**CHLORPYRIFOS – SEED TREATMENT AND GRANULAR USES: ESA ANALYSES:**

Most of the ESA Pilot chemicals’ (*i.e*., chlorpyrifos, diazinon, and malathion) use and usage involves flowable uses (*e.g*., emulsifiable concentrate, wettable powder). Therefore, the methods developed for analyzing terrestrial exposures in this BE focus on flowable uses; however, chlorpyrifos also has non-flowable uses: cattle eartag, seed treatments, and granular uses. For a discussion of the cattle eartag analysis, see **APPENDIX 4-4**.

Because exposures related to seed treatment and granular/bait uses are readily modeled using our current aquatic modeling approaches, these types of uses are incorporated into the aquatic exposure and WoE tools (PRZM/EXAMS and AquaWOE) used to help make effects determinations for listed aquatic species (and those that rely on aquatic species). However, due to differences in estimating potential exposures from seed treatment and granular/bait uses and flowable uses, these (seed treatment and granular/bait) uses are not as easily incorporated into the current modeling approach for assessing terrestrial exposures to listed terrestrial species. As such, given that flowable uses account for most of the use and usage of the three ESA pilot chemicals, including chlorpyrifos, exposure from these uses (flowable) are incorporated into the current terrestrial exposure and WoE tools (TED and TerrWOE) that are used to help make effects determinations for listed terrestrial species (and those that rely on terrestrial species). While the seed treatment and granular/bait uses are not built into these tools, they will still be considered when making effects determinations. A discussion of the methods for assessing seed treatments and granular uses for terrestrial species are described below.

For terrestrial organisms, the primary route of exposure to treated seeds and granules/baits is assumed to be via ingestion. Spray drift is not expected from these types of uses, therefore, potential terrestrial exposures are assumed to be limited to the sites of application. Chlorpyrifos can be used as a seed treatment for beans, corn, cotton, cucumber, peas, pumpkin, sorghum grain, triticale and wheat (see **Table 4-6.1**). All of these uses except bean, cucumber, peas, pumpkin, and triticale also have flowable uses of chlorpyrifos, and, therefore, would be captured by the overlap analyses of use sites and species for the flowable uses. Additionally, the bean, cucumber, peas, pumpkin, and triticale uses are captured in the spatial layers being used to represent other registered chlorpyrifos uses (*i.e*., vegetable and ground fruits or other grains) (see **ATTACHMENT 1-2**). Therefore, none of the chlorpyrifos seed treatment uses would represent a different use footprint than the one being captured by the flowable uses. The maximum seed treatment use rates, on a per acre basis, range from 0.003 lb a.i./acre to 2.2 lb a.i./acre depending on the use, with most rates at <0.4 lb a.i./acre (see **Table 4-6.1**). Therefore, except for the maximum use rates for the corn (1.9 lb a.i./acre) and cotton (2.2 lb a.i./acre) uses, the seed treatment use rates are lower than the maximum application rates for most of the flowable chlorpyrifos uses.

**Table 4-6.1. Currently Registered Chlorpyrifos Seed Treatment Uses and Application Rates.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Crop/Site** | **Method/****Equipment** | **Maximum Single Application Rate by Formulation1****(lb a.i./A)2** | **Maximum Application Rate (Per Crop Cycle)** | **Geographic Restrictions** | **Comments** |
| **BEANS** | Seed Treatment | 0.348 (ME)0.272 (WP)0.253 (EC) | 0.348  | ME is SLN3 only for ID | None |
| **CORN (ALL)** | Seed treatment | 0.021 (WP)1.9 (EC) | 1.9 | None | None |
| **COTTON** | Seed treatment | 2.2 (EC) | 2.2 | None | None |
| **CUCUMBER** | Seed treatment | 0.4 (EC) | 0.4 | None | Only seed treatments allowed |
| **PEAS** | Seed Treatment | 0.30 (WP)0.28 (EC) | 0.30 | None | None |
| **PUMPKIN** | Seed treatment | 0.3 (WP) | 0.3 | CA max single rate 0.000625 lb a.i./lb. | None |
| **SORGHUM GRAIN** | Seed treatment | 0.01 (EC) | 0.01 | None | None |
| **TRITICALE** | Seed treatment | 0.003 (EC) | 0.003 | None | Only seed treatments allowed. |
| **WHEAT** | Seed treatment | 0.003 (EC) | 0.003 | Only for use in AZ, CA, CO, ID, KS, MN, MO, NE, NM, NV, ND, OK, OR, SD, TX, UT, WA and WY | None |

1 EC - emulsifiable concentrate; WP – wettable powder in water soluble packet; ME – microencapsulated

2 Becker, J.; Ratnayake, S. Acres Planted per Day and Seeding Rates of Crops Grown in the United States, U.S. EPA OPP/BEAD, 2011; example calculations provided below:

Beans: 0.00058 lb a.i./lb seed / 960 seeds/lb seed x 418,176 seeds/A

Corn: 0.000625 lb a.i./lb seed / 1,800 seeds/lb seed x 59,739 seeds/A

Cotton: 0.00116 lb a.i./lb seed / 4,500 seeds/lb seed x 85,000 seeds/A

Cucumber: 0.00058 lb a.i./lb seed / 12,000 seeds/lb seed x 80,418 seeds/A

Peas: 0.000625 lb a.i./lb seed / 1,361 seeds/lb seed x 653,400 seeds/A

Pumpkin: 0.00058 lb a.i./lb seed / 1,600 seeds/lb seed x 7,260 seeds/A

Sorghum: 0.001 lb a.i./lb seed / 11,000 seeds/lb seed x 100,000 seeds/A

Triticale: 0.003 lb a.i./100 lb seed / 109 lb seed/A

Wheat: 0.003 lb a.i./100 lb seed /116 lb seed/A

3 SLN = Special Local Needs label

The current tools being used to help make effects determinations for terrestrial organisms (TED and TerrWOE) estimate potential exposures to terrestrial animals that eat seeds contaminated with chlorpyrifos from flowable uses. In the tools, the exposure values for contaminated seeds are provided in ppm (equivalent to mg a.i./kg). Based on results from the TED (for seeds as a dietary item), the single maximum flowable application rates modeled for chlorpyrifos, *i.e*., 1 lb a.i./acre, 4.0 and 6.0 lb a.i./acre, result in upper bound estimated seed concentrations of 15 ppm, 60 ppm, and 90 ppm, respectively. The chlorpyrifos seed treatment application rates are provided in (or can be converted to) ppm (mg a.i./kg-seed). Therefore, the concentrations from the various seed treatments can be directly compared to the estimated seed concentrations from flowable uses.

For example, all of the seed treatment rates result in seed concentrations higher than the chlorpyrifos concentration on seeds expected from a 1.0 lb a.i./acre flowable application (see **Table 4-6.2**). This means that in all cases, if a threshold for an animal that eats seeds is exceeded for a 1.0 lb a.i./acre flowable application rate, than the threshold would also be exceeded for all of the seed treatment uses. Additionally, the estimated seed concentrations from a 6.0 lb a.i./acre flowable application are similar (within an order of magnitude) to the seed concentrations for most of the seed treatment uses. This information will be considered in the effects determinations for any animal found on application sites that eats seeds (*e.g*., granivorous and omnivorous birds, mammals, and terrestrial invertebrates).

**Table 4-6.2. Chlorpyrifos Seed Treatment Application Rates Provided in ppm (mg a.i./kg-seed) Compared to the Estimated Seed Concentration from Flowable Uses at Various Application Rates.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Crop/Site** | **Maximum Application Rate for the Identified Seed Treatment (mg a.i./kg-seed)** | **How Many Times Is the Seed Treatment Concentration Over the Estimated Seed Concentration (15 ppm)****from a 1.0 lb a.i./acre Flowable Application Rate**  | **How Many Times Is the Seed Treatment Concentration Over the Estimated Seed Concentration (60 ppm)****from a 4.0 lb a.i./acre Flowable Application Rate**  | **How Many Times Is the Seed Treatment Concentration Over the Estimated Seed Concentration (90 ppm)** **from a 6.0 lb a.i./acre Flowable Application Rate**  |
| **BEANS** | 580 | 38.7 | 9.7 | 6.4 |
| **CORN (ALL)** | 625 | 41.7 | 10.4 | 6.9 |
| **COTTON** | 1,160 | 77.3 | 19.3 | 12.9 |
| **CUCUMBER** | 580 | 38.7 | 9.7 | 6.4 |
| **PEAS** | 625 | 41.7 | 10.4 | 6.9 |
| **PUMPKIN** | 580 | 38.7 | 9.7 | 6.4 |
| **SORGHUM GRAIN** | 1,000 | 66.7 | 16.7 | 11.1 |
| **TRITICALE** | 30 | 2 | 0.5 | 0.33 |
| **WHEAT** | 30 | 2 | 0.5 | 0.33 |

For the granular/bait uses, chlorpyrifos can be used on a variety of use sites (see **Table 4-6.3**). All of these uses except turnip and utilities also have flowable uses of chlorpyrifos, and, therefore, would be captured by the overlap analyses of use sites and species for the flowable uses. Additionally, the turnip and utility uses are captured in the spatial layers being used to represent other registered chlorpyrifos uses (*i.e*., vegetables and ground fruit and developed/open space developed land classes, respectively) (see **ATTACHMENTS 1-2** and **1-3**). Therefore, none of the chlorpyrifos granular/bait uses would represent a different use footprint than the one being captured by the flowable uses. The maximum granular application use rates range from 1.0 lb a.i./acre to 6.0 lb a.i./acre depending on the use, with most rates at <2.5 lb a.i./acre (see **Table 4-6.3**). Bait uses are limited to golf turf, ornamentals, and rights-of-ways and have a maximum application rate of 1.0 lb a.i./acre. Therefore, except for the maximum granular use rate for the ornamental (woody shrubs and vines) use (6.0 lb a.i./acre), the granular and bait use rates are similar to or lower than the maximum application rates for most of the flowable chlorpyrifos uses.

**Table 4-6.3. Currently Registered Chlorpyrifos Granular Uses and Application Rates.**

| **Crop/Site** | **Method/****Equipment** | **Maximum Single Application Rate by Formulation1****(lb a.i./A)** | **Maximum Application Rate (Per Crop Cycle)2** | **Maximum Application Number (Per Crop Cycle)** | **MRI (days)** | **Geographic Restrictions** | **Comments** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **ALFALFA** | Ground  | 1.0G | 1.0 | 1 | N/A | MO only | Stand is in production 3-5 years. Planted ¼” to ½” deep. |
| **ASPARAGUS** | Ground | 1.5G | 3.0 | 2 | [10]NS | Permitted in CA, the Midwest, and the Pacific NW | Do not apply more than 3.0 lb a.i./A between harvests. |
| **SUGAR BEETS** | Ground | 2.0G | 2.0 | 1 | N/A | None | Minimum Incorporation: 1 inch (for soil incorporated) |
| **COLE CROPS** (EXCLUDES CAULIFLOWER AND BRUSSELS SPROUTS) | Ground | 2.0G | 2.0 | 1 | N/A | None | Min. incorporation: 2 inches (for soil incorporated). One granular application permitted per year. |
| **BRUSSELS SPROUTS** | Ground | 2.25G | 2.25 | 1 | N/A | None | Minimum incorporation is 2 inches (for soil incorporated) |
| **CAULIFLOWER** | Ground | 2.3G | 2.3 | 1 | N/A | None | Only one granular application. Minimum incorporation is 2 inches (for soil incorporation) |
| **CORN** | Ground/ Aerial | 2.0G | 2.0 | 1 | 10 | None | The minimum incorporation depth is 2 inches (for soil incorporation). Two granular applications are allowed with a maximum single rate of 1.0 lb a.i./A or one granular application at 2 lb a.i./A. |
| **GINSENG (MEDiCINAL)** | Ground | 2.0G | 2.0 | 1 | NA | Permitted in MI and WI | Minimum incorporation is 4 inches. |
| **GOLF COURSE TURF** | Ground  | 1.0G, B | 2.0 | 2 | 7 | None | None |
| **NURSERY-STOCK** | Ground | 1.1G | NS | NS | NS | None | None |
| **ONIONS** | Ground | 1.0G | 1.0 | 1  | N/A | None | Incorporation is not specified on the label. |
| **ORNAMENTAL AND/OR SHADE TREES, HERBACEOUS PLANTS** | Ground | 1.0G, B | 2.0 | 2 | NS | None | Some labels include a MRI of 7 days. |
| **ORNAMENTAL LAWNS AND TURF, SOD FARMS (TURF)** | Ground | 1.0B | 2.0 | 2 | NS | None | Bait is used for fire ant control. |
| **ORNAMENTAL WOODY SHRUBS AND VINES** | Ground | 6.0G | 6.0 | 1 | N/A | None | None |
| **PEANUT** | Ground/ Aerial | 4.0G | 4.0 | 1 | 10 | None | Can make one application at 4.0 lb/acre or 2 applications at 2.0 lb/acre |
| **RADISH** | Ground (in furrow) | 2.8G | 2.8 | 1 | N/A | None | Only one granular application permitted. |
| **RIGHTS OF WAY, ROAD MEDIANS** | Ground | 1.0G, B | 2.0 | 2 | 7 | None | Apply when needed |
| **RUTABAGA** | Ground (in furrow) | 2.4G | 2.4 | 1 | N/A | Disallowed in CA and AZ | None |
| **SORGHUM GRAIN** | Ground (T-band) | 1.5G | 1.5 | 1 | N/A | None | None |
|  |  |
| **SOYBEAN** | Ground | 2.2G | 2.2 | 1 | N/A | None | None |
| **SWEET POTATO** | Ground | 2.1G | 2.1 | 1 | N/A | None | None |
| **TOBACCO** | Ground/ Aerial | 2.0G | 2.0 | 1 | N/A | None | None |
| **TURNIP** | Ground | 2.3G | 2.3 | 1 | N/A | None | Minimum incorporation depth is 2 inches; does not have a flowable use |
| **UTILITIES**For use in and around telecommunications, power, utilities and railroad systems equipment | Ground | 1G0.44 lb a.i./100 sq ft | 2 | 1 | NS | None | Applications permitted as needed. Broadcast product onto the ground covering the area of the pad location, plus a two foot perimeter around the outside of the pad location.  |

1 G = granular, B = bait

2 This is on a per year basis for uses that do not have crop cycles.

For terrestrial invertebrates, the primary routes of exposure from the granular uses of chlorpyrifos are expected to be via contact with contaminated soil and/or ingestion of contaminated plants that uptake chlorpyrifos from the soil. Since the application rates are similar, the soil concentrations from the granular uses are expected to be similar to the concentrations from the flowable uses. There are currently no methods available for adequately assessing exposure and risk via contaminated plants (from uptake). It is anticipated that the residue concentrations in plants from the granular uses will not be higher than the residues on plants from flowable uses (assuming similar application rates). Therefore, for terrestrial invertebrates, the estimated exposures from the flowable uses will be used as a proxy for the exposures from the granular uses.

For terrestrial vertebrates, the primary route of exposure is expected to be to birds found on the site of application that may ingest the granules as grit. Other vertebrates are not expected to ingest the granules. The currently registered chlorpyrifos granular products contain 15% a.i. (primarily for agricultural uses) or 2.5% a.i. (primarily for non-agricultural uses). To explore potential exposures to birds, the number of chlorpyrifos granules (15% a.i. products) that birds of different sizes would need to ingest to exceed the acute, mortality threshold is calculated using T-REX (see **Table 4-6.4**). Based on this analysis, 20 g. 100 g, and 1,000 g birds would need to ingest < 1, 5, and 73 granules, respectively, to exceed the mortality threshold. For the 2.5% a.i. granular products, 20 g. 100 g, and 1,000 g birds would need to ingest ~5, 31, and 437 granules, respectively, to exceed the mortality threshold (**Table 4-6.5**). These numbers will be considered when making the effects determination for bird species that may ingest chlorpyrifos granules on the site of application.

**Table 4-6.4. T-REX In-put and Outputs for the Chlorpyrifos Granular Exposure Estimates for Birds (15% a.i. products)**

|  |  |  |  |
| --- | --- | --- | --- |
| **In-put/Out-put** | **20 g Bird** | **100 g Bird** | **1,000 g Bird** |
| Weight of bird (kg) | 0.02 | 0.10 | 1.0 |
| Adjusted threshold, mg/kg-bw1 | 0.46 | 0.58 | 0.82 |
| mg a.i. needed to achieve the adjusted threshold for bird of assessed weight | 0.01 | 0.06 | 0.82 |
| Fraction of a.i. in formulated product  | 0.1500 | 0.1500 | 0.1500 |
| Weight of 1 granule (mg, obtained from registrant)2 | 0.075 | 0.075 | 0.075 |
| mg a.i./granule  | 0.0113 | 0.0113 | 0.0113 |
| No. of granules needed to achieve adjusted threshold | 0.81 | 5.16 | 72.8 |

1 Based on the 1-in-a-million threshold for mortality of 0.58 mg a.i./kg-bw for a 100 g bird

2 From USEPA 2008. Chlorpyrifos (CAS Reg. Chlorpyrifos (CAS Reg. No 2921-88-2; CAS Name *O,O’*-diethyl *O*-(3,5,6-trichloro-2-pyridinyl) phosphorothioate) Ecological Risk Review For Use on Ginseng in Wisconsin. United States Environmental Protection Agency, Office of Pesticide Programs, Washington, DC. DP Code 357388.

**Table 4-6.5. T-REX In-put and Outputs for the Chlorpyrifos Granular Exposure Estimates for Birds (2.5% a.i. products)**

| **In-put/Out-put** | **20 g Bird** | **100 g Bird** | **1,000 g Bird** |
| --- | --- | --- | --- |
| Weight of bird (kg) | 0.02 | 0.10 | 1.0 |
| Adjusted threshold, mg/kg-bw1 | 0.46 | 0.58 | 0.82 |
| mg a.i. needed to achieve the adjusted threshold for bird of assessed weight | 0.01 | 0.06 | 0.82 |
| Fraction of a.i. in formulated product  | 0.025 | 0.025 | 0.025 |
| Weight of 1 granule (mg, obtained from registrant)2 | 0.075 | 0.075 | 0.075 |
| mg a.i./granule  | 0.0019 | 0.0019 | 0.0019 |
| No. of granules needed to achieve adjusted threshold | 4.9 | 30.9 | 436.9 |

1 Based on the 1-in-a-million threshold for mortality of 0.58 mg a.i./kg-bw for a 100 g bird

2 Assumed to be the same as reported for the 15% a.i. granular products.

For the bait uses, it is assumed that terrestrial vertebrates and invertebrates may ingest the baits. Most of the chlorpyrifos granular baits contain 1% a.i. (except for the products registered for fire ant control which contain 5 or 7% a.i.). To help address potential exposures to terrestrial vertebrates from these uses, a similar approach to the one described for the granular uses (15% a.i products) above was conducted. For the baits, it is assumed that the weight of the bait is similar to the weight of a granule (15% a.i.). Since more than just birds may be expected to ingest the baits, the analyses are conducted for birds (used also as a proxy for terrestrial-phase amphibians and reptiles) and mammals (see **Tables 4-6.6** and **4-6.7**). Based on these analyses, for the 1% bait, birds that are 20 g, 100 g, and 1,000 g would need to ingest 12, 77, and 1,092 bait granules, respectively; and 15 g, 35 g, and 1,000 g mammals would need to ingest 110, 208, and 2,563 bait granules, respectively, to exceed the acute mortality thresholds. For the 7% ant baits, 20 g, 100 g, and 1,000 g birds would need to ingest 2, 11, and 156 bait granules, respectively; and 15 g, 35 g, and 1,000 g mammals would need to ingest 16, 30, and 366 bait granules, respectively, to exceed the acute mortality thresholds. These numbers will be considered when making the effects determination for bird, reptile, terrestrial-phase, and mammalian species that may ingest chlorpyrifos bait granules on the site of application.

**Table 4-6.6. T-REX In-put and Outputs for the Chlorpyrifos Bait Exposure Estimates for Terrestrial Vertebrates (1% a.i. products)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **In-put/Out-put** | **20 g Bird**1 | **100 g Bird** | **1,000 g Bird** | **15 g Mammal** | **35 g Mammal** | **1,000 g Mammal** |
| Weight of bird (kg) | 0.02 | 0.10 | 1.0 | 0.015 | 0.035 | 1.0 |
| Adjusted threshold, mg/kg-bw2 | 0.46 | 0.58 | 0.82 | 5.49 | 4.45 | 1.92 |
| mg a.i. needed to achieve the adjusted threshold for bird of assessed weight | 0.01 | 0.06 | 0.82 | 0.08 | 0.16 | 1.92 |
| Fraction of a.i. in formulated product  | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Weight of 1 granule (mg, obtained from registrant)3 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 |
| mg a.i./granule  | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 |
| No. of granules needed to achieve adjusted threshold | 12.2 | 77.3 | 1092.4 | 109.9 | 207.5 | 2563.4 |

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

2 Based on the 1-in-a-million threshold for mortality of 0.58 mg a.i./kg-bw for a 100 g bird and 2.5 mg a.i./kg-bw for a 350 g mammal

3 Assumed to be the same as reported for the 15% a.i. granular products.

**Table 4-6.7. T-REX In-put and Outputs for the Chlorpyrifos Bait Exposure Estimates for Terrestrial Vertebrates (7% a.i. products)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **In-put/Out-put** | **20 g Bird**1 | **100 g Bird** | **1,000 g Bird** | **15 g Mammal** | **35 g Mammal** | **1,000 g Mammal** |
| Weight of bird (kg) | 0.02 | 0.10 | 1.0 | 0.015 | 0.035 | 1.0 |
| Adjusted threshold, mg/kg-bw2 | 0.46 | 0.58 | 0.82 | 5.49 | 4.45 | 1.92 |
| mg a.i. needed to achieve the adjusted threshold for bird of assessed weight | 0.01 | 0.06 | 0.82 | 0.08 | 0.16 | 1.92 |
| Fraction of a.i. in formulated product  | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Weight of 1 granule (mg, obtained from registrant)3 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 |
| mg a.i./granule  | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 |
| No. of granules needed to achieve adjusted threshold | 1.7 | 11.1 | 156.1 | 15.7 | 29.6 | 366.3 |

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

2 Based on the 1-in-a-million threshold for mortality of 0.58 mg a.i./kg-bw for a 100 g bird and 2.5 mg a.i./kg-bw for a 350 g mammal

3 Assumed to be the same as reported for the 15% a.i. granular products.

Due to the broad range of terrestrial invertebrates that chlorpyrifos is used to control (as a broad-spectrum insecticide), it is assumed that any terrestrial invertebrate that might eat a chlorpyrifos bait granule (based on its diet and habitat preferences) would receive a lethal dose if it ingested a bait granule. Therefore, additional exposure analyses for terrestrial invertebrates are not conducted here.