (1996) Aqueous Photolysis of (Carbon 14) Ferbam in Artificial Light: Lab Project Number: 1002: 1884. Unpublished study prepared by PTRL East, Inc. 123 p.

161-3 Photodegradation-soil

MRID	Citation Reference
40088203	Carpenter, M. (1987) Determination of the Photodegradation Rate of [Carbon 14]-Ferbam: ABC Laboratory Project ID: #34374. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 192 p.
43999802	Nixon, W. (1996) Soil Surface Photolysis of (Carbon 14) Ferbam in Artificial Light: Lab Project Number: 1003: 1883. Unpublished study prepared by PTRL East, Inc. 100 p.

162-1 Aerobic soil metabolism

MRID	Citation Reference
40550601	Daly, D. (1987) Aerobic Soil Metabolism of carbon 14]-Ferbam: ABC Draft Final: 34369. Unpublished study prepared by ABC Laboratories, Inc. 37 p.
44368901	Nixon, W.; Atkins, R.; Coody, P. (1997) Aerobic Soil Metabolism of (carbon 14)Ferbam: (Final Report): Lab Project Number: 1004: 1903: 95047. Unpublished study prepared by PTRL East, Inc. 110 p.

162-2 Anaerobic soil metabolism

MRID	Citation Reference
40365301	Daly, D. (1987) Anaerobic Soil Metabolism of [Carbon 14]-Ferbam: ABC Preliminary Report #34370. Unpublished study prepared by ABC Laboratories, Inc. 226 p.
44565305	Coody, P.; Atkins, R. (1998) Anaerobic Metabolism of (carbon 14)Ferbam: Lab Project Number: 1005: 1969. Unpublished study prepared by PTRL East, Inc. 152 p.

162-3 Anaerobic aquatic metabolism

MRID	Citation Reference
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44565305 Coody, P.; Atkins, R. (1998) Anaerobic Metabolism of (carbon 14)Ferbam: Lab Project Number: 1005: 1969. Unpublished study prepared by PTRL East, Inc. 152 p.

163-1 Leach/adsorption/desorption

MRID	Citation Reference
98839	Munnecke, D.E. (1961) Movement of nonvolatile, diffusible fungicide through columns of soil. <i>Phytopathology</i> 51(Sep):593-599. (Also In unpublished submission received Jan 4, 1978 under 239- 1246; submitted by Chevron Chemical Co., Richmond, Calif.; CDL: 232569-S)
162088	Drury, P. (1986) Determination of Adsorption/Desorption Constants of [Carbon 14]-Ferbam: ABC Preliminary Rept. #34371. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 282 p.
5001190	Helling, C.S.; Dennison, D.G.; Kaufman, D.D. (1974) Fungicide movement in soils. <i>Phytopathology</i> 64(8):1091-1100.
40088204	Warren, J. (1986) Determination of Adsorption/Desorption Constants of [Carbon 14]-Ferbam: ABC Laboratory ID: #34371. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 306 p.

164-1 Terrestrial field dissipation

MRID	Citation Reference
40550902	Selman, F.; Moezpoor, E. (1988) Ferbam Peach Terrestrial Field Dissipation: Preliminary Report No. 35506. Unpublished study prepared by Analytical Bio-chemistry Laboratories, Inc. 65 p.
40603401	Selman, F.; Moezpoor, E. (1988?) Ferbam Apple Terrestrial Field Dissipation: Preliminary Report No. 35507. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 138 p.

Non-Guideline Study

MRID	Citation Reference
11559	Richardson, L.T. (19??) The persistence of Thiram in soil and its relationship to the microbiological balance and damping-off control. <i>Canadian Journal of Botany</i> 32(?):335-346. (Also in unpublished submission received Sep 26, 1972 under 1023-15; submitted by Upjohn Co., Kalamazoo, Mich.; CDL:024388-B)
117716.	Lemal, R. (1985) Determination of Vapor Pressure of Ferbam: [Iron tris (Dimethyldithiocarbamate)]: LPCD No. 162-85. Unpublished study prepared by UCB. 4 p.
98833	Kluge, E. (1969) The Effect of the Soil Reaction on the Degradation and Persistence of Thiuram, Ferbam, and Captan in the Soil. A translation of: ?Without Title . <i>Archiv fuer Pflanzenwchutz</i> , 5(4):263-271. (Unpublished study received Jan 4, 1978 under 239-1246; submitted by Chevron Chemical Co., Richmond, Calif.; CDL:232569-J)
41340903	Vandegans, J. (1987) Determination of the Stability Constant of Iron III-tris (N,N-Dimethyldithiocarbamate) or Ferbam: Lab Project Nos. F80312; UCB #F80312. Unpublished study prepared by C.P.R.S.--C.E.R.I.A. 18 p.

Ziram

71-1 Avian Single Dose Oral Toxicity (850.2100)

MRID	Citation Reference
103510	Oser (1959) Estimation of Acute Oral Toxicity of V51Z Dispersion in Pigeons: Laboratory No. 78955. (Unpublished study received on unknown date under 1965-26; prepared by Food and Drug Research Laboratories, Inc., submitted by R.T. Vanderbilt Co., Inc., East Norwalk, CT; CDL:050437-A)
41725701	Hakin, B.; Norman, A. (1989) Acute Oral Toxicity (LD50) of Ziram to the Bobwhite Quail: Lab Project Number: ZIR 17/90566. Unpublished study prepared by Huntingdon Research Centre Ltd. 29 p.

71-2 Avian Dietary Toxicity (850.2200)

MRID	Citation Reference
42386301	Hakin, B.; Norman, A.; Anderson, A.; et al. (1992) The Dietary Toxicity (LC50) of Ziram Technical to the Bobwhite Quail: Final Report: Lab Project Number: ZIR 19/901457. Unpublished study prepared by Huntingdon Research Centre Ltd. 32 p.
42386302	Hakin, B.; Norman, A.; Anderson, A.; et al. (1992) The Dietary Toxicity (LC50) of Ziram Technical to the Mallard Duck: Final Report: Lab Project Number: ZIR 18/901456. Unpublished study prepared by Huntingdon Research Centre Ltd. 32 p.
50939501	Stanfield, K. 2019. Ziram: Zebra Finch (<i>Taeniopygia guttata</i>) Dietary Acute Toxicity Test. Study performed by Smithers Viscient, Snow Camp, NC. Laboratory project number 13561.4100. Study sponsored by Ziram Task Force, Ashburn, VA. Study initiated September 17, 2018 and completed August 20, 2019.

850.2300 71-4 Avian Reproduction

MRID	Citation Reference
46622301	Frey, L.; Martin, K.; Beavers, J.; et al. (2000) Ziram Technical: A Reproduction Study with the Northern Bobwhite: Final Report. Project Number: 299/104. Unpublished study prepared by Wildlife International, Ltd. 163 p.
47286501	Temple, D.; Martin, K.; Beavers, J.; et al. (2007) Ziram: A Reproduction Study with the Mallard: Final Report. Project Number: 602/104, KP/029/01, KP/2006/45. Unpublished study prepared by Cerexagri, Inc., Taminco, n.v. and Wildlife International, Ltd. 263 p.
48115201	Piccirillo, V. (2010) Response to Data Evaluation Record for: A Reproduction Study on Mallard Duck with Ziram (MRID 47286501). Project Number: 2010/1. Unpublished study prepared by VJP Consulting, Inc. 6 p.

850.1075 72-1 Acute Toxicity to Freshwater Fish

MRID	Citation Reference
92338 or 107813	Hercules, Incorporated (1956) Fish Toxicity of Six Chemical Compounds. (Unpublished study received Jul 7, 1970 under 891-148; CDL:129350-A or 106037-B)
138214 ACC 72559	Dickhaus, S.; Heisler, E.; Reinhard. (1980) Examination for Acute Toxicity of Ziram in Rainbow-trout at Exposition of 96 Hours in the Bath Fluid: Report ID:1-7-139-80. (Unpublished study received Apr 10, 1984 under 3F2964; prepared by Pharmatox Forschung und Beratung GmbH, W. Ger., submitted by Rhone-Poulenc, Inc., Monmouth Junction, NJ; CDL:072559-A)
138215 ACC 72559	Dickhaus, S.; Heisler, E. (1980) Examination for Acute Toxicity of Ziram in Carp at Exposition of 96 Hours in the Bath Fluid: Report ID:1-7-140-80. (Unpublished study received Apr 10, 1984 under 3F2964; prepared by Pharmatox Forschung und Beratung GmbH, W. Ger., submitted by Rhone-Poulenc, Inc., Monmouth Junction, NJ; CDL:072559-B)
42386303	Douglas, M.; Stonehewer, R.; Macdonald, I. (1991) The Acute Toxicity of Ziram Technical to Bluegill Sunfish (<i>Lepomis macrochirus</i>): Final Report: Lab Project Number: ZIR 20(C)/901626. Unpublished study prepared by Huntingdon Research Centre Ltd. 27 p.
42386304	Douglas, M.; Bell, G.; Macdonald, I. (1991) The Acute Toxicity of Ziram Technical to Rainbow Trout (<i>Oncorhynchus mykiss</i>): Final Report: Lab Project Number: ZIR 20(B)/891173. Unpublished study prepared by Huntingdon Research Centre Ltd. 28 p.
47307901	Palmer, S.; Kendall, T.; Krueger, H. (2007) Ziram: A 96-hour Flow-Through Acute Toxicity Test With the Bluegill (<i>Lepomis macrochirus</i>): Final Report. Project Number: 602A/107. Unpublished study prepared by Wildlife International, Ltd. 37 p.
TN 1021	McCann, J.A. 24 hour LC50 with Rainbow trout and 76% ai = 300 PPB
46045902	Memmert, U. (2001) Sublethal Effects of Ziram 76 WG to Bluegill Sunfish (<i>Lepomis macrochirus</i>) After a Fourfold Application to a Water Sediment System. Project Number: 811438. Unpublished study prepared by RCC Umweltchemie Ag. 78 p.

850.1010 72-2 Acute Toxicity to Freshwater Invertebrates

MRID	Citation Reference
42386305	Douglas, M.; Bell, G.; Macdonald, I. (1991) The Acute Toxicity of Ziram Technical to <i>Daphnia magna</i> : Final Report: Lab Project Number: ZIR 20(A)/901625. Unpublished study prepared by Huntingdon Research Centre Ltd. 25 p.
47405701	Palmer, S.; Kendall, T.; Krueger, H. (2008) (Carbon 14)-Ziram: A 48-hour Flow-Through Acute Toxicity Test with the Cladoceran (<i>Daphnia magna</i>): Final Report. Project Number: 602A/108. Unpublished study prepared by Wildlife International, Ltd. 38 p.
46045901	Memmert, U. (2001) Chronic Toxicity of Ziram 76 WG to a Population of <i>Daphnia magna</i> After Fourfold Application. Project Number: 773987. Unpublished study prepared by RCC Umweltchemie Ag. 80 p.

72-3 Acute Toxicity to Estuarine/Marine Organisms

MRID	Citation Reference
43781601	Machado, M. (1995) Ziram--Acute Toxicity to Sheepshead Minnow (<i>Cyprinodon variegatus</i>) Under Flow-Through Conditions: Final Report: Lab Project Number: 95-6-5949: 13561.0395.6106.505. Unpublished study prepared by Springborn Labs, Inc. 77 p.
43781602	Dionne, E. (1995) Ziram--Acute Toxicity to the Eastern Oyster (<i>Crassostrea virginica</i>) Under Flow-Through Conditions: Final Report: Lab Project Number: 95-7-5965: 13561.0395.6108.504. Unpublished study prepared by Springborn Labs, Inc. 83 p.
43781603	Machado, M. (1995) Ziram--Acute Toxicity to Mysids (<i>Mysidopsis bahia</i>) Under Flow-Through Conditions: Final Report: Lab Project Number: 95-7-5967: 13561.0395.6107.515. Unpublished study prepared by Springborn Lab., Inc. 81 p.
40228401	Mayer, F.L. USEPA GulfBreeze Laboratory, 1986. – Pink shrimp and Longnose Killifish LC50 Eastern Oyster EC50 = 1000 ppb

850.1035 Mysid acute toxicity test

MRID	Citation Reference
47405702	Palmer, S.; Kendall, T.; Krueger, H. (2008) (Carbon 14)-Ziram: A 96-hour Flow-Through Acute Toxicity Test with the Saltwater Mysid (<i>Americamysis bahia</i>): Final Report. Project Number: 602A/109. Unpublished study prepared by Wildlife International, Ltd. 37 p.

850.1300 Daphnid chronic toxicity test

MRID	Citation Reference
46823301	Palmer, S.; Kendall, T.; Krueger, H. (2006) Ziram: A Flow-Through Life-Cycle Toxicity Test With The Cladoceran (<i>Daphnia magna</i>): Final Report. Project Number: 602A/101. Unpublished study prepared by Cerexagri, Inc. and Taminco, n.v. 57 p.

850.1350 Mysid chronic toxicity test

MRID	Citation Reference
46893103	Sutherland, C.; Kendall, T.; Krueger, H. (2006) Ziram: A Flow-Through Life-Cycle Toxicity Test With Saltwater Mysid (<i>Mysidopsis bahia</i>): Final Report. Project Number: 602A/102A. Unpublished study prepared by Wildlife International, Ltd. 72 p.
48115701	Sutherland, C.; Kendall, T.; Krueger, H. (2006) Ziram: A Flow-Through Life-Cycle Toxicity Test with the Saltwater Mysid (<i>Mysidopsis bahia</i>). Project Number: 602A/102A. Unpublished study prepared by Wildlife International, Ltd. 23 p.

850.1400 Fish early-life stage toxicity test Marine and Freshwater

MRID	Citation Reference
46856401	Sutherland, C.; Kendall, T.; Krueger, H. (2006) Ziram: An Early Life-Stage Toxicity Test with the Sheepshead Minnow (<i>Cyprinodon variegatus</i>): Final Report. Project Number: 602A/104. Unpublished study prepared by Wildlife International, Ltd. 73 p.

46893104 Palmer, S.; Kendall, T.; Krueger, H. (2006) Ziram: An Early Life-Stage Toxicity Test with Fathead Minnow (*Pimephales promelas*): Final Report. Project Number: 602A/103A. Unpublished study prepared by Wildlife International, Ltd. 66 p.

850.1500 Fish life cycle toxicity

MRID	Citation Reference
47435501	Palmer, S.; Kendall, T.; Krueger, H. (2008) Ziram: A Flow-Through Life-Cycle Toxicity Test with the Fathead Minnow (<i>Pimephales promelas</i>). Project Number: 602A/106A, RL/13/2/1. Unpublished study prepared by Wildlife International Ltd. 131 p.

850.4100 Terrestrial plant toxicity, Tier 1 (seeding emergence)

MRID	Citation Reference
46893101	Porch, J.; Krueger, H. (2006) Ziram: A Toxicity Test to Determine the Effects of the Test Substance on Seedling Emergence of Ten Species of Plants Grown Under Greenhouse Conditions: Final Report. Project Number: 602/102, KP/2006/21, 602/080505/SEEDM/10/SUB602. Unpublished study prepared by Wildlife International, Ltd and Cerexagri, Inc. 138 p.

850.4150 Terrestrial plant toxicity, Tier 1 (vegetative vigor)

MRID	Citation Reference
46893102	Porch, J.; Krueger, H. (2006) Ziram: A Toxicity Test to Determine the Effects of the Test Substance on Vegetative Vigor of Ten Species of Plants Grown Under Greenhouse Conditions: Final Report. Project Number: 602/103, KP/2006/22, 602/080505/VEGVIG10/GH/SUB602. Unpublished study prepared by Wildlife International, Ltd and Cerexagri, Inc. 175 p.

850.4225 Seedling emergence, Tier II

MRID	Citation Reference
46893101	Porch, J.; Krueger, H. (2006) Ziram: A Toxicity Test to Determine the Effects of the Test Substance on Seedling Emergence of Ten Species of Plants Grown Under Greenhouse Conditions: Final Report. Project Number: 602/102, KP/2006/21, 602/080505/SEEDM/10/SUB602. Unpublished study prepared by Wildlife International, Ltd and Cerexagri, Inc. 138 p.

850.4250 Vegetative vigor, Tier II

MRID	Citation Reference
46893102	Porch, J.; Krueger, H. (2006) Ziram: A Toxicity Test to Determine the Effects of the Test Substance on Vegetative Vigor of Ten Species of Plants Grown Under Greenhouse Conditions: Final Report. Project Number: 602/103, KP/2006/22, 602/080505/VEGVIG10/GH/SUB602. Unpublished study prepared by Wildlife International, Ltd and Cerexagri, Inc. 175 p.

123-2 Aquatic plant growth (850.4500 and 850.4550)

MRID	Citation Reference
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43833901 Hoberg, J. (1995) Ziram--Toxicity to the Freshwater Green Alga, *Selenastrum capricornutum*: Amended Final Report: Lab Project Number: 95-7-5971: 13561.0395.6101.430. Unpublished study prepared by Springborn Labs, Inc. 77 p.

5001505 Palmer, C.M.; Maloney, T.E. (1955) Preliminary screening for potential **algicides**. Ohio Journal of Science LV(1):1-8.

5003523 Maloney, T.E.; Palmer, C.M. (1956) Toxicity of six chemical compounds to thirty cultures of algae. Water and Sewage Works 103:509-513.

50814401 Softcheck, K.A. 2019. Ziram: A 96-Hour Toxicity Test with the Freshwater Diatom, *Navicula pelliculosa*. Unpublished study performed by Smithers Viscient, Wareham, Massachusetts. Smithers Viscient Study No. 13651.6110. Study sponsored and submitted by Ziram Task Force, VJP Consulting, Ashburn, Virginia. Study initiated July 28, 2017 and completed February 28, 2019.

50814402 Softcheck, K.A. 2019. Ziram – 96-Hour Toxicity Test with the Marine Diatom, *Skeletonema costatum*. Study conducted by Smithers Viscient, Wareham, Massachusetts. Laboratory Project ID: 13561.6111. Study sponsored by Ziram Task Force, VJP Consulting, Ashburn, Virginia. Study initiated July 28, 2017 and completed February 27, 2019.

50814403 Softcheck, K.A. 2019. Ziram: A 96-Hour Toxicity Test with the Freshwater Cyanobacterium, *Anabaena flos-aquae*. Unpublished study performed by Smithers Viscient, Wareham, Massachusetts. Smithers Viscient Study No. 13651.6112. Study sponsored and submitted by Ziram Task Force, VJP Consulting, Ashburn, Virginia. Study initiated July 28, 2017 and completed February 26, 2019.

850.4400 Aquatic plant toxicity test using Lemna spp. Tiers I and II

MRID	Citation Reference
46823302	Desjardins, D.; Kendall, T.; Krueger, H. (2006) Ziram: A 7-Day Static-Renewal Toxicity Test with Duckweed (<i>Lemna gibba</i> G3): Final Report. Project Number: 602A/105. Unpublished study prepared by Cerexagri, Inc. and Taminco, n.v. 44 p.

141-1 Toxicity to Honey bee – Tier I Toxicity Studies and Tier II Brood Studies

MRID	Citation Reference
41667901	Cole, J. (1989) The Acute Contact Toxicity to Honeybees of Technical Ziram: Final Report: Lab Project Number: ZIR 21/891454. Unpublished study prepared by Huntingdon Research Centre, Ltd. 21 p.
5001322	King, C.C. (1959) The effects of fungicides. Gleanings in Bee Culture 87:678-681.
36935	Atkins, Univ. of California Riverside Honeybee Acute Toxicity
50294101	Sekine, T. 2013. Effects of Ziram technical (Acute Contact and Oral) on Honey Bees (<i>Apis mellifera</i> L.) in the Laboratory. Unpublished study performed by Institut Für Biologische Analytik und Consulting IBACON GmbH, Rossdorf, Germany. Laboratory Report ID: 81401035. Study sponsored by Taminco BVBA, Gent, Belgium. Study completed September 30, 2013.

50294102	Sekine, T. 2014. Chronic Oral Toxicity Test of Ziram 76 WG on the Honey Bee (<i>Apis mellifera</i> L.) in the Laboratory. Unpublished study performed by Institut Für Biologische Analytik und Consulting IBACON GmbH, Rossdorf, Germany. Laboratory Report ID: 80776136. Study sponsored by Taminco BVBA, Gent, Belgium. Study completed August 29, 2014.
50294103	Schmitzer, S. 2013. Study on the Effects of Ziram 76 WG 76 WG on Honey Bee Brood (<i>Apis mellifera</i> L.) - Brood Feeding Test. Unpublished study performed by Institut Für Biologische Analytik und Consulting IBACON GmbH, Rossdorf, Germany. Laboratory Report ID: 80777031. Study sponsored by Taminco BVBA, Gent, Belgium. Study completed December 19, 2013.
50294104 and 50294105	Klockner, A. and S. Hecht-Rost. 2015. Semi-field Brood Study to Evaluate Potential Effects of Ziram 76 WG on Brood Development of Honeybees (<i>Apis mellifera</i> L.). Unpublished study performed by RIFCON GmbH, Hirschberg, Germany and Huntingdon Life Sciences, Eye Research Centre, Suffolk, UK. Laboratory Report ID: R1340242 and PFX0108. Study sponsored by Taminco BVBA, Gent, Belgium, a subsidiary of Eastman Chemical Company. Study portions completed March 17 and 18, 2015.

Non-Guideline Study Selections

MRID	Citation Reference
41338001	Christopher, D. (1989) Toxicity Studies with Ziram: Chemical Analysis of Ziram in Diets and Liquid Suspensions: Lab Report No. 3083076080; Procedure ZIR/2421/M10/89; Validation ZIR 16/1. Unpublished study prepared by Huntingdon Research Centre Ltd. 44 p. not sure what type of studies mammals or birds
45534701	Lamb, IV, J.; Hentz, K.; Matthews, S.; et al. (2001) Analysis of Common Mechanisms of Toxicity for Ethylenebisdithiocarbamates and Other Dithiocarbamates. Unpublished study prepared by BBL Sciences. 111 p.
47164601	Moore, D.; Breton, R.; Rodney, S.; et al. (2007) Generic Problem Formulation for California Red-Legged Frog. Project Number: 89320, 05232007. Unpublished study prepared by Cantox Environmental Inc. 87 p.
47164602	Holmes, C.; Vamshi, R. (2007) Data and Methodology Used for Spatial Analysis of California Red Legged Frog Observations and Proximate Land Cover Characteristics. Project Number: 3152007, WEI/252/03. Unpublished study prepared by Waterborne Environmental, Inc. (WEI). 19 p.
47308001	Piccirillo, V. (2007) Critical Review of the Aquatic Toxicity of Ziram. Project Number: 2007/1, ZTF/2001/1. Unpublished study prepared by Ziram Task Force and Taminco, n.v. and United Phosphorus, Inc. 6 p.
48033010	Nishihara, T.; Nishikawa, J.; Kanayama, T.; et al. (2000) Estrogenic Activities of 517 Chemicals by Yeast Two-Hybrid Assay. Journal of Health Science 46(4): 282-298.

161-1 Hydrolysis

MRID	Citation Reference
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142855 Lemal, R.; Boel, C.; Debondues, M. (1984) Ziram: Rate of Hydrolysis as a Function of pH. Unpublished study prepared by UCB, Drogenbos Laboratory. 6 p.

154985 Korotkova, O. (1976) Razlozhenie fungitsidov--proizvodnykh ditio- karbaminovoy kisloty (obzor literatury) [Decomposition of such fungicides as derivatives of dithiocarbamic acid (literature review)]. Khim. Sel'sk. Khoz. 12(11):869-874, 1974. Abstracted in Pest. Abs. 76-0215.

40497301 Daly, D.; Cranor, W. (1987) Determination of Hydrolysis Rate with ¹⁴C-Ziram: Final Report #33363. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 573 p.

43866701 Kim-Kang, H. (1995) Hydrolysis of (carbon 14)-Ziram in Water at pH 5, 6, and 9: Lab Project Number: XBL 94071: PRT00213: IDC433102. Unpublished study prepared by Xenobiotic Labs, Inc. and NPC Inc. 272 p.

161-2 Photodegradation-water

MRID	Citation Reference
153198	Carpenter, M. (1985) Determination of Photodegradation of Ziram in Aqueous Solution: Report 33369. Unpublished study prepared by Analytical Bio-Chemistry Labs., Inc. 53 p.
154985	Korotkova, O. (1976) Razlozhenie fungitsidov--proizvodnykh ditio- karbaminovoy kisloty (obzor literatury) [Decomposition of such fungicides as derivatives of dithiocarbamic acid (literature review)]. Khim. Sel'sk. Khoz. 12(11):869-874, 1974. Abstracted in Pest. Abs. 76-0215.
44097701	Kim-Kang, H. (1996) Aqueous Photolysis of (carbon 14)-Ziram: Lab Project Number: XBL94073: RPT00223: IDC 433102. Unpublished study prepared by XenoBiotic Labs, Inc. 245 p.

161-3 Photodegradation-soil

MRID	Citation Reference
153199	Carpenter, M. (1985) Determination of Photodegradation of Ziram on the Surface of Soil: Report 33370. Unpublished study prepared by Analytical Bio-Chemistry Labs., 60 p.
154985	Korotkova, O. (1976) Razlozhenie fungitsidov--proizvodnykh ditio- karbaminovoy kisloty (obzor literatury) [Decomposition of such fungicides as derivatives of dithiocarbamic acid (literature review)]. Khim. Sel'sk. Khoz. 12(11):869-874, 1974. Abstracted in Pest. Abs. 76-0215.
44228401	Reynolds, J. (1997) Photolysis of (carbon 14) Ziram on Soil: (Final Report): Lab Project Number: 96001: RPT00296: XBL 96001. Unpublished study prepared by XenoBiotic Laboratories, Inc. 179 p.

162-1 835.4100 Aerobic soil metabolism

MRID	Citation Reference
40061601	Cranor, W. (1987) Aerobic Soil Metabolism Study with [Carbon 14]- Ziram: Final Report #33366. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 85 p.
43985801	Kim-Kang, H. (1996) Aerobic Soil Metabolism of (carbon 14)- Ziram: Lab Project Number: XBL 94072: RPT00225. Unpublished study prepared by XenoBiotic Labs, Inc. 180 p.
47005202	Reibach, P. (2006) (Carbon 14)-Ziram Fungicide Soil Metabolism. Project Number: KP/2006/44. Unpublished study prepared by Cerexagri, Inc. 11 p.
46622302	Mamouni, A. and Piccirillo, V. (2001) Degradation Rate of (Carbon 14)-Ziram in Three Soils Incubated Under Aerobic Conditions. Project Number: 785744. Unpublished study prepared by RCC Umweltchemie Ag. 90 p.

835.3300 Soil biodegradation

MRID	Citation Reference
47005202	Reibach, P. (2006) (Carbon 14)-Ziram Fungicide Soil Metabolism. Project Number: KP/2006/44. Unpublished study prepared by Cerexagri, Inc. 11 p.

162-2 Anaerobic soil metabolism

MRID	Citation Reference
40061602	Cranor, W. (1987) Anaerobic Soil Metabolism Study with [Carbon 14]- Ziram: Final Report #33367. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc. 70 p.
44228402	Reynolds, J.; Smalley, J. (1997) Anaerobic Soil Metabolism of (carbon 14) Ziram: (Final Report): Lab Project Number: XBL96002: RPT00297: XBL 96002. Unpublished study prepared by XenoBiotic Laboratories, Inc. 111 p.

Aerobic Aquatic Metabolism

MRID	Citation Reference
46045903	Volkl, S. (2001) (Carbon 14)-Ziram: Route and Rate of Degradation in Aerobic Aquatic Systems. Project Number: 744693. Unpublished study prepared by RCC Umweltchemie Ag. 109 p.

163-1 Leach/adsorp/desorption

MRID	Citation Reference
151488	Warren, J. (1985) Leaching Characteristics of Aged Ziram: ABC Re- port #33364. Unpublished study prepared by Analytical Bio-Chem- istry Laboratories, Inc. 28 p.
153205	Analytical Bio-Chemistry Labs., Inc. (1985) Soil/Sediment Adsorp- tion/Desorption: [Ziram]: Rev. ABC Protocol #M-8007: Study No. 33368. Unpublished study. 13 p.
153206	Analytical Bio-Chemistry Labs., Inc. (1985) Leaching Character- istics in Soil: ABC Protocol #M-8102: Study No. 33365. Unpub- lished study. 14 p.

5001190 Helling, C.S.; Dennison, D.G.; Kaufman, D.D. (1974) Fungicide movement in soils. *Phytopathology* 64(8):1091-1100.

43873501 Spare, W. (1995) Adsorption/Desorption of (carbon 14)-Ziram: Lab Project Number: 2526: IDC 433102: 94072. Unpublished study prepared by Agrisearch Inc. 162 p.

164-1 Terrestrial field dissipation

MRID	Citation Reference
40061603	Selman, F. (1987) Ziram Soil Dissipation Study: ABC Preliminary Report #35028. Unpublished study prepared by Analytical Bio- Chemistry Laboratories, Inc. in cooperation with Morse Labora- tories, Inc. 112 p.
40061604	Selman, F. (1987) Ziram Soil Dissipation Study: ABC Preliminary Report #35029. Unpublished study prepared by Analytical Bio- Chemistry Laboratories, Inc. in cooperation with Morse Labora- tories, Inc. 109 p.
44548301	Novak, R.; Binari, L. (1998) Terrestrial Field Dissipation of Ziram 76 DF Fungicide in North Carolina: Final Report: Lab Project Number: F96-7204: GR96255: 96-0030. Unpublished study prepared by Grayson Research, Ltd., EN-CAS Analytical Laboratories, and NPC, Inc. 428 p.
44548302	Novak, R.; Binari, L. (1998) Terrestrial Field Dissipation of Ziram 76 DF Fungicide in California: Final Report: Lab Project Number: F96-7203: R319601: ML96-0606-ZTF. Unpublished study prepared by Research for Hire, Morse Laboratories, Inc., and NPC, Inc. 401 p.
46545601	Reibach, P. (2005) Terrestrial Field Dissipation of Ziram. Project Number: KP/2005/13. Unpublished study prepared by Cerexagri, Inc. 20 p.
ACC 259584	Warren, J. 1985. ABC # 33368

835.6100 Terrestrial field dissipation

MRID	Citation Reference
46545601	Reibach, P. (2005) Terrestrial Field Dissipation of Ziram. Project Number: KP/2005/13. Unpublished study prepared by Cerexagri, Inc. 20 p.

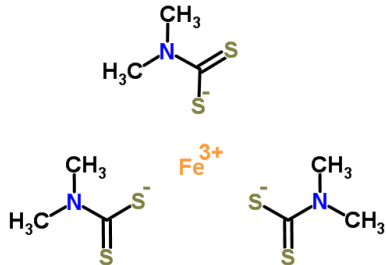
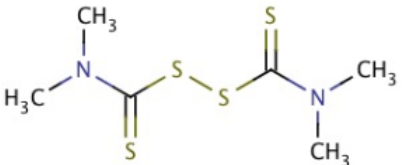
Non-Guideline Study

MRID	Citation Reference
146901 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Soil/Sediment Adsorption-Desorption": [Protocol only--Protocol #M-8007]. Un- published study. 9 p.
146902 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Leaching Characteristics of Soil Incorporated Test Material following Aerobic Aging": [Protocol only--Protocol #M-8406]. Unpublished study. 15 p.
146903 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Leaching Characteristics in Soil": [Protocol only--Protocol #M-8102]. Unpublished study. 9 p.
146904 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Determination of Hydrolysis Rate": [Protocol only--Protocol #M-8201]. Unpub- lished study. 9 p.

146905 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Determination of Photolysis Rate": [Protocol only--Protocol #M-8301]. Unpublished study. 9 p.
146906 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Determination of Photolysis Rate on the Surface of Soil": [Protocol only--Protocol #M-8304]. Unpublished study. 12 p.
146907 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Aerobic Soil Metabolism": [Protocol only--Protocol #M-8001]. Unpublished study. 13 p.
146908 protocol	Analytical Bio-Chemistry Laboratories, Inc. (1984) "Anaerobic Soil Metabolism": [Protocol only--Protocol #M-8002]. Unpublished study. 13 p.
154984	Klisenko, M.; Vekshtein, M. (1971) Kinetics of the hydrolysis of metal complexes of dialkyldithiocarbamic and ethylenebisdithiocarbamic acids in their dependence on the pH of the medium, and identification of their transformation products. J. Gen. Chem. of the U.S.S.R. 41(5):1125-1130.
40497300	Penwalt Corp. (1988) Submission of Hydrolysis Rate in Response to Groundwater Data Call-in for Ziram. Transmittal of 1 study.
N.A.	1990 Fate Database Oneliner Report Protocol for Terrestrial Field Dissipation study 1986
ACC 258212	Lemal, R. 1984. Ziram Determination of Octanol Water partition coefficient 1990 Fate Data Summary Lab Audit for Soil Dissipation Study

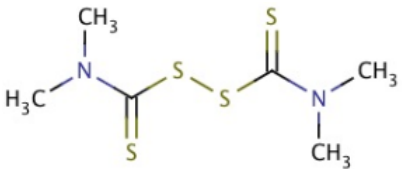
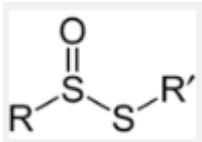
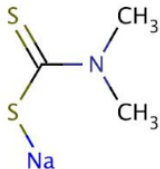
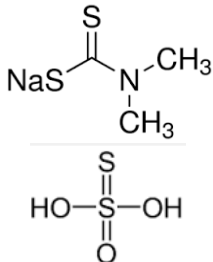
Appendix A. ROCKS Table

Table A-1. Ferbam and its Major Environmental Degradates

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (study length)
PARENT						
Parent Ferbam (PC Code: 034801)	ferric dimethyldithiocarbamate CAS No.: 14484-64-1 Formula: C ₉ H ₁₈ FeN ₃ S ₆ MW: 416.49 g/mol					
MAJOR TRANSFORMATION PRODUCTS						
Degradate Thiram (PC Code: 079801)	tetramethylthiram disulfide CAS No.: 137-26-8 Formula: C ₆ H ₁₂ N ₂ S ₄ MW: 240.43 g/mol		Hydrolysis pH 7	44071801	56.83% (0 day)	6.65% (30 days)
			Aqueous photolysis	43999801	63.3% (1 day)	0.5% (15 days)
			Aerobic soil	43999802	77.9% (0 days)	26.3% (150 days)
			Anaerobic soil	44565305	33.8% (0 days)	8.1% (364 days)
CS₂	carbon disulfide	$S=C=S$	Hydrolysis pH7	44071801	59.8% (30 days)	59.8% (30 days)
			Aqueous photolysis	43999801	6.8% (3 days)	0.2% (15 days)
			Anaerobic soil	44565305	50.7% (364 days)	50.7% (364 days)

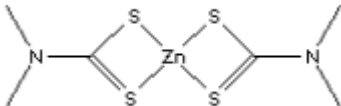
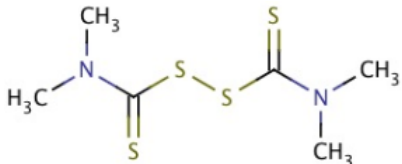
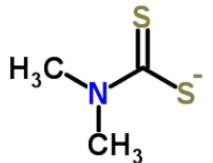
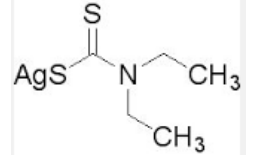
Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (study length)
			Soil photolysis	43999802	44.6% (15 days)	44.6% (15 days)
CO ₂	carbon dioxide	$\text{O}=\text{C}=\text{O}$	Hydrolysis pH 7	44071801	8.25% (30 days)	8.25% (30 days)
			Anaerobic soil	44565305	7.5% (364 days)	7.5% (364 days)
			Soil Photolysis	43999802	28.6% (15 days)	28.6% (15 days)

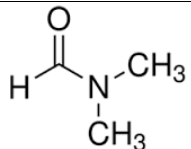
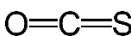
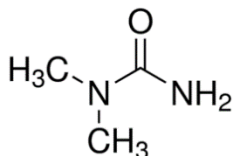
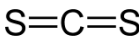
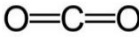
Table A-2. Thiram and its Major Environmental Degradates

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (study length)
PARENT						
Thiram	tetramethylthiuram disulfide CAS No.: 137-26-8 Formula: C ₆ H ₁₂ N ₂ S ₄ MW: 240.43 g/mol					
MAJOR TRANSFORMATION PRODUCTS						
	thiosulfinic acid		Hydrolysis pH 7	45714101	27.2% (30 days)	27.2% (30 days)
			Soil photolysis	45724501	82.5% (0 days)	17.2% (15 days)
	sodium dimethyl dithiocarbamate		Hydrolysis pH 7	45714101	12% (12 days)	0.0% (30 days)
	sodium dimethyl dithiocarbamate + thiosulfenic acid		Hydrolysis pH 9	45714101	66.8% (13 days)	66.8% (34 days)
CO₂	carbon dioxide	$O=C=O$	Aerobic soil	43734901	74.9% (205 days)	74.9% (205 days)
CS₂	carbon disulfide	$S=C=S$	Hydrolysis pH 9 & Aqueous photolysis	43999801	35% (30 days)	35% (30 days)

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (study length)
			Anaerobic Aquatic	43628501	17.2% (7 days)	0% (168 days)

Table A-3. Ziram and Its Major Environmental Degradates

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day) ^A	Final %AR (study length)
PARENT						
Ziram	Zinc bis (dimethyldithiocarbamate) CAS No.: 137-30-4 C ₉ H ₁₈ FeN ₃ S ₆ Formula: C ₆ H ₁₂ N ₂ S ₄ Zn MW: 305.813 g/mol					
MAJOR TRANSFORMATION PRODUCTS						
Thiram	Tetramethylthiuram disulfide CAS No.: 137-26-8 Formula: C ₆ H ₁₂ N ₂ S ₄ MW: 240.43 g/mol		Hydrolysis pH7	43866701	13.8% (4 hrs)	11.0% (72 hours)
			Soil photolysis	44228441	27.3% (24 hrs)	27.3% (24 hours)
			Aerobic soil	46622302	49.4% (1 hr)	0.3% (28 days)
			Anaerobic soil	44228402	1.03% (0 days)	0.41% (30 days)
			Aerobic aquatic	46045903	47.5% (6 hrs)	n.d. (101 days)
DDC	Dimethyldithiocarbamic acid		Hydrolysis pH 7	43866701	1.96% (72 hours)	1.96% (72 hours)
			Aqueous Photolysis	44097701	23.9% (18 hrs)	22.0% (24 hours)
DMTF	N,N-methylthioformamide		Soil Photolysis	44228401	3.06% (16 hrs)	2.99% (24 hours)
			Aqueous Photolysis	44097701	15.3% (24 hrs)	15.3% (24 hours)

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day) ^A	Final %AR (study length)
DMF	N,N-dimethylformamide		Soil Photolysis	44228401	4.51% (24 hrs)	4.51% (24 hours)
			Aqueous Photolysis	44097701	20.59% (24 hours)	20.59% (24 hours)
COS	Carbonyl sulfide		Hydrolysis pH 9	43806701	18.6% (30 days)	18.6% (30 days)
1,1-dimethylurea	1,1-dimethylurea		Aerobic Soil	43985801	10.5% (30 days)	5.25% (60 days)
CS₂	Carbon disulfide		Hydrolysis pH 7	43866701	81.6% (72 hrs)	81.6% (72 hours)
			Aerobic Aquatic	46045903	1.9% (101 days)	1.9% (101 days)
CO₂	Carbon dioxide		Aerobic Soil	43985801	48.3% (60 days)	48.3% (60 days)
			Aerobic Aquatic	46045903	81.5% (101 days)	81.5% (101 days)

Appendix B. Summary of Water Modeling of Thiram and the USEPA Standard Pond

Estimated Environmental Concentrations for Thiram are presented in Table 1 for the USEPA standard pond with the GAOnion WirrigSTD 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 9.2% of Thiram applied to the field eventually reaches the water body. The main mechanism of transport from the field to the water body is by runoff (100% of the total transport).

In the water body, pesticide dissipates with an effective water column half-life of 2.9 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 hydrolysis (effective average half-life = 3.6 days) followed by metabolism (25 days) and photolysis (33.3 days).

In the benthic region, pesticide dissipates slowly (125.7 days). The main source of dissipation in the benthic region is metabolism (effective average half-life = 129.5 days) followed by hydrolysis (4353.3 days). The vast majority of the pesticide in the benthic region (99.92%) is sorbed to sediment rather than in the pore water.

Table 1. Estimated Environmental Concentrations (ppb) for Thiram.

Peak (1-in-10 yr)	94.2
4-day Avg (1-in-10 yr)	41.6
21-day Avg (1-in-10 yr)	19.5
60-day Avg (1-in-10 yr)	8.24
365-day Avg (1-in-10 yr)	1.85
Entire Simulation Mean	0.536

Table 2. Summary of Model Inputs for Thiram.

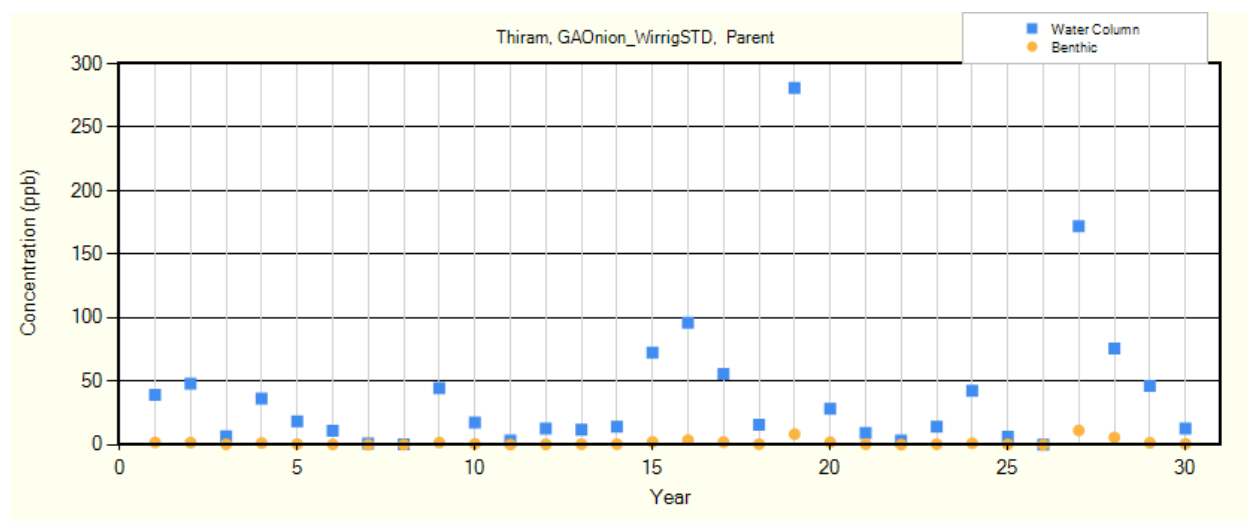
Scenario	GAOnion_WirrigSTD
Cropped Area Fraction	1
Koc (ml/g)	11507
Water Half-Life (days) @ 20 °C	24.93

Benthic Half-Life (days) @ 20 °C	129.3
Photolysis Half-Life (days) @ 25 °Lat	0.3
Hydrolysis Half-Life (days)	3.5
Soil Half-Life (days) @ 25 °C	8.55
Foliar Half-Life (days)	0
Molecular Weight	240.43
Vapor Pressure (torr)	1.72e-5
Solubility (mg/l)	16.5
Henry's Constant	0.0

Table 3. Application Schedule for Thiram.

Date (Days Since Emergence)	Type	Amount (kg/ha)	Eff.	Drift
-15	Placed at a depth of 0.635 cm	1.375	100	0

Figure 1. Yearly Peak Concentrations



Appendix C. Thiram, Ferbam, and Ziram, Ecotoxicity Data

The data presented in this appendix are from studies submitted by registrants or from the public literature, identified using ECOTOX (USEPA, 2009); the ECOTOX database was queried on December 26, 2018 using CAS Numbers 137-26-8 (thiram), 14484-64-1 (ferbam) and 137-30-4 (ziram). Because a ziram query had been previously evaluated for a 2008 assessment (USEPA, 2008), the query for ziram was a refresh since February 28, 2008. All dates were included in the queries for thiram and ferbam. Additionally, ECOTOX was queried again for all three chemicals on May 28, 2020 for any new papers published since the 2018 query. Public literature was searched for missing taxonomic groups and for studies with a more sensitive endpoint. Numerous studies were available with aquatic and terrestrial taxa, but most were studies that had already been submitted or studies that did not contain endpoints in usable units for risk calculation. For aquatic organisms, a copepod study with thiram (E177864) had a similar endpoint (though slightly lower $3 \text{ vs. } 3.4 \mu\text{g/L}$) than submitted studies (MRID 42488302) but did not have measured concentrations and so the difference was not considered to be certain enough for re-consideration of the endpoints and that study is used, rather, for characterization to support the endpoint used. Similarly, a ziram study with the diatom (*Nitzschia purgens*, E175889) at first appeared to be more sensitive than the most sensitive technical a.i. IC_{50} (inhibition concentration affecting 50% of the test organisms) from a submitted study (IC_{50} of $5.4 \text{ vs. } 67 \mu\text{g a.i./L}$, MRID 50814403) but this was a nonstandard “population” growth rate endpoint, and the study did not specify purity of the test substance, age of organisms, or duration, and with a submitted study using a formulation that was more sensitive ($2.4 \mu\text{g a.i./L}$, MRID 50792001), the study was not reviewed for use in risk calculations but is used for characterization and to support the endpoints used because it is in the same range. For terrestrial organisms, a chronic mouse study (E103999) with ferbam had no-effects, and lowest-effects dose-based endpoints of $500/ 1000 \text{ mg a.i./kg-bw}$ based on “abnormal reproduction” but this was a non-standard endpoint for use in risk calculations and was not considered since a dietary-based thiram endpoint for use in calculating ferbam risk (as a degradate) is available ($1.4 \text{ mg a.i./kg-diet}$, MRID 45441203). A house sparrow food avoidance study (E77673) with thiram did not have a usable toxicity endpoint but is useful for risk characterization. The review process did not result in any new toxicity data for use in risk calculations, though some are used for characterization.

The ecotoxicity data for thiram, ferbam, and ziram and their associated products have been reviewed previously in problem formulation documents for Registration Review (USEPA, 2015a and USEPA, 2015b) and for thiram and ziram, in the California red-legged frog assessment (USEPA, 2008). Comprehensive lists of available toxicity data from Supplemental and Acceptable studies are found in the following tables. New data reviewed since the problem formulations are denoted in the tables by an “N” superscript in the MRID column. Those new study reviews are summarized below.

The toxicity data are presented in this appendix as follows:

- C-1. Summary of Most Sensitive Endpoints for Aquatic and Terrestrial Taxa for Each Chemical
 - Table C-1-1. Most sensitive toxicity endpoints for aquatic organisms exposed to thiram.
 - Table C-1-2. Most sensitive toxicity endpoints for aquatic organisms exposed to ferbam.
 - Table C-1-3. Most sensitive toxicity endpoints for aquatic organisms exposed to ziram.
 - Table C-1-4. Most sensitive toxicity endpoints for terrestrial organisms exposed to thiram.
 - Table C-1-5. Most sensitive toxicity endpoints for terrestrial organisms exposed to ferbam.
 - Table C-1-6. Most sensitive toxicity endpoints for terrestrial organisms exposed to ziram.
- C-2. Comprehensive List of Toxicity Studies with Aquatic Organisms
 - Table C-2-1. Acute Toxicity to Freshwater Fish

- Table C-2-2. Chronic Toxicity to Freshwater Fish
- Table C-2-3. Acute Toxicity to Estuarine/Marine Fish
- Table C-2-4. Chronic Toxicity to Estuarine/Marine Fish
- Table C-2-5. Acute Toxicity to Freshwater Invertebrates
- Table C-2-6a. Chronic Toxicity to Freshwater Invertebrates
- Table C-2-6b. Effects to Zooplankton and Phytoplankton from Thiram Exposure in Aquatic Mesocosm
- Table C-7. Acute Toxicity to Estuarine/Marine Invertebrates
- Table C-2-8. Chronic Toxicity to Estuarine/Marine Invertebrates
- Table C-2-9a. Toxicity to Aquatic Plants
- Table C-2-9b. Additional details for New Thiram Non-vascular Aquatic Plant Studies
- Table C-2-9c. Additional details for New Ziram Non-Vascular Aquatic Plant Studies
- C-3. Comprehensive List of Toxicity Studies with Terrestrial Organisms
 - Table C-3-1. Acute Oral Toxicity to Birds
 - Table C-3-2. Sub-acute Dietary Toxicity to Birds
 - Table C-3-3. Chronic Toxicity to Birds
 - Table C-3-4. Acute Oral Toxicity to Mammals
 - Table C-3-5. Acute Inhalation Toxicity to Mammals
 - Table C-3-6. 2-Generation Reproductive Toxicity to Mammals
 - Table C-3-7a. Acute Contact Toxicity to Honey Bees (*Apis Mellifera*)
 - Table C-3-7b. Additional details for New Ziram Honey Bee Tunnel Study
 - Table C-3-8. Tier I and II Seedling Emergence - Thiram (MRID 50835301)
 - Table C-3-9. Tier I Vegetative Vigor – Thiram (MRID 50830201)
 - Table C-3-10. Tier I Seedling Emergence - Ziram (MRID 46893101)
 - Table C-3-11. Tier I Vegetative Vigor - Ziram (MRID 46893102)

C-1. Summary of Most Sensitive Endpoints for Aquatic and Terrestrial Taxa Tested for Each Chemical

Tables C-1-1 through **C-1-3** list the most sensitive toxicity endpoints available for aquatic organisms for the tree chemicals in the order of thiram, ferbam, and ziram. **Tables C-1-4** through **C-1-6** list the most sensitive toxicity endpoints for terrestrial organisms for the tree chemicals in the same order. **Sections C-2** and **C-3** contain comprehensive lists of aquatic and terrestrial studies, respectively. The tables in **Section 6** of the main body of this assessment contain the endpoints used to calculate risk, which in some cases contain toxicity endpoints other than these, and so these are presented here. For example the ferbam and ziram tables in **Section 6** contain some endpoints for thiram as the degradate in cases where it is more toxic.

Table C-1-1. Most sensitive toxicity endpoints for aquatic organisms exposed to thiram.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value				MRID or ECOTOX No./ Classification	Comments
			Endpoint	µg a.i./L	µg Feq/L ¹	µg Zeq/L ²		
Freshwater Fish (Surrogates for Vertebrates)								
Acute	Thiram TGAi (98.7%)	Bluegill sunfish (<i>Lepomis macrochirus</i>)	96-hr LC ₅₀	42	73	53	TN 996 Acceptable	Very highly toxic. This is a study from the U.S. Agricultural Research Service Lab and has a DER showing that raw data used to run statistical checks. Also, the rainbow trout thiram endpoint (LC ₅₀ of 46 ug thiram a.i./L) is very close and supports that toxicity in in this concentration range, although MRID 46249301 is a Supplemental study and has some uncertainties because the measured amounts dropped below 70% to “mimic natural conditions”; this was reviewed in 2011 and not re-reviewed.
	TEP (80%)	Harlequin Fish (<i>Rasbora heteromorpha</i>)	96-hr LC ₅₀	7	--	--	05020144 Supplemental/ Quantitative	Very highly toxic. Not fully acceptable due to protocol deviations, including test species, water change schedule and information gaps. Thiram TEP and not appropriate for ferbam or ziram.
Chronic (Full lifecycle)	TGAi (98.7%)	Fathead minnow (<i>Pimephales promelas</i>)	210-d NOAEC LOAEC (Reproduction and survival)	1.1 2.2	1.9 3.8	1.4 2.8	47824101 Acceptable	Based on significant (p<0.05) reductions in spawning frequency (69.5%), egg production (76.0%), and 4-week survival (24%); also, time to hatch observationally determined to be affected. ³
Chronic	TEP (80%)	Harlequin Fish (<i>R. heteromorpha</i>)	Calculated NOAEC With ACR: 11x: 32x 580x	0.63 0.22 0.012	--	--	05020144, TN 1001, 46249303, 00090293, 42514401, 51049801	Calculations of ACRs as follows: 128/12 = 11 382/12 = 32 540/0.98 = 580 Thiram endpoints: 7/ACR = Calc. NOAEC (e.g. 7/11=0.63).

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value				MRID or ECOTOX No./ Classification	Comments
			Endpoint	µg a.i./L	µg Feq/L ¹	µg Zeq/L ²		
Estuarine/Marine Fish (Surrogates for Vertebrates)								
Acute	TGAI (98.3%)	Sheepshead Minnow (<i>Cyprinodon variegatus</i>)	96-hr LC ₅₀	540	940	690	42514401 Acceptable	Highly toxic.
Chronic	TGAI (97.08% a.i., 8.4% radio-chemical purity)	Sheepshead Minnow (<i>C. variegatus</i>)	34-d NOAEC LOAEC (Length and dry wt.)	0.93 2.0	1.6 3.5	1.2 2.5	51049801 ^N Acceptable	Based on significant (p<0.05) 4.6% and 12% reductions in length and dry weight, both with dose-dependent patterns (7.2 and 16% respective reductions at the next higher treatment level). Radio-labeled study.
Freshwater Invertebrates (Water-Column Exposure)								
Acute	TGAI (98.0%)	Water Flea (<i>Daphnia magna</i>)	48-hr EC ₅₀	210	360	270	00164662 Acceptable	Highly toxic.
Chronic	TGAI (98.7%)	Water Flea	21-d NOAEC LOAEC (Dry weight)	20 40	35 69	25 51	47495001 Acceptable	Based on significant (p<0.05) 19% reduction in dry weight. <i>Daphnia</i> from the 40 and 81 µg a.i./L levels demonstrated treatment-related signs of toxicity, including lethargy, pale coloration, and/or small size. Mortality was 100% at the highest treatment level (81 µg a.i./L). The a.i. was radiolabeled and measured as TRR (total residues) in this study.
Estuarine/Marine Invertebrates (Water-Column Exposure)								
Acute	TGAI (98.3%)	Mysid Shrimp (<i>Americamysis bahia</i>)	96-hr LC ₅₀	3.36	5.82	4.27	42488302 Supplemental/ Quantitative	Very highly toxic. Test substance verification problems make the exposure concentration uncertain. Diluter water replacement was very high, however, and so the endpoint is usable for RQ calculations.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value				MRID or ECOTOX No./ Classification	Comments
			Endpoint	µg a.i./L	µg Feq/L ¹	µg Zeq/L ²		
Acute (Larval develop ment)	TGAI (98.3%)	Pacific Oyster (<i>Crassostrea gigas</i>)	48-hr EC ₅₀	4.7	8.1	6.0	42488301 Supplemental/ Qualitative	Very highly toxic. Analytical verification issues make the exposure questionable and useful only for risk characterization.
Chronic	No data available							
Freshwater Invertebrate (Sediment Exposure)								
Chronic	No data available							
Estuarine/ Marine Invertebrates (Sediment Exposure)								
Chronic	No data available							
Aquatic Plants and Algae								
Vascular	TGAI (98.7%)	Duckweed (<i>Lemna gibba</i>)	7-d IC ₅₀ NOAEC (Fron d no.)	1600 <57.4	2800 <99.4	2000 <73.0	45441202 Acceptable	NOAEC/ LOAEC of <57.4/ 57.4 based on significant (p<0.05) 9.5% reduction in frond number.
Non-vascular	TGAI (99.0%)	Green Algae (<i>Pseudo-kirchneriella subcapitata</i>)	120-hr IC ₅₀ IC ₀₅ (Biomass)	140 3	240 5	180 4	44086101, 44086001 Acceptable	Based on biomass reduction.
	TEP (71.0%)	Freshwater Diatom (<i>Navicula pelliculosa</i>)	96-hr IC ₅₀ NOAEC (Yield)	0.58 0.26	-- --	-- --	50792001 ^N Acceptable	NOAEC based on significant [p<0.05] 43% inhibition in yield at the LOAEC of 0.77 µg a.i./L. Most sensitive non-vascular endpoint but is from a TEP study and is included for characterization of thiram only.

Feq = Ferbam equivalents (see footnote¹ below); Zeq = Ziram equivalents (see footnote² below); TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient; hr = hour, d = day, wk = week; NOAEC and LOAEC = no- and lowest-observed adverse effects concentration; LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

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

¹ Feq calculated from thiram a.i. data using molecular wt. ratio (416.49/240.43).

² Zeq calculated from thiram a.i. data using molecular wt. ratio (305.8/240.43).

³ One of two replicates at 2.2 µg a.i./L did not achieve 90% hatch until day-7, while all controls hatched between days-4 and -5. However, the other replicate had 100% hatching by day-5 and so there is some uncertainty with this parameter.

Table C-1-2. Most sensitive toxicity endpoints for aquatic organisms exposed to ferbam

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in µg a.i./L (unless otherwise specified)	MRID or ECOTOX No./ Classification	Comments
Freshwater Fish (Surrogates for Vertebrates)					
Acute	TGAI (% unknown)	Carp (<i>Cyprinus carpio</i>)	48-hr LC ₅₀ = 90	05001997 Supplemental/ Quantitative	Very highly toxic. Study design was non-standard, but results may be used quantitatively to calculate risk.
Chronic	No data available				
Estuarine/Marine Fish (Surrogates for Vertebrates)					
Acute	TGAI (76%)	Longnose killifish (<i>Fundulus similis</i>)	96-hr LC ₅₀ = 800	40228401 Supplemental/ Quantitative	Highly toxic. From Meyer, 1986. ¹ Raw data not available for full acceptability but quantitatively usable.
Chronic	No data available				
Freshwater Invertebrates (Water-Column Exposure)					
Acute	No data available				
Chronic	No data available				
Estuarine/Marine Invertebrates (Water-Column Exposure)					
Acute (Shell Deposition)	TGAI (76%)	Eastern Oyster (<i>Crassostrea virginica</i>)	96-hr EC ₅₀ = 52	40228401 Supplemental/ Quantitative	Very highly toxic. From Meyer, 1986. ¹ Raw data not available for full acceptability but quantitatively usable.
Acute	TGAI (76%)	Pink Shrimp (<i>Penaeus duorarum</i>)	48-hr LC ₅₀ > 40,000	40228401 Supplemental/ Quantitative	Slightly toxic. From Meyer, 1986. ¹ Raw data not available for full acceptability but quantitatively usable.
Chronic	TGAI (97.6%)	Mysid Shrimp (<i>Americamysis bahia</i>)	28-d NOAEC = <1.2 LOAEC = 1.2 (F0 Body Length)	47784401 Supplemental/ Quantitative	Based on significant (p<0.05) 2.7% reduction in length. ²
Freshwater Invertebrate (Sediment Exposure)					
Chronic	No data available				
Estuarine/ Marine Invertebrates (Sediment Exposure)					
Chronic	No data available				
Aquatic Plants and Algae					
Vascular	No data available				
Non-vascular	No data available				

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient; hr = hour, d = day; NOAEC and LOAEC = no- and lowest-observed adverse effects concentration; LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

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

>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.

¹Meyer, F.L. 1986. Acute Toxicity Handbook of Chemicals to Estuarine Organisms. U.S. Environmental Protection Agency, Office of Research and Development, Gulf Breeze, FL, prepared for the Office of Pesticides and Toxic Substances. EPA/600/X-86/23, September, 1986.

²Based on significant ($p < 0.05$) 2.7% reduction in length followed by a dose-dependent pattern. According to Willian's test, the 2.7% reduction at the lowest concentration (1.2 $\mu\text{g a.i./L}$) was significant but it is unclear whether the reduction is biologically significant, especially since there was a 5% increase in dry weight at that treatment level. The potential effect at the lowest dose seems very low and even an almost 10-fold increase in dose (9.1 $\mu\text{g a.i./L}$) did not impact other parameters and still resulted in a $<10\%$ effect on length, while a doubling of the dose (2.3 $\mu\text{g a.i./L}$) still resulted in $<5\%$ effect on length. Therefore, confidence that the lowest dose is actually a biological effect is somewhat limited and risk may be characterized by considering that the LOAEC may actually be the 2nd lowest dose. A new study would not be anticipated to change the endpoint or provide meaningful information and so is not needed. Further, if a new study were conducted to find a NOAEC below this, the effect would need to be even lower than 2.7%, and any lower effect would certainly be within any measurement error and would not be feasible to determine. This line of consideration was not examined further because an acute-to-chronic ratio is available with thiram data and produces a slightly lower endpoint based on thiram toxicity for use in risk calculations. Rather this study helps to support that chronic toxicity is in this general concentration range.

Table C-1-3. Most sensitive toxicity endpoints for aquatic organisms exposed to ziram

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in µg a.i./L (unless otherwise specified)	MRID or ECOTOX No./ Classification	Comments
Freshwater Fish (Surrogates for Vertebrates)					
Acute	TGAI (98.2%)	Bluegill sunfish (<i>Lepomis macrochirus</i>)	96-hr LC ₅₀ = 570	47307901 Acceptable	Highly toxic. Flow-through radio-labeled study. Note: Although other endpoints were lower, either those studies were determined to not be quantitative or were from formulations.
Chronic (Early-life Stage)	TGAI (98.2%)	Fathead minnow	33-d NOAEC = 101 LOAEC = 195 (Post-hatch survival)	46893104 Acceptable	Based on significant (p<0.05) 22% reduction in juvenile (post-hatch) survival.
Chronic (Full Life Cycle)	TGAI (98.2%)	Fathead minnow	275-d NOAEC = 24 LOAEC = 51 (F ₀ length and weight)	47435501 Supplemental/ Quantitative	Based on significant (p<0.05) length and wet weight reductions of 10.8% and 39.0% in males at 39-weeks post-hatch. Although the dose: response curves were not linear, the weight of evidence shows a clear effect in that treatment range. Due to deviations in replication and length of time that the F1 generation were maintained, the study is not fully acceptable, but results may be used quantitatively to calculate risk.
Estuarine/Marine Fish (Surrogates for Vertebrates)					
Acute	TGAI (98.9%)	Sheepshead Minnow (<i>Cyprinodon variegatus</i>)	96-hr LC ₅₀ = 840	43781601 Acceptable	Highly toxic.
Chronic	TGAI (98.2%)	Sheepshead Minnow	34-d NOAEC = 27 LOAEC = 58 (Larval length and dry weight)	46856401 Acceptable	Based on significant (p<0.05) 4.5% and 13.0% respective reductions in larval length and dry weight.
Freshwater Invertebrates (Water-Column Exposure)					
Acute	TGAI (98.9%)	Water Flea (<i>Daphnia magna</i>)	48-hr EC ₅₀ = 48	42386305 Acceptable	Very highly toxic. Problems with ziram recovery in low treatments but had 11 treatments and did not use the low ones; around the LC ₅₀ were very good recoveries. Not Radio-labeled, but had enough treatment levels to only use the ones with good recoveries

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in µg a.i./L (unless otherwise specified)	MRID or ECOTOX No./ Classification	Comments
	TGAI (98.2%)	Water Flea	48-hr EC ₅₀ = 206	47405701 Acceptable	Flow-through, radio-labeled study. Used for characterization.
Chronic	TGAI (98.2%)	Water Flea	21-d NOAEC = 39 LOAEC = 78 (Length)	46823301 Acceptable	Based on significant (p<0.05) 6.4% reduction in length followed by a dose-dependent pattern.
Estuarine/Marine Invertebrates (Water-Column Exposure)					
Acute	TGAI (98.0%)	Mysid Shrimp (<i>Americamysis bahia</i>)	96-hr LC ₅₀ = 14	43781603 Acceptable	Very highly toxic. This is a radio-labeled study and even though was lower than the NOAEC in 46893103, The difference in toxicity may have to do with diluter turn-over (replacement) rates (see discussion in toxicity description below).
	TGAI (98.0%)	Mysid Shrimp	96-hr LC ₅₀ = 140	47405702 Acceptable	Flow-through, radio-labeled study. Included for characterization.
Acute (Shell Deposition)	TGAI (98.0%)	Eastern Oyster (<i>Crassostrea virginica</i>)	96-hr EC ₅₀ = 77	43781602 Acceptable	Very highly toxic. Used for characterization of mollusks. Not radio-labeled study.
Chronic	TGAI (98.2%)	Mysid Shrimp	27-d NOAEC = 16 LOAEC = 27 (Reproduction and dry weight)	46893103 Supplemental/ Quantitative	Based on significant (p<0.05) 38.0% and 11.1% respective reductions in young/ reproductive day and dry weight. Due to analytical variability over 20% the study is not fully acceptable; however, the radio-labeled verification is sufficient and the study is quantitatively usable.
Freshwater Invertebrate (Sediment Exposure)					
Chronic	No data available				
Estuarine/ Marine Invertebrates (Sediment Exposure)					
Chronic	No data available				
Aquatic Plants and Algae					
Vascular	TGAI (98.2%)	Duckweed (<i>Lemna gibba</i>)	7-d EC ₅₀ = 370 NOAEC = 35 (Biomass)	46823302 Acceptable	NOAEC/ LOAEC of 35/ 77 µg a.i./L based on significant (p<0.05) 19.7 inhibition of biomass, with a dose-dependent pattern.
Non-vascular	TGAI (98.0%)	Green Algae (<i>Pseudokirchneriella subcapitata</i>)	120-hr EC ₅₀ = 67 NOAEC <38 (Biomass)	43833901 Acceptable	NOAEC based on significant (p<0.05) 18% inhibition of biomass at the lowest concentration.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in µg a.i./L (unless otherwise specified)	MRID or ECOTOX No./ Classification	Comments
	TEP (71.9%)	Freshwater Cyanobacterium (<i>Anabaena flos-aquae</i>)	96-hr IC ₅₀ = 2.4 (1.4-4.0) NOAEC = 0.60 (Yield)	50814403 ^N Acceptable	NOAEC based on significant [p<0.05] 47% inhibition in yield at the LOAEC of 1,9 µg a.i./L. Most sensitive non-vascular endpoint but is from a TEP study and is included for characterization.

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient; hr = hour, d = day; NOAEC and LOAEC = no- and lowest-observed adverse effects concentration; LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

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

>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.

Table C-1-4. Most sensitive toxicity endpoints for terrestrial organisms exposed to thiram

Study Type	Test Sub- stance (% a.i.)	Test Species	Toxicity Value ¹				MRID or ECOTOX No./ Classification	Comments
			Endpoint (units) (chronic effect)	As thiram a.i.	Converted to ferbam equivalents (feq) ²	Converted to ziram equivalents (zeq) ³		
Birds (Surrogates for Terrestrial Amphibians and Reptiles)								
Acute Oral	TGAI (99.0%)	Ring-neck Pheasant (<i>Phasianus colchicus</i>)	14-d (single dose) LD ₅₀ (mg/kg-bw)	673	1170	856	00160000 Supplemental / Quantitative	Slightly toxic. Supplemental due to non-standard species and lack of information but quantitatively usable.
	TGAI (% unknown)	Passerine: Red-wing Blackbird (<i>Agelaius phoeniceus</i>)	(Single dose) LD ₅₀ (mg/kg- bw) ²	>100	>173	>127	00073683, 00020560 Supplemental / Quantitative	Included for characterization. ² Supplemental due to non-standard species and lack of information but quantitatively usable.
Sub-acute dietary	TGAI (95.0%)	Bobwhite quail (<i>Colinus virginianus</i>)	LC ₅₀ (mg/kg- diet) ²	3950	6840	5020	00022293 Acceptable	Slightly toxic.
	TGAI (97.08%)	Canary (<i>Serinus canaria</i>)	8-d LC ₅₀ (mg/kg- diet) ²	>4240	>7350	>5390	50835201 Acceptable	Included for characterization. ²
Chronic	TGAI (98.7%)	Mallard duck (<i>Anas platy- rhynchos</i>)	23-wk NOAEC LOAEC (mg/kg- diet) (Reproducti on and survival)	9.6 39.7	17 68.8	12 50.5	45441201 Acceptable	Based on significant (p<0.05) reductions in eggs set (35%), viable embryos (46%), live 3- week embryos (46%), normal hatchlings (56%), 14-d survivors (56%), eggs set/eggs laid (11%), normal hatchlings/live 3- week embryos (22%), normal hatchlings/eggs laid (26%).
Mammals								
Acute Oral	TGAI (99.0%)	Laboratory rat (<i>Rattus norvegicus</i>)	LD ₅₀ (mg/kg-bw)	1800	3100	2300	00153548 Acceptable	Slightly toxic.

Study Type	Test Sub-stance (% a.i.)	Test Species	Toxicity Value ¹				MRID or ECOTOX No./ Classification	Comments
			Endpoint (units) (chronic effect)	As thiram a.i.	Converted to ferbam equivalents (feq) ²	Converted to ziram equivalents (zeq) ³		
Acute Inhalation	TGAI (% unknown)	Laboratory rat (<i>R. norvegicus</i>)	LC ₅₀ (mg/L)	>2.60, < 5.04	>4.50, <8.73	>3.31, <6.41	40216501 Acceptable	
Chronic (2-generation repro-duction)	TGAI (100%)	Laboratory rat (<i>R. norvegicus</i>)	NOAEL LOAEL (mg/kg-bw/day) (F0 and F1 weight)	2 5	3 9	3 6	42095901 Acceptable	Based on decreased body weight of the F1 and F2 generations (NOAEL/ LOAEL:20 and 60 mg a.i./kg-diet).
Terrestrial Invertebrates								
Acute contact (adult)	TGAI (% unknown)	Honey bee (<i>Apis mellifera</i> L.)	48-hr LD ₅₀ (µg/bee)	73.7	128	93.8	00036935 Acceptable	Practically nontoxic.
Acute oral (adult)	TGAI (98.8%).	Honey bee (<i>A. mellifera</i>)	48-hr LD ₅₀ (µg/bee)	>106	>184	>135	50273401 ^N Acceptable	Practically nontoxic
Chronic oral (adult)	TGAI (98.8%).	Honey bee (<i>A. mellifera</i>)	10-d NOAEL LOAEL (µg/bee/day) (No effect)	≥4.32 >4.32	≥7.48 >7.48	≥5.49 >5.49	50273402 ^N Supplemental / Quantitative	Based on no significant effects to mortality. The results are nominal, but dose was adjusted for food consumption and purity. The results are quantitatively usable.
Acute oral (larval)	TGAI (98.08%).	Honey bee (<i>A. mellifera</i>)	7-d (single dose) LD ₅₀ (µg/larvae)	0.28	0.49	0.36	50940001 ^N Acceptable	Highly toxic.
Chronic oral (larval)	TGAI (98.2%)	Honey bee (<i>A. mellifera</i>)	22-d NOAEL LOAEL (µg/larvae/day) (Emergence)	0.0254 0.0757	0.0440 0.131	0.0323 0.0963	50669901 ^N Acceptable	Based on significant (p<0.05) 20% reduction in emergence. NOAEC/ LOAEC = 0.661/1.97 mg a.i./kg-diet

Study Type	Test Sub- stance (% a.i.)	Test Species	Toxicity Value ¹				MRID or ECOTOX No./ Classification	Comments
			Endpoint (units) (chronic effect)	As thiram a.i.	Converted to ferbam equivalents (feq) ²	Converted to ziram equivalents (zeq) ³		
Semi-field study	TEP (79.6%)	Honey bee (<i>A. mellifera</i>)	22-d (1-d exposure) NOAEC (µg/L) NOAEL (mg/kg- diet) (Egg termin- ation rate)	<3,180,000 <3180	<5,510,000 <5510	<4,040,000 <4050	50273403 ^N Supplemental / Quantitative	Based on significant (p<0.05) 51.8% increase in termination rate of eggs. No effects were found in mortality, larval development, or behavior at exposure, also 3180 mg a.i./kg- diet. A short-term small-scale feeding study and information provided was insufficient for a fully acceptable study, but results are quantitatively usable.
Semi-field study	TEP (79.6%)	Honey bee (<i>A. mellifera</i>)	26-d (7-d exposure) NOAEL (lb/acre) (No effects)	≥2.5	≥4.3	≥3.2	50273404 ^N and 50273405 ^N Supplemental / Quantitative	Based on no effects to survival, development, or brood parameters. Information provided was insufficient for a fully acceptable study, but results are quantitatively usable.
Terrestrial and Wetland Plants								

Study Type	Test Sub-stance (% a.i.)	Test Species	Toxicity Value ¹				MRID or ECOTOX No./ Classification	Comments
			Endpoint (units) (chronic effect)	As thiram a.i.	Converted to ferbam equivalents (feq) ²	Converted to ziram equivalents (zeq) ³		
Seedling Emergence	TEP (71.0%)	Various species (Monocots tested: corn, oat, onion, ryegrass; Dicots tested: bean, cabbage, cucumber, soybean, sugarbeet, tomato)	21-d Monocots (All Spp., Tier I): IC ₂₅ NOAEL/ LOAEL (lb/acre) (No effects)	>4.6 4.6/ >4.6	>8.0 8.0/ >8.0	>5.9 5.9/ >5.9	50835301 ^N Acceptable	Sugarbeet had significant (p<0.05) 32% reduction in survival and emergence in the Tier I part of the study, but then in Tier II had no significant effects. All other species had no effects up to 4.6 and 4.1 lb a.i./acre, respectively for monocots and dicots, measured amount.
			Dicots (Sugarbeet, Tier II): IC ₂₅ NOAEL/ LOAEL (lb/acre) (Emergence)	>4.1 4.1 / >4.1	>7.1 7.1 / >7.1	>5.2 5.2 / >5.2		
Vegetative Vigor	TEP (71.0%)	Various species (Monocots tested: corn, oat, onion, ryegrass; Dicots tested: bean, cabbage, cucumber, soybean, sugarbeet, tomato)	21-d Monocots (All Spp., Tier I): IC ₂₅ NOAEL/ LOAEL (lb/acre) (No effects)	>4.6 4.6/ >4.6	>8.0 8.0/ >8.0	>5.9 5.9/ >5.9	50830201 ^N Acceptable	Cabbage had significant (p<0.05) 16% reduction in dry weight. in the Tier I part of the study, but then in Tier II had no significant effects. All other species had no effects up to 4.6 and 4.1 lb a.i./acre, respectively for monocots and dicots, measured amount.
			Dicots (Cabbage, Tier II): IC ₂₅ NOAEL/ LOAEL (lb/acre) (Dry wt.)	>4.1 4.1 / >4.1	>7.1 7.1 / >7.1	>5.2 5.2 / >5.2		

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient; hr = hour, d = day, wk = week; NOAEC(L) and LOAEC(L) = no- and lowest-observed adverse effects concentration (or level); LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

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

>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.

¹ NOAEC(L) and LOAEC(L) are reported in the same units.

² An acceptable dietary acute study with a passerine is also available, 50835201^N, but is less sensitive than the quail study. It has an LC₅₀ of >4240 mg a.i./kg-diet and an EC₅₀ for food consumption of >>4240 mg a.i./kg-diet. Therefore, the uncertainty of the lower acute oral blackbird endpoint is greatly lessened but kept in the table for characterization.

Table C-1-5. Most sensitive toxicity endpoints for terrestrial organisms exposed to ferbam

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹	MRID or ECOTOX No./ Classification	Comments
Birds (Surrogates for Terrestrial Amphibians and Reptiles)					
Acute Oral	No Data				
Sub-acute dietary	TGAI (% unknown)	Bobwhite quail (<i>Colinus virginianus</i>)	8-d LC ₅₀ = 2940 mg a.i./kg-diet	00106146 Supplemental	Slightly toxic.
Chronic	No Data				
Mammals					
Acute Oral	TGAI (91.8%)	Laboratory rat (<i>Rattus norvegicus</i>)	LD ₅₀ >5,000 mg a.i./kg-bw	40561501 Acceptable	Practically nontoxic.
Acute Inhalation	TGAI (91.8%)	Laboratory rat (<i>R. norvegicus</i>)	LC ₅₀ = 0.40 mg a.i./L	41508101 Acceptable	Toxicity Category II – Moderately toxic
Chronic (2-generation reproduction)	No data available				
Terrestrial Invertebrates					
Acute contact (adult)	TEP (Fermate Formulation)	Honey bee (<i>Apis mellifera</i> L.)	48-hr LD ₅₀ >12.09 µg a.i./bee	00036935 Acceptable	Practically nontoxic.
Acute oral (adult)	No data available				
Chronic oral (adult)	No data available				
Acute oral (larval)	No data available				
Chronic oral (larval)	No data available				
Foliage Residue	No data available				
Semi-field study or full field study)	No data available				
Terrestrial and Wetland Plants					
Seedling Emergence	No data available				
Vegetative Vigor	No data available				

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient; hr = hour, d = day; LCxx/ LDxx = lethal concentration/dose affecting XX percent of test group.

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

¹ NOAEC(L) and LOAEC(L) are reported in the same units.

>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.

Table C-1-6. Most sensitive toxicity endpoints for terrestrial organisms exposed to ziram

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹	MRID or ECOTOX No./ Classification	Comments
Birds (Surrogates for Terrestrial Amphibians and Reptiles)					
Acute Oral	TGAI (98.5%)	Bobwhite quail (<i>Colinus virginianus</i>)	14-d (single dose) LD ₅₀ = 97 mg a.i./kg-bw	41725701 Acceptable	Moderately toxic.
	TGAI (93.6%)	Zebra Finch (<i>Taeniopygia guttata</i>)	8-d LD ₅₀ : 61 (56 to 67) mg a.i./kg bw/day	50939501 ^N Supplemental (Quantitative)	Moderately toxic. Added for characterization. This dose-based endpoint was calculated as mg a.i./kg-bw/day and is a conservative screening estimate of the dose-based LD ₅₀ due to multiple days of dosing which were conservatively attributed to a single (daily) dose. ²
Sub-acute dietary	TGAI (93.6%)	Zebra Finch (<i>T. guttata</i>)	8-d LC ₅₀ = 594 (417 to 797) mg a.i./kg-diet	50939501 ^N Supplemental (Quantitative)	Moderately toxic. As described above, food avoidance occurred and so some mortality could have been due to starvation. The dietary endpoint is quantitatively usable. ³
Chronic	TGAI (98.8%)	Mallard duck (<i>Anas platyrhynchos</i>)	20-wk NOAEC = 29 mg a.i./kg-diet LOAEC = 64 mg a.i./kg-diet (Reproduction, embryo viability, hatchability, and survival)	47286501 Acceptable	Based on significant (p<0.05) reductions in eggs set (37%); eggs set/eggs laid (30%); embryo viability: live 3-week embryos/ viable embryos (6.2%); hatchability: number of hatchlings (56%), hatchlings/ eggs laid (32%) hatchlings/ eggs set (25%), and hatchlings/ live 3-week embryos (30%); and survival: 14-day survivors (57%) and 14-day survivors/ eggs set (25%).
Mammals					
Acute Oral	TGAI (98.5%)	Laboratory rat (<i>Rattus norvegicus</i>)	LD ₅₀ = 267 mg a.i./kg-bw	41340401 Acceptable	Moderately toxic. LD ₅₀ for females; for combined sexes the LD ₅₀ is 320 mg a.i./kg-bw.
Acute Inhalation	TGAI (98.5%)	Laboratory rat (<i>R. norvegicus</i>)	LC ₅₀ = 0.06 mg a.i./L	41442001 Acceptable	Toxicity Category II

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹	MRID or ECOTOX No./ Classification	Comments
Chronic (2-generation reproduction)	TGAI (97.8%)	Laboratory rat (<i>R. norvegicus</i>)	NOAEL=14.8 mg a.i./kg-bw/day LOAEL=37.5 mg a.i./kg-bw/day (Growth and food consumption)	43935801 Acceptable	Significant reductions in F0 & F1 body weight, body weight gain, and food consumption.
Terrestrial Invertebrates					
Acute contact (adult)	TGAI (98.5%)	Honey bee (<i>Apis mellifera</i> L.)	48-hr LD ₅₀ > 200 µg a.i./bee ⁴	41667901 Acceptable	Practically nontoxic.
Acute oral (adult)	TGAI (98.7%)	Honey bee (<i>A. mellifera</i>)	48-hr LD ₅₀ >105 µg a.i./bee	50294101 Acceptable	Practically nontoxic.
Chronic oral (adult)	TEP (76.5%)	Honey bee (<i>A. mellifera</i>)	10-d NOAEL = 4.9 LOAEL = 8.5 µg a.i./bee/day (Mortality)	50294102 ^N Supplemental/ Quantitative	Based on significant (p<0.05) 16.7% mortality. The results are nominal, but dose was adjusted for food consumption and purity. The results are quantitatively usable.
Acute oral (larval)	No data available ⁵				
Chronic oral (larval)	No data available ⁵				
Foliage Residue	No data available				
Semi-field study	TEP (76.7%)	Honey bee (<i>A. mellifera</i>)	22-d (1-d exposure) NOAEC <2,300,000 µg a.i./L -diet (sugar soln.) (Egg termination rate)	50294103 ^N Supplemental/ Quantitative	Based on significantly (p<0.05) higher (22.6%) mean termination rates of eggs. No effects at treatments up to 3,450,000 µg a.i./L -diet (equivalent to 3,450 mg a.i./kg-diet if assume the sugar solution is the weight of water) found in mortality of adults, pupae or larvae. Information provided was insufficient (e.g., analytical verification and bee health details) for a fully acceptable study, but results are quantitatively usable.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value ¹	MRID or ECOTOX No./ Classification	Comments
Semi-field study	TEP (76.5%) and TGAi (98.2%)	Honey bee (<i>A. mellifera</i>)	26-d (7-d exposure) NOAEL = 2.03 lb a.i./acre (No effects)	50294104 ^N and 50294105 ^N Supplemental/ Quantitative	Based on no effects to survival, development, or brood parameters. Information provided was insufficient (e.g., analytical verification and bee health details for a fully acceptable study, but results are quantitatively usable.
Terrestrial and Wetland Plants					
Seedling Emergence	TEP (76.6%)	Various species	21-d Monocots (Most Sensitive Species not identified): IC ₂₅ >6.0 lb a.i./acre; NOAEL ≥6.0 lb a.i./acre (No effects) Dicots (Soybean): IC ₂₅ >6.0 lb a.i./acre; NOAEL <6.0 lb a.i./acre (Height)	46893101 Acceptable	Soybean had 16% reduction in height at the Tier I treatment level of 6.0 lbs a.i./acre which was determined by the reviewer to be biologically significant. All other species had no effects at 6.0 lb a.i./acre. Because no effects were greater than 25%, no Tier II study was conducted.
Vegetative Vigor	TEP (76.6%)	Various species	21-d Monocots (Ryegrass): IC ₂₅ >6.1 lb a.i./acre; NOAEL <6.1 lb a.i./acre (Dry weight) Dicots (Tomato): IC ₂₅ >6.1 lb a.i./acre; NOAEL <6.1 lb a.i./acre (Dry weight)	46893102 Acceptable	Ryegrass had 13% reduction in dry weight at the Tier I treatment level of 6.1 lbs a.i./acre which was determined by the reviewer to be biologically significant. Tomato had significant (p<0.05) 12% reduction in dry weight. All other species had no effects at 6.1 lb a.i./acre. Because no effects were greater than 25%, no Tier II study was required. ⁶

TGAi=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient; hr = hour, d = day, wk = week; NOAEC(L) and LOAEC(L) = no- and lowest-observed adverse effects concentration (or level); LCxx, ECxx, ICxx = lethal, effects, and inhibition concentrations affecting XX percent of test group.

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

>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.

¹ NOAEC(L) and LOAEC(L) are reported in the same units.

² The rangefinding study for this was initially designed as a dose-based study (OCSPP 850.2100). However, due to regurgitation, a dietary-based study (OCSPP 850.2200) was undertaken. This is consistent with EFED recommendations for passerines. In the definitive dietary study food avoidance was evident and because of this avoidance, calculating a dose from the consumed food did not follow the increasing gradient of exposure of the dietary concentrations. Therefore, the actual endpoint has uncertainties but can be used quantitatively as a dietary-based and a dose-based endpoint to calculate and characterize risk.

Due to multiple uncertainties, the study is classified as Supplemental. The dose-based endpoint is calculated as mg a.i./kg-bw/day and is a conservative screening estimate of the dose-based LD50 due to multiple days of dosing which were conservatively attributed to a single (daily) dose.

³Finches in the study also had significant reductions in body weight for the 649 and 1233 mg a.i./kg diet treatment groups. During the exposure period, the study author found significant reductions in food consumption for all treatment groups. During the post-exposure period, a significant increase in food consumption was noted in the 317 mg a.i./kg diet treatment group. Finches also exhibited clinical signs of toxicity including piloerection, wing drop, hyperactivity, asthenia, and lethargy were observed. Gross necropsies found birds were emaciated and had black material in the gastrointestinal tract. Several birds had feathers on the abdomen and surrounding vent that were coated in dark red-brown feces while other birds had black material in the lungs. Gross necropsies of several surviving birds revealed no remarkable findings.

⁴An acute contact study (MRID 00036935) had a lower endpoint (LD₅₀ of 46.7 µg a.i./bee) but was with a formulation (zerlate) without a specified purity. This endpoint is also used for characterization.

⁵Due to problems with ziram stability in royal jelly.

⁶One except was that radish had a Tier II study conducted due to two plants dying in Tier I. No effects were seen in the Tier II test up to 6.1 lbs a.i./A.

C-2. Comprehensive List of Toxicity Studies with Aquatic Organisms

Comprehensive lists of available toxicity data for fish, aquatic invertebrates and aquatic plants are found in **Tables C-1** through **C-9**. Summaries of data from most of the studies are found in the problem formulations (USEPA, 2015a and USEPA, 2015b) and for thiram and ziram, in **Appendices C** and **D** of the California red-legged frog assessment (USEPA, 2008); the new data reviewed since the problem formulation are denoted in the following tables by an “N” superscript in the MRID column and summarized here. Please note that aquatic studies presented in this appendix are generally in units of mg a.i./L (unless otherwise noted) for ease of presentation, whereas in the body of this assessment the units are typically in µg a.i./L (or µg equivalents/L when the thiram degradate is converted to units of parent ferbam or ziram) because this is the preferred unit used to compare toxicities among chemicals in EFED’s database.

New Studies Since Problem Formulations

For aquatic organisms, one new vertebrate study and six new aquatic plant studies were submitted since the problem formulations were written. The vertebrate study was an estuarine/marine fish early life-stage chronic study with the sheepshead minnow (*Cyprinodon variegatus*, MRID 51079801). The study was classified as acceptable and had NOAEC/ LOAEC of 0.00093/ 0.00200 mg a.i./L based on significant ($p < 0.05$) 4.6 and 12% respective reductions in length and weight, followed by dose-dependent patterns with 7.2 and 16% reductions at next higher treatment. Post-hatch survival was also affected at a higher concentration, with NOAEC/LOAEC = 0.00200/ 0.00093 mg a.i./L based on 30% biologically significant and treatment-related reduction (significant according to study author using Williams test). This was a 34-day (28-day post-hatch) radiolabeled study using HPLC (high-performance liquid chromatography).

Of the newly submitted aquatic plant studies, three were with thiram and three were with ziram, using the same three non-vascular plant species for each chemical. They were all with formulations; the thiram studies used Thiram Granuflo (71.0% a.i.) and the ziram studies used Ziram 76 DF (71.9% a.i.) or Ziram 76 WG (76.7% a.i.). Thiram was one to two orders-of-magnitude more toxic than ziram to the two diatom species tested, the freshwater diatom (*Navicula pelliculosa*) and the marine diatom (*Skeletonema costatum*), with respective IC_{50} s of 0.00058 and 0.00074 mg a.i./L for thiram and 0.111 and 0.0031 for ziram. For the cyanobacteria (*Anabaena flosaquae*), however, ziram was more toxic than thiram with IC_{50} s of 0.0024 mg a.i./L for ziram and 0.015 mg a.i./L for thiram.

Overview of Aquatic Toxicity Data

Fish

The available data indicate that thiram (**Table C-1-1**), ferbam (**Table C-1-2**), and ziram (**Table C-1-3**) TGAs are very highly toxic to freshwater fish and highly toxic to estuarine/marine fish on an acute exposure basis to the most sensitive species for which information is available. Looking at the full range of available data (4-5 species for each chemical) presented **Tables C-2-1** to **C-2-4** (**Tables C-2-1** and **C-2-3** contain the acute data), ferbam and ziram are moderately toxic to very highly toxic to fish, and thiram is highly toxic to very highly toxic. No clear difference was observed between cold-water and warm-water species. For freshwater fish, eight acute fish studies (with three spp.) were available with thiram, three studies (with three spp.) with ferbam, and seven (with four spp.) with ziram.

For thiram, the most sensitive species was the Harlequin fish (*Rasbora heteromorpha*) with an LC₅₀ of 7 µg thiram a.i./L from a formulation study. The most sensitive fish from a study with technical a.i. was the bluegill (*Lepomis macrochirus*), a warm-water fish. Multiple studies with bluegill had LC₅₀s ranging from 42 to 280 µg thiram a.i./L. The rainbow trout (*Oncorhynchus mykiss*), a cold-water fish, was slightly less sensitive, though close, with LC₅₀s ranging from 46 to 382 µg thiram a.i./L.

For ferbam, the 96-hr LC₅₀ values for three species of freshwater fish (bluegill, fathead minnow, *Pimephales promelas*, and carp, *Cyprinus carpio*) ranged from 90 (for the carp) to 3600 µg feq/L (for the bluegill). For thiram and ferbam, the LC₅₀ values had a range of two orders-of-magnitude.

For ziram, however, the data appeared to have greater variability, especially within the two bluegill studies, with LC₅₀s ranging from 9.7 to 570 µg zeq/L, almost two orders-of-magnitude for the same species. However, the lowest endpoint (LC₅₀ of 9.7 µg ziram a.i./L, MRID 42386303) was re-reviewed and determined to not be quantitatively usable due to issues with stability and test substance verification, making the exposure uncertain, and also controls were contaminated with test substance (D459398, amended 09/21/2020). Within the three rainbow trout studies, the LC₅₀s ranged from 230 to 1700 µg zeq/L. The high degree of within-species variability in the ziram freshwater fish acute dataset is further discussed below, along with information from the invertebrate studies.

Estuarine/marine fish were generally less sensitive to the three chemicals on an acute basis than freshwater fish, although the dataset was smaller with one study each for thiram and ferbam and two for ziram. See **Tables C-2-1** and **C-2-3** in **Appendix C** for more detail.

Chronic and sub-chronic fish toxicity data were available for thiram and ziram, but not ferbam. No Observable Adverse Effects Concentrations (NOAECs) were generally one to two orders-of-magnitude more sensitive than the acute LC₅₀s (with some exceptions in the ziram dataset explained later). For freshwater fish exposed to thiram in a fish life-cycle study, the fathead minnow (MRID 47824101) had significant ($p < 0.05$) reductions in spawning frequency (69.5%), egg production (76.0%), and 4-week survival (24%) at the LOAEC (2.2 µg thiram a.i./L, NOAEC was 1.1 µg thiram a.i./L) from 210-day exposure; also time to hatch was delayed by up to 2 days.

Fathead minnows exposed to ziram also had significant ($p < 0.05$) length and wet weight reductions of 10.8% and 39.0% in males at 39-weeks post-hatch from exposure to 51 µg zeq/L (NOAEC was 24 µg zeq/L) from a life-cycle study (275-days) and significant ($p < 0.05$) 22% reduction in juvenile (post-hatch) survival from exposure to 195 µg zeq/L (NOAEC was 101 µg zeq/L for this endpoint) from an early life-stage study (33-days). The rainbow trout study (MRID 42649303) was a non-guideline 28-day sub-chronic study in which four applications of thiram were made at 7-day intervals. In that study, growth rate was impaired by exposure to 20 µg thiram a.i./L (NOAEC was 12 µg thiram a.i./L).

For estuarine/marine fish, the sheepshead minnow (*Cyprinodon variegatus*; MRID 51049801) exposed to thiram had significant ($p < 0.05$) 4.6% and 12% reductions, relative to controls, in length and dry weight from exposure to 2.0 µg thiram a.i./L (NOAEC was 0.93 µg thiram a.i./L) from a 28-day early life-stage study. This was similar to the endpoint from the freshwater fathead minnow chronic (MRID 47824101; NOAEC/LOAEC of 1.1/2.2 µg thiram a.i./L) with thiram.

For ziram, the sheepshead minnow also showed toxicity effects in a similar concentration range to those from the fathead minnow, with significant ($p < 0.05$) 4.5% and 13.0% respective reductions in length and dry weight at the LOAEC of 58 µg zeq/L (NOAEC of 27 µg zeq/L; MRID 46856401).

For thiram, freshwater fish acute-to-chronic ratios (ACRs) of 11 (128/12 µg thiram a.i./L; MRID/Identifiers TN 1001 and 46249303) to 32 (382/12 µg thiram a.i./L; MRIDs 00090293 and 46249303) are available using rainbow trout data. Also, an estuarine/marine species ACR of 580 (540/0.93 µg thiram a.i./L; MRIDs 42514401 and 51049801) is available using sheepshead minnow data. With the rainbow trout, other acute endpoints were available for use in an ACR, but the one chosen for use was based on defensibility and sensitivity.

For ziram, however, no ACR could be calculated even though acute and chronic data were available for the fathead minnow because the acute value available (LC₅₀ of 8 µg zeq/L; an open literature supplemental/qualitative endpoint, MRID 05003523) was actually lower than the chronic endpoints (NOAEC range of 24 to 101 µg zeq/L, MRIDs 46893104 and 47435501). Therefore, usable fish ACRs of 11 and 32 are available for thiram using freshwater fish data, and possibly an ACR of 580 using sheepshead data, although that may be an outlier, but will be used for characterization.

The wide range of intra-species ziram LC₅₀s, which made the fathead minnow ACR impossible to calculate, was investigated. One example is the mysid data which show a full order-of-magnitude difference in LC₅₀s (MRIDs 43781603 and 47405702). Though not all of the studies were re-reviewed in depth, it may be noteworthy that the lower numbers were in general from older studies that did not have radio-labeled test substance and tended to have stability and analytical difficulties, especially at lower concentrations. All chronic fish studies were radio-labeled. Because ziram hydrolyses rapidly (see **Section 5**) into thiram, and thiram has similar toxicity, it is not clear whether all components of the total reactive residues are equally toxic and bioavailable components of the exposure. One theory is that thiram may be more toxic than ziram to aquatic invertebrates and fish and differences in diluter turn-over (water replacement) may be a factor in determining toxicity with ziram breaking down more to thiram in slower diluters. The differential toxicity is not clear even from toxicity studies that begin with one or the other because of ziram's break-down to thiram during the toxicity studies. For example, the two mysid acute studies with ziram noted above had LC₅₀s that varied by a factor of ten and the study with the lowest value (14 µg zeq/L, MRID 43781603) had only 6 daily turn-overs (more time to convert to thiram), while the one showing less toxicity (140 µg zeq/L, MRID 47405702) had ten daily turn-overs, and therefore should have had a higher ziram/thiram ratio.

Aquatic Invertebrates

The available data indicate that thiram (**Table C-1-1**), ferbam (**Table C-1-2**), and ziram (**Table C-1-3**) TGAs are highly toxic to very highly toxic to freshwater and estuarine/marine invertebrates on an acute exposure basis to the most sensitive species for which information is available. The only exception for which data are available is the pink shrimp (*Penaeus duorarum*; slight to moderate toxicity). Looking at the full range of available acute data (2-3 species for each chemical) presented in **Tables C-2-5 to C-2-8** (**Tables C-2-5 and C-2-7** contain the acute data), thiram is very highly toxic to both freshwater and estuarine/marine invertebrates, ferbam is slightly toxic to very highly toxic to estuarine/marine invertebrates (no freshwater data for ferbam), and ziram is highly toxic to very highly toxic to both freshwater and estuarine/marine invertebrates, with the exception of the pink shrimp (moderately toxic).

Chronic aquatic invertebrate toxicity data were available for all three chemicals, with ziram having both freshwater and estuarine/marine endpoints available. Chronic endpoints (NOAECs) were approximately one order-of-magnitude (ten-fold) more sensitive than the acute LC₅₀s with the exceptions of the pink shrimp which was less sensitive than other tested species and two cases discussed below where the

method of test substance measurement (whether radio-labeled or not) resulted in a range of endpoints for the water flea (*Daphnia magna*) and the mysid shrimp (*Americamysis bahia*).

For thiram, the freshwater water flea (MRID 47495001) had significant ($p < 0.05$) 19% reduction in dry weight at the LOAEC (40 $\mu\text{g a.i./L}$). *Daphnia* from the 40 and 81 $\mu\text{g a.i./L}$ levels demonstrated treatment-related signs of toxicity, including lethargy, pale coloration, and/or small size. Mortality was 100% at the next higher treatment level (81 $\mu\text{g a.i./L}$). No estuarine/marine invertebrate chronic data were available with thiram.

For ferbam, only estuarine/marine data were available for chronic exposures; the mysid shrimp had significant ($p < 0.05$) 2.7% reduction in F0 body length followed by a dose-dependent pattern (MRID 47784401). The 2.7% reduction at the lowest concentration (1.2 $\mu\text{g feq/L}$) was statistically significant but it is unclear whether the reduction is biologically significant, especially since there was a 5% increase in dry weight at that treatment level. The potential effect at the lowest dose seems very low and even an almost 10-fold increase in dose (9.1 $\mu\text{g feq/L}$) did not impact other parameters and still resulted in a $< 10\%$ effect on length, while a doubling of the dose (2.3 $\mu\text{g feq/L}$) still resulted in $< 5\%$ effect on length (3.9% reduction). Therefore, confidence that the lowest dose is a biologically significant effect is somewhat limited and risk may be characterized by considering that the LOAEC may actually be the 2nd lowest dose. A new study would not be anticipated to provide meaningful information since the % effect is already so low, and so is not needed. This line of consideration was not examined further because an acute-to-chronic ratio is available with thiram data and produces a slightly lower endpoint based on thiram toxicity for use in risk calculations. Rather this study helps to support that chronic toxicity is in this general concentration range suggested by the ACR-generated chronic value.

For ziram, the water flea had significant ($p < 0.05$) 6.4% reduction in length at 78 $\mu\text{g zeq/L}$ (radio-labeled measured amount) followed by a dose-dependent pattern with 7.0% reduction at the next higher concentration of 154 $\mu\text{g zeq/L}$ (NOAEC of 39 $\mu\text{g zeq/L}$, MRID 46823301). For estuarine/marine invertebrates, the mysid shrimp had significant ($p < 0.05$) 38.0% and 11.1% respective reductions in young/reproductive day and dry weight at 27 $\mu\text{g zeq/L}$ (NOAEC of 16 $\mu\text{g zeq/L}$, MRID 46893103), followed by dose-dependent patterns with respective reductions of 83.3% and 30.2% at the next higher concentration (65 $\mu\text{g a.i./L}$) at 27 $\mu\text{g zeq/L}$ (NOAEC of 16 $\mu\text{g zeq/L}$).

For thiram, a freshwater invertebrate ACR of 11 (210/20 $\mu\text{g thiram a.i./L}$, MRIDs 00164662 and 47495001) is available with the water flea. Applying this to the ziram mysid acute data (which is used here as a surrogate for thiram toxicity due to stability/analytical difficulties with the thiram acute mysid study, MRID 42488302) yields a chronic toxicity estimate of NOAEC = 1.0 $\mu\text{g thiram a.i./L}$ (11, 11 = 1.0; acute endpoint from MRID 43781603). This calculated endpoint is close to the non-definitive ferbam mysid chronic endpoint ($< 0.69 \mu\text{g thiram equivalents/L}$ when adjusted for molecular weights by multiplying by 240.43/416.49).

For ziram, an ACR of 5.3 (206/39 $\mu\text{g zeq/L}$, MRIDs 47405701 and 46823301) is available with the water flea in which both studies had radio-labeled exposure estimates. Another acute study with the water flea is available without radio-labeled exposure estimates in which the LC_{50} (48 $\mu\text{g zeq/L}$, MRID 42386305) is very close to the chronic endpoint (39 $\mu\text{g zeq/L}$) and not deemed appropriate for use in an ACR. Similarly, for the estuarine/marine mysid, two acute studies are available, one with radio-labeled exposure estimates (LC_{50} of 140 $\mu\text{g zeq/L}$, MRID 47405702), and the other without (LC_{50} of 14 $\mu\text{g zeq/L}$, MRID 43781603). Using the radiolabeled study with the mysid chronic endpoint (NOAEC of 16 $\mu\text{g zeq/L}$, MRID 46893103; also radio-labeled) results in an ACR of 8.8 (140/16). Therefore, usable aquatic

invertebrate ACRs of 11 for thiram, and 5.3 and 8.8 for ziram, are available.

Sediment toxicity studies were not available.

In general, thiram appears to be more toxic than ferbam to fish and possibly to aquatic invertebrates. Bluegill data are available for both and show thiram to be more toxic, although this does not hold true for limited estuarine/marine fish data, where toxicity appears similar. For aquatic invertebrates the data points were inconclusive because direct comparisons were not available for either species. The ferbam dataset only included acute fish and acute and chronic estuarine/marine invertebrate data. For ziram, a toxicity comparison with thiram was not clear, and the compounds showed somewhat similar toxicity. In some cases, ziram was more toxic, and in others thiram was more toxic. To add to the complexity ziram had a wide range of acute toxicity values within some species, specifically bluegill, water fleas, and mysid shrimp. As described above, this was attributed to difficulties with stability in the studies and some variability may have been a function of diluter turnover (replacement) rates and other factors influencing the amount of test substance to which organisms were exposed as well as the ratio of ziram to thiram. For aquatic plants, toxicity comparisons between ziram and thiram were not conclusive. While ziram appears to be more toxic to aquatic vascular (duckweed) and non-vascular (green algae) plants, this was not always clear because some thiram data were based on formulation studies, and where this was the case, those thiram endpoints were assumed to be thiram-specific and were not used for ferbam or ziram calculations.

Aquatic Vertebrate Toxicity

Freshwater Fish Toxicity

Table C-2-1. Acute Toxicity to Freshwater Fish

Species	% ai	96-hr LC ₅₀ (ppm ai)	Toxicity Category	MRID No. Author, Year	Study Classification
FERBAM					
Bluegill sunfish (<i>Lepomis macrochirus</i>)	95	3.6	Moderately toxic	05014941 Pickering & Henderson, 1966	Supplemental
Carp (<i>Cyprinus carpio</i>)	TGAI	0.09	Very highly toxic	05001997 Hashimoto & Fukami, 1969	Supplemental/ Quantitative ¹
Fathead Minnow (<i>Pimephales promelas</i>)	95	3.1	Moderately toxic	05014941 Pickering & Henderson, 1966	Supplemental
THIRAM					
Bluegill sunfish	99.0	0.042	Very highly toxic	TN 996 McCann, 1968	Acceptable
Bluegill sunfish	37.5	0.21 ²	Highly toxic	00002923, 00021610 Mastri, 1970	Supplemental
Bluegill sunfish	75	0.28	Highly toxic	00090294 McCann, 1972	Supplemental
Harlequin Fish (<i>Rasbora heteromorpha</i>)	80	0.007	Very highly toxic	05020144 Tooby et al., 1975	Supplemental

Species	% ai	96-hr LC ₅₀ (ppm ai)	Toxicity Category	MRID No. Author, Year	Study Classification
Rainbow trout (<i>Oncorhynchus mykiss</i>)	99.0	0.046	Very highly toxic	46249301 Peither, 2000	Supplemental
Rainbow trout	99.0	0.128	Highly toxic	TN 1001 McCann, 1976	Acceptable
Rainbow trout	37.5	0.14 ¹	Highly toxic	00002923, 00021610 Mastri, 1970	Supplemental
Rainbow trout	75	0.382	Highly toxic	00090293 McCann, 1972	Supplemental
ZIRAM					
Bluegill sunfish	98.9	0.0097	Very highly toxic	42386303 Douglas et al., 1991	Supplemental. Downgraded from acceptable (9/21/2020 amendment, D459398). Study had some issues with test substance stability/ analytical verification, and also test substance was found in controls. Was not a radio- labeled study. It is qualitatively usable for risk characterization.
Bluegill sunfish	98.2	0.57	Highly toxic	47307901 Palmer et al., 2007	Acceptable Note: Flow- through radio- labeled study.
Carp	TGAI	2.28	Moderately toxic	00138215 Dickhaus & Heisler, 1980	Supplemental Note: Test conducted with aeration, no control, no measured concentrations; not a radio- labeled study. Not a quantitative study.

Species	% ai	96-hr LC ₅₀ (ppm ai)	Toxicity Category	MRID No. Author, Year	Study Classification
Fathead Minnow	99.0	0.008	Very highly toxic	05003523 Maloney & Palmer, 1956	Supplemental Note: this is an open literature study that states in the write-up that it was preliminary; also, it was not a radio-labeled study. It is considered qualitative and not for risk calculations.
Rainbow trout	76	0.23	Highly toxic	TN 1021 McCann, 1976	Supplemental Note: Static jar test, not radio- labeled.
Rainbow trout	TGAI	0.27	Highly toxic	00138214 Dickhaus et al., 1980	Supplemental Note: Test conducted with aeration, no control, no measured concentrations; not a radio- labeled study. Not a quantitative study.
Rainbow trout	98.9	1.7	Moderately toxic	42386304 Douglas et al., 1991	Acceptable Note: not a radio-labeled study.

¹Study design based on the recommended procedures from the Japanese Ministry of Agriculture and Forestry, in which carp were exposed to the test substance in the water column (contact method producing an LC₅₀), orally, and topically (to the gills).

²Test substance: Vitavax Seed Protectant, 37.5% thiram and 37.5% carboxin

Table C-2-2. Chronic Toxicity to Freshwater Fish

Species	% ai	NOAEC / LOAEC (ppm ai)	Most Sensitive Endpoint	MRID No. Author, Year	Study Classification
FERBAM					
No data available					
THIRAM					
Fathead Minnow (<i>Pimephales promelas</i>)	98.7	0.0011 / 0.0022 ¹	F0 % spawning frequency, F0 egg production, F1 time to hatch, F1 4-wk survival	47824101 Krueger & Kendall, 2009	Acceptable
Rainbow Trout (<i>Oncorhynchus mykiss</i>)	81.2	0.012 / 0.020 ²	Growth rate	46249303 Memmert, 2001	Supplemental
ZIRAM					
Fathead Minnow	98.2	0.101 / 0.195 ³	Post-hatch survival	46893104 Palmer et al., 2006	Acceptable Note: this is a radio-labeled study.
Fathead Minnow	98.2	0.024 / 0.051 ⁴	F ₀ length and weight	47435501 Palmer et al., 2008	Supplemental/ Quantitative Note: this is a radio-labeled study.

¹ Full life cycle study, 210 days.

² Non-guideline 28-day sub-chronic study. 4 applications at 7 day intervals to 10:1 water:sediment systems.

³ Early-life stage study, 33 days (28 days post-hatch). Based on significant (p<0.05) 22% reduction in juvenile (post-hatch) survival. Mortality was 100% at the next higher treatment level (393 µg a.i./L).

⁴ Full life cycle study, 275 days. Based on significant (p<0.05) 5.2 % and 10.6% reductions in length and wet wt. at 8-weeks post-hatch, followed by a pattern that was somewhat dose-dependent, with the effect showing a fairly flat response until it dropped clearly in the 424 µg a.i./L treatment. Then, at test termination (25-weeks post-hatch), at the LOAEC (51 µg a.i./L), males had significant (p<0.05) length and wet weight reductions of 10.8% and 39.0%, with 16.9% and 61.2% respective reductions at the highest treatment level, which was 205 µg a.i./L at the end of the study due to mortality. Although the dose: response curves were not linear, the weight of evidence shows a clear effect in that treatment range. At 8 weeks post-hatch, juvenile fish were impartially reduced from four to two replicates. Four replicates per treatment concentration are the minimum required to achieve sufficient statistical power with hypothesis tests. Also, F1 generation fish were maintained for 4 weeks, rather than the recommended 8 weeks. Therefore, the study is not fully acceptable, but these deviations did not likely alter the endpoints and so results may be used quantitatively to calculate risk.

Estuarine/Marine Fish Toxicity

Table C-2-3. Acute Toxicity to Estuarine/Marine Fish

Species	% ai	96-hr LC ₅₀ (ppm ai)	Toxicity Category	MRID No. Author, Year	Study Classification
FERBAM					
Longnose killifish (<i>Fundulus similis</i>)	76	0.80	Highly toxic	40228401 Mayer, 1986	Supplemental
THIRAM					
Sheepshead Minnow (<i>Cyprinodon variegatus</i>)	98.3	0.54	Highly toxic	42514401 Croudace et al., 1992	Acceptable
ZIRAM					

Species	% ai	96-hr LC ₅₀ (ppm ai)	Toxicity Category	MRID No. Author, Year	Study Classification
Longnose killifish	TGAI	6.40 ¹	Moderately toxic	40228401 Mayer, 1986	Supplemental
Sheepshead Minnow	98.9	0.84	Highly toxic	43781601 Machado, 1995	Acceptable Note: not a radio-labeled study.

¹ 48-hr test

Table C-2-4. Chronic Toxicity to Estuarine/Marine Fish

Species	% ai	NOAEC / LOAEC (ppm ai)	Most Sensitive Endpoint	MRID No. Author, Year	Study Classification
FERBAM					
No data available					
THIRAM					
Sheepshead Minnow (<i>C. variegatus</i>)	TGAI (98.4%)	0.00093 / 0.00200	Length and Dry weight Based on significant (p<0.05) 4.6 and 12% respective reductions in length and weight, followed by dose-dependent patterns with 7.2 and 16% reductions at next higher treatment. ¹	51049801 ^N Marini, 2020	Acceptable
ZIRAM					
Sheepshead Minnow	98.2	0.027 / 0.058 ²	Length and dry weight of larvae	46856401 Sutherland et al., 2006	Acceptable

^N = new study since problem formulation.

¹ Early-life stage study, 34 days (28 days post-hatch). Radiolabeled study: using HPLC (high-performance liquid chromatography), thiram concentrations in the highest treatment (4 µg a.i./L) decreased from 84% to 42% from Day 0 to Day 34; however, the total radioactive residues were maintained within 8% of nominal

Additional Endpoint: Post-hatch survival NOAEC/LOAEC = 0.00200/0.00093 mg a.i./L based on 30% biologically significant and treatment-related reduction (significant according to study author using Williams test).

² Early-life stage study, 34 days (28 days post-hatch). Based on significant (p<0.05) 4.5% and 13.0% respective reductions in length and dry wt., with a non-linear dose:response curve, but with respective effects of 8.5% and 19.3% at the highest concentration (443 µg a.i./L).

Aquatic Invertebrate Toxicity

Freshwater Invertebrate Toxicity

Table C-2-5. Acute Toxicity to Freshwater Invertebrates

Species	% ai	48-hr EC ₅₀ (ppm ai)	Toxicity Category	MRID No. Author, Year	Study Classification
FERBAM					
No data available					
THIRAM					
Water flea (<i>Daphnia magna</i>)	98	0.21	Highly toxic	00164662 Husson, 1986	Acceptable
ZIRAM					
Water flea	98.9	0.048	Very highly toxic	42386305 Douglas et al., 1992	Acceptable Note: not a radio-labeled study.
Water flea	98.2	0.206	Highly toxic	47405701 Palmer et al., 2008	Acceptable Note: is a radio-labeled study.

Table C-2-6a. Chronic Toxicity to Freshwater Invertebrates

Species	% ai	NOAEC / LOAEC (ppm ai)	Most Sensitive Endpoint	MRID No. Author, Year	Study Classification
FERBAM					
No data available					
THIRAM					
Water flea (<i>Daphnia magna</i>)	98.7	0.020 / 0.040	Dry weight, clinical signs of toxicity	47495001 Krueger & Kendall, 2008	Acceptable
ZIRAM					
Water flea	98.2	0.039 / 0.078 ¹	Length	46823301 Palmer et al., 2006	Acceptable Note: this is a radio-labeled study.

¹ Based on significant (p<0.05) 6.4% reduction in length followed by a dose-dependent pattern with 7.0% reduction at the next higher concentration of 154 µg a.i./L.

Table C-2-6b. Effects to Zooplankton and Phytoplankton from Thiram Exposure in Aquatic Mesocosm

Species	% ai	Exposure	Effect	MRID Study Classification
Thiram				
Zooplankton Aquatic snail (<i>Gyraulus albus</i>) Leech (<i>Helobdella stagnalis</i>) Phytoplankton	Thiram 80WG	Designed to simulate effects of spray drift to a freshwater ecosystem; exposure concentrations: 0.001, 0.0032, 0.010, 0.032, 0.10, and 0.32 mg a.i./L.	Zooplankton and Other Invertebrates: NOAEC/ LOAEC: <0.001/ 0.001 based on effects to community similarity. NOAEC/ LOAEC: 0.0032/ 0.010 mg a.i./L based on significant reduction in taxa abundance. NOAEC/ LOAEC: 0.032/ 0.10 mg a.i./L based on effects to macrozoobenthic community similarity and population reductions for aquatic snails and leeches. NOAEC/ LOAEC: 0.032/ >0.032 mg a.i./L based on no effects to emergent insect community. Phytoplankton: NOAEC/LOAEC: 0.10/0.32 mg a.i./L Based on significant reduction in taxa abundance, diversity, evenness, and similarity.	46249304 Supplemental
Details of Mesocosm Study Design and Results - MRID 46249304: This study was intended to simulate the potential impact of Thiram 80 WG (a water dispersible formulation containing 81.2% of the active ingredient Thiram) contamination via spray drift from agricultural applications on a freshwater ecosystem under field conditions. A spray application method was used to simulate the entry of the test material into a water body by direct over-spray or spray drift. Four applications of seven treatment levels were made at 7-day intervals with identical application rates; therefore, exposure, although intermittent, had a similar exposure duration to the 21- to 27-day exposures used in the daphnid and mysid chronic studies presented here (Appendix C). The highest test concentration selected was intended to result in substantial acute adverse effects on at least some of the mesocosm taxa. The lower test concentrations were intended to permit the estimation of toxicant effects thresholds for the different taxa. The mesocosm study design included three replicate mesocosm ponds for the negative control group and one replicate mesocosm pond per treatment group. Seven treatment levels were used with nominal Thiram 80 WG formulation treatment concentrations ranging from 1.25 to 1250 µg formulation (Thiram 80 WG)/L, which corresponded to 1.0 to 1000 µg a.i./L nominal concentrations. Five of the seven treatment levels were analytically verified following each application and mean-measured concentrations were calculated and used to describe results for some treatment levels as available. This study was classified as supplemental because only five of the seven treatment levels were analytically verified and because this study does not fulfill any current guideline requirement. The overall short duration of the study (less than 1 year for the in-life portion of the study) did not allow for the comparison of the treated community structure compared to the structure from untreated or post-treatment years. In general, phytoplankton (at the community level) taxa abundance, diversity (based on the Shannon-Weaver index), evenness, and similarity (Steinhaus' and Stander's similarity indices) were significantly reduced during the treatment period at the two highest treatment levels tested; i.e, nominal 320 and 1000 µg a.i./L. No significant treatment-related reductions in any individual phytoplankton taxa were meaningfully identified during the treatment period. However, these significant reductions in the above community parameters were the result of indirect promoting effects in phytoplankton species. These indirect promoting effects were attributed to treatment-related reductions in zooplankton grazers and the subsequent rapid population growths of those phytoplankton taxa with the most rapid population development/growth rates at the nominal 320 and 1000 µg a.i./L. This conclusion is supported the significant increases in phytoplankton biomass at the nominal 320 and 1000 µg a.i./L treatment levels. Therefore, true treatment-related negative effects as a result of Thiram 80 WG application on the phytoplankton community can be excluded with high probability at least up to and including the nominal 100 µg a.i./L treatment level. Consequently, the NOAEC for individual phytoplankton taxa and the community as a whole was concluded to be 107 µg a.i./L (measured; nominally 100 µg a.i./L). Periphyton biomass was significantly reduced also at the nominal 320 and 1000 µg a.i./L treatment levels. Treatment-related effects on specific taxa were never discussed in the study report.				

Species	% ai	Exposure	Effect	MRID Study Class- ification
Consequently, the NOAEC for periphyton in general was concluded to be 107 µg a.i./L (measured; nominally 100 µg a.i./L). As noted by the study author, macrophytes were not added to the mesocosm ponds because they have a strong influence on water chemistry and can increase variability of planktonic biocoenosis drastically in small ponds. Therefore, macrophytes and or pieces of macrophytes were removed by hand at the addition of the natural sediment to the mesocosm ponds. Due to the significant negative concentration-effect relationship in zooplankton taxa abundance during the treatment period, the NOAEC for zooplankton taxa abundance was 2.1 µg a.i./L (measured; nominally 3.2 µg a.i./L). Zooplankton community diversity (based on ShannonWeaver Index) and evenness were not significantly affected during the during the treatment period. Similarity analysis of the treated zooplankton communities was compared to the control ponds using Steinhaus' and Stander's indices. The NOAEC value for zooplankton community similarity during the treatment period was <1.0 µg a.i./L (measured; nominally <1.0 µg a.i./L); i.e. less than the lowest treatment concentration tested. In general, the zooplankton community was dominated by Crustacea and Rotatoria species. The dominant cladocerans <i>Daphnia pulex</i> and <i>Daphnia magna</i> population densities were significantly reduced following the first treatment application at the two highest treatment levels, nominal 320 and 1000 µg a.i./L. Consequently, the NOAEC for <i>Daphnia pulex</i> and <i>Daphnia magna</i> during the treatment period was 107 µg a.i./L (measured; nominally 100 µg a.i./L). Thiram 80 WG applications had slight to strong effects on copepod nauplii during the treatment period at nominal treatment levels of 32 to 1000 µg a.i./L. Consequently, the NOAEC value for all copepod nauplii was determined to be 11.5 µg a.i./L (measured; nominally 10 µg a.i./L). Population densities of the rotifer <i>Keratella quadrata</i> were significantly reduced by Thiram 80 WG treatment at the nominal 10.0 through 1000 µg a.i./L treatment levels. Consequently, the NOAEC for <i>Keratella quadrata</i> was 2.1 µg a.i./L (measured; nominally 3.2 µg a.i./L). The population densities of <i>Brachionus urceolaris/variabilis</i> were significantly reduced during the treatment period at the nominal 32 through 1000 µg a.i./L treatment levels. Consequently, the NOAEC for <i>Brachionus urceolaris/variabilis</i> was concluded to be 11.5 µg a.i./L (measured; nominally 10 µg a.i./L). The growth rates of <i>Hexarthra miralintermedia</i> were significantly reduced at all treatment levels based on the reported EC₂₀ and EC₅₀ values (1.3 and 7.6 µg Thiram 80 WG formulation/L, respectively). Consequently, the NOAEC for <i>Hexarthra mira/intermedia</i> was <1.0 µg a.i./L (measured; nominally <1.0 µg a.i./L), i.e. less than the lowest treatment concentration tested. For those macrozoobenthic taxa collected and identified from the artificial substrate samplers (MASS), no significant negative concentration-effect relationships between Thiram 80 WG treatment concentrations and control taxa abundance, diversity, and evenness were identified. However, Steinhaus' similarity indices were significantly reduced at the nominal 100 through 1000 µg a.i./L treatment levels. Consequently, the NOAEC value for macrozoobenthic community similarity was nominal 32 µg a.i./L (note this treatment level was not analytically verified during the study). Due to lack of any significant negative treatment-related effects at any treatment level for the emergent insect community and any individual insect species that was collected via the emergence traps, the NOAEC was concluded to be 1060 µg a.i./L (measured; nominally 1000 ppb a.i.). The population densities of larvae of <i>Chironomus sp.</i> and <i>Chaoborus sp.</i> found in the MASS samples confirmed the results from the emergence traps that the populations of these individual species were clearly not affected (with the exception of overall macrozoobenthic community similarity) by Thiram 80 WG treatment at levels up to and including nominal 1000 µg a.i./L. Consequently, the NOAEC for MASS collected <i>Chironomus sp.</i> and <i>Chaoborus sp.</i> during the treatment period was 1000 µg a.i./L. Individual species that were collected via MASS only the aquatic snail <i>Gyraulus albus</i> and the leech <i>Helobdella stagnalis</i> had population densities that were reduced by the Thiram 80 WG application. These species were significantly reduced at the nominal 32 through 1000 µg a.i./L treatment levels. Consequently, the NOAEC for the aquatic snail <i>Gyraulus albus</i> and the leech <i>Helobdella stagnalis</i> was 11.5 µg a.i./L (measured; nominally 10 µg a.i./L).				

Estuarine/Marine Invertebrate Toxicity

Table C-2-7. Acute Toxicity to Estuarine/Marine Invertebrates

Species	% ai	96-hr EC ₅₀ or LC ₅₀ (ppm ai)	Toxicity Category	MRID No. Author, Year	Study Classification
FERBAM					
Eastern Oyster (<i>Crassostrea virginica</i>)	76	0.052	Very highly toxic	40228401 Mayer, 1986	Supplemental
Pink Shrimp (<i>Penaeus duorarum</i>)	76	>40 ¹	Slightly toxic	40228401 Mayer, 1986	Supplemental
THIRAM					
Pacific Oyster (<i>Crassostrea gigas</i>)	98.3	0.0047 ¹	Very highly toxic	42488301 Thompson et al., 1992	Supplemental/ Qualitative Downgraded from acceptable (9/21/2020 amendment, D459398). Study was non-radio-labelled there were difficulties measuring test concentrations so much that nominal concentrations were used. Uncertainties are acknowledged with exposure levels.
Mysid Shrimp (<i>Americamysis bahia</i> , formerly <i>Mysidopsis bahia</i>)	98.3	0.00336	Very highly toxic	42488302 Thompson et al., 1992	Supplemental/ Quantitative Downgraded from acceptable (9/21/2020 amendment, D459398). Study was non-radio-labelled there were difficulties measuring test concentrations so much that a correction factor was used to account for lack of data in the lower test concentrations. The diluters had a turnover (water exchanges) rate that was 40 times per day, so good attempts were made to keep the test substance in solution. Nonetheless, uncertainties are acknowledged.

Species	% ai	96-hr EC ₅₀ or LC ₅₀ (ppm ai)	Toxicity Category	MRID No. Author, Year	Study Classification
ZIRAM					
Eastern Oyster	98.0	0.077	Very highly toxic	43781602 Dionne, 1995	Acceptable Note: not a radio-labeled study.
Eastern Oyster	TGAI	1.00	Highly toxic	40228401 Mayer, 1986	Supplemental
Mysid Shrimp	98.0	0.014	Very highly toxic	43781603 Machado, 1995	Acceptable Note: not a radio-labeled study.
Mysid Shrimp	98.2	0.14	Highly toxic	47405702 Palmer et al., 2008	Acceptable Note: is a radio-labeled study.
Pink Shrimp	TGAI	>5 ¹	Moderately toxic	40228401 Mayer 1986	Supplemental

¹ 48-hr test

Table C-2-8. Chronic Toxicity to Estuarine/Marine Invertebrates

Species	% ai	NOAEC / LOAEC (ppm ai)	Most Sensitive Endpoint	MRID No. Author, Year	Study Classification
FERBAM					
Mysid Shrimp (<i>Americamysis bahia</i> , formerly <i>Mysidopsis bahia</i>)	97.6	<0.0012 / 0.0012 ¹	F ₀ body length	47784401 Gallagher et al., 2009	Supplemental/ Quantitative
THIRAM					
No data available					
ZIRAM					
Mysid Shrimp	98.2	0.016 / 0.027 ²	Reproduction and dry weight	46893103 Sutherland et al., 2006	Supplemental/ Quantitative Note: this is a radio-labeled study.

¹ Based on significant (p<0.05) 2.7% reduction in length followed by a dose-dependent pattern. According to Willian's test, the 2.7% reduction at the lowest concentration (1.2 µg a.i./L) was significant but it is unclear whether the reduction is biologically significant, especially since there was a 5% increase in dry weight at that treatment level. The potential effect at the lowest dose seems very low and even an almost 10-fold increase in dose (9.1 µg a.i./L) did not impact other parameters and still resulted in a <10% effect on length, while a doubling of the dose (2.3 µg a.i./L) still resulted in <5% effect on length. Therefore, confidence that the lowest dose is a biological effect is somewhat limited and risk may be characterized by considering that the LOAEC may be the 2nd lowest dose. A new study would not be anticipated to change the endpoint or provide meaningful information and so is not needed. Further, if a new study were conducted to find a NOAEC below this, the effect would need to be even lower than 2.7%, and any lower effect would certainly be within any measurement error and would not be feasible to determine. This line of consideration was not examined further because an acute-to-chronic ratio is available with thiram data and produces a slightly lower endpoint based on thiram toxicity for use in risk calculations. Rather this study helps to support that chronic toxicity is in this general concentration range.

² Based on significant (p<0.05) 38.0% and 11.1% respective reductions in young/reproductive day and dry weight followed by dose-dependent patterns with respective reductions of 83.3% and 30.2% at the next higher concentration (65 µg a.i./L). The measured concentrations in the study had variability over 20% and due to this and control reproduction (<3 young/female/reproductive day) the study was originally (2006) classified as invalid. However, this was a radio-labeled study and the analytical results were determined to be sufficient for quantitative use. Also, the requirement of having 3 young/female/reproductive day was determined to be problematic for most laboratories and the policy changed. The study was amended in 2015 and upgraded to Supplemental and may be used quantitatively to calculate risk.

Aquatic Plant Toxicity

Table C-2-9a. Toxicity to Aquatic Plants

Species	% ai	EC ₅₀ (ppm ai)	EC ₀₅ or NOAEC (ppm ai)	MRID No. Author, Year	Study Classification
FERBAM					
No data available					
THIRAM					
Duckweed (<i>Lemna gibba</i>)	98.7	7-d EC ₅₀ = 1.6	NOAEC < 0.057	45441202 Sutherland et al., 2001	Acceptable
Freshwater Diatom (<i>Navicula pelliculosa</i>)	TEP: Thiram Granuflo 71.0%	96-hr EC ₅₀ = 0.00058 (0.00017-0.0020)	NOAEC = 0.00026 (based on 43% inhibition of yield; see detail below in Table C-9b)	50792001 ^N	Acceptable
Marine diatom (<i>Skeletonema costatum</i>)	TEP: Thiram Granuflo 71.0%	96-hr EC ₅₀ = 0.00074 (NA-0.00089)	NOAEC = 0.0010 (based on 88% inhibition of area-under-curve; see detail below in Table C-9b)	50792002 ^N	Acceptable
Cyanobacteria (<i>Anabaena flos-aquae</i>)	TEP: Thiram Granuflo 71.0%	96-hr EC ₅₀ = 0.015 (0.0082-0.028)	NOAEC = 0.0034 (based on 65% inhibition of yield; see detail below in Table C-9b)	50792003 ^N	Acceptable
Green algae (<i>Pseudokirchneriella subcapitata</i>)	99.0	120-hr EC ₅₀ = 0.14	EC05 = 0.003	44086001, 44086101 Coates, 1996	Acceptable
ZIRAM					
Duckweed	98.2	7-d EC ₅₀ = 0.37	NOAEC = 0.03511	46823302 Desjardins et al., 2006	Acceptable
Green algae	98.0	120-hr EC ₅₀ = 0.067	NOAEC < 0.038	43833901 Hoeborg, 1995	Acceptable
Freshwater Diatom	TEP: Ziram 76 DF 71.6%	96-hr EC ₅₀ = 0.111 (0.104-0.122) [nominal]	NOAEC = 0.035 [nominal; 0.0019 initial measurement] (based on 65% inhibition of area-under-curve; see detail below in Table C-9c)	50814401 ^N	Supplemental (Qualitative) ²
Marine Diatom	TEP: Ziram 76 DF 71.9%	96-hr EC ₅₀ = 0.0031 (0.0031-0.0032)	NOAEC = 0.0013 (based on 58% inhibition of area-under-curve; see detail below in Table C-9c)	50814402 ^N	Supplemental (Quantitative) ³
Cyanobacteria	TEP: Ziram 76 DF 71.9%	96-hr EC ₅₀ = 0.0024 (0.0014-0.0040)	NOAEC = 0.00060 (based on 47% inhibition of yield; see detail below in Table C-9c)	50814403 ^N	Acceptable

^N New study reviewed since 2015 problem formulation. Detail added below.

¹ NOAEC/ LOAEC of 35/ 77 µg a.i./L based on significant (p<0.05) 19.7 inhibition of biomass, with a dose-dependent pattern.

² The endpoints are for qualitative use due to uncertainty around the test concentrations to which algae were exposed. There were differential recoveries in the initial-measured concentrations that resulted in a shift in the order of the test levels and so results were calculated based on nominal concentrations. However, the NOAEC of 35 µg a.i./L (nominal) has an initial measured concentration of 0.57 µg a.i./L which is almost two orders-of-magnitude less than nominal. The next lower treatment actually had a higher initial measured concentration of 0.79 µg a.i./L, indicating substantial noise and uncertainty in the amount, which also applies to the point estimates. Therefore, the results should only be used qualitatively.

³ Not all endpoints were calculable for yield and growth rate. Therefore, the study was not fully acceptable, but is classified as Supplemental/Quantitative and the results that were calculable may be used quantitatively for risk calculation.

Table C-2-9b. Additional details for New Thiram Non-vascular Aquatic Plant Studies

Information from MRIDs 50792001, 50792002, and 50792003 (note that these endpoints are presented in µg a.i./L)	
MRID 50792001 Results Synopsis:	
Test Organism: Freshwater diatom, <i>Navicula pelliculosa</i> (strain 661)	
Test Type (Flow-through, Static, Static Renewal): Static	
<i>Yield</i>	
IC ₀₅ : Not calculable	
IC ₅₀ : 0.58 µg a.i./L	95% C.I.: 0.17 to 2.0 µg a.i./L
NOAEC: 0.26 µg a.i./L (based on significant [p<0.05] 43% inhibition at the LOAEC of 0.77 µg a.i./L)	
<i>Growth rate</i>	
IC ₀₅ : 1.2 µg a.i./L	95% C.I.: N/A to 1.6 µg a.i./L
IC ₅₀ : 3.4 µg a.i./L	95% C.I.: 2.9 to 4.0 µg a.i./L
NOAEC: 0.77 µg a.i./L (based on significant [p<0.05] 17% inhibition at the LOAEC of 1.7 µg a.i./L)	
<i>Area under the curve (AUC)</i>	
IC ₀₅ : Not calculable	
IC ₅₀ : 0.88 µg a.i./L	95% C.I.: 0.35 to 2.2 µg a.i./L
NOAEC: 0.099 µg a.i./L (based on significant [p<0.05] 34% inhibition at the LOAEC of 0.26 µg a.i./L)	
Endpoints Affected: Yield, growth rate, and area under the curve	
Most Sensitive Endpoint: Yield	
MRID 50792002 Results Synopsis:	
Test Organism: Marine diatom, <i>Skeletonema costatum</i> (strain CCMP 1332)	
Test Type (Flow-through, Static, Static Renewal): Static	
<i>Yield</i>	
IC ₀₅ : 0.82 µg a.i./L	95% C.I.: N/A to 0.99 µg a.i./L
IC ₅₀ : 1.4 µg a.i./L	95% C.I.: 1.1 to 1.6 µg a.i./L
NOAEC: 1.0 µg a.i./L (based on significant [p<0.05] 90% inhibition at the LOAEC of 2.1 µg a.i./L)	
<i>Growth rate</i>	
IC ₀₅ : 1.1 µg a.i./L	95% C.I.: N/A to 1.3 µg a.i./L
IC ₅₀ : 2.1 µg a.i./L	95% C.I.: 1.9 to 2.2 µg a.i./L
NOAEC: 1.0 µg a.i./L (based on significant [p<0.05] 52% inhibition at the LOAEC of 2.1 µg a.i./L)	
<i>Area under the curve (AUC)</i>	
IC ₀₅ : 0.74 µg a.i./L	95% C.I.: N/A to 0.89 µg a.i./L
IC ₅₀ : 1.3 µg a.i./L	95% C.I.: 1.2 to 1.5 µg a.i./L
NOAEC: 1.0 µg a.i./L (based on significant [p<0.05] 88% inhibition at the LOAEC of 2.1 µg a.i./L)	
Endpoint(s) Affected: Yield, growth rate, and area under the curve	
Most Sensitive Endpoint: Area under the curve	
MRID 50792003 Results Synopsis:	

Test Organism: Cyanobacterium, <i>Anabaena flos-aquae</i> (strain 67)	
Test Type (Flow-through, Static, Static Renewal): Static	
<i>Yield</i>	
IC ₀₅ : 0.70 µg a.i./L	95% C.I.: N/A to 2.3 µg a.i./L
IC ₅₀ : 15 µg a.i./L	95% C.I.: 8.2 to 28 µg a.i./L
NOAEC: 3.4 µg a.i./L (based on significant [p<0.05] 65% inhibition at the LOAEC of 10 µg a.i./L)	
<i>Growth rate</i>	
IC ₀₅ : 41 µg a.i./L	95% C.I.: N/A to 61 µg a.i./L
IC ₅₀ : 86 µg a.i./L	95% C.I.: 63 to 118 µg a.i./L
NOAEC: 37 µg a.i./L (based on significant [p<0.05] 78% inhibition at the LOAEC of 120 µg a.i./L)	
<i>Area under the curve (AUC)</i>	
IC ₀₅ : 0.78 µg a.i./L	95% C.I.: N/A to 2.2 µg a.i./L
IC ₅₀ : 15 µg a.i./L	95% C.I.: 9.0 to 26 µg a.i./L
NOAEC: 3.4 µg a.i./L (based on significant [p<0.05] 59% inhibition at the LOAEC of 10 µg a.i./L)	
Endpoints Affected: Yield, growth rate, and area under the curve	
Most Sensitive Endpoint: Yield	

Table C-2-9c. Additional details for New Ziram Non-Vascular Aquatic Plant Studies

Information on MRIDs 50814401, 50814402, and 50814403 (note that these endpoints are presented in µg a.i./L):	
MRID 50814401 Results Synopsis:	
Test Organism: Freshwater diatom, <i>Navicula pelliculosa</i> (strain 611)	
Test Type (Flow-through, Static, Static Renewal): Static	
<i>Yield</i>	
IC ₀₅ : Not calculable	95% C.I.: N/A
IC ₅₀ : 35 - 110 µg a.i./L (nominal)	95% C.I.: N/A
NOAEC: 35 µg a.i./L (based on significant [p<0.05] 74% inhibition at the LOAEC of 100 µg a.i./L [nominal, corresponding to 1.9 µg a.i./L initial measured concentration]).	
<i>Growth rate</i>	
IC ₀₅ : 25 µg a.i./L (nominal)	95% C.I.: N/A to 39 µg a.i./L
IC ₅₀ : 139 µg a.i./L (nominal)	95% C.I.: 108 to 178 µg a.i./L
NOAEC: 35 µg a.i./L (based on significant [p<0.05] 48% inhibition at the LOAEC of 100 µg a.i./L [nominal, corresponding to 1.9 µg a.i./L initial measured concentration]).	
<i>Area under the curve (AUC)</i>	
IC ₀₅ : 95 µg a.i./L (nominal)	95% C.I.: 93 to 96 µg a.i./L
IC ₅₀ : 111 µg a.i./L (nominal)	95% C.I.: 104 to 122 µg a.i./L
NOAEC: 35 µg a.i./L (based on significant [p<0.05] 65% inhibition at the LOAEC of 100 µg a.i./L [nominal, corresponding to 1.9 µg a.i./L initial measured concentration]).	
Endpoint(s) Affected: Yield, growth rate, and area under the curve	
Most Sensitive Endpoint: Area under the curve (yield may have been more sensitive but an IC ₅₀ wasn't calculable)	
MRID 50814402 Results Synopsis:	
Test Organism: Marine diatom (<i>Skeletonema costatum</i>)	
Test Type (Flow-through, Static, Static Renewal): Static	
<i>Yield</i>	
IC ₀₅ : Not calculable	95% C.I.: N/A
IC ₅₀ : Not calculable	95% C.I.: N/A
NOAEC: 1.3 µg a.i./L (based on significant [p<0.05] 67% inhibition at the LOAEC of 3.2 µg a.i./L)	

<i>Growth rate</i>	
IC ₀₅ : Not calculable	95% C.I.: N/A
IC ₅₀ : Not calculable	95% C.I.: N/A
NOAEC: 1.3 µg a.i./L (based on significant [p<0.05] 26% inhibition at the LOAEC of 3.2 µg a.i./L)	
<i>Area under the curve (AUC)</i>	
IC ₀₅ : 2.6 µg a.i./L	95% C.I.: N/A - 2.7 µg a.i./L
IC ₅₀ : 3.1 µg a.i./L	95% C.I.: 3.1 – 3.2 µg a.i./L
NOAEC: 1.3 µg a.i./L (based on significant [p<0.05] 58% inhibition at the LOAEC of 3.2 µg a.i./L)	
Endpoint(s) Affected: Yield, growth rate, and area under the curve	
Most Sensitive Endpoint: Area under the curve	
MRID 50814403 Results Synopsis:	
Test Organism: Cyanobacterium, <i>Anabaena flos-aquae</i> (strain 67)	
Test Type (Flow-through, Static, Static Renewal): Static	
<i>Yield</i>	
IC ₀₅ : 0.36 µg a.i./L	95% C.I.: N/A to 0.81 µg a.i./L
IC ₅₀ : 2.4 µg a.i./L	95% C.I.: 1.4 to 4.0 µg a.i./L
NOAEC: 0.60 µg a.i./L (based on significant [p<0.05] 47% inhibition at the LOAEC of 1.9 µg a.i./L)	
<i>Growth rate</i>	
IC ₀₅ : 0.39 µg a.i./L	95% C.I.: 0.017 to 0.93 µg a.i./L
IC ₅₀ : 22 µg a.i./L	95% C.I.: 15 to 33 µg a.i./L
NOAEC: 0.60 µg a.i./L (based on significant [p<0.05] 14% inhibition at the LOAEC of 1.9 µg a.i./L)	
<i>Area under the curve (AUC)</i>	
IC ₀₅ : 0.29 µg a.i./L	95% C.I.: N/A to 0.61 µg a.i./L
IC ₅₀ : 3.3 µg a.i./L	95% C.I.: 2.2 to 4.8 µg a.i./L
NOAEC: 0.60 µg a.i./L (based on significant [p<0.05] 41% inhibition at the LOAEC of 1.9 µg a.i./L)	
Endpoint(s) Affected: Yield, growth rate, and area under the curve	
Most Sensitive Endpoint: Yield	

C-3. Comprehensive List of Toxicity Studies with Terrestrial Organisms

Comprehensive lists of available toxicity data for birds, terrestrial invertebrates (honey bees in this case), and terrestrial plants, as well as some data with the rat obtained from the Health Effects Division, are found in **Tables C-10** through **C-20**. Summaries of data from most of the studies are found in the problem formulations (USEPA, 2015a and USEPA, 2015b) and for thiram and ziram, in **Appendices C** and **D** of the California red-legged frog assessment (USEPA, 2008); the new data reviewed since the problem formulation are denoted in the following tables by an “N” superscript in the MRID column and summarized here.

New Studies Since Problem Formulations

For terrestrial organisms, two new passerine bird studies (one with thiram and one with ziram), ten new honey bee studies (six with thiram and four with ziram), and two new plant studies (seedling emergence and vegetative vigor studies with thiram) were submitted since the problem formulations were written.

The passerine (canary, *Serinus canaria*) dietary acute study with thiram (MRID 50835201) was less sensitive than a bobwhite quail (*Colinus virginianus*) study previously submitted (MRID 00022293); the bobwhite LC₅₀ was 3950 mg a.i./kg-diet vs. the canary EC₅₀ (based on food consumption) of >4240 mg a.i./kg-diet.

The passerine (zebra finch, *Taeniopygia guttata*) study with ziram (MRID 50939501) was originally intended to be a dose-based study. However, due to regurgitation in a rangefinding study, following 850.2100 (dose-based study), the study was switched to guideline 850.2200 (diet-based study), consistent with EFED recommendations for passerines. The study protocol was based on procedures outlined in OCSPP 850.2100 with modifications for OCSPP 850.2200. Both dose-based and dietary-based acute endpoints were calculated and should be characterized as a range of risk due to uncertainties. In the definitive dietary study food avoidance especially in the higher treatments was evident, with <1g/bird/day consumed in the three highest treatments. Due to this food avoidance, calculating a dose from the consumed food did not follow the increasing gradient of exposure of the dietary concentrations. The dose-based endpoint was calculated as mg a.i./kg-bw/day and is a conservative screening estimate of the dose-based LD₅₀ due to multiple days (5 days) of dosing and is conservatively attributed to a single (daily) dose. Because some mortality may have been due to starvation, both endpoints are used to characterize the range of risk. The a dose-based endpoint estimate was calculated and was slightly more sensitive than a bobwhite quail dose-based endpoint (MRID 41725701), with an LD₅₀ estimate of 61 mg a.i./kg-bw/day for the finch vs. 97 mg a.i./kg-bw for the bobwhite; the finch dose-based endpoint, however, was determined to not be usable for risk calculation due to insufficient information on each individual birds consumption. The dietary-based endpoint calculated from the study with the finch, LC₅₀ of 594 mg a.i./kg-diet, was more sensitive than other submitted studies with the mallard duck (*Anas platyrhynchos*) and bobwhite, with LC₅₀s of 5160->5200 mg a.i./kg-diet (MRIDS 42386302 and 42386301, respectively).

The honey bee studies largely filled data gaps not previously filled. For thiram, a new adult acute contact study (MRID 50273401) was less sensitive than a previously submitted study (MRID 00036935), with a contact LD₅₀ of >99 vs. 73.7 µg a.i./bee. A new adult acute oral LD₅₀ of >106 µg a.i./bee from the new study filled a data gap. Other new thiram studies that were submitted included a 7-day (single-dose) larval acute study (MRID 50940001) with an LD₅₀ of 0.28 µg a.i./larvae (dietary concentration of 8.2 mg a.i./kg-diet); a 10-day adult chronic toxicity study (MRID 50273402) with a NOAEL/ LOAEL of 4.32/ >4.32 µg a.i./bee (120/ >120 mg a.i./kg-diet) based on no effects to mortality or food consumption; and a 22-day larval chronic study (MRID 50669901) with a NOAEL/ LOAEL of 0.0254/ 0.0757 µg a.i./larvae/day (0.661/ 1.97 mg a.i./kg-diet) based on significant (p<0.05) 20% reductions in survival and emergence.

For thiram, Tier II studies were submitted. These included a 22-day honey bee brood feeding study (1-day of exposure; MRID 50273403) and a 26-day (7-day exposure) semi-field brood study (tunnel study) (MRID 50273404 and 50273405), both Tier II studies. The 22-day brood feeding study showed significant (p<0.05) 51.8% increase in termination rate of eggs at dietary exposure to 3180 mg a.i./kg-diet (NOAEL <3180 mg a.i./kg-diet; LOAEL ≤3180 mg a.i./kg-diet), with no effects to mortality, larval development, or behavior at that exposure. The 26-day tunnel study showed no effects to survival, development, or brood parameters (NOAEL ≥2.5 lb a.i./acre).

For ziram, a new adult acute contact study (MRID 50294101) was less sensitive than a previously submitted study (MRID 00036935), with a contact LD₅₀ of >100 vs. 46.7 µg a.i./bee. A new adult acute oral LD₅₀ of >105 µg a.i./bee from the new study filled a data gap. A new ziram 10-day adult chronic toxicity study (MRID 50294102) had a NOAEL/ LOAEL of 4.9/ 8.5 µg a.i./bee/day (173/ 300 mg a.i./kg-

diet) based on significant ($p < 0.05$) 16.7% mortality. The food consumption NOAEL/ LOAEL was 8.5/ 12.7 $\mu\text{g a.i./bee/day}$ (300/ 520 mg a.i./kg-diet) based on significant ($p < 0.05$) 18.6% feeding inhibition.

For ziram, Tier II studies were submitted. These included a 22-day honey bee brood feeding study (1-day of exposure; MRID 50291403) and a 26-day (7-day exposure) semi-field brood study (tunnel study) (MRID 50291404 and 50291405), both Tier II studies. The 22-day brood feeding study showed significant ($p < 0.05$) 22.6% increase in termination rate of eggs at dietary exposure to 2300 mg a.i./L-diet (2300 ppm or mg a.i./kg-diet assuming the weight of water for the sugar solution) and equivalent to 1.36 lb a.i./acre . The 26-day tunnel study showed no effects to survival, development, or brood parameters (NOAEL $\geq 2.03 \text{ lb a.i./acre}$).

The newly submitted plant studies were with thiram, a seedling emergence (MRID 50835301) and a vegetative vigor (MRID 50830201) study with the formulation, Thiram Granuflo (71.0% a.i.). Like the previously submitted ziram studies, effects were generally not found at the tested application rates. In the thiram studies, however, the Tier I seedling emergence and vegetative vigor studies each identified one plant that needed a Tier II test, but when it was conducted, no effects were found at the test levels. In the seedling emergence study (MRID 50835301), the Tier I data showed significant ($p < 0.05$) 32% reduction in sugarbeet survival and emergence at 4.6 lb a.i./acre . This triggered a Tier II study with the sugarbeet at a similar treatment level (4.1 lb a.i./acre). However, in that study, no significant effects were found in height, weight, survival, or emergence for sugarbeet. In the vegetative vigor study (MRID 50830201), the Tier I data showed significant ($p < 0.05$) 16% reduction in cabbage dry weight at 4.6 lb a.i./acre , triggering Tier II study with cabbage. However, no significant effects were found in Tier II height, weight, or survival for cabbage at a similar treatment level (4.1 lb a.i./acre). In both studies, plants tested included monocots: corn, oat, onion, and ryegrass; and dicots: bean, cabbage, cucumber, soybean, sugarbeet, and tomato.

Overview of Terrestrial Toxicity Studies

The available data indicate that thiram (**Table C-1-4**), ferbam (**Table C-1-5**), and ziram (**Table C-1-6**) TGAs are slightly toxic to moderately toxic to birds and mammals on an acute exposure basis to the most sensitive species for which information is available.

Looking at the full range of available bird data (2-7 species for each chemical) presented in **Tables C-3-1 to C-3-3**, all three chemicals are practically non-toxic to moderately toxic on an acute basis to avian species tested. No clear difference was observed between passerine species vs. other species tested, with one possible exception that in ziram dietary acute studies, the zebra finch (*Taeniopygia guttata*, a passerine) was more sensitive than the bobwhite quail (*Colinus virginianus*) or mallard duck (*Anas platyrhynchos*) with an LC_{50} of 594 mg zeq/kg-diet (MRID 50939501) compared with LC_{50} s of >5200 to 5160 mg zeq/kg-diet (MRIDs 42386301 and 42386302). However, at least a portion of the zebra finch toxicity may have been due to starvation, rather than inherent ziram toxicity. The zebra finch study was originally planned to be an oral dose study (OCSP 850.2100) but due to regurgitation in the rangefinding study was modified to be a dietary study (OCSP 850.2200). The dietary-based endpoint was more sensitive than those for the mallard and bobwhite. In the definitive dietary study food avoidance especially in the higher treatments was evident, with $<1\text{g/bird/day}$ consumed in the three highest treatments. Therefore, some mortality may have been due to starvation; this could not be determined from the study report. Some uncertainty is acknowledged due to the possibility that not all mortality in the finch study was from frank toxicity but may have also been due to severe food avoidance.

Chronic (also including sub-chronic) avian toxicity data were available for thiram and ziram, but not ferbam. The NOAECs for thiram and ziram were generally one to two orders-of-magnitude more sensitive than the acute dietary LC₅₀s.

Three chronic studies were available with thiram. In the first, a NOAEC was not determined for the mallard because effects were found at the lowest treatment level (50 mg thiram a.i./kg-diet; MRID 43612501), including reduced egg production, eggs set/eggs laid, and normal hatchlings/eggs laid. In a second thiram study with the mallard, a NOAEC and LOAEC of 9.6 and 39.7 mg thiram a.i./kg-diet were determined based on significant ($p < 0.05$) reductions in eggs set (35%), viable embryos (46%), live 3-week embryos (46%), normal hatchlings (56%), 14-d survivors (56%), eggs set/eggs laid (11%), normal hatchlings/live 3-week embryos (22%), normal hatchlings/eggs laid (26%). A thiram study with the bobwhite is also available, although not as sensitive as the mallard, with a NOAEC/ LOAEC of 500/ 2500 mg thiram a.i./kg-diet based on significant ($p < 0.05$) reductions in the egg production (eggs laid, eggs set, etc.); reductions in the percentages of eggs set of eggs laid, viable embryos of eggs set, normal hatchlings of eggs laid, normal hatchlings of eggs set, and 14-day old survivors of eggs set; and reductions in feed consumption, 14-day old survivor weight, and hen bodyweights at the 2500 mg thiram a.i./kg-diet treatment level when compared to the control.

One chronic study with the mallard was available with ziram. The NOAEC/ LOAEC of 29/ 64 mg zeq/kg-diet were based on significant ($p < 0.05$) reductions in eggs set (37%); eggs set/eggs laid (30%); embryo viability: live 3-week embryos/ viable embryos (6.2%); hatchability: number of hatchlings (56%), hatchlings/ eggs laid (32%) hatchlings/ eggs set (25%), and hatchlings/ live 3-week embryos (30%); and survival: 14-day survivors (57%) and 14-day survivors/ eggs set (25%).

Although a range of toxicity data for the rat (*Rattus norvegicus*) based on studies used in the past and those that are more recent (**Tables C-3-4 to C-3-6**), a full range of data for mammals is not included here but endpoints are selected in coordination with the Health Effects Division. The summary of most-sensitive mammalian endpoints for each chemical are found in **Tables C-1-4 through C-1-5**, as with the bird data). In general, ziram was the most toxic (moderately toxic), and ferbam the least toxic (practically non-toxic), of the three with thiram categorized as slightly toxic based on acute dosing studies. Similarly, inhalation studies were available for all three chemicals, with ziram being the most toxic and ferbam the least.

Chronic, two-generation studies were available for thiram and ziram but not ferbam. Laboratory rats fed diets containing thiram (NOAEC/ LOAEC of 20/ 60 mg thiram a.i./kg-diet; corresponding to dose-based NOAEL/ LOAEL of 2/ 5 mg thiram a.i./kg-bw/day, MRID 42095901) had a decreased body weight of the F1 and F2 generations. Rats fed diets containing ziram (dose-based NOAEL/ LOAEL of 14.8/ 37.5 mg zeq/kg-bw/day, MRID 43935801) had significant reductions in F0 and F1 generation body weights, body-weight gains, and food consumption. Although ziram was more toxic on an acute basis, thiram was more toxic on a chronic basis, and so thiram data were used to assess chronic risk for all three chemicals.

A full suite of honey bee data were available for thiram, but only acute contact data for ferbam. For ziram, toxicity data were available with adult bees, but not for larval bees due to stability problems with ziram in the larval food matrix, so the thiram data are used to assess risk to larva from ziram exposure. The two compounds had similar toxicity to honey bee adults, and while it is unclear if that holds true for larvae, the rapid breakdown of ziram to thiram suggests that evaluating ziram exposure to larvae using thiram toxicity data is a reasonable approach. Similarly, for ferbam, thiram data are used for risk

assessment. The single acute contact datapoint with ferbam was non-definitive (>) and did not provide a good comparison of ferbam and thiram toxicity to the honey bee given the disparity of tested doses. On an acute contact and oral basis, all three chemicals are practically non-toxic to the adult honey bee, although ferbam data were only for contact exposure (see **Tables C-1-4** through **C-1-5** for the most sensitive endpoints, and **Tables C-3-7a** and **C-3-7b** for more detail on all available honey bee studies). However, a single-dose larval study with thiram (MRID 50940001) showed thiram to be highly toxic to larva with an LD₅₀ of 0.28 µg thiram a.i./larva (dietary concentration of 8.2 mg a.i./kg-diet). Other studies available for thiram included a 10-day adult chronic toxicity study (MRID 50273402) with a NOAEL/ LOAEL of 4.32/ >4.32 µg a.i./bee (120/ >120 mg a.i./kg-diet) based on no effects to mortality or food consumption; and a 22-day larval chronic study (MRID 50669901) with a NOAEL/ LOAEL of 0.0254/ 0.0757 µg a.i./larvae/day (0.661/ 1.97 mg a.i./kg-diet) based on significant (p<0.05) 20% reductions in survival and emergence. For ziram, a 10-day adult chronic toxicity study (MRID 50294102) had a NOAEL/ LOAEL of 4.9/ 8.5 µg zeq/bee/day based on significant (p<0.05) 16.7% mortality. The food consumption NOAEL/ LOAEL was 8.5/ 12.7 µg a.i./bee/day (300/ 520 mg a.i./kg-diet) based on significant (p<0.05) 18.6% feeding inhibition.

For thiram, Tier II studies submitted using Thiram 80 WG formulation included a 22-day honey bee brood feeding study (single day exposure; MRID 50273403) and a 26-day (7-day exposure) semi-field brood study (tunnel study; MRID 50273404 and 50273405). In the 22-day brood feeding study bee colonies were placed *ca.* 50 meters behind the test facility in a meadow with free access to natural food sources. Each colony (3 replicates per treatment group) was provided with treated (single application), untreated, or reference treated sugar solutions in a feeding trough which was placed in an empty magazine on top of the populated bee magazine. Bees in this study showed a significant (p<0.05) 51.8% increase in termination rate of eggs at dietary exposure to 3180 mg a.i./kg-diet (NOAEL <3180 mg a.i./kg-diet; LOAEL ≤3180 mg a.i./kg-diet), with no effects to mortality, larval development, or behavior at that exposure. In the 26-day tunnel study, four replicate tunnels for each control, treatment, and reference group were placed in a field of *Phacelia tanacetifolia*, and bee colonies were placed in the tunnels shortly before full flowering of the crop and six days prior to application; for the residue portion, the colonies were set up in the tunnels 14 days before application. This study showed no effects to survival, development, or brood parameters (NOAEL ≥2.5 lb a.i./acre).

For ziram, Tier II studies were submitted using a Ziram 76 WG formulation. These included a 22-day honey bee brood feeding study (single day of exposure; MRID 50294103) and a 26-day (7-day exposure) semi-field brood study (tunnel study; MRID 50294104 and 50294105). In the 22-day brood feeding study, three replicate colonies, a control, and a reference group, were set up in an uncultivated field 28 days before application. This study showed significant (p<0.05) 22.6% increase in termination rate of eggs at dietary exposure to 2300 mg a.i./L-diet (2300 ppm or mg a.i./kg-diet assuming the weight of water for the sugar solution) and equivalent to 1.36 lb a.i./acre. In the 26-day tunnel study (following OECD Guidance document No. 75, 2007), four replicate tunnels for each control, treatment, and reference group were placed in a field of *Phacelia tanacetifolia*, and bee colonies were placed in the tunnels shortly before full flowering of the crop and thirteen days prior to application; This study showed no effects to survival, development, or brood parameters (NOAEL ≥2.03 lb a.i./acre).

For ziram bee data, the registrant sent a waiver request (MRID 50940401, DP Barcode: 454570+, dated September 18, 2020) asking that thiram acute and chronic larval bee studies (LAO and LCO) be used for ziram and that these studies with ziram be waived due to poor stability of ziram in royal jelly. Information was provided from two rangefinding studies, showing endpoint estimates with NOEL/LOELs around 0.3 to 3 µg/larva nominal range although stability was poor.

The available data for terrestrial plants exposed to formulated products of either thiram (71.0% a.i.) or ziram (76.6% a.i.), indicate that neither thiram nor ziram cause measurable effects to seedling emergence or growth from exposure to seeds in treated soils, or to plant growth and survival from direct exposure to foliage, at application rates equivalent to 4.1-4.6 lbs thiram a.i./A and 6.0-6.1lbs zeq/A. In the thiram studies (MRIDs 50835301 and 50830201) sugarbeet had significant ($p<0.05$) 32% reduction in survival and emergence and cabbage had significant ($p<0.05$) 16% reduction in dry weight in the Tier I part of each respective study, but then in Tier II of both studies had no significant effects. No ferbam terrestrial plant data were available.

In general, for terrestrial vertebrates and invertebrates, thiram and ferbam appear to be similarly toxic, though few ferbam toxicity data were available. Ziram may be slightly more toxic than thiram from acute exposures, but toxicities were similar and with ziram's rapid breakdown to thiram, especially for chronic exposure, thiram is largely used to assess risk from ziram exposures.

Avian Toxicity

Table C-3-1. Acute Oral Toxicity to Birds

Species	% ai	LD ₅₀ (mg a.i./kg-bw)	Toxicity Category	MRID Author, Year	Study Classification
FERBAM					
No data available					
THIRAM					
Mallard duck (<i>Anas platyrhynchos</i>)	99.0	>2800	Practically non-toxic	00160000 Hudson et al., 1984	Acceptable
Red-wing blackbird (<i>Agelaius phoeniceus</i>)	TGAI	>100	Moderately toxic	00073683, 00020560 Schafer, 1972	Supplemental/ Quantitative ¹
Ring-neck pheasant (<i>Phasianus colchicus</i>)	99.0	673	Slightly toxic	00160000 Hudson et al., 1984	Supplemental/ Quantitative ²
Starling (<i>Sturnus vulgaris</i>)	TGAI	>100	Moderately toxic	00073683, 00020560 Schafer, 1972	Supplemental
ZIRAM					
Zebra Finch (<i>Taeniopygia guttata</i>)	93.6%	61 (56 to 67) mg a.i./kg-bw/day ¹	Moderately toxic	50939501 ^N Stanfield, 2018	Supplemental/ Quantitative ³
Bobwhite quail (<i>Colinus virginianus</i>)	98.5	97	Moderately toxic	41725701 Hakin & Norman, 1989	Acceptable

^N = new study since problem formulation.

¹The is a collection of toxicity data from the Denver Wildlife Research Center and contains information on several chemicals. The species tested is non-standard and available information is limited but the data are quantitatively usable.

²The is a handbook of toxicity from the U.S. Fish and Wildlife Service and contains information on several chemicals. The species tested is non-standard and available information is limited but the data are quantitatively usable.

³The study protocol was based upon procedures outlined in OCSPP 850.2100 with modifications for OCSPP 850.2200. Both dose-based and dietary-based acute endpoints were calculated and should be characterized as a range of risk due to uncertainties. A rangefinding study following 850.2100 (dose-based study) showed regurgitation, and so the study was switched to guideline 850.2200 (diet-based study), consistent with EFED recommendations for passerines. In the definitive dietary study food avoidance especially in the higher treatments was evident, with <1g/bird/day consumed in the three highest treatments. Due to this food avoidance, calculating a dose from the consumed food did not follow the increasing gradient of

exposure of the dietary concentrations. The dose-based endpoint was calculated as mg a.i./kg-bw/day and is a conservative screening estimate of the dose-based LD₅₀ due to multiple days (5 days) of dosing and is conservatively attributed to a single (daily) dose.

Table C-3-2. Sub-acute Dietary Toxicity to Birds

Species	% ai	LC ₅₀ (mg a.i./kg-diet)	Toxicity Category	MRID Author, Year	Study Classification/ Notes
FERBAM					
Bobwhite quail (<i>Colinus virginianus</i>)	TGAI	2940	Slightly toxic	00106146 Fink & Reno, 1973	Supplemental
Mallard duck (<i>Anas platyrhynchos</i>)	TGAI	>4640	Slightly toxic	00106148 Fink & Reno, 1973	Supplemental
THIRAM					
Bobwhite quail	95.0	3950	Slightly toxic	00022293 Hill et al., 1975	Acceptable
Canary (<i>Serinus canaria</i>)	97.08	>4240 Additional Endpoint: Food Consumption EC ₅₀ >4240	Slightly toxic	50835201 ^N Stanfield, 2019	Acceptable The study author calculated a Discrimination Threshold using food consumption data: DT = 250 mg a.i./kg-diet
Japanese quail (<i>Coturnix japonica</i>)	95.0	>5000	Practically non-toxic	00022293 Hill et al., 1975	Supplemental
Mallard duck	95.0	>5000	Practically non-toxic	00022293 Hill et al., 1975	Acceptable
Ring-neck pheasant (<i>Phasianus colchicus</i>)	95.0	>5000	Practically non-toxic	00022293 Hill et al., 1975	Supplemental
ZIRAM					
Zebra Finch (<i>Taeniopygia guttata</i>)	93.6%	594 (417 to 797) Slope: 4.5 (2.2 to 6.9) ¹	Moderately toxic	50939501 ^N Stanfield, 2018	Supplemental/ Quantitative
Bobwhite quail	98.5	>5200	Practically non-toxic	42386301 Hakin et al., 1992	Acceptable
Mallard duck	98.5	5156	Practically non-toxic	42386302 Hakin et al., 1992	Acceptable

^N = new study since problem formulation.

¹The study protocol was based upon procedures outlined in OCSP 850.2100 with modifications for OCSP 850.2200. Both dose-based and dietary-based acute endpoints were calculated and should be characterized as a range of risk due to uncertainties. A rangefinding study following 850.2100 (dose-based study) showed regurgitation, and so the study was switched to guideline 850.2200 (diet-based study), consistent with EFED recommendations for passerines. In the definitive dietary study food avoidance especially in the higher treatments was evident, with <1g/bird/day consumed in the three highest treatments. Some mortality may have been due to starvation; the study report was unclear. Both endpoints should be used to characterize the range of risk.

Table C-3-3. Chronic Toxicity to Birds

Species	% ai	NOAEC / LOAEC (mg a.i./kg-diet)	Most Sensitive Endpoint	MRID No. Author, Year	Study Classification
FERBAM					
No data available					
THIRAM					
Bobwhite quail (<i>Colinus virginianus</i>)	97.5	500 / 2500	Egg production, eggs set/eggs laid, viable embryos/eggs set, normal hatchlings/eggs set, 14-d survivors/eggs set, feed consumption, 14-d survivor bodyweight, hen bodyweight	43612502 Beavers et al., 1995	Acceptable
Mallard duck (<i>Anas platyrhynchos</i>)	97.5	<50 / 50	Egg production, eggs set/eggs laid, normal hatchlings/eggs laid	43612501 Beavers et al., 1995	Supplemental
Mallard duck	98.7	9.6 / 39.7	Eggs set, viable embryos, live 3-week embryos, normal hatchlings, 14-d survivors, eggs set/eggs laid, normal hatchlings/live 3-wk embryos, normal hatchlings/eggs laid	45441201 Gallagher et al., 2001	Acceptable
ZIRAM					
Mallard duck	98.8	29 / 64	Eggs set, eggs set/eggs laid, embryo viability, hatchability, 14-day survivors, 14-day survivors/eggs set	47286501 Temple et al., 2007	Acceptable

Mammalian Toxicity

Table C-3-4. Acute Oral Toxicity to Mammals

Species	% ai	LD ₅₀ (mg a.i./kg-bw)	Toxicity Category	MRID Author, Year	Study Classification
FERBAM					
Laboratory rat (<i>Rattus norvegicus</i>)	91.8	>5,000	Practically non-toxic	40561501 Reijnders, 1987	Acceptable

Species	% ai	LD ₅₀ (mg a.i./kg-bw)	Toxicity Category	MRID Author, Year	Study Classification
Laboratory rat	TGAI	>17,000	Practically non-toxic	Farm Chemicals Handbook	Unknown
THIRAM					
Laboratory rat	99.0	1800 (F) 3700 (M) 2600 (M & F)	Slightly toxic	00153548 Thouin, 1985	Acceptable
ZIRAM					
Laboratory rat	98.5	267 (F) 381 (M) 320 (M & F)	Moderately toxic	41340401 Liggett & Allan, 1989	Acceptable

Table C-3-5. Acute Inhalation Toxicity to Mammals

Species	% ai	4-hr LC ₅₀ (mg a.i./L)	Toxicity Category	MRID Author, Year	Study Classification
FERBAM					
Laboratory rat (<i>Rattus norvegicus</i>)	91.8	0.40	Toxicity Category II	41508101 Hardy & Jackson, 1988	Acceptable
THIRAM					
Laboratory rat	TGAI	>0.1	Not determined	00152556 Debets, 1985	Acceptable
Laboratory rat	TGAI	2.60 < LC ₅₀ < 5.04	Not determined	40216501 Maedgen & Lain, 1987	Acceptable
ZIRAM					
Laboratory rat	98.5	0.06 (F) 0.08 (M)	Toxicity Category II	41442001 Jackson & Hardy, 1989	Acceptable

Table C-3-6. 2-Generation Reproductive Toxicity to Mammals

Species	% ai	NOAEL / LOAEL (mg a.i./kg-bw)	Most Sensitive Endpoint	MRID No. Author, Year	Study Classification
FERBAM					
No data available					
THIRAM					
Laboratory rat (<i>Rattus norvegicus</i>)	97.5	2 / 5	F1 & F2: Body weight (detail below)	42095901 York, 1991	Acceptable

Species	% ai	NOAEL / LOAEL (mg a.i./kg-bw)	Most Sensitive Endpoint	MRID No. Author, Year	Study Classification
Added Detail on Endpoints from 42095901 above: Parental/Systemic NOAEL/ LOAEL = 60/180 ppm (5/14 mg/kg/day) based on decreased body weight during gestation and lactation (F0 and F1 generations) and pre-mating (males and females; F1 generation). Offspring NOAEL/ LOAEL = 20/60 ppm (2/5 mg/kg/day) based on decreased body weight of the F1 and F2 generations. Reproductive NOAEL ≥ 180 ppm (12.2 mg/kg/day). LOAEL was not determined Additional Endpoint previously used; Endpoints updated by HED (email 6/22/2020): NOAEL/LOAEL: 1.5 / 2.9 (M); 2.3 / 4.6 (F) F0: Mean maternal body weight & food consumption, male food consumption.					
Laboratory rat	100	1.4 / 4.2 (M) 1.6 / 4.7 (F)	F0 & F1: Body weight	45441203 Turck, 1997	Acceptable
ZIRAM					
Laboratory rat	97.8	14.8 / 37.5	F0 & F1: Body weight, body weight gain, food consumption	43935801 Nemec, 1996	Acceptable

Terrestrial Invertebrate Toxicity

Table C-3-7a. Acute Contact Toxicity to Honey Bees (*Apis Mellifera*)

Guideline Study	% ai	Endpoint (µg a.i./bee unless otherwise noted)	Toxicity Category	MRID Author, Year Study Classification	Notes
FERBAM					
850.3020 Contact - Adult Acute	Fermate form.	Contact: 48-hr LD ₅₀ : >12.09	Practically non-toxic	00036935 Atkins & Anderson, 1967 Acceptable	
THIRAM					
850.3020 Contact - Adult Acute	TGAI	Contact: 48-hr LD ₅₀ : 73.72	Practically non-toxic	00036935 Atkins et al., 1975 Acceptable	
850.3020 and NG Oral and Contact - Adult Acute	TGAI 98.8%	Contact: 48-hr LD ₅₀ : >99 Oral: 48-hr LD ₅₀ : >106	Practically non-toxic	50273401 ^N Kling, 2010 Acceptable	
NG ACO – Adult Chronic	TGAI 98.6%	10-day Dose (µg a.i./bee/day): LD ₅₀ : >4.32 Slope: N/A NOAEL: 4.32	--	50273402 ^N Verge, 2014 . Supplemental/ Quantitative	The results are nominal, but dose was adjusted for food consumption and purity. The results are quantitatively usable.

Guideline Study	% ai	Endpoint ($\mu\text{g a.i./bee}$ unless otherwise noted)	Toxicity Category	MRID Author, Year Study Classification	Notes
		LOAEL: >4.32 Dietary Conc. (mg a.i./kg-diet): LC ₅₀ : >120 Slope: N/A NOAEL: 120 LOAEL: >120 based on no effects to mortality.			Based on no significant ($p < 0.05$) effects to mortality. Additional Food-Consumption Endpoints: Dose ($\mu\text{g a.i./bee/day}$)/ Dietary (mg a.i./kg-diet): LD ₅₀ : >4.32/ >120 Slope: N/A NOAEL: 4.32/ 120 LOAEL: >4.32 />120 Based on no significant ($p < 0.05$) effects to food consumption.
NG LAO (single dose)	TGAI 97.08%	7-day (single dose) Dose ($\mu\text{g a.i./larva}$): LD ₅₀ : 0.28 (0.21-0.37) Slope: N/A Dietary Conc. (mg a.i./kg-diet): LC ₅₀ : 8.2 (6.2-11) Slope: N/A	Highly toxic	50940001 ^N Picard, 2019 Acceptable	Additional Endpoints: NOAEL/LOAEL: 0.090/ 0.25 $\mu\text{g a.i./larva}$ (2.6/ 7/4 mg a.i./kg-diet) based on 44% mortality. This was a single-dose (1-day of treated food) study with measured concentrations converted to dose.
NG LCO	TGAI 98.2%	22-day Emergence: Dose ($\mu\text{g a.i./larva/day}$): LD ₅₀ : 0.0872 (0.0419-0.340) Slope: 0.62 (0.327-0.914) NOAEL: 0.0254 LOAEL: 0.0757 Dietary Conc. (mg a.i./kg-diet): LC ₅₀ : 2.27 (1.09-8.88) NOAEL: 0.661 LOAEL: 1.97 based on significant ($p < 0.05$) 20% reduction.	--	50669901 ^N Colli, 2017 Acceptable	Additional Endpoints: Day-15 Mortality: Dose ($\mu\text{g a.i./larva/day}$): LD ₅₀ : 0.151 (0.0648-1.04) Slope: 0.591 (0.294-0.889) NOAEL: 0.0254 LOAEL: 0.0757 Dietary Conc. (mg a.i./kg-diet): LC ₅₀ : 3.94 (1.68-27.2) NOAEL: 0.661 LOAEL: 1.97 based on significant ($p < 0.05$) 25% reduction. See note below.
Additional information for MRID 50669901: On day-15, there was also 29 to 22% reduction in survival at the lowest three treatment levels (0.072-0.661 mg a.i./kg-diet). These reductions were determined not to be biologically significant or treatment-related because the mortality pattern was not clearly dose-dependent and because OECD 239 allows 15% control mortality suggesting some expected mortality under laboratory conditions. Additionally, on day-22, the negative control had 19% mortality, with the lower three treatments having only 6-9% more than the control. The weight of evidence shows clear effects at the next higher treatment level, with reduction in mortality (25-39% from day-15 to 22) and emergence (20% reduction on day 22) at the 1.97 $\mu\text{g a.i./g-diet}$ treatment level.					
NG SFT – Tier II Brood feeding study (a short-term small-scale colony feeding study)	TEP: Thiram 80 WG 79.6%	22-day (1-day exposure) Dietary Conc. (mg a.i./L): NOAEC: <3,180 (NOAEL: <3180 mg a.i./kg-diet)	N/A	50273403 ^N Tanzler, 2013 Supplemental/ Quantitative	At 3180 mg a.i./kg-diet, termination rate of eggs was significantly increased by 51.8%. No effects were found in mortality, larval development, or behavior at that exposure.

Guideline Study	% ai	Endpoint (µg a.i./bee unless otherwise noted)	Toxicity Category	MRID Author, Year Study Classification	Notes
submitted for larval study requirements, 850.3040 also applies)		based on significantly (p<0.05) increased termination rate of eggs.			
Additional information for MRID 50273403: The Thiram 80 WG application at 3180 mg a.i./kg-diet (3.18 g a.i./L of the test sugar-water solution) had no effect on worker honey bee mortality, pupae mortality, behavior, or larval development (young or old). However, the brood termination rate in the eggs (67.8%) was significantly increased (p≤0.05) compared to the control group (16.0%; a 51.8% difference) and all colonies treated with Thiram 80 WG showed termination rates greater than 50%.					
NG SFT + FTR – Tier II Semi-field brood study (tunnel study submitted for larval study, 850.3040 also applies)	TEP: Thiram 80 WG 79.6%	26-day (7-day exposure) Field Exposure (lb a.i./acre): NOAEL: 2.5 based on no effects to survival, development, or brood parameters.	--	50273404 ^N Hecht-Rost, 2015 Supplemental/ Quantitative	Based on no significant (p<0.05) effects. Additional information below.
Supplemental Information	TEP: Thiram 80 WG 79.6%	--	--	50273405 ^N Claben, 2015 Supplemental Information (no endpoints)	Supplies analytical method report for support of 50273404.
Additional information for MRIDs 50273404 and 50273405: Thiram 80 WG application at 2.5 lb a.i./acre (3.5 kg product/ha, 2.8 kg a.i./ha) during full flowering and daily bee flight had no effect on honeybee worker mortality, pupal mortality, or foraging activity. No treatment-related effects were observed for bee behavior, colony size, or brood development. No treatment-related effects were observed for brood termination rate or brood compensation index. Overall, the Thiram 80 WG treatment had no effect on honeybees. The reference material (Insegar, 0.6 kg a.i./ha; 150 g fenoxycarb/ha) caused clear effects on adult and pupal mortality and the brood, demonstrating the sensitivity of the test system. The flower and pollen load residues from bees were higher compared to the pollen (inside the hive) and nectar (forager bees) residues. No thiram residues were detected in the nectar (inside hives).					
Supplemental Information on Other Insect Species: Ladybird beetle (<i>Stethorus punctum</i>)	TEP WP: 65%	48-hour LC₅₀ < 1.3 lb a.i./100 gal. water	--	00059461 Colburn and Asquith, 1973 Supplemental Information	Available information indicated that adult predaceous Ladybird beetles had 100% survival when exposed to a formulation containing 1.3 lb a.i./100 gal. water.
ZIRAM					
850.3020 Contact - Adult Acute	Zerlate form.	Contact: 48-hr LD ₅₀ : 46.65	Practically non-toxic	00036935 Atkins & Anderson, 1967 Acceptable	
850.3020 Contact - Adult Acute	TGAI 98.5	Contact: 48-hr LD ₅₀ : >200	Practically non-toxic	41667901 Cole, 1989 Acceptable	
850.3020 and NG Contact and Oral -	TGAI 98.7%	Contact: 48-hr LD ₅₀ : >100 Oral: 48-hr LC ₅₀ : >105	Practically non-toxic	50294101 ^N Sekine, 2013 Acceptable	

Guideline Study	% ai	Endpoint (µg a.i./bee unless otherwise noted)	Toxicity Category	MRID Author, Year Study Classification	Notes
Adult Acute					
NG ACO – Adult Chronic	TEP: Ziram 76 DF 76.5%	10-day Dose (µg a.i./bee/day): LC ₅₀ : 11.6 (10.1-13.3) Slope: 4.8 (3.4-6.2) NOAEL: 4.9 LOAEL: 8.5 based on significant (p<0.05) 16.7% mortality. Dietary Conc. (mg a.i./kg-diet): LC ₅₀ : 449 (386-526) Slope: 4.32 (3.12-5.52) NOAEC: 173 LOAEC: 300	--	50294102 ^N Sekine, 2014 Supplemental/ Quantitative	The results are nominal, but dose was adjusted for food consumption and purity. The results are quantitatively usable. Additional Food-Consumption Endpoints: Dose (µg a.i./bee/day): IC ₅₀ : >21.6 (extrapolated estimate of 83.5 µg a.i./bee/day was above highest treatment) NOAEL: 8.5 LOAEL: 12.7 µg a.i./bee/day based on significant (p<0.05) 18.6% feeding inhibition. Dietary Conc. (µg a.i./kg-diet): IC ₅₀ : >900 (extrapolated estimate of 3860 mg a.i./kg-diet was above highest treatment) NOAEL: 300 LOAEL: 520
NG SFT – Tier II Brood feeding study (850.3040 also applies)	TEP: Ziram 76 DF 76.7%	22-day (1-day exposure) Field Exposure (mg a.i./L): NOAEL: <2300 based on termination rate of eggs	N/A	50294103 ^N Schmitzer, 2013 Supplemental/ Quantitative	Based on significantly (p<0.05) higher (22.6%) mean termination rates of eggs (Endpoint can also be expressed as <1.36 lb a.i./ac and as <2300 mg a.i./kg- diet if assume the weight of water for the feeding solution). At 3450 mg a.i./L (2.03 lb a.i./ac) significantly (p<0.05) higher (54.3%) mean termination rate of young larvae. No effects at the two levels found in mortality of adults, pupae or larvae.

Guideline Study	% ai	Endpoint (µg a.i./bee unless otherwise noted)	Toxicity Category	MRID Author, Year Study Classification	Notes
Additional Information for MRID 50294103: Honey bee (<i>Apis mellifera</i> L.) colonies were fed a Ziram 76 WG treated sugar diet at nominal rates of 0 (negative control), 2.00, and 3.00 kg Ziram 76 WG/ha (1.52 kg a.i./ha and 2.28 kg a.i./ha, respectively, which calculates to 1.36 and 2.03 lb a.i./ac) in natural field conditions to determine effects on mortality and bee brood development. The test included a sugar syrup control and a reference control. The two treatment solutions fed to the bees were 2300 mg a.i./L and 3450 mg a.i./L solutions (2300 and 3450 ppm-diet) and if the sugar solution is assumed to have the weight of water these would be equivalent to 2300 and 3450 mg a.i./kg-diet treatment levels. However, this is only a rough estimate since the sugar solution would be slightly heavier than a pure water solution, but the specific gravity of the solution was not provided. The honey bee colonies were exposed for 1 day using three replicates per treatment level and were monitored for 21 days after application. The study author reported that the single feeding application of Ziram 76 WG had no effect on adult honey bee mortality, or pupae and larvae mortality, as mortality over the entire post-application phase showed no statistically significant difference from controls in any of the treatment groups. Though mean termination rates of old larvae were slightly higher in both test item treatment groups, they were not statistically significant when compared to controls. The mean termination rates of the eggs in both treatment groups were statistically significantly higher when compared to controls. The termination rate of young larvae in higher treatment group (2.03 lb a.i./ac; 3.00 kg Ziram 76 WG/ha) was statistically significantly different from controls, whereas the termination rate in the lower treatment group (1.36 lb a.i./ac; 2.00 kg Ziram 76 WG/ha) was not. Additionally, in 2017, a waiver request for using 50294103 and 50294104 (adult brood studies) to waive larval acute and chronic (LAO and LCO) and EFED recommended denying it (DP 441186).					
NG SFT + FTR – Tier II Semi-field brood study (tunnel study, 850.3040 also applies)	TEP and TGAI: Ziram 76 DF 76.5% And TGAI 98.2%	26-day (7-day exposure) Field Exposure (lb a.i./acre): NOAEL: 2.03 based on no effects to survival, development, or brood parameters.	N/A	50294104 ^N and 50294105 ^N Klockner and Hecht-Rost, 2015 (both) Supplemental/Quantitative	No effects were found at application levels of 2.03 lb a.i./ac based on survival of adult worker bees and bee pupae, foraging activity, colony condition (brood, food, and colony strength), and bee brood. 50294105 provides method validation for determining thiram in oilseed rape flowers and honey; accuracy and precision noted to be adequate.
Additional Information for 50294104 and 50294105: Ziram 76 WG was applied at a nominal rate of 2.68 lb/ac. (3.0 kg/ha; equivalent to 2.03 lb a.i./ac.) to flowering plants (<i>Phacelia tanacetifolia</i>) under semi-field conditions, with a water control and a reference (Insegar) control. The honey bee (<i>Apis mellifera</i>) colonies were exposed for 7 days using four replicate tunnel tents per treatment level. Following the 7-day test exposure, the hives were monitored for an additional 19 days at another site. The application (2.03 lb a.i./ac.) during full flowering and daily bee flight was reported by the study author to have no effect on the survival of adult worker bees and bee pupae, foraging activity, colony condition (brood, food, and colony strength) as well as on bee brood. Conspicuous behavior observations (intoxication symptoms, paralysis, inability to fly, and cramping) were only recorded on the day of application, the day after (day-1) and on day-4. No detectable residues of Ziram were detected above the level of quantitation in any control samples collected throughout the study period, nor were they detected in samples collected before application. Residues of Ziram found in treated samples were a maximum in flowers (tunnel 1) and pollen samples (foraging bees and pollen traps, tunnel 2). Residues were a minimum in nectar (in-hive) samples for both tunnels.					

^N = new study since problem formulation.

Table C-3-7b. Additional details for New Ziram Honey Bee Tunnel Study

Excerpt from MRID 50294103: Summary of Effects of Ziram 76 WG on honey bee brood ^a	
Test item	Ziram 76 WG
Test species	Honey bees (<i>Apis mellifera</i> L.) (complete colonies)
Exposure	via treated sugar solution

Treatment (Nominal concentrations)	Untreated Control	Ziram 76 WG (2.00 kg/ha) ^b	Ziram 76 WG (3.00 kg/ha) ^b	Reference Item (Insegar, 0.75 g fenoxycarb as/L)
Rate per L sugar solution (product) ¹⁾	-	3.03 g/L	4.55 g/L	3.0 g/L
Rate per L sugar solution (a.s.) ¹⁾	-	2.30 g Ziram/L	3.45 g Ziram/L	0.75 g a.s./L
Termination rate off the eggs (%) ²⁾	9.6%	32.2%* (22.6% greater than control)	58.9%*	99.8%*
Termination rate of the young larvae (%) ²⁾	24.4%	53.3%	78.7%* (54.3% greater than control)	99.8%*
Termination rate of the old larvae (%) ²⁾	3.3%	11.3%	17.6%	26.9%
Mean brood termination rate over all stages	12.3%	32.2%	51.7%	75.5%*
Mean mortality of worker bees/colony/day During pre-application phase ³⁾	8.9	7.8	3.3	14.2
During the entire post-application phase ³⁾	8.5	5.6	8.9	18.7*
Mean mortality of pupae/colony/day During pre-application phase ⁴⁾	0.1	0.3	0.1	2.9
During the entire post-application phase ⁴⁾	1.7	1.9	0.8	0.8
Mean Number of Bees before Application ⁵⁾	16770	15210	12351	13860

a Data obtained from Table 1 on page 12 of study report

b Nominal concentrations are equivalent to an active substance concentration of 2.30 and 3.45 g Ziram/L, taking into consideration the nominal concentration of the product 760 g/kg Ziram.

- 1) Test and reference item was mixed in sugar solution
- 2) Mean termination rate of 3 colonies per treatment group
- 3) Mean number of dead honeybees per day and colony found in dead bee traps
- 4) Mean number of dead pupae/larvae per day and colony found in dead bee traps
- 5) Mean number of bees per colony

Statistics: * = statistically significant compared to the control; Student t-test, $\alpha = 0.05$, pairwise comparison, two-sided (before application), one-sided greater (after application); reported by study author

Note: The reviewer noted that the 2300 mg a.i./L and 3450 mg a.i./L solutions are also viewed as 2300 ppm and 3450 ppm dietary treatments and if the sugar solution is assumed to have the weight of water these would be equivalent to 2300 and 3450 mg a.i./kg-diet treatment levels. However, this is only a rough estimate since the sugar solution would be slightly heavier than a pure water solution, but the specific gravity of the solution was not provided.

Terrestrial Plant Toxicity

No terrestrial plant toxicity data is available for ferbam or thiram. Data for ziram, another dimethyldithiocarbamate fungicide that degrades to thiram, are provided here.

Table C-3-8. Tier I and II Seedling Emergence (21-day) - Thiram (MRID 50835301^N; Marchessault, 2019; Acceptable)¹

Species	Seedling Height		Seedling Dry Weight		Emergence	
	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)
Monocots Tier I						
Corn (<i>Zea mays</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Oat (<i>Avena sativa</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Onion (<i>Allium cepa</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6

Species	Seedling Height		Seedling Dry Weight		Emergence	
	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)
Ryegrass (<i>Lolium perenne</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Dicots Tier I						
Bean (<i>Phaseolus vulgaris</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Cabbage (<i>Brassica oleracea</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Cucumber (<i>Cucumis sativus</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Soybean (<i>Glycine max</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Sugarbeet (<i>Beta vulgaris</i>)	4.6	>4.6	4.6	>4.6	<4.6	ND ²
Tomato (<i>Lycopersicon esculentum</i>)	4.6 ³	>4.6	4.6	>4.6	4.6	>4.6
Dicots Tier II (Sugarbeet Only)						
Sugarbeet	4.1	>4.1	4.1	>4.1	<4.1	4.1

^N = new study since problem formulation.

¹ Study used a TEP (typical end-use product), Thiram Granulfo (71.0% thiram a.i. w/w).

² Sugarbeet had significant (p<0.05) 32% reduction in survival and emergence at 4.6 lb a.i./acre, triggering Tier II. However, no significant effects were found in Tier II.

³ An EC₀₅/IC₀₅ of 2.19 (95% C.I.: N/A-7.87) was calculated for height and could not be discounted because the dose:response was linear in that treatment range. However, this was not determined to be statistically significant (p<0.05) and so the NOAEL was determined to be 4.6 lb a.i./acre, though some uncertainty is acknowledged.

Table C-3-9. Tier I Vegetative Vigor (21-day) – Thiram (MRID 50830201^N; Marchessault,2019; Acceptable)¹

Species	Plant Height		Dry Weight		Survival	
	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)
Monocots Tier I						
Corn (<i>Zea mays</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Oat (<i>Avena sativa</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Onion (<i>Allium cepa</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Ryegrass (<i>Lolium perenne</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Dicots Tier I						
Bean (<i>Phaseolus vulgaris</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6

Species	Plant Height		Dry Weight		Survival	
	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)
Cabbage (<i>Brassica oleracea</i>)	4.6	>4.6	<4.6	ND ²	4.6	>4.6
Cucumber (<i>Cucumis sativus</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Soybean (<i>Glycine max</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Sugarbeet (<i>Beta vulgaris</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Tomato (<i>Lycopersicon esculentum</i>)	4.6	>4.6	4.6	>4.6	4.6	>4.6
Dicots Tier II (Cabbage Only)						
Cabbage	4.1	>4.1	4.1	>4.1	<4.1	4.1

^N = new study since problem formulation.

¹ Study used a TEP (typical end-use product), Thiram Granulfo (71.0% thiram a.i. w/w).

² Cabbage had significant (p<0.05) 16% reduction in dry weight at 4.6 lb a.i./acre, triggering Tier II. However, no significant effects were found in Tier II.

Table C-3-10. Tier I Seedling Emergence - Ziram (MRID 46893101; Porch & Krueger, 2006; Acceptable)

Species	Seedling Height		Seedling Dry Weight		Emergence	
	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)
Monocots						
Corn (<i>Zea mays</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0
Onion (<i>Allium cepa</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0
Ryegrass (<i>Lolium perenne</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0
Wheat (<i>Triticum aestivum</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0
Dicots						
Cabbage (<i>Brassica oleracea</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0
Lettuce (<i>Lactuca sativa</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0
Radish (<i>Raphanus sativus</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0
Soybean (<i>Glycine max</i>)	<6.0 ¹	>6.0	6.0	>6.0	6.0	>6.0
Tomato (<i>Solanum lycopersicum</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0
Turnip (<i>Brassica rapa</i>)	6.0	>6.0	6.0	>6.0	6.0	>6.0

¹ Decrease in height of 16%; not statistically significant but considered biologically significant.

Table C-3-11. Tier I Vegetative Vigor - Ziram (MRID 46893102; Porch & Krueger, 2006; Acceptable)

Species	Plant Height		Dry Weight		Survival	
	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)	NOAEL (lbs a.i./A)	IC ₂₅ (lbs a.i./A)
Monocots						
Corn (<i>Zea mays</i>)	6.1	>6.1	6.1	>6.1	6.1	>6.1
Onion (<i>Allium cepa</i>)	6.1	>6.1	6.1	>6.1	6.1	>6.1
Ryegrass (<i>Lolium perenne</i>)	6.1	>6.1	<6.1 ²	>6.1	6.1	>6.1
Wheat (<i>Triticum aestivum</i>)	6.1	>6.1	6.1	>6.1	6.1	>6.1
Dicots						
Cabbage (<i>Brassica oleracea</i>)	6.1	>6.1	6.1	>6.1	6.1	>6.1
Lettuce (<i>Lactuca sativa</i>)	6.1	>6.1	6.1	>6.1	6.1	>6.1
Radish (<i>Raphanus sativus</i>) ¹	6.1	>6.1	6.1	>6.1	6.1	>6.1
Soybean (<i>Glycine max</i>)	6.1	>6.1	6.1	>6.1	6.1	>6.1
Tomato (<i>Solanum lycopersicum</i>)	6.1	>6.1	<6.1 ³	>6.1	6.1	>6.1
Turnip (<i>Brassica rapa</i>)	6.1	>6.1	6.1	>6.1	6.1	>6.1

¹ A Tier II test was conducted for radish because 2 plants died in Tier I. No effects were seen in the Tier II test up to 6.1 lbs a.i./A.

² Decrease in dry weight of 13%; not statistically significant but considered biologically significant.

³ Decrease in dry weight of 12%; statistically significant.

Appendix D. Output for Terrestrial Modeling – Avian and Mammalian

D-1: Output for Foliar Uses

Example Output for TREX:

TREX MODEL INPUTS		
These values will be used in the calculation of exposure estimates for foliar, granular, liquid and/or seed applications of pesticides.		
Chemical Identity and Application Information		
Chemical Name:	Thiram	
Seed Treatment? (Check if yes)	☐	FALSE
Use:	Residential	
Product name and form:		
% A.I. (leading zero must be entered for formulations <1% a.i.):	100.00%	
Application Rate (lb ai/acre)	16.33	
Half-life (days):	35	
Application Interval (days):	7	
Number of Applications:	3	
Are you assessing applications with variable rates or intervals?	no	
Assessed Species Inputs (optional, use defaults for RQs for national level assessments)		
What body weight range is assessed (grams)?	Birds	Mammals
Small	20	15
Medium	100	35
Large	1000	1000
Avian		

Endpoint	Toxicity value	Indicate test species below	Option al Test Organism Body weight (g)	Option al Test Species Name	Toxicity Value Reference (MRID)
LD50 (mg/kg-bw)	673.00	Other	1000.00	Ring neck pheasant	160000;
LC50 (mg/kg-diet)	3950.00	Bobwhite quail			22293
NOAEL (mg/kg-bw)		Bobwhite quail			
NOAEC (mg/kg-diet)	9.60	Mallard duck			45441201

Enter the Mineau et al. Scaling Factor		1.15
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Mammalian		
	Acute Study	Chronic Study
Size (g) of mammal used in toxicity study Default rat body weight is 350 grams	350	350
Endpoint	Toxicity value	Reference (MRID)
LD50 (mg/kg-bw)	1800.00	153548
LC50 (mg/kg-diet)		
Reported Chronic Endpoint	2.00	42095901
Is dietary concentration (mg/kg-diet) reported from the available chronic mammal study? (yes or no)	yes	
Enter dietary concentration (mg/kg-diet)	20.00	

Summary of Risk Quotient Calculations Based on Upper Bound Kenaga EECs

Table X. Upper Bound Kenaga, Acute Avian Dose-Based Risk Quotients		
		EECs and RQs

Size Class (grams)	Adjusted LD50	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
20	374.26	11732.10	31.35	5377.21	14.37	6599.31	17.63	733.26	1.96	4595.07	12.28	162.95	0.44
100	476.45	6690.14	14.04	3066.32	6.44	3763.21	7.90	418.13	0.88	2620.31	5.50	92.92	0.20
1000	673.00	2995.27	4.45	1372.83	2.04	1684.84	2.50	187.20	0.28	1173.15	1.74	41.60	0.06

Table X. Upper Bound Kenaga, Subacute Avian Dietary Based Risk Quotients										
LC50	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
3950	10301.26	2.61	4721.41	1.20	5794.46	1.47	643.83	0.16	4034.66	1.02

Size class not used for dietary risk quotients

Table X. Upper Bound Kenaga, Chronic Avian Dietary Based Risk Quotients										
NOA EC (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
10	10301.26	1073.05	4721.41	491.81	5794.46	603.59	643.83	67.07	4034.66	420.28

Size class not used for dietary risk quotients

Table X. Upper Bound Kenaga, Acute Mammalian Dose-Based Risk Quotients													
Size Class (grams)	Adjusted LD50	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	3956.09	9821.46	2.48	4501.50	1.14	5524.57	1.40	613.84	0.16	3846.73947	0.9723577	136.4092	0.0345
35	3200.90	6787.94	2.12	3111.14	0.97	3818.22	1.19	424.25	0.13	2658.6116	0.8305818	94.277007	0.0295

1000	1384.4 9	1573.8 1	1.14	721.3 3	0.52	885.2 7	0.64	98.36	0.07	616.408 421	0.4452 245	21.858 455	0.01 58
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Table X. Upper Bound Kenaga, Acute Mammalian Dietary Based Risk Quotients										
LC50 (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
0	10301.26	#DIV/0!	4721.41	#DIV/0!	5794.46	#DIV/0!	643.83	#DIV/0!	4034.66	#DIV/0!

Size class not used for dietary risk quotients

Table X. Upper Bound Kenaga, Chronic Mammalian Dietary Based Risk Quotients										
NOAEC (ppm)	EECs and RQs									
	Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds/Large Insects		Arthropods	
	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
20	10301.26	515.06	4721.41	236.07	5794.46	289.72	643.83	32.19	4034.66	201.73

Size class not used for dietary risk quotients

Table X. Upper Bound Kenaga, Chronic Mammalian Dose-Based Risk Quotients													
Size Class (grams)	Adjusted NOAEL	EECs and RQs											
		Short Grass		Tall Grass		Broadleaf Plants		Fruits/Pods/Seeds		Arthropods		Granivore	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
15	4.40	9821.46	2234.35	4501.50	1024.08	5524.57	1256.82	613.84	139.65	3846.74	875.12	136.41	31.03
35	3.56	6787.94	1908.57	3111.14	874.76	3818.22	1073.57	424.25	119.29	2658.61	747.52	94.28	26.51
1000	1.54	1573.81	1023.07	721.33	468.91	885.27	575.48	98.36	63.94	616.41	400.70	21.86	14.21

D-2: Lists and Output for Seed Treatments

**Table D-2-1. Seed Treatment
Minimum and Maximum Labeled
Application Rates and Seeding
Rates¹**

Row Labels	Seeding Rate (from TREX), lb seed/A	Max of A.I.	Min of A.I.	Max lb/A	Min lb/A
ALFALFA	15	0.00175	0.00175	0.02625	0.02625
BARLEY	138.3	0.0025	0.000391	0.34575	0.0540753
BEANS, DRIED-TYPE	163.4	0.000867	0.000384	0.1416678	0.0627456
BEANS, MUNG	163.4	0.000984	0.000984	0.1607856	0.1607856
BEANS, SUCCULENT (SNAP)	435.6	0.000656	0.000384	0.2857536	0.1672704
BEETS	25	0.00263	0.00248	0.06575	0.062
BROCCOLI	2.6	0.00263	0.00248	0.006838	0.006448
BRUSSELS SPROUTS	0.4	0.00263	0.00248	0.001052	0.000992
BUCKWHEAT	72	0.000867	0.000867	0.062424	0.062424
CABBAGE	2.2	0.00263	0.00248	0.005786	0.005456
CANOLA\RAPE	8.2	0.0021	0.000846	0.01722	0.0069372
CARROT (INCLUDING TOPS)	11.9	0.00263	0.00248	0.031297	0.029512
CASTOR BEAN	8.2	0.00148	0.00141	0.012136	0.011562
CAULIFLOWER	0.3	0.00263	0.00248	0.000789	0.000744
CELERY		0.0025	0.0025	0	0
CHARD, SWISS	25	0.00263	0.00248	0.06575	0.062
CHICORY	0.8	0.00164	0.00141	0.001312	0.001128
CLOVER	30	0.00175	0.00175	0.0525	0.0525
COLLARDS	4	0.00263	0.00248	0.01052	0.00992
Coniferous/Evergreen/Softwood (non-food)		0.021	0.0101	0	0
CORIANDER	8	0.00156	0.00156	0.01248	0.01248
CORN, FIELD	29.6	0.00106	0.000469	0.031376	0.0138824
CORN, SWEET	33.2	0.00164	0.000867	0.054448	0.0287844
COTTON	18.9	0.00141	0.000608	0.026649	0.0114912
COWPEAS	163.4	0.000656	0.000609	0.1071904	0.0995106
CUCUMBER	11.6	0.00148	0.00141	0.017168	0.016356
EGGPLANT		0.00213	0.00188	0	0
ENDIVE (ESCAROLE)	0.8	0.00263	0.00248	0.002104	0.001984
FLAX	156	0.00164	0.000938	0.25584	0.146328

**Table D-2-1. Seed Treatment
Minimum and Maximum Labeled
Application Rates and Seeding
Rates¹**

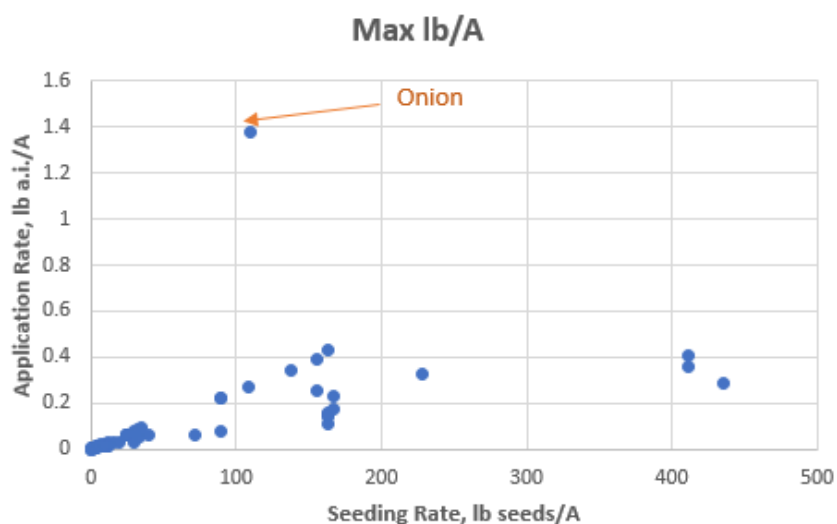
Row Labels	Seeding Rate (from TREX), lb seed/A	Max of A.I.	Min of A.I.	Max lb/A	Min lb/A
Flowering plants	4	0.00263	0.00201	0.01052	0.00804
Grass/Turf	25	0.00263	0.000867	0.06575	0.021675
KALE	5.8	0.00263	0.00248	0.015254	0.014384
KOHLRABI	2.6	0.00263	0.00248	0.006838	0.006448
LENTILS	163.4	0.000938	0.000938	0.1532692	0.1532692
LETTUCE	0.8	0.00263	0.00248	0.002104	0.001984
MELONS, CANTALOUPE	2.2	0.00148	0.00141	0.003256	0.003102
MELONS, WATER	9.1	0.00148	0.00141	0.013468	0.012831
MILLET (UNSPECIFIED)	30	0.0025	0.000625	0.075	0.01875
MUSTARD	7	0.00263	0.00201	0.01841	0.01407
Non-flowering Plants		0.00263	0.0025	0	0
OATS	90	0.0025	0.000391	0.225	0.03519
OATS (SILAGE)	90	0.000867	0.000867	0.07803	0.07803
OKRA		0.00197	0.00188	0	0
ONION	110	0.0125	0.00188	1.375	0.2068
PARSLEY	40	0.00156	0.00156	0.0624	0.0624
PEANUTS	228.3	0.00142	0.000867	0.324186	0.1979361
PEAS (UNSPECIFIED)	411	0.000984	0.000938	0.404424	0.385518
PEAS, DRIED-TYPE	411	0.000867	0.000867	0.356337	0.356337
PEPPER	4.2	0.00263	0.00248	0.011046	0.010416
PUMPKIN	4.5	0.00148	0.00141	0.00666	0.006345
RADISH	32.7	0.00263	0.00248	0.086001	0.081096
RICE	166.7	0.00136	0.000432	0.226712	0.0720144
RYE	90	0.0025	0.000506	0.225	0.04554
SAFFLOWER (UNSPECIFIED)	35	0.00259	0.000625	0.09065	0.021875
SESAME	12	0.000984	0.000938	0.011808	0.011256
SMALL SEEDED LEGUMES	163.4	0.00263	0.00248	0.429742	0.405232
SORGHUM	9.1	0.0025	0.000625	0.02275	0.0056875
SORGHUM (SILAGE)		0.00176	0.00176	0	0
SOYBEANS	166.7	0.00103	0.000384	0.171701	0.0640128
SPINACH	25	0.00263	0.00248	0.06575	0.062

**Table D-2-1. Seed Treatment
Minimum and Maximum Labeled
Application Rates and Seeding
Rates¹**

Row Labels	Seeding Rate (from TRES), lb seed/A	Max of A.I.	Min of A.I.	Max lb/A	Min lb/A
SQUASH (ALL OR UNSPECIFIED)	8	0.00148	0.00141	0.01184	0.01128
SUGAR BEET	4.8	0.00263	0.00248	0.012624	0.011904
SUNFLOWER	4	0.00259	0.000625	0.01036	0.0025
TOMATO	1.1	0.00197	0.00188	0.002167	0.002068
TRITICALE	109	0.0025	0.000288	0.2725	0.031392
TURNIP (ROOT)	6	0.00263	0.00248	0.01578	0.01488
VETCH	9	0.00175	0.00175	0.01575	0.01575
WHEAT	156	0.0025	0.000391	0.39	0.060996

¹List from the "Maximum Use Scenario Report" (February 26, 2019 PLUS report from BEAD, Biological and Economic Analysis Division).

**Figure D-2-1: Charts of Minimum and Maximum Application Rates from Table D-2-2 Plotted
Against Seeding Rates**



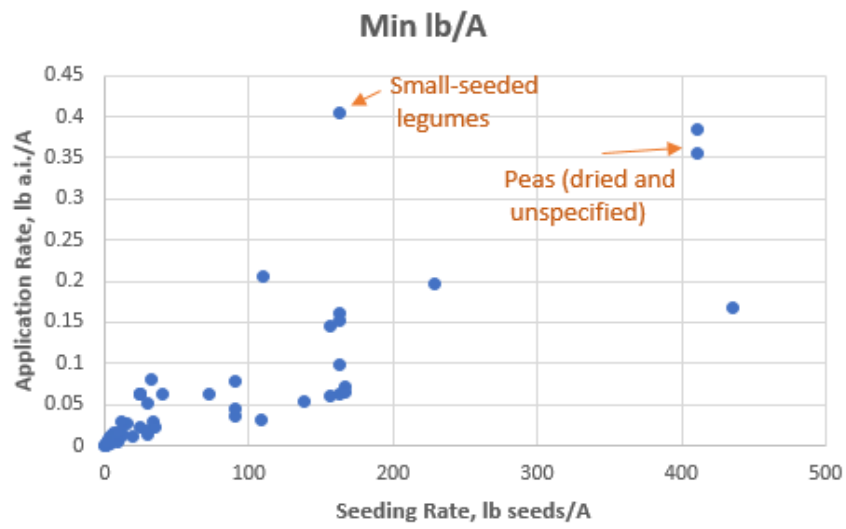


Table D-2-2. Seed Treatment Maximum Labeled Application Rate and Seeding Rates with Applications Ranked by Pounds per Acre

Use Site	Max. Rate/ Application lb a.i./lb seed	Max. Rate (from TREX) lb seed /acre	Max. App. Rate lb a.i./ acre ¹
ONION	0.0125	110	1.3750
SMALL SEEDED LEGUMES (used dry bean rate)	0.00263	163.4	0.4297
PEAS (UNSPECIFIED)	0.000984	411	0.4044
WHEAT	0.0025	156	0.3900
PEAS, DRIED-TYPE	0.000867	411	0.3563
BARLEY	0.0025	138.3	0.3458
PEANUTS	0.00142	228.3	0.3242
BEANS, SUCCULENT (SNAP)	0.000656	435.6	0.2858
TRITICALE (used triticale for forage)	0.0025	109	0.2725
FLAX (used spring wheat rate)	0.00164	156	0.2558
RICE	0.00136	166.7	0.2267
OATS	0.0025	90	0.2250
RYE	0.0025	90	0.2250
SOYBEANS	0.00103	166.7	0.1717
BEANS, MUNG (used dry bean rate)	0.000984	163.4	0.1608
LENTILS (used dry bean rate)	0.000938	163.4	0.1533
BEANS, DRIED-TYPE	0.000876	163.4	0.1431
COWPEAS (used dry bean rate)	0.000656	163.4	0.1072
SAFFLOWER (UNSPECIFIED)	0.00259	35	0.0907
RADISH	0.00263	32.7	0.0860
OATS (SILAGE)	0.000867	90	0.0780
MILLET (UNSPECIFIED)	0.0025	30	0.0750
BEETS	0.00263	25	0.0658
CHARD, SWISS (used beet rate)	0.00263	25	0.0658
Grass/Turf (used perennial grass rate)	0.00263	25	0.0658
SPINACH	0.00263	25	0.0658
BUCKWHEAT	0.000867	72	0.0624
PARSLEY	0.00156	40	0.0624
CORN, SWEET	0.00164	33.2	0.0544
CLOVER	0.00175	30	0.0525

Use Site	Max. Rate/ Application lb a.i./lb seed	Max. Rate (from TREX) lb seed /acre	Max. App. Rate lb a.i./ acre ¹
CORN, FIELD	0.00106	29.6	0.0314
CARROT (INCLUDING TOPS)	0.00263	11.9	0.0313
COTTON	0.00141	18.9	0.0266
ALFALFA	0.00175	15	0.0263
SORGHUM	0.0025	9.1	0.0228
MUSTARD	0.00263	7	0.0184
CANOLA\RAPE	0.0021	8.2	0.0172
CUCUMBER	0.00148	11.6	0.0172
TURNIP (ROOT)	0.00263	6	0.0158
VETCH	0.00175	9	0.0158
KALE	0.00263	5.8	0.0153
MELONS, WATER	0.00148	9.1	0.0135
SUGAR BEET	0.00263	4.8	0.0126
CORIANDER (used dill weed rate)	0.00156	8	0.0125
CASTOR BEAN (used rape rate)	0.00148	8.2	0.0121
SQUASH (ALL OR UNSPECIFIED)	0.00148	8	0.0118
SESAME	0.000984	12	0.0118
PEPPER	0.00263	4.2	0.0110
COLLARDS	0.00263	4	0.0105
Flowering plants (used sunflower rate)	0.00263	4	0.0105
SUNFLOWER	0.00259	4	0.0104
BROCCOLI	0.00263	2.6	0.0068
KOHLRABI (used broccoli rate)	0.00263	2.6	0.0068
PUMPKIN	0.00148	4.5	0.0067
CABBAGE	0.00263	2.2	0.0058
MELONS, CANTALOUPE	0.00148	2.2	0.0033
ENDIVE (ESCAROLE) (used lettuce rate)	0.00263	0.8	0.0021
LETTUCE	0.00263	0.8	0.0021
TOMATO	0.00188	1.1	0.0021
CHICORY (used lettuce rate)	0.00164	0.8	0.0013
BRUSSELS SPROUTS	0.00263	0.4	0.0011
CAULIFLOWER	0.00263	0.3	0.0008
CELERY	0.0025	No Information in TREX	Not Calculated

Use Site	Max. Rate/ Application lb a.i./lb seed	Max. Rate (from TREX) lb seed /acre	Max. App. Rate lb a.i./ acre ¹
Coniferous/Evergreen/Softwood (non-food)	0.021	No Information in TREX	Not Calculated
EGGPLANT	0.00213	No Information in TREX	Not Calculated
Non-flowering Plants	0.00263	No Information in TREX	Not Calculated
OKRA	0.00197	No Information in TREX	Not Calculated
SORGHUM (SILAGE)	0.00176	No Information in TREX	Not Calculated

¹ Maximum rate in lbs a.i./acre calculated by multiplying the maximum label rate (in lb a.i./lb seed) by the seeding rate (in lbs seed/ acre) found on the Seed Treatment sheet in the TREX program: lb a.i./lb seed * lbseed/acre = lb a.i./acre.

TREX Output Example:

Chemical: Name of seed treatment formulation: Percent AI in formulation:		Thiram- Triticale				Data inputs are in blue	
		0					
		100%			Density of product (lbs/gal):		8.33
Endpoints		Reported	Tested Body Weight (g)	Adjusted LD50	Size class for adjusted LD50		
Avian LD50:		673.00	1000	374.26	Small (20g)		
Avian repro. NOAEC:		9.60		476.45	Medium (100g)		
				673.00	Large (1000g)		
		Mammalian LD50:		1800.00	350		
Mammalian NOAEL:		20.00		3200.90	Medium (35g)		
				1384.49	Large (1000g)		
			Adjusted NOAEL for Mammals				
			Small (15g)	4.40			
			Medium (35g)	3.56			
			Large (1000g)	1.54			
Animal Size	Crop	Maximum Applicatio n 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)	
Small	triticale for forage	0.21	1952.34	494.12	413.65	2.22	
Medium				281.77	285.89		
Large				126.15	66.28		
Crop	Risk Quotients†						
	Avian (20 g)			Mammalian (15 g)			
	Acute (# 1)	Acute (# 2)	Chronic	Acute (# 1)	Acute (# 2)	Chronic	
triticale for forage	1.32	0.30	203.37	0.10	0.04	94.10	
	Avian (100 g)			Mammalian (35 g)			
	Acute (# 1)	Acute (# 2)	Chronic	Acute (# 1)	Acute (# 2)	Chronic	
triticale for forage	0.59	0.05	203.37	0.09	0.02	80.38	
	Avian (1000 g)			Mammalian (1000 g)			
	Acute (# 1)	Acute (# 2)	Chronic	Acute (# 1)	Acute (# 2)	Chronic	
triticale for forage	0.19	0.00	203.37	0.05	0.00	43.09	

Acute RQ #1 = (mg ai /kg-bw/day) / LD50

Acute RQ #2 = mg ai ft-2 / (LD50*bw)

Avian Chronic RQ = mg kg-1 seed / NOAEL

Mammalian Chronic RQ = mg a.i./kg-bw/day / adjusted NOAEL

Seed Treatment Calculations Per Seed and Area:

Onion:

Seed Risk Assessment Characterization Tool 1.0

Inputs Parameters

Product Information		
Application Rate	38	fl oz/cwt
Percent ai in formulation	50%	
Density of product formulation	9.5	lbs/gal

Toxicity			Test Species		
LD50, avian	673	mg/kg-bw	Other	If Other, please specify BW:	1000 g
LD50, mammal	1800	mg/kg-bw	Rat	If Other, please specify BW:	g
NOAEC, avian	9.6	mg/kg-diet	Mallard	If Other, please specify BW:	g
NOAEL, mammal	2	mg/kg-bw	Rat	If Other, please specify BW:	g
Enter Mineau et al. scaling factor	1.15	Default scaling factor = 1.15 (Mineau et al. 1996) (0.5 for nonlisted species, 0.1 for listed species)			
Acute LOC	0.5				

Seed Information		
Type of Seed	onion	Select Crop from List
Seeding Method	In-furrow or drill seed planting	Select Seeding Method from List
Seeding Rate		
Minimum	71,280	seed/A
Maximum	3,136,320	seed/A
Manual or Override Value		seed/A

Number of Seeds per Pound		
Minimum	100,000	seeds/lb of seeds
Maximum	130,000	seeds/lb of seeds
Manual or Override Value		seeds/lb of seeds
Consumption Efficiency	100%	

Estimated application rate lbs a.i./A	
Maximum Application Rates Assuming Max A.I./Seed (lbs a.i./A)	Minimum Application Rates Assuming Max A.I./Seed (lbs a.i./A)
4.42E-01	3.40E-01
1.01E-02	7.73E-03

Acute #1					
Birds			Mammals		
Small	Medium	Large	Small	Medium	Large
59	372	5261	464	876	10822
76	484	6839	603	1138	14069
81.94	516.67	7306.94	644.44	1216.67	15030.56
4644.44	29577.78	417938.89	36850.00	69544.44	859772.22
0.05%	0.06%	0.06%	3.99%	2.97%	0.87%
3.08%	3.16%	3.39%	228.23%	170.02%	49.92%
268.3	1796.8	N/A	N/A	N/A	N/A
0.93%	6.24%	N/A	N/A	N/A	N/A
405.47	2362.4	N/A	N/A	N/A	N/A
1.41%	8.20%	N/A	N/A	N/A	N/A

Chronic #1					
Birds			Mammals		
Small	Medium	Large	Small	Medium	Large

1	1	8	1	2	24
1	1	11	1	3	31
1.39	1.39	11.11	1.39	2.78	33.33
61.11	61.11	15.28	1.39	4.17	43.06
< 0.01%	< 0.01%	< 0.01%	< 0.01%	< 0.01%	< 0.01%
0.04%	< 0.01%	< 0.01%	< 0.01%	0.01%	< 0.01%
4.5	4.83	N/A	N/A	N/A	N/A
0.02%	0.02%	N/A	N/A	N/A	N/A
5.34	4.88	N/A	N/A	N/A	N/A
0.02%	0.02%	N/A	N/A	N/A	N/A

Acute #2					
Birds			Mammals		
Small	Medium	Large	Small	Medium	Large
1.96E+00	1.54E+00	1.09E+00	1.85E-01	2.29E-01	5.29E-01
2.54E+00	2.00E+00	1.41E+00	2.41E-01	2.97E-01	6.87E-01

Canola/Rape:

Seed Risk Assessment Characterization Tool 1.0

Inputs Parameters

Product Information		
Application Rate	6.4	fl oz/cwt
Percent ai in formulation	44%	
Density of product formulation	10.1	lbs/gal

Toxicity			Test Species			
LD50, avian	673	mg/kg-bw	Other	If Other, please specify BW:	1000	g
LD50, mammal	1800	mg/kg-bw	Rat	If Other, please specify BW:		g
NOAEC, avian	9.6	mg/kg-diet	Mallard	If Other, please specify BW:		g
NOAEL, mammal	2	mg/kg-bw	Rat	If Other, please specify BW:		g
Enter Mineau et al. scaling factor	1.15	Default scaling factor = 1.15 (Mineau et al. 1996) (0.5 for nonlisted species, 0.1 for listed species)				
Acute LOC	0.5					

Seed Information		
Type of Seed	rape	
Seeding Method	In-furrow or drill seed planting	
Seeding Rate		
Minimum	435,600	seed/A
Maximum	740,520	seed/A
Manual or Override Value		seed/A
Number of Seeds per Pound		
Minimum	13,000	seeds/lb of seeds

Select Crop from List

Select Seeding Method from List

Maximum	13,000	seeds/lb of seeds	
Manual or Override Value	13,000	seeds/lb of seeds	
Consumption Efficiency	100%		

RESULTS TABLES

	Estimated application rate lbs a.i./A	
	Maximum Application Rates Assuming Max A.I./Seed (lbs a.i./A)	Minimum Application Rates Assuming Max A.I./Seed (lbs a.i./A)
Based on maximum seeding rate	1.27E-01	1.27E-01
Based on minimum seeding rate	7.45E-02	7.45E-02

	Acute #1					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Seed concern (min # seeds)	48	307	4336	382	722	8921
Seed concern (max # seeds)	48	307	4336	382	722	8921
Minimum Forage area of concern (ft2)	282.35	1805.88	25505.88	2247.06	4247.06	52476.47
Maximum Forage area of concern (ft2)	480.00	3070.00	43360.00	3820.00	7220.00	89210.00
Minimum Percent of Home Range (%)	0.19%	0.19%	0.21%	13.92%	10.38%	3.05%
Maximum Percent of Home Range (%)	0.32%	0.33%	0.35%	23.66%	17.65%	5.18%
Minimum forage time of concern (s)	560.0	2029.9	N/A	N/A	N/A	N/A
Percent of minimum foraging time (%)	1.94%	7.05%	N/A	N/A	N/A	N/A
Maximum forage time of concern (s)	9781.07	2029.9	N/A	N/A	N/A	N/A
Percent of maximum foraging time (%)	33.96%	7.05%	N/A	N/A	N/A	N/A

	Chronic #1					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large

Seed concern (min # seeds)	1	1	7	1	2	20
Seed concern (max # seeds)	1	1	7	1	2	20
Minimum Forage area of concern (ft2)	5.88	5.88	41.18	5.88	11.76	117.65
Maximum Forage area of concern (ft2)	10.00	10.00	41.18	5.88	11.76	117.65
Minimum Percent of Home Range (%)	< 0.01%	< 0.01%	< 0.01%	0.04%	0.03%	< 0.01%
Maximum Percent of Home Range (%)	< 0.01%	< 0.01%	< 0.01%	0.04%	0.03%	< 0.01%
Minimum forage time of concern (s)	11.7	6.61	N/A	N/A	N/A	N/A
Percent of minimum foraging time (%)	0.04%	0.02%	N/A	N/A	N/A	N/A
Maximum forage time of concern (s)	203.77	6.61	N/A	N/A	N/A	N/A
Percent of maximum foraging time (%)	0.71%	0.02%	N/A	N/A	N/A	N/A

	Acute #2					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Minimum LD50 / ft2 using seed incorporation	1.88E+01	1.48E+01	1.05E+01	1.78E+00	2.20E+00	5.10E+00
Maximum LD50 / ft2 using seed incorporation	1.88E+01	1.48E+01	1.05E+01	1.78E+00	2.20E+00	5.10E+00

Peas (Unspecified) Garden Peas Used as the Representative:

Seed Risk Assessment Characterization Tool 1.0

Inputs Parameters

Product Information		
Application Rate	3	fl oz/cwt
Percent ai in formulation	44%	
Density of product formulation	9.5	lbs/gal

Toxicity			Test Species			
LD50, avian	673	mg/kg-bw	Other	If Other, please specify BW:	1000	g
LD50, mammal	1800	mg/kg-bw	Rat	If Other, please specify BW:		g
NOAEC, avian	9.6	mg/kg-diet	Mallard	If Other, please specify BW:		g
NOAEL, mammal	2	mg/kg-bw	Rat	If Other, please specify BW:		g
Enter Mineau et al. scaling factor	1.15	Default scaling factor = 1.15 (Mineau et al. 1996) (0.5 for nonlisted species, 0.1 for listed species)				
Acute LOC	0.5					

Seed Information		
Type of Seed	pea, garden	
Seeding Method	In-furrow or drill seed planting	
Seeding Rate		
Minimum	87,120	seed/A
Maximum	522,720	seed/A
Manual or Override Value		seed/A
Number of Seeds per Pound		
Minimum	13,000	seeds/lb of seeds

Select Crop from List

Select Seeding Method from List

Maximum	13,000	seeds/lb of seeds	
Manual or Override Value	13,000	seeds/lb of seeds	
Consumption Efficiency	100%		

RESULTS TABLES

	Estimated application rate lbs a.i./A	
	Maximum Application Rates Assuming Max A.I./Seed (lbs a.i./A)	Minimum Application Rates Assuming Max A.I./Seed (lbs a.i./A)
Based on maximum seeding rate	3.94E-02	3.94E-02
Based on minimum seeding rate	6.57E-03	6.57E-03

	Acute #1					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Seed concern (min # seeds)	109	696	9835	867	1637	20233
Seed concern (max # seeds)	109	696	9835	867	1637	20233
Minimum Forage area of concern (ft2)	908.33	5800.00	81958.33	7225.00	13641.67	168608.33
Maximum Forage area of concern (ft2)	5450.00	34800.00	491750.00	43350.00	81850.00	1011650.00
Minimum Percent of Home Range (%)	0.60%	0.62%	0.66%	44.75%	33.35%	9.79%
Maximum Percent of Home Range (%)	3.62%	3.72%	3.99%	268.49%	200.11%	58.74%
Minimum forage time of concern (s)	1271.7	4602.1	N/A	N/A	N/A	N/A
Percent of minimum foraging time (%)	4.42%	15.98%	N/A	N/A	N/A	N/A
Maximum forage time of concern (s)	22211.18	4602.1	N/A	N/A	N/A	N/A
Percent of maximum foraging time (%)	77.12%	15.98%	N/A	N/A	N/A	N/A

	Chronic #1					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large

Seed concern (min # seeds)	1	2	15	2	4	45
Seed concern (max # seeds)	1	2	15	2	4	45
Minimum Forage area of concern (ft2)	8.33	16.67	125.00	16.67	33.33	375.00
Maximum Forage area of concern (ft2)	50.00	100.00	125.00	16.67	33.33	375.00
Minimum Percent of Home Range (%)	< 0.01%	< 0.01%	< 0.01%	0.10%	0.08%	0.02%
Maximum Percent of Home Range (%)	0.03%	0.01%	< 0.01%	0.10%	0.08%	0.02%
Minimum forage time of concern (s)	11.7	13.22	N/A	N/A	N/A	N/A
Percent of minimum foraging time (%)	0.04%	0.05%	N/A	N/A	N/A	N/A
Maximum forage time of concern (s)	203.77	13.22	N/A	N/A	N/A	N/A
Percent of maximum foraging time (%)	0.71%	0.05%	N/A	N/A	N/A	N/A

	Acute #2					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Minimum LD50 / ft2 using seed incorporation	1.66E+00	1.31E+00	9.24E-01	1.57E-01	1.94E-01	4.49E-01
Maximum LD50 / ft2 using seed incorporation	1.66E+00	1.31E+00	9.24E-01	1.57E-01	1.94E-01	4.49E-01

Lima Beans:

Seed Risk Assessment Characterization Tool 1.0

Inputs Parameters

Product Information		
Application Rate	2.2	fl oz/cwt
Percent ai in formulation	75%	
Density of product formulation	5.01	lbs/gal

Toxicity			Test Species			
LD50, avian	673	mg/kg-bw	Other	If Other, please specify BW:	1000	g
LD50, mammal	1800	mg/kg-bw	Rat	If Other, please specify BW:		g
NOAEC, avian	9.6	mg/kg-diet	Mallard	If Other, please specify BW:		g
NOAEL, mammal	2	mg/kg-bw	Rat	If Other, please specify BW:		g
Enter Mineau et al. scaling factor	1.15	Default scaling factor = 1.15 (Mineau et al. 1996) (0.5 for nonlisted species, 0.1 for listed species)				
Acute LOC	0.5					

Seed Information		
Type of Seed	bean, lima	Select Crop from List
Seeding Method	In-furrow or drill seed planting	Select Seeding Method from List
Seeding Rate		
Minimum	29,040	seed/A
Maximum	95,040	seed/A
Manual or Override Value		seed/A
Number of Seeds per Pound		
Minimum	907	seeds/lb of seeds

Maximum	907	seeds/lb of seeds	
Manual or Override Value		seeds/lb of seeds	
Consumption Efficiency	100%		

RESULTS TABLES

	Estimated application rate lbs a.i./A	
	Maximum Application Rates Assuming Max A.I./Seed (lbs a.i./A)	Minimum Application Rates Assuming Max A.I./Seed (lbs a.i./A)
Based on maximum seeding rate	6.77E-02	6.77E-02
Based on minimum seeding rate	2.07E-02	2.07E-02

	Acute #1					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Seed concern (min # seeds)	12	74	1042	92	173	2143
Seed concern (max # seeds)	12	74	1042	92	173	2143
Minimum Forage area of concern (ft2)	Seed size too big.	Seed size too big.	47758.33	4216.67	7929.17	98220.83
Maximum Forage area of concern (ft2)	Seed size too big.	Seed size too big.	156300.00	13800.00	25950.00	321450.00
Minimum Percent of Home Range (%)	Seed size too big.	Seed size too big.	0.39%	26.12%	19.39%	5.70%
Maximum Percent of Home Range (%)	Seed size too big.	Seed size too big.	1.27%	85.47%	63.44%	18.66%
Minimum forage time of concern (s)	Seed size too big.	Seed size too big.	N/A	N/A	N/A	N/A
Percent of minimum foraging time (%)	Seed size too big.	Seed size too big.	N/A	N/A	N/A	N/A
Maximum forage time of concern (s)	Seed size too big.	Seed size too big.	N/A	N/A	N/A	N/A
Percent of maximum foraging time (%)	Seed size too big.	Seed size too big.	N/A	N/A	N/A	N/A

	Chronic #1					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large

Seed concern (min # seeds)	1	1	2	1	1	5
Seed concern (max # seeds)	1	1	2	1	1	5
Minimum Forage area of concern (ft2)	Seed size too big.	Seed size too big.	91.67	45.83	45.83	229.17
Maximum Forage area of concern (ft2)	Seed size too big.	Seed size too big.	91.67	45.83	45.83	229.17
Minimum Percent of Home Range (%)	Seed size too big.	Seed size too big.	< 0.01%	0.28%	0.11%	0.01%
Maximum Percent of Home Range (%)	Seed size too big.	Seed size too big.	< 0.01%	0.28%	0.11%	0.01%
Minimum forage time of concern (s)	Seed size too big.	Seed size too big.	N/A	N/A	N/A	N/A
Percent of minimum foraging time (%)	Seed size too big.	Seed size too big.	N/A	N/A	N/A	N/A
Maximum forage time of concern (s)	Seed size too big.	Seed size too big.	N/A	N/A	N/A	N/A
Percent of maximum foraging time (%)	Seed size too big.	Seed size too big.	N/A	N/A	N/A	N/A

	Acute #2					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Minimum LD50 / ft2 using seed incorporation	5.23E+00	4.11E+00	2.91E+00	4.95E-01	6.12E-01	1.41E+00
Maximum LD50 / ft2 using seed incorporation	5.23E+00	4.11E+00	2.91E+00	4.95E-01	6.12E-01	1.41E+00

Triticale:

Seed Risk Assessment Characterization Tool 1.0

Inputs Parameters

Product Information		
Application Rate	3	fl oz/cwt
Percent ai in formulation	13%	
Density of product formulation	9.3	lbs/gal

Toxicity			Test Species			
LD50, avian	673	mg/kg-bw	Other	If Other, please specify BW:	1000	g
LD50, mammal	1800	mg/kg-bw	Rat	If Other, please specify BW:		g
NOAEC, avian	9.6	mg/kg-diet	Mallard	If Other, please specify BW:		g
NOAEL, mammal	2	mg/kg-bw	Rat	If Other, please specify BW:		g
Enter Mineau et al. scaling factor	1.15	Default scaling factor = 1.15 (Mineau et al. 1996) (0.5 for nonlisted species, 0.1 for listed species)				
Acute LOC	0.5					

Seed Information		
Type of Seed	triticale for forage	
Seeding Method	In-furrow or drill seed planting	
Seeding Rate		
Minimum	109	seed/A
Maximum	109	seed/A
Manual or Override Value	109	seed/A
Number of Seeds per Pound		
Minimum	13,000	seeds/lb of seeds

Maximum	13,000	seeds/lb of seeds	
Manual or Override Value	13,000	seeds/lb of seeds	
Consumption Efficiency	100%		

Manually input the seeding rate (from TREX) and the min and max seeds/lb seeds (11,500 and 13000 seeds/lb) each in separate runs and copied the output below. Seed weight information obtained from an Riverdale Agricultural Service, Muscoda, WI (<http://www.riverdaleagservice.com/index.cfm?show=10&mid=30>).

	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Seed concern (min # seeds)	329	2091	29540	2605	4917	60769
Seed concern (max # seeds)	371	2364	33393	2944	5559	68695
Minimum Forage area of concern (ft2)	13147926.61	83563266.06	1180515963.30	104104403.67	196499559.63	2428529944.95
Maximum Forage area of concern (ft2)	14826385.32	94473247.71	1334494568.81	117651963.30	222156000.00	2745279082.57
Minimum Percent of Home Range (%)	8724.88%	8923.32%	9578.48%	644775.00%	480405.90%	141011.27%
Maximum Percent of Home Range (%)	9838.70%	10088.35%	10827.84%	728682.38%	543131.26%	159403.14%
Minimum forage time of concern (s)	4328.4	15631.2	N/A	N/A	N/A	N/A
Percent of minimum foraging time (%)	15.03%	54.28%	N/A	N/A	N/A	N/A
Maximum forage time of concern (s)	75599.51	15631.2	N/A	N/A	N/A	N/A
Percent of maximum foraging time (%)	262.50%	54.28%	N/A	N/A	N/A	N/A

	Chronic #1					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Seed concern (min # seeds)	1	5	52	7	12	153
Seed concern (max # seeds)	1	5	52	7	12	153
Minimum Forage area of concern (ft2)	39963.30	199816.51	2078091.74	279743.12	479559.63	6114385.32
Maximum Forage area of concern (ft2)	39963.30	199816.51	2078091.74	279743.12	479559.63	6114385.32
Minimum Percent of Home Range (%)	26.52%	21.34%	16.86%	1732.60%	1172.44%	355.03%
Maximum Percent of Home Range (%)	26.52%	21.34%	16.86%	1732.60%	1172.44%	355.03%
Minimum forage time of concern (s)	11.7	33.06	N/A	N/A	N/A	N/A
Percent of minimum foraging time (%)	0.04%	0.11%	N/A	N/A	N/A	N/A

Maximum forage time of concern (s)	203.77	33.06	N/A	N/A	N/A	N/A
Percent of maximum foraging time (%)	0.71%	0.11%	N/A	N/A	N/A	N/A

	Acute #2					
	Birds			Mammals		
	Small	Medium	Large	Small	Medium	Large
Minimum LD50 / ft2 using seed incorporation	6.13E-04	4.81E-04	3.41E-04	5.79E-05	7.16E-05	1.66E-04
Maximum LD50 / ft2 using seed incorporation	6.92E-04	5.44E-04	3.85E-04	6.55E-05	8.10E-05	1.87E-04

Appendix E. Output for Pollinator Modelling

Example BeeRex Output for Thiram:

Table 1. User inputs (related to exposure)

Description	Value
Application rate	16.33
Units of app rate	lb a.i./A
Application method	foliar spray
Are empirical residue data available?	no

Table 2. Toxicity data

Description	Value (µg a.i./bee)
Adult contact LD50	73.7
Adult oral LD50	<i>106</i>
Adult oral NOAEL	<i>4.32</i>
Larval LD50	0.28
Larval NOAEL	0.0254

Note: These are non-definitive (>) endpoints and all associated RQs are not true RQs, but risk ratios of exposure to toxicity (in red italics).

Table 5. Results (highest RQs)

Exposure	Adults	Larvae
Acute contact	0.59825	NA
Acute dietary	<i>4.95</i>	792.94
Chronic dietary	<i>121.43</i>	8741.05

Table 3. Estimated concentrations in pollen and nectar

Application method	EECs (mg a.i./kg)	EECs (µg a.i./mg)
foliar spray	1796.3	1.7963
soil application	NA	NA
seed treatment	NA	NA
tree trunk	NA	NA

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

Life stage	Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (µg a.i./bee)	Acute RQ	Chronic RQ
Larval	Worker	1	1.9	0	0	0.0341297	0.12189179	1.343689
		2	9.4	0	0	0.1688522	0.60304357	6.647724
		3	19	0	0	0.341297	1.21891786	13.43689
		4	0	60	1.8	111.01134	396.469071	4370.525
		5	0	120	3.6	222.02268	792.938143	8741.05
	Drone	6+	0	130	3.6	239.98568	857.091714	9448.255
	Queen	1	1.9	0	0	0.0341297	0.12189179	1.343689
		2	9.4	0	0	0.1688522	0.60304357	6.647724
		3	23	0	0	0.413149	1.47553214	16.26571
		4+	141	0	0	2.532783	9.04565357	99.71587
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	119.723395	1.12946599	27.71375
	Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	268.72648	2.53515547	62.2052
	Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	110.83171	1.04558217	25.65549
	Worker (foraging for pollen)	>18	0	43.5	0.041	78.2126983	0.73785564	18.10479
	Worker (foraging for nectar)	>18	0	292	0.041	524.5932483	4.94899291	121.4336
	Worker (maintenance of hive in winter)	0-90	0	29	2	55.6853	0.52533302	12.89012
	Drone	>10	0	235	0.0002	422.1308593	3.9823666	97.71548
	Queen (laying 1500 eggs/day)	Entire lifestage	525	0	0	9.430575	0.08896769	2.183003

Example BeeRex Output for Ferbam (expressed as thiram a.i.):

Table 1. User inputs (related to exposure)

Description	Value
Application rate	5.2
Units of app rate	lb a.i./A
Application method	foliar spray
Are empirical residue data available?	no

Table 2. Toxicity data

Description	Value (µg a.i./bee)
Adult contact LD50	73.7
Adult oral LD50	106
Adult oral NOAEL	4.32
Larval LD50	0.28
Larval NOAEL	0.0254

Table 3. Estimated concentrations in pollen and nectar

Application method	EECs (mg a.i./kg)	EECs (µg a.i./mg)
foliar spray	572	0.572
soil application	NA	NA
seed treatment	NA	NA
tree trunk	NA	NA

Table 5. Results (highest RQs)

Exposure	Adults	Larvae
Acute contact	0.190502	NA
Acute dietary	1.58	252.50
Chronic dietary	38.67	2783.43

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

Life stage	Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (μg a.i./bee)	Acute RQ	Chronic RQ
Larval	Worker	1	1.9	0	0	0.010868	0.03881429	0.427874
		2	9.4	0	0	0.053768	0.19202857	2.11685
		3	19	0	0	0.10868	0.38814286	4.27874
		4	0	60	1.8	35.3496	126.248571	1391.717
		5	0	120	3.6	70.6992	252.497143	2783.433
	Drone	6+	0	130	3.6	76.4192	272.925714	3008.63
	Queen	1	1.9	0	0	0.010868	0.03881429	0.427874
		2	9.4	0	0	0.053768	0.19202857	2.11685
		3	23	0	0	0.13156	0.46985714	5.179528
		4+	141	0	0	0.80652	2.88042857	31.75276
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	38.1238	0.35965849	8.824954
	Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	85.5712	0.80727547	19.80815
	Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	35.2924	0.33294717	8.169537
	Worker (foraging for pollen)	>18	0	43.5	0.041	24.905452	0.23495709	5.765151
	Worker (foraging for nectar)	>18	0	292	0.041	167.047452	1.57591936	38.66839
	Worker (maintenance of hive in winter)	0-90	0	29	2	17.732	0.16728302	4.10463
	Drone	>10	0	235	0.0002	134.4201144	1.26811429	31.11577
	Queen (laying 1500 eggs/day)	Entire lifestage	525	0	0	3.003	0.02833019	0.695139

Example BeeRex Output for Ziram:

Table 1. User inputs (related to exposure)

Description	Value
Application rate	7.6
Units of app rate	lb a.i./A
Application method	foliar spray
Are empirical residue data available?	no

Table 5. Results (highest RQs)

Exposure	Adults	Larvae
Acute contact	0.218763	NA
Acute dietary	2.33	287.03
Chronic dietary	49.83	3199.06

µg a.i./mg

µg a.i./mg

µg a.i./mg

Table 2. Toxicity data

Description	Value (µg a.i./bee)
Adult contact LD50	93.8
Adult oral LD50	105
Adult oral NOAEL	4.9
Larval LD50	0.36
Larval NOAEL	0.0323

Table 3. Estimated concentrations in pollen and nectar

Application method	EECs (mg a.i./kg)	EECs (µg a.i./mg)
foliar spray	836	0.836
soil application	NA	NA
seed treatment	NA	NA
tree trunk	NA	NA

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

Life stage	Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (µg a.i./bee)	Acute RQ	Chronic RQ
Larval	Worker	1	1.9	0	0	0.015884	0.04412222	0.491765
		2	9.4	0	0	0.078584	0.21828889	2.432941
		3	19	0	0	0.15884	0.44122222	4.917647
		4	0	60	1.8	51.6648	143.513333	1599.529
		5	0	120	3.6	103.3296	287.026667	3199.059
	Drone	6+	0	130	3.6	111.6896	310.248889	3457.882
	Queen	1	1.9	0	0	0.015884	0.04412222	0.491765
		2	9.4	0	0	0.078584	0.21828889	2.432941
		3	23	0	0	0.19228	0.53411111	5.952941
		4+	141	0	0	1.17876	3.27433333	36.49412
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	55.7194	0.53066095	11.37131
	Worker (brood and queen tending, nurse bees)	6 to 17	0	140	9.6	125.0656	1.19110095	25.52359
	Worker (comb building, cleaning and food handling)	11 to 18	0	60	1.7	51.5812	0.49124952	10.52678
	Worker (foraging for pollen)	>18	0	43.5	0.041	36.400276	0.3466693	7.428628
	Worker (foraging for nectar)	>18	0	292	0.041	244.146276	2.32520263	49.82577
	Worker (maintenance of hive in winter)	0-90	0	29	2	25.916	0.24681905	5.28898
	Drone	>10	0	235	0.0002	196.4601672	1.87104921	40.09391
	Queen (laying 1500 eggs/day)	Entire lifestage	525	0	0	4.389	0.0418	0.895714

AgDrift Output for Pollinator Distances:

Ground Applications:

AgDRIFT - [x]

File Edit Tier View Toolbox Help

Title: Thiram

Boom Height:
☐ Low Boom
☒ High Boom

Drop Size Distribution:
☒ ASAE Very Fine to Fine
☐ ASAE Fine to Medium/Coarse

Data Percentile:
☐ 50th Percentile
☒ 90th Percentile

Extended Settings:
☐ Access Extended Settings
Number of Swaths:

Information:
High Boom ASAE Very Fine to Fine
Boom Height: 1.27 m (50 in)
Swath Width: 13.72 m (45 ft)
Dv0.5: 175 um
Application Efficiency [%] (20 swaths): 97.96

AgDRIFT® Tier I Ground

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 16.3 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: 32.81 ft
Initial Average Deposition: 0.081 g/ha 1.32 lb/ac 0.0148 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 16.3 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: 278.87 ft
Initial Average Deposition: 0.0081 g/ha 0.1353 lb/ac 0.0015 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 2.63 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: out of range ft
Initial Average Deposition: 0.0005 g/ha 0.0081 lb/ac 9.13E-05 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 2.63 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: 6.56 ft
Initial Average Deposition: 0.5 g/ha 1.31 lb/ac 0.0147 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 2.63 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: 49.21 ft
Initial Average Deposition: 0.051 g/ha 0.1341 lb/ac 0.0015 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 2.63 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: 593.82 ft
Initial Average Deposition: 0.0031 g/ha 0.0082 lb/ac 9.13E-05 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 2.63 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: out of range ft
Initial Average Deposition: 0.0007 g/ha 0.0019 lb/ac 2.09E-05 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 5.20 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: 13.12 ft
Initial Average Deposition: 0.25 g/ha 1.3 lb/ac 0.0146 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 5.20 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: 98.42 ft
Initial Average Deposition: 0.026 g/ha 0.1352 lb/ac 0.0015 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 5.20 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: 921.9 ft
Initial Average Deposition: 0.0016 g/ha 0.0083 lb/ac 9.32E-05 mg/cm²

Plot Export Print Calc Close

Terrestrial Assessment

Terrestrial Field Definition:
☒ Point Deposition
☐ User-defined Area Average
Downwind Width of Area Average: 208.7 ft

Tier I Settings:
Active Rate: 5.20 lb/ac

Calculations:
Distance To Point or Area Average From Edge of Application Area: out of range ft
Initial Average Deposition: 0.0004 g/ha 0.0019 lb/ac 2.10E-05 mg/cm²

Plot Export Print Calc Close

254

255

Aerial Applications (only for Thiram Strawberry and Peach Uses; Represented by Peach):

The screenshots show the AgDRIFT software interface for a Terrestrial Assessment. The main window is titled "AgDRIFT - [*]" and contains a menu bar (File, Edit, Tier, View, Toolbox, Help) and a title field set to "Thiram".

The "Drop Size Distribution" section has four radio buttons:

- ☐ ASAE Very Fine to Fine
- ☒ ASAE Fine to Medium (default)
- ☐ ASAE Medium to Coarse
- ☐ ASAE Coarse to Very Coarse

The "Terrestrial Field Definition" section has two radio buttons:

- ☒ Point Deposition
- ☐ User-defined Area Average

 The "Downwind Width of Area Average" is set to 208.7 ft.

The "Tier I Settings" section shows an "Active Rate" of 2.63 lb/ac.

The "Calculations" section shows:

- Distance To Point or Area Average From Edge of Application Area: 0 ft
- Fraction of Applied: 0.5
- Initial Average Deposition: 1473.3 g/ha, 1.31 lb/ac, 0.0147 mg/cm²

The bottom screenshot shows a "Calculations" section with:

- Distance To Point or Area Average From Edge of Application Area: 75.46 ft
- Fraction of Applied: 0.051
- Initial Average Deposition: 150.28 g/ha, 0.1341 lb/ac, 0.0015 mg/cm²

The bottom-right screenshot shows a "Calculations" section with:

- Distance To Point or Area Average From Edge of Application Area: out of range ft
- Fraction of Applied: 0.0031
- Initial Average Deposition: 9.13 g/ha, 0.0082 lb/ac, 9.13E-05 mg/cm²

Appendix F. Terrestrial Plant Assessment Output (Trex)

TerrPlant v. 1.2.2

Green values signify user inputs (Tables 1, 2 and 4).

Input and output guidance is in popups indicated by red arrows.

Table 1. Chemical Identity.	
Chemical Name	Thiram
PC code	79801
Use	Turf
Application Method	Ground
Application Form	Spray
Solubility in Water (ppm)	16.5

Table 2. Input parameters used to derive EECs.			
Input Parameter	Symbol	Value	Units
Application Rate	A	16.33	y
Incorporation	I	1	none
Runoff Fraction	R	0.02	none
Drift Fraction	D	0.05	none

Table 3. EECs for Thiram. Units in y.		
Description	Equation	EEC
Runoff to dry areas	$(A/I)*R$	0.3266
Runoff to semi-aquatic areas	$(A/I)*R*10$	3.266
Spray drift	$A*D$	0.8165
Total for dry areas	$((A/I)*R)+(A*D)$	1.1431
Total for semi-aquatic areas	$((A/I)*R*10)+(A*D)$	4.0825

Table 4. Plant survival and growth data used for RQ derivation. Units are in y.				
Plant type	Seedling Emergence		Vegetative Vigor	
	EC25	NOAEC	EC25	NOAEC
Monocot	>4.6 ¹	x	>4.6 ¹	x
Dicot	>4.1	x	>4.1	x

¹The EC₂₅s were non-definitive, greater-than (>) values; therefore, no definitive RQs were calculable.

Table 5. Risk ratios (similar to RQ values but using non-definitive endpoints) for plants in dry and semi-aquatic areas exposed to Thiram through runoff and/or spray drift.*				
Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Monocot	non-listed	(<)0.11	(<)0.75	<0.1
Monocot	listed	#VALUE!	#VALUE!	#DIV/0!
Dicot	non-listed	(<)0.12	(<)0.84	<0.1
Dicot	listed	#VALUE!	#VALUE!	#DIV/0!

*If ratio (screening for RQ) > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.

TerrPlant v. 1.2.2

Green values signify user inputs (Tables 1, 2 and 4).

Input and output guidance is in popups indicated by red arrows.

Table 1. Chemical Identity.	
Chemical Name	Thiram
PC code	79801
Use	Strawberry
Application Method	Aerial
Application Form	Spray
Solubility in Water (ppm)	16.5

Table 2. Input parameters used to derive EECs.			
Input Parameter	Symbol	Value	Units
Application Rate	A	3.3	y
Incorporation	I	1	none
Runoff Fraction	R	0.02	none
Drift Fraction	D	0.05	none

Table 3. EECs for Thiram. Units in y.		
Description	Equation	EEC
Runoff to dry areas	$(A/I)*R$	0.066
Runoff to semi-aquatic areas	$(A/I)*R*10$	0.66
Spray drift	$A*D$	0.165
Total for dry areas	$((A/I)*R)+(A*D)$	0.231
Total for semi-aquatic areas	$((A/I)*R*10)+(A*D)$	0.825

Table 4. Plant survival and growth data used for RQ derivation. Units are in y.				
Plant type	Seedling Emergence		Vegetative Vigor	
	EC25	NOAEC	EC25	NOAEC
Monocot	>4.6 ¹	x	>4.6 ¹	x
Dicot	>4.1	x	>4.1	x

¹The EC₂₅s were non-definitive, greater-than (>) values; therefore, no definitive RQs were calculable

Table 5. Risk ratios (similar to RQ values but using non-definitive endpoints) for plants in dry and semi-aquatic areas exposed to Thiram through runoff and/or spray drift.*				
Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Monocot	non-listed	<0.1	(<)0.18	<0.1
Monocot	listed	#VALUE!	#VALUE!	#DIV/0!
Dicot	non-listed	<0.1	(<)0.20	<0.1
Dicot	listed	#VALUE!	#VALUE!	#DIV/0!

*If ratio (screening for RQ) > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.

TerrPlant v. 1.2.2

Green values signify user inputs (Tables 1, 2 and 4).

Input and output guidance is in popups indicated by red arrows.

Table 1. Chemical Identity.	
Chemical Name	Ferbam (expressed as Thiram a.i.)
PC code	34801
Use	Citrus
Application Method	Ground
Application Form	Spray
Solubility in Water (ppm)	130 (ferbam) 16.5 (thiram)

Table 2. Input parameters used to derive EECs.			
Input Parameter	Symbol	Value	Units
Application Rate	A	5.2	y
Incorporation	I	1	none
Runoff Fraction	R	0.05	none
Drift Fraction	D	0.01	none

Table 3. EECs for Ferbam (expressed as Thiram a.i.). Units in y.		
Description	Equation	EEC
Runoff to dry areas	$(A/I)*R$	0.26
Runoff to semi-aquatic areas	$(A/I)*R*10$	2.6
Spray drift	$A*D$	0.052
Total for dry areas	$((A/I)*R)+(A*D)$	0.312
Total for semi-aquatic areas	$((A/I)*R*10)+(A*D)$	2.652

Table 4. Plant survival and growth data used for RQ derivation. Units are in y.				
Plant type	Seedling Emergence		Vegetative Vigor	
	EC25	NOAEC	EC25	NOAEC
Monocot	>4.6 ¹	x	>4.6 ¹	x
Dicot	>4.1	x	>4.1	x

¹The EC₂₅s were non-definitive, greater-than (>) values; therefore, no definitive RQs were calculable.

Table 5. Risk ratios (similar to RQ values but using non-definitive endpoints) for plants in dry and semi-aquatic areas exposed to Ferbam (expressed as Thiram a.i.) through runoff and/or spray drift.*				
Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Monocot	non-listed	<0.1	(<)0.58	<0.1
Monocot	listed	#VALUE!	#VALUE!	#DIV/0!
Dicot	non-listed	<0.1	(<)0.65	<0.1
Dicot	listed	#VALUE!	#VALUE!	#DIV/0!

*If ratio (screening for RQ) > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.

TerrPlant v. 1.2.2

Green values signify user inputs (Tables 1, 2 and 4).

Input and output guidance is in popups indicated by red arrows.

Table 1. Chemical Identity.	
Chemical Name	Ziram
PC code	34805
Use	Nectarine/ Peach
Application Method	Ground
Application Form	Spray
Solubility in Water (ppm)	0.97

Table 2. Input parameters used to derive EECs.			
Input Parameter	Symbol	Value	Units
Application Rate	A	7.6	y
Incorporation	I	1	none
Runoff Fraction	R	0.01	none
Drift Fraction	D	0.01	none

Table 3. EECs for Ziram. Units in y.		
Description	Equation	EEC
Runoff to dry areas	$(A/I)*R$	0.076
Runoff to semi-aquatic areas	$(A/I)*R*10$	0.76
Spray drift	$A*D$	0.076
Total for dry areas	$((A/I)*R)+(A*D)$	0.152
Total for semi-aquatic areas	$((A/I)*R*10)+(A*D)$	0.836

Table 4. Plant survival and growth data used for RQ derivation. Units are in y.				
Plant type	Seedling Emergence		Vegetative Vigor	
	EC25	NOAEC	EC25	NOAEC
Monocot	>6 ¹	x	>6.1 ¹	x
Dicot	>6	x	>6.1	x

¹The EC₂₅s were non-definitive, greater-than (>) values; therefore, no definitive RQs were calculable.

Table 5. Risk ratios (similar to RQ values but using non-definitive endpoints) for plants in dry and semi-aquatic areas exposed to Ziram through runoff and/or spray drift.*				
Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Monocot	non-listed	<0.1	(<)0.14	<0.1
Monocot	listed	#VALUE!	#VALUE!	#VALUE!
Dicot	non-listed	<0.1	(<)0.14	<0.1
Dicot	listed	#VALUE!	#VALUE!	#VALUE!

*If ratio (screening for RQ) > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group. In this case, the

Appendix G. AgDrift Output for Spray Drift Distances for Aquatic Concentrations

Spray-Drift Distances to Fish TEP endpoint concentrations (Note: concentration is in parts per trillion):

Residential Use:

High Boom/Fine Droplets:

AgDRIFT - [*]

File Edit Tier View Toolbox Help

Title: Thiram

Boom Height:
☐ Low Boom
☒ High Boom

Drop Size Distribution:
☒ ASAE Very Fine to Fine
☐ ASAE Fine to Medium/Coarse

Data Percentile:
☐ 50th Percentile
☒ 90th Percentile

Extended Settings:
☐ Access Extended Settings
Number of Swaths:

Information:
High Boom ASAE Very Fine to Fine
Boom Height: 1.27 m (50 in)
Swath Width: 13.72 m (45 ft)
Dv0.5: 175 um
Application Efficiency (%) (20 swaths): 97.96

AgDRIFT® Tier I Ground

Aquatic Assessment

Aquatic Body Definition:
☒ EPA-Defined Pond
☐ EPA-Defined Wetland
☐ User-defined Water Body
Downwind Water Body Width: ft
Average Depth: ft

Tier I Settings:
Active Rate: lb/ac

Calculations:
Distance To Water Body From Edge of Application Area: ft
Initial Average Deposition: g/ha lb/ac
Initial Average Concentration: ng/L (ppt)

Plot Export Print **Calc** Close

Aquatic Assessment

Aquatic Body Definition:
☒ EPA-Defined Pond
☐ EPA-Defined Wetland
☐ User-defined Water Body
Downwind Water Body Width: ft
Average Depth: ft

Tier I Settings:
Active Rate: lb/ac

Calculations:
Distance To Water Body From Edge of Application Area: ft
Initial Average Deposition: g/ha lb/ac
Initial Average Concentration: ng/L (ppt)

Plot Export Print **Calc** Close

Aquatic Assessment

Aquatic Body Definition:
☒ EPA-Defined Pond
☐ EPA-Defined Wetland
☐ User-defined Water Body
Downwind Water Body Width: ft
Average Depth: ft

Tier I Settings:
Active Rate: lb/ac

Calculations:
Distance To Water Body From Edge of Application Area: ft
Initial Average Deposition: g/ha lb/ac
Initial Average Concentration: ng/L (ppt)

Plot Export Print **Calc** Close

Low Boom/ Medium to Coarse Droplets:

AgDRIFT - [*]

File Edit Tier View Toolbox Help

Title
Thiram Residential

Boom Height
☒ Low Boom
☐ High Boom

Drop Size Distribution
☐ ASAE Very Fine to Fine
☒ ASAE Fine to Medium/Coarse

Data Percentile
☐ 50th Percentile
☒ 90th Percentile

Extended Settings
☐ Access Extended Settings
Number of Swaths:

Information
Low Boom ASAE Fine to Medium/Coarse
Boom Height: 0.508 m (20 in)
Swath Width: 13.72 m (45 ft)
Dv0.5: 341 um
Application Efficiency (%) (20 swaths): 99.27

AgDRIFT® Tier I Ground

Aquatic Assessment

Aquatic Body Definition
☒ EPA-Defined Pond
☐ EPA-Defined Wetland
☐ User-defined Water Body
Downwind Water Body Width: 208.7 ft
Average Depth: 6.56 ft

Tier I Settings
Active Rate: 16.33 lb/ac

Calculations
Distance To Water Body From Edge of Application Area: 0 ft
Initial Average Deposition: 0.0109 Fraction of Applied
 199.43 g/ha 0.178 lb/ac
Initial Average Concentration: 9973.88 ng/L (ppt)

Plot Export Print Calc Close

Aquatic Assessment

Aquatic Body Definition
☒ EPA-Defined Pond
☐ EPA-Defined Wetland
☐ User-defined Water Body
Downwind Water Body Width: 208.7 ft
Average Depth: 6.56 ft

Tier I Settings
Active Rate: 16.33 lb/ac

Calculations
Distance To Water Body From Edge of Application Area: 300 ft
Initial Average Deposition: 0.0015 Fraction of Applied
 27.34 g/ha 0.0244 lb/ac
Initial Average Concentration: 1367.19 ng/L (ppt)

Plot Export Print Calc Close

Peach

High Boom/ Fine Droplets:

AgDRIFT - [*]

File Edit Tier View Toolbox Help

Title
Thiram Peach

Boom Height
☐ Low Boom
☒ High Boom

Drop Size Distribution
☒ ASAE Very Fine to Fine
☐ ASAE Fine to Medium/Coarse

Data Percentile
☐ 50th Percentile
☒ 90th Percentile

Extended Settings
☐ Access Extended Settings
Number of Swaths:

Information
High Boom ASAE Very Fine to Fine
Boom Height: 1.27 m (50 in)
Swath Width: 13.72 m (45 ft)
Dv0.5: 175 um
Application Efficiency (%) (20 swaths): 97.96

AgDRIFT® Tier I Ground

Low Boom/Coarse Droplets:

AgDRIFT® Tier I Ground