UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

PC Code : 059101
DP Barcode: 424487

December 23, 2014

MEMORANDUM

SUBJECT: Chlorpyrifos: Updated Drinking Water Assessment for Registration Review

TO: Joel Wolf, Chemical Review Manager
Tom Myers, Team Leader
Kevin Costello, Branch Chief
Risk Management and Implementation Branch 2
Pesticide Re-Evaluation Division (7508P)

THROUGH: Dana Spatz, Chief
Environmental Risk Branch 3
Environmental Fate and Effects Division (7507P)

Dana Spatz

FROM: Rochelle F. H. Bohaty, Ph.D., Chemist
Environmental Risk Branch 3
Environmental Fate and Effects Division (7507P)

Rochelle F H Bohaty

PEER REVIEW: James Hetrick, Ph.D., Senior Science Advisor
Environmental Risk Branch 3
Environmental Fate and Effects Division (7507P)

James A. Hetrick

This document provides an update to the registration review drinking water assessment (DWA) for chlorpyrifos. A preliminary DWA was completed in 2011[1] and posted to the docket for public comment. Since this assessment was completed and in response to public comment, several additional analyses were completed focusing on: 1) clarifying labeled uses, 2) evaluating volatility and spray drift, 3) revising aquatic modeling input values, 4) comparing aquatic modeling and monitoring data, 5) summarizing the effects of drinking water treatment, and 6) updating model simulations using current exposure tools. The first five topics are discussed in the **Additional Analyses** section of this assessment or are attached (**APPENDIX 1**: Registered Use Clarification; **APPENDIX 2**: Spray Drift Considerations; **APPENDIX 3**: Volatility Considerations) to this assessment. The new model runs are presented in the **Updated Modeling Simulation** section of this document. The additional analyses did not change the exposure assessment conclusions previously reported in the preliminary DWA.

[1] Bohaty, R. Revised Chlorpyrifos Preliminary Registration Review Drinking Water Assessment, June 20, 2011, PC Code: 059101; DP Barcode: 368388, 389480

ABSTRACT

A national screening level drinking water assessment was completed for the registration review of chlorpyrifos, with focus on the agricultural uses. The primary drinking water residue of concern is chlorpyrifos-oxon, the predominant chlorpyrifos transformation product formed during drinking water treatment (*e.g.*, chlorination). To illustrate a range of estimated drinking water concentrations (EDWC), two maximum label rate application scenarios were selected to represent high and low end exposures, i.e., tart cherries at 5 applications totaling 14.5 pounds per acre per year, and bulb onions at a single application of 1 pound per acre per year, respectively. The application of chlorpyrifos to tart cherries resulted in concentrations that exceeded the drinking water level of comparison (DWLOC); whereas, chlorpyrifos applications to bulb onions result in concentrations below the DWLOC. Concentrations in groundwater are not expected to exceed the DWLOC.

To investigate whether other chlorpyrifos application scenarios may result in concentrations that exceed the DWLOC, a screen of all available surface water modeling scenarios was completed considering three different application dates and a single application at several different application rates that ranged from one to six pounds. This analysis showed that even with only one application, several chlorpyrifos uses may exceed the DWLOC at rates lower than maximum labeled rates (both single as well as yearly), including an application rate of one pound per acre per year. The analysis also showed that the DWLOC exceedances are not expected to be uniformly distributed across the country.

Further analysis was conducted to look at the spatial distribution of EDWCs at a regional level, as well as by using a drinking water intake watershed approach. This exercise demonstrated that chlorpyrifos applications will result in variable drinking water exposures that are highly localized and that the highest exposures generally occur in small hydrologic regions where there is a high percent cropped area on which chlorpyrifos use could occur.

Finally, EDWCs were compared to monitoring data. This analysis showed that when modeling scenarios are parameterized to reflect reported use and EDWCs are adjusted to reflect percent cropped area, the EDWCs are within an order of magnitude of the measured concentrations reported in the monitoring data. Therefore, although there are uncertainties associated with the model input parameters for which conservative assumptions were made (*e.g.*, one aerobic aquatic metabolism half-life value multiplied by the uncertainty factor of three, stable hydrolysis, 100% of the cropped watershed is treated on the same day, and use of the Index Reservoir as the receiving waterbody), these assumptions do not appear to lead to an overly conservative estimate of exposure. In addition, evaluation of the monitoring data further illustrates that exposures are highly localized. Additional work can be done to examine EDWCs on a regional and/or watershed scale to pinpoint community drinking water systems where exposure to chlorpyrifos-oxon as a result of chlorpyrifos applications may pose an exposure concern.

RESULTS SUMMARY

EDWCs are provided for chlorpyrifos and chlorpyrifos-oxon. Chlorpyrifos EDWCs were multiplied by 0.9541 (molecular weight correction factor) and 100% (maximum conversion during water purification) to generate chlorpyrifos-oxon EDWCs. Essentially, the concentration of chlorpyrifos and chlorpyrifos-oxon are the same. A 100% conversion factor for the oxidation of chlorpyrifos to chlorpyrifos-oxon was used as an approximation based on empirical bench scale laboratory data that indicate chlorpyrifos rapidly oxidizes to form chlorpyrifos-oxon almost quantitatively during typical water treatment (chlorination).[2]

---

[2] Duirk, S. E.; Collette, T. W.; Degradation of Chlorpyrifos in Aqueous Chlorine Solutions: Pathways, Kinetics, and Modeling. *Environ. Sci. Technol.*, 2006, *40(2)*, 546-550.

There are limited data available on the removal efficiency of chlorpyrifos prior to oxidation or the removal efficiency of chlorpyrifos-oxon during the drinking water treatment process. Based on empirical data showing that more than 75 percent of community water systems use chlorination to disinfect drinking water in the United States[3], the assumption of exposure to chlorpyrifos-oxon equivalent to 100% conversion of chlorpyrifos is not considered overly conservative. It is possible that some drinking water treatment procedures, such as granular activated carbon filtration and water softening (increased rate of chlorpyrifos-oxon hydrolysis at pH > 9) could reduce the amount of chlorpyrifos-oxon in finished drinking water; however, these treatment methods are not typical practices across the country for surface water.

While there is the potential to have both chlorpyrifos and chlorpyrifos-oxon present in finished drinking water, limited (or no) information is available to readily quantify how much of each form remains following treatment. In the absence of available information, all the chlorpyrifos that enters a drinking water treatment facility is assumed to be converted to chlorpyrifos-oxon during treatment.

Although chlorpyrifos-oxon has a hydrolysis half-life of 5 days, the drinking water treatment simulation half-life for chlorpyrifos-oxon is approximately 12 days.[4,5,6] Therefore, once chlorpyrifos-oxon forms during treatment, little transformation is expected to occur before consumption (during drinking water distribution). There is a wide range of treatment processes and sequences of treatment processes employed at community water systems across the country and there are limited data available on a community water system specific basis to assess the removal or transformation of chlorpyrifos during treatment. These processes are not specifically designed to remove pesticides and pesticide transformation products including chlorpyrifos and chlorpyrifos-oxon. In general, drinking water treatment processes, with the exception of activated carbon,[7] have been shown to have little impact on removal of pesticide residues. Additional discussion of drinking water treatment can be found in the ***Drinking Water Treatment*** section of this DWA or in the preliminary DWA.

National Screen

The 2011 preliminary DWA, as well as the additional analyses completed as part of this assessment, indicate that exposure to chlorpyrifos-oxon in drinking water derived from surface water may pose an exposure concern. Since a large number of chlorpyrifos uses were identified in the preliminary DWA as triggering a concern, a bounding estimate of exposure was completed using a screening level national assessment approach. This was done to determine which currently registered uses could result in exposure to chlorpyrifos-oxon in drinking water that exceed the DWLOC.

Use of chlorpyrifos on tart cherries is expected to result in the highest EDWC. EDWCs for chlorpyrifos and chlorpyrifos-oxon[8] are reported below for Tier I groundwater and Tier II surface water model

---

[3] Community Water System Survey 2006; U.S. Environmental Protection Agency, Washington, DC 20460 **May 2009** (survey data)
[4] Tunink, A. Chlorpyrifos-oxon: Determination of hydrolysis as a function of pH, 2010 (MRID 48355201; acceptable)
[5] Wu, J.; Laird, D. A. Abiotic Transformation of Chlorpyrifos to Chlorpyrifos Oxon in Chlorinated Water. *Environ. Toxcol.Chem.*, **2003**, 22(2), 261-264.
[6] Tierney, D. P.; Christensen, B. R.; Culpepper, V. C. Chlorine Degradation of Six Organophosphate Insecticides and Four Oxons in Drinking Water Matrix. *Submitted by Syngenta Crop Protection, Inc.* **2001**.
[7] *Progress Report on Estimating Pesticide Concentrations in Drinking Water and Assessing Water Treatment Effects on Pesticide Removal and Transformation: A Consultation.* FIFRA Scientific Advisory Panel Meeting, September 29, 2000; SAP Report No. 2001-02 February 12, 2011.
[8] Chlorpyrifos EDWCs were multiplied by 0.9541 (molecular weight correction factor) and 100% (maximum conversion during water purification) to generate chlorpyrifos-oxon EDWCs. Additional details on the potential

simulations. Because chlorpyrifos is used on a number of agricultural crops, as well as turf, a drinking water intake percent cropped area (PCA) adjustment factor of 1 was used.[9,10] While the model input values[11] have been updated since the preliminary assessment, the results presented in **Table 1** are similar to those previously reported.

Table 1. Estimated Drinking Water Concentrations Resulting from the Use of Chlorpyrifos

Residue	Surface Water				Groundwater
	1-in-10 Year Peak Concentration µg/L	21-day Average Concentration µg/L	1-in-10 Year Annual Average Concentration µg/L	30 Year Annual Average Concentration µg/L	SCI-GROW Tier I Concentration µg/L[a]
Michigan Tart Cherries					
Chlorpyrifos	129	83.8	39.2	29.7	0.16
Chlorpyrifos-oxon	123	80.0	37.4	28.3	0.15
Georgia Bulb Onion					
Chlorpyrifos	6.2	3.1	1.2	0.8	0.01
Chlorpyrifos-oxon	5.9	3.0	1.1	0.8	0.01

a. SCI-GROW resulted in higher EDWCs than PRZM-GW simulations.

In order to better define the extent to which other chlorpyrifos use scenarios may result in an exposure concern, the Health Effects Division developed a 21-day average DWLOC of 3.9 µg/L for chlorpyrifos-oxon[12] that could be compared to model output values. Uncertainties in this approach include potential temporal aspects of relative concentrations from day to day on AChE inhibition, geospatial distribution of exposure as a result of variability in use, environmental factors, and drinking water treatment processes.

Previous risk assessments[13] suggest that typical upper bound application rates for chlorpyrifos are similar to the maximum single application rates for a wide range of crops; however, often the number of typical applications per year is lower than the maximum number of applications currently permitted on product labels (*i.e.*, summarized in **Master Use Summary Document**). Considering this information, a screening

impacts on drinking water treatment on chlorpyrifos and chlorpyrifos-oxon see the **Additional Analyses** section on Drinking Water Treatment.

[9] U.S. Environmental Protection Agency Brady, D. Guidance on Development and Use of Community Water System Drinking Water Intake Percent Cropped Area Adjustment Factors for Use in Drinking Water Exposure Assessments: 2014 Updated, September 12, 2014.

[10] U.S. Environmental Protection Agency, Bohaty, R., Carleton, J., Crk, T., Echeverria, M., Ruhman, M., Thawley, M., Thurman, N., Villanueva, P., White, K., Development of Community Water System Drinking Water Intake Percent Cropped Area Adjustment Factors for Use in Drinking Water Exposure Assessments: 2014 Update, September 9, 2014.

[11] *Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides*, Version 2.1, October 22, 2009.

[12] The average 21-day concentration of chlorpyrifos-oxon necessary to cause 10% AChE inhibition was determined by HED to be 217 ppb. This value was divided by the safety factors (50x; 4.3 ppb) and then the contribution from food (0.4 ppb) was subtracted out to give to derive a DWLOC (3.9 ppb).

[13] Dawson, J., Bohaty, R., Mallampalli, N. Evaluation of the Potential Risks from Spray Drift and the Impact of Potential Risk Reduction Measures, June 20, 2012 PC 059101 DP 399483 and 399485.

analysis (see the DWA for details) was completed to determine which chlorpyrifos uses do not exceed the DWLOC, based on a single application of chlorpyrifos per year at 1 and 4 pounds of chlorpyrifos per acre. The results for 1 and 4 pounds per acre are reported here as a representation of the range of potential chlorpyrifos application rates, bearing in mind that chlorpyrifos can be applied at lower and higher single rates (*e.g.,* an application rate of 6 pounds per acre on citrus). This analysis showed that over a 30 year period, the current maximum application rate scenarios, as well as maximum single application rates for a wide range of chlorpyrifos use scenarios, may result in multiple 21-day average concentrations that exceed the DWLOC (**Figure 1**).

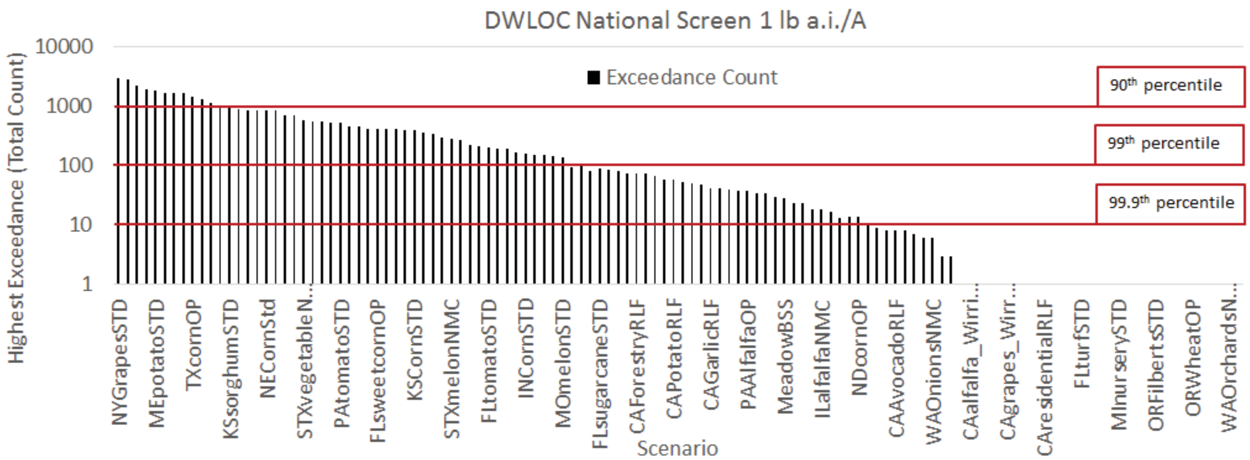


Figure 1. National Screen: Exceedance Count/Percent (one application per year)

Regional Screen

Although there are several exceedances of the DWLOC on a national basis, the incidence of high exposures is expected to be highly localized. While it is currently extremely challenging to assess exposure on a local scale due to the unavailability of data and wide range of characteristics [*i.e.*, environmental such as soil, weather, etc. or otherwise (*e.g.*, drinking water treatment process)] that affect the vulnerability of a given community drinking system to chlorpyrifos-oxon contamination, a method was developed to examine the potential geospatial concentration differences for two Hydrological Unit Code (HUC) 2 Regions – HUC 2 Region 17: Pacific Northwest and HUC 2 Region 3: South Atlantic-Gulf, in order to identify use patterns that may result in EDWCs that exceed the DWLOC on a regional basis.[14] This analysis considered all potential chlorpyrifos use sites within the HUC 2 regions based on the National Agricultural Statistics Service cropland data layers and survey data. Due to the uncertainty associated with some urban uses (e.g., wide area/general outdoor treatment) that are represented by the impervious scenarios, modeled results from the impervious scenarios are not included in this analysis. Additional clarification from the registrants is needed in order to determine if these uses pose an exposure concern.

For HUC 2 Region 17, four chlorpyrifos scenarios were identified as a potential concern based on maximum single application rates of 1 and 4 pounds per acre. However, for HUC 2 Region 3, several chlorpyrifos use scenarios were identified that could exceed the DWLOC.

[14] http://water.usgs.gov/GIS/huc.html

Watershed Screen

The uses that exceeded the DWLOC from the regional screening exercise for HUC 2 Region 3 were further explored for one example by utilizing the drinking water intake (DWI) watershed database. This example shows an overlap of potential chlorpyrifos use sites that may result in an exceedance of the DWLOC with watersheds that supply source water for community drinking water systems. In addition, this analysis shows that exposure is not uniform within a HUC 2 Region and that some watersheds are more vulnerable than others. Watershed vulnerability is expected to be greatest for smaller watersheds with high percent cropped areas. Smaller community water systems are generally more vulnerable due to short distribution times and the reliance of chlorination to treat source surface water as well as limited access to other treatment methods such as granular activated carbon.

Monitoring Data Analysis

Water monitoring data from the USGS National Water-Quality Assessment Program (NAWQA), USEPA/USGS Pilot Reservoir Monitoring Program, USDA Pesticide Data Program (PDP), and California Department of Pesticide Regulation (CDPR) were evaluated in the preliminary DWA with reference to an acute exposure to chlorpyrifos and its degradation product chlorpyrifos-oxon. The monitoring data showed chlorpyrifos detections at low concentrations, generally not exceeding 0.5 µg/L. For example, USGS NAWQA, which contains an extensive monitoring dataset for chlorpyrifos and chlorpyrifos oxon, reports a peak chlorpyrifos detection of 0.57 µg/L in surface water with a detection frequency of approximately 15%. CDPR has detected chlorpyrifos concentrations greater than 1 µg/L in surface water on several occasions, with an observed peak chlorpyrifos concentration of 3.96 µg/L. Sampling frequencies in these monitoring programs were sporadic and generally range from once per year to twice per month.

Since the preliminary assessment, water monitoring data from Washington State Department of Ecology and Agriculture (WSDE/WSDA) Cooperative Surface Water Monitoring Program[15,16], Dow AgroSciences (MRID 44711601), and Oregon Department of Environmental Quality were evaluated and are presented as part of this update. The previously referenced data have also been re-examined to consider short-term exposure (*i.e.*, 21-day average concentrations) considering the importance of the single day exposure and the temporal relationship of exposure. A summary of all surface water monitoring data examined to date for chlorpyrifos are presented in **Table 2**. Some of the monitoring programs analyzed for chlorpyrifos-oxon; however, the number of detections, as well as the concentrations, was generally much lower. Since the majority of the conversion of chlorpyrifos to chlorpyrifos-oxon is assumed to occur during drinking water treatment, and not in the environment, the monitoring data presented in **Table 2** are limited to chlorpyrifos.

[15] Sargeant, D, Dugger, D. Newell, E., Anderson, P, Cowles, J. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams 2006-2008 Triennial Report, **February 2010** (Washington State Department of Ecology and Washington State Department of Agriculture)
https://fortress.wa.gov/ecy/publications/summarypages/1003008.html;
http://agr.wa.gov/PestFert/natresources/docs/swm/2008_swm_report.pdf

[16] Sargeant, D., Newell, E., Anderson, P., Cook, A. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams 2009-2011 Triennial Report, **February 2013** (Washington State Department of Ecology and Washington State Department of Agriculture) http://agr.wa.gov/FP/Pubs/docs/377-SWM2009-11Report.pdf

Table 2. Surface Water Monitoring Data Summary for Chlorpyrifos

Monitoring Data	Scale	Years of Sampling (number of samples)	Detection Frequency (%)	Maximum Concentration (µg/L)
USGS NAWQA	National	1991-2012 (30,542)	15	0.57
California Department of Pesticide Regulation	State	1991-2012 (13,121)	20	3.96
Washington State Department of Ecology and Agriculture Cooperative Surface Water Monitoring Program	State	2003-2013 (4,091)	8.4	0.4
USDA Pesticide Data Program	National	2004-2009 (raw water; 1,178) 2001-2009 (finished water; 2,918)	0	na
USGS-EPA Pilot Drinking Water Reservoir	National	1999-2000 (323)	5.3	0.034
Oregon Department of Environmental Quality	Watershed (Clackamas)	2005-2011 (363)	13	2.4
MRID 44711601	Watershed (Orestimba Creek)	1996-1997 (1,089)	61	2.22

In general, the monitoring data include sampling sites that represent a wide range of aquatic environments including small and large water bodies, rivers, reservoirs, and urban and agricultural locations, but are limited for some areas of the United States where chlorpyrifos use occurs. Also, the sampling sites, as well as the number of samples, vary by year. In addition, the vulnerability of the sampling site to chlorpyrifos contamination varies substantially due to use, soil characteristics, weather and agronomic practices. None of the monitoring programs examined to date were specifically designed to target chlorpyrifos use (except the Registrant Monitoring Program MRID 44711601); therefore, peak concentrations (and likely 21-day average concentrations) of chlorpyrifos and chlorpyrifos-oxon likely went undetected in these programs. See the Revised Chlorpyrifos Preliminary Registration Review Drinking Water Assessment dated June 30, 2011 for further details on the monitoring programs discussed here. http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2008-0850-0026

In general, sampling frequency needs to be approximately equal to the duration of exposure concern.[17] The chlorpyrifos monitoring data evaluated thus far also show that as sample frequency increases, so does

[17] U.S. Environmental Protection Agency. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel: Problem Formulation for the Reassessment of Ecological Risks from the Use of Atrazine, **June 12-14, 2012**, Docket Number: EPA-HQ-OPP-2012-0230.

the detection frequency. This is evident in the registrant-submitted monitoring data, as well as examination of individual sampling sites within the various datasets.

Therefore, while there are many individual samples collected and analyzed for chlorpyrifos (or chlorpyrifos-oxon) across the United States, it would not be appropriate to combine these data sources to generate exposure estimates or to use these datasets to represent exposure on a national or even regional basis. Thus, comparing the monitoring data results to the DWLOC would not be a reasonable approach for the reasons given above, including limited sample frequency, limited use information, and sampling site variability, on a national or even a regional basis. Model estimated concentrations should be considered suitable upper bound concentrations for chlorpyrifos and chlorpyrifos-oxon.

Additionally, model simulations were completed to represent two different water monitoring datasets - Washington State Department of Ecology and Agriculture (WSDE/WSDA) Cooperative Surface Water Monitoring Program and Dow AgroSciences (MRID 44711601) Orestimba Creek. For both of these water monitoring programs, enough information was available, including chlorpyrifos use information as well as the PCA, to parameterize the model. In these simulations, the modeled EDWCs were within an order of magnitude of the measured concentrations. This suggests that the modeling results are not overly conservative and supports the use of the model to estimate chlorpyrifos-oxon concentrations in drinking water.

Additional modeling can be done to pinpoint regions or watersheds where EDWCs may exceed the DWLOC. This would include completing the regional assessment presented here for all HUC 2 Regions and crop uses, as well as considering multiple applications per year. Nevertheless, based on the current analysis, concentrations of chlorpyrifos-oxon in drinking water are expected to be highly localized primarily in small watersheds with high PCA.

Synopsis

In summary, examination of chlorpyrifos agricultural use across the country indicates that there are a number of uses that may result in potential exposure to chlorpyrifos-oxon in finished drinking water at levels that exceed the DWLOC. The EDWCs for tart cherries and bulb onion reported here are expected to provide a reasonable bounding estimation of exposure based on maximum rates included in the **Master Use Summary Document**. This analysis showed that the maximum use scenario for tart cherries exceeds the DWLOC, while it does not for bulb onions.

The rate used for the bulb onion simulation was 1 pound chlorpyrifos per acre; therefore a screen of all Surface Water Concentration Calculator modeling scenarios was done using a single application of chlorpyrifos. This analysis showed that exceedances are expected even for one application of chlorpyrifos applied at 1 pound per acre per year.

While there are uncertainties associated with the model input parameters for which conservative assumptions were made (*e.g.*, one aerobic aquatic metabolism half-life value multiplied by the uncertainty factor of 3, stable hydrolysis, 100% of the cropped watershed is treated on the same day, and use of the Index Reservoir as the receiving waterbody), these assumptions do not appear to lead to an overly conservative estimate of exposure based on a comparison of model estimates with measured concentrations. Comparison of model estimated concentrations with measured concentrations suggests that model estimates are consistent with measured concentrations when actual application rates and representative SWCC scenarios are considered and a PCA adjustment factor is applied to the model estimates. This modeling/monitoring comparison suggests that when growers use maximum application rates, or even rates much lower than maximum, chlorpyrifos-oxon concentrations in drinking water could pose an exposure concern for a wide range of chlorpyrifos uses. However, these exposures are not expected to be uniformly distributed across the country. Additional analyses are needed in order to pinpoint the exact community water systems where concentrations may be of concern.

BACKGROUND

The 2001 Interim Reregistration Eligibility Decision (IRED) considered exposure to chlorpyrifos in drinking water[18,19] and recommended the quantitative use of monitoring data to estimate chlorpyrifos exposure. At the time of the IRED, chlorpyrifos concentrations in groundwater (greater than 2000 µg/L) from termiticide uses were the primary focus of drinking water exposure. The model estimated concentrations were orders of magnitude lower than the measured concentrations. Subsequent to the IRED, the termiticide use was canceled.

The preliminary drinking water assessment conducted in 2011[1] recommended the use of surface water EDWCs for chlorpyrifos-oxon derived from modeling, and concluded that a range of chlorpyrifos uses could lead to high levels (peak concentrations greater than 100 µg/L) of chlorpyrifos in surface water that could potentially be used by community water systems to supply drinking water. Once chlorpyrifos reaches a drinking water treatment facility, it readily converts to chlorpyrifos-oxon upon disinfection (primarily oxidative treatment methods such as chlorination). Therefore, chlorpyrifos and chlorpyrifos-oxon were considered residues of concern in the preliminary assessment to account for the variation of drinking water treatment methods.

UPDATED MODELING SIMULATIONS

Revision of Metabolism Model Input Values

In December 2011, EFED along with Canada's Pest Management Regulatory Agency (PMRA) completed the NAFTA degradation kinetics project. As part of this project, guidance[20] was developed describing a general approach for calculating and selecting representative half-life values from soil and aquatic transformation studies for risk assessment and exposure modeling. In 2013, EFED published a standard operating procedure (SOP)[21] for following the NAFTA kinetics guidance. Updated kinetic analyses were completed for chlorpyrifos following the recently updated SOP[22] using the PestDF Tool (version 0.8.13) along with R (version 3.1.0). The kinetic analyses are provided in **APPENDIX 4:** Kinetic analysis and the results are summarized in **Table 3**. **Table 3** also provides the previously reported half-life values for comparison.

---

[18] U.S. Environmental Protection Agency, Finalization of Interim Reregistration Eligibility Decisions (IREDs) and Interim Tolerance Reassessment and Risk Management Decisions (TREDs) for the Organophosphate Pesticides, and Completion of the Tolerance Reassessment and Reregistration Eligibility Process for the Organophosphate Pesticides, September 28, 2001

[19] Barrett, M, Nelson, H, Rabert, W., Spatz, D. Reregistration Eligibility Science Chapter for Chlorpyrifos Fate and Environmental Risk Assessment Chapter, June 2000

[20] *Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media*, Health Canada, U.S. Environmental Protection Agency, December 21, 2011.

[21] Bohaty, R., Eckel, W., Shamim, M., Spatz, D., White, K., Young, D. Standard Operating Procedure for Using the NAFTA Guidance to Calculate Representative Half-life Values and Characterizing Pesticide Degradation, November 20, 2013.

[22] Bohaty, R., Eckel, W., Shamim, M., Spatz, D., White, K., Young, D. Standard Operating Procedure for Using the NAFTA Guidance to Calculate Representative Half-life Values and Characterizing Pesticide Degradation, December 1, 2014 (Draft).

Table 3. Environmental Fate and Transport Characteristics of Chlorpyrifos

Parameter	Test System Name or Characteristics	Previously Report Half-life Values	NAFTA Representative Half-life Values (fitting model)	Study ID	Study Status
Laboratory Data					
Aerobic Soil Metabolism Half-life ($t_{1/2}$)	Commerce	11 days	19 days (IORE)	Acc. 241547 MRID 00025619)	Acceptable
	Barnes	22 days	36.7 days (IORE)		
	Miami	24 days	31.1 days (IORE)		
	Catlin	34 days	33.4 days (SFO)		
	Norfolk	102 days	156 days (DFOP)		
	Stockton Clay	107 days	297 days (IORE)		
	German	141 days	193 (IORE)		
	Sandy loam	180 days	185 days (DFOP)	MRID 42144911	Acceptable
Aerobic Aquatic Metabolism Half-life ($t_{1/2}$)	Water, pH 8.1 Sediment, pH 7.7 25 ˚C	30.5 days	30.4 days (SFO)	MRID 44083401	Supplemental
Anaerobic Soil Metabolism half-life ($t_{1/2}$)	Commerce	15 days	78 (IORE)	MRID 00025619	Acceptable
	Stockton	58 days	171 days (SFO) Values represent only anaerobic phase		
Anaerobic Aquatic Metabolism half-life ($t_{1/2}$)	Commerce pH 7.4	39 days	50.2 days (IORE)	MRID 00025619	Supplemental
	Stockton pH 5.9	51 days	125 days (SFO)		

Model Simulations

Groundwater

Tier I groundwater EDWCs for chlorpyrifos and chlorpyrifos-oxon were calculated using SCI-GROW (Screening Concentration in Groundwater, version 2.3, August 8, 2003) and PRZM-Groundwater (PRZM-GW version 1.0, December 11, 2012), using the GW-GUI (Graphical User Interface, version 1.0, December 11, 2012).[23] For Tier I groundwater assessments, the results from the model (either SCI-GROW or PRZM-GW) that provides the highest EDWCs is recommended for incorporation into the human health assessment, along with surface water EDWCs in order to provide an upper bound estimation of the potential impact of chlorpyrifos use on drinking water supplies. Model input values for SCI-GROW and PRZM-GW are provided in **Table 4** and **Table 5**, respectively, and reflect current input parameter guidance.[11] **Table 6** and **Table 7** highlight the use scenarios simulated for Michigan tart cherries and Georgia onions (*i.e.*, bulb onion production), respectively.

Based on the surface water EDWCs reported in the preliminary drinking water assessment (see **Figure 2)** and the application rates included in the **Chlorpyrifos Master Use Summary Document**, chlorpyrifos applications to tart cherries is expected to provide upper bound EDWCs, while chlorpyrifos applications to bulb onion is expected to provide a lower bound value. These use scenarios were confirmed by the

[23] http://www.epa.gov/oppefed1/models/water/

Biological and Economic Analysis Division (BEAD) as reasonably representative based on the maximum label rates for tart cherries and bulb onions prior to model simulations.[24]

Table 4. **SCI-GROW Input Parameters**

Parameter (units)	Input Value	Data Source	Comments
Application Rate (lb a.i./A)	See **Table 6 and Table 7**	Master Use Summary Document	Maximum yearly application rate is for tart cherries and bulb onion (see **ATTACHMENT 1**: **Master Use Summary Document**).
Number of Applications	See **Table 6 and Table 7**	Master Use Summary Document	For tart cherries the five different applications were combined into one. (see **ATTACHMENT 1**: **Master Use Summary Document**)
Soil Metabolism Half-life (days)	96	MRID 00025619	Half-life values of 19, 36.7, 31.1, 33.4, 156, 297, 193, and 185 days were obtained from empirical data following the NAFTA kinetics guidance. The median half-life value of 96 days was used in SCI-GROW modeling.
K_{oc} (mL/g_{oc})	5860	Acc. 260794	Soil binding for chlorpyrifos is correlated with organic carbon content (*i.e.*, the coefficient of variation for K_{oc} values is less than that for K_d values). The median K_{oc} value (K_{oc} values = 7300, 5860 and 4960 mL/g) was used for modeling.

Table 5. PRZM-GW Input Parameters

Parameter (units)	Input Value	Data Source	Comments
Application Rate (kg a.i./ha) Number of Applications Application Date Annual Application Retreatment Application Method	See **Table 6**	**Master Use Summary Document**	Maximum yearly application rate for chlorpyrifos is for tart cherries and bulb onions (see **ATTACHMENT 1**: **Master Use Summary Document**).
Hydrolysis Half-life (days)	81	MRIDs 00155577 and 40840901	Since aerobic aquatic metabolism is not considered as part of groundwater modeling, a maximum hydrolysis value of 72 and 81 days was used in model simulations.
Aerobic Soil Metabolism Half-life (days)	170.6	Acc. # 241547 and MRID 42144911	Half-life values of 19, 36.7, 31.1, 33.4, 156, 297, 193, and 185 days were obtained from empirical data following the NAFTA kinetics guidance. The 90th percentile confidence bound on the mean chlorpyrifos half-life value is 118.9 + [(1.415 x 103.3)/√8)] = 170.6 days.
K_{oc} (mL/g_{oc})	6040	Acc. # 260794	Soil binding for chlorpyrifos is correlated with organic carbon content (*i.e.*, the coefficient of variation for K_{oc} values is less than that for K_d values). The mean K_{oc} value (K_{oc} values = 7300, 5860 and 4960 mL/g) was used for modeling.

[24] Email from Clayton, Myers, RE: Chlorpyrifos Use March 26, 2014

Table 6. Michigan Tart Cherry Chlorpyrifos Application Scenario

Application Number	Application Timing; Type	Date	Method	Application Rate (lb a.i./A)	Formulation	Comments
1	Dormant/delayed Dormant; broadcast	4/1	Aircraft	2.0	liquid	150 ft. buffer for aerial applications
2	Foliar; broadcast	5/15	Orchard blast	4.0	liquid	50 ft. buffer for orchard blast applications
3	Foliar; broadcast	5/25	Orchard blast	4.0	liquid	50 ft. buffer for orchard blast applications
4	Foliar; broadcast	6/4	Orchard blast	2.0	liquid	50 ft. buffer for orchard blast applications
5	Foliar; Post harvest trunk drench	8/1	Ground (hand-held or backpack)	2.5	liquid	25 ft. buffer for ground boom applications

Table 7. Georgia Onion Chlorpyrifos Application Scenario

Application Number	Application Timing; Type	Date	Method	Application Rate (lb a.i./A)	Formulation	Comments
1	preplant; soil	12/4	Ground	1.0	liquid	25 ft. buffer for ground boom applications

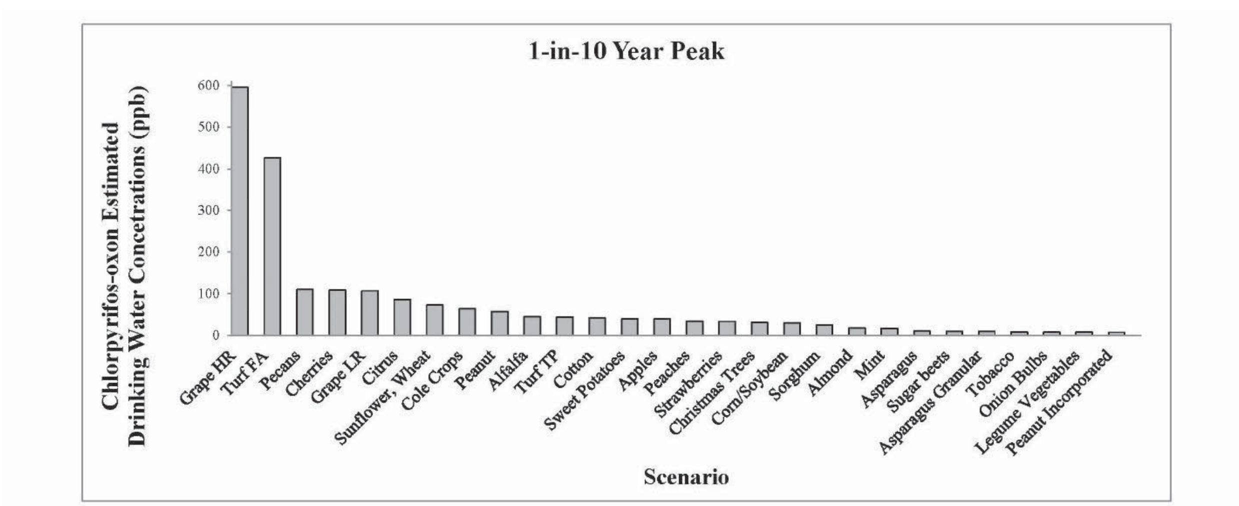


Figure 2. Summary of 1-in-10 Year Peak Chlorpyrifos-oxon EDWCs Previously Reported in the Preliminary Drinking Water Assessment for Registered Uses of Chlorpyrifos-oxon Derived From Surface Water

The tart cherries use has the highest annual application rate (14.5 pounds per acre per year with a maximum single application rate of 4.0 pounds per acre) of all the chlorpyrifos uses highlighted in the **Master Use Summary Document**. Tart cherries was also identified in the preliminary DWA as an application scenario with a high end exposure based on surface water simulations, even though it does not represent the highest single application rate scenario for chlorpyrifos. The highest single application rate for chlorpyrifos is for citrus at 6.0 pounds per acre (10.5 pounds per acre per year). This annual rate reduction is not expected to substantially change the exposure estimates and; therefore, are not expected to alter the risk assessment conclusions. Bulb onion production in Georgia was identified as a lower bound scenario, as the maximum single and yearly application rate is 1 pound per acre. Although chlorpyrifos is not expected to pose a significant groundwater exposure (K_{oc} > 1000 mL/g_{oc}), the tart cherries and bulb onion application scenarios were also considered for groundwater modeling.

Tier I groundwater EDWCs for chlorpyrifos and chlorpyrifos-oxon are provided in **Table 8** and **Table 9**, respectively. EDWCs are not expected to be greater than 0.16 µg/L for chlorpyrifos and 0.15 µg/L for chlorpyrifos-oxon (based on SCI-GROW). These EDWCs are expected to be an upper bound value and may not actually reflect groundwater concentrations across the country, but rather reflect the potential exposure in vulnerable groundwater supplies. The reported groundwater EDWCs for chlorpyrifos-oxon are representative of drinking water supplies that utilize oxidative treatment methods such as chlorination. In general, drinking water taken from private wells is not treated; however, community drinking water supplied by wells may be treated with chlorine in order to protect drinking water during distribution.

Table 8. Estimated Drinking Water Concentrations of Chlorpyrifos in Groundwater

Crop/Scenario	SCI-GROW	PRZM-GW		
	µg/L	Highest Daily Value µg/L	Post Breakthrough Average µg/L	Average Simulation Breakthrough Time days
Tart Cherries				
Florida Citrus	0.16	0.06	Incomplete with 100 year simulation	
Florida Potato		5.0E-11		
Wisconsin Corn		9.4E-05		
Georgia Peanuts		3.6E-08		
North Carolina Cotton		2.9E-06		
Delmarva Sweet Corn		0.0001		
Bulb Onion				
Florida Citrus	0.01	0.0043	Incomplete with 100 year simulation	
Florida Potato		3.9E-12		
Wisconsin Corn		6.0E-06		
Georgia Peanuts		2.6E-09		
North Carolina Cotton		2.3E-07		
Delmarva Sweet Corn		9.2E-06		

Table 9. Estimated Drinking Water Concentrations of Chlorpyrifos-oxon in Treated Groundwater

Crop/Scenario	SCI-GROW	PRZM-GW		
	ug/L	Highest Daily Value µg/L	Post Breakthrough Average µg/L	Average Simulation Breakthrough Time days
Tart Cherries				
Florida Citrus	0.15	0.06	Incomplete with 100 year simulation	
Florida Potato		4.8E-11		
Wisconsin Corn		9.0E-05		
Georgia Peanuts		3.4E-08		
North Carolina Cotton		2.8E-06		
Delmarva Sweet Corn		0.0001		
Bulb Onion				
Florida Citrus	0.01	0.0041	Incomplete with 100 year simulation	
Florida Potato		3.7E-12		
Wisconsin Corn		5.7E-06		
Georgia Peanuts		2.5E-09		
North Carolina Cotton		2.23E-07		
Delmarva Sweet Corn		8.8E-06		
EDWCs for chlorpyrifos-oxon were derived from EDWCs calculated for chlorpyrifos because chlorpyrifos is expected to transform to chlorpyrifos-oxon during drinking water treatment. Chlorpyrifos EDWCs were multiplied by 0.9541 (molecular weight correction factor) and 100% (maximum conversion during water purification) to generate chlorpyrifos-oxon EDWCs.				

Surface Water

Tier II surface water EDWCs for chlorpyrifos and chlorpyrifos-oxon were calculated using the Surface Water Concentration Calculator (SWCC) version 1.106. The SWCC uses PRZM version 5.0+ (PRZM5) and the Variable Volume Water Body Model (VVWM). PRZM is used to simulate pesticide transport as a result of runoff and erosion from an agricultural field. VVWM estimates environmental fate and transport of pesticides in surface water. The input parameters used in SWCC simulations are presented in **Table 10**.

National Screen

Tart cherries and onions were modeled as upper and lower bound exposure scenarios for surface water for reasons described above in the groundwater section of this assessment. Tier II EDWCs for surface water are presented in **Table 11** for chlorpyrifos in untreated surface water and chlorpyrifos-oxon following oxidative drinking water treatment. Tier II modeling results were corrected using the DWI PCA adjustment factor.[9,10] Since chlorpyrifos is registered for use on turf (including sod farms, golf courses, road medians and industrial areas) a PCA of 1 (considers 100% of the watershed can and is treated) was applied to surface water modeling results for this national screening analysis. EDWCs for chlorpyrifos-oxon were derived from EDWCs for chlorpyrifos by multiplying chlorpyrifos EDWCs by 0.9541 (molecular weight adjustment factor) and 100% (maximum conversion of chlorpyrifos to chlorpyrifos-oxon during water treatment).

Although the model simulations suggest relatively high concentrations of chlorpyrifos in the receiving waterbody, only a small amount (≤ 1.2%) applied to the field reaches the water body for the two scenarios examined. This is consistent with a runoff study conducted by the registrant (MRID 00144906) that suggests that the amount of chlorpyrifos transported from a treated field (corn watersheds in Illinois) to proximal water bodies is generally less than one percent of the applied material.[25] Depending on the scenario used in the modeling simulations, the transport of chlorpyrifos from the field to the receiving water body is either primarily through runoff or erosion (**Table 11**) and the total mass transported from the field may be higher than 1.2% for other SWCC scenarios.

While model simulations consider the required aquatic spray drift buffers, these buffers may also reduce the transport of chlorpyrifos via runoff and erosion of chlorpyrifos from the field to the water body. Spray drift buffers provide distance between the field and the neighboring water body; however, it is unclear to what extent they may act like a filter strip. EFED does not currently have an exposure tool to assess the impact of vegetative filter strips (VFS) on reducing runoff and erosion; however, the development and maintenance of VFS is highly variable. Large runoff or erosion events are trigged by larger storm events, which are likely to overcome the buffer or VFS with sheet or channelized flow providing a direct conduit to the nearby water body. A U.S. Geological Survey (USGS) report suggests that sheet flow is expected at distances up to 100 feet.[26] Moreover, a review article on the reduction of herbicide concentrations from fields with VFS was not able to document a decline in herbicide concentrations in receiving water bodies as a result of VFS, and that data specifically on a watershed scale is lacking.[27] In addition, this review concluded that retention of sediment as a function of the VSF width was nonlinear, with most of the retention occurring within the first few meters.

Once in the water body, chlorpyrifos dissipation is scenario specific; however, the primary mechanisms of chlorpyrifos dissipation are volatilization, metabolism and washout. Based on laboratory studies chlorpyrifos is expected to partition to sediment; however, this does not mean a complete reduction in chlorpyrifos in the water column is expected.

---

[25] McCall, P. J., Oliver, G. R., McKeller, R. L. Modeling the runoff potential and behavior of chlorpyrifos in a terrestrial aquatic watershed (DowElanco unpublished report GH-C 1964) 1984

[26] U. S. Department of Agriculture, National Resources Conservation Service, Small Watershed Hydrology WinTR-55 User Guide, January 2009.

[27] Krutz, L. J., Senseman, S. A., Zablotowicz, R. M., Matocha, M. A., Reducing Herbicide Runoff from Agricultural Fields with Vegetative Filter Strips: A Review, Weed Science, **2005**, *53*, 353-367.

Table 10. SWCC Input Parameters

Parameter (units)	Input Value	Data Source	Comments
Molecular Weight (g/mol)	350.57	product chemistry	
Water Solubility (mg/L) 20 °C	1.4	MRID 41829006	The water solubility of chlorpyrifos is reported to be between 0.5-2.0 mg/L for temperatures between 20-25 °C. Based on data submitted to EPA, 1.4 mg/L was used in modeling.
Vapor Pressure (torr) 25 °C	1.87×10^{-5} torr	product chemistry BC 2062713	
Henry's Law Constant	6.2×10^{-6} atm - m^3/mol	calculated	
Application Rate (kg a.i./ha)	See **Table 6**	**Master Use Summary Document**	Maximum yearly application rate for use on tart cherries (see **ATTACHMENT** 1**: Master Use Summary Document**). Tart cherries was also previously determined to be a high exposure scenario (see **Figure 1**)
Number of Applications			
Application Date			
Spray Drift	3.9% (aerial)[a] 0.9% (airblast)[b] 0.8% (ground)[c]	AgDRIFT modeling based on label restrictions	Labels contain aquatic buffer distances of 25, 50 and 150 ft. for ground, airblast and aerial applications.
Application Efficiency	0.99 (ground; air-blast)) 0.95 (aerial)	Default Values	
Crop Application Method	See **Table 6**	**Master Use Summary Document**	
Incorporation Depth			
Hydrolysis Half-life (days)	0	MRIDs 00155577 (Acc. # 260794) and 40840901	Since the aerobic aquatic metabolism half-life value was not corrected for hydrolysis, it is possible that hydrolysis would be double-counted in the model simulation. Therefore, hydrolysis was set to 0 (stable) here as it is already accounted for in the aerobic aquatic metabolism study and input parameter.
Aqueous Photolysis (days)	29.6	MRID 41747206	
Aerobic Soil Metabolism Half-life (days)	170.6 (109)	Acc. # 241547 and MRID 42144911	Half-life values of 19, 36.7, 31.1, 33.4, 156, 297, 193, and 185 days were obtained from empirical data following the NAFTA kinetics guidance. The 90th percentile confidence bound on the mean chlorpyrifos half-life value is 118.9 + [(1.415 x 103.3)/√8)] = 170.6 days.
Aerobic Aquatic Metabolism Half-life (days)	91.2 (91.5)	MRID 44083401	Only one half-life value is available, so this value (30.4 days) was multiplied by 3 to get 91.5 days. The 30.4 day half-life value was not corrected for hydrolysis as hydrolysis data conducted under the same experimental conditions were not provided. In addition, the aerobic aquatic metabolism study was conducted under slightly basic conditions (pH 7.7). Chlorpyrifos hydrolysis is pH dependent and faster under basic conditions.
Anaerobic Aquatic Metabolism Half-life (days)	203 (63)	MRID 00025619	The 90th percentile confidence bound on the mean chlorpyrifos half-life value determined following the NAFTA kinetics guidance is 87.6 + [(3.078 x 52.9)/√2)] = 202.7 days.

K_{oc} (mL/g_{oc})	6040	Acc. # 260794	Soil binding for chlorpyrifos is correlated with organic carbon content (*i.e.*, the coefficient of variation for K_{oc} values is less than that for K_d values). The mean K_{oc} value (K_{oc} values = 7300, 5860 and 4960 mL/g) was used for modeling.
Percent Cropped Area	1.0	PCA guidance[d]	

a. Aerial: 150 ft. distance to water body from edge of field based on labeled buffer; ASAE fine to medium ($dv_{0.5}$ = 255 µm; labels specify 255-340 µm); Index Reservoir - downwind water body width 82 m (fraction applied 0.0331); Streams – 4 m (fraction applied 0.0552); Adjusted Spray drift fraction 0.0331 (spray drift fraction for the Index Reservoir) + [0.0552 (spray drift fraction for all Stream) x 0.114 (Surface areas of all streams/surface area of reservoir)] = 0.039
b. Air-blast: 50 ft. distance to water body from edge of field based on labeled buffer; droplet size not specified; sparse (young, dormant); Index Reservoir - downwind water body width 82 m (fraction applied 0.0056); Streams – 4 m (fraction applied 0.0265); Adjusted Spray drift fraction 0.0056 (spray drift fraction for the Index Reservoir) + [0.0265 (spray drift fraction for all Stream) x 0.114 (Surface areas of all streams/surface area of reservoir)] = 0.0086
c. Ground: 25 ft. distance to water body from edge of field based on labeled buffer; ASAE Fine to medium/course [$dv_{0.5}$ = 341 µm; labels specify 255-340 µm which is larger than ASAE very fine to fine ($dv_{0.5}$ = 175 µm); highboom; 90th percentile; Index Reservoir - downwind water body width 82 m (fraction applied 0.0061); Streams – 4 m (fraction applied 0.0164); Adjusted Spray drift fraction 0.0061 (spray drift fraction for the Index Reservoir) + [0.0164 (spray drift fraction for all Stream) x 0.114 (Surface areas of all streams/surface area of reservoir)] = 0.0079
d. See **Footnotes 9** and **10**.

Scenario: MICherriesSTD; GAOnion_WirringSTD (Weather: W14850, W03822, respectively)
EFED file room barcode (BC)

Table 11. Estimated Drinking Water Concentrations of Chlorpyrifos in Untreated Surface Water (Model Output Values; PCA 1.0; all ag + turf)

Absolute Peak	1-in-10 Year Concentration (ppb)				Relative Transport	Field to Water[a]
	Peak	21-day Average	Annual Average	30 Year Annual Average		
Michigan Tart Cherries						
172 (164)[b]	129 (123)	83.8 (80.0)	39.2 (37.4)	29.7 (28.3)	Runoff 18% Erosion 77% Drift 5%	1.2%
Georgia Bulb Onion						
8.5 (8.1)	6.2 (5.9)	3.1 (3.0)	1.2 (1.1)	0.8 (0.8)	Runoff 78% Erosion 18% Drift 3%	<1%

a. The relative amount of the material applied to the field that is transported off field and into the water body (*i.e.*, index reservoir).
b. Bracketed concentrations are for chlorpyrifos-oxon in treated drinking water

EFED recommends the use of the EDWCs presented in **Table 11** in the human health risk assessment conducted for chlorpyrifos (and chlorpyrifos-oxon), as these values are expected to provide bounds on the exposure as a result of the currently registered uses as described in the **Master Use Summary Document**. It should be noted that there are still a few uses, specifically urban uses (*e.g.*, wide area treatment of miscellaneous pests) that need to be clarified in order to determine the potential exposure as a result of these uses.

To screen the potential exposure resulting from the large number of other currently registered uses of chlorpyrifos, a batch run simulation was completed for **one** chlorpyrifos application per year for all current SWCC standard scenarios (n=124). A ground application was simulated for three different application dates; 30 days preemergence (-30dpe), 7 days postemergence (7dpe) and 30 days postemergence (30dpe).

While spray drift is expected to be higher for aerial applications, the application efficiency is higher for ground applications, and when both parameters are considered, the resulting EDWCs are generally similar. Therefore, if an exposure concern is triggered for a ground application, it is expected that there would also be exposure concern for other application types including aerial and airblast applications.

EDWCs are highly sensitive to the application date, which is variable from year to year; therefore, examination of multiple application dates was done to better understand the potential variability in EDWCs as a result of application date. In addition, the three selected application dates generally represent the various types [*i.e.*, timing of application permitted (*e.g.*, pre-plant, at plant, foliar, and dormant)] of applications currently allowed for a number of the registered uses of chlorpyrifos.

Figure 3 presents the range of the highest 21-day average chlorpyrifos-oxon concentrations for each of the application dates assessed for all scenarios compared to the DWLOC for chlorpyrifos-oxon resulting from chlorpyrifos applications at 1 pound per acre. The national default DWI PCA of 1 for all agricultural and turf was used in this analysis. Absent from this analysis are the impervious scenarios (*i.e.*, CAImperviousRLF), due to the uncertainty associated with the registered uses that are represented by these scenarios. As mentioned above, clarification from the registrants is needed in order to determine if these uses pose an exposure concern.

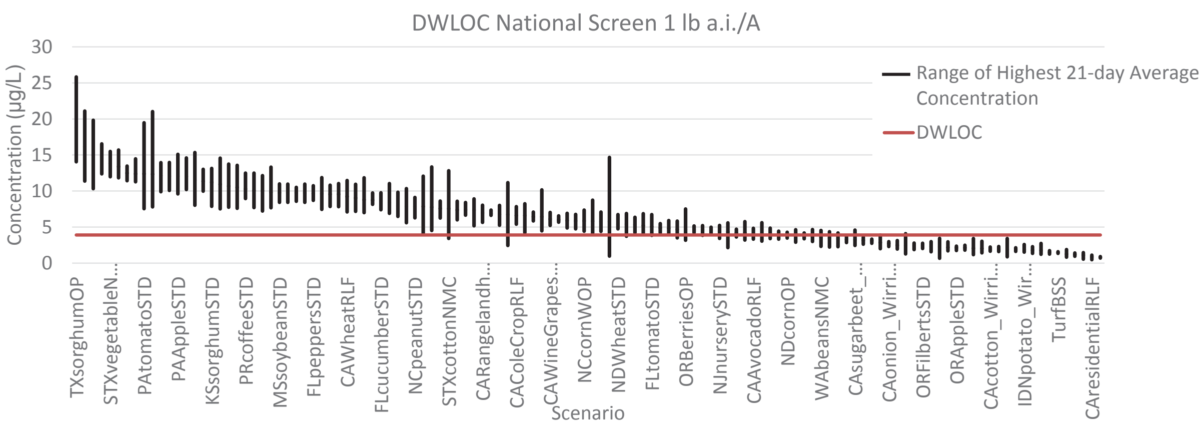


Figure 3. National Screen: Estimated Chlorpyrifos-oxon Concentration by Scenario (one application per year)

Figure 4 presents the total number of exceedance periods (*i.e.*, 21-days) over the entire model simulation (approximately 30 years, but is scenario dependent) for the application date that results in the highest number of exceedances calculated for 1 and 4 pound(s) per acre for each standard SWCC scenario. Also shown are the number of exceedances that correspond to the 99.9th, 99th, and 90th percentiles, i.e., 10, 100, and 1000 exceedances, respectively. The exceedance count was calculated using an Excel macro to screen the daily concentration time series files generated by the SWCC. For this analysis, the 21-day DWLOC[28] for chlorpyrifos-oxon was adjusted by the molecular weight adjustment factor to calculate the corresponding chlorpyrifos concentration for use in the Excel macro, since the time series data generated

[28] 3.9 ppb oxon / 0.9541 oxon molecular weight adjustment factor = 4.1 ppb chlorpyrifos

by the SWCC are for chlorpyrifos and does not consider the transformation of chlorpyrifos to chlorpyrifos-oxon as a result of drinking water treatment. An uncertainty with using the 21-day average concentration as the DWLOC is the temporal relationship of chlorpyrifos and corresponding chlorpyrifos-oxon concentrations from day to day. For example, a one day exposure concentration may result in an average 21-day concentration that exceeds the 21-day DWLOC while a more constant exposure over 21 days may also result in an average 21-day concentration that exceeds the 21-day DWLOC. Alternatively a one day exposure concentration may not trigger a risk concern using this approach, as the average 21-day concentration may be below the DWLOC.

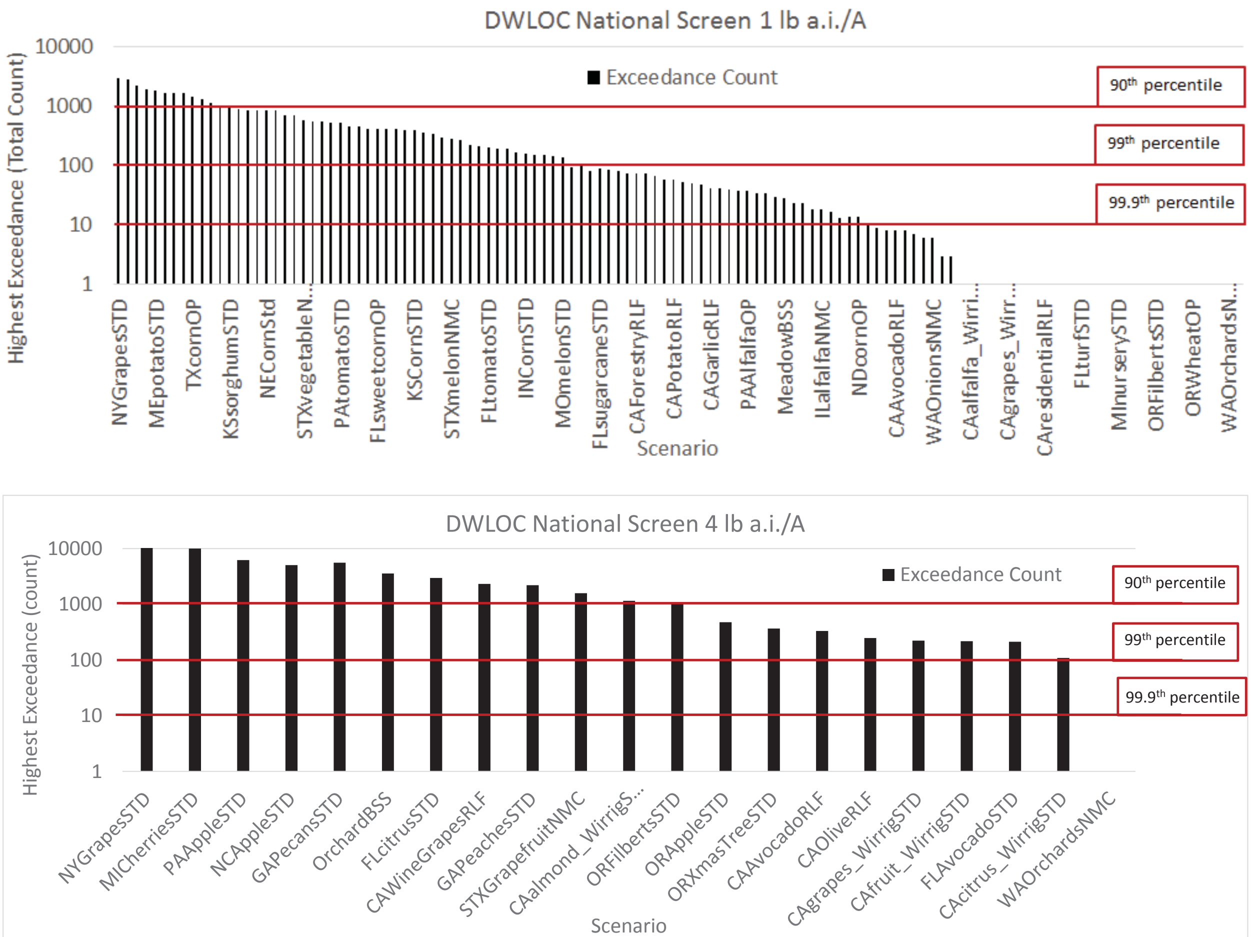


Figure 4. National Screen: Exceedance Count/Percent (one application per year)

Not all the SWCC scenarios represent use sites where 4 pounds of chlorpyrifos can be applied; therefore, the results presented in **Figure 4** are only for those SWCC scenarios that reasonably represent use sites where chlorpyrifos can be applied at a single application rate up to 4 pounds per acre. For the graphs, the left y-axis corresponds to the number of 21-day time periods where the average concentration exceeds the DWLOC. There are approximately 10,000 21-day time periods per 30 year simulation. The labels on the right y-axis represents the DWLOC exceedance percentile based on the total number of 21-day time periods.[29]

Considering maximum single application rates and the representation of the scenarios, at least one 21-day average concentration was determined to be greater than the DWLOC for all use sites/crops except for

[29] Exceedance Count/~10000; the actual number of days included in each simulation was considered

pumpkin (**Table 12**). A summary of the results for all the scenarios and all application rates [1, 2 (2.3 for citrus scenarios), 3, 4, and 6 pounds] is provided in **ATTACHMENT 2**. **Table 13** provides a snapshot of the scenarios that result in a 21-day average concentration that exceeds the DWLOC, and examples of the represented uses. This is not intended to be a comprehensive list, but rather to associate the simulated scenario to chlorpyrifos use scenarios.

Using this approach, the number of 21-day exceedance periods associated with a single event cannot easily be parsed out, nor can the number of 21-day exceedance periods associated with individual events. Note that the application date that results in the highest 21-day average concentration does not always correspond to the application date that results in the highest number of 21-day averaging periods that exceed the DWLOC. In addition, examination of the EDWC exceedances across the modeled scenarios highlight that exposure concentrations of chlorpyrifos and chlorpyrifos-oxon are not expected to be uniform across the country.

Table 12. National Screening Results Using DWLOC Approach – Scenario Representation and Labeled Rate Comparison for Uses that Do Not Exceed the DWLOC

Use Site/Crop (representative scenario)	Highest[a] 21-day Average Concentration ppb (application date)	Maximum Single Application Rate	Comments
Pumpkin (FLCucumbersSTD)	3.3 (-30dpe) – at 0.3 lb a.i./A	0.3 (aerial and ground liquid)	This is a preplant seed treatment and assumes 100% of the applied material washes off the seed coat in the field and is available for transport.

a. Referenced EDWCs reflect highest 21-day average concentration calculated for each of the three application dates simulated.

Table 13. National Screening Results Using DWLOC Approach – Scenario Representation and Labeled Rate Comparison for Example Uses that Exceed the DWLOC

Scenario	Highest 21-day Average Concentration ppb (application date)	21-day Exceedance Count		Represented Use Site Examples (maximum single application rate)
		Highest[a] (application date[b])	Percent[c]	
1 lb a.i./A				
MScornSTD	16.5 (-30dpe) at 1.0 lb a.i./A	2273	21	Corn [2 lb a.i./A (aerial and ground)] Soybean [1 lb a.i./A (aerial); 2.2 (ground)]
TXcornOP	13.9 (30dpe) at 1.0 lb a.i./A	1418	13	
ILcornSTD	14.6 (30dpe) at 1.0 lb a.i./A	1697 (-30pde)	16	
MScotton	19.8 (-30dpe) at 1.0 lb a.i./A[g]	1697	16	Cotton [1 lb a.i./A (foliar aerial and ground); seed treatment permitted at 2.2 lb a.i./A]
NCcotton	14.4 (7dpe) at 1.0 lb a.i./A	2768 (-30pde)	25	
TXcotton	15.1 (30dpe) at 1.0 lb a.i./A	868	8	
NYgrape	15.7 (-30dpe) at 1.0 lb a.i./A	2918 (30pde)	27	Grape [2.25 lab a.i./A (ground)]
TXsorghumOP	25.8 (30dpe) at 1.0 lb a.i./A	1328 (-30pde)	12	Wheat [1 lb a.i./A (aerial and ground)] Sunflower [2 lb a.i./A (aerial and ground)] Other Grains: Sorghum [3.3 lb a.i./A (granular)[d]] Alfalfa [1 lb a.i./A (aerial and ground)]
TXwheatOP	21.0 (-30dpe[h]) at 1.0 lb a.i./A	705	6	
PAVegetableNMC	21.1 (30dpe) at 1.0 lb a.i./A	1972 (7dpe)	18	Vegetables and Ground Fruit: Strawberry [2 lb a.i./A (aerial and ground)] Radish [3 lb a.i./A (ground)[f]] Pepper [1 lb a.i./A (ground)] Onion [1 lb a.i./A (ground)]
CAlettuce	12.8 (-30dpe) at 1.0 lb a.i./A	840	8	
MEpotato	10.7 (-30dpe) at 1.0 lb a.i./A	1857	17	Other Row Crops: Tobacco [2 lb a.i./A (aerial and ground)] Sugarbeets [2 lb a.i./A (granular)[d]] Peanuts [4 lb a.i./A (granular)[e]] Sweet Potato [2 lb a.i./A (aerial and ground)]
NCsweetpotatoSTD	13.5 (30dpe) at 1.0 lb a.i./A	1006	9	
2 lb a.i./A				
MIcherriesSTD	19.6 (30dpe) at 2.0 lb a.i./A	4574	42	Orchards and Vineyards (Tree fruit and Nuts): Fruit and Nuts [4 lb a.i./A (ground)] Pecans [2 lb a.i./A (air); 4.3 (ground)] Apple [2 lb a.i./A (air and ground)] Peach [2 lb a.i./A (air); 3 (ground)]
GApecansSTD	20.7 (-30dpe) at 2.0 lb a.i./A	1353 (30dpe)	12	
PAapples	29.1 (30dpe) at 2.0 lb a.i./A	1212	11	

NCPeanutSTD	21.0 (30dpe) at 2.0 lb a.i./A	2282 (-30dpe)	21	Peanut 2.0 lb a.i./A (aerial and ground) 4 lb a.i./A (granular ground)
FLCitrusSTD	10.1 (30dpe) at 2.0 lb a.i./A	684	6	Citrus 6.0 lb a.i./A [ground including airblast] 2.3 lb a.i./A (aerial)

a. The highest number of 21-day time periods where the average concentration exceeds the DWLOC of the three use scenarios considered (*i.e.*, application date -30dpe, 7dpe, or 30dpe).
b. If different than the application date reported for the highest 21-day average concentration.
c. The highest percent of 21-day time periods where the average concentration exceeds the DWLOC. There are approximately 10,000 21-day time periods per 30 year simulation; however, it should be noted that not all scenarios contain exactly 30 years of weather data.
d. [1.0 (air and ground)]
e. [2.0 (air and ground)]
f. Incorporated or in furrow otherwise [1.0 (air and ground)]
g. A preplant seed treatment is permitted at 2.2 lb a.i./A and assumes 100% of the applied material washes off the seed coat in the field and is available for transport.
h. The application date that resulted in the highest 21-day average concentration does not represent the registered use; however, the other applications dates also result in exceedances (21-day average EDWCs range from 7.1- 8.2 for the two application dates)

Typical use rates were also examined for Michigan tart cherries to characterize what the actual exposure may be as a result of current use practices. For this analysis, two applications at 2 pounds per acre were assumed since the upper bound typical rate for cherries is 2 pounds per acre (99.6^{th} centile) with an average number of applications of 1.1 per year.[30] The use scenario modeled is provided in **Table 14** while the results are presented in **Table 15**. A national DWI PCA of 1 was considered for this analysis. The regional maximum PCA for HUC 2 Region 4: Great Lakes, where tart cherries are predominately grown, is also 1. If only the orchards and vineyards crop group is considered, the maximum DWI PCA in HUC 2 Region 4 is 0.05. This suggests the relative contribution (ignoring the application rate and corresponding EDWC) of chlorpyrifos transported to an aquatic body as a result of an application to tart cherries is expected to be lower than the contribution from other use sites within the watershed. If the only chlorpyrifos use permitted within this region was orchards and vineyards, the resulting EDWCs would not be expected to exceed the DWLOCs.

Additional analyses are needed in order to determine if other uses within HUC 2 Region 4 would result in an exposure concern. Considering only the maximum DWI PCAs calculated for individual crop groups within the HUC 2 Region 4, corn (PCA = 0.35), soybean (PCA = 0.20), and turf (PCA = 0.85) are likely to present the highest exposure concerns.

Table 14. Typical Michigan Tart Cherry Chlorpyrifos Application Scenario

Application Number	Application Timing; Type	Date	Method	Application Rate (lb a.i./A)	Formulation	Comments
1	Dormant/delayed Dormant; broadcast	4/30	Orchard blast	2.0	liquid	50 ft. buffer for orchard blast applications
2	Foliar; broadcast	6/1	Orchard blast	2.0	liquid	50 ft. buffer for orchard blast applications

30 Becker, J., Stebbins, K., *Typical Use Data for Chlorpyrifos*, **June 24, 2011**.

Table 15. Estimated Drinking Water Concentrations of Chlorpyrifos in Untreated Surface Water (Model Output Values; PCA 1.0; all ag + turf) for Typical Use on Tart Cherries

Absolute Peak	1-in-10 Year Concentration (ppb)				Relative Transport	Field to Water[a]
	Peak	21-day Average	Annual Average	30 Year Annual Average		
Michigan Tart Cherries						
55.2 (52.7)[b]	40.0 (38.2)	25.8 (24.6)	10.6 (10.1)	7.9 (7.5)	Runoff 18% Erosion 80% Drift 2%	1.2%

a. The relative amount of the material applied to the field that is transported off field and into the water body (*i.e.*, index reservoir).
b. Bracketed concentrations are for chlorpyrifos-oxon in treated drinking water

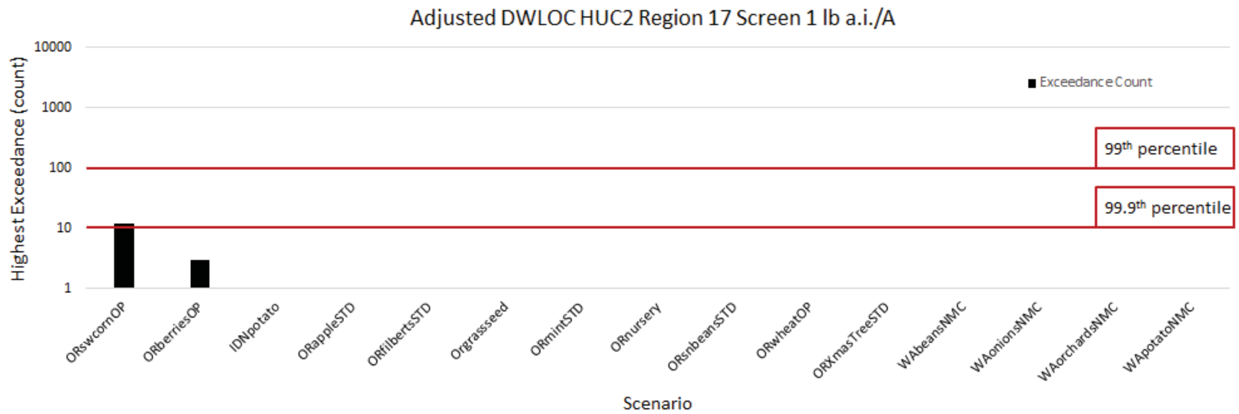
In summary, this analysis shows that the current maximum single application rates for a wide range of chlorpyrifos use scenarios may result in a 21-day average concentration that exceed the DWLOC. Again, this DWLOC approach does not consider the temporal aspects of the exposure concentrations on AChE inhibition or the geospatial distribution of exposure, but provides a means to easily identify use patterns that should not result in EDWCs that exceed the DWLOC.

Regional Screen

To examine the potential geospatial concentration differences, a regionally-specific analysis was completed for two Hydrological Unit Code (HUC) 2 Regions – HUC 2 Region 3: South Atlantic-Gulf and HUC 2 Region 17: Pacific Northwest. These two HUC 2 regions were selected to represent the range of SWCC standard scenarios that fall within the HUC 2 regions, the different chlorpyrifos use scenarios expected to occur within the HUC 2 region, as well as to provide a reasonable representation of the bounds of potential exposure on a regional basis. The same model simulations that were used in the national screen were used in this analysis; however, regional DWI PCAs, as well as the molecular weight adjustment factor, were used to adjust the EDWCs to estimate the potential exposure to chlorpyrifos-oxon in drinking water. The maximum regional DWI PCAs for all agriculture plus turf are 0.74 and 0.65 for the Pacific Northwest and the South Atlantic-Gulf HUC 2 Regions, respectively.

The total number of exceedance periods (*i.e.*, 21-days) over the entire model simulation (approximately 30 years) for the application date that results in the highest number of exceedances calculated for 1 and 4 pound(s) per acre for each standard SWCC scenario that falls within the HUC 2 Region are presented. The exceedance count was calculated using the Excel macro mentioned above; however, the 21-day DWLOC for chlorpyrifos-oxon was adjusted by the molecular weight adjustment factor as well as the maximum regional DWI PCA to calculate the corresponding chlorpyrifos concentration, since the time series data generated by the SWCC are for chlorpyrifos. The corresponding chlorpyrifos concentrations are 5.5 µg/L[31] and 6.3 µg/L[32] for the Pacific Northwest and the South Atlantic-Gulf HUC 2 Regions, respectively. The results of this analysis are presented in **Figure 5** for HUC 2 Region 17: Pacific Northwest for a single application of chlorpyrifos at 1 and 4 pounds per acre. The results for HUC 2 Region 3: South Atlantic-Gulf are provided in **Figure 6** for a single application at 1 and 4 pounds per acre. Only the results from the scenarios that reasonably represent current chlorpyrifos uses within the respective regions are presented in these figures.

[31] 3.9 ppb chlorpyrifos-oxon / 0.9541 / 0.74 = 5.5 ppb chlorpyrifos
[32] 3.9 ppb chlorpyrifos-oxon / 0.9541 / 0.65 = 6.3 ppb chlorpyrifos



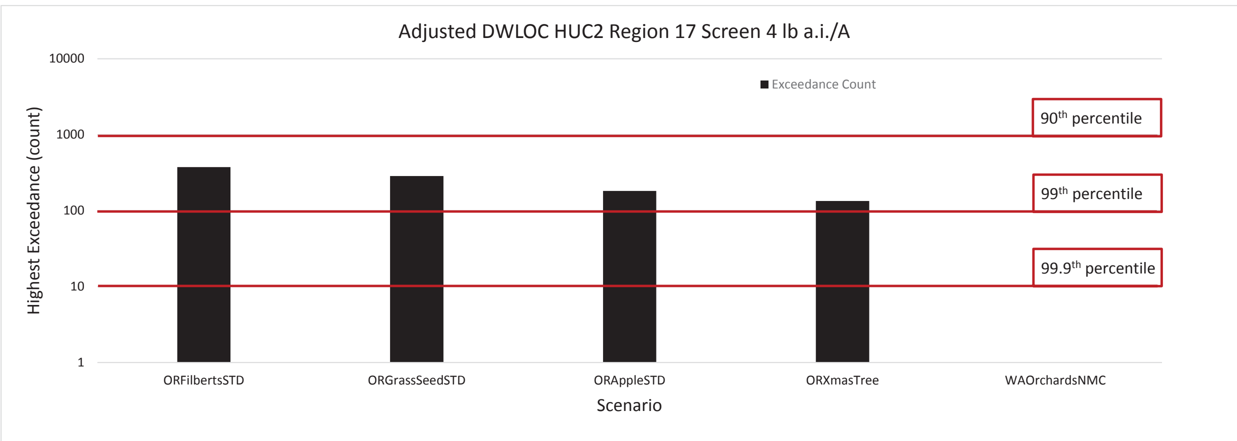


Figure 5. Regional Screening Results Using DWLOC Approach for HUC 2 Region 17: Pacific Northwest

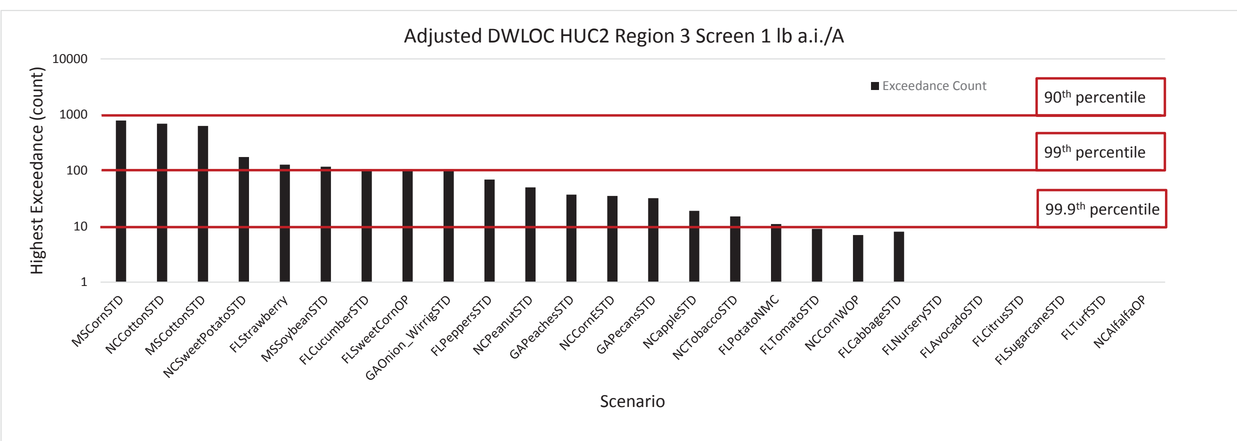


Figure 6. Regional Screening Results Using DWLOC Approach for HUC 2 Region 3: South Atlantic-Gulf

For HUC 2 Region 17: Pacific Northwest, exceedances are only observed for two scenarios (ORSWCornOP and ORBerriesOP) at a single application rate of 1 pound per acre. When a single application rate of 4 pounds per acre is considered, several scenarios (ORFilbertSTD, ORGrassSeedSTD, ORAppleSTD, ORXmasTree) result in 21-day average concentrations that exceed the DWLOC. The tree fruit and nut fruit scenarios may represent a 4 pounds per acre application rate for chlorpyrifos applied to fruit and nuts trees [for non-bearing (not to bear fruit within 1 year)] in nurseries including: almonds, citrus, filbert, apple, cherry, nectarine, peach, pear, plum, and prune]. Additional clarification is needed on this use to confirm that this scenario represents the registered use. The grass seed scenario is representative of the potential use sites for ornamental lawns and turf and sod farms. However, the maximum single application rate is 3.76 pounds per acre. The concentrations will be slightly lower than those calculated for a 4 pound application, reducing the number of likely exceedances.

In contrast to the results presented for the Pacific Northwest, a larger number of scenarios (primarily representing corn, cotton, soybean, and vegetable and ground fruit, and fruit and nut tree use sites) were determined to result in 21-day average concentrations that exceed the DWLOC when only a single application rate at 1 pound per acre is considered. More exceedances are expected for higher application rates; however, not all of the SWCC scenarios considered in the 1 pound analysis would be representative of use sites where higher chlorpyrifos applications are permitted.

This analysis underscores the regional exposure variations that likely exist across the United States. For those scenarios where exceedances are already expected, more exceedances would be expected for multiple applications. However, for those use scenarios where a single application does not result in exceedances, additional analyses are needed to explore the potential of multiple applications per year, as this screen only considered one application per year. Similar to the national analysis, this regional approach does not parse out the number of 21-day exceedance periods associated with a single event, or the number of 21-day exceedance periods associated with individual events within a given year. Furthermore, the temporal variability in concentrations is an uncertainty.

This regional analysis does not confirm overlap of potential chlorpyrifos use sites with vulnerable watersheds. To investigate this further, potential use sites (*i.e.*, corn[33]) were overlaid with the drinking water intake delineated watersheds (**Figure 7)**. The watersheds with a maximum yearly 21-day average concentration that exceeds the DWLOC are shaded in **Figure 7**. The cropland overlay used is for corn and does not take into account other chlorpyrifos uses that occur within the HUC 2 Region. However, the average pounds of chlorpyrifos applied per 1,000 acres of farmland by state was used to highlight the chlorpyrifos expected use intensity within the region. These data should not be used as a means to calculate an application rate for chlorpyrifos per acre as the data are provided in terms of acres of total farmland and not acres of farmland treated with chlorpyrifos. It should be noted that use information on a smaller scale (*e.g.*, crop reporting district, county or watershed) may be available; however, the sample size for small geographical areas are generally low.

There are a number of known DWIs that do not have delineated watersheds. For some of these DWIs, surrogate PCAs have been assigned from the HUC 12 region PCAs[34] that encompass the intake, while other known intakes[35] do not have a surrogate PCA at this time. None of these intakes or surrogate HUC 12s are presented in **Figure 7**. Additional analysis could be done, overlaying the intake locations that do not have PCAs with potential chlorpyrifos use sites.

---

[33] Cropland Data Layer for corn aggregated for the years 2010 through 2013
[34] 634 surrogate HUC 12 PCA were developed for the United States
[35] 761 “new” intakes and 359 canals or aqueducts

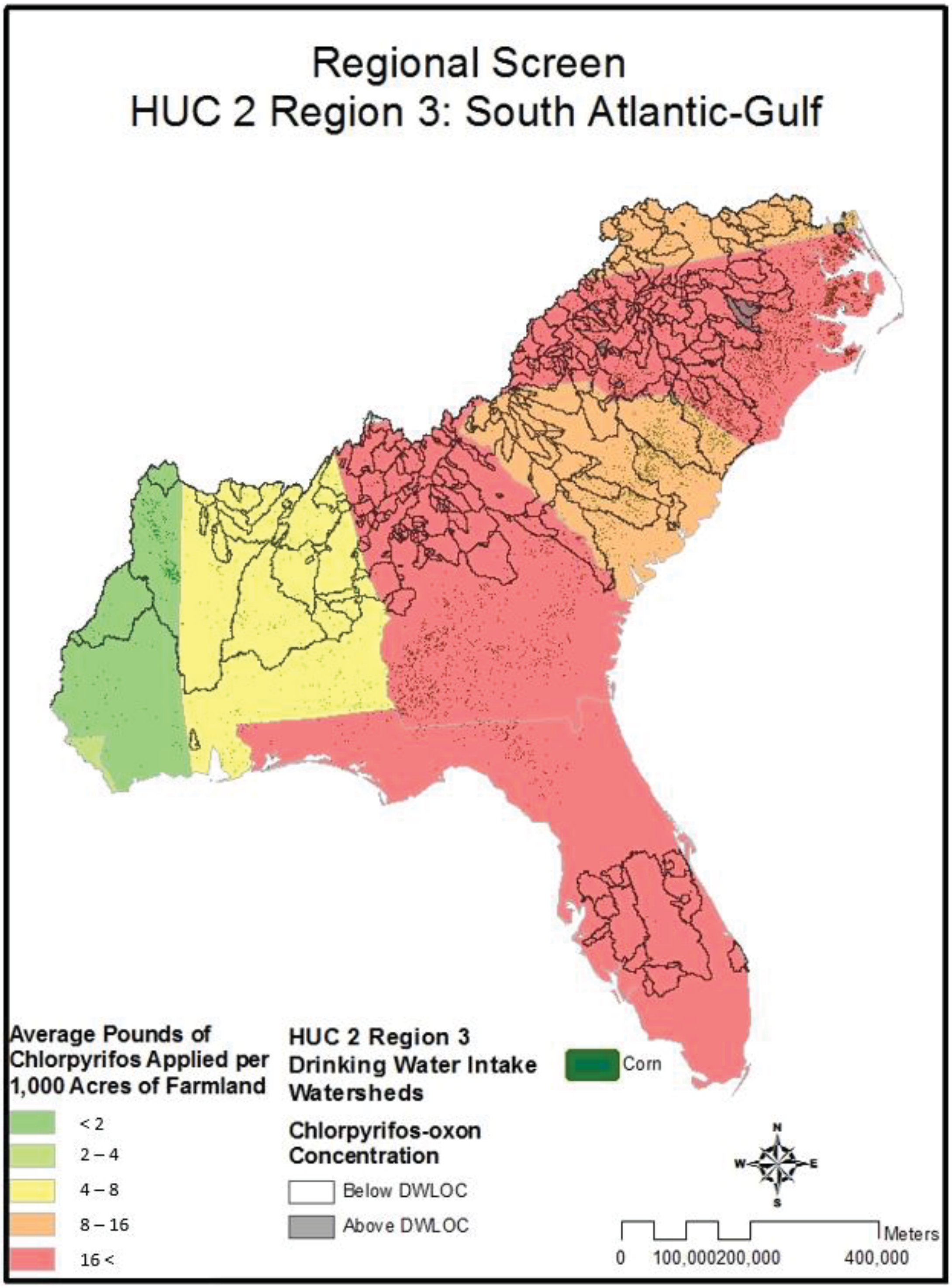


Figure 7. Region 3: South Atlantic-Gulf: Corn Cropland Overlay with Drinking Water Intake Watersheds Where the 21-day Average Concentrations are expected to Exceed the DWLOC

Figure 8 provides the ranking distribution of the highest 21-day average EDWCs for the three application dates assessed for HUC 2 Region 3 for corn. This distribution does not include DWIs that have been assigned a surrogate HUC 12 PCA, or those intakes where a PCA has not been developed. The y-axis of this graph represents the highest 21-day average concentration, while the x-axis represents the relative rank of the 21-day average concentration for each of the DWI watersheds (*i.e.*, DWI PCA corrected EDWCs) from the highest to the lowest. This distribution suggests that depending on the application date, there is generally more than one (n=13) community drinking water system that could be using source surface water for supplying drinking water where a 21-day average concentration of chlorpyrifos or the corresponding chlorpyrifos-oxon is estimated to be higher than the DWLOC.

For additional characterization, the exceedance count for the DWIs where the 21-day average concentration is expected to exceed the DWLOC at least once was determined. These results are presented in **Figure 9**.

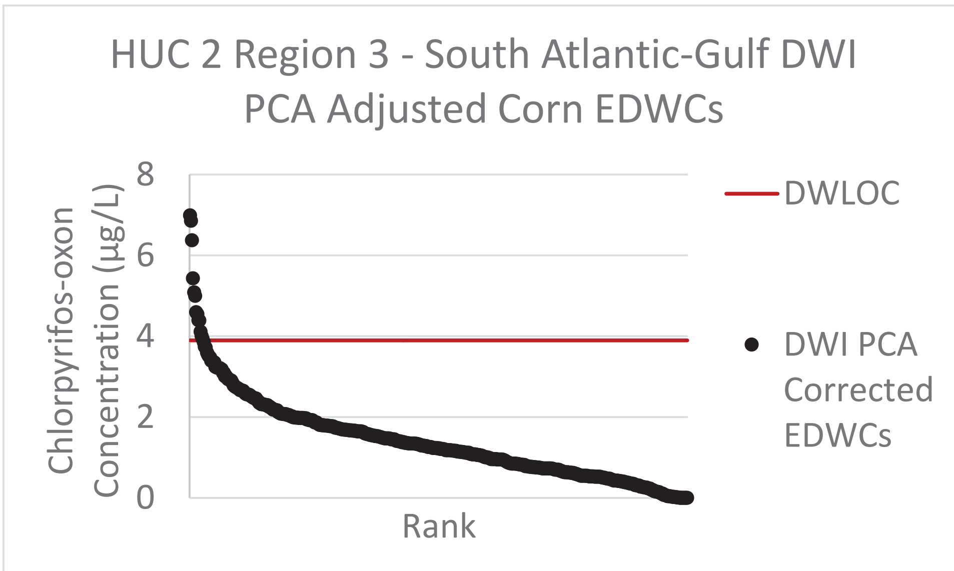


Figure 8. Regional Distribution of the Maximum Yearly Corn 21-day EDWC for DWI Watershed in Region 3: South Atlantic-Gulf

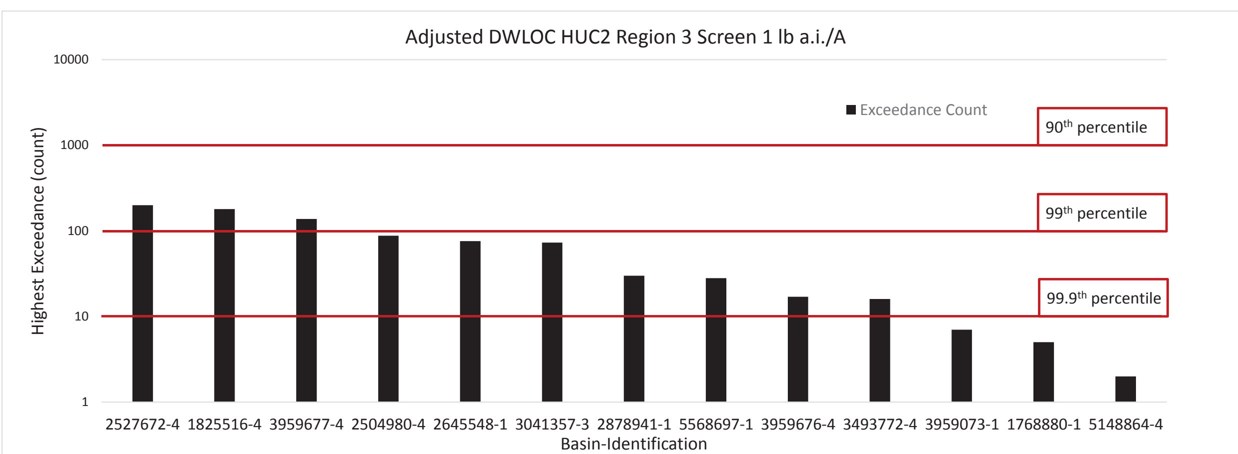


Figure 9. Regional Screening Results Using DWLOC Approach for Vulnerable Drinking Water Intakes Falling Within HUC 2 Region 3: South Atlantic-Gulf;

While the field size and the index reservoir (the receiving water body) used in the SWCC simulations may provide reasonable upper bound EDWCs on a national scale, the watershed sizes and the receiving water bodies represented by the DWI dataset vary substantially from very large to very small (**Figure 10**). The index reservoir represents a vulnerable drinking water scenario in the Midwest (*i.e.*, Shipman City Lake in Shipman, Illinois) and although the index reservoir serves as a screening tool, it represents the drainage area/normal capacity of a drinking water reservoir in other parts of the United States.[36] In addition, as the water body size changes, the relative watershed size is also expected to change. Therefore, the mass coming from the treated watershed relative to the waterbody volume may stay relatively the same for vulnerable scenarios. Nevertheless, the assumption that the entire watershed is treated with chlorpyrifos on the same day at the same rate is likely conservative for larger watersheds (27,887 square mile; 95th centile). However, as the watershed size decreases it is more likely that an entire watershed could be treated with chlorpyrifos on the same day, especially when considering some of the small watersheds (1 square mile; 10th centile). The index reservoir is approximately 0.67 square miles.

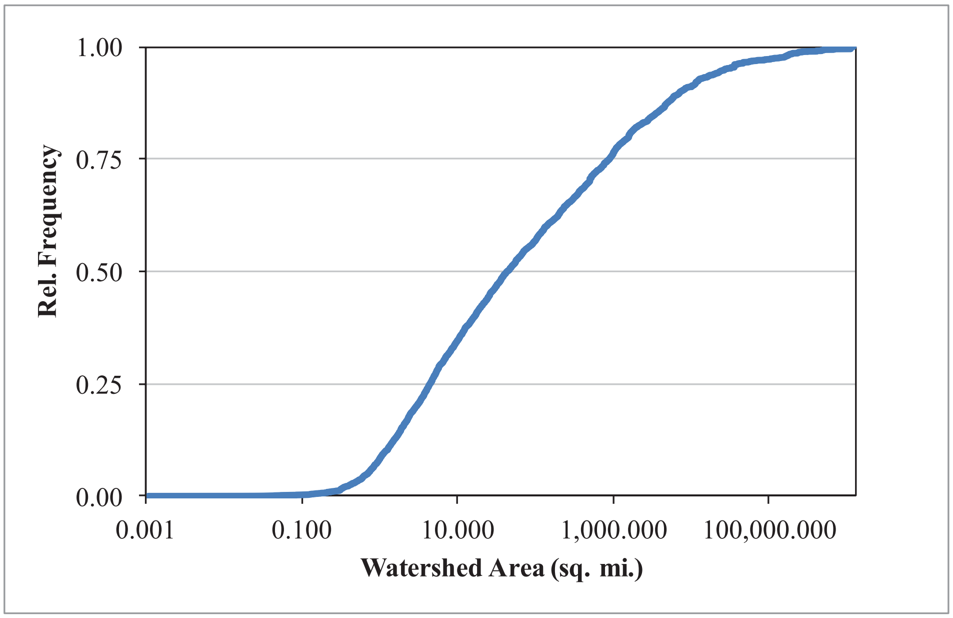


Figure 10. Drinking Water Intake Watershed Size Distribution

Based on the regional analysis for HUC 2 Region 3, up to 3% of the watersheds may have chlorpyrifos concentrations high enough that upon drinking water treatment, the concentration of chlorpyrifos-oxon will exceed the DWLOC resulting from chlorpyrifos application made to corn at 1 pound per acre. In addition, this analysis shows there is overlap with the potential use sites (corn) and known chlorpyrifos use with watersheds that supply source surface water for community drinking water systems. This analysis also demonstrates that even within a HUC 2 region, there is a wide range of estimated concentrations that are expected to be highly localized (*e.g.*, watershed/community drinking water system); however, the community water systems where chlorpyrifos and chlorpyrifos-oxon exposure is expected to be higher than the DWLOC can be identified with reasonable certainty.

Additional analysis is needed in order to appropriately characterize the expected exposure for other chlorpyrifos uses within HUC 2 Region 3, as well as the intakes that do not have delineated watersheds or surrogate HUC 12 PCAs. Examination of the other HUC 2 Regions could be completed.

---

[36] U.S. Environmental Protection Agency. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel: Proposed Methods for Basin-scale Estimation of Pesticide Concentrations in Flowing Water and Reservoirs for Tolerance Reassessment; Linear Low Dose Extrapolation for Cancer Risk Decisions; DDVP Risk Issues; FQPA 10 Safety Factor Status Report; and Chlorothalonil: Mechanism for the Formation of Renal and Forestomach Tumors, **July 29-30, 1998**.

ADDITIONAL ANALYSES

Modeling and Monitoring Data Comparison

As part of the preliminary DWA, several sources of surface water and groundwater monitoring data were examined. Sources included: USGS National Water-Quality Assessment Program (NAWQA), USEPA/USGS Pilot Reservoir Monitoring Program, USDA Pesticide Data Program (PDP), California Department of Pesticide Regulation (CDPR), and National Center for Water Quality Research (NCWQR) at Heidelberg College.[37,38] In summary, the monitoring data showed that detections of chlorpyrifos are much more likely to occur in surface water than groundwater, and concentrations in surface water are generally higher than groundwater.

We conclude from our analysis of the available surface water monitoring data that it likely underestimates chlorpyrifos and chlorpyrifos-oxon concentrations in drinking water, and thus it is not recommended for quantitative risk assessment purposes. These water monitoring sampling programs did not specifically target chlorpyrifos use and likely do not represent high chlorpyrifos use areas. In addition, sample timing may not have corresponded with applications or runoff events; therefore, detections cannot be directly associated with a particular use pattern or site. In addition, monitoring locations, sampling frequencies, and sampling timing were not designed to capture peak concentrations. Model generated times series data along with anticipated use (*i.e.*, sporadic) suggest that monitoring programs need to sample frequently in order to capture peak concentrations of chlorpyrifos in surface water. Even in the case of a pesticide such as atrazine, which has a more consistent use pattern, the sample frequency should be daily, otherwise a bias factor is recommend to be applied to ensure peak concentrations are captured.[39]

Since the finalization of the preliminary DWA, three additional water monitoring datasets were evaluated. The Washington State Department of Ecology and Agriculture (WSDE/WSDA) Cooperative Surface Water Monitoring Program published two reports on multi-year aquatic monitoring studies conducted in Washington.[15,16] Dow AgroSciences submitted data (MRID 44711601) for a surface water monitoring study conducted on a tributary of the San Joaquin River in California. A summary of these studies is provided below.

California (Registrant Monitoring Program MRID 44711601)

Sampling was conducted at three locations on the lower reach of Orestimba Creek for one year (May 1, 1996 to April 30, 1997). Daily time-proportional composite samples[40] were collected, along with weekly samples. The report included chlorpyrifos use information for fields that drained into the creek or had the potential to contribute spray drift[41]. All chlorpyrifos applications were made to alfalfa and walnut by aerial equipment and were made during the irrigation season. The total mass of chlorpyrifos applied to all the fields that were identified to have the potential to impact the creek was 2.2 lb a.i./A (1308 kg).

---

[37] Note, at the time of the preliminary DWA was completed the NCWQR data had not been thoroughly reviewed by EPA and since this time the authors have indicated that proper quality assurance and quality control standards may not have been met.
[38] A discussion of each of the individual datasets is provided in the preliminary assessment.
[39] U.S. Environmental Protection Agency. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel Meeting: Problem Formulation for the Reassessment of Ecological Risks from the Use of Atrazine, **June 12-14, 2012**, Docket Number: EPA-HQ-OPP-2012-0230
[40] Hourly samples were collected and composited over a 24-hour period; relatively large fluctuations in stream flow were anticipated during unattended operation of the auto samplers
[41] Fields within 305 m buffer on either side of the mid-stream line

Applications occurred throughout the study period (or the day prior to study initiation) with, at most, three fields treated in the study area on the same day. The report suggests that typical chlorpyrifos use occurred during the study period, with the exception of dormant season applications to tree crops, which were limited due to the rainy weather during the study.

The measured concentrations at the three sample locations are provided in **Figure 91**. The highest measured concentration was 2.2 µg/L and was associated with a chlorpyrifos application to alfalfa followed by flood irrigation.

In several cases, the weekly grab samples were observed to have higher concentrations of chlorpyrifos. This suggests that the composite sampling methodology used in the study for daily samples resulted in the dilution of peak daily concentrations. Thirteen chlorpyrifos peak concentrations could be associated with specific events. The report authors suggest that nine of the events were related to spray drift (peak concentrations occurring within a three day window of application,) and were not linked to an irrigation event. The other four events were linked to irrigation tail water. Flood irrigation was reportedly used in the treated fields. Most of the peak concentrations were observed following chlorpyrifos applications to walnuts. The report noted that many of the walnut orchards are planted adjacent to the creek with an outside row located on the creek bank. This practice was done to maximize drainage from the orchard floor directly into the stream channel. It is unclear if any buffer zones were in place during application, but the observed concentrations suggest that the spray drift occurred during application even in the absence of adverse wind conditions.

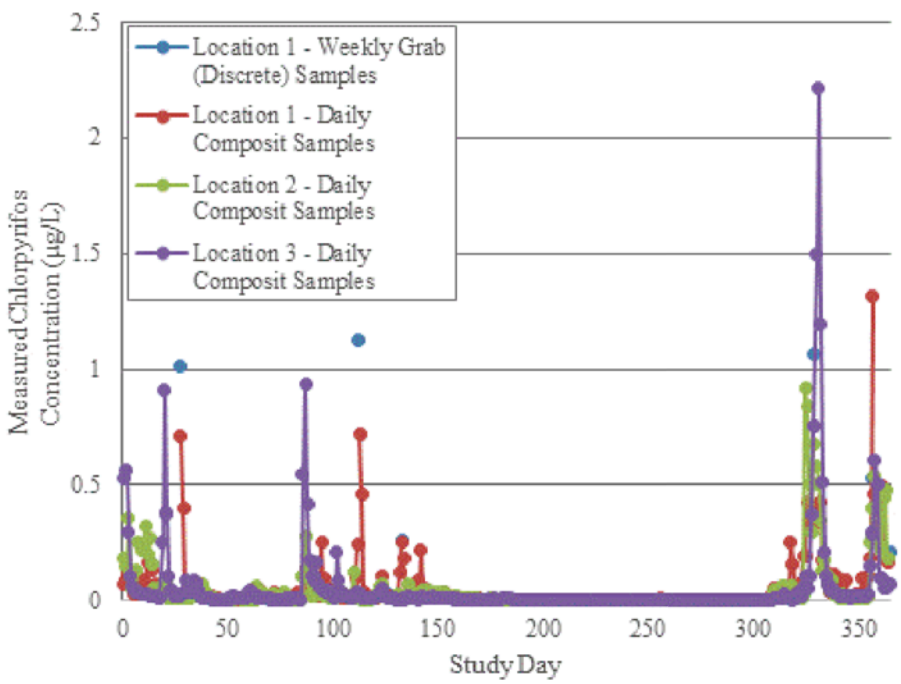


Figure 91. Orestimba Creek Water Monitoring Data (May 1, 1996 to April 30, 1997)

Not all monitored concentrations were observed shortly after the application event. There is one example where the peak measured concentration (0.32 µg/L) associated with an application event occurred 56 days after application. The detection was associated with an irrigation event. This suggests that chlorpyrifos residues available for transport may persist on the field for several days (approximately two months) after application. No detections of chlorpyrifos were observed during the rainy season.

Representative model simulations were completed for comparative purposes and are presented in

Table 16. The scenarios used in this analysis are provided in
Table 16, while chemical specific model input values are provided in **Table 10**. The estimated peak concentrations are higher than the measured concentrations; however, the estimated concentrations are within an order of magnitude of the measured concentrations.

The estimated concentrations are expected to be highly conservative for a few reasons. A PCA adjustment factor was not applied and it is known that the entire watershed was not treated on the same day or planted with crops that chlorpyrifos may be applied. The report noted that approximately 80 percent of the watershed was forest. If the remaining watershed was assumed to be treated (PCA = 0.20) the peak estimated concentrations are in reasonable agreement with the measured concentrations. Also, the amount of chlorpyrifos applied to the entire area of influence was only 2.2 lb a.i./A spread out over the course of the study. The model simulations assumed all the chlorpyrifos applied over the course of the study (one year) was applied as a single application event. Lastly, the model simulation also considered a worst case spray drift scenario. It is unclear if any drift reduction technologies (spray drift buffer, large droplet sizes, etc.) were utilized; however, spray drift reduction strategies (*i.e.*, buffers) were not added to the chlorpyrifos labels until the Interim Registration Eligibility Decision in February 2002.

Table 16. Surface Water Concentration Calculator Simulation Results Comparison with Orestimba Creek Surface Water Monitoring Data

Represented Location	Represented Crop Use	Estimated Drinking Water Concentration μg/L (PCA adjusted concentration)			Maximum Detected Chlorpyrifos Concentration (associated use)
		1-in-10 Year Peak	1-in-10 Year Annual Average	30 Year Average	
1	Walnut	13.4 (2.68)	2.35 (0.47)	1.73 (0.35)	1.32 μg/L (walnut, spray drift) June 11, 1997 (day 357)
2	Alfalfa	5.66-12.9 (1.13-2.58)	0.69-1.56 (0.14-0.31)	0.61-1.39 (0.12-0.28)	0.92 μg/L (alfalfa, flood irrigation) May 6, 1997 (day 325)
3					1.22 μg/L (alfalfa, flood irrigation) May 13, 1997 (day 331)

a. CA Almond, 1/2.2 lb a.i./A(assumes total annual application of chlorpyrifos was made to the single field on one day), June 10, aerial application [0.95; 0.135 (spray drift assuming no buffer zones or droplet size restrictions)
b. CA Alfalfa, 1/2.2 lb a.i./A (assumes total annual application of chlorpyrifos was made to the single field on one day) or 1/1.0 lb a.i./A (maximum currently registered application rate), May 6, aerial application [0.95; 0.135 (spray drift assuming no buffer zones or droplet size restrictions)

This analysis suggests that the model estimated concentrations of chlorpyrifos compare well with monitoring data when the model is parameterized to reflect the actual use and the PCA. Therefore, it is expected that the model estimated chlorpyrifos concentrations provide a reasonable upper bound of concentrations that may occur in the environment based on the modeled use and PCA applied. In addition, this dataset indicates sporadic detections and rapidly fluctuating concentrations of chlorpyrifos, further supporting the use of model EDWCs for deriving a reasonable upper bound estimation of chlorpyrifos exposure in drinking water.

The time series data were further investigated to identify bias factors. The approach employed was the same as that developed for atrazine.[39] The results are presented in the **Table 17**. Bias factors were developed for each of the three sampling sites included in the study.

Based on this bias factor analysis, if monitoring data were available, for example, with a sample frequency of 21 days, a bias factor of 6.0 would be needed to adjust the measured concentration to obtain an upper bound estimate of the 21-day average exposure concentration. For the same sample frequency, a bias factor of 32 is needed to adjusted measured concentrations to capture an upper bound average daily concentration.

Table 17. Bias Factor Values Developed based on Orestimba Creek Surface Water Monitoring Data

Annual Rolling Average Maxima	Sampling Frequency		
	7-day	14-day	21-day
	Average Bias Factor (range of bias factors)[a]		
Daily	4.35 (3.05 – 5.99)	12.0 (5.73 – 14.2)	14.3 (4.36 – 31.7)
21-day	2.08 (1.35 – 2.99)	3.34 (1.96 – 5.12)	3.06 (1.43 – 5.98)
a. Bias factors calculated based on the three different sampling sties included in the monitoring study.			

Washington State

Sampling focused on salmon-bearing streams in five different basins within Washington. Primarily weekly sampling was conducted during the pesticide use season; however, some daily sampling was also conducted. While the study did not specifically target chlorpyrifos use, nor did the report provide pesticide use information, some pesticide use survey data was obtained from WSDA. In addition, the report included information on the PCA for each of the basins included in the report.

The highest chlorpyrifos detections occurred within the Lower Yakima Agricultural Watershed (**Table 18**). The highest concentration (0.27 µg/L) was detected in Spring Creek in 2007. Within the Lower Yakima Agricultural Watershed, use of chlorpyrifos includes: wine grapes (early dormant spray), tree fruits (early dormant spray), and mint (late season). Chlorpyrifos detection frequencies ranged from 3 to 68% for weekly sampling. Daily samples were collected (mid-May-June) for one year at one location. When daily and weekly sampling frequencies of detection were compared, daily sampling detection frequency was more than 25% higher.

Table 18. WSDA Monitoring Summary for Chlorpyrifos (2006-2011)

Location	Spring Creek	Sulphur Creek Wasteway	Marion Drain
Maximum Detected Chlorpyrifos Concentration	0.27 µg/L	0.28 µg/L	0.12 µg/L
Sample Year[a]	2007	2009	2006 and 2007
Watershed Size (acres)	27,373	103,010	80,491
PCA[b]	50	42	66
Primary Crops (PCA)[c]	Apples (4); Concord Grape (6); CRP (12%); Wine Grape (7); Hops[d] (3); Wheat (12)	Apples (5); Corn (8); Concord Grape (7); Wine Grape (4); Wheat (3)	Apples (9); Corn (12); Concord Grape (3); Hops (13); Mint (6); Wheat (8)

a. The exact sampling date is not provided in the report.
b. Percent cropped area provided for each basin in the report; includes grass, hay, and CRP (Conservation Reserve Program)
c. Survey data from report
d. Not a registered chlorpyrifos use

Combined with the chlorpyrifos use information (type/timing of application), maximum label rates, and PCA, model simulations were completed for comparative purposes. The use scenarios used in model simulations for this analysis are provided in **Table 19**, while chemical specific model input values are provided in **Table 10**. Note that a range of application dates was examined and the date that provided the highest concentration is reported. The results of this analysis are shown in **Table 19**. In addition, the maximum detected concentrations were adjusted based on the maximum bias factor (2.99 based on a peak concentration and a sampling interval of 7 days) developed (presented in **Table 17)** for Orestimba Creek Surface Water Monitoring Data and are reported in **Table 19.**

Table 19. Surface Water Concentration Calculation Simulation Comparison with Washington State Department of Ecology and Agriculture Cooperative Surface Water Monitoring Program

Represented Location	Represented Crop Use	Model Output *PCA Corrected for Total Cropland* *(PCA Corrected for Specific Crop[a])*				Maximum Detected Chlorpyrifos Concentration (bias factor adjusted value)
		Absolute Peak	1-in-10 Year Peak	1-in-10 Year Annual Average	30 Year Average	
Spring Creek	Apples[b]	4.0 *2.0* *(0.16)*	2.6 *1.3* *(0.10)*	0.35 *0.18* *(0.01)*	0.23 *0.12* *(0.01)*	0.27 µg/L (0.81)
	Grape[c,d]	4.3 *2.2* *(0.56)*	1.7 *0.85* *(0.22)*	0.25 *0.13* *(0.03)*	0.15 *0.08* *(0.02)*	
Sulphur Creek Wasteway	Apples[b]	4.0 *1.7* *(0.20)*	2.6 *1.1* *(0.13)*	0.35 *0.15* *(0.02)*	0.23 *0.10* *(0.01)*	0.28 µg/L (0.84)
	Grape[c,d]	4.3 *1.8* *(0.47)*	1.7 *0.71* *(0.19)*	0.25 *0.11* *(0.03)*	0.15 *0.06* *(0.02)*	
Marion Drain	Apples[b]	4.0 *2.6* *(0.36)*	2.6 *1.7* *(0.23)*	0.35 *0.23* *(0.03)*	0.23 *0.15* *(0.02)*	0.12 µg/L (0.36)
	Grape	4.3 *2.8* *0.13*	1.7 *1.1* *0.05*	0.25 *0.17* *0.01*	0.15 *0.01* *<0.01*	
	Mint	6.1 *4.0* *(0.37)*	3.0 *2.0* *(0.18)*	0.36 *0.24* *(0.02)*	0.22 *0.15* *(0.01)*	

a. PCA adjusted EDWCs reflect EDWCs if only the crop specified is treated within the watershed
b. ORApple, w24243 (Yakima), 1/2.0 lb a.i./a, dormant 1/14 (dates examined: 1/1-3/31 based on emergence date in scenario), ground application
c. CAGrape, w24243 (Yakima), 2/2.0 lb a.i./a, 7-day application retreatment, dormant 1/13 (dates examined: 1/1-1/23 based on emergence date in scenario), ground application
d. Individual and combined PCA for concord and wine grapes.
e. ORMint, w24243 (Yakima), 1/2.0 lb a.i./a, 8/17 (8/1-9/31), ground application

Current national spray drift restrictions were considered as part of this analysis.

The estimated peak concentrations including bias factor adjusted concentrations are generally higher but never greater than an order of magnitude higher than the maximum observed concentrations when a total cropland PCA is applied to the output values. The estimated concentrations may be higher than the measured values because 1) the sampling program missed the peak concentration, 2) the monitored locations were less vulnerable than the standard "scenarios" used in the model simulations, and/or 3) the application rate and dates were different between the monitoring program and model simulations. Another consideration is the site to site extrapolation of bias factors. At this time, the relative differences between the vulnerability of the sampling sites along Orestimba Creek and those sites included in this dataset are unknown. Therefore, the appropriateness of applying the bias factors calculated for the Orestimba Creek data across the board to a dataset like NAWQA, where the site vulnerability varies substantially, is uncertain.

When individual crop PCAs are considered, the estimated peak concentrations in some cases underestimate the measured maximum concentrations. This may be the result of multiple chlorpyrifos applications (*i.e.*, multi-crop) contributing to the measured concentration.

This analysis demonstrates that the model estimated concentrations reasonably compare to measured concentrations. This suggests that if the maximum labeled rates were applied, as simulated using the SWCC, the model EDWCs provide a reasonable upper bound on the potential exposure and are not overly conservative.

USGS National Water-Quality Assessment Program (NAWQA)

The NAWQA data were re-examined and the bias factor needed to result in a 21-day exceedance was calculated for each sampling site. Based on this analysis, the lowest bias factor calculated for a maximum 21-day average concentration to exceed the DWLOC was 8.2. The highest calculated bias factor for a 21-day average concentration based on a 21-day sampling interval was 6 based on the Orestimba Creek Surface Water Monitoring data. This would suggest that none of the sites exceeded the DWLOC. However, using a crude approximation of the sampling frequency (365 divided by the number of samples taken in a year), these sites had samples taken less frequently than every 21 days. Thus, a larger bias factor is likely needed to account for the limited sampling at these sites in order to estimate an upper bound 21-day average concentration. Therefore, it is likely that only of a few sampling sites included in the NAWQA dataset may have actually had a 21-day average concentration that exceeded the DWLOC. This suggests actual use of chlorpyrifos differs from the maximum rates included in the **Master Use Summary Document**. This is consistent with the typical rate analysis completed by BEAD.[30,42]

The conclusion of the **Model Simulations** section of this document (*i.e.*, chlorpyrifos and the corresponding chlorpyrifos-oxon concentrations vary substantially across the United States, and the exceedances of the DWLOC are highly localized) is underscored by this analysis. In addition, the relative differences between the vulnerability of the sampling sites along Orestimba Creek and those sites included in the NAWQA dataset are unknown. Therefore, the appropriateness of applying the bias factors calculated for the Orestimba Creek data across the board to a dataset like NAWQA, where the site vulnerability varies substantially, is uncertain.

Drinking Water Treatment

The preliminary DWA concluded that there are a number of different drinking water treatment processes that may impact the amount of chlorpyrifos and chlorpyrifos-oxon in drinking water and that the variation and combinations of processes used by the different treatment plant across the country make it difficult to estimate the exact amount of chlorpyrifos or chlorpyrifos-oxon that may be in drinking water on a national basis. In absence of evaluating each individual community drinking water treatment facility separately, the preliminary DWA recommended that all of the chlorpyrifos that enters a drinking water treatment facility be assumed to remain after treatment, as well as to assume that all the chlorpyrifos entering the facility was converted to chlorpyrifos-oxon during treatment. This was recommended to provide a bounding estimate of the potential exposure. It is likely that this approach overestimates the potential of exposure to chlorpyrifos and chlorpyrifos-oxon in drinking water distributed by some community drinking water systems, because processes like filtering with activated carbon, sedimentation, or water softening are not considered. Recent publications that examined the effectiveness of the use of activated carbon have shown that the source of activated carbon has a significant impact on the removal

---

[42] Stebbins, K., *Additional Typical Use Data for Chlorpyrifos*, **January 11, 2012**

efficiency of various organic compounds. **Table 20** includes additional information on the breakdown of drinking water treatment processes used across the United States and supports the recommendations of the preliminary DWA, as well as empirical data on the percent removal of chlorpyrifos under such conditions.[43]

All facilities distributing drinking water derived from surface water are required to filter and disinfect.[44] The majority of treatment plants use chlorine as a disinfectant; however, less than 18% rely solely on chlorine. Generally, smaller community water systems rely on chlorination as their primary drinking water treatment method. Larger systems are more likely to use alternative disinfectant process to chlorine, such as chloramines when compared to smaller treatment plants. On average, 15% of treatment plants are not using chlorine. Water softening and chlorination are the most effective ways to reduce chlorpyrifos concentrations in surface source drinking water. However, use of chlorination results in the formation of chlorpyrifos-oxon.

To date, studies looking at the removal efficiency of chlorpyrifos across a range of treatment process have not looked at the formation of the chlorpyrifos-oxon. Moreover, no data are currently available on the percent chlorpyrifos-oxon reduction under typical drinking water treatment conditions. Water softening is expected to reduce the concentration of chlorpyrifos and chlorpyrifos-oxon due to rapid hydrolysis. While the USGS-EPA Pilot Reservoir Monitoring Program monitored raw and finished water, the correlation between sampling was not adequate, as finished water sampling generally occurred before raw water sampling. The removal of chlorpyrifos or chlorpyrifos-oxon from other processes such as sedimentation and flocculation is also unknown. However, in general, these processes have not been shown to be effective treatment processes for removing pesticides.

One study[45] examined the impact of pesticide removal on a combination of potential drinking water treatment methods; however, this study did not assess the formation or dissipation of chlorpyrifos-oxon. The results of this study are consistent with other available data (**Table 20**) that examined the reduction of chlorpyrifos under individual treatment processes. EFED is not aware of data for individual treatment plants on the impact of pesticide removal specifically for chlorpyrifos and chlorpyrifos-oxon. EFED is also unaware of any monitoring data for chlorpyrifos or chlorpyrifos-oxon at the point of consumption (*i.e.*, consumer tap water).

---

[43] Chamberlain, E. Shi, H., Wang, T., Ma, Y., Fulmer, A., Adams. C. J Agric. Food Chem. **2012**, *60*, 354-363.
[44] (54 FR 27486, June 29, 1989) (EPA, 1989b) 40 CFR Parts 141 and 142 Drinking Water; National Primary Drinking Water Regulations; Filtration, Disinfection; Turbitity, Giardia lamblia, Viruses, Legionella, and Heterotrophic Bacteria; Final Rule
[45] Ormand, M. P., Miguel, N., Claver, A., Matesanz, J. M., Ovelleiro, J. L. Chemosphere, **2008**, *71*, 97-106.

Table 20. Screening Analysis of Chlorpyrifos Degradation Under Typical Drinking Water Treatment Processes (surface water)

Treatment Method[a]	*FC*		*MCA*		*ClO_2*		*MnO_4-*		*UV*		*H_2O_2*		*O_3*		*Softening*
	pH 6.6	***pH 8.6***	***pH 6.6***	***pH 8.6***	***pH 6.6***	***pH 8.6***	***pH 6.6***	***pH 8.6***	***pH 6.6***	***pH 8.6***	***pH 6.6***	***pH 8.6***	***pH 6.6***	***pH 8.6***	***pH 12***
Percent Reduction[b]	90.3	85.7	8.7	9.2	34.3	27.5	15.3	5.2	14.5	1.9	7.6	3.1	60.9	30.3	100.0
System Population Category	***Percentage of Plants Performing Each Treatment Practice for Surface Water***[c]														
100 or less	98.4		0		0		1.6		3.1		-	-	0		0
101-500	79		1.2		0		9.2		1.7		-	-	*1.4*		2.5
501-3,300	97.4		2.2		0		7.8		2.2		-	-	1.5		3.4
3,301-10,000	80.8		13.7		11		24.7		1.4		-	-	*1.4*		19.2
10,001-50,000	80.5		14.8		8.7		32.9		1.3		-	-	1.2		16.9
50,001-100,000	75.1		17.1		18.5		26.8		2.6		-	-	11.8		5.2
100,001-500,000	78.9		32.4		14		26.3		4.7		-	-	15.8		11.8
Over-500,000	78.0		35.6		2.5		21.2		1.7		-	-	14.4		21.2

a. Experimental time was representative of typical drinking water treatment condition
b. See footnote 43
c. U.S. EPA Office of Water 2006 Community Water System Survey, **May 2009** (survey data)
Chlorine (FC); Chlorine dioxide (ClO_2); Chloramines (MCA); Lime/soda ash softener (assumed to be similar to hydrolysis at pH 12); Ultraviolet light (UV); Ozone (O_3); Potassium permanganate (MnO_4-)

APPENDIX 1: Registered Use Clarification

In the preliminary DWA, several uncertainties relating to the registered uses of chlorpyrifos were identified, including:

1) Application restrictions provided on many chlorpyrifos labels are on a per season or crop cycle basis. For some crops there can be multiple seasons per year; however, the number of potential crops grown on the same field either as a result of multiple crops or crop rotations that may be treated with chlorpyrifos is not defined.

2) Some labels did not provide maximum single or annual application rates for chlorpyrifos or application retreatment intervals. This was common for trunk spray or basal drenches, which were reported as dilution factors.

3) Some labels restrict the amount of a specific chlorpyrifos formulation (*i.e.*, products), but do not restrict total active ingredient (a.i.) that may be applied. Therefore, the use of multiple chlorpyrifos-containing formulations is possible.

In order to seek clarification of chlorpyrifos usage, the Agency compiled a **Master Use Summary Document** (**ATTACHMENT 1)** reflective of the use profile of all active product labels (as of January 2012). All currently registered labels were reevaluated to define the labeled uses. Currently, many of the product labels do not state a maximum number of applications allowed per year or crop season. Through discussions with the registrants, EFED believes that the detailed information on maximum application rates and use patterns given in the **Master Use Summary Document** will be implemented on all chlorpyrifos labels. The chlorpyrifos drinking water assessment is based on the information shown in the **Master Use Summary Document**. If for any reason the final chlorpyrifos labels contain higher application rates, higher numbers of applications, and/or shorter minimum retreatment intervals, the actual exposure to chlorpyrifos and chlorpyrifos-oxon may be greater than presented in this assessment.

Highlights of this effort are provided below.

1. For chlorpyrifos soil treatments to grape east of the continental divide, the single application rate was provided as a dilution factor. Based on a high density vineyard planting of nearly 3000 vines per acre [vines spaced 4 feet by 4 feet approximately 2756 vines (11-15ft^2 (3.75-4.4 ft) can be planted (*e.g.*, 62719-301)] chlorpyrifos could be applied at an application rate of 33 lbs a.i./acre. While the calculated single application rate is correct, based on the dilution factor provided on chlorpyrifos labels and the potential vine density, the registrants indicated that this high application rate was not an intended use. As a result, the registrants agreed to update the labels to reflect a maximum single application rate of 2.25 lb a.i./A for all chlorpyrifos soil treatments on grape east of the continental divide.

2. Turf labels do not restrict the number of chlorpyrifos applications per year, nor provide a minimum retreatment interval. The registrants agreed to update the label to reflect a maximum single application rate of 3.76 lb a.i./A with no more than two applications per year. Therefore, 7.52 lb a.i./A would be the highest yearly application of chlorpyrifos permitted on turf.

3. The registrants have also agreed to update the labels to restrict the amount of chlorpyrifos that may be applied per year in terms of a.i./A by use site rather than in terms per season or crop cycle.

4. The registrants have agreed to reduce the number of chlorpyrifos applications for some crops such as tart cherries.

Although the current chlorpyrifos labels do not yet reflect the revisions agreed to by the registrants and reflected in the **Master Use Summary Document**, the use summary document is being used to define the use profile for chlorpyrifos for the purposes of updating the registration review DWA for chlorpyrifos.

As mentioned above, the uncertainties associated with the use of chlorpyrifos use on grapes and turf have been resolved, and as a result, these crops use are no longer expected to result in the highest chlorpyrifos or chlorpyrifos-oxon concentrations as previously reported in the preliminary assessment.

Despite the on-going label clarification efforts, there are still a number of uncertainties associated with the current chlorpyrifos use scenarios included on the **Master Use Summary Document**. **ATTACHMENT 1** summarizes the remaining **Master Use Summary Document** uncertainties including assumptions made in the absence of information, if the use was assessed as part of the preliminary DWA, or this update, and the potential impact of the use relating to drinking water exposure. In general, reasonable assumptions could be made for agricultural crop use sites; however, for some use sites (*e.g.*, commercial/institutional/ industrial premises/equipment), the use could not be reasonably assessed based on missing information, including single and yearly application rates. For these use sites, realistic assumptions could be made that result in drinking water exposure scenarios that are higher than those presented in this updated DWA.

APPENDIX 2: Spray Drift

In June of 2012, EPA finalized its evaluation of the potential risks from spray drift of chlorpyrifos.[46] Results of this assessment indicated spray drift from application of chlorpyrifos using current (in 2012) label requirements generally resulted in risk estimates of concern for locations immediately adjacent to treated fields. To address these risks, buffer zones and drift reduction technologies (*i.e.*, larger droplet sizes) for sensitive sites[47] were implemented, in addition to restricting all aerial applications to 2.0 lb a.i./A or less except when chlorpyrifos is used to treat Asian citrus psyllid. In this situation, chlorpyrifos application may be applied at a rate of up to 2.3 lb a.i./A by aerial equipment.

The buffer zones and drift reduction technologies only apply to sensitive sites and do not protect aquatic environments; therefore, were not considered as part of the exposure modeling for drinking water in this update. Nevertheless, the aerial application rate restriction of 2.0 lb a.i./A (2.3 lb a.i./A for Asian citrus psyllid) is an across the board restriction and; therefore, was considered as part of this update and is reflected in the **Chlorpyrifos Master Use Summary Document**.

Spray drift estimates were updated to reflect the most recent offsite deposition guidance[48,49] and considered the currently labeled buffer restrictions [25 ft. (ground), 50 ft. (air-blast), 150 ft. (aerial)] for aquatic water bodies. However, this updated analysis does not consider the court ordered spray drift buffers [60 ft. (ground and air-blast) and 300 ft. (aerial)] required for salmon bearing steams, as these buffers are only required in three states, California, Oregon, and Washington and are not required as part of the labeling under the Federal Insecticide, Fungicide, and Rodenticide Act.

[46] Dawson, J., Bohaty, R., Mallampalli, N. Evaluation of the Potential Risks from Spray Drift and the Impact of Potential Risk Reduction Measures, June 20, 2012 PC 059101 DP 399483 and 399485.
[47] Sensitive sites are areas frequented by non-occupational bystanders (especially children). These include residential lawns, pedestrian sidewalks, outdoor recreational areas such as school grounds, athletic fields, parks and all property associated with buildings occupied by humans for residential or commercial purposes. Sensitive sites include homes, farmworker housing, or other residential buildings, schools, daycare centers, nursing homes, and hospitals. Non-residential agricultural buildings, including barns, livestock facilities, sheds, and outhouses are not included in this prohibition.
[48] U.S. Environmental Protection Agency, Brady, D. Guidance on Modeling Offsite Deposition of Pesticides via Spray Drift for Ecological and Drinking Water Assessments, December 20, 2013
[49] U.S. Environmental Protection Agency, White, K., Khan, F., Peck, C., Corbin, M. Guidance on Modeling Offsite Deposition of Pesticides via Spray Drift for Ecological and Drinking Water Assessments, December 19, 2013

APPENDIX 3: Chlorpyrifos and Chlorpyrifos-oxon Volatility

While laboratory studies suggest that volatilization is not likely to play a significant role in the dissipation of chlorpyrifos in the environment, field data suggest otherwise. Chlorpyrifos has been detected in air samples and as a result, EPA requested a field volatility study[50] as part of the data call-in requirements for the registration review of chlorpyrifos. EPA reviewed two field volatility studies (summarized below) that indicate volatilization of chlorpyrifos and/or chlorpyrifos-oxon from treated crops is a pathway of dissipation in the environment that may result in exposure to vapor phase or redeposited chlorpyrifos and chlorpyrifos-oxon downwind of a treated field. The two studies were conducted at rates much lower than the current maximum single broadcast application. While the absolute flux for chlorpyrifos observed in the potato study is higher than the alfalfa study, the flux profiles[51] are similar in both studies.

Study 1: Alfalfa

Dow AgroSciences (DAS) recently submitted a field volatility study that measured both vapor phase chlorpyrifos and chlorpyrifos-oxon in air samples following an application of a low VOC (volatile organic compounds or volatile organic chemicals) formulation[52,53,54] of chlorpyrifos to alfalfa. Approximately 30% of the applied chlorpyrifos was emitted from the treated field in the first 24 hours (28% considering chlorpyrifos only; 30% considering chlorpyrifos and chlorpyrifos-oxon combined). The flux profile for chlorpyrifos is similar to those generally observed for fumigants in that there is a peak emission shortly after application during the warmer part of the day. The study measured chlorpyrifos for a period of 72 hours following application.

Study 2: Potato

A field volatility study published in the open literature was conducted with the application of a non-low VOC formulation of chlorpyrifos applied to potatoes.[55,56] This study only measured parent chlorpyrifos

[50] **EPA MRID 48883201:** *Direct Flux Measurement of Chlorpyrifos and Chlorpyrifos-Oxon Emissions Following Applications of Lorsban Advanced Insecticide to Alfalfa*; Authors: Aaron Rotondaro and Patrick Havens; Sponsor: Dow AgroSciences LLC, 9330 Zionsville Road Indianapolis, IN 46268-1054, **2012**.
[51] A flux profile is the emissions from a treated field over a defined period of time (*i.e.*, an hourly time series of flux estimates during a period of measurement following application).
[52] California's Department of Pesticide Regulation (Cal DPR) defines a low VOC pesticide formulation when the total emission potential (see **footnote 53**) is 25% or less (see **footnote 54**). The emission rate corresponds to total VOC emissions and not specially one component of the formulation (*i.e.*, the active ingredient). EPA does not currently define low VOC pesticide formulations.
[53] Emission potential is based on Thermogravimetric Analysis; Oros, D., Spurlock, F. California Department of Pesticide Regulation, ESTIMATING PESTICIDE PRODUCT VOLATILE ORGANIC COMPOUND OZONE REACTIVITY. PART 1: SPECIATING TGA -BASED VOLATILE ORGANIC COMPUND EMISSIONS USING CONFIDENTIAL STATEMENTS OF FORMULA, January 27, 2011 http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/analysis_memos/2286_segawa.pdf
[54] Proposed regulation can be found at: http://www.cdpr.ca.gov/docs/legbills/rulepkgs/12-001/text.pdf
[55] EPA MRID 48998801: *Volatilization of the Pesticides Chlorpyrifos and Fenpropimorph from a Potato Crop*; Authors: Minze Leistra, Johan H. Smelt, J. Hilbrand Weststrate, Frederik VanDenBerg, and Rene Aalderink; Sponsor: This work was carried out within the framework of the EU APECOP project Effective Approaches for Assessing the Predicted Environmental Concentrations of Pesticides (QLK4-CT-1999-01338) and of Research Program 416, Pesticides and the Environment, of the Dutch Ministry of Agriculture, Nature and Food Quality; Citation: Leistra, M; Smelt, J. H.; Weststrate, J. H.; Van Den Berg, F; Aalderink, R. Environ. Sci. Technol. **2006**, *40*, 96-102.
[56] Since the raw data for this study could not be obtained, the flux rates could not be independently verified by EPA and, thus, evaluation of experimental details and associated data quality review of this study is not as rigorous as that

and did not measure concentrations of chlorpyrifos-oxon. Approximately 71% of the applied chlorpyrifos was estimated to volatilize from the treated field within 24 hours following application, assuming continuous flux.[57]

While volatility has been observed to be a major route of dissipation of chlorpyrifos in the environment, the extent of deposition following volatilization and the area of deposit off a treated field is unknown. As a conservative approach, all the applied chlorpyrifos is assumed to be available for runoff, spray drift, and erosion in this update. The reported EDWCs may be higher than concentrations that would be found in the environment because volatilization is not accounted for in model simulations. Volatility is the likely reason chlorpyrifos is detected in remote regions or in precipitation collected from locations far from potential applications sites. In addition, in some cases chlorpyrifos monitoring is conducted from irrigation canals which discharge to streams and rivers and chlorpyrifos is not observed in the irrigation water yet is samples of river water reveal concentrations of chlorpyrifos. This may be the result of volatilization followed by redeposition.

---

associated with the alfalfa study. The results from this study are presented in this assessment to provide another line of evidence of the potential volatility of chlorpyrifos, as demonstrated in the registrant submitted study, and to help describe the potential variability in chlorpyrifos flux rates due to different study conditions (*e.g.*, crop canopy, formulation, and weather).

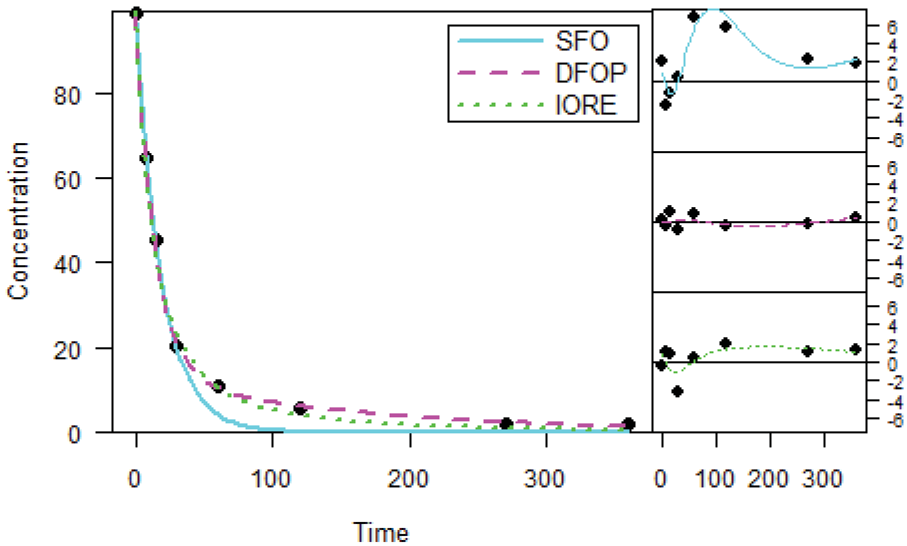
[57] Sampling did not occur at night; therefore, in order to develop a 24 hour flux profile. EPA developed a flux rate for the missing sampling periods by averaging the flux rate prior to and after the time period when sample collection did not occur.

APPENDIX 4: NAFTA Kinetic Analysis

Aerobic Soil Metabolism

MRID 00025619 Aerobic Soil Metabolism (Commerce)

Day	Percent Applied
0	98.9
7	64.6
14	45.2
30	20.5
60	11.0
120	5.80
270	2.20
360	1.90

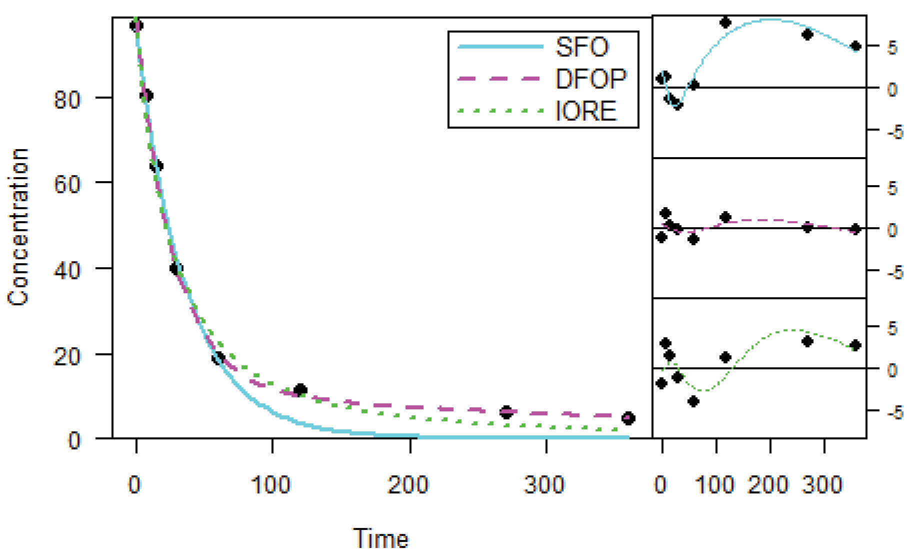


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	13.2	44	9	96.9	k = 0.0524
DFOP	11.9	62.8	1.8	98.8	f = 0.869, k_0 = 0.0697, k_1 = 0.00617
IORE	11.6	63	4.1	99.4	N = 1.54, k = 0.0061

S_C	28.3
S_{SFO}	99
Slow $t_{1/2}$	112
$t_{R\ IORE}$	19

MRID 00025619 Aerobic Soil Metabolism (Barnes)

Day	Percent Applied
0	96.8
7	80.3
14	63.8
30	40.0
60	18.8
120	11.2
270	6.20
360	4.60

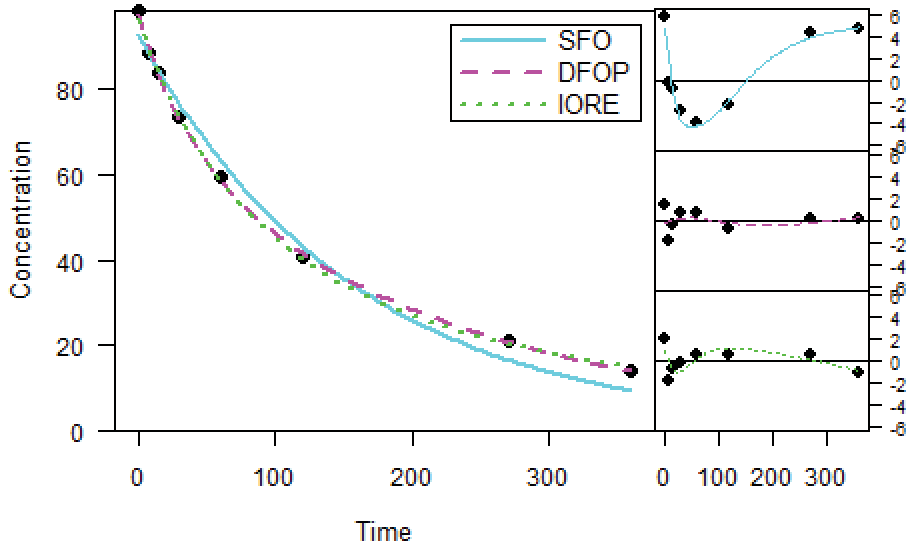


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	25.3	84.1	7.9	96	k = 0.0274
DFOP	23	122	2.3	98	f = 0.881, k_0 = 0.0358, k_1 = 0.00237
IORE	22.6	122	5.2	98.8	N = 1.53, k = 0.00321

S_C	75.7
S_{SFO}	126
Slow $t_{1/2}$	292
$t_{R\ IORE}$	36.7

MRID 00025619 Aerobic Soil Metabolism (Norfolk)

Day	Percent Applied
0	98.5
7	88.4
14	83.9
30	73.7
60	59.3
120	40.8
270	20.9
360	14.0

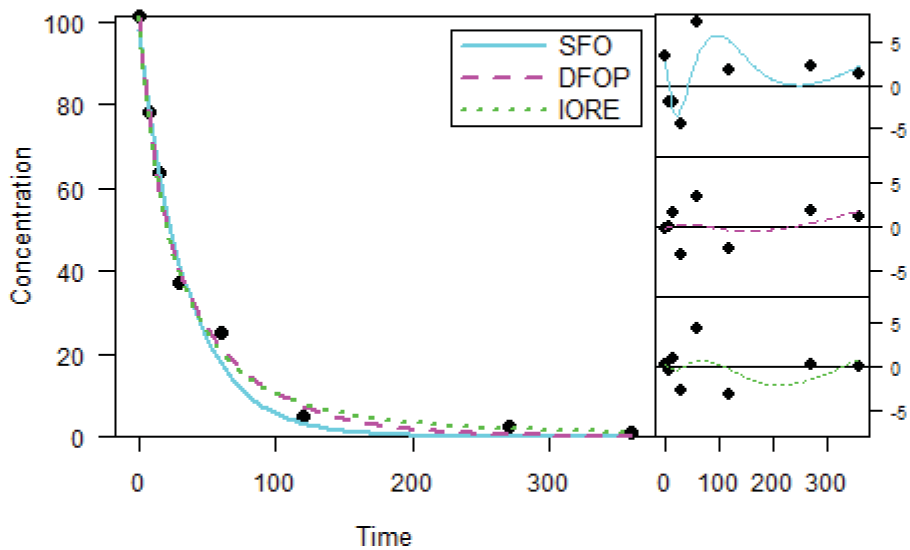


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	109	362	4.8	92.6	k = 0.00636
DFOP	90.7	441	1.4	97.1	f = 0.292, k_0 = 0.0263, k_1 = 0.00444
IORE	89.5	527	1.6	96.4	N = 1.62, k = 0.000577

S_C	16
S_{SFO}	104
Slow $t_{1/2}$	156
$t_{R\ IORE}$	159

MRID 00025619 Aerobic Soil Metabolism (Miami)

Day	Percent Applied
0	101.
7	78.2
14	63.7
30	37.2
60	25.0
120	4.90
270	2.30
360	1.20

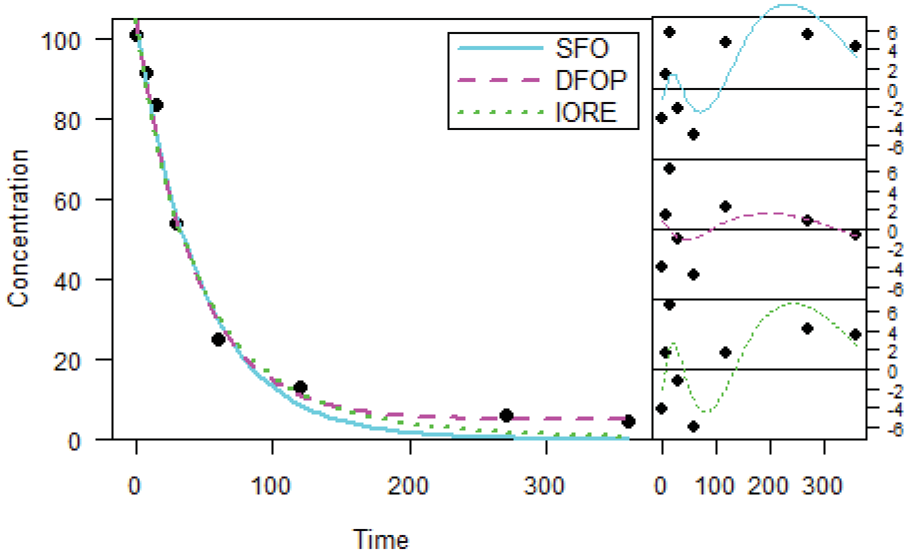


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	24.3	80.8	7.2	97.9	k = 0.0285
DFOP	21	102	4.8	102	f = 0.401, k_0 = 0.0735, k_1 = 0.0176
IORE	21.3	103	4.8	101	N = 1.43, k = 0.00526

S_C	59.4
S_{SFO}	102
Slow $t_{1/2}$	39.4
$t_{R\ IORE}$	31.1

MRID 00025619 Aerobic Soil Metabolism (Catlin)

Day	Percent Applied
0	101.
7	91.5
14	83.7
30	53.9
60	25.1
120	13.3
270	6.00
360	4.40

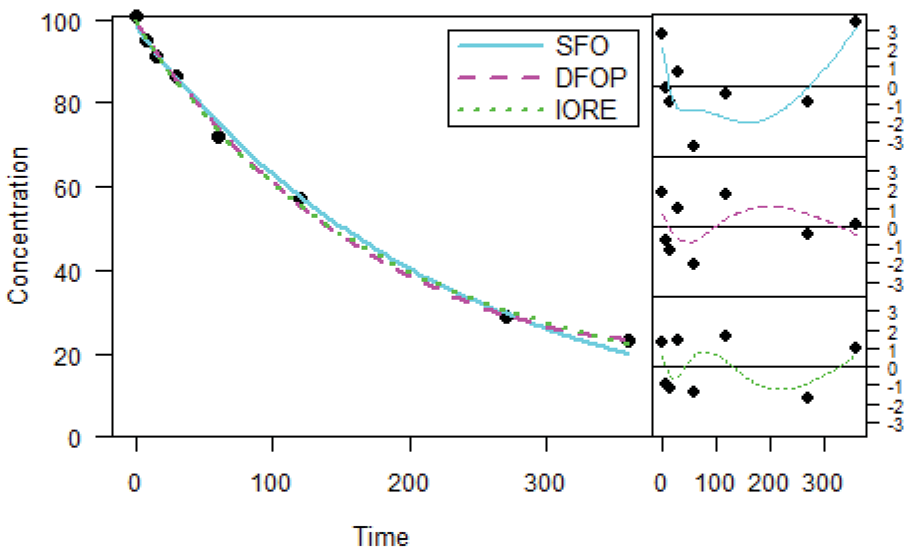


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	33.4	111	7.2	104	k = 0.0207
DFOP	32.1	124	6.4	105	f = 0.957, k_0 = 0.023, k_1 = -0.000367
IORE	32.3	127	7.4	105	N = 1.2, k = 0.00923

S_C	208
S_{SFO}	145
Slow $t_{1/2}$	-1.89e+0
$t_{R\ IORE}$	38.1

MRID 00025619 Aerobic Soil Metabolism (German)

Day	Percent Applied
0	101.
7	95.1
14	91.4
30	86.7
60	72.0
120	57.2
270	28.7
360	23.3

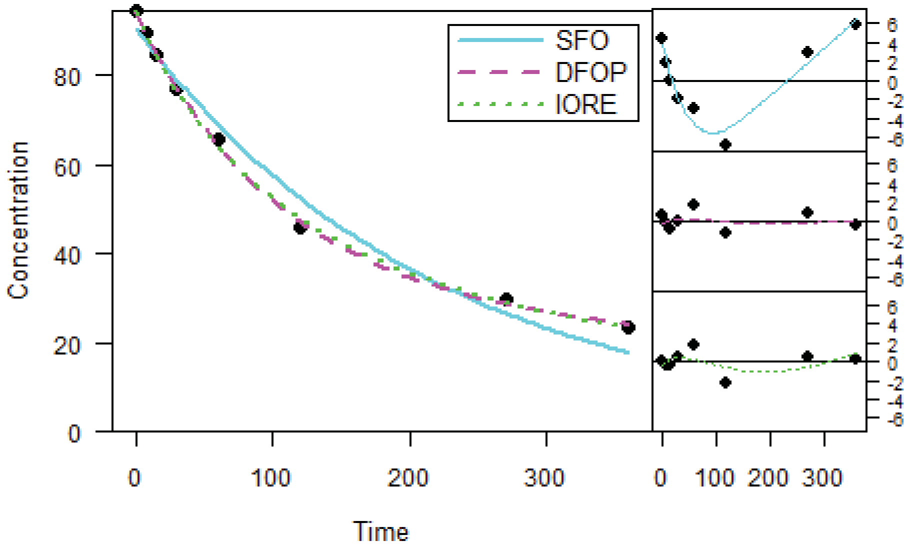


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	156	518	2.3	98.3	k = 0.00444
DFOP	NA	NA	1.7	99.3	f = 0.996, k_0 = 0.00496, k_1 = -0.00803
IORE	145	640	1.7	99.8	N = 1.33, k = 0.00119

S_C	23.2
S_{SFO}	33.1
Slow $t_{1/2}$	-86.4
$t_{R\ IORE}$	193

MRID 00025619 Aerobic Soil Metabolism (Stockton Clay)

Day	Percent Applied
0	94.6
7	89.3
14	84.7
30	76.9
60	65.8
120	45.7
270	29.5
360	23.6

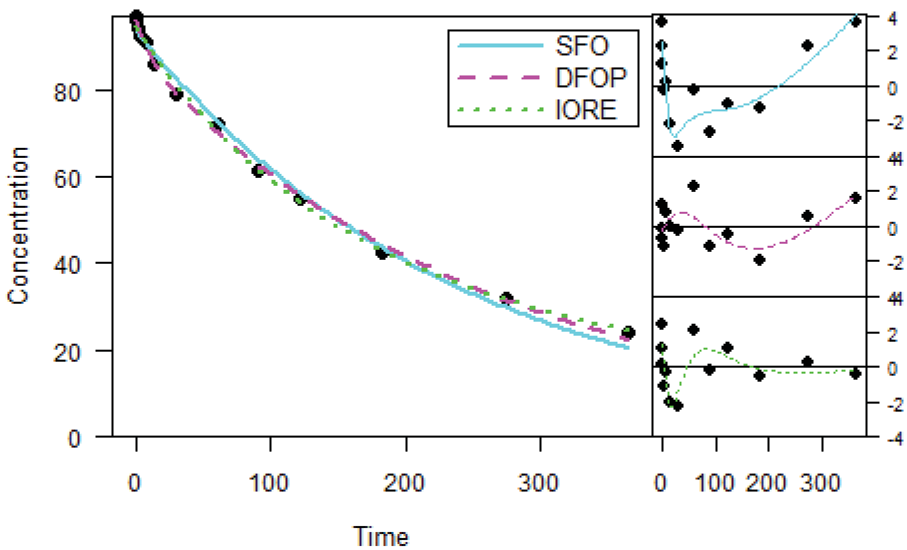


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	153	508	4.9	90.3	k = 0.00453
DFOP	120	1176	1.3	94	f = 0.651, k_0 = 0.0101, k_1 = 0.00106
IORE	124	985	1.4	94.5	N = 1.9, k = 0.000132

S_C	14.3
S_{SFO}	124
Slow $t_{1/2}$	652
$t_{R\ IORE}$	297

MRID 42144911 Aerobic Soil Metabolism

Day	Percent Applied
0	97.1
0	95.8
1	94.3
3	92.1
7	91.0
14	86.0
30	79.0
61	72.2
91	61.3
122	55.1
183	42.3
275	31.9
365	24.0

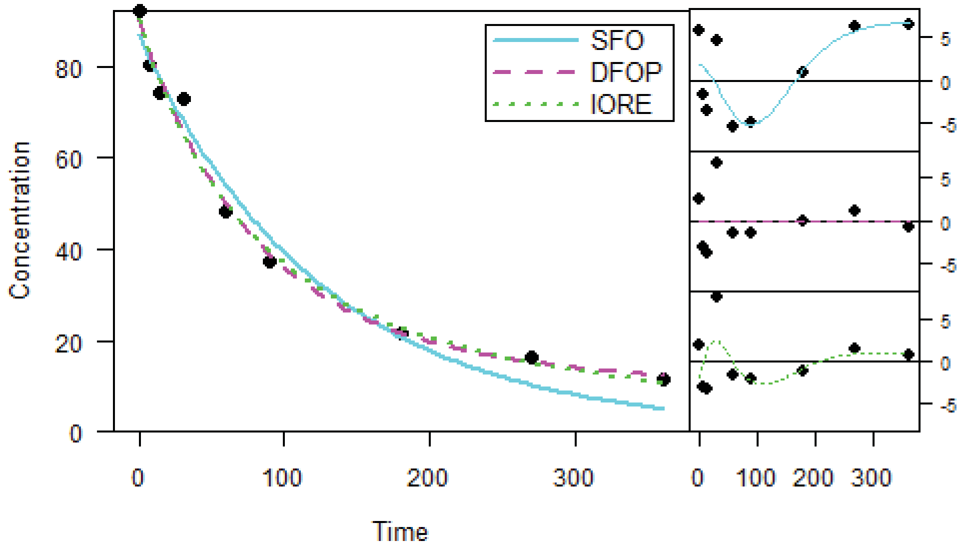


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	166	551	2.5	93.5	k = 0.00418
DFOP	162	592	1.4	95.9	f = 0.0849, k_0 = 0.0775, k_1 = 0.00374
IORE	156	812	1.5	94.7	N = 1.5, k = 0.000553

S_C	29.4
S_{SFO}	64.8
Slow $t_{1/2}$	185
$t_{R\ IORE}$	245

Anaerobic Aquatic (MRID 0025619) Stockton

Day	Chlorpyrifos
0	92.4
7	80.4
14	74.1
30	73.0
60	48.5
90	37.4
180	21.7
270	16.4
360	11.5

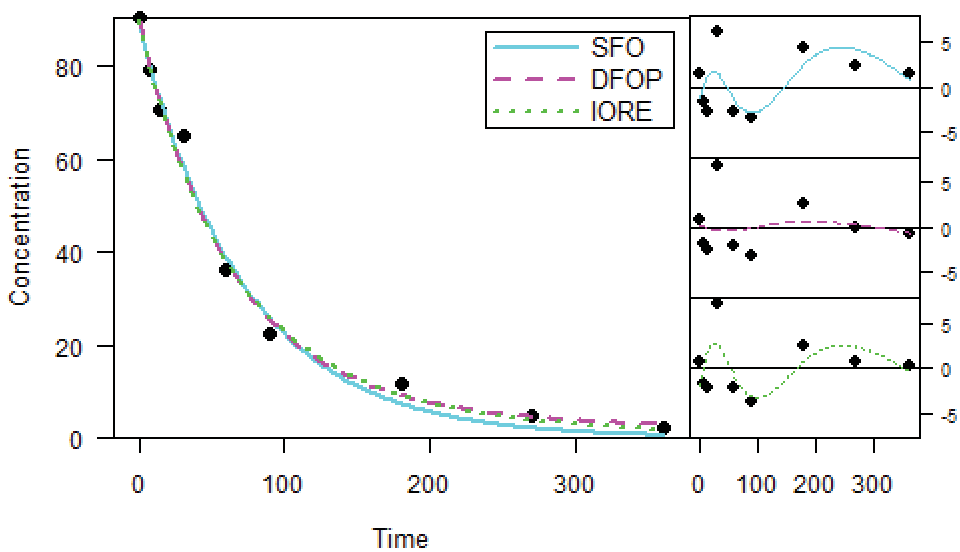


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	87.3	290	7.5	86.8	k = 0.00794
DFOP	72.3	551	5.4	89.9	f = 0.792, k_0 = 0.0129, k_1 = 0.00134
IORE	72.3	415	5.3	90.5	N = 1.59, k = 0.000819

S_C	129
S_{SFO}	205
Slow $t_{1/2}$	517
$t_{R\ IORE}$	125

Anaerobic Aquatic (MRID 0025619) Commerce

Day	Chlorpyrifos
0	90.6
7	79.1
14	70.7
30	64.9
60	36.1
90	22.3
180	11.7
270	4.60
360	2.10

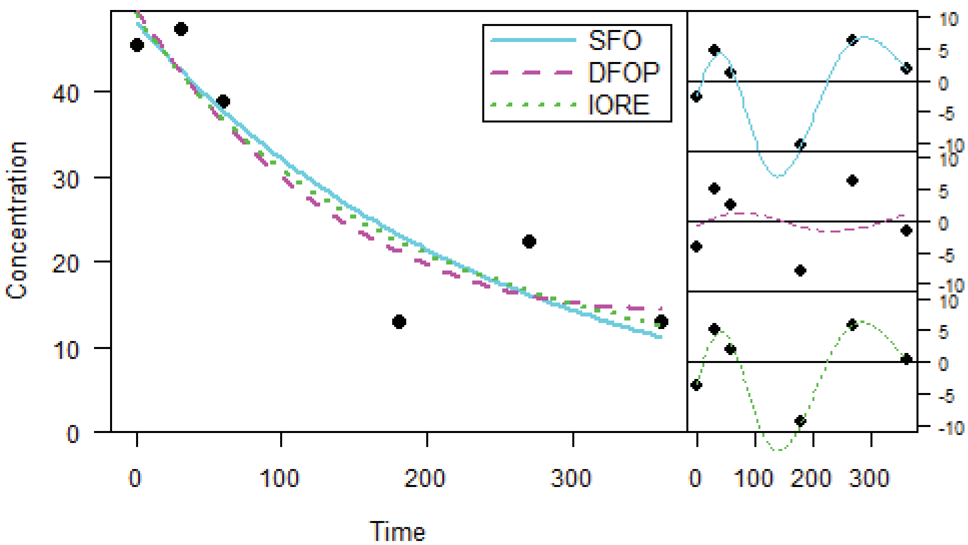


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	50.2	167	6.1	89	k = 0.0138
DFOP	48.1	182	6.3	89.8	f = 0.916, k_0 = 0.0159, k_1 = 0.00292
IORE	48	184	6.1	90	N = 1.17, k = 0.00717

S_C	121
S_{SFO}	95.3
Slow $t_{1/2}$	237
$t_{R\ IORE}$	55.3

Anaerobic Soil(MRID 0025619) Stockton

Day	Chlorpyrifos
0	45.5
30	47.4
60	38.8
180	13.1
270	22.3
360	12.9

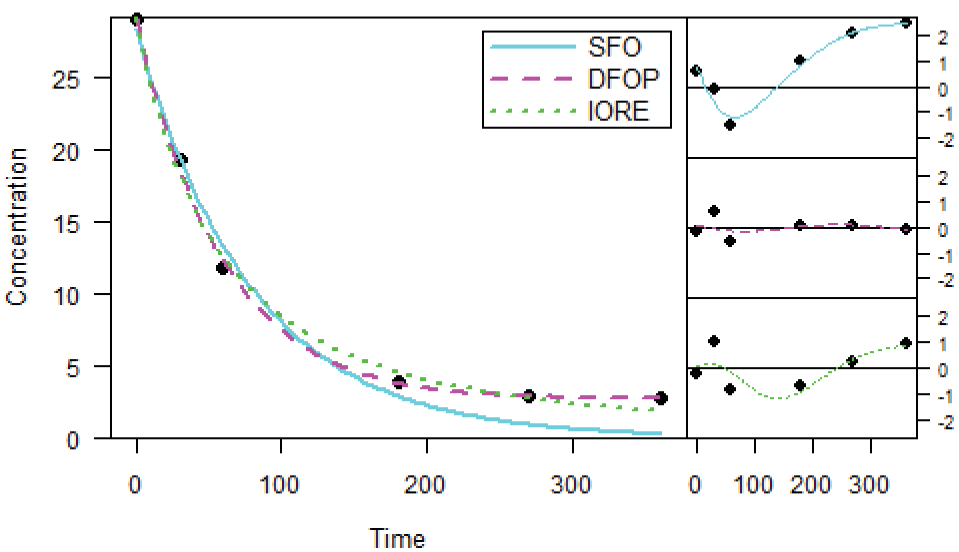


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	171	568	14	48.1	k = 0.00405
DFOP	NA	NA	17	49.6	f = 0.972, k_0 = 0.00553, k_1 = -0.0048
IORE	156	766	15	49.2	N = 1.44, k = 0.000945

S_C	331
S_{SFO}	174
Slow $t_{1/2}$	-144
$t_{R\ IORE}$	231

Anaerobic Soil(MRID 0025619) Commerce

Day	Chlorpyrifos
0	29.0
30	19.3
60	11.8
180	3.90
270	3.00
360	2.80



	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SFO	55	183	10	28.4	k = 0.0126
DFOP	47.6	NA	2.9	29.2	f = 0.93, k_0 = 0.0163, k_1 = -0.000869
IORE	47.4	260	5.4	29.2	N = 1.55, k = 0.00281

S_C	6.22
S_{SFO}	14.1
Slow $t_{1/2}$	-798
$t_{R\ IORE}$	78.2

Attachment 1. Chlorpyrifos Use Summary

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
AGRICULT-URAL FARM PREMISES Livestock housing and holding areas (such as hog barns, empty chicken houses, dairy areas, milkrooms, calf hutches, calving pens and parlors).		✓		Indoor general surface spray	backpack sprayer; high and low sprayer (pressure or volume)	0.075 lb a.i./ 1000 ft sq 1.2 EC, ME	[14.4] NS	NA	12	NA	NA	NS	NS		Only permitted for use in poultry houses
ALFALFA		✓		At plant	groundboom	1.0 G	1.0	1.0	[1] NS	1	21	24	[10] NS	Missouri only	Lower PHI permitted for EC rates 0.33 lb a.i./A (7 d) and 0.67 lb a.i./A (14 d) e.g. Reg. No. 62719-591 Stand is in production 3-5 years. Planted ¼” to ½” deep.
		✓		Foliar	aerial or ground/ broadcast, chemigation	1.0 EC	[4.0] NS	4.0	[4] NS	4	21	24	10		Lower PHI permitted for EC rates 0.33 lb a.i./A (7 d) and

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															0.67 lb a.i./A (14 d) *e.g.*, Reg. No. 62719-591 Multiple harvests (or cuttings) per year when used for feed/fodder and 1 harvest per year when grown for seed. Cuttings occur about every 30 days. Only 1 crop cycle per year but up to 9 cuttings, varies by geography.
				Total		**1.0**	**5.0**	**5.0**	**[5] NS**	**5**	**21**	**24**	**[10] NS**		Represents Missouri scenario otherwise 4.0 lb a.i./A per is max.
ALMOND		✓		**dormant/ delayed dormant**; broadcast	aircraft, airblast	2.0 WDG, WP	2.0	NA	1	NA	NA	24	10	Restricted use in California.	
		✓		**foliar**;	aircraft, airblast	2.0	6.0	NA	3	NA	14		10		

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
				broadcast		WDG,WP									
		✓		pre-plant, foliar; **trunk spray/drench or pre-plant dip**	handheld, backpack, drench/dip, handgun, and low pressure hand wand	2.5 (3.0/100 gal) WDG	2.5	NA	1	NA	14		NS		
		✓		Dormant/ delayed dormant; foliar; **orchard floors** broadcast	ground boom, handgun, chemigation	4.0 EC*	4.0	NA	2	NA	14		10	Restricted use in California. Only one dormant application can be made.	
				Total	**--**	**4.0**	**14.5**	**NA**	**7**	**NA**	**14**		**NS**		Excludes nursery applications (See general "Fruits" listing)
APPLE		✓		**dormant/ delayed dormant**; broadcast	aircraft, airblast	2.0 EC 2.0 WDG 1.5 WP	2	2.0	1	1	NA	24/ 4 d	10d		Reflects spray drift mitigation measures.
		✓		pre-plant, foliar; **trunk spray/drench or pre-plant dip**;	handheld, backpack, drench/dip, handgun, and low pressure hand wand	1.5 (1.5 lb ai/100 gal) WDG	1.5	NA	1	1	28	4d	NS	Use permitted in states east of the Rockies except Mississippi.	

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
				ground											
				Total		**2.0**	**3.5**		**2**						
ASPARAGUS		✓		Foliar, pre-harvest; broadcast	aircraft, ground boom	1.0 EC, WDG	1.0	1.0	1	1	1	24	10		
		✓		Postharvest, broadcast	aircraft, ground boom	1.0 EC, WDG	2.0	2.0	2	1	1	24	10		
					granular soil band treatment ground boom	1.5 G	3.0	3.0	2	2	180	24	[10] NS	Permitted in California, the Midwest, and the Pacific Northwest 19713-505, 19713-521, 5481-525, 62719-34, 83222-34	Do not apply more than 3.0 lb a.i./A between harvests.
				Total		**1.5 G**	**3.0 G 2.0**	**3.0 G 2.0**	3	3	1	24	10		
BEANS		✓		Preplant; Seed treatment	Seed Treatment	*0.016-0.348* 0.000798 lb ai/lb seed ME *0.013-0.272* 0.000625 lb ai/lb seed	NS	[0.348] NS	NS	[1] NS	NS	NS	NS	ME is SLN only for ID	Italics highlight the range of application rates depending on the number of seeds per lb and the number

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
						WP *0.012-0.253* 0.00058 lb ai/lb seed EC									of seeds planted per acre. Seeding rate information provide by BEAD.[4]
BEEF/RANGE/ FEEDER CATTLE (MEAT)/ DAIRY CATTLE (NON-LACTATING)				Summer, late fall, spring; impregnated collar/tag	Animal treatment (ear tag)	0.0066 lb/animal	[0.0099] NS	NA	3	NA	NS	NS	NS		Reg. No. 39039-6 Cattle ear tags are assumed to last 4-6 months Two tags per animal at 0.0033 lb a.i./tag in the summer and one tag per animal at 0.0033 lb a.i./A.
BEETS (UNSPECIFIED; TABLE OR SUGAR) "grown for seed"		✓		At plant, soil band treatment	Ground boom	1.0 EC	NS	1	NS	1		24		Allowed in Oregon Court ordered buffer of 60 ft for ground chlorpyrifos application is required for "affected waterways".	Minimum Incorporation: 2 inches

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
		✓		Preplant, soil incorporated treatment	Broadcast/ ground boom	1.9 EC	NS (2.8 ID)	NS	1	NS				Allowed in Oregon and Idaho	OR-09007; 62719-591 ID-090002; 62719-591
				Total		**1.9**	**NS**	**NS**	**NS**	**NS**		**24**			One or the other type of application.
SUGAR BEETS		✓		Preplant, soil incorporated treatment	Broadcast/ ground boom	1.0 EC 2.0 G	3.0	2.0	1	1	NA	24	10		Minimum Incorporation: 1 inch
		✓		At plant, soil band treatment	Broadcast/ ground boom	1.0 EC, WDG 2.0 G	3.0	2.0	1	1	30	24	10		
		✓		Postplant, soil band	Broadcast/ ground boom	2.0 G	3.0	2.0	1	1	30	24	10		
		✓		Post-emergence band treatment; broadcast	Broadcast/ ground boom	1.0 EC, WDG	3.0	1.0	3	1	30	24	10		
		✓		broadcast	Aircraft, ground boom, chemigation	1.0 EC, WDG	3.0	1.0	3	1	30	24	10		EC is not for use in MS
				Total		**1.0 EC 2.0 G**	**4.0**	**[4.0] NS**	**3**	**[3] NS**	**30**	**24**	**10**		One granular application at 2.0 a.i./A and two liquid applications at 1.0 a.i./A per

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															year. Also assumed per crop cycle.
CARROT Grown for Seed (INCLUDING TOPS)		✓		Foliar pre-bloom broadcast	aircraft, ground boom	0.94 EC	0.94	1	1	1	7	24	NA	Oregon and Washington Court ordered buffer of 60 ft for ground and 300 ft for aerial application is required for "affected waterways".	OR090011 SLN Expires: 12/31/2018 WA090011 SNL Expires: 12/31/2016 Carrots take two years to produce seed. All commercial production of the carrot (vegetable) takes place in the first year when the plant is nowhere near blooming.
CHERRIES		✓		**dormant/ delayed dormant**; broadcast	aircraft, airblast	2.0 WDG, EC 1.5 WP	2.0	NA	1	NA	NS	24	10		
		✓		**foliar**; broadcast	airblast	4.0 EC	10.0	NA	5	NA	14	24	10		Tart cherry only
					aircraft	2.0									Reflects spray drift mitigation

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
		✓		Foliar, post harvest; **trunk spray/drench**	handheld, backpack, drench/dip, handgun, and low pressure hand wand	2.5 (3.0/100 gal) WDG, EC	2.5	NA	1	NA	2	24	[10] NS		Only some labels specify a 10 d MRI.
				Total	**--**	**4.0**	**4.5 (sweet)** **14.5 (tart only)**		**6**						Excludes nursery applications (See general "Fruits" listing) The foliar applications only apply to tart cherries, thus, sweet cherry scenarios (*e.g.*, Pacific NW) annual application rate would be 4.5 lb total a.i./year.
CHRISTMAS TREE PLANTATIONS		✓		**foliar**; broadcast	helicopter, orchard blast	1.0 EC, WDG, WP	3.0	NA	3	NA	[0] NS	24	7	Aerial applications via helicopter are only permitted in Washington and Oregon.	

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
		✓		post harvest; **Stump Treatment**	handheld, backpack, drench/dip, handgun, and low pressure hand wand	2.5 (3.0/100 gal) EC, WDG	2.5	NA	1	NA	NA		7		
				Total		**2.5**	**5.5**		**4**						
CITRUS		✓		**foliar**; broadcast	airblast, ground boom	6.0 WP, WSP, EC	7.5	NA	2	NA	35 (21 for low rate s)	5d	30 (10 for low rates)	6.0 lb a.i. /A is only permitted in California and Arizona. The max single rate in other states is restricted to 4 lb a.i./A.	
		✓			aircraft	2.3 WP, WSP, EC					21	5	10	Florida, California, and potentially Texas	Aerial application used to control psyllid, the vector for citrus greening. Reflects spray drift mitigation
		✓		foliar; **orchard floors broadcast**	ground boom, chemigation, handheld, backpack, drench/dip, handgun, and	1.0 G*, WSP, EC	3.0	NA	3	NA	28	24/ 5 d	10		

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate Per Year lb a.i./A	Maximum Application Rate Per CC[2] lb a.i./A	Maximum Application Number Per Year	Maximum Application Number Per CC[2]	PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
					low pressure hand wand										
				Total	--	**6.0**	**10.5**		**5**						Registered labels permit both foliar and soil applications in the same orchard. Total excludes nursery applications (See general “Fruits” listing)
CLOVER (GROWN FOR SEED)		✓		Preplant	Ground boom	1.9 EC	1.9	1.9	1	1	NS	24	NA	Use only permitted in Oregon.	OR-0900100; master label: 62719-591 Either a preplant or post plant application is allowed.
		✓		Post-Plant Foliar	aircraft and ground boom										
COLE CROPS (EXCLUDES CAULIFLOWER AND BRUSSELS SPROUTS)		✓		Preplant, soil incorporated treatment	Ground boom	2.0 EC, WDG, G	4.0	2.0	2	1	30	24	10		Min. incorporation: 2 inches
		✓		At plant, soil band treatment	Ground boom					1					One granular application permitted per year.
		✓		Post plant	Ground boom					1					

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
		✓		Foliar Established Plantings, soil sidedress treatment	Ground boom					1					
		✓		Foliar, broadcast	Aircraft, ground boom, chemigation	1.0 EC, WDG, WP	4.0	3.0	4	3	21		10		Multiple crops per year are possible in some locations.
				Total			**8.0**	**5**	**6**	**4**					Some labels restrict the yearly application rate to 3 lb a.i./A. The maximum number of crops per year is 2.
BRUSSELS SPROUTS		✓		At plant, soil band treatment	Ground boom	2.0 EC; G	2.0	[2.0] NS							
		✓		Preplant, soil incorporated treatment	Ground boom				2	1	21	24	10		Minimum incorporation is 2 inches
		✓		Postplant, soil application	Ground boom	2.25 EC, G	2.25	[2.25] NS							
		✓		Foliar broadcast	Aircraft, Ground boom	1.0 EC	[5.3] NS	3.0	NS	3			10		83222-20, 84930-7, 86363-3 specify a 7 day MRI. All other labels

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate Per Year lb a.i./A	Maximum Application Rate Per CC[2] lb a.i./A	Maximum Application Number Per Year	Maximum Application Number Per CC[2]	PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
															specify a 10 day MRI. The PHI stated 84930-7 is conflicting [p. 4 (21 days and p. 19 (30 days)]
				Total		**2.3**	**5.3**		**NS**		**21**	**24**	**7**		Assume one application of either at plant, preplant, or postplant followed with additional foliar applications.
CAULI-FLOWER		✓		At plant, soil band treatment	Ground boom	2.0 EC 2.3 G	2.0 EC 2.25 G	NS	[1] NS	1	21	3d	10		Only one granular application.
		✓		Preplant, soil incorporated treatment	Ground boom	2.3 G 2.0 EC	2.3	NS	[1] NS	1	30, EC, 21 G				Minimum incorporation is 2 inches
		✓		Postplant, soil application	Ground boom										
		✓		Foliar broadcast	aircraft, ground boom	1.0 EC	[5.3] NS	3.0	NS	3	21		10		
				Total		**2.3**	**5.3**	**[5.3] NS**	**NS**	**[4] NS**	**21**	**24**	**10**		Assume one application at either plant, preplant, or

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															postplant followed with additional foliar applications.
COMMERCIAL /INSTITUTION-AL/ INDUSTRIAL PREMISES/ EQUIP. (INDOOR) Non-food areas of manufacturing, industrial, and food processing plants; warehouses; ship holds; railroad boxcars.				Broadcast	Product Container	0.4373 lb a.i./100 sq ft 190.5 G	NS	NA	NS	NA	NA	NS	NS		For treatment of fire ants
				Crack and Crevice/Void	Sprayer/ Injection	0.0625 lb a.i./1000 sq ft 2.7 ME	NS	NA	NS	NA	NA	NS	NS		499-419
				Crack and Crevice/Spot	Sprayer/ Injection	0.0424 lb/gal ME	NS	NA	NS	NA	NA	NS	7		
COMMERCIAL /INSTITUTION AL /INDUSTRIAL PREMISES/EQ UIP. (OUTDOOR) Outdoor commercial use around non-food areas of manufact-uring, industrial,				Soil broadcast	Low and High Pressure, Backpack, Handgun Sprayers	0.0247 lb a.i./1000 sq ft 1.1 ME	NS	NA	NS	NA	NA	NS	NS		
				Directed spray		0.1132 lb a.i./1000 sq ft 4.9 ME	NS	NA	NS	NA	NA	NS	NS		Specific to: Inside and outside dumpsters and other trash holding containers, trash corrals and

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
and food processing plants; warehouses; ship holds; railroad boxcars															other trash storage areas.
				Crack and Crevice/void/ general outdoor		0.0424 lb/gal ME	NS	NA	NS	NA	NA	NS	7		
CONIFERS AND DECIDUOUS TREES; PLANTATION, NURSERY		✓	?	**foliar**; broadcast	Ground boom	1.0 EC	3	NA	6	NA	7	24	7		
		✓	?	foliar; **stump treatment**	backpack, drencher, low pressure hand wand	0.3 EC	0.3	NA	1	NA	7	24	7		
				Total		**1.0**	**3**	**NA**	**6**	**NA**	**7**	**24**	**7**		The total number of applications assumed is either 3 foliar applications or 2 foliar applications with one stump treatment.
CORN (ALL)		✓		Preplant	ground/ **soil incorporated** conservation tillage, in furrow, broadcast, chemigation,	3.0 EC 2.0 G	3.0	3.0	NS	3	NA	24/ 5 EC	10		19713-520, 19713-599, 33658-26, 34704-857, 72693-11, 83222-20

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
					soil band										The minimum incorporation depth is 2 inches.
					soil incorporated aerial conservation tillage	2.0 EC, G									
		✓			ground/ conservation tillage, in furrow, broadcast, chemigation, soil band	1.0 EC 2.0 G	3.0	3.0	NS	3	21		10		19713-520
		✓		Storage or preplant seed treatment	Seed treatment	*0.001-0.021* 0.000625 lb a.i./ lb seed WP *0.1-1.9* 0.058 lb a.i./ lb seed FC	[?] NS	[1.9] NS	[?] NS	1	NS	NS	NS		Italics highlight the range of application rates depending on the number of seeds per lb and the number of seeds planted per acre. Seeding rate information provide by BEAD.[4]
		✓		At plant	soil incorporated,	2.0	[?] NS	3.0	[?] NS	3	21	24	10		

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
					conservation tillage	G									
		✓		Post emergence	Aerial or ground, broadcast, chemigation	1.5 EC 1.0 WDG	NS	3.0	NS	3	21	24/ 5d (EC	10		A brush on max single rate is permitted at 1.0 lb ai/a (72693-11)
		✓		Foliar	Aerial or ground/ broadcast, granule, seed and chemigation	1.5 EC	3.0	3.0	NS	3	21		10		
				Total		**3.0**	**8.1**	**8.1**	**NS**	**4**	**21**		**10**		Two granular applications are allowed with a maximum single rate of 1.0 lb a.i./A or one granular application at 2 lb a.i./A. Total with seed treatment PHI: 21 d except Delaware and Florida (7 d)
COTTON		✓		Storage or preplant seed treatment	Seed treatment	*0.8-2.2* 0.00116 lb/lb seed	[2.2] NS	[2.2] NS	[1] NS	1	NS	NS	NS		264-932 Rates in italics highlight the

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate Per Year lb a.i./A	Maximum Application Rate Per CC[2] lb a.i./A	Maximum Application Number Per Year	Maximum Application Number Per CC[2]	PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
						EC									potential range of application rates depending on the number of seeds per lb and the number of seeds planted per acre. Seeding rate information provide by BEAD.[2]
		✓		Foliar	aerial, chemigation, ground boom	1.0 EC, WDGP	3	3.0	3	3	14	24	10		Except MS
				Total		**1.0**	**3.2**	**3.2**	**3**	**3**	**14**	**24**	**10**		1.6 lb a.i./A is max single rate (seed treatment) **Total with seed treatment** 1 crop cycle per year assumed
CRANBERRY		✓		Foliar	aircraft, ground boom/ broadcast and chemigation	1.5 EC, WDG	3.0	NA	2	NA	60	24	10	Not for use in Mississippi.	Do not apply to bogs when flooded.
CUCUMBER		✓		Storage or preplant seed treatment	Commercial seed treatment	*0.4* 0.00058 lb/lb seed EC	NS	0.1	2	1	NS	NS	NS		Seeding rate information provide by BEAD.[2] 264-932,

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															62719-221, CA040004 Per registrant 2 CCs per year
FIGS		✓		**dormant/ delayed dormant**; soil application	ground boom	2.0 WDG, EC	2.0	NA	1	NA	217	4 d	NS	Use is restricted to California only.	Incorporation to 3 inches is suggested but not required following application.
FILBERTS/ HAZELNUT		✓		**dormant/ delayed dormant**; broadcast	aircraft, airblast	2.0 WP	2.0	NA	1	NA	14	24	10		
		✓		**foliar**; broadcast	aircraft, airblast	2.0 WDG, WP, EC	6.0	NA	3	NA	14		10		Some labels specify a retreatment interval of 10 days.
				Total		**2.0**	**6.0**	**NS**	**3.0**	**NA**	**14**	**24**	**10**		Excludes nursery applications (See general “Fruits” listing)
FOOD PROCESSING PLANT PREMISES (NONFOOD CONTACT)				When needed, crack and crevice treatment, spot treatment		0.0424 lb/ gal ME	NS	NA	NS	NA	NA	NS	7		53883-264, 84575-3 Spot Treatment: Do not exceed two square feet per individual spot.

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
FOREST PLANTINGS (REFORESTATION PROGRAMS) (TREE FARMS, TREE PLANTATION, ETC.)			✓	Foliar, broadcast	ground boom	1.0 EC	6.0	NA	6	NA		24	7		
			✓	Foliar, stump treatment	direct spray, drencher	0.34 EC	6.0	NA	[18] NS	NA			7		
FOREST TREES (SOFTWOODS, CONIFERS)			✓	Foliar, broadcast	ground boom, drencher	0.61 EC	3.6	NA	NS	NA	24		7		
			✓	Foliar, stump treatment	direct spray	[3.6] 2.4 lb a.i./100 gal EC	3.6	NA	NS	NA			7		Application rate is provided as a dilution factor.
FRUITS & NUTS Non-bearing (not to bear fruit within 1 year) fruit trees in nurseries (includes: almonds, citrus, filbert, apple, cherry, nectarine, peach, pear, plum, prune).		✓		Foliar-Non-bearing nursery broadcast	High/low volume spay/ hand held sprayer/power sprayer	4.0 EC	4.0	NA	NS	NA	14	NS	7		For nectarines and peaches, the use is restricted to one application of no more than 3 lb a.i./A per cc. For apples, the max rate is 2 lb a.i./A per crop cycle and the use is restricted to 1 application (either canopy

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															or trunk drench) per year. Example label, 62719-254
		✓		Foliar-Non-bearing nursery trunk drench	drencher, high and low pressure sprayer	2.0 WDG	2.0	NA	NS	1	14		7		
				Total		**4.0**	**6.0**								Maximum Single Rates: 3.0 (nectarines and peaches) 2.0 (apples) Maximum Yearly Rates: 3.0 (nectarines and peaches) 2.0 (apples)
GINSENG (MEDCINAL)		✓		Preplant, post-emergence	Ground, soil broadcast	2.0 G	2.0	NA	1	NA	365	24	NA	Permitted in Michigan and Wisconsin	MI110006,WI110003) Minimum incorporation: 4 inches Application should be followed by rainfall or overhead watering. Valid until June 29, 2016.

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
GOLF COURSE TURF				When needed, soil broadcast/ spot treatment	Ground, low pressure	1.0 EC	2.0	NA	2	NA		24	NS		
				Foliar, broadcast,	Ground boom, handgun, low pressure and backpack	1.0 EC, G, B	2.0	NA	2	NA			NS		Chemigation not allowed for the EC formulation.
					Tractor drawn spreader, push type spreader, belly grinder	1.0 G						[24] NS	7		
				Mound treatment	Granule applicator	1.0 G	2.0	NS	2	NS		NS	7		
				Total		**2.0**	**2.0**	**NA**	**2**	**NA**	**NS**		**NS**		
GRAPES		✓		Dormant/ Delayed Dormant (pre-bloom)	Ground boom, broadcast, drench high/low spray volume	1.0 WDG, EC	1.0	1	1	NA	35	24	NS	East of the continental divide only.	Do not use in conjunction with soil surface applications for grape borer control.
		✓				2.0 EC	2.0	1	1	NA	35			Permitted in Colorado, Idaho, and Washington	CO080008, ID090004, WA090002 Master label: 62719-591
		✓		Foliar	Ground/	2.25	2.25	1	1	NA	35		NS	Permitted	

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
					broadcast, basal spray and drench (soil treatment)	EC								east of the continental divide.	
		✓				1.0 EC	3.0	3	3	NA	35		NS	California	CA080010
		✓		Postharvest, dormant/ delayed dormant	Ground boom, broadcast	2.0 EC	2.0	1	1	NA	NS		NS	California	CA080009
				Total		**2.25**	**2.25**	**1**			**35**	**24**	**NS**	Permitted east of the continental divide.	
						2.0	**5.0**	**4**			**NS**		**NS**	California	
GRASS FORAGE/ FODDER/HAY		✓		Foliar, broadcast	Aircraft, ground boom, chemigation	1.0 EC	3.0	NA	3	NA	NS	24		Permitted in Nevada, Oregon, Washington, and Idaho	NV080004, NV940002, OR090009, WA090010, ID090003
GREENHOUSE		✓		early evening, aerosol, fog or fumigation	Total release fogger	0.029 0.0066 lb a.i./1000 sq. ft PL	NS	NA	NS	NA	NS	NS	2		
HOUSEHOLD/ DOMESTIC DWELLINGS INDOOR PREMISES	✓			When needed	Bait station	0.0003 lb/bait station	NS	NA	NS	NA	NA	NS	NS		9688-67
HYBRID COTTONWOO		✓		Foliar, dormant,	High volume (dilute)	1.9 EC	[2.0] NS	6.0	[1] NS	3		24	7	Washington	WA090004

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
D/ POPLAR PLANTATIONS				delayed dormant; broadcast	Low volume (concentrate)										Energy wood plantations may be harvested as often as every 2-3 years; pulpwood 5-10 years; and saw timber 15-20 years. (Arkansas production guide). In Washington the crop takes 2-8 years
LEGUME VEGETABLES		✓		Preplant, soil treatment	Ground boom	1.0 EC, WDG	1.0	NA	1	NA	NS	24	NA		No MRI because application only once a year
		✓		At planting, soil treatment	Ground boom	1.0 EC, WDG	1.0	NA	1	NA	NS		NA		
				Total		**1.0**	**1.0**	**NA**	**1**	**NA**	**NS**	**24**	**NS**		Assumed either a preplant or an at plant treatment.
MINT/ PEPPERMINT/ SPEARMINT		✓		Preplant soil incorporated	Aerial or ground/ broadcast	2.0 EC, WDG	[2.0] NS	2.0	[1] NS	1	90	24	NA	No use in Mississippi.	19713-599, 33658-26, 34704-857, 67760-28, 84229-25, 84930-7, OR940027

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															MRI NA due to once per crop cycle application
		✓		Post-emergence, Postharvest, Foliar	Chemigation, ground/ airblast	2.0 EC	2.0	2.0	[1] NS	2	90		NS	No use in Mississippi.	Postharvest application retreatment not specified on some labels.
				Total		**2.0**	**4.0**	**4.0**	**2.0**	**3**	**90**	**24**	**NS**		Labels allow one growing season application including pre-plant and one post-harvest application per season.
MOSQUITO CONTROL; HOUSEHOLD/ DOMESTIC DWELLINGS OUTDOOR PREMISES; RECREATION AL AREAS	✓			When needed; broadcast	Ultra low volume air and ground	0.01 EC	0.26	NA	26	NS	NA	NS	24 h	In Florida: Do not apply by aircraft unless approved by the Florida Dept of Ag.	Aerial applications may be made at altitudes ranging from 75-300 ft (see labels for specifics). For use by federal, state, tribal or local government officials or by

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															persons certified in the appropriate category or authorized by the state or tribal lead regulatory agency.
NECTARINE		✓		**dormant/ delayed dormant** broadcast	airblast, handgun	3.0 WDG, EC	3.0	NA	1	NA	NS	24/ 4d	10		83222-20 others at 2 lb a.i./a
					Aircraft	2.0 WDG, EC									Updated to reflect spray drift mitigation.
		✓		pre-plant, foliar; **trunk spray/drench or pre-plant dip**	Handgun, low pressure backpack, dip	2.5 (3.0/100 gal) WDG, EC	2.5	NA	1	NA	14		5		There is no application retreatment interval specified on some of the label. The application rate is provided as a dilution factor.
				Total		**3.0**	**5.5**	**NA**	**2**	**NA**					Some labels limit the amount a.i./A per year. Multiple types of applications can occur such

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															as preplant, trunk drench and dormant, delayed dormant applications. Excludes nursery applications (See general "Fruits" listing)
NONAGRICULTURAL OUTDOOR BUILDINGS/STRUCTURES to and around outside surfaces of nonresidential buildings and structures. Permitted areas of use include fences, pre-construction foundations, refuse dumps, outside of walls, and other areas where pests congregate or				Outdoor general surface/ Band (may be better if called perimeter)	Ground sprayer/ band sprayer	1.0 EC	NS	NA	NS	NA	NA	NS	NS		

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
have been seen															
NURSERY-STOCK: : Ornamental nursery stock annuals, perennials and woody plants being grown in the field, in ball and burlap or in containers outdoor and in greenhouses				Dormant/ Delayed Dormant	high spray	3.0 EC	3.0	NA	1	NA		24	NS		
				Preplant	Ground boom, soil incorporated	4.0 EC, WP	NS	NA	NS	NA					
				foliar, soil directed	Tractor drawn spreader, push type spreader, belly grinder, gravity fed backpack, spoon	1.1 G									
				Total		**4.0**	**CBD**		**3**						
ONIONS		✓		Post plant (seeding) Broadcast	Ground boom	1.0 EC	1.0	NS	2	NS	60	24	NS		
		✓		At plant, soil drench or basal spray	Ground boom	1.0 EC, WDG, G	1.0		1						2 inch incorporation

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
				Total		2.0	2.0		2		60	24	NS		
ORNAMENTAL AND/OR SHADE TREES, HERBACEOUS PLANTS		✓		Foliar broadcast	Ground boom, air blast, handgun, low and high pressure hand wands	2.0 EC, WP 1.0 G, B	2.0	NA	[2] NS	NA	NS	24	NS		Some labels include a MRI of 7 days.
		✓		Dormant /Delayed Dormant	Handgun, low pressure and backpack	3.0 EC	3.0	NA	1	NA	NS		7		Low volume spray permitted for concentrated solutions and lower rates.
ORNAMENTAL LAWNS AND TURF, SOD FARMS (TURF)		✓		When needed, broadcast, soil or spot treatment	ground boom (WP only), high pressure hand wand	3.76 EC, WP	7.52	NA	2	NA	NS	24	NS		
		✓		NS	Tractor drawn spreader, push type spreader, belly grinder	1.0 B	2.0	NA	2	NA	NS	24	NS		Bait is used for fire ant control.
ORNAMENTAL NON-FLOWERING PLANTS		✓		Foliar, broadcast, soil drench	Chemigation, ground boom, low and high pressure handwand, handgun, backpack sprayer, sprinkling can	0.007/gal ME	NS	NA	12	NA	NA	24	NS		Application rate provided as a dilution factor. Restricted use—occupational only
ORNAMENTAL				Foliar	Ground boom,	2.0	2.0	NA	[1]	NA	NS	24	NS		Several labels

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
WOODY SHRUBS AND VINES				broadcast	air blast, handgun, low and high pressure sprayer, backpack	EC, WDG 0.01 lb/gal EC	0.01 lb/gal		NS						do not restrict the application rate in lb a.i./A. Examples include 16.5 lb/100 gal (228-625) and 1.0 lb/100 gal (829-280).
				Dormant/ delayed dormant		1.0 EC 0.005 lb/gal EC	1.0	NA	[1] NS	NA					
				Preharvest	Tractor drawn spreader, push type spreader, belly grinder	6.0 G	6.0	NA	[1] NS	NA					
				Preplant, potted, bailed-and burlapped, containerized	groundboom, handgun, low and high pressure sprayer, backpack, drench	1.0 EC	NS	1	NS	1					
				Pretransplant	groundboom	4.0 WP	[48.0] NS	4	12	4					
				Total		**6.0 G** **4.0 WP**	**CBD**		**CBD**						
PEACH		✓		**dormant/**	airblast	3.0	3.0	NA	1	NA	10	24/	NS		83222-20 (all

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
				delayed dormant broadcast		EC 2.0 WDG						4d			other labels restrict to 2 lb ai/a)
					aircraft,	2.0 EC 2.0 WDG							NS		Updated to reflect spray drift mitigation.
		✓		**Post-harvest** broadcast	airblast	2.5 (3.0/100 gal) EC	2.5	NA	1	NA	NA		NS	Permitted in Georgia and South Carolina	GA0400001, SC040001 SLN Expires:
					aircraft	2.0 (3.0/100 gal) EC	2.0								GA0400001, SC040001 SLN Expires: Updated to reflect spray drift mitigation
		✓		pre-plant, foliar; **trunk spray/drench or pre-plant dip**; ground	handheld, backpack, drench/dip, handgun, and low pressure hand wand	2.5 (3.0/100 gal) WDG	2.5	NA	1	NA	14	5	NS		Some labels do not specify minimum retreatment interval.
				Total		**3.0**	**5.5**	**NA**	**3**	**NA**	**NA**	**24**	**NS**		It is possible that multiple types of applications can occur such as soil, foliar and/or post-harvest and
						3.0	**8.0**	**NA**	**3**	**NA**	**NA**	**24**	**NS**	Permitted in Georgia and South Carolina	

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															dormant/ delayed dormant applications. Excludes nursery applications (See general "Fruits" listing)
PEANUT		✓		Preplant	Aerial or ground/ broadcast	2.0 EC, WDG	[4.0] NS	4.0	[2] NS	2	NA	24	10	Do not apply aerial in Mississippi	Assumes one crop cycle per year.
		✓		At plant, postplant		4.0 G	[4.0] NS	4.0	2	2	21	24	10		
		✓		At pegging		2.0 G EC, WDG	[4.0] NS	4.0	2	[2] NS	21	24	10		
				Total		**4.0 G 2.0 EC, WDG**	**4.0**	**4.0**	**2**	**2**	**10**	**24**	**10**		
PEAR		✓		**dormant/ delayed dormant** broadcast	aircraft, airblast	2.0 WDG, EC	2.0	NA	1	NA	NA	24	NA	Restricted use in California.	83222-20 allows 3.0 lb a.i./ A; however, this does not match the 2001 RED.
		✓		**Post-harvest** broadcast	aircraft, airblast	2.0 WDG, EC	2.0	NA	1	NA	NA	24	NS	Permitted in California, Oregon and Washington.	

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
				Total		**2.0** **WDG, EC**	**4.0**	**NA**	**2**	**NA**	**NA**	**24**	**NS**		Multiple types of applications may occur in within a year in California, Oregon and Washington such as a post-harvest application and a dormant, delayed dormant. Excludes nursery applications (See general "Fruits" listing)
PEAS		✓		Preplant Seed treatment	Seed Treatment	0.30 0.000625 lb/lb seed WP 0.28 0.00058 lb/lb seed EC	NS	NS	NS	NS	NS	NS	NS		There is a range of potential application rates depending on the number of seeds per lb and the number of seeds planted per acre. Seeding information provide by BEAD.[2]

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
PECANS		✓		**dormant/ delayed dormant** broadcast	aircraft, airblast	2.0 EC, WDG	2.0	NA	1	NA	14	24	10		66222-19 and 66222-233
		✓		**foliar**; broadcast	airblast	4.3 EC, WDG	6.3	NA	3	NA	14		10		Some labels require a 28 d PHI
					aircraft	2.0 EC, WDG									Updated to reflect spray drift mitigation.
		✓		foliar; **orchard floors broadcast**	Ground boom, chemigation	4.3 EC, WDG	4.3	NA	2	NA	14		10		
				Total		**4.3**	**12.6**	**NA**	**6**	**NA**	**14**	**24**	**10**		Considers multiple type of applications (*e.g.*, dormant, foliar broadcast, and orchard floor) but excluding nursery For nursery applications (See general "Fruits" listing)
PEPPER		✓		Foliar	Ground broadcast	1.0 WDG	[8] NS	8.0	[8] NS	8	7	24	10	Permitted in Florida	FL040005; 1 crop cycle per year.
PINEAPPLE		✓		Postplant	Ground boom,	2.0	6.0	6.0	3	NA	365	24	30	Permitted in	HI090001

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
					broadcast	EC								Hawaii	SNL Expires: March 29, 2014. Do not make applications beyond three months after planting.
PLUM/ PRUNE		✓		**dormant/ delayed dormant**; broadcast	Aircraft, airblast	2.0 EC, WDG	2.0	NA	1	NA	NA	24/ 4d	10		
		✓		foliar; **trunk spray/drench**	handheld, backpack, drench/dip, handgun, and low pressure hand wand	2.5 3.0/100 gal WDG	2.5	NA	1	NA	NA		10		
				Total		**2.5**	**4.5**	NA	2	NA					Excludes nursery applications (See general “Fruits” listing)
POULTRY LITTER		✓		When needed, animal bedding/litter treatment.	Sprayer	0.07126 a.i./1000 sq ft 3.1 ME	NS	NA	NS	NA	NA		NS		53883-264, 84575-3
PUMPKIN		✓		Preplant Seed treatment	Seed treatment	0.3 0.00058 lb /lb seed	[0.3] NS	[1] NS	[1] NS	1	NS	NS	NS	California maximum single rate	There is a range of potential application

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
						WP								0.000625 lb a.i./lb.	rates depending on the number of seeds per lb and the number of seeds planted per acre. Seeding information provide by BEAD.[4]
RADISH		✓		Foliar	Broadcast ground	1.0 EC	NS	1	NS	1	NS	24	NS	permitted in Oregon	OR090012 on radish grown for seed. Label valid until December 31, 2012. (per registrant SLN still valid)
		✓		Preplant	Soil incorporation ground	3.0 EC	12.0	3	4	1	NS	NS	10		
		✓		At plant/post-plant	In furrow drench/ treatment	3.0 EC 2.8 G	[15.0] NS	3	[5] NS	1	30, EC, 7, G	24	10		Only one granular application permitted.
				Total		**3.0**	**[22.0] NS**	**2**	**[9] NS**						Only one preplant or at plant application is assumed.

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
RIGHTS OF WAY, ROAD MEDIANS				When needed, soil broadcast	Granular or low pressure wand	1.0 EC, G, Bait	[2.0] NS	NA	2	NA	NA	NS	7		Apply when needed
RUTABAGA		✓		Preplant	Chemigation, Groundboom	2.4 EC, WDG	[4.8] NS	2.4	[2] NS	1	30	24	10		
					Aerial	2.0 EC, WDG		2.0							Updated to reflect spray drift mitigation.
		✓		At plant/post-plant	In furrow drench/ treatment	2.4 EC, G WDG	4.8	2.4	[2] NS	1	7	24	10	Disallowed in California and Arizona.	Two crop cycles per year
				Total		**2.4**	**[9.6] NS**	**4.8**	**[4] NS**	**2**		**24**	**10**		
SEWER MANHOLE COVERS AND WALLS				When needed	Low pressure	0.31 lb/manhole RTU	NS	NA	NS	NA	NA	NA	NS		3 pints product/ manhole
SEED ORCHARD TREES		✓		**foliar**; broadcast	Ground boom	1.0 EC	3.0	3.0	NS	NA	30	24	7		62719-575, 62719-615
		✓			High volume sprayer	2.5 0.01 a.i./tree 0.02 EC	2.5	NS	[1] NS	NA	30	24	7		Cone worm treatment (62719-575 and 62719-615) Treatment of 1000 trees per acre would results in an single application rate of 10 lb a.i./a.

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate Per Year lb a.i./A	Maximum Application Rate Per CC[2] lb a.i./A	Maximum Application Number Per Year	Maximum Application Number Per CC[2]	PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
															DAS: 1000 is a bit high, typically for orchards 312 trees per acre
		✓		foliar; **stump treatment**	backpack, drencher, low pressure hand wand,	0.3 EC	0.3	1.0	NS	NA	30	24	7		62719-575, 62719-615
				Total		**1.0**	**5.8**	**3**	**NS**	**NA**	**30**	**24**	**7**		The total number of applications assumed is either three foliar applications or two foliar applications with one stump treatment.
SORGHUM GRAIN		✓		Seed Treatment	Seed treatment	[0.0009] 0.01-0.0024 lb ai/ 100 lbs seed EC	0.01	0.01	[1] NS	1	NA	NS	NS		264-932
		✓		Preplant Soil Directed	Ground Spreader/T Band	1.5 G	1.5	1.5	[1] NS	1	60	24	10		
		✓		Foliar/Post emergent	Ground, Aerial, Chemigation	1.0 EC, WDG	1.5	[1.5] NS	[1] NS	3	30	24	10		PHI varies across labels
				Total		**3.3**	**3.01**	**3.01**	**[3]**	**3**	30	24	10		One crop cycle

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
						G **1.0** **EC, WDG**			**CBD**						per year.
SOYBEAN		✓		foliar , post-emergence soil broadcast	broadcast ground, aerial, chemigation	1.0 EC, WDG	3.0	3.0	3	3	28	24	14		One crop cycle per year.
		✓		At plant/post plant treatment; soil band	ground boom	2.2 G 1.0 EC	3.0	3.0	1 (G), 3 (EC)	1 (G), 3 (EC)	28	24	10		
				Total		**1.0** **EC, WDG** **2.2** **G**	**3.0**	**3.0**	**3**	**3**					One crop cycle per year.
STRAW-BERRIES		✓		Pre-plant	Aerial or ground/ broadcast	2.0 EC	2.0	**NS**	1	NS	NA	24	10	No use in Mississippi	33658-26
		✓		Foliar	Aerial or ground/ broadcast, foliar spray	1.0 EC, WDG	2.0	**NS**	2	**NS**	21	24	10		Two applications (2 lb ai) for all products per cc.
		✓		Post harvest	Ground directed spray	1.0 EC, WDG	2.0	**NS**	2	**NS**	21		14		
				Total		**2.0**	**4.0**		**3**						One preplant application and two foliar and/or postharvest application

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															permitted per year.
SUNFLOWER		✓		At plant	Aerial/ground	2.0 G	3.0	3.0	[1] NS	1	42	24	10		Per registrant 1 cc per year
		✓		Preplant		2.0 EC, WDG	3.0	3.0	[1] NS	1	42		10		2 inches min incorporation
		✓		Post emergent or foliar		1.5 EC, WDG	3.0	3.0	[2] NS	2	42		10		
				Total		**2.0**	**5.0**	**5.0**	**3**	**3**					Assumed either an at plant or preplant application followed with two foliar applications. One crop cycle per year
SWEET POTATO		✓		Preplant, soil broadcast	Aircraft, ground boom	2.1 G, EC, WDG	2.1	NS	1	1	125	24		LA090002, MS080007, NC090001 permits 60 PHI	
					Aircraft	2.0 G, EC, WDG									Updated to reflect spray drift mitigation.
TOBACCO		✓		Preplant	Aircraft, ground boom	2.0 EC, G, WDG	2.0	NS	1	1	7	24	NA		
TRITICALE		✓		Storage Commercial Slurry Seed Treatment	Seed treatment	0.003 0.0024 lb ai/ 100 lbs seed EC	[0.003] NS	[1] NS	[1] NS	[1] NS	NA	[10] NS	[10] NS		264-932 Seeding information provide by BEAD.[4]

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
															One crop cycle per year.
TURNIP		✓		Preplant	soil incorporation/ ground boom, handgun	2.3 G, WDG	[4.6] NS	2.3	[2] NS	1	30	24	10		Minimum incorporation: 2 inches.
		✓		Postplant	Soil incorporation/ ground boom, handgun	2.3 G, WDGP	[4.6] NS	2.3	[2] NS	1	30	24	10		Minimum incorporation: 2 inches.
				Total		**2.3**	**4.6**	**2.3**	**2**	**1**	**30**	**24**	**10**		Assumed either a preplant or postplant application. Two crop cycles per year
UTILITIES For use in and around telecommunicatio ns, power, utilities and railroad systems equipment: Buried cables, cable television pedestals, cables, pad-mounted electric power transformers, telephone cables,				When needed, broadcast	Product container	190.5 G 0.44 lba.i./100 sq ft (see comments)	NS	NS	NS	NS	NS	NS	NS		Applications permitted as needed. Reg. Nos. 13283-14, 13283-17 Broadcast product onto the ground covering the area of the pad location, plus a two foot perimeter around the outside of the

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
underground vaults, telecommunications equipment, power and utilities equipment															pad location.
WALNUTS		✓		**dormant/ delayed dormant**; broadcast	Aircraft, airblast	2.0 EC, WDG	2.0	NA	1	NA	14		10		62719-301 (12 lb a.i./A)
		✓		**foliar**; broadcast	aircraft, airblast, chemigation	2.0 EC, WDG	4.0	NA	2	NA	14	24	10		Some labels do not specify retreatment interval.
		✓		foliar; **orchard floors broadcast**	Ground boom, chemigation	4.0 EC, WDG	4.0	NA	1	NA	14		10		
				Total		**4.0**	**10.0**		**4**						Excluding nursery applications; includes dormant, foliar broadcast, and orchard floor. For nursery applications (See general "Fruits" listing)
WIDE AREA/ GENERAL	✓	✓		when needed, Broadcast	Ground sprayer	0.5084 lb ai/100 gal	[1.02] NS	NA	2	NA	NA	NS	NS		66222-19

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate Per Year lb a.i./A	Maximum Application Rate Per CC[2] lb a.i./A	Maximum Application Number Per Year	Maximum Application Number Per CC[2]	PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
OUTDOOR TREATMENT For ants and other misc. pests.						EC									
						1	NS	NA	NS	NA	NA		NS		228-624
				when needed, Drench	Drench	[1] 8.2 lb a.i/100 gal EC	NS	NA	NS	NA	NA		NS		228-625
				Total		[1]	NS	NA	NS	NA	NA				
WHEAT		✓		Slurry Seed Treatment	Seed treatment	0.003 0.0024 lb ai/ 100 lbs seed EC	[0.006] NS	1	[2] NS	1	NA	NA	NA		Seeding information provide by BEAD.[4]
		✓		Foliar, soil treatment	Ground, broadcast	0.5 EC	[8.0] NS	4.0	[2] NS	1	14/ 28	24	14		PHI: 14 forage or hay, 28 grain or straw
		✓		Post-emergence foliar	Ground, Aerial, Chemigation	1.0 EC	[4.0] NS	2.0	[4] NS	2	14/ 28		NS	Only for use in AZ, CA, CO, ID, KS, MN, MO, NE, NM, NV, ND, OK, OR, SD, TX, UT, WA and WY	Label states 1.0 lb ai/A for cereal leaf beetles and then state max rate 0.5 lb ai/A in restriction). Some labels restrict no more than 2 applications per crop/season PHI 14 forage or hay, 28 grain or straw
				Total		**[1] 4.0**	[12.006]	**[6.003] 5.0**	[8] NS	[4] 2					MO otherwise 2.0 plus seed

Crop/Site	Residential	Agricultural	Forestry	Timing; Application Type	Method/ Equipment	Maximum Single Application Rate by Formulation[1] (lb a.i./A)	Maximum Application Rate		Maximum Application Number		PHI (days)[3]	REI (hours)[3]	MRI (days)[3]	Geographic Restrictions	Comments
							Per Year lb a.i./A	Per CC[2] lb a.i./A	Per Year	Per CC[2]					
						EC									treatment
WOOD PROTECTION TREATMENT TO BUILDINGS/ PRODUCTS OUTDOOR				When needed, Wood surface treatment	Low pressure handwand, backback sprayer, paintbrush	16.65 lb/10,000 sq ft 0.17 lb a.i./gal EC	NS	NA	NS	NA	NS	NS	NS		
						0.08 lb ai/gal EC, RTU EC, ME	NS	NA	NS	NA	NS	NS	NS		Apply 1 gal per 100 sq ft of wood

1. EC - emulsifiable concentrate; WDG – water dispersible granular in water soluble packet; WP – wettable power in water soluble packet; B – bait (granular), G – granular; ME – microencapsulated; RTU – ready to use.
2. Reported as per crop cycle or per season
3. PHI – Preharvest interval; REI – reentry interval; MRI – Minimum retreatment interval
4. Becker, J.; Ratnayake, S. Acres Planted per Day and Seeding Rates of Crops Grown in the United States, U.S. EPA OPP/BEAD, 2011; example calculations provided below:
   Beans: 0.00058 lb a.i./lb seed / 960 seeds/lb seed x 418,176 seeds/A [pgs. 19, 81 (beans, succulent)]
   Corn: 0.000625 lb a.i./lb seed / 1,800 seeds/lb seed x 59,739 seeds/A [pgs. 24, 81 (corn, sweet)]
   Cotton: 0.00116 lb a.i./lb seed / 4,500 seeds/lb seed x 85,00 seeds/A [pgs. 13, 81]
   Cucumber: 0.00058 lb a.i./lb seed / 12,000 seeds/lb seed x 80,418 seeds/A [pgs. 25, 81]
   Peas: 0.000625 lb a.i./lb seed / 1,361 seeds/lb seed x 653,400 seeds/A [pgs. 34, 82]
   Pumpkin: 0.00058 lb a.i./lb seed / 1,600 seeds/lb seed x 7,260 seeds/A [pgs. 37, 82]
   Sorghum: 0.001 lb a.i./lb seed / 11,000 seeds/lb seed x 100,000 seeds/A [pgs. 16, 39]
   Triticale: 0.003 lb a.i./100 lb seed / 109 lb seed/A [pg.16]
   Wheat: 0.003 lb a.i./100 lb seed /116 lb seed/A [pg. 16]
   [ ] indicate assumptions that are made when the information is not specified but can be inferred