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Chlorpyrifos

Proposed Interim Registration Review Decision
Case Number 0100

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Approved by: _____

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I. INTRODUCTION

This document is the Environmental Protection Agency's (the EPA or the agency) Proposed Interim Registration Review Decision (PID) for chlorpyrifos (PC Code 059101, case 0100), and is being issued pursuant to 40 CFR §155.56 and §155.58. A registration review decision is the agency's determination whether a pesticide continues to meet, or does not meet, the standard for registration in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The agency may issue, when it determines it to be appropriate, an interim registration review decision before completing a registration review. Among other things, the interim registration review decision may determine that new risk mitigation measures are necessary, lay out interim risk mitigation measures, identify data or information required to complete the review, and include schedules for submitting the required data, conducting the new risk assessment and completing the registration review. Additional information on chlorpyrifos, can be found in the EPA's public docket (EPA-HQ-OPP-2008-0850) at www.regulations.gov.

FIFRA, as amended by the Food Quality Protection Act (FQPA) of 1996, mandates the continuous review of existing pesticides. All pesticides distributed or sold in the United States must be registered by the EPA based on scientific data showing that they will not cause unreasonable risks to human health or to the environment when used as directed on product labeling. The registration review program is intended to make sure that, as the ability to assess and reduce risk evolves and as policies and practices change, all registered pesticides continue to meet the statutory standard of no unreasonable adverse effects. Changes in science, public policy, and pesticide use practices will occur over time. Through the registration review program, the agency periodically re-evaluates pesticides to make sure that as these changes occur, products in the marketplace can continue to be used safely. Information on this program is provided at http://www.epa.gov/pesticide-reevaluation. In 2006, the agency implemented the registration review program pursuant to FIFRA § 3(g) and will review each registered pesticide every 15 years to determine whether it continues to meet the FIFRA standard for registration.

The EPA is issuing a PID for chlorpyrifos so that it can (1) move forward with aspects of the registration review that are complete and (2) implement interim risk mitigation (see Appendix A). EPA is currently working with the National Marine Fisheries Service (NMFS) under a reinitiated Endangered Species Act (ESA) consultation, and NMFS plans to issue a revised biological opinion for chlorpyrifos in June 2022. The U.S. Fish and Wildlife Service (FWS) has not yet completed a biological opinion for chlorpyrifos. EPA will complete any necessary consultation with NMFS and FWS for chlorpyrifos prior to completing the chlorpyrifos registration review. See section I. B. and Appendix B for more information. See Appendix C for additional information on the endocrine screening for the chlorpyrifos registration review.

Chlorpyrifos (O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate) is a broad-spectrum, chlorinated organophosphate insecticide used to control a variety of foliar and soil-borne insects. Pesticide products containing chlorpyrifos are registered for use on many agricultural crops, with the highest uses on corn, soybeans, alfalfa, oranges, wheat, and walnuts in terms of pounds of chlorpyrifos applied per year. Additionally, chlorpyrifos products are registered for use on non-food sites such as ornamental plants in nurseries, golf course turf, as wood treatment, and as an ear tag for cattle. There are also public health uses including aerial and ground-based mosquito adulticide fogger treatments, use as fire ant control in nursery stock grown in USDA-designated quarantine areas, and for some tick species that may transmit diseases such as Lyme disease.

The Reregistration Eligibility Document for chlorpyrifos was issued July 31, 2006.[1] In 1996, the Food Quality Protection Act set a more stringent safety standard to be especially protective of infants and children. After finalizing the chlorpyrifos risk assessments for reregistration, EPA identified the need to modify certain chlorpyrifos uses to meet the revised standard of safety, and to address health and environmental risks from chlorpyrifos exposure. In 1997, the registrant, Dow AgroSciences (now known as Corteva), voluntarily agreed to cancel chlorpyrifos registrations for indoor broadcast use and direct pet treatments, except pet collars. In December 2001, the majority of the remaining chlorpyrifos residential products were subject to voluntary phase out/cancellation. Further changes included label revisions such as buffer zones to ensure environmental and worker safety in 2002. Additional spray drift mitigation and reduced application rates were added in 2012 to be protective of bystanders in sensitive areas including schools and recreational areas. Current chlorpyrifos residential uses are limited to granular ant mound use (commercial applicator only) and roach bait in child-resistant packaging (for homeowner use). Chlorpyrifos can be applied as a seed treatment, by chemigation, airblast, and other ground applications (e.g., groundboom, tractor-drawn spreader), aerial applications, handheld applications (e.g., handwand, handgun, backpack sprayer, rotary spreader), and as an impregnated ear tag for some types of cattle. Products containing chlorpyrifos have almost every type of formulation including wettable powder, emulsifiable concentrate, flowable concentrate, water-soluble packets (WSP), and granules. There are currently four technical registrants. The first product containing chlorpyrifos was registered in 1965 and the Tolerance Reassessment and Risk Management Decision (TRED) was published in 2002. Reregistration was completed with the 2006 update to the Organophosphate Cumulative Risk Assessment.

This document is organized in five sections: the *Introduction*, which includes this summary; *Use and Usage*, which describes how and why chlorpyrifos is used and summarizes data on its use; *Scientific Assessments*, which summarizes the EPA's risk and benefits assessments, updates or revisions to previous risk assessments, and provides broader context with a discussion of risk characterization; the *Proposed Interim Registration Review Decision*, which describes the mitigation measures proposed to address risks of concern and the regulatory rationale for the EPA's PID; and, lastly, the *Next Steps and Timeline* for completion of this registration review.

[1] https://www3.epa.gov/pesticides/chem_search/reg_actions/reregistration/red_PC-059101_1-Jul-06.pdf

A. Summary of Chlorpyrifos Registration Review

Pursuant to 40 CFR § 155.50, the EPA formally initiated registration review for chlorpyrifos with the opening of the registration review docket for the case. The following summary highlights the docket opening and other significant milestones that have occurred thus far during the registration review of chlorpyrifos.

- March 2009 – The *Chlorpyrifos. Human Health Assessment Scoping Document in Support of Registration Review* and *Chlorpyrifos Summary Document* were posted to the docket for a 60-day public comment period.

- May 2009 – The *Preliminary Problem Formulation for the Ecological Risk and Environmental Fate, Endangered Species, and Drinking Water Assessments for Chlorpyrifos* was posted to the docket.

- October 2009 – The *Chlorpyrifos Final Work Plan* (FWP) was issued. The agency received nine comments on the *Chlorpyrifos Summary Document.* The comments received did not change the data and risk assessment needs or schedule for the chlorpyrifos registration review. The agency also published:
  - *Response to Comments on Preliminary Problem Formulation for Ecological Risk and Environmental Fate, Endangered Species and Drinking Water Assessments for Chlorpyrifos*
  - *Chlorpyrifos. Health Effects Division Response to Comments on the Registration Review Preliminary Work Plan*
  - *BEAD Response to Comments on Chlorpyrifos Preliminary Work Plan*

- September 2010 – The *Chlorpyrifos Generic Data Call (GDCI-059101-967)* was issued. There are no studies outstanding from the DCI that are needed to complete the registration review of chlorpyrifos.

- July 6, 2011 – The agency published the *Chlorpyrifos Preliminary Human Health Assessment for Registration Review,* as well as the following supporting materials, to the public docket for a 90-day comment period:
  - *Chlorpyrifos: Occupational and Residential Exposure Assessment*
  - *Revised Chlorpyrifos Acute and Chronic Dietary Exposure and Risk Assessments*
  - *Revised Chlorpyrifos Preliminary Registration Review Drinking Water Assessment*
  - *Chlorpyrifos. Registration Review Action for Chlorpyrifos. Summary of Analytical Chemistry and Residue Data.*
  - *Chlorpyrifos Carcinogenicity: Review of Evidence from the U.S. Agricultural Health Study (AHS) Epidemiologic Evaluations 2003-2009*
  - *Reader's Guide to the Preliminary Human Health Risk Assessment for Chlorpyrifos*
  - *Chlorpyrifos: Tier II Incident Report*

- July 15, 2011 – The agency published the *Revised Chlorpyrifos Preliminary Registration Review Drinking Water Assessment - Appendix D - Typical Use Data for Chlorpyrifos and Spray Drift Mitigation Decision for Chlorpyrifos* and *Occupational and Residential Appendices A* through *H*.

- July 2012 – The agency published *Chlorpyrifos – Evaluation of the Potential Risks from Spray Drift and the Impact of Potential Risk Reduction Measures*, *Spray Drift Mitigation Decision for Chlorpyrifos*, Appendices E, F, and G of the *Evaluation of the Potential Risks from Spray Drift and the Impact of Potential Risk Reduction Measures,* and the *Evaluation of Columbia University Epidemiology Study Claims Related to Brain Abnormalities and Pre-Natal Exposures to Chlorpyrifos.*

- February 2013 – The *Chlorpyrifos Preliminary Evaluation of the Potential Risks from Volatilization* was published for a 30-day public comment period.

- July 2014 – The agency published the *Chlorpyrifos: Reevaluation of the Potential Risks from Volatilization in Consideration of Chlorpyrifos Parent and Oxon Vapor Inhalation Toxicity Studies.*

- December 2014 – The agency published the *Chlorpyrifos: Revised Human Health Risk Assessment for Registration Review* and the following:
    - *Chlorpyrifos: Updated Drinking Water Assessment for Registration Review*
    - *Chlorpyrifos Updated DWA Attachment 12/23/2014*
    - *Chlorpyrifos Acute and Steady State Dietary (Food Only) Exposure Analysis to Support Registration Review*
    - *Chlorpyrifos: Updated Occupational and Residential Exposure Assessment for Registration Review*

- June 2015 – The agency published the *Chlorpyrifos: Quality Assurance Assessment of the Chlorpyrifos Physiologically Based Pharmacokinetic/Pharmacodynamic Model for Human Health Risk Assessment Applications.*

- April 2016 – The *Draft Biological Evaluations for Chlorpyrifos, Diazinon, and Malathion* were published for a 60-day comment period.[2]

- November 2016 – EPA issued the *Chlorpyrifos: Revised Human Health Assessment for Registration Review* along with the *Chlorpyrifos Refined Drinking Water Assessment for Registration Review.*

- January 2017 – The agency announced the availability of the following:
    - *Endangered Species Act Section 7 Formal Consultation Letter for Chlorpyrifos, Diazinon, and Malathion*
    - *Response to Comments on the Draft Biological Evaluations for Chlorpyrifos, Diazinon, and Malathion*

[2] https://www3.epa.gov/pesticides/nas/chlorpyrifos/draft-chlorpyrifos.pdf

- *Final Biological Evaluations for Chlorpyrifos, Diazinon, and Malathion*[3]

- September 2020 – The agency issued the *Chlorpyrifos: Draft Ecological Risk Assessment for Registration Review* and *Chlorpyrifos: Third Revised Human Health Risk Assessment for Registration Review* in addition to the following:
  - *Updated Chlorpyrifos Refined Drinking Water Assessment for Registration Review*
  - *Evaluating the Impact of Removal of the 10X FQPA Safety Factor on Chlorpyrifos Drinking Water Concentrations*
  - *Usage of chlorpyrifos (PC# 059101) on alfalfa grown for alfalfa hay and seed, cotton, soybeans, sugar beets, spring and winter wheat, Michigan asparagus, Florida and Texas citrus, and Oregon strawberries by hydrologic region (two-digit HUC)*

- December 2020 – The agency is completing the PID for chlorpyrifos, in preparation for publication in the docket for a 60-day public comment period. The agency is also taking comments on the *Chlorpyrifos: Draft Ecological Risk Assessment for Registration Review* and *Chlorpyrifos: Third Revised Human Health Risk Assessment for Registration Review* issued September 21, 2020. In addition, the agency is also issuing:
  - *Benefits of Agricultural Uses of Chlorpyrifos (PC# 059101)*
  - *Chlorpyrifos (PC# 059101) Usage and Benefits Assessment for Non-crop Uses*
  - *Average and maximum application rates and average number of applications of chlorpyrifos (PC# 059101) used in cherries, corn, peaches, pecans, and peppers by hydrologic region (two-digit HUC)*
  - Chlorpyrifos (059101) National and State Summary Use and Usage Summary Matrix

B. Endangered Species Consultation

Chlorpyrifos was one of the first three pilot chemicals that EPA conducted a nationwide ESA consultation. EPA completed a biological evaluation and initiated consultation with the FWS and NMFS in January 2017. [4] Pursuant to a consent decree, at the end of December 2017, NMFS issued its Biological Opinion (BiOp) on chlorpyrifos, diazinon, and malathion.[5] In July 2019, EPA re-initiated formal consultation with NMFS on the December 2017 BiOp.[6] EPA re-initiated consultation because new information on how the pesticides were actually being used may show that the extent of the effects of the actions may be different than what was previously considered. As part of this re-initiation, EPA provided additional usage data it believes may be relevant to the consultation. In its transmittal of this information to NMFS, EPA also referenced usage data and information that had been recently submitted by the registrants of pesticide products containing chlorpyrifos, malathion, and diazinon. After reviewing information EPA provided to NMFS on the 2017 BiOp, NMFS determined that it was appropriate to revise the chlorpyrifos,

[3] https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment
[4] https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment
[5] https://www.fisheries.noaa.gov/resource/document/biological-opinion-pesticides-chlorpyrifos-diazinon-and-malathion
[6] https://www.regulations.gov/document?D=EPA-HQ-OPP-2018-0141-0136

malathion, and diazinon BiOp. NMFS plans to issue a revised final BiOp for chlorpyrifos, diazinon, and malathion by June 2022. FWS has not yet issued a BiOp on chlorpyrifos. EPA plans to address risks to listed species and critical habitats from use of chlorpyrifos as part of the final registration review decision, pending completion of the nationwide consultation process.

C. Other Chlorpyrifos Actions

In September 2007, the Pesticide Action Network North America (PANNA) and Natural Resources Defense Council (NRDC) filed a Petition requesting that the EPA revoke all tolerances for chlorpyrifos under section 408(d) of the Federal Food, Drug and Cosmetic Act (FFDCA) and cancel all chlorpyrifos registrations under FIFRA. Public dockets were opened for the transmittal of public documents pertaining to this petition in EPA-HQ-OPP-2007-1005 and EPA-HQ-OPP-2015-0653.

The registration review of chlorpyrifos and the organophosphates (OPs) has presented EPA with numerous novel scientific issues that the agency has taken to multiple FIFRA Scientific Advisory Panel (SAP) meetings.[7] Many of these complex scientific issues formed the basis of the 2007 petition filed by PANNA and NRDC and EPA therefore decided to address the Petition on a similar timeframe to EPA's registration review schedule.

Throughout the development and revisions to the human health draft risk assessment, and after seeking the expertise of the SAP in 2016, the EPA issued the order to deny the petition in March 2017. The agency concluded that the science addressing neurodevelopmental effects remained unresolved and further evaluation of the science during the remaining time for completion of registration review was warranted. The agency specified it would continue to review the science addressing pre- and postnatal neurodevelopmental effects of chlorpyrifos, and those actions are described in further detail in this PID.

Petitioners and other parties filed objections to directly challenge the denial order. In July 2019, the EPA issued a final order denying objections to EPA's March 2017 order denying PANNA and NRDC's 2007 Petition to revoke all tolerances and cancel all registrations for chlorpyrifos.[8] That 2019 order has been challenged by the Petitioners in the Ninth Circuit, which heard oral arguments in that case in July 2020. *LULAC v. Wheeler*, No. 19-71979 (9th Cir.). To date, the Court had not yet issued a decision on the agency's decision to deny the petition to revoke chlorpyrifos tolerances.

Documents pertaining to the chlorpyrifos Petition to revoke all tolerances and cancel all registrations for chlorpyrifos (docket EPA-HQ-OPP-2007-1005) and chlorpyrifos tolerance rulemaking (docket EPA-HQ-OPP-2015-0653) may be found at www.regulations.gov.[9]

[7] https://www.epa.gov/sap/fifra-scientific-advisory-panel-meetings
[8] https://www.regulations.gov/document?D=EPA-HQ-OPP-2007-1005-0527
[9] https://www.regulations.gov/docket?D=EPA-HQ-OPP-2007-1005 and https://www.regulations.gov/docket?D=EPA-HQ-OPP-2015-0653, respectively

D. Approach for Presenting Risk Estimates and Uncertainty Factors

As noted in the previous section, the registration review of chlorpyrifos and the OPs has presented EPA with numerous novel scientific issues, notably the potential for neurodevelopmental effects on the young (pre-natal, infants and children), that the agency has taken to multiple FIFRA SAP meetings since the completion of reregistration.[10] The agency completed a weight-of-the-evidence (WOE) analysis for neurodevelopmental effects using the "Framework for Incorporating Human Epidemiologic & Incident Data in Health Risk Assessment."[11] The WOE analysis integrated quantitative and qualitative findings from experimental toxicology studies, epidemiology studies, and physiologically-based pharmacokinetic-pharmacodynamic (PBPK-PD) modeling. [12] EPA has also considered the emerging new information from laboratory animal and mechanistic studies in addition to epidemiology studies that identified potential concern for increased sensitivity and susceptibility for the young from neurodevelopmental effects in the development of this PID. Despite several years of study, the science addressing neurodevelopmental effects remains unresolved. Due to this uncertainty, EPA has retained the FQPA 10X safety factor in its human health risk assessment in order "to take into account potential pre- and post-natal toxicity and completeness of the data with respect to exposure and toxicity to infants and children." FFDCA § 408(b)(2)(C). For consistency, EPA has also applied an additional 10X database uncertainty factor (UF_{DB}) in its assessment of occupational risks.

Notwithstanding, EPA recognizes that the science is evolving on this topic, and that there may be new information available prior to the completion of registration review that may impact the agency's conclusions about these effects. Most recently, EPA held a FIFRA SAP meeting from September 15 to September 18, 2020 to assess new approach methodologies that might be used to evaluate developmental neurotoxicity in EPA's assessment of risks to human health. EPA will consider the input and recommendations from the September 2020 FIFRA SAP once the SAP report is released in December 2020. In order to provide a fuller picture of the potential risk estimates and the evolving understanding of the potential for neurodevelopmental effects, EPA has also assessed the potential risks assuming a reduction to 1X of the FQPA SF and the UF_{DB}.

This PID presents the risk estimates as reflected in the 2020 human health risk assessment. EPA is proposing mitigation measures to mitigate risks estimated based on the retention of the 10X FQPA SF and UF_{DB}. EPA is also presenting measures to mitigate risks assuming a reduction to 1X. Depending on the recommendations of the SAP, EPA's conclusions about risk, and thus proposed mitigation measures, may be revised.

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[10] https://www.epa.gov/sap/fifra-scientific-advisory-panel-meetings

[11] U.S. Environmental Protection Agency. 2016. Framework for Incorporating Human Epidemiologic and Incident Data in Health Risk Assessment, December 28, 2016. Available at https://www3.epa.gov/pesticides/EPA-HQ-OPP-2008-0316-DRAFT-0075.pdf.

[12] The PBPK-PD model was used to derive toxicological points of departure (PoDs) and to determine the appropriate intra-species and inter-species uncertainty factors. https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0941.

II. USE AND USAGE

Chlorpyrifos is a broad-spectrum insecticide and miticide registered for use for control of numerous insect pests and some mite pests. Products containing chlorpyrifos are registered for over 50 agricultural uses including fruit and vegetable crops, tree nuts, sorghum, wheat, and other food uses. Chlorpyrifos is also used to treat non-food uses such as cotton, nursery and landscape ornamentals, Christmas trees, golf course turf, greenhouse plants, as well as non-structural wood treatments such as utility poles and fence posts, cockroach bait stations, and as a mosquito adulticide. Many commercially-applied pesticide products containing chlorpyrifos are classified as restricted use products (RUPs), which can only be applied by certified applicators or those under their supervision. There is only one product currently registered for homeowner use which is formulated as a child-resistant bait station for cockroach control (EPA Reg. No. 9688-67). There are over 60 FIFRA Section 3 registrations, including eight technical registrations, and over 30 FIFRA Section 24(c) Special Local Need registrations for products containing chlorpyrifos, which include co-formulated products (i.e., those with multiple active ingredients in addition to chlorpyrifos). Overall usage has declined in the past decade but increased for some specific uses, such as sorghum, sweet corn, sunflowers, tobacco and pears. Since 2019, several states, including California, Hawaii, New York, Maryland, and Oregon, have initiated state-level actions to phase out all or most uses of chlorpyrifos.

Chlorpyrifos products are available in a variety of formulations, including wettable powders, granules, emulsifiable concentrates, WSPs, cattle ear tags, and bait stations. Chlorpyrifos products may be applied via groundboom sprayer, aircraft, tractor-drawn spreader, hand-wand, backpack sprayer, mechanically-pressurized handgun, and belly grinder. Application may take place throughout the agricultural season or throughout the year for non-agricultural applications.

Approximately 5.1 million pounds of chlorpyrifos were used each year for agricultural purposes in the United States between 2014 and 2018. Soybeans, alfalfa and corn make up nearly 50% of the total volume of chlorpyrifos used in the United States each year, with soybeans alone accounting for nearly 25% of total pounds applied. Less than 6% of each crop (i.e., soybeans, alfalfa and corn), however, is treated with chlorpyrifos. In addition to soybeans, alfalfa, and corn, crops with relatively high usage of chlorpyrifos (i.e., those with 100,000 lbs applied per year or more) include almonds, apples, grapes (wine, table, and raisins combined), oranges, peanuts, pecans, sugar beets, walnuts, spring wheat, and winter wheat. At least 40%, of the total acreage planted with apples, grapefruit, and asparagus is treated with chlorpyrifos. There has been a general trend of decreased usage in terms of pounds applied per year from 1998-2018, although acres treated has remained relatively stable (Kynetec, 2019.)[13]

Chlorpyrifos is registered for a number of non-crop uses including turf and ornamentals, tree farms and forest trees, cattle ear tags, livestock housing, rights of way, building perimeters, wood protection treatments, general outdoor treatments for ants and other pests, and wide area mosquito adulticide treatments. The majority of chlorpyrifos products registered for residential treatments were voluntarily cancelled or phased out by the registrants between 1997 and 2001. While usage data is not available for all non-agricultural use sites, available data indicate that the

[13] Kynetec USA, Inc. 2019. "The AgroTrak® Study from Kynetec USA, Inc." Database Subset: 1998-2018.

majority of non-agricultural chlorpyrifos usage in terms of pounds of active ingredient were applied to ornamental lawns and turf. Within this market segment, turf farms account for the majority of usage, with 70,000 pounds of chlorpyrifos applied to approximately 64,000 acres. Nursery and greenhouse use on ornamentals are a close second, with 50,000 pounds applied to approximately 67,000 acres (Kline, 2012).[14] Far fewer pounds of chlorpyrifos were applied for wide area mosquito treatment, with only 10,000 pounds applied annually. However, due to very low application rates typically used for mosquito adulticides, treatments for mosquitos account for the vast majority of non-crop acres treated with chlorpyrifos, with over 1,000,000 acres reported to be treated for this purpose (Kline, 2017).[15] Chlorpyrifos is also registered for use on the following additional surveyed non-crop sites: wide area/general outdoor treatment (for ants and other miscellaneous pests), buildings/premises, rights of way/utilities, and trees. However, while Kline and Company does survey these sites, the surveys did not report any usage for these sites, indicating that chlorpyrifos is not widely used in these sectors (Kline, 2016[16] and Kline, 2017). Chlorpyrifos is also registered for use on livestock areas and animal quarters, but usage data on pounds applied are unavailable for these sites.

III. SCIENTIFIC ASSESSMENTS

A. Human Health Risks

A summary of the agency's human health risk assessment is presented below. The agency used the most current science policies and risk assessment methodologies to prepare a risk assessment in support of the registration review of chlorpyrifos. For additional details on the human health assessment for chlorpyrifos, see the *Chlorpyrifos: Third Revised Human Health Risk Assessment for Registration Review*, which is available in the public docket.

1. Hazard Characterization

Chlorpyrifos is known to form chlorpyrifos-oxon, 3,5,6-trichloro-2-pyridinol (TCP), and 3,5,6-trichloro-2-methoxypyridine (TMP). Chlorpyrifos undergoes desulfuration, reacting in bioactivation to degrade to the more toxic and potent acetylcholinesterase (AChE) inhibitor, chlorpyrifos oxon. Due to rapid deactivation through hydrolytic cleavage by a process called diarylation, the oxon is highly unstable and breaks down to release TCP, which is not a U.S residue of concern.

The hazard characterization for chlorpyrifos and its oxon degradate is based on adverse health effects in animals and humans related to AChE inhibition, and potential for neurodevelopmental effects. Guideline animal toxicity studies have historically been used in support of the 10% red

[14] Kline and Company. 2012. Professional Turf and Ornamental Markets for Pesticides and Fertilizers 2012: U.S. Market Analysis and Opportunities. [Accessed April 2020.]
[15] Kline and Company. 2017. Professional Pest Management Markets for Pesticides 2016: United States Market Analysis and Opportunities 2016. [Accessed April 2020.]
[16] Kline and Company. 2016. Mosquito Control Markets 2015: U.S. Market Analysis and Opportunities. [Accessed April 2020.]

blood cell (RBC) AChE inhibition point of departure (POD) for chlorpyrifos in EPA risk assessments.

Since the agency has used the PBPK-PD model for chlorpyrifos to simulate human RBC AChE inhibition, the default 10X inter-species uncertainty factor (to account for uncertainty in relying on animal toxicity data to estimate a human toxicity endpoint) is not warranted and is reduced to 1X. The PBPK-PD model also incorporates inter-individual variation in response to chlorpyrifos to estimate a distribution of administered doses that could have resulted in 10% RBC AChE inhibition in humans, meaning a data derived extrapolation factor (DDEF) can be applied in lieu of the default intraspecies uncertainty factor. The agency has selected the 99th percentile of the distribution to account for variation of sensitivity. The intra-species DDEF is 4X for chlorpyrifos and 5X for the oxon for all groups except females of reproductive age for whom the 10X intra-species factor was retained.

The 2020 revised human health risk assessment presents potential risks with the 10X FQPA Safety Factor (SF), reflecting the uncertainties around doses that may cause pre- and postnatal neurodevelopmental effects, as well as 1X to demonstrate the range of potential risk estimates.

The uncertainty factors and total level of concern (LOC) for each subpopulation is as follows:

Table 1: Uncertainty Factor Summary

Uncertainty Factor	FQPA 10X			FQPA 1X		
	Females	All other Subpopulations		Females	All other Subpopulations	
		Food (parent)	Drinking Water (oxon)		Food (parent)	Drinking Water (oxon)
Interspecies	1	1	1	1	1	1
Intraspecies	10	4	5	10	4	5
FQPA	10	10	10	1	1	1
Total LOC	**100**	**40**	**50**	**10**	**4**	**5**

2. Risk Summary and Characterization

Steady State

As with other OPs, chlorpyrifos exhibits a phenomenon known as steady state AChE inhibition. Following repeated exposure at the same level, the degree of inhibition reaches equilibrium with production of new, uninhibited enzyme and the amount of AChE inhibition in a given dose remains consistent across exposure duration. After reaching steady state, the amount of AChE inhibition at a select dose remains constant across exposure duration. It generally takes approximately 2 to 3 weeks for this class of chemicals to reach steady state (U.S. EPA, 2002); however, this timeframe can vary with select chemicals. As such, the agency evaluated potential risks from steady state exposure in lieu of chronic exposure.

Dietary (Food + Water) Risks

FOOD

Both the acute and steady state dietary (food only) exposure analyses for chlorpyrifos were highly refined and incorporated monitoring data for almost all foods. Most of the food residues used were based upon USDA's Pesticide Data Program (PDP) monitoring data except in a few instances where no appropriate PDP data were available. Chlorpyrifos is routinely included in PDP monitoring.

The only residue of concern for the dietary (food only) assessment is chlorpyrifos. Food exposures do not incorporate potential exposure from food handling establishment (FHE) uses since the agency did not identify any registered FHE uses. Therefore, food exposures are based only upon field use of chlorpyrifos. At the 99.9th percentile of exposure the subgroup with the highest acute exposure was females (13-49 years old) at 3.2 % acute population adjusted dose for food ($aPAD_{food}$) with the 10X FQPA safety factor retained. For the steady state dietary (food only) exposure analyses, the population subgroup with the highest exposure was children (1 to <2 years old) at 9.7% of the $ssPAD_{food}$ at the 99.9th percentile of exposure. No potential risks of concern were identified from exposure to chlorpyrifos in food only. With the FQPA SF reduced to 1X, acute and steady state dietary risk estimates are <1% of the $aPAD_{food}$ and $ssPAD_{food}$ for all populations.

WATER

Drinking Water Assessment and Refinements

The *Updated Chlorpyrifos Refined Drinking Water Assessment for Registration Review* builds upon refinements from the 2014 and 2016 assessments at the Tier 3 assessment level, which included a screening-level approach at the national, regional, and watershed level as well as monitoring data and effects from water treatment systems. Based on regional screening, the incidence of high exposures is expected to be highly localized. However, assessing exposure on a local scale is difficult without regional-specific data and considering several local characteristics including soil type(s) and weather conditions. To further account for exposure on a local scale, EPA examined the potential geospatial concentration differences between two Hydrological Unit Code (HUC 2) Regions. This method was developed to identify use patterns that may result in estimated drinking water concentrations (EDWCs) that exceed the Drinking Water Level of Comparison (DWLOC) on a regional basis.

Moreover, the 2020 assessment incorporates the following additional refinements:

- New surface water model scenarios (i.e., soil, weather, and crop data);
- Use of community water system percent cropped area (PCA) adjustment factors and state level percent crop treated (PCT) data; and
- Quantitative use of surface water monitoring data.

Quantitative use of surface water monitoring data underwent external review in November 2019 from the FIFRA SAP and the remaining refinements were open to public comment and external

peer review. Utilization of the aforementioned factors and data elevates the drinking water assessment to a Tier 4 assessment level, the most highly refined assessment tier.[17] The *Framework for Conducting Pesticide Drinking Water Assessments for Surface Water (DWA Framework)* (USEPA, 2020) includes a description of how these methods fit into the overall tiered drinking water assessment process.

Drinking Water Level of Comparison (DWLOC) Approach

Given the potential drinking water risks of concern previously identified during the registration review of chlorpyrifos, the *Updated Chlorpyrifos Refined Drinking Water Assessment (DWA) for Registration Review* focuses on a subset of high-benefit[18] [19] and/or critical uses in defined areas of the country:

- Alfalfa
- Apple
- Asparagus
- Cherry
- Citrus
- Cotton
- Peach
- Soybean
- Sugar beet
- Strawberry
- Wheat (Spring and Winter)

For a drinking water assessment which utilizes a DWLOC, the calculated DWLOC is compared to the EDWC. When the EDWC is greater than the DWLOC, there may be a risk concern for exposures to chlorpyrifos and/or chlorpyrifos oxon. Conversely, when the EDWC is less than the DWLOC, there are no risks of concern.

Both chlorpyrifos and the chlorpyrifos oxon are residues of concern in drinking water. With the 10X FQPA safety factor, the lowest acute DWLOC and steady state DWLOC calculated were 23 ppb and 4 ppb, respectively, for the most sensitive population, infants (<1 year old). The DWLOCs are 230 ppb and 43 ppb, respectively, without retention of the 10X FQPA safety factor. Drinking water concentrations of chlorpyrifos oxon above the DWLOC indicate a potential risk concern.

Table 2: DWLOC Values for Chlorpyrifos-Oxon for Infants

DWLOC (ppb) for infants				
	Chlorpyrifos		**Chlorpyrifos-oxon**	
Safety Factor	10X	1X	10X	1X
Steady State	17	180	**4**	**43**
Acute	100	1000	23	230

[17] https://www.epa.gov/sap/meeting-information-november-19-22-2019-scientific-advisory-panel

[18] A high benefit indicates that there are no alternative pesticides for a pest on a specific crop or alternatives products are expensive or less efficacious. Target pests in these crops include alfalfa weevil, lygus bugs, scale, and two spotted spider mites. Additional details are provided in Section III.C. of this document.

[19] https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0943

As noted earlier, several refinements were considered in the *Updated Chlorpyrifos Refined Drinking Water Assessment (DWA),* including usage data, percent cropped area aggregation, and percent cropped area-percent crop treated aggregation. These refinements are reflected in the below EDWCs and discussed in detail in the *Updated Chlorpyrifos Refined Drinking Water Assessment (DWA).*

Table 3: Surface Water Sourced Estimated Drinking Water Concentrations Resulting from Different Refinements for a Subset of 11 High-Benefit Chlorpyrifos Uses (Assuming Upper Bound Application Parameters)

2-digit HUC Name Overlapping States[1]	2-digit HUC Uses	Maximum 1-in-10 Year Estimated Chlorpyrifos-oxon Concentrations in Source Surface Water (µg/L)			
		Maximum 2-digit HUC Use Site-Specific Percent Cropped Area[2]		Percent Cropped Area Aggregation[3]	Percent Cropped Area-Percent Crop Treated Aggregation[4]
		1-day Average	21-day Average	21-day Average	21-day Average
Mid-Atlantic VT, NY, PA, NJ, MD, DE, WV, DC, VA	HUC-02 Apple and Peach	1.0	0.8	-	-
South Atlantic-Gulf VA, NC, SC, GA, FL, TN, MS	HUC-03 Cotton, Citrus, Peach, and Soybean	3.1	1.8	-	-
Great Lakes WI, MN, MI, IL, IN, OH, PA, NY	HUC-04 Alfalfa, Sugar beet, Apple, Cherry, Peach, Soybean, and Asparagus	22.8	19.6	3.4	-
Ohio IL, IN, OH, PA, WV, VA, KY, TN	HUC-05 Apple and Soybean	5.3	4.0	-	-
Tennessee VA, KY, TN, NC, GA, AL, MS	HUC-06 Apple	0.4	0.2	-	-
Upper Mississippi MN, WI, SD, IA, IL, MO, IN	HUC-07 Alfalfa, Sugar beet, and Soybean	9.9	7.2	5.4	3.2
Souris-Red-Rainy ND, MN, SD	HUC-09 Alfalfa, Sugar beet, Soybean, Spring Wheat,	8.3	5.6	5.2[4]	3.3

	and Winter Wheat				
Missouri MT, ND, WY, SD, MN, NE, IA, CO, IA, KS, MO	HUC-10 Alfalfa, Soybean, Spring Wheat, and Winter Wheat	5.7	3.6	-	-
Arkansas-White-Red CO, KS, MO, NM, TX, OK, AR, LA	HUC-11 Alfalfa, Soybean, and Winter Wheat	3.9	3.9	-	-
Texas-Gulf NM, TX, LA	HUC-12 Citrus, Peach, and Winter Wheat	1.1	0.7	-	-
Pacific Northwest WA, ID, MT, OR, WY, UT, NV	HUC-17 Alfalfa, Sugar beet, Apple, and Strawberry	8.5	6.1	2.5	-

Green shading indicates concentrations are below the 10X DWLOC (1-day = 43 µg/L and 21-day = 4 µg/L) while red shading indicates concentrations are above the 10X DWLOC.
- indicates values are not calculated because the concentrations in the prior step were below the 10x DWLOC.
[1] Sites are listed that include any overlap with the HUC-2 region.
[2] Use site-specific PCA refers to the use of a percent cropped area adjustment factor to adjust EDWCs to account only for the potential use sites (e.g., for example for HUC-03 the PCA is the summation of individual percent cropped area for orchard, cotton, and soybean) within each individual community water system where chlorpyrifos is being considered (see column "2-digit HUC Uses").
[3] PCA aggregation refers to the use of individual percent cropped area adjustment factors to proportionally allocate pesticide residue contribution in the development of EDWCs based on potential chlorpyrifos use sites (i.e., land use data) for individual watersheds. This analysis was done using the model output 1-in-10 year values and does not account for temporal residue contributions.
[4] PCA-PCT aggregation refers to the use of individual percent cropped area adjustment factors to proportionally allocate pesticide residue contribution in the development of EDWCs based on known chlorpyrifos use for individual watersheds. This analysis was done using the model output 1-in-10 year values and does not account for temporal residue contributions.
[5] The use pattern specific PCA is higher (i.e., >1) than all-ag PCA (0.95). Therefore, the use pattern specific PCA is capped at all-ag value and the use pattern PCA should not exceed the all-agricultural PCA. However, when aggregating the individual use residue contributions results, this capping cannot be completed.

Based on the most refined EDWCs, concentrations of chlorpyrifos and chlorpyrifos-oxon in drinking water are not likely to exceed the drinking water level of comparison (DWLOC) for the subset of 11 uses considered with the retention of the 10X FQPA safety factor. The consideration of additional crops would likely result in exceedances of the DWLOC if the 10X FQPA SF is retained. Dietary risks of concern from public health uses, such as mosquito adulticide treatment, are not expected at either the 1X or 10X.

EDWCs from the 2016 drinking water assessment for agricultural uses were compared to the DWLOCs to assess currently labels uses at the 1X FQPA safety factor. With a 1X FQPA safety factor, most of the current labeled uses result in drinking water concentrations below the DWLOC. Uses with drinking water concentrations above the DWLOC include, peppers, trash storage bins, and wood treatment, in all areas of the country. Additionally, uses with 1-in-10 year

21-day average drinking water concentrations above the 21-day average DWLOC in certain HUCs include corn, tart cherries, citrus, pecan, and peach. For additional information on the chlorpyrifos EDWCs at the 1X, please see *Evaluating the Impact of Removal of the 10X FQPA Safety Factor on Chlorpyrifos Drinking Water Concentrations.*[20]

Cancer

Chlorpyrifos has also been evaluated for cancer and is classified as "not likely to be carcinogenic to humans." Guideline carcinogenicity studies and epidemiological data are available from the Agricultural Health Study (AHS). Preliminary associations with breast, lung, colorectal, and prostate cancer warrant monitoring follow-up and additional research. There is no compelling evidence of an association with other cancer sites (C. Christensen, 6/16/11, D388167). The AHS chlorpyrifos carcinogenicity studies have been summarized in the memorandum, *Chlorpyrifos Carcinogenicity: Review of Evidence from the U.S. Agricultural Health Study (AHS) Epidemiologic Evaluations 2003-2009* (Christensen, D388167, 6/16/2011).

Residential Exposure Risks

Currently, chlorpyrifos products registered for residential use are limited to roach bait products (EPA Reg. No. 9688-67) or ant mound treatments which may only be applied by commercial applicators. The active ingredient is contained within a bait station which eliminates the potential for human contact; therefore, residential exposure to chlorpyrifos via these products is considered negligible. The majority of products registered for residential treatment were voluntarily cancelled or phased out by the registrants between 1997 and 2001.

There is a potential for exposure to the general population from use on golf courses following treatment with chlorpyrifos products or from exposures which occur following aerial or ground-based ultra-low volume (ULV) mosquito applications made directly in residential areas. Risk estimates for dermal and inhalation exposure were combined since the toxicological endpoint, RBC AChE inhibition, is the same for each of these exposure routes. With retention of the 10X FQPA SF, the residential post-application LOC for children is 40 and the adult residential post-application LOC is 100. Regardless of whether the FQPA SF is retained at 10X or reduced to 1X, there are no residential post-application risk estimates of concern for the registered uses of chlorpyrifos. The assessment of steady state golfer post-application exposures (dermal only) to chlorpyrifos treated turf resulted in no risks of concern to children/youth 6 to <16 years old (Margin of Exposure (MOEs) = 1,200 to 9,900) or adults (MOE = 1,000 to 5,400). With minimum MOEs of 400, there were no combined risks of concern identified for children 1 to <2 years old (dermal, inhalation, and incidental) or adults (dermal and inhalation) from post-application exposures following public health mosquito applications.

Aggregate Risk Assessment

A DWLOC approach was used to calculate the amount of exposure that could occur without exceeding the level of concern for acute and steady state aggregate assessments. This was to

[20] https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0942

account for the available space in the "total aggregate risk cup" for exposures to chlorpyrifos oxon in drinking water after accounting for exposures to parent chlorpyrifos from food and residential uses. The calculated DWLOCs were then compared to the EDWCs of chlorpyrifos and chlorpyrifos oxon modeled under a variety of conditions.

With residential exposures considered negligible, the acute aggregate assessment includes only food and drinking water. The steady state aggregate assessment includes exposures from food, drinking water, and residential uses (golf courses). As previously mentioned, the drinking water assessment is highly refined incorporating multiple screening exercises and comparing modeling results to monitoring data.

When considering all currently registered agricultural and non-agricultural uses of chlorpyrifos, aggregate exposures are of concern. If considering only the uses that result in DWLOCs below the EDWCs, aggregate exposures are not of concern.

Non-Occupational Spray Drift Risks

Spray drift from ground or aerial applications can be a potential source of non-occupational exposure to chlorpyrifos. The potential risks from spray drift exposure and the impact of potential risk reduction measures were assessed in a July 2012 memorandum.[21] To increase protection for children and other bystanders, chlorpyrifos technical registrants voluntarily agreed to spray drift mitigation measures including lower application rates, increased droplet sizes, and buffer zones.

There are no risk estimates of concern incorporating the agreed-upon buffer distances and droplet sizes/nozzle types by the EPA and the technical registrants in 2012 with or without the 10X FQPA SF for aerial or groundboom applications. There were no combined (dermal + incidental oral) risks for children 1 to < 2 years old at the field edge from indirect spray drift exposure to chlorpyrifos and there were no dermal risk estimates of concern at the field edge for adults (females 13 - 49 years old). Aerial applications are not permitted at rates higher than 2.0 lb a.i./ except for treatment of Asian Citrus Psyllid (citrus use) at application rates up to 2.3 lbs a.i./A. For aerial applications at this highest rate, MOEs of concern were identified within 10 feet from the edge of the field. However, current buffer distances required on the label mitigate these potential risks of concern.

The EPA assessed post-application exposures to residential bystanders from spray drift and volatilization. This assessment focuses primarily on individuals who live on, work in, or frequent areas adjacent to chlorpyrifos-treated agricultural fields. In June 2014, a re-evaluation of the 2013 preliminary volatilization assessment was conducted to present the results of two new vapor studies and their impact (MRIDs 49119501 and 49210101). These studies demonstrated that no toxicity occurred even at the saturation concentration, which is the highest physically achievable concentration. As such, there are no anticipated risks of concern from exposure to the volatilization of either chlorpyrifos or chlorpyrifos oxon with or without retention of the 10X FQPA SF.

[21] https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0103

Cumulative Risks

Chlorpyrifos is a member of the OP class of pesticides. EPA considers OPs to express toxicity through a common biochemical interaction with cholinesterase which may lead to several potential cholinergic effects and, consequently, the OPs should be considered as a group when performing cumulative risk assessments. The agency first completed a cumulative risk assessment for the OPs in 2001, a revised cumulative risk assessment for the OPs was completed in 2002[22], and an updated OP cumulative risk assessment was completed in 2006.[23] The cumulative effects of exposure to multiple OPs, including chlorpyrifos, are evaluated in those documents. Prior to the completion of registration review, the agency will update the OP cumulative risk assessment to incorporate any toxicity and exposure information available since 2006.

Occupational Handler Risks

Occupational handlers mixing, loading, and/or applying pesticide products containing chlorpyrifos may be exposed to chlorpyrifos dermally or by inhalation. PBPK-PD model-derived PODs (dermal and inhalation), which were specifically set up for occupational exposure scenarios, were used to estimate handler risks. The steady state approach accounts for short-term exposure duration, as well as for workers that are exposed over longer periods of time (i.e., intermediate-term exposures). The dermal and inhalation risk estimates were combined since the toxicological endpoint, RBC AChE inhibition, is the same for each of these exposure routes.

The human health risk assessment presents estimates assuming both that the database uncertainty factor (UF_{DB}) has been retained at 10X and has been reduced to 1X. If the database uncertainty factor is retained, the total LOC for occupational exposure assessment is 100X for adults (represented by females 13-49). If the database uncertainty SF is reduced to 1X, the total LOC for occupational exposure assessment is 10X for adults (represented by females 13-49).

Two hundred eighty-eight steady state occupational handler scenarios were assessed for non-seed treatments. Assuming a 10X database uncertainty factor is retained (LOC = 100), 119 scenarios are of concern with label-specified personal protective equipment (PPE; baseline attire, chemical resistant gloves, coveralls, and a protection factor (PF) 10 respirator) (MOEs < 100). Risks of concern for 45 additional exposure scenarios could potentially be mitigated if engineering controls are used. Without retention of the 10X database uncertainty factor (UF_{DB}) (LOC = 10), 19 non-seed treatment scenarios are of concern with baseline attire, chemical resistant gloves, coveralls, and an elastomeric half mask (PF 10) respirator (MOEs < 10). If

[22] US EPA, 2002. https://nepis.epa.gov/Exe/ZyNET.exe/9100BFLL.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2000+Thru+2005&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C00thru05%5CTxt%5C00000023%5C9100BFLL.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

[23] US EPA, 2006. https://www regulations.gov/document?D=EPA-HQ-OPP-2006-0618-0002

engineering controls are used, risks of concern for 15 additional scenarios could potentially be mitigated. The changes to the inputs are not expected to result in significant changes to the risk estimates and have not been updated at this time.[24]

A total of 93 commercial seed treatment scenarios were assessed for chlorpyrifos. The revised human health risk assessment identified 22 seed-treatment scenarios of concern with the assumption that the 10X UF_{DB} is retained. Seed treatment uses include corn, cotton (delinted), cucumber, pumpkin, sorghum grain, triticale (wheat), and a variety of beans. No potential risks of concern were identified with scenarios assessed for cucumber, pumpkin, sorghum grain and triticale or for planting seeds previously treated with chlorpyrifos. If the 10X UF_{DB} is reduced to 1X, there are no seed-treatment scenarios of concern for chlorpyrifos. Potential risks of concern were found for the following with retention of the 10X UF_{DB}:

Table 4: Occupational Risks of Concern from Seed Treatment at the 10X UF_{DB}[1]

Formulation and PPE	Loader/Applicator[2]	Sewer	Bagger	Multiple Activities Worker
Liquid (with double layer PPE (coveralls), gloves, and an elastomeric half mask respirator (PF 10)	Corn = 67 - 95 Cotton = 33 - 46	Cotton = 50-71	Corn = 96 - 140 Cotton = 46 - 65	Beans = 61 - 86 Corn = 50 - 71 Cotton = 24 - 34
Liquid (microencapsulated)	Beans only: 59 - 83	Beans only: 91 - 130	Beans only: 84 - 120	Beans only: 44 - 62
Wettable Powder via WSP	Beans = 75 – 110 Corn = 62 - 88	Corn = 96 - 140	Corn = 89 - 130	Beans 57 – 79 Corn = 47 - 66

[1] LOC with 10X = 100
[2] Maximum MOEs with listed PPE

NON-SEED TREATMENT

Aerial and/or Chemigation applications

Several chlorpyrifos formulations may be applied by aerial or chemigation application. These include liquids, wettable powders, granule formulations, and water dispersable granules. The maximum application rate for aerial application is 2.3 lbs a.i./A for use on citrus.

Even with the use of engineering controls (closed systems), mixing and loading resulted in risks of concern to workers at the 1X UF_{DB} for four uses: corn (pre-plant), peanut, sweet potato, and sunflower. These risks of concern were limited to granular formulations for these uses. The MOE for aerial application of granular formulations of chlorpyrifos on peanuts is 5. MOEs for other

[24] Some occupational handler exposure inputs have changed since the previous ORE assessments were completed in 2011 (W. Britton, D388165, 06/27/2011), 2014 (W. Britton, D424484, 12/29/2014), and 2016 (W. Britton, D436317, 11/03/2016) (e.g., amount of seed treated per day, seed planted per day).

aerial granular applications are 9.4 (sweet potato), 9.5 (sunflower, tobacco), and 9.6 (corn). Without the 10X UF_{DB}, MOEs for mixing and loading for aerial applications ranges from 0.61 to 6.7 for uses with risks of concern with baseline PPE (long-sleeved shirt, long pants, socks and shoes). Use of the highest 2 tiers of refinement (double layer (coveralls), gloves, and an elastomeric half mask respirator or engineering controls result in MOEs of 4.7 to 66 for mixing and loading granular formulations.

For mixing/loading liquids and wettable powders (WP), nearly all scenarios resulted in MOEs below the LOC of 100 (with retention of the 10X UF_{DB}). With the exception of ornamental shade trees and herbaceous plants (MOE = 130 with engineering controls), the risk estimates for mixers and loaders for all remaining formulations were below the LOC of 100 with a range of 9.6 to 71 for citrus, tree nuts (almonds, filberts, hazelnuts), tree fruit (apple, cherries), cole crops (excludes Brussels sprouts and cauliflower), Christmas tree plantations, and nursery stock (pre-plant). Potential risks to aerial or chemigation applicators were found for all starting formulations of spray applications and granules for the following uses with MOEs from 5 to 94: peanut, sweet potato, sunflower, tobacco, sod farms (turf), corn (pre-plant and post-emergence), alfalfa, cotton (except Mississippi), soybean, wheat, sorghum, and Christmas tree plantations. All remaining aerial applications were above the LOC of 100 and, therefore, not of concern.

Airblast applications

Chlorpyrifos may be applied by airblast application at rates from 1.0 to 6.0 lbs a.i./acre to citrus, tree nuts, tree fruits, grapes, asparagus, and to shade trees, herbaceous plants, Christmas tree plantations, and ornamental woody shrubs and vines. Formulations that may be applied by airblast include liquid/soluble/emulsifiable concentrate (L/SC/EC), WP in WSP, and dry flowable/water dispersable granule (DF/WSG) in WSP. Risk estimates for mixing, loading, and applying airblast applications were mostly above the LOC of 100 with the use of engineering controls. At a rate of 6.0 lbs a.i./acre (California and Arizona citrus), MOEs ranged from 64 to 67 for mixing and loading WSP formulations. MOEs for mixing, loading, and applying citrus outside of California and Arizona were 98. Mixing, loading, and applying all formulations for tree nuts (pecans) ranged from 89 to 91. MOEs for remaining uses ranged from 98 to 390 with engineering controls. All airblast application scenarios without engineering controls, even those with use of chemical resistant headgear, resulted in potential risks of concern with MOEs from 0.55 to 4.2, which is below the LOC with or without retention of the 10X UF_{DB}.

There were no risks of concern for occupational handlers mixing and loading WSP formulations except and as mentioned above for citrus and tree nuts (pecans). However, with the use of double layer (coveralls), gloves, and an elastomeric half mask respirator, only the following uses resulted in MOEs above the agency's LOC of 100 for all other formulations (L/SC/EC):

- Cherries, tree fruits (pear, plum/prune (dormant, delayed dormant), tree nuts (almonds, filberts, hazelnuts, pecans, walnuts); MOE = 110
- Ornamental and/or shade trees, ornamental woody shrubs and vines, herbaceous plants, Christmas tree plantations, grapes; MOEs = 220

Risk estimates for all levels of PPE for the remaining uses were from 4.6 to 71 for mixers and loaders and were, therefore, of concern with retention of the 10X UF_{DB}.

Groundboom applications

Groundboom application is one of the most widely used application methods for chlorpyrifos. Nearly every use resulted in potential risks of concern from mixing, loading, or applying without the use of PPE above baseline levels (long-sleeved shirt, long pants, socks and shoes) for mixers, loaders, and applicators with retention of the 10X UF_{DB}. Risk estimates of concern were still identified for groundboom applicators with engineering controls on corn (pre-plant, MOE = 67) and cotton (except in Mississippi, MOE = 99) and mixers and loaders for the following uses:

Table 5: Groundboom Risk Estimates with MOEs < 100 with Engineering Controls

Formulation	Crop/Target Category	MOE with baseline PPE	MOEs with double layer (coveralls), gloves and respirator	MOE with engineering controls
Mixers and Loaders				
Liquid/Soluble Concentrate/Emulsifiable Concentrate (L/SC/EC)	Corn (pre-plant)	1.9	14	39
	Cotton (except MS)	2.7	22	58
	Tree nut orchard floors (pecans, almonds, walnuts)	3.2 - 3.5	25 - 26	68 - 73
	Ornamental lawns and turf, sod farms	3.7	28	77
	Radish (pre-plant)	4.6	35	96
Wettable powder in water-soluble packet (WSP)	Ornamental lawns and turf, sod farms	N/A	N/A	51
	Ornamental woody shrubs and vines (pre-transplant)	N/A	N/A	67
Dry flowable/water-soluble granule in WSP	Tree nut orchard floors (pecans, almonds, walnuts)	N/A	N/A	46 - 48
	Corn, sorghum grain, soybean	N/A	N/A	79
	Rutabaga	N/A	N/A	80
	Turnip	N/A	N/A	86
	Sweet potato	N/A	N/A	92
	Cole crops (excludes Brussels sprouts and cauliflower), mint (peppermint and	N/A	N/A	98

	spearmint), peanut, sunflower			
Applicator Risk Estimates with MOEs < 100 with Engineering Controls or Maximum PPE				
Spray (all starting formulations)	Corn (pre-plant), cotton (except Mississippi)	4.8 – 7.2	31 - 47	67 - 99
	Corn (post-emergence), tree nut orchard floors (pecans, almonds, walnuts), ornamental lawns and turf, sod farms (turf)	8.3 - 9.8	54 - 62	110 - 130
	Radish, alfalfa, cotton, sorghum grain, soybean, wheat,	12 - 15	78 - 94	170 - 210
	Rutabaga	15	94	210

Use of engineering controls resulted in mixer/loader risk estimates above the LOC of 100 for mixing and loading for the following uses (MOEs = 120 – 190):

- At a rate of 4.0 lbs a.i./acre: nursery stock (pre-plant)
- At a rate of 2.0 to 2.4 lbs a.i./acre: Brussels sprouts (at plant and post-emergence), cauliflower, cole crops, figs (only in California), grapes (foliar, dormant, delayed dormant), mint, peanut, pineapple, rutabaga, strawberries (pre-plant), sunflower (pre-plant) sweet potato (pre-plant and soil broadcast), and tobacco (preplant).
- At a rate of 1.9 lbs a.i./acre: beets (table, sugar, at plant), clover (grown for seed, foliar), hybrid cottonwood and polar plantations
- At a rate of 1.5 lbs a.i./acre: cranberry
- At a rate of 1.0 lbs a.i./acre: alfalfa, cotton, sorghum grain, soybean, and wheat

Mixer and loader risk estimates for these crops with double layer (coveralls), gloves, and an elastomeric half mask respirator range from 42 to 71. Applicator risks estimates with this level of PPE ranged from 31 to 470 with risks of concern identified for use on corn (pre-plant and post-emergence) and cotton (except MS), rutabaga, alfalfa, soybean, sorghum grain, wheat, radish (preplant), tree nut orchard floors (pecans, almonds, walnuts) and ornamental lawns and turf with MOEs up to 94.

With the exception of microencapsulated formulations for ornamental non-flowering plants and wettable powder for citrus orchard floors and cole crops (excluding Brussels sprouts and cauliflower), all remaining uses present potential risks of concern to mixers, loaders, and applicators with baseline PPE (long-sleeved shirt, long pants, socks, and shoes). MOEs for mixers and loaders range up to 27 and up to 72 for applicators. Use of double layer (coveralls), gloves, and an elastomeric half mask respirator results in risk estimates up to 220 for mixers and loaders and 470 for applicators and are not of concern.

Flaggers

Although the use of global positioning systems (GPS) has vastly replaced the use of flaggers to guide aerial applications, the agency continues to assess exposure as use of flaggers is not explicitly prohibited on pesticide products containing chlorpyrifos. At the 1X UF_{DB}, all risk estimates were above the LOC of 10 and, therefore, are not of concern. Nearly all applications of chlorpyrifos products results in potential risks of concern for flaggers with the maximum amount of PPE (double layer (coveralls), gloves, and PF10 respirator) at the 10X UF_{DB}; risk estimates of concern ranged from 15 to 88 with the maximum PPE (where the LOC with the 10X UF_{DB} is 100). No risks of concern were identified for flaggers with granule application to turf nor for applications to sweet potato, corn (pre-plant), sunflower, and tobacco with the maximum amount of PPE.

Handheld application methods[25]

Assessment of handheld application methods typically assumes mixer, loader, and applicator exposure to the same occupational handler.

Manually-pressurized handwand and handgun

Manually-pressurized handwand application is limited to mostly non-food uses such as ornamental plants, nursery stock, poultry litter, and industrial and commercial areas. Food uses include select tree nuts and tree fruits. With the use of single layer (long-sleeved shirt and long pants) and gloves, most uses are above the EPA's LOC of 10 at the 1X UF_{DB} (MOEs = 3.9 – 9,000) No risks of concern were identified at the 1X UF_{DB} from spot treatment applications (0.023 lbs a.i./Acre). Without gloves, MOEs ranged from 2.6 – 110 with risks of concern for use on applications that were not considered spot treatments (i.e., applications of 40 gallons or to 1,000 square feet). MOEs were below the LOC of 100 at the 10X UF_{DB} for the following handwand applications with maximum PPE (double layer (coveralls)) gloves, and an elastomeric half mask respirator:

- Wood protection treatment (MOE = 82)
- Nursery, pine seedlings (MOE = 90)
- Indoor commercial, institutional, industrial premises, food processing plant premises (MOE = 16)

Risks of concerns were found for nearly all scenarios with manually-pressurized handgun applications and formulations with the exception of:

- WSP application to ornamental woody shrubs and vines (MOEs = 440 to 2100); and
- All formulations registered for use on seed orchard tree (MOEs = 1800 – 8300).

Remaining risk estimates with use of double layer (coveralls), gloves, and an elastomeric half mask respirator ranged from 11 to 83. An MOE of 83 was determined for ornamental and/or shade trees, herbaceous plants, and grapes (WSP formulation only).

[25] Assessment assumes mixing, loading, and application are conducted by some the same individual and does not include use of engineering controls.

Tractor-drawn spreader

At the 10X UF_{DB}, no occupational handler risks of concern were identified with use of tractor-drawn spreaders. Nor were risks of concern found with use of a SmartBox®. SmartBox® systems are closed application systems that are considered to be protective as engineering controls. Retention of the 10X UF_{DB} resulted in risks of concern with use of only baseline PPE. MOEs range up to 71 except for use of golf course turf, rights of way, and road medians where the MOE is 120. Application to most uses are above the LOC of 100 with use of gloves, respirator, and coveralls or engineering controls. Even with engineering controls (excluding SmartBox systems), risk estimates are below 100 for application to soybean, corn, and ornamental woody shrubs and vines for mixers, loaders, and applicators (MOEs = 53 – 89).

Backpack Sprayers

Risks of concern from backpack sprayers without retention of the 10X UF_{DB} were limited to use on ornamental and/shade trees, herbaceous plants, ornamental woody shrubs and vines, wide-area general outdoor treatment, and outdoor commercial/institutional/industrial premises, non-agricultural outdoor buildings and structures.

MOEs for liquid concentrate application by backpack sprayer ranged from 1.5 – 76 and exceeded the agency's LOC of 100 for all levels of PPE except as follows:

Table 6: Risk Estimates for Backpack Sprayer Applications[1]

Formulation	Application type	Crop/Targeted Use	PPE	MOE
Dry flowable/water-dispersable granule in WSP	Broadcast (foliar)	Grapes (pre-bloom)	Double layer (coveralls), gloves, and an elastomeric half mask respirator	94
	Trunk spray/Drench	Tree fruits (apple)		100
	Drench/Soil-Ground-directed	Grapes (pre-bloom)		130
Liquid/soluble concentrate/emulsifiable concentrate	Broadcast (foliar)	Golf course turf		94
	Spot treatment applications (0.023 A treated)	Ornamental and/or Shade Trees, herbaceous plants	Baseline	320
		Ornamental lawns and turf, sod farms (turf)		350
		Outdoor commercial/institutional/industrial premises, non-agricultural buildings and structures, golf course turf		1300
Microencapsulated formula	Broadcast (foliar)	Ornamental woody shrubs and vines	Double layer	94

		Ornamental non-flowering plants	(coveralls), gloves, and an elastomeric half mask respirator	130
	Directed broadcast	Outdoor commercial/institutional/industrial premises	Baseline	230
	Broadcast	Agricultural farm premises	Baseline	400
	Broadcast	Poultry litter	Baseline	1100
WSP	Spot	Ornamental woody shrubs and vines (pre-transplant)	Baseline	330
	Spot	Outdoor lawns and turf, Sod Farms (turf)	Baseline	350
	Broadcast	Ornamental woody shrubs and vines	Baseline	930

[1]Select uses with risk estimates below the LOC of 100 were included if chlorpyrifos was considered a high benefit.

Granule formulations

Application of chlorpyrifos granule formulations by hand is limited to non-agricultural uses. Applications by spoon resulted is risk estimates from 1400 to 5700 and were not of concern. Regardless of PPE, all applications with a belly grinder with retention of the 10X UF_{DB} resulted in potential risks of concern with a maximum MOE of 43. Hand dispersal resulted in potential risks on concern with or without retention of the 10X UF_{DB} and regardless of PPE for treatment of commercial/institutional/industrial premises and utilities with MOEs from 0.49 to 1.4. Treatment of golf courses and sod farms by the same method were of concern with baseline PPE (MOE = 90; long-sleeved shirt, long pants, no gloves and no respirator). Hand dispersal and rotary spreader application resulted in MOEs below the LOC of 100 with retention of the 10X UF_{DB} for ornamental woody shrubs and vines regardless of PPE with MOEs up to 53. With baseline PPE, MOEs for all other remaining uses treated by rotary spreader were 63 to 70. Use of maximum PPE (double-layer (coveralls), gloves, and an elastomeric half mask respirator) results in MOEs of 290 to 320.

Non-Food and Other Application Methods:
Application of cattle eartags, bait stations, and total release foggers (greenhouses) are considered to have negligible exposure; therefore, there were no risks of concern identified to occupational handlers for these treatment methods. However, potential risks of concern were identified for all levels of personal protective equipment using paint brushes and rollers for wood protection treatment. Regardless of PPE, all applications with a brush roller resulted in potential risks of concern with retention of the 10X UF_{DB} with a maximum MOE of 45.

Wide-area Mosquito Abatement

With label required single layer (long-sleeved shirt and long pants) and gloves, MOEs for mixing and loading wide area mosquito applications were below the agency's LOC of 100 for aerial applications and above the LOC for ground applications. Aerial applications were assessed assuming only engineering control and were not of concern. With the retention of the 10X UF_{DB}, ground applications were only above the LOC of 100 with the use of engineering controls. Without engineering controls, ground applicator MOEs were of concern. Ultra-low volume (ULV) wide-area applications by airblast were below the LOC of 10 without retention of the 10X UF_{DB} with MOEs ranging from 4.4 to 5.6.

Occupational Post-Application Risks

Most crops and activities require a restricted entry interval (REI) of 24 hours on current chlorpyrifos labels. However, in some cases such as citrus fruits, REIs are up to 5 days after application. Occupational post-application risks have been updated to incorporate PBPK-derived steady state PODs based on 10% RBC AChE inhibition. Assuming the UF_{DB} is reduced to 1X, most post-application risk estimates are not of concern 1 day after application. Likewise, the majority of the post-applications scenarios are not of concern 1 day after application (REI = 24 hours) assuming the UF_{DB} of 10X is retained. However, for some activities result in risks of concern up to as many as 10 days following application for the non-microencapsulated formulations and > 35 days for the microencapsulated formulation.

The residue of concern for occupational post-application exposures is the chlorpyrifos parent compound, although it may be possible that the formation of chlorpyrifos oxon is greater and its degradation slower in greenhouses when compared to the outdoor environment. Dermal exposure to the oxon on foliar surfaces from reentry into an outdoor environment previously treated with chlorpyrifos is not anticipated and, therefore, has not been assessed.

The agency has numerous dislodgeable foliar residue (DFR) studies for several chlorpyrifos registered uses. Specifically, the DFR studies examined the use of 1) granular formulations on turf and sweet corn; 2) emulsifiable concentrate formulations on citrus, sugar beets, sweet corn, pecans, cotton, and turf; 3) a microencapsulated liquid formulation on ornamentals; 4) a total release aerosol formulation on ornamentals; and 5) wettable powder formulations on pecans, almonds, apples, tomato, cauliflower, and turf. These studies varied in location and calculations using each of these studies yield different risk estimates. The agency is presenting the full range of post-application risk estimates in Appendix D1 of this PID.

Dermal exposure assessment on outdoor foliar surfaces was limited to chlorpyrifos exposure only. Exposure to chlorpyrifos oxon on foliar surfaces from reentry into an outdoor environment (e.g., field crops and orchards) previously treated with chlorpyrifos is not anticipated and, therefore, was not assessed. Occupational post-application assessments were performed for: 1) exposures to the parent compound chlorpyrifos in outdoor environments (all uses), 2) exposures to the parent chlorpyrifos indoors (e.g., greenhouses) and 3) exposures to both the parent and chlorpyrifos oxon in greenhouses. Occupational dermal post-application exposures were assessed in greenhouses using conservative assumptions of oxon formation.

A quantitative occupational post-application inhalation risk assessment is not required for chlorpyrifos or chlorpyrifos oxon due to the lack of toxicity from the vapor phase of these chemicals, even at the saturation concentration. Post-application exposure from seed treatment is not expected.

The agency's LOC for occupational post-application risks is 100 at the 10X UF_{DB} and 10 at the 1X UF_{DB}. Post-application exposure to agricultural workers from commercial seed treatment is not expected. The agency has identified potential risks of concern for the following uses and activities. The comprehensive list of REIs by crop, post-application activity, and study location yielding those risk estimates are presented in Appendix D1.

Greenhouse

Chlorpyrifos may be applied to food and non-food uses in greenhouses. Chlorpyrifos formulations used in greenhouses include emulsifiable concentrate, microencapsulated liquid, wettable powder in WSP, and total release foggers. The chlorpyrifos parent compound is the residue of concern for occupational post-application dermal exposures; however, available exposure data indicate chlorpyrifos oxon may form in indoor environments.[26] It is uncertain if the formation of the oxon is greater and its deactivation slower in greenhouses when compared to the outdoor environment. Workers reentering indoor environments (i.e., greenhouses) previously treated with chlorpyrifos could potentially be exposed to the more toxic oxon as chlorpyrifos degrades. Risks for reentry into treated greenhouses for the parent chlorpyrifos plus chlorpyrifos oxon were estimated using a total toxic residue approach for all four formulations used in greenhouses.[27] A conservative assumption of 5% (0.05) of the total chlorpyrifos was estimated as present as DFR in greenhouses and available for contact during post-application activities. Five percent is the high-end value for the percent of parent that metabolized during the course of the residue studies. Risk estimates after treatment for total release fogger and liquid concentrate formulations were not of concern 0 to 6 days. For the microencapsulated formulation, MOEs are not of concern 3 to > 35 days after treatment (the completion of the monitoring period), depending on the exposure activity considered.

3. Human Incidents

Chlorpyrifos incidents were previously reviewed in 2011.[28] The human incident databases that were reviewed are:

- Office of Pesticide Programs Incident Data System (OPP IDS);
- National Pesticide Information Center (NPIC);
- NIOSH's Sentinel Event Notification System for Occupational Risks (SENSOR);
- California Pesticide Illness Surveillance Program Incident Data (CA PISP).

Incident information from each of these databases follows.

[26] J.L. Martinez Vidal, et al. 1998. Diminution of Chlorpyrifos and Chlorpyrifos Oxon in Tomatoes and Green Beans Grown in Greenhouses. J. of Agric. and Food Chem. 46 (4), 1440–1444.
[27] Total DFR (µg/cm^2) = [Chlorpyrifos DFR (µg/cm^2) * TAF] + [Chlorpyrifos DFR (µg/cm^2)]
[28] Chlorpyrifos: Tier II Incident Report https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0032

IDS

The IDS consists of the Aggregate IDS and Main IDS. In Aggregate IDS, queried from January 1, 2002 to May 27, 2010, there are 745 incidents involving chlorpyrifos. Prior to 2011, there are 247 cases reported that involve the active ingredient chlorpyrifos for the Main IDS. Of these cases, 141 cases are reported for the single chemical chlorpyrifos in the database. Most of these incidents were categorized as Human Moderates (HCs); 12 were categorized as Human Majors (HBs); and one was categorized as fatality (HA). Fifteen of these incidents were reported as affecting children 6 years old or under (2 HBs and 13 HCs). These latter incidents appear to be due to accidental ingestion and post application exposure to cancelled products. Main IDS-reported chlorpyrifos incidents appear to have decreased substantially in this period from 43 incidents in 2002, to 2 incidents in 2010. The initial large reductions generally coincide with the dates for which regulatory actions were taken.

NPIC

Similar to Poison Control Centers, NPIC's primary purpose is to provide information on a variety of pesticide topics and direct callers for pesticide incident investigation and emergency treatment. While NPIC does collect information about incidents, it generally receives fewer reports than IDS. From 2002 to 2010, 178 cases were reported for chlorpyrifos in the NPIC database. Of these cases, 88 were reviewed because, in these cases, chlorpyrifos was used as a single chemical and had a certainty classification of probable, possible, or unclassified. Eight of the chlorpyrifos cases were associated with children six years old or younger.

NIOSH SENSOR

The NIOSH SENSOR database is not national in scope and is limited to participation of 13 states.[29][30] For the 2011 human incident report, the agency analyzed NIOSH SENSOR data from 1998-2007. SENSOR focuses on occupational pesticide incidents, although both occupational and non-occupational incidents are included in the database. For NIOSH SENSOR from 1998 to 2007, there were 635 cases reported for chlorpyrifos in the database. Of these cases, 348 involved chlorpyrifos use as a single chemical only and had a certainty classification of definite, probable, or possible. There was one death due to suicide. Eight cases were classified as high severity; 60 cases, as moderate severity; and 279 cases, as low severity. Of the 348 chlorpyrifos-only cases, 18 cases involved children six years old or younger. These latter incidents were mostly due to accidental ingestions, misapplications around the home, and drift from nearby properties. Generally, chlorpyrifos incidents involved workers in agricultural or professional application occupations, homeowners and individuals at work but their job was not related to pesticide application, and to individuals exposed through drift.

California PISP

One hundred and sixty-four cases are attributable to chlorpyrifos-only exposures were reported to the California PISP between 1999 and 2008. Of these cases, 87 were occupational incidents and 77 were non-occupational incidents. A number of these incidents appear to be due to accidents and misuse. Drift of chlorpyrifos from adjacent fields appears to be the cause of the

[29] https://www.cdc.gov/niosh/topics/pesticides/overview html
[30] Only twelve states had participated between 1998- 2007.

most incidents in PISP accounting for 56% of the cases reported to PISP from 1999 to 2008. In the NIOSH SENSOR database, chlorpyrifos application appears to lead to the most incidents, being responsible for 46% reported to NIOSH SENSOR from 1998 to 2007. The chlorpyrifos incidents reported have declined substantially (95%) among residential users from 2002 to May 27, 2010; however, the rate of occupational incidents reported remained the same during this reporting period.

Overall, the incident data suggest that incidents associated with chlorpyrifos are declining over time. IDS incident reports decreased by 95% from 2002 to 2010, and NPIC incident reports have decreased by 92% from 2002 to 2010. The decrease in the number of chlorpyrifos incidents can be temporally associated with the phase out/cancellation of most residential chlorpyrifos products.

Health effects reported include neurological (e.g., tremors, headaches, dizziness, seizures), gastrointestinal (e.g., nausea, abdominal pain), respiratory (e.g., choking, coughing, shortness of breath), ocular (e.g., pain, itchiness), dermal (e.g., rash, lesions), and cardiovascular symptoms. Patients could exhibit multiple symptoms. The incidents reported have been reviewed and the agency will continue to monitor these incidents and remain alert for any changes in trend or patterns.

4. Tolerances

The 2020 revised chlorpyrifos human health risk assessment recommended changes to various tolerance levels to conform with the agency's rounding practice (*i.e.*, adding a trailing zero) at that time. Since the 2020 risk assessment was issued, the agency has decided to follow the Organization for Economic Coordination and Development (OECD) rounding class practice, which does not recommend adding a trailing zero. The EPA notes that the tolerance expression for chlorpyrifos in the 40 CFR§180.342 will be updated to comply with the S. Knizner 5/27/09 memo as follows:

> Tolerances are established for residues of chlorpyrifos, including its metabolites and degradates, in or on the commodities in the table below. Compliance with the tolerance levels specified below is to be determined by measuring only chlorpyrifos (*O,O* -diethyl *O* -(3,5,6-trichloro-2-pyridyl) phosphorothioate.

Based on data indicating that residues of chlorpyrifos may be present, EPA is recommending that tolerances be established for chlorpyrifos on the following: cotton, gin byproducts (15 ppm); grain, aspirated fractions (30 ppm); corn, field, milled byproducts (0.1 ppm); and wheat, milled byproducts (1.5 ppm). These recommendations, along with recommendations for revisions to current tolerances based on the (OECD rounding class practice, commodity definition revisions, crop group conversions/revisions, and harmonization with Codex, are presented in Tables 7 and 8.

Table 7: Summary of Tolerance Revisions for Chlorpyrifos (40 CFR §180.342(a)).[1]			
Commodity/ Correct Commodity Definition	**Established Tolerance (ppm)**	**Recommended Tolerance (ppm)**	**Comments**
Alfalfa, forage	3.0	3	Corrected values to be consistent with OECD Rounding Class Practice.
Grain, aspirated fractions	--	22	Recommended tolerance based on submitted residue data.
Beet, sugar, dried pulp	5.0	5	Corrected values to be consistent with OECD Rounding Class Practice.
Beet, sugar, roots	1.0	1	Corrected values to be consistent with OECD Rounding Class Practice.
Beet, sugar, leaves [2]	--	8	Commodity definition revision. Corrected values to be consistent with OECD Rounding Class Practice.
Beet, sugar, tops	8.0	remove	
Brassica, leafy greens, subgroup 4-16B	--	1	Crop group conversion/revision.[3,4]
Cherry, sweet	1.0	1	Corrected values to be consistent with OECD Rounding Class Practice.
Cherry, tart	1.0	1	Corrected values to be consistent with OECD Rounding Class Practice.
Fruit, citrus, group 10-10, dried pulp	--	5	Crop group conversion/revision. Corrected values to be consistent with OECD Rounding Class Practice.
Citrus, dried pulp	5.0	remove	
Fruit, citrus, group 10-10, oil	--	20	Crop group conversion/revision.
Citrus, oil	20	remove	
Corn, field, forage	8.0	8	Corrected values to be consistent with OECD Rounding Class Practice.
Corn, field, stover	8.0	8	Corrected values to be consistent with OECD Rounding Class Practice.
Corn, milled byproducts	--	0.1	Recommended tolerance based on submitted residue data.
Corn, sweet, forage	8.0	8	Corrected values to be consistent with OECD Rounding Class Practice.
Corn, sweet, stover	8.0	8	Corrected values to be consistent with OECD Rounding Class Practice.
Cotton, gin	--	15	Recommended tolerance based on

byproducts			submitted residue data.
Cotton, undelinted seed	0.2	0.3	Harmonization with Codex.
Cranberry	1.0	1	Corrected values to be consistent with OECD Rounding Class Practice.
Fruit, citrus, group 10-10	--	1	Crop group conversion/revision. Corrected values to be consistent with OECD Rounding Class Practice.
Fruit, citrus, group 10	1.0	remove	
Kohlrabi	--	1	Crop group conversion/revision.[3,4]
Kiwifruit, fuzzy	--	2	Commodity definition revision. Corrected values to be consistent with OECD Rounding Class Practice.
Kiwifruit	2.0	remove	
Milk	--	0.01	Commodity definition revision. Corrected values to be consistent with OECD Rounding Class Practice.
Milk, fat	--	0.3	
Milk, fat (Reflecting 0.01 ppm in whole milk)	0.25	remove	
Pepper, bell	--	1	Commodity definition revision. Corrected values to be consistent with OECD Rounding Class Practice.
Pepper, nonbell	--	1	
Pepper	1.0	remove	
Peppermint, fresh leaves	--	0.8	Commodity definition revision.
Peppermint, tops	0.8	remove	
Peppermint, oil	8.0	8	Corrected values to be consistent with OECD Rounding Class Practice.
Radish, roots	--	2	Commodity definition revision. Corrected values to be consistent with OECD Rounding Class Practice
Radish	2.0	remove	
Rutabaga, roots	--	0.5	Commodity definition revision.
Rutabaga	0.5	remove	
Spearmint, fresh leaves	--	0.8	Commodity definition revision.
Spearmint, tops	0.8	remove	
Spearmint, oil	8.0	8	Corrected values to be consistent with OECD Rounding Class Practice.
Sorghum, grain, stover	2.0	2	Corrected values to be consistent with OECD Rounding Class Practice.
Strawberry	0.2	0.3	Harmonization with Codex.
Sweet potato, tuber	--	0.05	Commodity definition revision.
Sweet potato, roots	0.05	remove	

Turnip, roots	1.0	1	Corrected values to be consistent with OECD Rounding Class Practice.
Turnip, leaves	--	0.3	Commodity definition revision.
Turnip, tops	0.3	remove	
Vegetable, brassica, head and stem, group 5-16	--	1	Crop group conversion/revision.[3] Corrected values to be consistent with OECD Rounding Class Practice.
Vegetable, brassica, leafy, group 5	1.0	remove	
Wheat, forage	3.0	3	Corrected values to be consistent with OECD Rounding Class Practice.
Wheat, milled byproducts	--	1.5	Recommended tolerance based on submitted residue data.
Wheat, straw	6.0	6	Corrected values to be consistent with OECD Rounding Class Practice.

[1] This table only includes recommended revisions to established tolerances and recommended establishment of new tolerances. For a complete list of all established tolerances see the International Residue Level Summary (IRLS) in Appendix 4.
[2] Sugar beet leaves/tops are no longer considered a significant livestock feed item. Commodity/tolerance may be removed.
[3] The recommended conversion of existing tolerance in/on **Vegetable, brassica, leafy, group 5** is to the following: **Vegetable, brassica, head and stem, group 5-16; Brassica, leafy greens, subgroup 4-16B;** and **Kohlrabi (**"Crop Group Conversion Plan for Existing Tolerances as a Result of Creation of New Crop Groups under Phase IV (4-16, 5-16, and 22)" dated 11/3/2015).
[4] HED is recommending for individual tolerances of 1 ppm for Kohlrabi based on the currently established tolerance for this commodity as part of crop group 5 (Vegetable, brassica, leafy). Kohlrabi is displaced by the crop group conversion noted in the footnote 3 above.

Table 8: Tolerance Revisions for Chlorpyrifos (40 CFR §180.342(c))[1, 2]

Commodity/ Correct Commodity Definition	Established Tolerance (ppm)	Recommended Tolerance (ppm)	Comments
Asparagus	5.0	5	Corrected values to be consistent with OECD Rounding Class Practice.

[1] This table only includes recommended revisions to established tolerances. For a complete list of all established tolerances see the IRLS in Appendix 4.
[2] Regional registrations.

The agency intends to undertake these tolerance actions pursuant to its Federal Food, Drug Cosmetic Act (FFDCA) authority. The agency will consider the input and recommendations from the September 2020 FIFRA Scientific Advisory Panel (SAP) on new approach methodologies for neurodevelopmental toxicity once the SAP report is released. After receiving the SAP's conclusions, EPA will examine the need for further tolerance actions.

5. Human Health Data Needs

The following residue chemistry data deficiencies were identified for chlorpyrifos. These data are not required to support this PID.

- 860.1500:
  - Separate magnitude of the residue studies for lemons are needed after application of Lorsban 4E and 75% WDG formulations in order to reevaluate the existing tolerance for chlorpyrifos for the citrus fruit crop group.
  - Magnitude of the residue studies are needed to establish a tolerance for residues of chlorpyrifos on wheat hay.

- 860.1520:
  - Processing studies are needed for soybean meal, hulls and refined oil.

B. Ecological Risks

A summary of the agency's ecological risk assessment is presented below. As stated earlier in this document, as part of the EPA's responsibility under the ESA, the agency completed a nationwide biological evaluation for chlorpyrifos initiated consultation with the NMFS in January 2017. In July 2019, EPA re-initiated formal consultation. NMFS is planning to issue a revised final BiOp for chlorpyrifos, diazinon, and malathion by June 2022. FWS has not yet issued a BiOp on chlorpyrifos.

Because the EPA's assessment of listed species is contained in its biological evaluation mentioned above, only the potential risks for non-listed species are described below.

The agency used the most current science policies and risk assessment methodologies to prepare a risk assessment in support of the registration review of chlorpyrifos. The agency has compiled an evaluation of risks to non-listed species for registration review in the document *Chlorpyrifos Draft Ecological Risk Assessment for Registration Review*. That document is based in part on the agency's biological evaluation for chlorpyrifos.[31] For additional details on the ecological assessment for chlorpyrifos, see the *Chlorpyrifos Draft Ecological Risk Assessment for Registration Review* (September 15, 2020), which is available in the public docket.

1. Risk Summary and Characterization

Chlorpyrifos prevents the natural breakdown of various cholines by inhibiting cholinesterase activity and ultimately causing the neuromuscular system to seize. Chlorpyrifos will initially enter the environment via direct application and may move off-site via runoff, spray drift, or volatilization. As it degrades, chlorpyrifos forms chlorpyrifos-oxon, TCP, and TMP. Further discussion on the consideration of residues of concern, the fate of chlorpyrifos, and study

[31] https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment

information may be found in the biological evaluation[32] and the previously issued drinking water assessments.[33] [34]

Terrestrial Risks

Mammals

The streamlined ecological risk assessment identified acute and chronic risks of concern from most uses for chlorpyrifos. Acute risk estimates for mammals from chlorpyrifos exposure ranged from 0.01 to 10. Half of the uses assessed resulted in acute RQs of 5 or greater (LOC = 0.5). Chronic risks in animals based on reproductive effects, a 30% loss of pups, ranged from 0.66 to 625. All chronic RQs based on a 4 to 5% decrease in body weight resulted in potential exceedances to the agency's LOC of 1 with a range of 2.01 to 1900. Fifty percent of uses resulted in RQs greater than 148 based on a reproductive endpoint and over 450 based on body weight loss.

Birds, Reptiles, and Terrestrial-Phase Amphibians

Acute RQs ranged from 0.07 to 380 with over half of all uses resulting in RQs greater than 93 (LOC = 0.5). Risk estimates for birds were based on significant reproductive effects, an 83% reduction in eggs laid. More than half of uses assessed resulted in chronic RQs above 14 with a total range of 0.60 to 58 (LOC = 1). As a result, there may be adverse effects to birds, as well as to terrestrial-phase amphibians and reptiles for which birds serve as surrogates.

Terrestrial Invertebrates (honeybees)

Consistent with its use as an insecticide, chlorpyrifos is highly toxic to adult honeybees on an acute exposure basis. The 2017 biological evaluation did not include the review of one acute larval honeybee study from Corteva. MRID 49960301 was submitted on the effects of chlorpyrifos to honeybee larvae after acute *in vitro* exposure. This study resulted in an LD_{50} of 0.0165 µg a.i./larva. This represented the most sensitive endpoint available for effects to honeybee larvae and was used as the endpoint for risk estimation. Acute RQs range from 820 to 4900 with exceedances for all uses (LOC = 0.4). Chronic toxicity data is not available for chlorpyrifos; therefore, the risk picture for terrestrial invertebrates is incomplete.

After EPA issued the problem formulation and registration review DCI for chlorpyrifos, EPA released its June 2014 *Guidance for Assessing Pesticide Risks to Bees*[35]. This 2014 guidance lists additional pollinator studies that were not included in the chlorpyrifos registration review DCI. Due to the timing of the chlorpyrifos DCI being issued before the guidance came out, EPA is not requiring any additional studies for assessing pollinators as part of registration review, although EPA continues to consider whether additional pollinator data are needed for chlorpyrifos. If the

[32] https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment
[33] https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0198
[34] https://www.regulations.gov/document?D=EPA-HQ-OPP-2015-0653-0437
[35] Available at https://www.epa.gov/sites/production/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf

agency determines that additional pollinator exposure and effects data are necessary for chlorpyrifos, then the EPA will issue a DCI to obtain these data. The pollinator studies that could be required are listed in Table 9 below.

Table 9: Potential Pollinator Data Requirements

Guideline #	Study
Tier 1	
850.3020	Acute contact toxicity study with adult honey bees
850.3030	Honey bee toxicity of residues on foliage
Non-Guideline (OECD 213)	Honey bee adult acute oral toxicity
Non-Guideline (OECD 237)	Honey bee larvae acute oral toxicity
Non-Guideline	Honey bee adult chronic oral toxicity
Non-Guideline	Honey bee larvae chronic oral toxicity
Tier 2†	
Non-Guideline	Field trial of residues in pollen and nectar
Non-Guideline (OECD 75)	Semi-field testing for pollinators
Tier 3†	
850.3040	Full-Field testing for pollinators

† The need for higher tier tests for pollinators will be determined based upon the results of lower tiered tests and/or other lines of evidence and the need for a refined pollinator risk assessment.

Terrestrial and Aquatic Plants

Risk quotients for aquatic vascular, non-vascular, and terrestrial plants did not exceed EPA's LOC of 1 with a total range of < 0.01 to 0.42. In addition, there were no vegetative vigor effects seen for either monocots or dicots and no seedling emergence effects were observed for monocots. There are some incidents involving plants from chlorpyrifos exposure, but potential risks to terrestrial or aquatic plants from chlorpyrifos exposure is considered limited.

Aquatic Risks

Fish and Aquatic-Phase Amphibians

The acute and chronic effects of chlorpyrifos exposure have been studied extensively in aquatic organisms. The acute LC_{50} for estuarine/marine and freshwater fish were 0.37 and 1.7 µg a.i./L, respectively. The chronic NOAEC was 0.28 µg a.i./L for estuarine fish but was not determined for freshwater fish which had a LOAEC of 0.251 µg a.i./L. Endpoints for fish were based on a 52% in fecundity for freshwater fish with a LOAEC of 0.251 µg a.i./L, lower than that of 0.48 µg a.i./L, for estuarine fish with 32% reduction in fecundity.

As with mammals, the majority of acute and all chronic RQs exceeded EPA's LOC of 0.5 for acute risks and 1 for chronic risks. Over 50% of uses assessed resulted in acute RQs above 33 with a range of .42 to 160. Chronic RQs reached a maximum of 135. Given the many use patterns affiliated with chlorpyrifos use, potential risks to fish and aquatic-phase amphibians from chlorpyrifos exposure can be expected.

Aquatic Invertebrates

All RQs for aquatic invertebrates were well above the agency's LOC of 0.5 for acute risks and 1 for chronic risks. Maximum acute and chronic RQs were 4300 and 8600, respectively, with 50% of all uses having RQs over 880 and 1540, respectively. Since chlorpyrifos is registered for a number of uses patterns across the United States, there exists the potential for risks to aquatic invertebrates.

2. Ecological Incidents

Numerous notable ecological incidents (e.g., significant fish kills, bee kills, large number of bird deaths) have been reported for all taxa for chlorpyrifos, including plants. These incidents summarized herein are based on the incidents reported for the chlorpyrifos Biological Evaluation and were reported with a high certainty level that chlorpyrifos was the associated causative agent. The biological evaluation on chlorpyrifos provided an extensive analysis of reported incidents broken down by individual taxa. Chlorpyrifos was reported as the 'possible,' 'probable,' or 'highly probable' causative agent for 110 adverse aquatic incidents (e.g., fish kills), 64 incidents involving birds, and 43 terrestrial plant incident reports. Some of the terrestrial plant incident reports were associated with spray drift, but most involved damage to the crop treated.

Additionally, 36 bee incidents were classified with a certainty index of 'possible', 'probable' or 'highly probable'. All of the terrestrial invertebrate incident reports involve honeybees, with bees being exposed via foraging on treated plants or by spray drift.

On August 14, 2020, an updated incident report was generated from the Incident Data System (IDS) for the time period from approximately January 1, 2015 to August 14, 2020. There were 20 unique incidents reported associated with nontarget organism in IDS. All of these incidents were associated with bee kills, except for one where the organism impacted was not specified. Two aggregate incidents, one presumed to involve bees, and one involving non-specified wildlife, were additionally reported.

EPA will continue to monitor ecological incident information as it is reported to the agency. Detailed analyses of these incidents are conducted if reported information indicates concerns for risk to non-target organisms.

3. Ecological and Environmental Fate Data Needs

No additional ecological or environmental fate data are required to support this registration review decision. EPA will consider requiring submission of pollinator data as a separate action.

C. Benefits Assessment

Based on a recent analysis[36] conducted by the agency for agricultural uses of chlorpyrifos, the total annual economic benefit of chlorpyrifos to crop production is estimated to be $19 - $130 million. These estimates are based on the additional costs of alternative pest control strategies likely to be used in the absence of chlorpyrifos or reduced revenue for some crops that do not have effective alternatives to chlorpyrifos for some pests. In some cases, effective alternatives could not be found; for those crops, the benefit of chlorpyrifos was estimated by yield or quality losses if chlorpyrifos were no longer available for use.

The high benefits are reflected in the wide use of chlorpyrifos on many different crops. However, despite this widespread usage, the majority of the benefits are concentrated in specific crops and regions that rely on chlorpyrifos without available effective alternatives to control pests. In particular, there are potentially high total benefits of chlorpyrifos usage in the production of sugar beets in Minnesota and North Dakota, oranges in California, peaches in the Southeastern U.S., and soybeans and apples throughout the U.S. The high-end total benefit for each of these crops is estimated to be in excess of $7 million per year. High total benefits are driven by high per-acre cost of production without chlorpyrifos in the case of sugar beets, orange, apple, and peach, and by the extent of acres treated in the case of large field crops like soybean despite relatively low benefits per acre.

For most non-crop uses, the agency's assessment[37] concluded that, chlorpyrifos is no longer recommended or heavily used for critically important insect pests. However, there a few exceptions to this overall conclusion. For pests of public health concern, such as mosquitoes and certain ticks, chlorpyrifos is one of a limited set of effective options available for wide area or broadcast use in specific use settings, such as government agency mosquito control districts (when suppressing adult mosquitoes), and golf courses (for ticks). For mosquitoes, chlorpyrifos also has value as one of a few insecticides that can be used against pyrethroid-resistant populations or to delay the onset of such resistance. While effective alternatives are available, due to the consequences to public health posed by the serious diseases transmitted by these pests, chlorpyrifos provides an important resistance management tool to sustain the effectiveness of non-organophosphate alternatives.

Similarly, for the protection of certain types of cattle livestock from horn flies, chlorpyrifos confers a benefit to control fly populations that have developed tolerance to pyrethroids, a widely used class of insecticides. In addition, for horn fly populations that have not yet developed pyrethroid resistance, chlorpyrifos is an active ingredient that, when used in rotation with pyrethroids, could mitigate, delay or even avoid insecticide resistance. Finally, for producers of outdoor-grown nursery plant stock, chlorpyrifos is one of a very limited set of insecticide options that qualify producers' products for pest-free certification in southeastern U.S. states that are currently under a USDA quarantine intended to prevent the spread of imported fire ants.

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[36] Mallampalli, N., Waterworth, R., and Berwald, D. 2020. Benefits of Agricultural Uses of Chlorpyrifos (PC# 059101). Biological and Economic Analysis Division memorandum to the Pesticide Re-Evaluation Division. Official record available through the chlorpyrifos docket at www.regulations.gov.

[37] Mallampalli, N. and C. Paisley-Jones. 2020. Chlorpyrifos Benefits Assessment for Non-crop Uses. Biological and Economic Analysis Division memorandum to the Pesticide Re-Evaluation Division. Official record available through the chlorpyrifos docket at www.regulations.gov.

IV. PROPOSED INTERIM REGISTRATION REVIEW DECISION

A. Proposed and Considered Risk Mitigation and Regulatory Rationale

Chlorpyrifos poses potential dietary and aggregate risks associated with drinking water exposure for currently labelled uses with and without the 10X FQPA safety factor, and mitigation is being proposed to reflect the range of potential risks. With the exception of seed-treatment uses, both occupational handler and post-application risks of concern were identified with and without the 10X UF_{DB}. PPE, use restrictions, and REI extensions are being considered to address these potential risks. The agency is also proposing spray drift management label language, pesticide resistance management label language, and other labeling updates consistent with those which are being required for other pesticides in registration review.

The agency will consider the input and recommendations from the September 2020 FIFRA Scientific Advisory Panel (SAP) on new approach methodologies for neurodevelopmental toxicity once the SAP report is released. After receiving the SAP's conclusions, EPA may further revise the human health risk assessment and proposed/considered mitigation. The agency is currently in discussions with the registrants regarding the proposed/considered mitigation measures.

1. Use Cancellations

To mitigate potential dietary exposure to chlorpyrifos, the agency is proposing to limit application to select uses in certain regions of the U.S. where the EDWCs for those uses are lower than the DWLOCs. Table 10 provides a list of the high-benefit agricultural uses that the agency has determined will not pose potential risks of concerns with an FQPA safety factor of 10X and may be considered for retention. In addition to the agricultural uses listed below, the agency may also retain use on public health pests such as mosquitos, ticks, and fire ants. The agency will consider registrant and stakeholder input on the subset of crops and regions from the public comment period and may conduct further analysis to determine if any other limited uses may be retained.

Table 10: Agricultural Uses Proposed for Retention in Chlorpyrifos Labels with an FQPA Safety Factor of 10X

Use Site	State for retention at the 10X[1]
Alfalfa	AZ, CO, IA, ID, IL, KS, MI, MN, MO, MT, ND, NE, NM, NV, OK, OR, SD, TX, UT, WA, WI, WY
Apple	AL, DC, DE, GA, ID, IN, KY, MD, MI, NJ, NY, OH, OR, PA, TN, VA, VT, WA, WV
Asparagus	MI
Cherry (tart)	MI
Citrus	AL, FL, GA, NC, SC, TX
Cotton	AL, FL, GA, NC, SC, VA
Peach	AL, DC, DE, FL, GA, MD, MI, NC, NJ, NY, OH, PA, SC, TX, VA, VT, WV

Soybean	AL, CO, FL, GA, IA, IL, IN, KS, KY, MN, MO, MT, NC, ND, NE, NM, OH, OK, PA, SC, SD, TN, TX, VA, WI, WV, WY
Strawberry	OR
Sugar beet	IA, ID, IL, MI, MN, ND, OR, WA, WI
Wheat (spring)	CO, KS, MO, MT, ND, NE, SD, WY
Wheat (winter)	CO, IA, KS, MN, MO, MT, ND, NE, OK, SD, TX, WY
[1]Only specific uses in specific 2-digit HUCs were assessed as described in the 2020 drinking water assessment. These specific uses are based on usage data and may not reflect maximum label rates on current labels.	

With a 1X FQPA safety factor, the majority of labeled chlorpyrifos uses result in drinking water concentrations below the DWLOC. Uses with drinking water concentrations above the DWLOC include, 1) peppers, 2) trash storage bins, and 3) wood treatment. In addition, six uses as noted in Table 11 below, can only be retained in certain states. Otherwise, all labeled chlorpyrifos uses can be retained nationwide.

Table 11: Regional Restrictions for Corn, Tart Cherries, Citrus, Pecan, and Peach with an FQPA Safety Factor of 1X	
Use Site	**State for retention at the 1X[1]**
Corn	AL, AR, FL, GA, IA, IL, IN, KS, KY, LA, MN, MO, MS, MT, NC, ND, NE, NY, OH, OK, PA, SC, SD, VA, VA, WI, WV, WY
Cherries (tart) 3 lb a.i./A	WA, OR, ID, MT (Deer Lodge, Flathead, Granite, Lake, Lincoln, Mineral, Missoula, Powell, Ravalli, Sanders, and Silver Bow counties)
Cherries (tart) 2 lb a.i./A	MI, WA, OR, ID, MT (Deer Lodge, Flathead, Granite, Lake, Lincoln, Mineral, Missoula, Powell, Ravalli, Sanders, and Silver Bow counties)
Citrus	AL, FL, GA, NC, SC, TX
Pecan	AL, FL, GA, NC, NM, OK, SC, TX
Peach	AL, DC, DE, FL, GA, MD, MI, NC, NJ, NY, OH, PA, SC, TX, VA, VT, WV
[1]Only specific uses in specific states listed above were assessed as described in the 2020 supplemental document. These specific uses were assessed based on actual application rates from reported usage data and may not reflect maximum label rates on current labels. If usage data were not available no additional refinement was possible, therefore, the state would not be listed.	

Stakeholders and registrants identified to EPA particular crops they considered to be important chlorpyrifos uses.[38] EPA estimated the benefits of chlorpyrifos in these, and many other crops

[38] https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0938

with chlorpyrifos use.[39] Uses that were identified by stakeholders and registrants as important were alfalfa, citrus, cotton, soybean, sugar beet, and wheat. The estimated per acre benefits for alfalfa were low, at around $1 per acre, but over 1 million acres are treated annually, so total benefits were over $1 million. For citrus, there are potential high benefits for California lemons in some cases, with benefits of $290 per acre. The high-end benefit estimate for California oranges was similar. However, chlorpyrifos use is already restricted in California, with almost all uses banned after 2020.[40] Estimated benefits of chlorpyrifos in cotton are up to $14 per acre, with total benefits of up to $6.1 million annually. The benefit of chlorpyrifos in soybean is up to $4 per acre, and with over 3 million acres treated annually, the total benefit could be about $12 million. Sugar beets had potentially very high per acre benefits of almost $500 per acre in parts of Minnesota and North Dakota, leading to high-end estimated benefits over $30 million overall. Per acre benefits in wheat are estimated to be low, about $1 per acre in both spring and winter wheat, with a total benefit for both crops of about $1.3 million. In addition to these crops, EPA estimated high per-acre economic benefits to growers.

Crops that EPA concluded have potentially high benefits per-acre were: apples (nationwide), where alternatives for some pests could cost up to $51 per acre more than chlorpyrifos; asparagus, where the lack of alternatives in Michigan specifically could lead to yield losses of up to $450 per-acre; tart cherries in Michigan, where uncontrolled pest pressure could lead to yield losses of up to $201 per-acre; peaches in the southeastern U.S., where uncontrolled pest pressure could lead to yield losses of up to $430 per acre in Georgia and South Carolina; strawberries in Oregon, where uncontrolled soil pests (garden symphylans) could lead to abandonment of strawberry acreage, with a loss that corresponds to over $7,800 per acre.

2. PPE

The agency is providing the details for all currently labelled uses that would require additional PPE should those uses be retained. Given the current proposal in Section IV.A.1., should cancellation of uses be pursued, only the subset of remaining uses will be identified as requiring the additional PPE described below.

As specified in Section III.A.2., of the 288 steady state occupational handler scenarios assessed for non-seed treatments, 119 scenarios are of concern with label-specified personal protective equipment (PPE; baseline attire, chemical resistant gloves, coveralls, and an elastomeric half mask respirator) assuming the 10X UF_{DB} (MOEs < 100). Risks of concern for 45 additional exposure scenarios could potentially be mitigated if engineering controls are used.

If the 10X database uncertainty factor is reduced to 1X (LOC = 10), 19 scenarios are of concern with label-specified PPE (MOEs < 10). Risks of concern for 15 additional scenarios could potentially be mitigated if engineering controls are used.

[39] Mallampalli, N., Waterworth, R., and Berwald, D. 2020. Benefits of Agricultural Uses of Chlorpyrifos (PC# 059101). Biological and Economic Analysis Division memorandum to the Pesticide Re-Evaluation Division. Official record available through the chlorpyrifos docket at www.regulations.gov.
[40] https://www.cdpr.ca.gov/docs/chlorpyrifos/pdf/chlorpyrifos_action_plan.pdf

a. PPE Requirements – potential risks with the 10X UF_{DB}

Airblast applications

With the exception of citrus and tree nuts (pecans), risk estimates for mixing and loading formulations in WSP were above the LOC of 100. The agency is considering reducing the rate of citrus from 6.0 lbs a.i./Acre to 4.0 lbs a.i./Acre due to occupational risks identified to airblast applicators. Although the MOEs for tree nuts (pecans) and citrus at the lower rate do not meet the LOC of 100, chlorpyrifos is regarded as a high benefit to these uses.

For the remaining formulations (L/SC/EC), risk estimates for mixers and loaders are below the LOC with the following PPE:

Table 12: Considered engineering controls and PPE for risks of concern from airblast applications

Crop/Use	PPE/Engineering controls	MOE
Citrus, Non-bearing Fruit and Nut Trees (Nursery)	Engineering controls	140
Tree Fruits (Nectarine, Peach - Dormant, Delayed Dormant)		190
Cherries, tree fruits (pear, plum/prune (dormant, delayed dormant), tree nuts (almonds, filberts, hazelnuts, pecans, walnuts)	Double layer (coveralls), gloves, and either a particulate filtering facepiece (PF5)	110
Ornamental and/or shade trees, ornamental woody shrubs and vines, herbaceous plants, Christmas tree plantations, grapes	Single layer (long pants and long sleeve shirt), gloves	150

To address potential risks of concerns from mixing and loading L/SC/EC formulations for airblast application, the agency is considering engineering controls or PPE as listed for the uses in Table 12.

MOEs for mixing and loading airblast applications for citrus at an application rate of 6.0 lbs a.i./acre (CA and AZ) are 67 for WSP formulations and 96 for L/SC/EC formulations. Given other risks of concern from this rate, the agency is considering reducing this application rate for Arizona to 4 lbs a.i./acre. Exposures in California are considered negligible after 2020. See Section IV.3. below for additional details regarding proposed application rate reductions.

All airblast application scenarios without engineering controls (i.e., enclosed cabs) resulted in risk estimates of concern without retention of the 10X UF_{DB}. MOEs for these scenarios ranged from 0.55 to 4.2. With engineering controls, MOEs were below the LOC of 100 for tree nuts (pecans) and citrus at 89 and 98, respectively, however, chlorpyrifos provides high benefits for use on these food crops. EPA, as a result, is considering requiring engineering controls for all airblast applications.

Groundboom applications

With the retention of the 10X UF_{DB}, EPA is considering requiring engineering controls (closed systems) to address potential risks of concerns to occupational handlers mixing and loading L/SC/EC chlorpyrifos formulations for groundboom applications for the following uses:

- Nursery stock (pre-plant)
- Brussels sprouts (at plant and post-emergence), cauliflower, cole crops, grapes (foliar, dormant, delayed dormant), mint (peppermint, spearmint), peanut, pineapple, rutabaga, strawberries (pre-plant), sunflower (pre-plant) sweet potato (pre-plant and soil broadcast), and tobacco (pre-plant).
- Beets (table, sugar, at plant), clover (grown for seed, foliar), hybrid cottonwood and polar plantations
- Cranberry
- Alfalfa, cotton, sorghum grain, soybean, and wheat
- Radishes (pre-plant).

Addition of engineering controls (closed systems) for mixing and loading L/SC/EC formulations for radishes is 96 and below the LOC of 100. Chlorpyrifos, however, is considered a high benefit for this use.

For the remaining groundboom applications that may be mitigated with additional PPE, EPA is considering the following measures for mixers and loaders in Table 13 and measures for applicators in Table 14:

Table 13: Considered PPE for Mixing and Loading Groundboom applications: L/SC/EC

Crop/Use	Proposed PPE	MOE[1]
Carrots	Double layer (coveralls), gloves, and a particulate filtering facepiece (PF 5)	110
Carrots	Double layer (coveralls), and gloves	92
Ornamental and/or shade trees, herbaceous plants, ornamental woody shrubs and vines		91
Asparagus, beets (table, sugar; at plant), citrus orchard floors, forest plantings (reforestation, plantation, tree farm), grass (forage/fodder/hay), legume vegetables, nonagricultural outdoor buildings and structures, onions		91
Conifers and deciduous trees, seed orchard trees		96

Golf course (fairways, tees, greens)	Single layer (long-sleeved shirt and long pants) and gloves	150

[1]MOE < LOC; however, chlorpyrifos is considered to be a high benefit to this use.

Table 14: Considered PPE or Engineering Controls for Groundboom Applicators		
Crop/Use	**Considered PPE or considered engineering controls**	**MOE[1]**
Alfalfa, sorghum grain, soybean, and wheat	Engineering controls	200
Ornamental lawns and turf, sod farms (turf)		130
Radish (pre-plant)		170
Turnip		86
Alfalfa, sorghum grain, soybean, and wheat	Double layer (coveralls), gloves, and an elastomeric half mask respirator	92
Nursery stock (pre-plant)	Double layer (coveralls), gloves, and a particulate filtering facepiece respirator	110
Brussels sprouts (at plant and post-emergence), cauliflower, cole crops, grapes (foliar, dormant, delayed dormant), mint (peppermint, spearmint), peanut, pineapple, strawberries (pre-plant), sunflower (pre-plant) and tobacco (pre-plant		110
Brussels sprouts (post-plant), grapes (foliar)		96
Clover (grown for seed, foliar), hybrid cottonwood and polar plantations		110
Rutabaga		88
Alfalfa, Sorghum Grain, Soybean, Wheat		87
Sweet potato (pre-plant and soil broadcast)	Single layer, gloves, and an elastomeric half mask respirator	88
Cranberry	Single layer, gloves, and a particulate filtering facepiece respirator	120
Beets (table, sugar; at plant), clover (grown for seed; foliar), hybrid cottonwood/poplar plantations		90

Asparagus, beets (table, sugar; at plant), citrus orchard floors, cole crops (excludes Brussels sprouts and cauliflower), cotton, forest plantings (reforestation, plantation, tree farm), grapes (dormant, delayed dormant), grass (forage/fodder/hay), legume vegetables, nonagricultural outdoor buildings and structures, onions, peppers, and strawberries	Single layer (long-sleeved shirt and long pants) and gloves	120
Ornamental and/or shade trees, herbaceous plants, ornamental woody shrubs and vines		120
Carrots		130
Conifers and deciduous trees, seed orchard trees		170
Forest trees (softwoods and conifers)		200
Golf course (fairways, tees, greens)		250

[1]MOE < LOC; however, chlorpyrifos is considered to be a high benefit to this use.

Handheld and Tractor-drawn Spreader applications

The agency is considering requiring the use of double layer PPE (coveralls), gloves, and an elastomeric half mask respirator, for mixers, loaders, and applicators applying chlorpyrifos liquid concentrate formulations via manually-pressurized handwand for wood protection treatment and to pine seedlings in a nursery. Although the MOEs are 82 and 90, respectively, and therefore are of concern at the 10X UF_{DB}, the agency considers chlorpyrifos to be of high benefit for these uses.

To increase MOEs to the LOC of 100, the agency is considering requiring additional PPE for manually-pressurized handwand application on the following uses:

- Single layer (long-sleeved shirt, long pants, socks, and shoes), gloves, and a particulate filtering facepiece for wide area/general outdoor treatment
- Single layer (long-sleeved shirt, long pants, socks, and shoes) and gloves for: Christmas tree plantations, conifers and deciduous trees; plantation nurseries, grapes, seed orchard trees, forest trees (softwoods, conifers), golf course turf, mounds/nests, non-agricultural outdoor buildings and structures, ornamental woody shrubs and vines, ornamental non-flowering plants, outdoor commercial/institutional/industrial premises (see master label description), agricultural farm premises, poultry litter, tree fruits (cherries, nectarines, peaches, plum/prunes), tree nuts (almonds) - pre-plant, tree nuts (apple) - pre-plant, and fruits and nuts (non-bearing, see master label description).

Regardless of PPE, risk estimates for application with mechanically pressurized handgun were below EPA's LOC of 100 for all uses except ornamental woody shrubs and vines and seed orchard trees (MOEs = 440 to 8,300); MOEs of concern ranged from 2.1 to 83 for all other uses and were therefore of concern.

For the following backpack sprayer applications and formulations, the PPE listed below is being proposed in Table 15:

Table 15: Considered Mitigation for Backpack Sprayer Applications

Formulation	Application type	Crop/Targeted Use	PPE[1]	MOE
Dry flowable/water-dispersable granule in WSP	Broadcast (foliar)	Grapes (pre-bloom)	Double layer (coveralls), gloves, and an elastomeric half mask respirator	94[2]
	Trunk spray/Drench	Tree fruits (apple)		100
	Drench/Soil-Ground-directed	Grapes (pre-bloom)		150
L/SC/EC	Broadcast (foliar)	Golf course turf		94[2]
	Spot treatment applications (0.023 A treated)	Ornamental and/or Shade Trees, herbaceous plants	Baseline	320
		Ornamental lawns and turf, sod farms (turf)		350
		Outdoor commercial/institutional/industrial premises, non-agricultural buildings and structures, golf course turf		1300
Microencapsulated formula	Broadcast (foliar)	Ornamental woody shrubs and vines	Double layer (coveralls), gloves, and an elastomeric half mask respirator	94[2]
		Ornamental non-flowering plants		130
	Directed broadcast	Outdoor commercial/institutional/industrial premises	Baseline	230
	Broadcast	Agricultural farm premises	Baseline	400
	Broadcast	Poultry litter	Baseline	1100
WSP	Spot	Ornamental woody shrubs and vines (pre-transplant)	Baseline	330
	Spot	Outdoor lawns and turf, Sod Farms (turf)	Baseline	350

	Broadcast (foliar)	Ornamental woody shrubs and vines	Baseline	930

[1]Baseline PPE includes long-sleeved shirt, long pants, shoes, no gloves, and no respirator.
[2] Although additional PPE does not result in MOEs above the LOC of 100 with the retention of the 10X UF_{DB}, chlorpyrifos is considered a high benefit for these uses.

The above-mentioned uses are the only uses which meet the agency's LOC of 100 with retention of the 10X UF_{DB}. All remaining uses treated by backpack sprayer applications are considered below in section IV.A.3 for possible application method prohibitions.

Tractor-drawn spreader applications

To address risks of concern to occupational handlers applying chlorpyrifos by tractor-drawn spreader, EPA is considering use of additional PPE. Most MOEs for mixers, loaders, and applicators are above the LOC of 100 with use of a SmartBox®, which is considered an engineering control. The EPA is considering additional PPE as follows for the uses in Table 16:

Table 16: Considered mitigation for tractor-drawn applications

Crop/Targeted Use	PPE	MOE[1]
Mixers/Loaders		
Ornamental woody shrubs and vines	Double layer (coveralls), gloves, and an elastomeric half mask respirator	91
Alfalfa	Single layer (long-sleeved shirt and long pants) and an elastomeric half mask respirator	98
Rutabaga	Single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece	100
Sweet potato		120
Brussels	Single layer (long-sleeved shirt and long pants) and a particulate filtering facepiece	92
Asparagus		120
Nursery stock		220
Citrus orchard floors, onions, ornamental lawns and turf, sod farms (turf)		180
Applicators		
Peanut	Double layer (coveralls), gloves, and an elastomeric half mask respirator	110
Sorghum grain		110
Ornamental woody shrubs and vines		96
Radish		85

Rutabaga	Single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece	97
Alfalfa		92
Cauliflower (post-plant), Turnip	Single layer (long-sleeved shirt and long pants) and a particulate filtering facepiece	86
Brussels Sprouts (post-plant)		86
Sweet potato		92
Cole crops (except cauliflower), ginseng, sugar beets, sunflower, tobacco		98
Asparagus		130
Nursery stock	Single layer (long-sleeved shirt and long pants), gloves	98
Citrus orchard floors, onions, ornamental lawns and turf, sod farms (turf)	Double layer (coveralls), gloves	87

[1] Although additional PPE does not result in MOEs above the LOC of 100 with the retention of the 10X UF_{DB}, chlorpyrifos is considered a high benefit for these uses.

Hand dispersal application

At baseline PPE, MOEs for the following uses are below the EPA's LOC of 100 when treated by rotary spreader or hand dispersal application. Therefore, the agency is considering requiring the following PPE:

Table 17: Considered Mitigation for Applications by Rotary Spreader or Hand Dispersal

Crop/Target Category	Application Equipment	Application Type	PPE	MOEs
Nursery stock	Rotary spreader	Broadcast	Double layer (coveralls) and gloves	110
Golf course turf, ornamental and/or shade trees, herbaceous plants, ornamental lawns and turf, sod farms (turfs)			Single layer (long sleeved shirt, long pants) and gloves	100
Golf course (turf) sod farms (turf)	Hand dispersal	Spot		130

Risk estimates for all other uses (ornamental woody shrubs and vines, commercial/institutional/industrial premises, utilities (pad)) fall below the LOC of 100 with maximum PPE (double layer (coveralls), gloves, and an elastomeric half mask respirator) and with retention of the 10X UF_{DB}. Therefore, the remaining uses are considered for possible application method prohibitions as addressed below in section IV.A.3.

Wide Area Mosquito Abatement

Risk estimates of concern were found for occupational handlers mixing, loading, and applying for wide-area mosquito treatment. Chlorpyrifos is not the primary pesticide used for the majority of wide-area mosquito treatment programs. However, given the public health concern for mosquito as vectors for a number of pathogens, there are high benefits for maintaining chlorpyrifos to treat adult mosquitos, particularly in areas with high pest pressure.

Without engineering controls, MOEs for applying wide area treatments of mosquito adulticide by ground are of concern. Thus, EPA is considering requiring engineering controls (enclosed cab) for airblast and aerial application of wide area mosquito treatment and double layer (coveralls), gloves, and an elastomeric half mask respirator for mixing and loading airblast and aerial applications.

b. PPE Requirements – potential risks without the 10X UF_{DB}

Aerial and Chemigation Application

Due to potential risks of concern to mixers and loaders for aerial application even without retention of the 10X UF_{DB}, EPA is considering requiring the following:

Table 18: Considered Mitigation for Mixing and Loading for Aerial and Chemigation Applications at the 1X FQPA Safety Factor

Crop/Target Category	Formula	Considered Engineering Controls or PPE	MOE
Aerial, Chemigation			
Citrus	L/SC/EC	Double layer (coveralls), gloves, and either a particulate filtering facepiece or an elastomeric half mask respirator	11
Non-bearing fruit and nut trees (nursery), radish (pre-plant), turfgrass (sod or seed)			12
Cherries, hybrid cottonwood/poplar plantations, mint (peppermint and spearmint), peanut, rutabaga, strawberries			12

(pre-plant), sunflower (pre-plant), sweet potato, tobacco, tree fruits (apple,), nectarine, peach, pear, plum/prune), tree nuts (almonds, filberts, hazelnuts, pecans, walnuts), turfgrass (ornamental and sod farms)			
Clover (grown for seed), cranberry, sunflower (post-emergence/ foliar)			13
Asparagus, Brussels sprouts, cauliflower, cole crops, strawberries, sugar beets, radish	L/SC/EC	Single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece	13
Aerial Application			
Corn (post-emergence)	L/SC/EC	Engineering Controls	13
Corn (pre-plant)	Granule	Double layer (coveralls), gloves, and either a particulate filtering facepiece or an elastomeric half mask respirator	13
Alfalfa, corn (pre-plant), cotton (except Mississippi), sorghum, soybean, wheat	L/SC/EC	Single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece	13
Christmas tree plantations			18
Carrots			19
Peanut	Granule		10
Sweet potato			20
Chemigation Application			
Tree nuts, orchard floors, (pecans)	L/SC/EC	Engineering controls	15
Tree nut orchard floors (almonds, walnuts)			17

Corn (pre-plant)			22
Corn (post-emergence)		Single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece	13
Alfalfa, corn (pre-plant), cotton (except Mississippi), sorghum, soybean, wheat			18

Groundboom Application

Mixing and loading all formulations in WSP resulted in MOEs above 10 and are not of concern at the UF_{DB} of 1X. Mixing and loading most L/SC/EC formulations with single layer (long-sleeved shirt, long pants) and a particulate filtering facepiece results in risks of concern for most uses. MOEs ranged from 1.9 to 28 with risks of concerns for the following uses: Corn (pre-plant and post-emergence), radish (pre-plant), rutabaga, Brussels sprouts (at-plant, post-plant), grapes (foliar, dormant, delayed dormant), sweet potato (pre-plant, soil broadcast), cotton (except Mississippi), cole crops, cauliflower, mint (peppermint, spearmint), peanut, pineapple, strawberries (pre-plant), sunflower (pre-plant), tobacco (pre-plant), cranberry, alfalfa, cotton, sorghum grain, soybean, wheat, beets (table, sugar; at plant), clover (grown for seed; foliar), hybrid cottonwood/poplar plantations, tree nut orchard floors (pecans, almonds, walnuts), nursery stock (pre-plant), ornamental lawns and turf, and sod farms.

With the addition of gloves for these uses, the range of MOEs increases to 11 – 56 and are no longer of concern at the UF_{DB} of 1X.

Groundboom application risks of concern were identified for corn (pre-plant), tree nut orchard floors (pecans, almonds, walnuts), and cotton (except Mississippi) (MOEs = 5.3 – 9.9). With the use of single layer (long-sleeved shirt, long pants) and gloves, all risk estimates for groundboom applicators are greater than 10 are not of concern at the UF_{DB} of 1X.

Airblast and Handheld Applications

For mixing and loading L/SC/EC for airblast applications, EPA is considering single layer (long-sleeved shirt and long pants) and gloves for the following uses:

- Citrus (CA and AZ); MOE = 24
- Citrus, Non-bearing Fruit and Nut Trees (Nursery); MOE = 36
- Tree Fruits (Nectarine, Peach - Dormant, Delayed Dormant); MOE = 48

EPA is also considering requiring double layer (coveralls) and gloves for backpack application on wide-area general outdoor treatment, and outdoor commercial/institutional/industrial premises, non-agricultural outdoor buildings and structures. The MOEs with this additional PPE range from 12 to 19.

For handheld applications, EPA is considering requiring single layer (long-sleeved and long pants) and gloves for:

- Brush roller application to wood protection treatment (MOE = 16) and structural (e.g., warehouses, food handling establishments, and home bathrooms (MOE = 33)).
- Manually-pressurized handwand application to: Wood protection treatment, nursery (pine seedlings), wide area/ general outdoor treatment, Christmas tree plantations, conifers and deciduous trees; plantation nurseries, grapes, seed orchard trees, forest trees (softwoods, conifers), golf course turf, mounds/nests, non-agricultural outdoor buildings and structures, indoor commercial/institutional/industrial premises (see master label description), food processing plant premises, ornamental woody shrubs and vines, ornamental non-flowering plants, tree fruits (cherries, nectarines, peaches, plum/prunes), tree nuts (almonds) - pre-plant, and tree nuts (apple) - pre-plant.

c. Additional PPE Labeling Updates and Requirements

PPE Label Consistency Updates

In addition, the agency is considering updating the glove and respirator statements currently on labels. The proposed new glove and respirator language does not fundamentally change the PPE that workers need to use, and therefore should impose no impacts on users.

For gloves in particular, all statements that refer to the chemical resistance category selection chart are proposed to be removed from chlorpyrifos labels, as they might cause confusion for users. These statements are proposed to be replaced with specific chemical-resistant glove types, consistent with the Label Review Manual.[41]

Respirator Requirement for Chlorpyrifos Handlers

To mitigate potential inhalation risk to occupational handlers, the agency is considering requiring a respirator and, for pesticides covered by the Worker Protection Standard[42] (WPS), the associated fit test, training, and medical evaluation for the aforementioned formulations and uses.

The EPA has recently required fit testing, training, and medical evaluations[43] for all handlers who are required to wear respirators and whose work falls within the scope of the WPS.[44] If a chlorpyrifos handler currently does not have a respirator, an additional cost will be incurred by the handler or the handler's employer, which includes the cost of the respirator plus, for WPS-covered products, the cost for a respirator fit test, training, and medical exam.

[41] https://www.epa.gov/pesticide-registration/label-review-manual
[42] 40 CFR 170
[43] Fit testing, training, and medical evaluations must be conducted according to OSHA regulations 29 CFR § 1910.134, 29 CFR § 1910.134(k)(1)(i) through(vi), and 29 CFR § 1910.134, respectively.
[44] 40 CFR 170 (see also Appendix A of Chapter 10 of the Label Review Manual, available at https://www.epa.gov/pesticide-registration/label-review-manual). [45] Economic Analysis of the Agricultural Worker Protection Standard Revisions. Biological and Economic Analysis Division, Office of Pesticide Programs, U.S. EPA. 2015. p. 205. Available at www regulations.gov, docket number EPA-HQ-OPP-2011-0184-2522.

Respirator costs are extremely variable depending upon the protection level desired, disposability, comfort, and the kinds of vapors and particulates being filtered. Based on available information that the EPA has, the cost of the respirators (whether disposable or reusable) is relatively minor in comparison to the fit-test requirement under the Worker Protection Standard. The agency expects that the average cost of a particulate filtering facepiece respirator is lower than the average cost of an elastomeric half mask respirator. The estimated cost of a respirator fit test, training and medical exam is about $180 annually.[45] The impact of the proposed respirator requirement is likely to be substantially lower for a chlorpyrifos handler who is already using a respirator because the handler or handler's employer uses other chemicals requiring a respirator in the production system or as part of the business (*i.e.*, the handler or employer will only incur the cost of purchasing filters for the respirator on a more frequent basis). Respirator fit tests are currently required by the Occupational Safety and Health Administration (OSHA) for other occupational settings to ensure proper protection.[46]

The EPA acknowledges that requiring a respirator and the associated fit testing, training, and medical evaluation places a burden on handlers or employers. However, the proper fit and use of respirators is essential to accomplish the protections respirators are intended to provide. In estimating the inhalation risks, and the risk reduction associated with different respirators, the EPA's human health risk assessments assume National Institute for Occupational Safety and Health (NIOSH) protection factors (*i.e.*, respirators are used according to OSHA's standards). If the respirator does not fit properly, use of chlorpyrifos may cause unreasonable adverse effects on the pesticide handler.

Engineering Requirement for Handlers

EPA is considering requiring that a closed pesticide delivery system be used for mixing and loading chlorpyrifos for applications to several uses as described above. Professional applicators likely have closed pesticide delivery systems because they handle multiple chemicals, some of which likely already require closed pesticide delivery systems. Thus, the impacts of this restriction would likely be small for situations where hired applicators are used. Individual or independent growers are much less likely to have closed pesticide delivery systems than commercial firms, so these restrictions could impede their ability to use chlorpyrifos. Users who do not already have the appropriate equipment would have to hire a commercial firm to make chlorpyrifos applications, probably at an increase in cost, or use an alternative insecticide, which (as described above) could be more expensive and (in some cases) less efficacious. Users could also invest in a closed pesticide delivery system. The cost of a closed pesticide delivery system varies and depends on the complexity of the system. Based on available information, the cost of the equipment may have been around $300.[47] It seems unlikely, however, that a grower would incur such an expense if chlorpyrifos is the only chemical applied to the field that requires a closed pesticide delivery system.

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[45] Economic Analysis of the Agricultural Worker Protection Standard Revisions. Biological and Economic Analysis Division, Office of Pesticide Programs, U.S. EPA. 2015. p. 205. Available at www.regulations.gov, docket number EPA-HQ-OPP-2011-0184-2522.

[46] 29 CFR § 1910.134

[47] Giles K., & Billing, R. 2013. Designs and Improvements in Closed Systems. Report to: Ken Everett, Pesticide Enforcement Branch, California Department of Pesticide Regulation.

EPA is also considering the requirement of an enclosed cab for airblast applications of chlorpyrifos. Users that do not currently own a tractor with an enclosed cab could hire commercial applicators to apply chlorpyrifos, at an increased cost, or switch to alternative insecticides. As described above, users face increased costs using the available alternatives for some uses, and for some crops (i.e., California oranges, apples, and Southeastern peaches) effective alternatives are not available and yield and quality losses are possible. The characteristics of some orchards do not lend themselves well to enclosed cabs. In these situations, this requirement will most likely result in growers using alternatives insecticides.

3. Use Prohibitions, Application Method Restrictions, and Rate Reductions

For the following application methods, potential risk estimates of concern could not be resolved with additional PPE or engineering controls. For that reason, the EPA is considering additional options for mitigating these risks, including application method prohibitions, restricting use of particular application methods to select use sites, and/or application rate reductions.

The subset of uses that are ultimately retained to address potential dietary risk (discussed in section IV.A.1) will impact the mitigation approach taken to address potential occupational risk. At this time, the EPA is presenting use prohibitions and application restrictions for risk estimates that were below the LOC. Once the EPA considers the SAP's conclusions, the EPA may further revise the human health risk assessment and proposed/considered mitigation. This includes consideration of additional refinements to the occupational risk estimates where possible. The EPA will also consider the benefits of the crops that are ultimately retained, as well as public comments, prior to finalizing any use prohibitions and/or application restrictions.

The impacts of the prohibitions and restrictions on uses will depend on the use site. As described in Section III.C, there are alternatives available to chlorpyrifos for most use sites, at an increased cost to users in many cases. There are exceptions, and some chlorpyrifos users could see reductions in pest control using the alternatives, resulting in reduced yield or quality of some crops.

a. Use Prohibitions and Application Restrictions – with the 10X UF_{DB}

Aerial and chemigation applications

Even with engineering controls, risks of concern were identified for most uses from mixing and loading for aerial and chemigation applications. Most MOEs for mixers and loaders with engineering controls ranged from 9.6 to 71. Exceptions include mixing and loading for ornamental and/or shade trees, herbaceous plants (WP in WSP), ornamental non-flowering plants (microencapsulated formula) and mosquito/vector control (L/SC/EC). Therefore, EPA is considering limiting application to select uses or prohibit aerial and chemigation application of chlorpyrifos to all uses except chemigation application of microencapsulated formula on ornamental non-flowering plants and mosquito/vector control. See Appendix A for a complete list of considered prohibited uses.

Although the use of global positioning systems (GPS) has vastly replaced the use of flaggers to guide aerial applications, the agency continues to assess exposure as use of flaggers is not explicitly prohibited on pesticide products containing chlorpyrifos. All liquid applications of chlorpyrifos products results in potential risks of concern for flaggers with the maximum amount of PPE (double layer (coveralls), gloves, and an elastomeric half mask respirator). Potential risks of concern were identified for flaggers with granule application for treatment of peanuts regardless of PPE. Use of chlorpyrifos granule products also resulted in risks of concern without use of a respirator for application on sweet potato, corn (pre-plant), sunflower, and tobacco. No risks of concern were identified for flaggers with granule application to sod farms (turf). Therefore, the agency is considering prohibiting use of flagger for all applications except granule application to sod farms (turf).

Groundboom application

Risk estimates with engineering controls were still below EPA's LOC of 100 for mixing and loading the following formulations and respective uses (MOEs = 39 – 98):

- Liquid/Soluble Concentrate: Corn (pre-plant and post-emergence), cotton (except MS), tree nut orchard floors (pecans, almonds, walnuts), ornamental lawns and turf, and sod farms
- Wettable powder in WSP: Ornamental lawns and turf, sod farms (turf), ornamental woody shrubs and vines (pre-transplant)
- Dry flowable (DF) /water-soluble granule (WSG) in WSP: Tree nut orchard floors (pecans, almonds, walnuts), corn, sorghum grain, soybean, rutabaga, and turnip

Consequently, EPA is considering prohibiting chlorpyrifos application to the above uses and formulations by groundboom application. This would also address risks of concern to groundboom applicators for corn (pre-plant), cotton (except Mississippi).

WSP formulations are assessed having the protection factor of engineering controls. The DF/WSG in WSP formulations do not fully meet the LOC of 100 for sweet potato (pre-plant, soil broadcast), cole crops (excludes Brussels sprout and cauliflower), mint (peppermint and spearmint), peanut, sunflower, and tobacco with MOEs ranging from 92 to 98. Chlorpyrifos is regarded as a high benefit for these uses.

Airblast application

Risk estimates for mixing and loading with engineering controls for citrus (CA and AZ at a rate of 6.0 lbs a.i./Acre) resulted in MOEs of 96 (L/SC/EC) and 67 (wettable powder in WSP and DF/WDG in WSP). The MOE for airblast application to citrus at the highest rate was 64 with engineering controls. Given recent chlorpyrifos restrictions in the state of California, use in California is expected to be negligible after 2020. EPA is considering reducing the application rate applied to citrus in Arizona to 4.0 lbs a.i./acre. MOEs for this reduced rate are 98 and still below the EPA's LOC of 100. However, citrus is recognized as a high-benefit use for chlorpyrifos. Reducing this rate will also address potential post-application risks of concern for citrus (assuming retention the 10X UF_{DB}).

Tractor-drawn spreader

Use of double layer (coveralls), gloves, and a half face respirator results in the highest MOEs for mixing, loading, or applying chlorpyrifos by tractor-drawn spreader. MOEs for mixing and loading soybean and corn were 74 and 79, respectively. Engineering controls, excluding applications by SmartBox®, results in slightly lower risk estimates. Consequently, EPA is considering prohibiting tractor drawn spreader application on these uses.

Handheld application methods

Regardless of PPE, risk estimates for application with mechanically pressurized handgun were below EPA's level of concern for all uses except ornamental woody shrubs and vines and seed orchard trees (MOEs = 440 to 8300); MOEs of concern ranged from 2.1 to 83 for all other uses. As a result, EPA is considering limiting mechanically-pressurized handgun application only to ornamental woody shrubs and vines and seed orchard trees.

The agency is considering prohibiting manually pressurized handwand application to indoor commercial/institutional/industrial premises and food processing plant premises. The risk estimate for these uses is 16 with maximum PPE.

To address risks of concern to occupational handlers using backpack sprayers, the agency is considering prohibiting all uses with the retention of the 10X UF_{DB} except for the formulations, uses, and conditions listed in Section IV.A.2.

The highest MOEs with maximum PPE (double-layer (coveralls), gloves, and an elastomeric half mask respirator) for application of chlorpyrifos by belly grinder or brush roller are 43 and 45, respectively. Given the limited uses for this application method, none of which are food uses, the agency is considering prohibiting application of chlorpyrifos by these handheld methods.

EPA is also considering prohibiting application of granular formulation by hand dispersal to commercial/institutional/industrial premises and utilities (pad) and by belly grinder to ornamental wood shrubs and vine. Prohibiting application to sewer manholes by brush roller may also be considered. MOEs for these applications with double layer (coveralls), gloves, and an elastomeric half mask respirator ranged from 1.4 to 7.1.

Microencapsulated formulations on ornamentals in nurseries and in greenhouses (post-application)

Occupational post-application risks of concern from microencapsulated formulations extend up to >35 days for ornamentals in nurseries and greenhouses. Extending REIs beyond a week, even on the basis on select activities, is not considered practical. Other uses which have risk estimates below the agency's LOC of 100 at the FQPA safety factor of 10X include grape and cole crops. For these uses, EPA is in the process of determining the most appropriate DFR study to

characterize risks for mitigation. Given the alternative formulations of chlorpyrifos available with significantly shorter REIs, EPA is considering prohibiting microencapsulated formulations for use on ornamentals in nurseries and greenhouses.

Seed Treatment

Occupational handlers applying chlorpyrifos for seed treatment may potentially conduct multiple tasks, such as sewing, bagging, loading, and applying. Additional activities increase the amount of potential exposure to these workers. These activities were assessed with the maximum amount of PPE available:

Table 19: Seed Treatment Activities and PPE

Activity	Maximum PPE assessed
Sewing seeds after seed treatment	Single layer (long sleeved shirt and long pants), no gloves and no respirator
Bagging seeds after seed treatment	
Loading/Applying liquid for seed treatment	Double layer (coveralls), gloves and PF10 respirator
Multiple activities for seed-treatment	

As a result, the agency is considering prohibiting use of chlorpyrifos as a seed treatment for the following formulations and crops based on risks to multiple activities workers or occupational handlers that conduct multiple activities for seed treatment (e.g., applying and bagging):

- Liquid formulation on beans, corn, cotton
- Microencapsulated formulation on beans
- Wettable powder in WSP on beans and corn

b. Use Prohibitions and Application Restrictions – without the 10X UF_{DB}

MOEs for aerial application of granular formulations of chlorpyrifos on peanuts is 5 with engineering controls. MOEs for other aerial granular applications range are 9.4 (sweet potato) and 9.5 (sunflower, tobacco) also with engineering controls. Therefore, EPA is considering prohibiting this application method on peanuts. Although the risk estimates are still below a LOC of 10 for sweet potato, sunflower, and tobacco, these uses are proposed to be retained given the benefits associated with the use of chlorpyrifos on these crops.

The agency is also considering prohibiting backpack sprayer application to ornamental and/shade trees, herbaceous plants, ornamental woody shrubs and vines. MOEs for application to these non-food sites are 3.8 with maximum PPE (double layer (coveralls), gloves, and an elastomeric half mask respirator) and therefore are of concern.

For handheld applications, EPA is considering prohibiting brush roller application for sewer manholes and hand dispersal to commercial/institutional/industrial premises and utilities (pad). With double layer (coveralls), gloves, and an elastomeric half mask respirator, the MOE is 1.4

for broadcast hand dispersal application to commercial/institutional/industrial premises and utilities (pad) and, therefore, is below the LOC. The agency is also considering prohibiting application with belly grinders on ornamental woody shrubs and vines. With maximum PPE, the MOE is 7.1 and below the LOC of 10 for these uses.

4. Re-Entry Interval

With retention of the 10X UF_{DB}, risk estimates exceed the LOC of 100 for over 30 activities/uses. These include: berries, field and row crops, tree fruit (deciduous, evergreen), forestry, tree nuts (almonds), ornamental nurseries (non-bearing fruit trees), fruiting vegetables, brassica vegetables, leafy vegetables, and grapes. As multiple DFR studies were submitted for many uses, the MOEs for chlorpyrifos on these crops may vary depending on activity and study location. EPA is in the process of determining the most appropriate DFR study to characterize risks for mitigation. Proposed REIs for uses with identified risks of concern may extend over one week. At the 1X UF_{DB}, the MOEs exceed the LOC for approximately 10 crop groups with proposed REIs extending from 2 to 5 days. See Appendix D2 for the mitigation being considered to address occupational post-application risks of concern. Mitigation measures for other risks of concern may impact the selection of uses that are maintained and, thus, how EPA addresses these post-application risks of concern.

5. Pesticide Resistance Management

Pesticide resistance occurs when genetic or behavioral changes enable a portion of a pest population to tolerate or survive what would otherwise be lethal doses of a given pesticide. The development of such resistance is influenced by a number of factors. One important factor is the repeated use of pesticides with the same mode (or mechanism) of action. This practice kills sensitive pest individuals but allows less susceptible ones in the targeted population to survive and reproduce, thus increasing in numbers. These individuals will eventually be unaffected by the repeated pesticide applications and may become a substantial portion of the pest population. An alternative approach, recommended by resistance management experts as part of integrated pest management (IPM) programs, is to use pesticides with different chemical modes (or mechanisms) of action against the same target pest population. This approach may delay and/or prevent the development of resistance to a particular mode (or mechanism) of action without resorting to increased rates and frequency of application, possibly prolonging the useful life of pesticides.

The EPA is proposing to include resistance-management labeling for insecticides/acaricides from PRN 2017-1, for products containing chlorpyrifos, in order to provide pesticide users with easy access to important information to help maintain the effectiveness of useful pesticides.[48] Resistance management label language for insecticides may be found at: https://www.epa.gov/pesticide-registration/pesticide-registration-notices-year.

[48] https://www.epa.gov/pesticide-registration/pesticide-registration-notices-year

Additional information on the EPA's guidance for resistance management can be found at the following website: https://www.epa.gov/pesticide-registration/prn-2017-1-guidance-pesticide-registrants-pesticide-resistance-management.

6. Spray Drift Management

EPA is proposing label changes to reduce off-target spray drift and establish a baseline level of protection against spray drift that is consistent across all chlorpyrifos products. Reducing spray drift is expected to reduce the extent of environmental exposure and risk to non-target plants and animals, including listed species whose range and/or critical habitat co-occur with the use of chlorpyrifos. These spray drift reduction measures, once finalized in the Interim Decision, will be considered in forthcoming consultation with the Services, as appropriate.

EPA is proposing the following spray drift mitigation language to be included on all chlorpyrifos product labels for products applied by liquid spray application. The proposed spray drift language includes mandatory, enforceable statements and supersede any existing language already on product labels (either advisory or mandatory) covering the same topics. EPA is also providing recommendations that allow chlorpyrifos registrants to standardize all advisory language on chlorpyrifos product labels. Registrants must ensure that any existing advisory language left on labels does not contradict or modify the new mandatory spray drift statements proposed in this PID, once effective.

• Applicators must not spray during temperature inversions.

• For aerial applications,
  - Do not apply when wind speeds exceed 10 mph at the application site.
  - The boom length must be 65% or less of the wingspan for fixed wing aircraft and 75% or less of the rotor diameter for helicopters. Applicators must use ½ swath displacement upwind at the downwind edge of the field.
  - The release height must be no higher than 10 feet from the top of the crop canopy or ground, unless a greater application height is required for pilot safety.

• For groundboom applications,
  - Do not apply when wind speeds exceed 10 mph at the application site.
  - Apply with a release height no more than 3 feet above the ground or crop canopy.

• Airblast applications:
  - Sprays must be directed into the canopy.
  - Do not apply when wind speeds exceed 10 miles per hour at the application site.
  - User must turn off outward pointing nozzles at row ends and when spraying outer row.

Buffers were required to mitigate potential spray drift risk to bystanders in the July 2012 *Spray Drift Mitigation Decision for Chlorpyrifos.* Buffer distances implemented as a result of that decision are not superseded by this PID, and are included below for reference:

Table 20: Buffer Distances				
Application rate (lb ai/A)	Nozzle Droplet Type	Required Setback (Buffer Zones) (feet)		
		Aerial	Airblast	Ground
>0.5 - 1	coarse or very coarse	10	10	10
>0.5 - 1	medium	25	10	10
>1 - 2	coarse or very coarse	50	10	10
>1 - 2	medium	80	10	10
>2 - 3	coarse or very coarse	80[1]	10	10
>2 - 3	medium	100[1]	10	10
>3 - 4	medium or coarse	NA[2]	25	10
>4	medium or coarse	NA	50	10

[1]Aerial application of greater than 2 lb ai/A is only permitted for Asian Citrus Psyllid control, up to 2.3 lb ai/A.
[2]NA is not allowed.

Spray drift mitigation for chlorpyrifos has the potential to decrease an applicator's flexibility to make timely applications for both ground and aerial applications (e.g., windspeed and temperature inversions). Applicators may see a decrease in flexibility of application timing and an increase in managerial effort for scheduling production activities, ultimately increasing costs for the user if chlorpyrifos applications are not made in a timely manner. Some users may be forced to use alternative insecticides, which may be more costly and/or less effective than chlorpyrifos. Fixed-wing aircraft will have reduction in usable boom length, which may necessitate more passes to complete an application, potentially increasing application costs. EPA has determined the changes in release height and swath displacement will have minimal impact on aerial applications. The agency anticipates little impact with residential buffers and considers that this size buffer corresponds to good application practices when applying near residential areas.

7. Updated Water-Soluble Packaging Language for Chlorpyrifos

EPA is proposing updated directions for use language be added to chlorpyrifos labels that are packaged in WSP, consistent with the language being proposed across WSP products in registration review. The improved clarity is expected to ensure proper use of these products and to minimize exposure to occupational handlers.

B. Tolerance Actions

The chlorpyrifos tolerance expressions established 40 CFR § 180.342 will be updated to incorporate newly revised crop group definitions, OECD rounding class practice, commodity definition revisions, crop group conversions/revisions, and harmonization with Codex. The agency will consider the input and recommendations from the September 2020 FIFRA Scientific Advisory Panel (SAP) on new approach methodologies for neurodevelopmental toxicity once the

SAP report is released. After receiving the SAP's conclusions which are anticipated in December 2020, EPA will examine the need for further tolerance actions. The agency will use its FFDCA rulemaking authority to make the needed changes to the tolerances. Refer to Section III.A.4 for details.

C. Proposed Interim Registration Review Decision

In accordance with 40 CFR § 155.56 and § 155.58, the agency is issuing this PID. The agency has made the following PID: (1) no additional data from registrants are required at this time and (2) changes to the affected registrations and their labeling are needed at this time, as described in Section IV. A and Appendix A.

The agency has concluded that there is no evidence demonstrating that chlorpyrifos potentially interacts with estrogen, androgen, or thyroid pathways. Therefore, EDSP Tier 2 testing is not recommended. For more information, see the *EDSP Weight of Evidence Conclusions on the Tier 1 Screen Assays for the List 1 Chemicals*[49] and Appendix C. The proposed mitigation described in this document is expected to reduce the extent of environmental exposure and may reduce risk to listed species whose range and/or critical habitat co-occur with the use of chlorpyrifos.

D. Data Requirements

The agency does not anticipate calling-in additional data for registration review of chlorpyrifos at this time. The EPA will consider requiring submission of pollinator and residue chemistry data as a separate action.

V. NEXT STEPS AND TIMELINE

A. Proposed Interim Registration Review Decision

A Federal Register Notice will announce the availability of this PID for chlorpyrifos and will allow a 60-day comment period. If there are no significant comments or additional information submitted to the docket during the comment period that leads the agency to change its PID, the EPA may issue an interim registration review decision for chlorpyrifos. However, a final decision for chlorpyrifos may be issued without the agency having previously issued an interim decision. A final decision on the chlorpyrifos registration review case will occur after: (1) an endangered species determination under the ESA and any needed § 7 consultation with the Services, and (2) the agency completes a revised cumulative risk assessment for OPs.

B. Implementation of Mitigation Measures

[49] https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0849

Once the Interim Registration Review Decision is issued, the chlorpyrifos registrants must submit amended labels that include the label changes described in Appendix A. The agency will issue a label table after considering the input and recommendations from the September 2020 FIFRA Scientific Advisory Panel (SAP) on new approach methodologies for neurodevelopmental toxicity. The revised labels and requests for amendment of registrations must be submitted to the agency for review within 60 days following issuance of the Interim Registration Review Decision in the docket.

Appendix A: Summary of Proposed and Considered Actions for Chlorpyrifos

NOTE: The proposed and considered actions below reflect the suite of mitigation measures being considered for each of the currently labeled chlorpyrifos uses. If the agency moves forward with the use restrictions being proposed to reduce dietary exposure from drinking water, select occupational and post-application actions proposed below may not be needed. The agency will reexamine the proposed and considered mitigation after considering public input during the comment period and conclusions from the 2020 SAP.

Registration Review Case#: 0100
PC Code: 059101
Chemical Type: Insecticide
Chemical Family: Organophosphate
Mode of Action: Acetylcholinesterase inhibition

Affected Population(s)	Source of Exposure	Route of Exposure	Duration of Exposure	Potential Risk(s) of Concern	Proposed Actions with 10X FQPA SF	Proposed Actions with the 1X FQPA SF
Infants and children	Dietary (drinking water)	Ingestion	Acute Steady state	Neurotoxicity	To reduce potential dietary exposure to chlorpyrifos, the agency is considering label amendments to limit use of chlorpyrifos to the 11 high-benefit and/or critical uses (alfalfa, apple, cherries (tart), asparagus, citrus, cotton, peach, soybean, strawberry, sugar beet, wheat (spring), and wheat (winter)) in select regions, as well as public health uses, as identified in Section IV.A.1. of this PID.	To reduce potential dietary exposure to chlorpyrifos, the agency is considering label amendments to prohibit the following uses: Peppers, trash storage bins, and wood treatment; and restrict the following uses to certain regions: corn, cherries (tart), citrus, pecans and peach; and reduce the application rate for cherries (tart) by region, as identified in Section IV.A.1. of this PID.
Females 13-49 years of age	Dietary (drinking water)	Ingestion	Acute Steady state	Neurotoxicity		
Considered mitigation for Occupational Risks of Concern						
Affected Population(s)	**Source of Exposure**	**Route of Exposure**	**Duration of Exposure**	**Potential Risk(s) of Concern**	**Mitigation Actions Considered with 10X UF_{DB}**	**Mitigation Actions Considered with the 1X UF_{DB}**
Occupational handler risks from mixing and loading most aerial and chemigation applications: Liquid/Soluble Concentrate/Emulsifiable	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting aerial and chemigation application of chlorpyrifos to all uses except for aerial use on ornamental non-flowering	Consider prohibiting application of granules on peanuts. Consider use of double layer (coveralls), gloves, and an

Concentrate (L/SC/EC) and granule					plants and as a wide area mosquito adulticide (L/SC/EC). Consider requiring double layer (coveralls), gloves, and an elastomeric half mask respirator for mixing and loading aerial mosquito adulticide applications.	elastomeric half mask respirator, for: Citrus, non-bearing fruit and nut trees (nursery), radish (pre-plant), turfgrass (sod or seed), cherries, hybrid cottonwood/poplar plantations, mint (peppermint and spearmint), peanut, rutabaga, strawberries (pre-plant), sunflower (pre-plant), sweet potato, tobacco, tree fruits (apple, nectarine, peach, pear, plum/prune), tree nuts (almonds, filberts, hazelnuts, pecans, walnuts), turfgrass (ornamental and sod farms), clover (grown for seed), cranberry, sunflower (post-emergence/foliar). Consider single layer (long-sleeved shirt and long pants), gloves and a particulate filtering facepiece for: Asparagus, Brussels sprouts, cauliflower, cole crops, strawberries, sugar beets, and radish.
Occupational handler risks from mixing and loading aerial application only: L/SC/EC and granule	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting all aerial application of chlorpyrifos on ornamental non-flowering plants and as a wide area mosquito adulticide (L/SC/EC). Consider requiring double layer (coveralls), gloves, and an elastomeric half mask respirator for mixing and loading aerial mosquito adulticide applications.	L/SC/EC: • Consider requiring engineering controls for mixing and loading corn (post-emergence). • Consider requiring single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece for: Alfalfa, cotton (except Mississippi),

						sorghum, wheat, Christmas tree plantations, and carrots. Granule: • Consider double layer (coveralls), gloves, and either a particulate filtering facepiece or an elastomeric half mask respirator for corn (pre-plant). • Consider requiring single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece for peanut and sweet potato.
Occupational handler risks from mixing and loading chemigation only applications: L/SC/EC	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting all chemigation application of chlorpyrifos.	Consider requiring engineering controls for mixing and loading for use on: Tree nuts, orchard floors (pecans, almonds, walnuts), corn (pre-plant). Consider single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece for mixing a loading for: Alfalfa, cotton (except Mississippi), sorghum, soybean, and wheat.
Occupational handler risks from mixing and loading most aerial and chemigation applications: Dry flowable/water-dispersable granules (DF/WDG) in WSP	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting all aerial and chemigation application of chlorpyrifos DF/WDG in WSP formulations.	N/A

Occupational handler risks from mixing and loading most aerial and chemigation applications: Wettable Powder (WP), and Spray (all starting formulations	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application of WP to all uses except ornamental and/or shade trees, herbaceous plants. Consider prohibiting application of spray (all starting formulations) to the following uses: Citrus, carrots, corn (post-emergence), alfalfa, corn (pre-plant), Christmas tree plantations, cole crops, cotton (except Mississippi), sorghum, soybean, wheat, asparagus, Brussels sprouts, cauliflower, cole crops, strawberries, sugar beets, radish, clover (grown for seed; foliar), corn (post-emergence), cranberry, hybrid cottonwood/ poplar plantations grown for pulp, sunflower (post-emergence/ foliar), non-bearing fruit and nut trees (nursery), radish (pre-plant), sweet potato (pre-plant), cherries, mint (peppermint and spearmint), peanut, rutabaga, strawberries (pre-plant), sunflower (pre-plant), tobacco, tree fruits (apple, fig (CA only), nectarine, peach, pear, plum/prune), ornamental and/or shade trees, herbaceous plants, tree	N/A

					nuts (almonds, filberts/hazelnuts, pecans, walnuts), and turfgrass (ornamental and sod farms).	
Occupational handler risks from mixing and loading groundboom applications for: L/SC/EC	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application of L/SC/EC formulations by groundboom to: Corn (pre-plant, post-emergence), cotton (except Mississippi), tree nut orchard floors (pecans, almonds, walnuts), ornamentals lawns and turf, sod farms. Consider requiring engineering controls for mixing and loading L/SC/EC formulations for: Radish (pre-plant), alfalfa, cotton, sorghum grain, soybean, wheat, rutabaga, Brussels sprouts (at plant, post-plant), grapes (foliar, dormant, delayed dormant), sweet potato (pre-plant, soil broadcast), nursery stock (preplant), cole crops, cauliflower, mint (peppermint, spearmint), peanut, pineapple, strawberries (pre-plant), sunflower (pre-plant), tobacco (pre-plant), beets (table, sugar, at plant), clover (grown for seed; foliar), hybrid cottonwood/poplar plantations, and cranberry.	Consider requiring single layer (long-sleeved shirt, long pants), gloves, and a particulate filtering facepiece for: Corn (pre-plant and post-emergence), radish (pre-plant), rutabaga, Brussels sprouts (at-plant, post-plant), grapes (foliar, dormant, delayed dormant), sweet potato (pre-plant, soil broadcast), cotton (except Mississippi), cole crops, cauliflower, mint (peppermint, spearmint), peanut, pineapple, strawberries (pre-plant), sunflower (pre-plant), tobacco (pre-plant), cranberry, alfalfa, cotton, sorghum grain, soybean, wheat, beets (table, sugar; at plant), clover (grown for seed; foliar), hybrid cottonwood/poplar plantations, tree nut orchard floors (pecans, almonds, walnuts), nursery stock (pre-plant), ornamental lawns and turf, and sod farms.

					Consider requiring double layer (coveralls), gloves and particulate filtering facepiece for carrots. Consider requiring double layer (coveralls) and gloves for: Asparagus. beets (tables, sugar, at plant), citrus orchard floors, forest plantings (reforestation, plantation, tree farm), grass (forage/fodder/hay), legume, vegetables, nonagricultural outdoor buildings and structures, and onions. Consider requiring single layer (long-sleeved shirt and long pants) and gloves for: Conifers and deciduous trees, seed orchard trees, ornamental and/or shade trees, herbaceous plants, ornamental woody shrubs and vines, and golf course (fairways, tees, greens).	
Occupational handler risks from mixing and loading groundboom applications for: DF/WDG in WSP	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application of DF/WDG in WSP to: Tree nut orchard floors (pecans, walnuts, almonds), corn, sorghum grain, soybean, rutabaga, and turnip.	N/A
Occupational handler risks from mixing and loading	Air Residues	Dermal absorption	Acute Steady state	Neurotoxicity	Consider prohibiting application of WP (in WSP) to	N/A

groundboom applications for: WP (in WSP)		Inhalation			ornamental lawns and turf, sod farms (turf), and ornamental woody shrubs and vines (pre-transplant).	
Occupational handler risks from applying groundboom applications for: Spray (all starting formulations) considered for prohibition or engineering controls	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application of spray (in all starting formulations) to corn (pre-plant). Consider engineering controls for application on: Alfalfa, cotton, sorghum grain, wheat, radish, turnip, ornamental lawns and turf and sod farms (turf).	N/A
Occupational handler risks from applying groundboom applications for: Spray (all starting formulations) considered for additional PPE	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider double layer (coveralls), gloves, and an elastomeric half mask respirator for: Alfalfa, sorghum grain, soybean, and wheat. Consider double layer (coveralls), gloves, and particulate filtering facepiece for: Brussels sprouts (at plant, post-plant, and post-emergence), cauliflower, cole crops, , grapes (foliar, dormant, delayed dormant), mint (peppermint, spearmint), peanut, pineapple, rutabaga, strawberries (pre-plant), sunflower (pre-plant) sweet potato (pre-plant and soil broadcast), tobacco (pre-plant), nursery stock (pre-	Consider requiring single layer (long-sleeved shirt, long pants) and gloves for application to corn (pre-plant), tree nut orchard floors (pecans, almonds, walnuts), and cotton (except Mississippi).

					plant), rutabaga, clover (grown for seed, foliar), hybrid cottonwood and poplar plantations and potentially alfalfa, sorghum grain, soybean, and wheat. Consider single layer (long-sleeved shirt and long pants), gloves, and an elastomeric half mask respirator for: sweet potato (pre-plant and soil broadcast). Consider single layer, gloves, and particulate filtering facepiece for: Cranberry, beets (table, sugar; at plant), clover (grown for seed), and hybrid cottonwood and poplar plantations. Consider single layer and gloves for the following: Carrots, asparagus, beets (table, sugar, at plant), citrus orchard floors, cole crops (excludes Brussels sprouts and cauliflower), cotton, forest plantings (reforestation, plantation, tree farm), grapes (dormant, delayed dormant), grass (forage/fodder/hay), legume vegetables, nonagricultural outdoor buildings and structures, onions, peppers,	

					strawberries, ornamentals and/or shade trees, herbaceous plants, ornamental woody shrubs and vines, conifers and deciduous trees, seed orchard trees, forest trees (softwoods and conifers), and golf course (fairways, tees, and greens).	
Occupational handler risks from airblast applications: Mixing and loading L/SC/EC	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider requiring engineering controls for: Citrus, non-bearing fruit and nut trees (nursery), and tree fruits (nectarine, peach - dormant, delayed dormant). Consider requiring double-layer (coveralls), gloves, and an elastomeric half mask respirator (PF10) for: Cherries, tree fruits (pear, plum/prune (dormant, delayed dormant), and tree nuts (almond, filberts, hazelnuts, pecans, walnuts). Consider requiring single layer (long pants and long-sleeved shirt) and glove for: Ornamental and/or shade trees, ornamental woody shrubs and vines, herbaceous plants, Christmas tree plantations, and grapes.	Consider requiring single layer (long-sleeved shirt and long pants) and gloves for: Citrus, non-bearing fruit and nut trees (nursery), tree fruits (nectarine, peach - dormant, delayed dormant).
Occupational handler risks from airblast applications:	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider reducing application rate from 6.0 lbs a.i./Acre to 4.0 lbs a.i./Acre in Arizona.	N/A

Mixing and loading DF/WDG in WSP and WP (in WSP)						
Occupational handler risks from airblast applications: Applying spray (all starting formulations)	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider reducing application rate from 6.0 lbs a.i./Acre to 4.0 lbs a.i./Acre in Arizona. Consider requiring engineering controls for all uses.	N/A
Occupational handler: Seed treatment for liquid, microencapsulated, and wettable powder via WSP to multiple activities workers when applied on beans, corn, and cotton.	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting seed-treatment for the following uses and formulations: • Liquid formulation on beans, corn, cotton • Microencapsulated formulation on beans • Wettable powder in WSP on beans and corn	N/A
Occupational handler: Mixing and loading, and applying by tractor-drawn spreader	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application on corn, soybean. Consider single layer (long-sleeved shirt and long pants) and an elastomeric half mask respirator for alfalfa. Consider single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece for: Rutabaga and sweet potato.	N/A

					Consider single layer (long-sleeved shirt and long pants), and a particulate filtering facepiece for: Asparagus, cole crops, (excludes Brussels sprouts and cauliflower), ginseng, sugar beets, sunflower, citrus orchard floors, onions, tobacco, ornamental lawns and turf, sod farms (turf), and nursery stock.	
Occupational handler: Application by tractor-drawn spreader					Consider requiring double layer (coveralls), gloves, and an elastomeric half mask respirator for: Peanut and sorghum grain. Consider requiring double layer (coveralls) and gloves for: Citrus orchard floors, onions, ornamental lawns and turf, and sod farms (turfs). Consider requiring single layer (long-sleeved shirt and long pants), gloves, and a particulate facepiece for: Radish, rutabaga, and alfalfa. Consider requiring single layer (long-sleeved shirt and long pants) and a particulate facepiece for: Cauliflower (post-plant), turnip, Brussels sprouts (post-plant), sweet potato, cole crops (except	

					cauliflower) ginseng, sugar beets, sunflower, and tobacco.	
Occupational handler: Wide area mosquito adulticide applications from mixing, loading, and applying ground (airblast surrogate) and aerial applications.	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider requiring double layer (coveralls), gloves, and an elastomeric half mask respirator for mixers and loaders. Consider requiring engineering controls for applicators.	Consider requiring gloves and chemical resistant headgear for ground (airblast surrogate) applicators Consider requiring engineering controls for aerial applicators.
Occupational handler: Mechanically-pressurized handgun applications	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application by mechanically-pressurized handgun for all uses except on ornamental woody shrubs and vines and seed orchard trees.	Consider requiring double layer (coveralls), gloves, and a particulate filtering facepiece respirator
Occupational handler: Manually-pressurized handwand	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application to Indoor commercial, institutional, industrial premises, food processing plant premises. Consider requiring double layer PPE (coveralls), gloves, and an elastomeric half mask respirator (PF10) for wood treatment and nursery (pine seedlings). Consider requiring single layer (long-sleeved shirt and long pants), gloves, and a particulate filtering facepiece for wide area/general outdoor treatment.	Consider single layer (long-sleeved shirt and long pants) and gloves for Wood protection treatment, nursery (pine seedlings), wide area/ general outdoor treatment, Christmas tree plantations, conifers and deciduous trees; plantation nurseries, grapes, seed orchard trees, forest trees (softwoods, conifers), golf course turf, mounds/nests, non-agricultural outdoor buildings and structures, indoor commercial/institutional/industrial premises (see master label description), food processing plant premises, ornamental woody shrubs and vines, ornamental non-flowering plants, tree fruits

					Consider single layer (long-sleeved shirt and long pants) and gloves for: Christmas tree plantations, conifers and deciduous trees; plantation nurseries, grapes, seed orchard trees, forest trees (softwoods, conifers), golf course turf, mounds/nests, non-agricultural outdoor buildings and structures, ornamental woody shrubs and vines, ornamental non-flowering plants, outdoor commercial/institutional/industrial premises (see master label description), agricultural farm premises, poultry litter, tree fruits (cherries, nectarines, peaches, plum/prunes), tree nuts (almonds) - pre-plant, tree nuts (apple) - pre-plant, and fruits and nuts (non-bearing, see master label description).	(cherries, nectarines, peaches, plum/prunes), tree nuts (almonds) - pre-plant, and tree nuts (apple) - pre-plant.
Occupational handler: application by • Belly grinder • Brush roller • Rotary spreader • Hand dispersal	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application by brush roller and belly grinder. Consider prohibiting application to ornamental woody shrubs and vines by rotary spreader. Consider requiring single layer (long-sleeved shirt and long	Consider prohibiting brush roller application for sewer manholes. Consider requiring single layer (long-sleeved shirt and long pants) and gloves for brush roller application to wood protection treatment and structural (e.g., warehouses, food handling establishments, home bathrooms)

					pants) and gloves for rotary spreader application to nursery stock, golf course turf, ornamental and/or shade trees, herbaceous plants, ornamental lawns and turf, sod farms (turf). Consider prohibiting hand dispersal to commercial/ institutional/industrial/premis es, utilities (pad). Consider requiring single layer (long-sleeved shirt and long pants) and gloves for hand dispersal (spo.t treatment) to golf course (turf), sod farm (turf).	Consider prohibiting belly grinder application for ornamental woody shrubs and vines Consider prohibiting hand dispersal to commercial/institutional/industrial premises and utilities (Pad)
Occupational handler risks from backpack sprayer applications: L/SC/EC	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting application by broadcast (soil and foliar) and drench/soil-/ground-directed to: ornamental and/or shade trees, herbaceous plants, outdoor commercial/institutional/indu strial premises, non-agricultural outdoor buildings and structures, wide area/ general outdoor treatment, wood protection treatment, Christmas tree plantations, tree fruit (cherries), seed orchard trees, grapes, and forest trees (softwoods, conifers)	Consider prohibiting broadcast (foliar) application with backpack sprayer of L/SC/EC on ornamental and/or shade trees, herbaceous plants. Consider double layer (coveralls) and glove for outdoor commercial/institutional/industrial premises, non-agricultural outdoor buildings and structures, and wide area/ general outdoor treatment.

					Consider limiting broadcast (foliar) application to golf course turf with double layer (coveralls), gloves, and an elastomeric half mask respirator. Consider limiting use on the following for only spot treatment with baseline PPE: ornamental and/or shade trees, herbaceous plants, ornamental lawns and turf, sod farms (turf), outdoor commercial/institutional/industrial premises, non-agricultural outdoor buildings and structures, and golf course turf.	
Occupational handler risks from backpack sprayer applications: DF/WDG in WSP	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting broadcast (foliar) or drench/soil/ground-directed application to: ornamental woody shrubs and vines, Christmas tree plantations, tree fruits (cherries), tree nuts (almond), tree fruit (nectarine, peach, plum/prune), fruit and nut (non-bearing, nursery), tree fruits (apple). Consider requiring double layer (coveralls), gloves, and an elastomeric half mask respirator for broadcast	Consider prohibiting backpack sprayer of dry flowable/water-dispersible granules in WSP for broadcast (foliar) on ornamental woody shrubs and vines.

					(foliar) application to grapes (pre-bloom), trunk spray/drench to tree fruits (apple) and drench/soil-ground directed grapes (pre-bloom).	
Occupational handler risks from backpack sprayer applications: WSP	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting broadcast use on ornamental and/or shade trees, herbaceous plants.	Consider prohibiting backpack sprayer broadcast application of WSP on ornamental and/or shade trees, herbaceous plants
Occupational handler risks from backpack sprayer applications: ME					Consider requiring double layer (coveralls), gloves, and an elastomeric half mask respirator for ornamental non-flowering plants and ornamental woody shrubs and vines.	N/A
Occupational handler: Flagging	Air Residues	Dermal absorption Inhalation	Acute Steady state	Neurotoxicity	Consider prohibiting flagging and require use of GPS or mechanical flagging systems with the exception of granule application to sod farms (turf).	N/A
Occupational post-application risks of concern	Residues	Dermal absorption	Acute Steady state	Neurotoxicity	Consider prohibiting use of microencapsulated formulations on ornamentals in nurseries and greenhouses. Considering extending REIs for select uses and activities. See Appendix D2 for potential REI extensions.	Considering extending REIs for select uses and activities. See Appendix D2 for potential REI extensions.
Proposed Ecological Mitigation						
Avian	Residues on treated site	Ingestion	Acute Chronic	Developmental Reproductive	Application method restrictions are expected to reduce risks to non-target organisms.	
Mammals	Residues on treated site	Ingestion	Acute Chronic	Developmental Reproductive		

Terrestrial Invertebrates	Residues on treated site	Dermal absorption Ingestion	Acute Chronic	Acute toxicity	Proposing label changes to reduce off-target spray drift and establish a baseline level of protection against spray drift that is consistent across all chlorpyrifos products.
Fish	Water	Dermal absorption Ingestion	Acute Chronic	Acute toxicity	
Aquatic Invertebrates	Water	Dermal absorption Ingestion	Acute Chronic	Acute toxicity	

Appendix B: Endangered Species Assessment

This Appendix provides general background about the agency's assessment of risks from pesticides to endangered and threatened (listed) species under the Endangered Species Act (ESA). Additional background specific to chlorpyrifos appears at the conclusion of this Appendix.

In 2013, the EPA, along with the Fish and Wildlife Service (FWS), the National Marine Fisheries Service (NMFS), and the United States Department of Agriculture (USDA) released a summary of their joint Interim Approaches for assessing risks to endangered and threatened (listed) species from pesticides. These Interim Approaches were developed jointly by the agencies in response to the National Academy of Sciences' (NAS) recommendations that discussed specific scientific and technical issues related to the development of pesticide risk assessments conducted on federally threatened and endangered species.

Since that time, EPA has conducted biological evaluations (BEs) on three pilot chemicals representing the first nationwide pesticide consultations (final pilot BEs for chlorpyrifos, malathion, and diazinon were completed in January 2017). These initial pilot consultations were envisioned to be the start of an iterative process. The agencies are continuing to work to improve the consultation process. For example, after receiving input from the Services and USDA on proposed revisions to the pilot interim method and after consideration of public comments received, EPA released an updated *Revised Method for National Level Listed Species Biological Evaluations of Conventional Pesticides* (i.e., Revised Method) in March 2020.[50] During the same timeframe, EPA also released draft BEs for carbaryl and methomyl, which were the first to be conducted using the Revised Method.

Also, a provision in the December 2018 Farm Bill included the establishment of a FIFRA Interagency Working Group to provide recommendations for improving the consultation process required under section 7 of the Endangered Species Act for pesticide registration and Registration Review and to increase opportunities for stakeholder input. This group includes representation from EPA, NMFS, FWS, USDA, and the Council on Environmental Quality (CEQ). Given this new law and that the first nationwide pesticide consultations were envisioned as pilots, the agencies are continuing to work collaboratively as consistent with the congressional intent of this new statutory provision. EPA has been tasked with a lead role in this group, and EPA hosted the first Principals Working Group meeting on June 6, 2019.

Chlorpyrifos was one of the first three pilot chemicals that EPA conducted a nationwide ESA consultation. EPA completed a biological evaluation and initiated consultation with the FWS and NMFS in January 2017. [51] Pursuant to a consent decree, at the end of December 2017, NMFS issued its Biological Opinion (BiOp) on chlorpyrifos, diazinon, and malathion. [52] In July 2019,

[50] https://www.epa.gov/endangered-species/revised-method-national-level-listed-species-biological-evaluations-conventional
[51] https://www.epa.gov/endangered-species/biological-evaluation-chapters-chlorpyrifos-esa-assessment
[52] https://www.fisheries noaa.gov/resource/document/biological-opinion-pesticides-chlorpyrifos-diazinon-and-malathion

EPA re-initiated formal consultation with NMFS on the December 2017 BiOp.[53] EPA re-initiated consultation because new information on how the pesticides were actually being used may show that the extent of the effects of the actions may be different than what was previously considered. As part of this re-initiation, EPA provided additional usage data it believes may be relevant to the consultation. In its transmittal of this information to NMFS, EPA also referenced usage data and information that had been recently submitted by the registrants of pesticide products containing chlorpyrifos, malathion, and diazinon. After reviewing information EPA provided to NMFS on the 2017 BiOp, NMFS determined that it was appropriate to revise the chlorpyrifos, malathion, and diazinon BiOp. NMFS plans to issue a revised final BiOp for chlorpyrifos, diazinon, and malathion by June 2022. FWS has not yet issued a BiOp on chlorpyrifos. EPA plans to address risks to listed species and critical habitats from use of chlorpyrifos as part of the final registration review decision, pending completion of the nationwide consultation process.

[53] https://www.regulations.gov/document?D=EPA-HQ-OPP-2018-0141-0136

Appendix C: Endocrine Disruptor Screening Program

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

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

Under FFDCA § 408(p), the agency must screen all pesticide chemicals. Between October 2009 and February 2010, the EPA issued test orders/data call-ins for the first group of 67 chemicals, which contains 58 pesticide active ingredients and 9 inert ingredients. The agency has reviewed all of the assay data received for the List 1 chemicals and the conclusions of those reviews are available in the chemical-specific public dockets. Chlorpyrifos is on List 1 and the review conclusions are available in the chlorpyrifos public docket EPA-HQ-OPP-2008-0850.[54] A second list of chemicals identified for EDSP screening was published on June 14, 2013,[55] and includes some pesticides scheduled for Registration Review and chemicals found in water. Neither of these lists should be construed as a list of known or likely endocrine disruptors. For further information on the status of the EDSP, the policies and procedures, the lists of chemicals, future lists, the test guidelines and the Tier 1 screening battery, please visit the EPA website.[56]

[54] EDSP Weight of Evidence Conclusions on the Tier 1 Screening for the List 1 Chemicals https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0849
[55] See http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPPT-2009-0477-0074 for the final second list of chemicals.
[56] https://www.epa.gov/endocrine-disruption

In this PID, the EPA is making no human health or environmental safety findings associated with the EDSP screening of chlorpyrifos. Before completing this registration review, the agency will make an EDSP FFDCA § 408(p) determination.

Appendix D1: Occupational Post-Application Risks of Concern[1]

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
Berry: Low	Strawberry LC, WP Hand Harvesting	1.0	40	AZ	40 at Day 0	48 at Day 1 78 at Day 2 88 at Day 3 120 at Day 4
	Cranberry LC, WDG Hand Harvesting, Scouting	1.5	26	AZ	26 at Day 0	32 at Day 1 52 at Day 2 58 at Day 3 83 at Day 4 100 at Day 5
Mint	Peppermint/ Spearmint LC, WDG Irrigation	2.0	10	CA	10 at Day 0	86 at Day 1 120 at Day 2
			11	OR	11 at Day 0	110 at Day 1
			3.5	MN	110 at Day 1	110 at Day 1
Grapes	Grapes, LC Hand weeding, scouting	2.0	92	CA	92 at Day 0	390 at Day 1
	Grapes, LC Hand weeding, scouting		11	CA	11 at Day 0	46 at Day 1 100 at Day 2
	Grapes, LC Hand harvesting, leaf pulling, tying/training (wine grape)		6	CA	25 at Day 1	55 at Day 2 63 at Day 3 73 at Day 4 85 at Day 5 98 at Day 6 110 at Day 7
	Grape, LC Turning (table grape only)		3	CA	13 at Day 1	29 at Day 2 33 at Day 3 38 at Day 4 44 at Day 5 51 at Day 6 59 at Day 7 69 at Day 8 79 at Day 9 92 at Day 10 110 at Day 11

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
Field and Row Crops: Tall	Corn: Sweet; Corn: Field, Including Grown for Seed WDG Detassling, hand harvesting)	1.5	0.8	IL	26 at Day 1	68 at Day 2 180 at Day 3
			1.0	MN	30 at Day 1	66 at Day 2 140 at Day 3
			1.4	OR	54 at Day 1	200 at Day 3
	Corn: Sweet; Corn: Field, Including Grown for Seed WDG Detassling, hand harvesting	1.0	1.2	IL	40 at Day 1	100 at Day 3
			1.5	MN	46 at Day 1	99 at Day 3 220 at Day 4
			2.1	OR	81 at Day 1	310 at Day 3
Tree Fruit: Deciduous	Apples, Cherries, Peaches, Pears, Plums, Prunes, Nectarines (Dormant and Delayed Dormant) LC for all, WDG for all, and WP for apples only Scouting, pruning, training	2.0	30	CA	480 at Day 1	480 at Day 1
			15	WA	63 at Day 2	180 at Day 3
			21	NY	50 at Day 2	110 at Day 3
	Apples, Cherries, Peaches, Pears, Plums, Prunes, Nectarines (Dormant and Delayed Dormant) LC for all, WDG for all, and WP for apples only	2.0	13	CA	200 at Day 1	200 at Day 1
			6	WA	26 at Day 2	76 at Day 3 130 at Day 4
			9	NY	21 at Day 2	45 at Day 3 96 at Day 4 180 at Day 5

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
	Hand harvesting					
	Apples, Cherries, Peaches, Pears, Plums, Prunes, Nectarines (Dormant and Delayed Dormant) LC for all, WDG for all, and WP for apples only Thinning fruit	2.0	5	CA	78 at Day 1	110 at Day 2
			2	WA	10 at Day 1	30 at Day 2 50 at Day 3 83 at Day 4 140 at Day 5
			3	NY	8 at Day 1 18 at Day 2	37 at Day 3 69 at Day 4 130 at Day 5
	Nectarine (WDG and emulsifiable concentrate (EC)) & Peaches (EC) (Dormant and Delayed Dormant) Transplanting	3.0	51	CA	51 at Day 0	810 at Day 1
			25	WA	110 at Day 1	110 at Day 1
			35	NY	35 at Day 1	84 at Day 1 180 at Day 2
	Nectarine (WDG and emulsifiable concentrate (EC)) & Peaches (EC) (Dormant and Delayed Dormant) Scouting, pruning, training	3.0	20	CA	20 at Day 0	320 at Day 2
			10	WA	10 at Day 0	42 at Day 1 120 at Day 2
			14	NY	14 at Day 1	33 at Day 2 73 at Day 3 160 at Day 4
	Nectarine (WDG and emulsifiable concentrate	3.0	8.4	CA	130 at Day 1	130 at Day 1
			4	WA	17 at Day 1	51 at Day 2 85 at Day 3 140 at Day 4

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
	(EC)) & Peaches (EC) (Dormant and Delayed Dormant) Hand harvesting		6	NY	14 at Day 1	33 at Day 2 73 at Day 3 160 at Day 4
	Nectarine (WDG and emulsifiable concentrate (EC)) & Peaches (EC) (Dormant and Delayed Dormant) Thinning fruit	3.0	3.3	CA	52 at Day 1	71 at Day 3 97 at Day 4 130 at Day 5
			2	WA	7 at Day 1 20 at Day 2	33 at Day 3 56 at Day 4 93 at Day 5 160 at Day 6
			2	NY	5 at Day 1 12 at Day 2	25 at Day 3 46 at Day 4 85 at Day 5 160 at Day 6
	Cherries (Sour) Transplanting	4.0	38	CA	38 at Day 0	610 at Day 1
			19	WA	19 at Day 0	80 at Day 1 230 at Day 2
			26	NY	26 at Day 0	140 at Day 2
	Cherries (Sour) Scouting, pruning, training		15	CA	15 at Day 0	240 at Day1
			7.5	WA	32 at Day 1	92 at Day 3 150 at Day 4
			10	NY	10 at Day 0	25 at Day 2 55 at Day 3 120 at Day 4
	Cherries (Sour) Hand harvesting		6.3	CA	100 at Day 1	100 at Day 1
			3.1	WA	13 at Day 1	38 at Day 2 64 at Day 3 110 at Day 5
			4.3	NY	10 at Day 1	23 at Day 2 48 at Day 3 89 at Day 4 160 at Day 5
	Cherries (Sour) Thinning fruit		2.4	CA	39 at Day 1	53 at Day 2 73 at Day 3 99 at Day 4 140 at Day 5
			1.2	WA	5.1 at Day 1 15 at Day 2	25 at Day 3 42 at Day 4 70 at Day 5 120 at Day 6

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
			1.7	NY	4 at Day 1 8.8 at Day 2 19 at Day 3	35 at Day 4 64 at Day 5 120 at Day 6
Tree Fruit: Evergreen	Citrus LC, WDG Hand harvesting	4.0	21;	CA	21 at Day 0	89 at Day 1 200 at Day 2
	Citrus LC, WDG Transplanting	6.0 (CA and AZ)	86	CA	86 at Day 0	360 at Day 1
	Citrus LC, WDG Scouting, Hand pruning		34	CA	34 at Day 0	140 at Day 1
	Citrus LC, WDG Hand harvesting		14	CA	14 at Day 0	60 at Day 1 130 at Day 2
Forestry	Hybrid Cottonwood/ Poplar Plantations (Dormant and Delayed Dormant) LC Scouting	2.0	180	CA	180 at Day 0	180 at Day 1
			87	WA	87 at Day 0	370 at Day 1
			21	NY	21 at Day 0	50 at Day 1 110 at Day 2
	Hybrid Cottonwood/ Poplar Plantations (Dormant and Delayed Dormant) LC Irrigation	2.0	30	CA	30 at Day 0	480 at Day 1
			15	WA	15 at Day 0	63 at Day 1 180 at Day 2
			6.3	NY	15 at Day 1	33 at Day 2 71 at Day 3 130 at Day 4

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
	Hybrid Cottonwood/ Poplar Plantations (Dormant and Delayed Dormant) LC Irrigation	2.0	9	CA	150 at Day 1	150 at Day 1
			4.6	WA	19 at Day 1	56 at Day 2 94 at Day 3 160 at Day 4
Tree Nuts[2]	Almonds (Dormant and Delayed Dormant) Harvesting Mechanical (Shaking)	4.0	37	CA	37 at Day 0	76 at Day 1 210 at Day2
			45	CA	45 at Day 0	730 at Day 1
			1700	TX	1700 at Day 0	1700 at Day 0
			280	LA	280 at Day 0	280 at Day 0
			160	GA	160 at Day 0	160 at Day 0
	Almonds (Dormant and Delayed Dormant) Transplanting	4.0	31	CA	31 at Day 0	63 at Day 1 180 at Day 2
			38	CA	38 at Day 0	27,000 at Day 1
			1400	TX	1400 at Day 0	1400 at Day 0
			230	LA	230 at Day 0	230 at Day 0
			130	GA	130 at Day 0	130 at Day 0
	Almonds (Dormant and Delayed Dormant) Scouting	4.0	12	CA	12 at Day 0	25 at Day 1 70 at Day 2 120 at Day 3
			15	CA	15 at Day 0	240 at Day 1
			560	TX	560 at Day 0	560 at Day 0
			92	LA	92 at Day 0	92 at Day 0 1300 at Day 1
			53	GA	53 at Day 0	480 at Day 1
Ornamentals/ Nurseries (Outdoor Only)	Non-bearing Fruit Trees (Peach, Nectarine) Container moving, hand pruning, tying/training	3.0	51	CA	51 at Day 0	810 at Day 1
			25	WA	25 at Day 0	110 at Day 1
			35	NY	35 at Day 0	84 at Day 1 180 at Day 2
Field and Row Crops	Alfalfa (LC, WDG), Soybean (LC, WDG) Scouting	1.0	26	CA	26 at Day 0	82 at Day 1 280 at Day 2
			12	TX	12 at Day 0	340 at Day 1
			10	MS	10 at Day 0	1500 at Day 1
			29	CA	29 at Day 0	380 at Day 1
			12	TX	12 at Day 0	340 at Day 1

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
			38	AZ	38 at Day 0	210 at Day 1
	Alfalfa		15	CA	15 at Day 0	47 at Day 1 160 at Day 2
			6.9	TX	6.9 at Day 0	200 at Day 1
	LC, WDG		6	MS	6 at Day 0	890 at Day 1
			17	CA	17 at Day 0	220 at Day 1
	Irrigation		7	TX	370 at Day 1	370 at Day 1
			22	AZ	22 at Day 0	120 at Day 1
Vegetable: Fruiting	Pepper	1.0	26	CA	26 at Day 0	82 at Day 1 280 at Day 2
	WDG		12	TX	12 at Day 0	340 at Day 1
			10	MS	10 at Day 0	1500 at Day 1
	Hand harvesting, tying		29	CA	29 at Day 0	380 at Day 1
			12	TX	12 at Day 0	640 at Day 1
			38	AZ	38 at Day 0	210 at Day1
	Pepper		15	CA	15 at Day 0	47 at Day 1 160 at Day 2
	WDG		6.9	TX	200 at Day 1	200 at Day 1
			5.6	MS	890 at Day 1	890 at Day 1
	Irrigation		17	CA	17 at Day 1	220 at Day 1
			7	TX	370 at Day 1	370 at Day 1
Vegetable: Head and Stem Brassica	Broccoli (WP, WDG), Brussels sprouts (LC, WP, WDG), cabbage (WP, WDG), cauliflower (WP, WDG) Hand Weeding	1.0	40	AZ	40 at Day 0	48 at Day 1 78 at Day 2 88 at Day 3 120 at Day 4
	Broccoli (WP, WDG), Brussels sprouts (LC, WP, WDG), cabbage (WP, WDG), cauliflower (WP, WDG) Irrigation		23	AZ	23 at Day 0	28 at Day 1 45 at Day 2 51 at Day 3 72 at Day 4 89 at Day 5 110 at Day 6
	Broccoli (WP, WDG), Brussels sprouts (LC, WP, WDG), cabbage (WP, WDG),		10	AZ	10 at Day 0	13 at Day 1 20 at Day 2 23 at Day 3 33 at Day 4 40 at Day 5 49 at Day 6 61 at Day 7

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
	cauliflower (WP, WDG) Scouting, hand harvesting					75 at Day 8 92 at Day 9 110 at Day 10
Vegetable: Leafy	Collards (WP, WDG), Bok Choy (WP), Kale (WP, WDG), Kohlrabi (WP, WDG) Hand harvesting	1.0	40	AZ	40 at Day 0	48 at Day 1 78 at Da y2 88 at Day 3 120 at Day 4
	Collards (WP, WDG), Bok Choy (WP), Kale (WP, WDG), Kohlrabi (WP, WDG) Irrigation		23	AZ	23 at Day 0	28 at Day 1 45 at Day 2 51 at Day 3 72 at Day 4 89 at Day 5 110 at Day 6
Vegetable, leafy	Cole Crops: Including Brussels sprouts (LC) and cauliflower (EC) Hand weeding	2.0	16	AZ	16 at Day 0	48 at Day 1 78 at Day 2 88 at Day 3 120 at Day 4
	Cole Crops: Including Brussels sprouts (LC) and cauliflower (EC) Irrigation		11	AZ	11 at Day 0	28 at Day 1 45 at Day 2 51 at Day 3 72 at Day 4 89 at Day 5 110 at Day 6
	Cole Crops: Including Brussels sprouts (LC) and cauliflower (EC) Hand weeding, topping		5	AZ	13 at Day 1	20 at Day 2 23 at Day 3 33 at Day 4 40 at Day 5 49 at Day 6 61 at Day 7 75 at Day 8 92 at Day 9 110 at Day 10
Cotton	Cotton	1.0	31	CA	31 at Day 0	100 at Day 1

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
	LC, WDG Module builder operator		15	TX	15 at Day 0	420 at Day 1
			12	MS	12 at Day 0	1900 at Day 1
			36	CA	36 at Day 0	470 at Day 1
			14	TX	14 at Day 0	780 at Day 1
			47	AZ	47 at Day 0	260 at Day 1
	Cotton LC, WDG Picker operator, raker		12	CA	12 at Day 0	38 at Day 1 130 at Day 2
			6	TX	160 at Day 1	160 at Day 1
			4	MS	710 at Day 1	710 at Day 1
			14	CA	14 at Day 0	180 at Day 1
			5	TX	290 at Day 1	290 at Day 1
			18	AZ	18 at Day 0	98 at Day 1 420 at Day 2
	Cotton LC, WDG Tramper		6	CA	18 at Day 1	61 at Day 2 91 at Day 3 140 at Day 4
			3	TX	75 at Day 1	190 at Day 2
			2	MS	340 at Day 1	340 at Day 1
			6	CA	84 at Day 1	130 at Day 2
			3	TX	140 at Day 1	140 at Day 1
			8	AZ	46 at Day 1	200 at Day 2
Turfgrass	Turf grown for sod or seed LC, WP Maintenance, harvesting slab, transplanting/planting	3.76	40	CA (Very high exposure activities)	40 at Day 0	130 at Day 1
			56	IN (Very high exposure activities)	56 at Day 0	300 at Day 1
			34	MS (High exposure activities)	34 at Day 0	560 at Day 1
			21	CA (High exposure activities)	21 at Day 0	130 at Day 1
			8	IN (High exposure activities)	30 at Day 1	100 at Day 2
			14	MS (High exposure activities)	14 at Day 1	130 at Day 1
Microencapsulated Formulation Application						
Nursery (Microencap.	Ornamentals – Nurseries and Greenhouses	1.4	74	Ornamentals-smooth	74 at Day 0	120 at Day 0.33 40 at Day 1 29 at Day 2 260 at Day 3

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
Formulations)	Container moving, hand pruning, pinching, tying/training		50	Ornamentals- hairy	50 at Day 0	140 at Day 1
	Ornamentals – Nurseries and Greenhouses Irrigation		9.0	Ornamentals- smooth	5 at Day 1 4 at Day 2 32 at Day 3	Over 35 days; MOE = 30 or less at Day 35
			6	Ornamentals- hairy	17 at Day 1	
	Ornamentals – Nurseries and Greenhouses Hand harvest, cut flower		3.6	Ornamentals- smooth	2 at Day 1 1 at Day 2 12 at Day 3	Over 35 days; MOE = 12 or less at Day 35
			2	Ornamentals- hairy	7 at Day 1 7 at Day 2 8at Day 3 13 at Day 4	
Greenhouse						
Greenhouse (Total Release Fogger and. Liquid Concentrate Formulations)	Ornamentals – *Liquid Concentrates* Commercial Ornamentals, Greenhouse Production: Bedding Plants, Cut Flowers, Flowering Hanging Baskets, Potted Flowers, Ornamentals, Trees and Shrubs – *Total Release Foggers* Irrigation handset	2	10	CA	10 at Day 0	86 at Day 1 120 at Day 2
			11	OR	11 at Day 0	110 at Day 1
			3.5	MN	110 at Day 1	110 at Day 1
	Ornamentals – *Liquid Concentrates* Commercial Ornamentals, Greenhouse Production: Bedding Plants, Cut Flowers, Flowering Hanging		3.7	CA	34 at Day 1	48 at Day 2 69 at Day 3 98 at Day 4 140 at Day 5
			4.3	OR	42 at Day 1	350 at Day 2
			1.4	MN	44 at Day 1	68 at Day 2 100 at Day 3

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
	Baskets, Potted Flowers, Ornamentals, Trees and Shrubs – *Total Release Foggers* Hand harvesting flowers					
	Ornamentals – *Liquid Concentrates* Commercial Ornamentals, Greenhouse Production: Bedding Plants, Cut Flowers, Flowering Hanging Baskets, Potted Flowers, Ornamentals, Trees and Shrubs Total release aerosol foggers Hand harvest cut flowers	0.29	18	Ornamentals- hairy	18 at Day 0	44 at Day 1 140 at Day 2
Greenhouse - Oxon						
Greenhouse nursery	Greenhouse nursery Irrigation handset	2.0	5.0	CA	45 at Day 1	64 at Day 2 91 at Day3 130 at Day 4
			5.7	OR	56 at Day 1	460 at Day 2
			1.9	MN	59 at Day 1	90 at Day 2 140 at Day 3
	Greenhouse nursery Hand harvest		2.0	CA	18 at Day 1	25 at Day 2 36 at Day 3 51 at Day 4 73 at Day 5 100 at Day 6
			2.2	OR	22 at Day 1	180 at Day 2
			0.7	MN	23 at Day 1	36 at Day 2 55 at Day 3 84 at Day 4

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0[3]	DFR Study Location	MOE; Estimated REI Range (days)[4] for LOC >10	MOE; Estimated REI Range (days)[5] for LOC > 100
						130 at Day 5

[1]Range of MOEs is dependent on study used. See Appendix 11 for full range of occupational post-application risk estimates.[57]
[2] Formulations: EC = emulsifiable concentrate, LC = liquid concentrate, WDG = water dispersed granular, WP = wettable powder
[3] Dermal LOC = 10
[4] Dermal LOC = 100

[57] https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0958

Appendix D2: Considered Mitigation for Occupational Post-Application Risks of Concern[1]

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10[3]	Considered REI (days) for LOC of 100[3]
Berry: Low	Strawberry, LC, WP Hand Harvesting	1.0	40	AZ	N/A	Day 3: 88 Day 4: 120
	Cranberry LC, WDG Hand Harvesting (raking), scouting	1.5	26		N/A	Day 4: 83 Day 5: 100
Mint	Peppermint/Spearmint LC, WDG Irrigation	2.0	10	CA	N/A	Day 1: 86 Day 2: 120
			11	OR	N/A	N/A
			3.5	MN	N/A	N/A
Grapes	Grapes, LC Hand weeding, scouting	2.0	11	CA	N/A	Day 2: 100
	Grapes, LC Hand harvesting, leaf pulling, tying/training (wine grape)		6	CA	N/A	Day 4: 73 Day 5: 85 Day 6: 98 Day 7: 110
	Grape, LC Turning (table grape only)		3	CA	N/A	Day 9: 79 Day 10: 92 Day 11: 110
Field and Row Crops: Tall	Corn: Sweet; Corn: Field, Including Grown for Seed Sweet and Field Corn (including grown for seed) (LC), Sunflower, sorghum (LC, WDG)	1.5	0.8	IL	N/A	Day 3: 180
			1.0	MN	N/A	Day 3: 140
			1.4	OR	N/A	Day 2: 200

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
	Detassling, hand harvesting (corn only)					
	Corn: Sweet; Corn: Field, Including Grown for Seed Sweet and Field Corn (including grown for seed) (LC), Sunflower, sorghum (LC, WDG) Detassling, hand harvesting (corn only)	1.0	1.2	IL	N/A	Day 2: 100
			1.5	MN	N/A	Day 2: 99 Day 3: 220
			2.1	OR	N/A	Day 1: 81 Day 2: 310
Tree Fruit: Deciduous	Apples, Cherries, Peaches, Pears, Plums, Prunes, Nectarines (Dormant and Delayed Dormant) LC for all, WDG for all, and WP for apples only Scouting, pruning, training	2.0	30	CA	N/A	N/A
			15	WA	N/A	Day 1: 63 Day 2: 180
			21	NY	N/A	Day 2: 110
	Apples, Cherries, Peaches, Pears, Plums, Prunes, Nectarines (Dormant and Delayed Dormant) LC for all, WDG for all, and WP for apples only Hand harvesting	2.0	13	CA	N/A	N/A
			6	WA	N/A	Day 2: 76 Day 3: 130
			9	NY	N/A	Day 3: 96 Day 4: 180
	Apples, Cherries, Peaches, Pears, Plums, Prunes, Nectarines (Dormant and Delayed Dormant)	2.0	5	CA	N/A	Day 2: 110

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
	LC for all, WDG for all, and WP for apples only Thinning fruit		2	WA	N/A	Day 4: 83 Day 5: 140
			3	NY	Day 1: 8 Day 2: 18	Day 5: 130
	Nectarine (WDG and EC) & Peach (EC) (Dormant and Delayed Dormant) Transplanting	3.0	51	CA	N/A	N/A
			25	WA	N/A	N/A
			35	NY	N/A	Day 1: 84 Day 2: 180
	Nectarine (WDG and emulsifiable concentrate (EC)) & Peaches (EC) (Dormant and Delayed Dormant) Scouting, pruning, training	3.0	20	CA	N/A	Day 1: 320
			10	WA	N/A	Day 2: 120
			14	NY	N/A	Day 2: 73 Day 3: 160
	Nectarine (WDG and emulsifiable concentrate (EC)) & Peaches (EC) (Dormant and Delayed Dormant) Hand harvesting	3.0	8.4	CA	N/A	N/A
			4	WA	N/A	Day 3: 85 Day 4: 140
			6	NY	N/A	Day 3: 64 Day 4: 120
	Nectarine (WDG and emulsifiable concentrate (EC)) & Peaches (EC) (Dormant and Delayed Dormant) Thinning fruit	3.0	3.3	CA	N/A	Day 3: 97 Day 4: 130
			2	WA	Day 1: 7 Day 2: 20	Day 5: 93 Day 6: 160
			2	NY	Day 2: 12	Day 5: 85 Day 6: 160
	Cherries (Sour) Transplanting	4.0	38	CA	N/A	N/A
			19	WA	N/A	Day 1: 80 Day 2: 230
			26	NY	N/A	Day 2: 140
	Cherries (Sour)		15	CA	N/A	N/A

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
	Scouting, pruning, training		7.5	WA	N/A	Day 2: 92 Day 3: 150
			10	NY	N/A	Day 3: 120
	Cherries (Sour) Hand harvesting		6.3	CA	N/A	N/A
			3.1	WA	N/A	Day 4: 110
			4.3	NY	N/A	Day 4: 89 Day 5: 160
	Cherries (Sour) Thinning fruit		2.4	CA	N/A	Day 3: 73 Day 4: 99 Day 5: 140
			1.2	WA	5.1 at Day 1 15 at Day 2	Day 5: 70 Day 6: 120
			1.7	NY	4 at Day 1 8.8 at Day 2 19 at Day 3	Day 6: 120
Tree Fruit: Evergreen	Citrus LC, WDG – not CA or AZ Hand harvesting	4.0	21	CA	N/A	Day 1: 89 Day 2: 200
	Citrus AZ and CA = LC, WDG; all states = WP Hand harvesting	6.0 (CA and AZ)	14	CA	N/A	Day 2: 130
Forestry	Hybrid Cottonwood (grown for pulp)/ Poplar Plantations (Dormant and Delayed Dormant) LC Hand weeding	2.0	180	CA	N/A	N/A
			87	WA	N/A	N/A
	Hybrid Cottonwood (grown for pulp)/ Poplar Plantations (Dormant and Delayed Dormant) LC Scouting	2.0	30	CA	N/A	N/A
			15	WA	N/A	Day 2: 180
			21	NY	N/A	Day 2: 110

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
	Hybrid Cottonwood/ Poplar Plantations (Dormant and Delayed Dormant)	2.0	6.3	NY	N/A	Day 3: 71 Day 4: 130
	LC		9	CA	N/A	N/A
	Irrigation		4.6	WA	N/A	Day 3: 94 Day 4: 160
Tree Nuts	Almonds (Dormant and Delayed Dormant)	4.0	37	CA	N/A	Day 1: 76 Day 2: 210
			45	CA	N/A	N/A
	Harvesting Mechanical (Shaking)		1700	TX	N/A	N/A
			280	LA	N/A	N/A
			160	GA	N/A	N/A
	Almonds (Dormant and Delayed Dormant)	4.0	31	CA	N/A	Day 2: 180
			38	CA	N/A	N/A
	Transplanting		1400	TX	N/A	N/A
			230	LA	N/A	N/A
			130	GA	N/A	N/A
	Almonds (Dormant and Delayed Dormant)	4.0	12	CA	N/A	Day 2: 70 Day 3: 120
			15	CA	N/A	N/A
	Scouting		560	TX	N/A	N/A
			92	LA	N/A	N/A
			53	GA	N/A	N/A
Ornamentals/ Nurseries (Outdoor Only)	Non-bearing Fruit Trees (Peach, Nectarine)	3.0	51	CA	N/A	N/A
			25	WA	N/A	N/A
	Container moving, hand pruning, tying/training, transplanting		35	NY	N/A	Day 1: 84 Day 2: 180
Field and Row Crops	Alfalfa (LC, WDG), Soybean (LC, WDG)	1.0	26	CA	N/A	Day 1: 82 Day 2: 280
			12	TX	N/A	N/A
	Scouting		10	MS	N/A	N/A
			29	CA	N/A	N/A
			12	TX	N/A	N/A
			38	AZ	N/A	N/A
	Alfalfa		15	CA	N/A	Day 2: 160
			6.9	TX	N/A	N/A
	LC, WDG		6	MS	N/A	N/A
			17	CA	N/A	N/A
	Irrigation		7	TX	N/A	N/A

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
			22	AZ	N/A	N/A
Field and Row Crops: Low to Medium (Outdoor Only)	Pepper WDG Hand harvesting, tying	1.0	26	CA	N/A	Day 1: 82 Day 2: 280
			12	TX	N/A	N/A
			10	MS	N/A	N/A
			29	CA	N/A	N/A
			12	TX	N/A	N/A
			38	AZ	N/A	N/A
	Pepper WDG Irrigation		15	CA	N/A	Day 2: 160
			6.9	TX	N/A	N/A
			5.6	MS	N/A	N/A
			17	CA	N/A	N/A
			7	TX	N/A	N/A
Vegetable: Fruiting	Pepper WDG Hand harvesting, tying	1.0	26	CA	N/A	Day 1: 82 Day 2: 280
			12	TX	N/A	N/A
			10	MS	N/A	N/A
			29	CA	N/A	N/A
			12	TX	N/A	N/A
			38	AZ	N/A	N/A
	Pepper WDG Irrigation		15	CA	N/A	Day 2: 160
			6.9	TX	N/A	N/A
			5.6	MS	N/A	N/A
			17	CA	N/A	N/A
			7	TX	N/A	N/A
Vegetable: Head and Stem Brassica	Broccoli (WP, WDG), Brussels sprouts (LC, WP, WDG), cabbage (WP, WDG), cauliflower (WP, WDG) Hand Weeding	1.0	40	AZ	N/A	Day 2: 78 Day 3: 88 Day 4: 120
	Broccoli (WP, WDG), Brussels sprouts (LC, WP, WDG), cabbage (WP, WDG), cauliflower (WP, WDG) Irrigation		23	AZ	N/A	Day 4: 72 Day 5: 89 Day 6: 110
	Broccoli (WP, WDG), Brussels sprouts (LC, WP, WDG), cabbage (WP, WDG),		10	AZ	N/A	Day 8: 75 Day 9: 92 Day 10: 110

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
	cauliflower (WP, WDG) Scouting, hand harvesting					
Vegetable: Leafy	Collards (WP, WDG), Bok Choy (WP), Kale (WP, WDG), Kohlrabi (WP, WDG) Hand harvesting	1.0	40	AZ	N/A	Day 2: 78 Day 3: 88 Day 4: 120
	Collards (WP, WDG), Bok Choy (WP), Kale (WP, WDG), Kohlrabi (WP, WDG) Irrigation		23	AZ	N/A	Day 4: 72 Day 5: 89 Day 6: 110
Vegetable, leafy	Cole Crops: Including Brussels sprouts (LC) and cauliflower (EC) Hand Weeding	2.0	16	AZ	N/A	Day 2: 78 Day 3: 88 Day 4: 120
	Cole Crops: Including Brussels sprouts (LC) and cauliflower (EC) Irrigation		11	AZ	N/A	Day 4: 72 Day 5: 89 Day 6: 110
	Cole Crops: Including Brussels sprouts (LC) and cauliflower (EC) Hand harvesting, topping		5	AZ	N/A	Day 8: 75 Day 9: 92 Day 10: 110
Cotton	Cotton LC, WDG Mechanical harvesting- Module builder operator	1.0	31	CA	N/A	N/A
			15	TX	N/A	N/A
			12	MS	N/A	N/A
			36	CA	N/A	N/A
			14	TX	N/A	N/A
			47	AZ	N/A	N/A
	Cotton LC, WDG		12	CA	N/A	Day 2: 130
			6	TX	N/A	N/A
			4	MS	N/A	N/A
			14	CA	N/A	N/A
			5	TX	N/A	N/A

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
	Picker operator, raker		18	AZ	N/A	Day 1: 98 Day 2: 420
	Cotton LC, WDG Tramper		6	CA	N/A	Day 3: 91 Day 4: 140
			3	TX	N/A	Day 1: 75 Day 2: 190
			2	MS	N/A	N/A
			6	CA	N/A	Day 1: 84 Day 2: 130
			3	TX	N/A	N/A
			8	AZ	N/A	Day 2: 200
Microencapsulated Formulation Application						
Nursery (Microencap. Formulations)	Ornamentals – Nurseries and Greenhouses Container moving, hand pruning, pinching, tying/training	1.4	74	Ornamentals- smooth	N/A	Day 0.33: 120 Day 1: 40 Day 2: 29 Day 3: 260
			50	Ornamentals- hairy	N/A	N/A
	Ornamentals – Nurseries and Greenhouses Irrigation		9.0	Ornamentals- smooth	Day 1: 5 Day 2: 4 Day 3: 32	Proposed cancelling use of microencapsulated formulations in nurseries MOE = 30 or less at Day 35
			6	Ornamentals- hairy	Day 1: 17	
	Ornamentals – Nurseries and Greenhouses Hand harvest, cut flower		3.6	Ornamentals- smooth	Day 1: 2 Day 2: 1 Day 3: 12	Proposed cancelling use of microencapsulated formulations in nurseries MOE = 12 or less at Day 35
			2	Ornamentals- hairy	Day 1: 7 Day 2: 7 Day 3: 8 Day 5: 13	
Greenhouse						
Greenhouse (Total Release Fogger and. Liquid Concentrate Formulations)	Ornamentals – *Liquid Concentrates* Commercial Ornamentals, Greenhouse Production: Bedding Plants, Cut Flowers, Flowering Hanging	2	10	CA	N/A	Day 1: 86 Day 2: 120
			11	OR	N/A	N/A
			3.5	MN	N/A	N/A

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
	Baskets, Potted Flowers, Ornamentals, Trees and Shrubs – *Total Release Foggers* Irrigation handset					
	Ornamentals – *Liquid Concentrates* Commercial Ornamentals, Greenhouse Production: Bedding Plants, Cut Flowers, Flowering Hanging Baskets, Potted Flowers, Ornamentals, Trees and Shrubs – *Total Release Foggers* Hand harvesting flowers		3.7	CA	N/A	Day 4: 98 Day 5: 140
			4.3	OR	N/A	Day 2: 350
			1.4	MN	N/A	Day 3: 100
	Ornamentals – *Liquid Concentrates* Commercial Ornamentals, Greenhouse Production: Bedding Plants, Cut Flowers, Flowering Hanging Baskets, Potted Flowers, Ornamentals, Trees and Shrubs Total release aerosol foggers Hand harvesting (flowers)	0.29	18	Ornamentals- hairy	N/A	Day 2: 140
Greenhouse - Oxon						
Greenhouse nursery	Greenhouse nursery	2.0	5.0	CA	N/A	Day 3: 91 Day 4: 130

Crop Group	Crop, Formulation, Activity[2]	App. Rate (lbs ai/A)	MOEs at Day 0	DFR Study Location	Considered REI (days) for LOC of 10^3	Considered REI (days) for LOC of 100^3
	Irrigation handset		5.7	OR	N/A	Day 2: 460
			1.9	MN	N/A	Day 2: 90 Day 3: 140
	Greenhouse nursery		2.0	CA	N/A	Day 5: 73 Day 6: 100
			2.2	OR	N/A	Day 2: 180
	Hand harvest		0.7	MN	N/A	Day 4: 84 Day 5: 130

[1]Risk estimates may be found: https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0850-0958
[2] Formulations: EC = emulsifiable concentrate, LC = liquid concentrate, WDG = water dispersed granular, WP = wettable powder
[3]N/A = REI of 24 hours is protective of risks of concern.