Department of Pesticide Regulation

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MEMORANDUM

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DATE: October 2, 2017

SUBJECT: EVALUATION AND OPTIONS FOR INTERIM MITIGATION MEASURES TO REDUCE ACUTE CHLORPYRIFOS EXPOSURE TO BYSTANDERS

The Department of Pesticide Regulation's (DPR's) August 2017 draft risk assessment identified potential unacceptable exposures under current chlorpyrifos use practices. To address the potential unacceptable exposures DPR issued a "Directive for Interim Mitigation Measures to Address Health Risk from Chlorpyrifos" (Interim Directive), dated August 30, 2017. To implement the Interim Directive, this document describes several options to reduce these exposures to no more than the regulatory target margin of exposure (MOE) of 100. Also as specified in the Interim Directive, the options focus on mitigating acute bystander exposures to chlorpyrifos applications made for the production of agricultural commodities.

Outline

Background – Chlorpyrifos Use for 2013-2015 and Application Practices

As of July 2017, there were 43 products registered for use in California, not counting products used for manufacture. Nine of these products are registered only for non-production agriculture or non-agricultural uses. The products with highest use for 2013-2015 were Lorsban Advanced, Vulcan, Warhawk, Warhawk Clearform, and Govern 4E (Table 1). These three products accounted for more than 60 percent of chlorpyrifos use from 2013-2015. In addition, there are nine Special Local Need registrations.

Table 1. Chlorpyrifos use by product for all 43 products, 2013-2015.

	Chlorpyrifos Use (pounds)				
Product Name	**2013**	**2014**	**2015**	**Average**	**Percent**
Lorsban Advanced	660,517	486,592	499,611	548,906	42.4
Vulcan	87,503	163,263	169,129	139,965	10.8
Warhawk	190,484	137,731	70,869	133,028	10.3
Govern 4E Insecticide	107,152	133,314	47,513	95,993	7.4
Warhawk Clearform		20,458	148,323	84,390	6.5
Whirlwind	50,074	59,061	31,302	46,812	3.6
Lock-On Insecticide	56,928	58,690	23,927	46,515	3.6
Chlorpyrifos 4E AG	76,638	49,894	12,161	46,231	3.6
Nufos 4E	52,035	54,990	18,778	41,934	3.2
Lorsban-4E	35,225	44,734	12,571	30,843	2.4
All other products	152,742	103,635	72,425	115,080	8.9
Total	1,469,298	1,312,361	1,106,608	1,296,089	100.0

As shown in Table 2, more than 99 percent of the chlorpyrifos used is for agricultural commodities (production agriculture); use for non-production agriculture (e.g., golf courses, cemeteries) or non-agricultural sites (e.g., structural, institutional) is low.

Table 2. Chlorpyrifos use by type of site, 2013-2015.

	Chlorpyrifos Use (pounds)				
Site Type	**2013**	**2014**	**2015**	**Average**	**Percent**
Production Agriculture	1,465,618	1,310,114	1,102,952	1,292,895	99.8
Non-Production Agriculture and Non-Agricultural	3,680	2,247	3,656	3,194	0.2
Total	1,469,298	1,312,361	1,106,608	1,296,089	100.0

Since the Interim Directive only includes production agriculture uses, the remaining data in this document are for those uses only. As shown in Table 3, more than 98 percent of the production agriculture applications are as liquids. Chlorpyrifos is used to control a variety of insects in numerous crops, including alfalfa, almonds, broccoli, cotton, citrus, and walnuts (Table 4). The application size and application rate vary by crop. Cotton has the largest application size, with an average size of 108 acres. Orange has the highest application rate, with an average rate of 3.44 pounds active ingredient per acre (Table 5). Major use areas include the Central Valley, Central Coast region, and Imperial County (Table 6 and Figure 1). Use occurs year-round, with peak use during the summer (Table 7). Approximately 70 percent of the chlorpyrifos is applied using ground application methods and approximately 30 percent by aircraft (Table 8). According to labels, specific application methods include aerial, airblast, ground boom, sprinkler chemigation, and some specialized methods for nursery applications.

Table 3. Chlorpyrifos production agriculture use by formulation, 2013-2015.

	Chlorpyrifos Use (pounds)				
Formulation Type	**2013**	**2014**	**2015**	**Average**	**Percent**
Liquid Concentrate	818,081	600,827	568,104	662,337	51.2
Emulsifiable Concentrate	618,330	685,432	520,219	607,993	47.0
Granular/Flake	26,115	22,151	13,989	20,752	1.6
Wettable Powder	2,310	1,167	489	1,322	0.1
Flowable Concentrate	275	0	0	138	0.0
Microencapsulated	0	13	2	8	0.0
Total	1,465,115	1,309,590	1,102,803	1,292,503	100.0

Table 4. Chlorpyrifos production agriculture use by crop, 2013-2015.

	Chlorpyrifos Use (pounds)				
Crop	**2013**	**2014**	**2015**	**Average**	**Percent**
Almond	450,403	302,066	308,957	353,809	27.4
Alfalfa	198,179	278,316	123,748	200,081	15.5
Walnut	166,340	187,152	133,242	162,245	12.6
Orange	152,976	162,986	145,390	153,784	11.9
Cotton	158,134	95,401	85,773	113,103	8.8
Grapes	76,017	62,391	71,466	69,958	5.4
Grapes, Wine	37,918	27,465	46,811	37,398	2.9
Lemon	31,259	36,424	41,164	36,282	2.8
Tangerine	23,321	38,857	37,065	33,081	2.6
Sugarbeet	35,078	31,620	29,104	31,934	2.5
All Other Crops	135,492	86,913	80,083	100,829	7.8
Total	1,465,115	1,309,590	1,102,803	1,292,503	100.0

Table 5. Chlorpyrifos application size and rate for production agriculture use by crop, 2013-2015.

Crop	Annual Use (lbs)	Annual Number of Applications	Average Application Size (ac)	Average Application Rate (lbs/ac)
Almond	353,809	2,208	86	1.81
Alfalfa	200,081	6,302	60	0.53
Walnut	162,245	2,457	36	1.84
Orange	153,784	1,714	26	3.44
Cotton	113,103	1,111	108	0.95
Grapes	69,958	813	48	1.77
Grapes, Wine	37,398	337	61	1.80
Lemon	36,282	619	18	2.85
Tangerine	33,081	515	33	1.97
Sugarbeet	31,934	651	67	0.73

Table 6. Chlorpyrifos production agriculture use by county, 2013-2015.

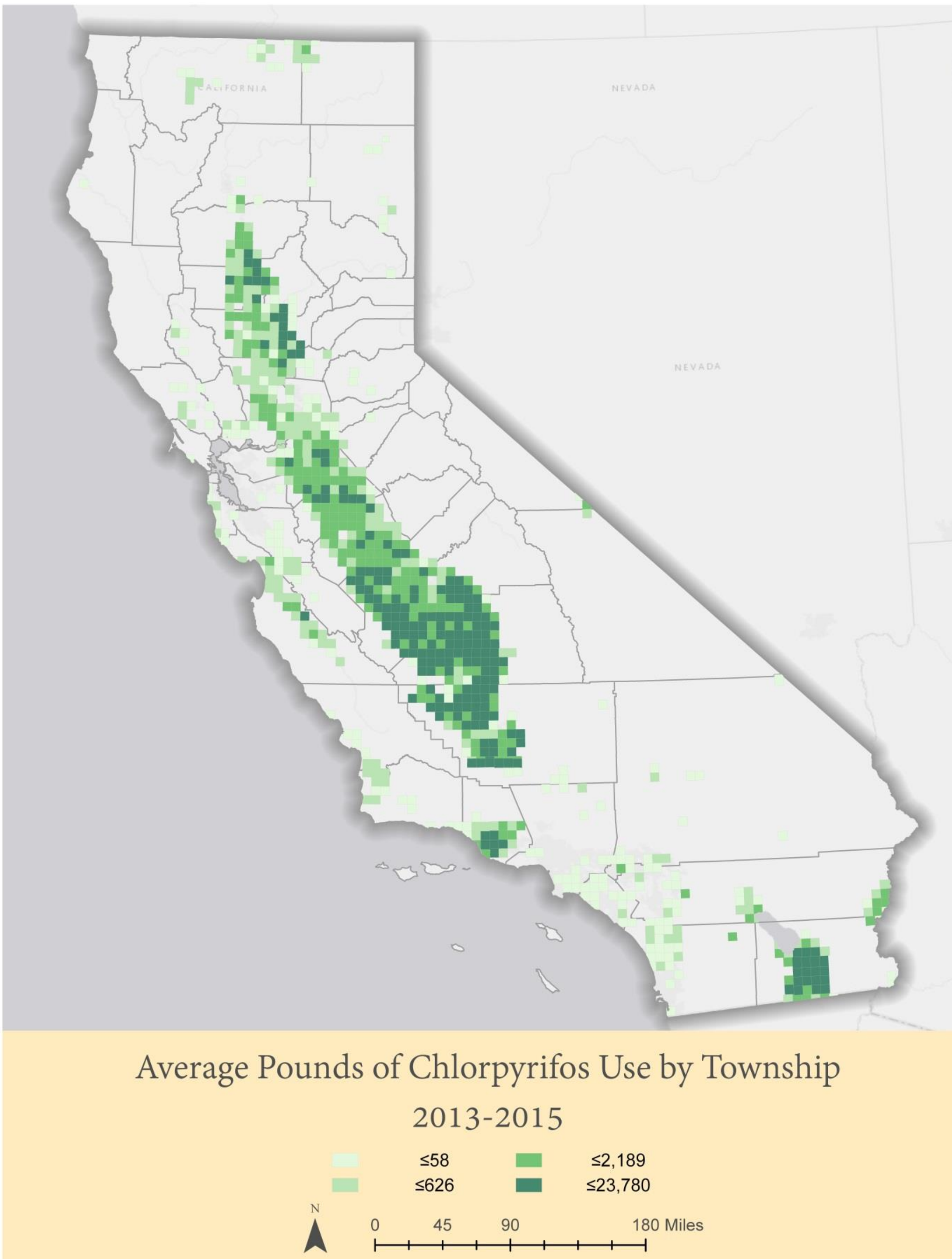
	Chlorpyrifos Use (pounds)				
County	**2013**	**2014**	**2015**	**Average**	**Percent**
Kern	325,792	256,763	285,490	289,348	22.4
Fresno	248,059	233,039	174,986	218,695	16.9
Tulare	222,000	188,820	144,771	185,197	14.3
Kings	148,936	86,218	86,571	107,242	8.3
Imperial	102,960	125,244	71,489	99,897	7.7
Stanislaus	64,683	45,221	33,580	47,828	3.7
San Joaquin	49,541	50,445	35,334	45,106	3.5
Merced	41,178	53,812	38,148	44,380	3.4
Madera	36,988	35,844	31,484	34,772	2.7
Butte	33,050	37,401	23,829	31,427	2.4
All Other Counties	191,928	196,784	177,121	188,611	14.6
Total	1,465,115	1,309,590	1,102,803	1,292,503	100.0

Table 7. Chlorpyrifos production agriculture use by month, 2013-2015.

	Chlorpyrifos Use (pounds)				
Month	**2013**	**2014**	**2015**	**Average**	**Percent**
Jan	74,411	72,079	82,655	76,382	5.9
Feb	54,652	131,915	103,080	96,549	7.5
Mar	132,683	99,979	84,812	105,825	8.2
Apr	64,227	100,718	107,659	90,868	7.0
May	253,681	106,847	81,541	147,356	11.4
Jun	112,909	103,209	101,859	105,992	8.2
Jul	291,615	235,476	196,109	241,067	18.7
Aug	240,764	239,774	133,201	204,580	15.8
Sep	121,024	100,622	82,774	101,473	7.9
Oct	66,938	68,051	51,194	62,061	4.8
Nov	22,074	31,792	26,431	26,766	2.1
Dec	30,138	19,127	51,488	33,584	2.6
Total	1,465,115	1,309,590	1,102,803	1,292,503	100.0

Table 8. Chlorpyrifos production agriculture use by application method, 2013-2015.	**Chlorpyrifos Use (pounds)**				
Application Method	**2013**	**2014**	**2015**	**Average**	**Percent**
Air	483,623	392,301	269,495	381,806	29.5
Ground	969,425	910,171	830,429	903,342	69.9
Other	12,067	7,119	2,879	7,355	0.6
Total	1,465,115	1,309,590	1,102,803	1,292,503	

Figure 1. Statewide use map.



Background – Current Chlorpyrifos Use Restrictions to Mitigate Bystander Exposures

Labels and DPR's recommended permit conditions include requirements to mitigate bystander exposures. These labels include:

- Setbacks from sensitive areas, defined as "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." The setback distance varies depending on method of application, application rate, and nozzle size (Table 9). DPR's recommended permit conditions described below contain larger setbacks.

Table 9. Setback distances required by labels.

Nozzle	App Rate (pounds/acre)	Setback (feet)		
		Aerial	Airblast	Ground
Coarse	>0.5-1	10	10	10
Medium	>0.5-1	25	10	10
Coarse	>1-2	50	10	10
Medium	>1-2	80	10	10
Coarse	>2-3	80	10	10
Medium	>2-3	100	10	10
Coarse	>3-4	NA	25	10
Medium	>3-4	NA	50	10
Coarse	>4	NA	50	10

(NA is not allowed)

- Only pesticide handlers are permitted in the setback area during application. Do not apply if anyone other than a mixer, loader, or applicator, is in the setback area. Exception: vehicles and persons riding bicycles that are passing through the setback area on public or private roadways are permitted.

- Best management practices for aerial, ground boom, and orchard airblast applications:
    - Mandatory practices for aerial applications include restrictions for boom width, nozzle orientation, droplet size, application height, and wind speed.
    - Mandatory practices for ground boom applications include restrictions for droplet size, application height, and wind speed.

  - Mandatory practices for orchard airblast applications include restrictions for nozzle direction, wind speed, and turning off outside nozzles, and when turning corners.

Labels also include advisories for drift reduction.

In 2015, DPR designated chlorpyrifos as a restricted material when labeled for the production of an agricultural commodity, and implemented mitigation measures in the form of recommended permit conditions that included the following based on best practices.

- Table 10. Minimum distances to sensitive sites:

Application Method	**Minimum Setback Distance (feet)**
Ground Boom	25
Chemigation	25
Airblast	50
Aerial (fixed wing or rotary)	150

- All applications must take place with a wind speed of three to 10 miles per hour.

- For airblast applications:
  - Spray the outside crop row from outside in, directing the spray into the treatment area and shutting off nozzles on the side of the sprayer away from the treatment area.
  - Shut off top nozzles when treating smaller trees, vines, or bushes to minimize spray movement above the canopy.

In addition to the specific chlorpyrifos requirements described above, several general requirements for all pesticide applications address bystander exposure, including the following: Title 3, California Code of Regulations (3CCR), section 6614. Protection of Persons, Animals, and Property.
(a) An applicator prior to and while applying a pesticide shall evaluate the equipment to be used, meteorological conditions, the property to be treated, and surrounding properties to determine the likelihood of harm or damage.
(b) Notwithstanding that substantial drift would be prevented, no pesticide application shall be made or continued when:

(1) There is a reasonable possibility of contamination of the bodies or clothing of persons not involved in the application process;

(2) There is a reasonable possibility of damage to nontarget crops, animals, or other public or private property; or
(3) There is a reasonable possibility of contamination of nontarget public or private property, including the creation of a health hazard, preventing normal use of such property. In determining a health hazard, the amount and toxicity of the pesticide, the type and uses of the property and related factors shall be considered.

<u>Background – Risk Assessment</u>

DPR released a draft health risk assessment in December 2015 that identified several scenarios with potentially unacceptable risk, primarily from exposure through ingestion and dermal exposure <http://www.cdpr.ca.gov/docs/risk/rcd/chlorpyrifos_draft.pdf>. Since then, DPR has made revisions to the risk assessment based on the statutorily mandated peer review comments from the Office of Environmental Health Hazard Assessment (OEHHA) and other reviews. There remains a difference of opinion between DPR and OEHHA scientists on elements of the risk assessment analysis that would impact the final regulatory target. The revised draft risk assessment, released in August 2017, identified additional scenarios with potentially unacceptable risks, including inhalation exposures to the public that will require review <http://www.cdpr.ca.gov/docs/risk/rcd/chlorpyrifos_draft_evaluation_2017.pdf>. As described in the Interim Directive, DPR will implement interim mitigation measures as soon as possible, based on the MOE for cholinesterase inhibition estimated in the August 2017 draft risk assessment. DPR will address potential developmental neurotoxic effects and longer-term exposures, if needed, after DPR finalizes its risk assessment.

The Interim Directive specifies the development and implementation of mitigation measures that reduce acute aggregate exposures to non-occupational bystanders so that the exposures do not exceed a regulatory target MOE of 100. The MOE is determined from the critical human equivalent No Observed Effect Level (NOEL) from a toxicology study or the Point of Departure (PoD) using a Physiologically-Based Pharmacokinetic – Pharmacodynamic (PBPK-PD) model and the estimated worst-case exposure.

$$\text{MOE} = \frac{\text{NOEL or PoD}}{\text{Worst-Case Exposure (route specific: dermal, inhalation, oral)}}$$

The aggregate MOE is determined by combining the MOEs for the individual routes of exposure.

$$\text{Aggregate MOE} = \frac{1}{\dfrac{1}{\text{MOE (dermal)}} + \dfrac{1}{\text{MOE (inhalation)}} + \dfrac{1}{\text{MOE (oral)}}}$$

The August 2017 draft risk assessment includes reference doses and reference concentrations that are equivalent to a MOE of 100. These are estimates of the concentration or dose of chlorpyrifos to which a person can be exposed that is likely to be without an appreciable risk of deleterious effects. The reference dose varies with the type of exposure. In other words, the same amount of chlorpyrifos will cause a different level of cholinesterase inhibition depending on if it is ingested, absorbed through the skin, or inhaled. Therefore, a single reference dose cannot be determined for an aggregate MOE of 100. DPR's regulatory target MOE of 100 would be equivalent to a reference concentration of 23.7 micrograms per cubic meter ($\mu g/m^3$) if inhalation was the only type of exposure. The majority of chlorpyrifos exposure is due to inhalation, but some of the aggregate exposure is due to ingestion and dermal absorption. The reference concentration of 23.7 $\mu g/m^3$ would be equivalent to 1.65 parts per billion if chlorpyrifos was a vapor. However, most of the chlorpyrifos in air is likely in aerosol form, so parts per billion or parts per million are inappropriate units of measure.

The interim mitigation measures will focus on reducing inhalation exposures because the August 2017 risk assessment indicates that is the exposure with the highest risk (or lowest MOE). The inhalation exposure at a specific distance normally varies with application method, application rate, and number of acres treated. Chlorpyrifos air concentrations were estimated using the AGricultural DISPersal (AGDISP) model for aerial applications. The AGDISP model cannot estimate air concentrations for other types of applications, and application-site air monitoring data were not available.[1] Therefore, the AGDISP model air concentration estimates for aerial applications were used as surrogates for ground boom and airblast applications. AGDISP

[1] The Air Resources Board monitored a chlorpyrifos aerial application in 2014, and published a report in December 2016. They also monitored a chlorpyrifos airblast application in 2015, and published a report in August 2017. These reports will be evaluated for the final risk assessment and mitigation.

provides one-hour time-weighted average concentrations. See the appendix for a more detailed discussion of the modeled one-hour air concentrations. No air concentration estimates were made for sprinkler chemigation or other application methods.

There are several key uncertainties or assumptions in the risk assessment that affect the mitigation options.

- The August 2017 draft risk assessment assumes that all of the chlorpyrifos in air may potentially inhibit cholinesterase. Chlorpyrifos in air potentially occurs in two forms: aerosols and vapor. However, not all of the chlorpyrifos aerosols have sizes that are inhalable and chlorpyrifos in vapor form has less potential to inhibit cholinesterase. Therefore, the inhalation risk is overestimated. Additionally, risk from inhalable aerosols likely only occurs during the application itself and shortly after.

- The August 2017 risk assessment used AgDrift and AGDISP models estimates of deposition outside the treated areas to estimate dermal exposures. The models were used to estimate deposition for aerial, ground boom, and airblast application methods.

- While AgDrift and AGDISP were used for determining exposures, PBPK-PD modeling was used to generate PoDs for calculating MOEs. The MOEs assume that a person exposed to an application was exposed to other chlorpyrifos applications every day for the previous 20 days. Pesticide use reports for 2013-2015 indicate that applications in any four square mile area occurred on no more than eight days in any 21-day period.

- AGDISP version 8.28 was used to estimate deposition and air concentrations. U.S. EPA used version 8.26, and version 8.29 is now available. The different versions produce different drift estimates for certain scenarios.

In summary, the August 2017 risk assessment includes several uncertainties or assumptions that potentially overestimate the risk and lead to more stringent mitigation measures than needed to meet the regulatory target.

Mitigation Options – Overview

In general, there are three categories of mitigation measures to address bystander exposure: buffer zones, application method restrictions, and use limits. Each of these measures is discussed below.

The August 2017 draft risk assessment identified children one to two years old as having the highest risk, and females 13-49 years old as having the second highest risk. Current requirements, particularly the label requirements for setbacks and buffer zones mitigate the exposures to females 13-49 years old. Therefore, only one to two year old children need additional mitigation measures. The following section describes separate mitigation measures for direct inhalation and dermal exposure during applications, and indirect dermal and oral exposure following applications due to deposition on surfaces. DPR can implement both sets of measures or apply the more stringent measures for the application period to the post-application period to simplify the requirements.

Mitigation Options – Buffer Zones and Setbacks

In many cases, buffer zones are synonymous with setbacks, but in this context setbacks differ from buffer zones. Setbacks are used to mitigate exposure to children one to two years old because they are the most sensitive population. A setback is a distance between the sensitive site and an application site. Buffer zones are used to mitigate exposure to female bystanders 13-49 years old. A buffer zone is an area surrounding an application site where only handling and other specified activities are allowed. Table 11 indicates when a setback and/or buffer zone is needed to achieve a MOE of 100.

Table 11. Periods when August 2017 draft risk assessment indicates that a setback or buffer zone is needed to achieve a MOE of 100 for populations with highest risk.

Setback or Buffer Zone	During Application (direct inhalation and dermal exposure)	After Application (indirect dermal and oral exposure)
Setback distance from sensitive site needed to mitigate 1 to 2-year-old child exposure?	Yes	Yes
Buffer zone around application needed to mitigate 13 to 49-year-old female exposure?	No	No

Setback Distances

The one to two year-old child exposure and resulting size of the setback varies with application method and application rate. As explained in the Application Limits section below, the setback distances do not vary with acreage. The August 2017 draft risk assessment included exposure estimates for three application methods: aerial (fixed wing and rotary), airblast, and ground boom (20 inches above the target [low] and 50 inches above the target [high]). The MOEs for fixed wing and rotary were very similar, and the MOEs for low boom and high boom were very similar (Appendix). Therefore, only the lowest MOEs (fixed wing and high boom) that resulted in the longest setbacks were used. Sprinkler chemigation is the one major method that is not included in the August 2017 draft risk assessment. This method should be grouped with airblast or ground boom. Tables 12 and 13 show the setback distances needed to achieve a MOE of 100. The setbacks shown in Table 13 are shorter than the ones in current recommended permit conditions (Table 10).

Table 12. Setback distances needed to achieve a MOE of 100 <u>during</u> application to mitigate direct inhalation and dermal exposure.

Application Rate (pounds/acre)	**Setback Distance (feet) by Application Method**		
	Aerial	**Airblast**	**Ground Boom**
1	250	150	150
2	500	350	350
2.3	500	---	---
4	Not allowed	400	400
6	Not allowed	500	Not allowed

Table 13. Setback distances needed to achieve a MOE of 100 <u>after</u> application to mitigate indirect dermal and oral exposure.

Application Rate (pounds/acre)	**Setback Distance (feet) by Application Method**		
	Aerial	**Airblast**	**Ground Boom**
1	10	<25	<25
2	100	<25	<25
2.3	100	---	---
4	Not allowed	25	<25
6	Not allowed	50	Not allowed

Setback Durations

The setback during application primarily mitigates inhalation exposure. To ensure that the particles/aerosols in air have dissipated, the duration of the setback during application should be extended until one or two hours after the application. A one-hour period would be consistent with the AGDISP modeling used for the August 2017 draft risk assessment.

The setback after application mitigates indirect exposure from deposition on surfaces. The surface deposition will take several days to dissipate, but the exact time is not evaluated in the August 2017 draft risk assessment, and it will vary depending on type of surface and environmental conditions. The current recommended permit conditions do not specify a duration for the setback, so it is permanent. If greater flexibility is needed, a setback duration of several days could be set. For example, the chlorpyrifos restricted entry interval (REI) used to protect workers from dermal exposure in the treated area varies from one to five days, depending on the crop. However, REIs may be inappropriate to mitigate indirect dermal and oral exposure for children.

Application Rate Definition for Setbacks

Chlorpyrifos labels specify the application rate for certain crops as an amount per 1000 feet of row rather than an amount per acre. For these applications, a "broadcast equivalent application rate" similar to the one specified by fumigant labels should be used.

Mitigation Options – Application Method Restrictions

Current label requirements include numerous application method restrictions, and the AGDISP modeling used for the August 2017 draft risk assessment reflects the current label requirements.

Aerial application method restrictions

The following current label requirements likely include all needed application method restrictions for aerial applications to mitigate drift to bystanders

- The boom width must not exceed 75% of the wingspan or 90% of the rotor blade.
- Nozzles must always point backward, parallel with the air stream, and never be pointed downward more than 45 degrees.
- Nozzles must produce a medium or coarser droplet size (255 to 340 microns volume median diameter) per ASABE Standard 572.1 under application conditions. Airspeed, pressure, and nozzle angle can all effect droplet size. See manufacturers catalog or USDA/NAAA Applicators Guide for spray size quality ratings.
- Do not make applications at a height greater than 10 feet above the top of the target plants unless a greater height is required for aircraft safety. Making applications at the lowest height that is safe reduces exposure of droplets to evaporation and wind.
- Use upwind swath displacement and apply only when wind speed is 3 to 10 mph as measured by an anemometer. Do not apply product when wind speed exceeds 10 mph.
- If application includes a no-spray zone, do not release spray at a height greater than 10 feet above the ground or crop canopy.

The AGDISP model version 8.28 used for the August 2017 draft risk assessment indicates that spray volume (i.e., the number of gallons of spray mix applied per acre), has a significant effect for exposures to aerial applications. For example, a fixed wing application at a rate of 1 pound active ingredient per acre and a spray volume of 2 gallons of spray mix per acre has a setback of

250 feet. The same application with a spray volume of 15 gallons of spray mix per acre has a setback of 1320 feet. The reason for this difference is uncertain. However, AGDISP model version 8.29 approved by U.S. EPA in December 2016 indicates little or no difference with spray volume. The aerial setbacks shown above assume a spray volume of 2 gallons per acre. There are three options for the mitigation measures: 1) include an expanded table of setback distances that varies with spray volume based on AGDISP model 8.28; 2) limit the spray volume; or 3) assume there is no difference in setbacks with spray volume based on the analysis using AGDISP model 8.29.

Airblast application method restrictions

The following current label requirements include most needed application method restrictions for ground boom applications to mitigate drift to bystanders.

- Direct nozzles so spray is not projected above the canopies.
- Apply only when wind speed is 3 to 10 mph at the application site as measured by an anemometer outside of the orchard/vineyard on the upwind side.
- Outward pointing nozzles must be shut off when turning corners at row ends.

The following current recommended permit conditions for airblast applications should be continued.

- Spray the outside crop row from outside in, directing the spray into the treatment area and shutting off nozzles on the side of the sprayer away from the treatment area.
- Shut off top nozzles when treating smaller trees, vines, or bushes to minimize spray movement above the canopy.

The Vulcan label (registration number 66222-233) requires airblast applications to turn off outward pointing nozzles at row ends and when spraying the outer <u>two</u> rows. This more stringent requirement could be required for all airblast applications.

Ground boom application method restrictions

The following current label requirements include most needed application method restrictions for ground boom applications to mitigate drift to bystanders.

- Choose only nozzles and pressures that produce a medium or coarse droplet size (255 to 400 microns volume median diameter) per ASABE Standard 572.1. See manufacturers catalog or USDA/NAAA Applicators Guide for spray size quality ratings.
- Apply with nozzle height no more than 4 feet above the ground or crop canopy.
- Do not apply product when wind speed exceeds 10 mph as measured by an anemometer

Current recommended permit conditions specify that all applications must take place with a wind speed of three to 10 miles per hour. This requirement should be continued.

Sprinkler chemigation application method restrictions

The current label requirements prohibit applications when wind speed favors drift beyond the area intended for treatment. Additionally, end guns must be turned off during the application if they irrigate non-target areas.

Other potential application method restrictions

Time restrictions, such as prohibiting applications either during the day or night are likely to have little impact on exposures. The highest inhalation exposures occur during the application period, and conditions that contribute to high air concentrations, such as calm conditions and low inversions can occur during day or night applications.

Weather restrictions such as wind direction requirements, are likely infeasible or difficult to enforce; therefore, we do not recommend them.

Mitigation Options – Application Use Limits

Acreage Limits

The AGDISP modeling used for the August 2017 draft risk assessment indicates that beyond a certain size the number of acres treated has little or no effect on the air concentrations and off-site deposition because most of the drift from large applications falls within the treated area. A limit on the number of acres treated for individual applications may be warranted. Air monitoring and air dispersion modeling for other pesticides indicate that air concentrations vary with acreage. However, there is insufficient data to determine an appropriate size at this time.

Application Rate Limits

In 2014 DPR contracted with the University of California-Integrated Pest Management (UC-IPM) Program develop guidelines for use of chlorpyrifos on four major crops.
http://ipm.ucanr.edu/IPMPROJECT/CDPR_Chlorpyrifos_critical_use_report.pdf
It's unlikely that reductions in application rate are feasible without affecting efficacy.

Other issues

Other types of applications

The mitigation measures described above are meant to address liquid applications. Chlorpyrifos can also be applied as granules, but these applications comprise less than two percent of the use (Table 3). Unless specifically exempted, the aerial setbacks described above would apply to granule applications. Ground applications of granules usually have negligible drift so no additional mitigation measures are likely needed for those applications.

Some labels allow drip chemigation applications, but these have negligible drift, so mitigation measures are likely not needed.

Alternatives

As mentioned above, DPR contracted with UC-IPM to develop and extend guidelines and practices for growers of alfalfa, almond, citrus and cotton to facilitate clear documentation of decision-making about critical uses of chlorpyrifos in reduced-risk pest management strategies. Intensive and facilitated meetings were held with growers, pest control advisors, and cooperative extension experts working in these crops to gather data on the critical uses of this insecticide. Participants identified 10-14 pests from each crop for which chlorpyrifos was an important pest management tool, but only two or three for which few or no alternatives exist. Participants stressed that even though alternatives exist for some pests, situations arise when a single application of chlorpyrifos to control multiple pests was a better solution than multiple applications of other chemicals, such as pyrethroids. Participants found that chlorpyrifos was often less disruptive to natural enemies that help to keep some pest population sizes down than are other chemicals (such as pyrethroids).

Following these focused meetings, in 2015 workshops were developed and held at 13 locations throughout California to bring the findings of the discussions to a wide audience of growers of these four crops. UC-IPM developed an online decision support tool that aids in assessing options and in making management choices for the major insect pests of these crops was developed; it can be accessed on their webpage at <http://www2.ipm.ucanr.edu/decisionsupport/>, or on smartphones in the field. The decision support tool has been accessed approximately 11,000 times.

Appendix with MOE Tables

The inhalation portion of the aggregate MOEs in the following tables is based on the estimated one-hour time-weighted average (TWA) air concentrations from aerial applications using the AGDISP model. The ground application methods used aerial application air concentrations as surrogates. The following text and tables were provided by Terri Barry, Human Health Assessment Branch, and is based on the information in the August 2017 draft risk assessment, Appendix 2.

Pesticide applications are comprised of a group of single swaths of the application equipment traveling back and forth across a target of the application (e.g. agricultural field). The mass released by each swath can be partitioned into: 1) in-swath deposition, 2) on target but out of swath deposition, and 3) spray drift comprised of mass that never contacts the target of the application. Spray drift is comprised of off-site horizontal deposition and the mass that remains aloft. AGDISP spray drift modeling assumes: 1) the application starts at the downwind side, 2) the wind direction is constant in the same direction for the entire application (e.g. for all of the 50 aerial application swaths), and 3) the wind direction is perpendicular to all of the swaths. These assumptions result in modeled values representing, for the given meteorological conditions, the maximum spray drift leaving the target. As a pesticide application continues, the location of each swath moves further and further away from the downwind edge of the entire application. Each swath deposits some mass on the application target and some mass escapes the target to be carried off-site. In addition, for each successive swath, any mass still aloft at the downwind edge will decrease relative to the earlier swaths. As a result, less and less of the mass released on any successive swath ends up off target – either as horizontal deposition or mass in the air. Appendix 2 of the August 2017 draft risk assessment discusses the number of swaths for each application type (aerial, ground boom, and orchard airblast) where all of the mass from a single upwind swath is deposited on the target.

The AGDISP model provides one-hour TWA air concentrations at chosen distances from the downwind edge of an aerial application. A fixed wing aerial application represents the most rapid application method available and a one-hour TWA air concentration is appropriate to capture the mass aloft associated with those applications. At the same application size and application rate per acre, the one-hour air concentrations associated with an aerial application will be higher than one-hour air concentrations for either a ground boom or orchard airblast application because: 1) aircraft travel much faster and 2) the release height of the mass is higher. Thus, more mass of a pesticide will both be released and travel off-site from an aerial application in that one-hour interval than from ground boom or orchard airblast. The model assumes the wind direction is invariant during that hour; therefore all of the spray drift that escapes the application target will be collected in one distinct direction. The invariant wind direction is a reasonable worst case assumption.

It is true that for the same size application that ground boom and orchard airblast applications take longer over all to complete than an aerial application. It may seem like a longer application time will lead to higher air concentrations and, thus, higher exposure. However, longer term air concentrations for a steady release such as a ground boom or orchard airblast application will always be less than a one-hour air concentration. Longer term air concentrations estimated or measured with a the entire duration to complete an application of the same size for ground boom or orchard airblast will be lower than a one-hour air concentration for the same application for two reasons: 1) the wind direction will not be constant over the entire application duration and 2) for a constant release, longer time averaged air concentrations will be lower than a one-hour air concentration due to shifts in location of a spray drift plume.

Table 14a. Aggregate MOEs and descriptions excerpted from August 2017 draft risk assessment for:

- 1 – 2 year olds; and
- Aerial applications.

DPR's regulatory target is a MOE of at least 100. MOEs used to derive setback distances are highlighted.

The modeling used to estimate the air concentrations and surface deposition for the aggregate MOEs included the following: a boom length of 76.3 percent of semi-span or rotor diameter, swath width of 60 feet for fixed wing or 1.2 times the rotor diameter for helicopter, a swath-displacement of 37 percent, no half-boom effect or swath offset, 10 miles per hour mph) wind, air temperature 65 degrees F, and humidity of 50 percent. Number of nozzles for each aircraft is the default in the AGDISP library.

		MOE		
Aircraft	**Distance From Application (feet)**	**1 pound/acre**	**2 pounds/acre**	**2.3 pounds/acre**
Fixed wing, AT802A	10	43	25	22
	25	48	28	25
	50	55	32	30
	100	68	42	39
	250	95	65	61
	500	127	98	94
	1000	193	178	172
	1320	240	229	224
	2608	386	383	377
Helicopter, Bell 205	10	34	19	17
	25	45	26	24
	50	58	34	32
	100	74	47	44
	250	102	73	70
	500	142	115	111
	1000	212	188	185
	1320	248	231	228
	2608	364	353	348

Table 14b. Aggregate MOEs expressed as "equivalent" air concentrations. DPR's regulatory target MOE of at least 100 would be equivalent to an air concentration of no greater than 23.7 μg/m^3 if that was the only type of exposure. The majority of chlorpyrifos exposure is due to inhalation, but some of the aggregate exposure is due to ingestion and absorption through skin. The ingestion and dermal exposures are converted to equivalent air concentrations to estimate aggregate exposure. The equivalent air concentrations below were calculated by multiplying the target MOE of 100 by the reference concentration of 23.7 μg/m^3 and dividing by the corresponding MOE in the previous table. For example, Table 14a shows that a fixed wing application of one pound per acre at ten feet has a MOE of 43 (upper left part of previous table). The equivalent air concentration for this MOE is 100 × 23.7 ÷ 43 = 55.1 μg/m^3, as shown in the upper left part of this table. The equivalent air concentrations used to derive setback distances are highlighted.

		Equivalent Air Concentration (μg/m^3)		
Aircraft	**Distance From Application (feet)**	**1 pound/acre**	**2 pounds/acre**	**2.3 pounds/acre**
Fixed wing, AT802A	10	55.1	94.8	107.7
	25	49.4	84.6	94.8
	50	43.1	74.1	79.0
	100	34.9	56.4	60.8
	250	24.9	36.5	38.9
	500	18.7	24.2	25.2
	1000	12.3	13.3	13.8
	1320	9.9	10.3	10.6
	2608	6.1	6.2	6.3
Helicopter, Bell 205	10	69.7	124.7	139.4
	25	52.7	91.2	98.8
	50	40.9	69.7	74.1
	100	32.0	50.4	53.9
	250	23.2	32.5	33.9
	500	16.7	20.6	21.4
	1000	11.2	12.6	12.8
	1320	9.6	10.3	10.4
	2608	6.5	6.7	6.8

Table 15a. Aggregate MOEs excerpted from August 2017 draft risk assessment for:

- 1 – 2 year olds; and
- Airblast applications to sparse orchard

DPR's regulatory target is a MOE of at least 100. MOEs used to derive setback distances are highlighted.

The orchard airblast scenarios models are empirical fits to field trial data. There are no input variables beyond the orchard type for orchard airblast. For example, weather conditions cannot be changed. The empirical model outputs reflect the weather conditions at the time of the field trials. For orchard airblast, the only orchard type affected by wind speed was dormant apples where the wind speeds for the field trials varied between 4 mph and 12 miles per hour.

	MOE			
Distance From Application (feet)	**1 pound/acre**	**2 pounds/acre**	**4 pounds/acre**	**6 pounds/acre**
25	63	38	23	18
50	72	46	29	23
75	81	52	35	24
100	88	58	40	32
150	98	68	48	25
200	107	76	57	25
250	115	84	65	59
300	122	91	74	25
500	147	120	107	105
1000	218	205	197	196

Table 15b. Aggregate MOEs expressed as "equivalent" air concentrations. DPR's regulatory target MOE of at least 100 would be equivalent to an air concentration of no greater than 23.7 µg/m^3 if that was the only type of exposure. The majority of chlorpyrifos exposure is due to inhalation, but some of the aggregate exposure is due to ingestion and absorption through skin. The ingestion and dermal exposures are converted to equivalent air concentrations to estimate aggregate exposure. The equivalent air concentrations below were calculated by multiplying the target MOE of 100 by the reference concentration of 23.7 µg/m^3 and dividing by the corresponding MOE in the previous table. For example, Table 15a shows that a fixed wing application of one pound per acre at ten feet has a MOE of 63 (upper left part of previous table). The equivalent air concentration for this MOE is $100 \times 23.7 \div 63 = 37.6$ µg/m^3, as shown in the upper left part of this table. The equivalent air concentrations used to derive setback distances are highlighted.

	Equivalent Air Concentration (µg/m^3)			
Distance From Application (feet)	**1 pound/acre**	**2 pounds/acre**	**4 pounds/acre**	**6 pounds/acre**
25	37.6	62.4	103.0	131.7
50	32.9	51.5	81.7	103.0
75	29.3	45.6	67.7	98.8
100	26.9	40.9	59.3	74.1
150	24.2	34.9	49.4	94.8
200	22.1	31.2	41.6	94.8
250	20.6	28.2	36.5	40.2
300	19.4	26.0	32.0	94.8
500	16.1	19.8	22.1	22.6
1000	10.9	11.6	12.0	12.1

Table 16a. Aggregate MOEs and descriptions excerpted from August 2017 draft risk assessment for:

- 1 – 2 year olds; and
- Ground boom, 90th percentile

DPR's regulatory target is a MOE of at least 100. MOEs used to derive setback distances are highlighted.

The ground boom scenarios models are empirical fits to field trial data. There are no input variables beyond spray quality (droplet spectra) and boom height for ground boom. For example, weather conditions cannot be changed. The empirical model outputs reflect the weather conditions at the time of the field trials. The ground boom field trials were conducted near Plainview, Texas. The weather during the field trials covered a wide range of conditions. The ground boom medium/coarse field trials showed environmental conditions spanning 5 miles per hour to 20 miles per hour wind speeds, 44º F to 91º F air temperatures, and 8 percent to 82 percent relative humidity.

		MOE			
Boom Height	**Distance From Application (feet)**	**1 pound/acre**	**2 pounds/acre**	**4 pounds/acre**	**6 pounds/acre**
High, 50 inches above target	25	68	42	27	20
	50	75	47	31	24
	75	82	53	36	24
	100	88	58	40	33
	150	98	67	48	25
	200	107	75	56	25
	250	114	83	64	58
	300	121	90	72	25
	500	146	119	105	102
	1000	216	202	192	188
Low, 20 inches above target	25	70	43	28	21
	50	76	49	32	25
	75	83	55	37	25
	100	89	60	41	34
	150	99	68	49	25
	200	108	76	57	25
	250	115	84	65	60
	300	122	91	74	25
	500	147	120	107	105
	1000	218	204	196	195

Table 16b. Aggregate MOEs expressed as "equivalent" air concentrations. DPR's regulatory target MOE of at least 100 would be equivalent to an air concentration of no greater than 23.7 μg/m^3 if that was the only type of exposure. The majority of chlorpyrifos exposure is due to inhalation, but some of the aggregate exposure is due to ingestion and absorption through skin. The ingestion and dermal exposures are converted to equivalent air concentrations to estimate aggregate exposure. The equivalent air concentrations below were calculated by multiplying the target MOE of 100 by the reference concentration of 23.7 μg/m^3 and dividing by the corresponding MOE in the previous table. For example, Table 16a shows that a fixed wing application of one pound per acre at ten feet has a MOE of 68 (upper left part of previous table). The equivalent air concentration for this MOE is 100 × 23.7 ÷ 68 = 34.9 μg/m^3, as shown in the upper left part of this table. The equivalent air concentrations used to derive setback distances are highlighted.

		Equivalent Air Concentration (μg/m^3)			
Boom Height	**Distance From Application (feet)**	**1 pound/acre**	**2 pounds/acre**	**4 pounds/acre**	**6 pounds/acre**
High, 50 inches above target	25	34.9	56.4	87.8	118.5
	50	31.6	50.4	76.5	98.8
	75	28.9	44.7	65.8	98.8
	100	26.9	40.9	59.3	71.8
	150	24.2	35.4	49.4	94.8
	200	22.1	31.6	42.3	94.8
	250	20.8	28.6	37.0	40.9
	300	19.6	26.3	32.9	94.8
	500	16.2	19.9	22.6	23.2
	1000	11.0	11.7	12.3	12.6
Low, 20 inches above target	25	33.9	55.1	84.6	112.9
	50	31.2	48.4	74.1	94.8
	75	28.6	43.1	64.1	94.8
	100	26.6	39.5	57.8	69.7
	150	23.9	34.9	48.4	94.8
	200	21.9	31.2	41.6	94.8
	250	20.6	28.2	36.5	39.5
	300	19.4	26.0	32.0	94.8
	500	16.1	19.8	22.1	22.6
	1000	10.9	11.6	12.1	12.2

Table 17a. Aggregate MOEs and descriptions excerpted from August 2017 draft risk assessment for:

- 13 – 49 year old female; and
- Aerial applications by

MOEs used to derive setback distances are highlighted.

The modeling used to estimate the air concentrations and surface deposition for the aggregate MOEs included the following: a boom length of 76.3 percent of semi-span or rotor diameter, swath width of 60 feet for fixed wing or 1.2 times the rotor diameter for helicopter, a swath-displacement of 37 percent, no half-boom effect or swath offset, 10 miles per hour wind, air temperature 65 degrees F, and humidity of 50 percent. Number of nozzles for each aircraft is the default in the AGDISP library.

		MOE		
Aircraft	**Distance From Application (feet)**	**1 pound/acre**	**2 pounds/acre**	**2.3 pounds/acre**
Fixed wing, AT802A	10	165	102	95
	25	177	112	104
	50	197	128	120
	100	230	157	148
	250	294	221	211
	500	361	303	294
	1000	480	457	449
	1320	546	532	526
	2608	694	692	688
Helicopter, Bell 205	10	138	83	77
	25	167	105	98
	50	202	133	124
	100	243	170	161
	250	308	244	236
	500	390	341	333
	1000	504	472	468
	1320	553	532	529
	2608	671	663	659

Table 17b. Aggregate MOEs expressed as “equivalent” air concentrations. DPR’s regulatory target MOE of at least 100 would be equivalent to an air concentration of no greater than 23.7 µg/m^3 if that was the only type of exposure. The majority of chlorpyrifos exposure is due to inhalation, but some of the aggregate exposure is due to ingestion and absorption through skin. The ingestion and dermal exposures are converted to equivalent air concentrations to estimate aggregate exposure. The equivalent air concentrations below were calculated by multiplying the target MOE of 100 by the reference concentration of 23.7 µg/m^3 and dividing by the corresponding MOE in the previous table. For example, Table 17a shows that a fixed wing application of one pound per acre at ten feet has a MOE of 165 (upper left part of previous table). The equivalent air concentration for this MOE is 100 × 23.7 ÷ 165 = 14.4 µg/m^3, as shown in the upper left part of this table. The equivalent air concentrations used to derive setback distances are highlighted.

		Equivalent Air Concentration (µg/m^3)		
Aircraft	**Distance From Application (feet)**	**1 pound/acre**	**2 pounds/acre**	**2.3 pounds/acre**
Fixed wing, AT802A	10	14.4	23.2	24.9
	25	13.4	21.2	22.8
	50	12.0	18.5	19.8
	100	10.3	15.1	16.0
	250	8.1	10.7	11.2
	500	6.6	7.8	8.1
	1000	4.9	5.2	5.3
	1320	4.3	4.5	4.5
	2608	3.4	3.4	3.4
Helicopter, Bell 205	10	17.2	28.6	30.8
	25	14.2	22.6	24.2
	50	11.7	17.8	19.1
	100	9.8	13.9	14.7
	250	7.7	9.7	10.0
	500	6.1	7.0	7.1
	1000	4.7	5.0	5.1
	1320	4.3	4.5	4.5
	2608	3.5	3.6	3.6

Table 18a. Aggregate MOEs and descriptions excerpted from August 2017 draft risk assessment for:
13 – 49 year old female

- Airblast applications to sparse orchard

DPR's regulatory target is a MOE of at least 100. MOEs used to derive setback distances are highlighted.

The orchard airblast scenarios models are empirical fits to field trial data. There are no input variables beyond the orchard type for orchard airblast. For example, weather conditions cannot be changed. The empirical model outputs reflect the weather conditions at the time of the field trials. For orchard airblast, the only orchard type affected by wind speed was dormant apples where the wind speeds for the field trials varied between 4 miles per hour and 12 miles per hour.

	MOE			
Distance From Application (feet)	**1 pound/acre**	**2 pounds/acre**	**4 pounds/acre**	**6 pounds/acre**
25	197	128	83	64
50	222	150	101	81
75	240	167	116	95
100	255	181	130	108
150	279	205	154	134
200	299	226	177	160
250	316	245	200	186
300	331	263	222	211
500	381	328	301	298
1000	498	479	467	468

Table 18b. Aggregate MOEs expressed as “equivalent” air concentrations. DPR’s regulatory target MOE of at least 100 would be equivalent to an air concentration of no greater than 23.7 μg/m^3 if that was the only type of exposure. The majority of chlorpyrifos exposure is due to inhalation, but some of the aggregate exposure is due to ingestion and absorption through skin. The ingestion and dermal exposures are converted to equivalent air concentrations to estimate aggregate exposure. The equivalent air concentrations below were calculated by multiplying the target MOE of 100 by the reference concentration of 23.7 μg/m^3 and dividing by the corresponding MOE in the previous table. For example, Table 18a shows that a fixed wing application of one pound per acre at ten feet has a MOE of 197 (upper left part of previous table). The equivalent air concentration for this MOE is 100 × 23.7 ÷ 197 = 12.0 μg/m^3, as shown in the upper left part of this table. The equivalent air concentrations used to derive setback distances are highlighted.

	Equivalent Air Concentration (μg/m^3)			
Distance From Application (feet)	**1 pound/acre**	**2 pounds/acre**	**4 pounds/acre**	**6 pounds/acre**
25	12.0	18.5	28.6	37.0
50	10.7	15.8	23.5	29.3
75	9.9	14.2	20.4	24.9
100	9.3	13.1	18.2	21.9
150	8.5	11.6	15.4	17.7
200	7.9	10.5	13.4	14.8
250	7.5	9.7	11.9	12.7
300	7.2	9.0	10.7	11.2
500	6.2	7.2	7.9	8.0
1000	4.8	4.9	5.1	5.1

Table 19a. Aggregate MOEs and descriptions excerpted from August 2017 draft risk assessment for:

- 13 – 49 year old female; and
- Ground boom, 90th percentile

DPR's regulatory target is a MOE of at least 100. MOEs used to derive setback distances are highlighted.

The ground boom scenarios models are empirical fits to field trial data. There are no input variables beyond spray quality (droplet spectra) and boom height for ground boom. For example, weather conditions cannot be changed. The empirical model outputs reflect the weather conditions at the time of the field trials. The ground boom field trials were conducted near Plainview, Texas. The weather during the field trials covered a wide range of conditions. The ground boom medium/coarse field trials showed environmental conditions spanning 5 miles per hour to 20 miles per hour wind speeds, 44º F to 91º F air temperatures, and 8 percent to 82 percent relative humidity.

		MOE		
Boom Height	**Distance From Application (feet)**	**1 pound/acre**	**2 pounds/acre**	**4 pounds/acre**
High, 50 inches above target	25	207	137	90
	50	226	154	105
	75	242	169	118
	100	256	182	131
	150	279	205	154
	200	298	226	176
	250	315	245	199
	300	331	262	221
	500	380	327	300
	1000	498	478	466
Low, 20 inches above target	25	208	138	91
	50	227	154	105
	75	242	169	119
	100	256	183	131
	150	279	206	155
	200	299	226	177
	250	316	245	200
	300	331	263	222
	500	381	328	300
	1000	498	479	466

Table 19b. Aggregate MOEs expressed as “equivalent” air concentrations. DPR’s regulatory target MOE of at least 100 would be equivalent to an air concentration of no greater than 23.7 μg/m^3 if that was the only type of exposure. The majority of chlorpyrifos exposure is due to inhalation, but some of the aggregate exposure is due to ingestion and absorption through skin. The ingestion and dermal exposures are converted to equivalent air concentrations to estimate aggregate exposure. The equivalent air concentrations below were calculated by multiplying the target MOE of 100 by the reference concentration of 23.7 μg/m^3 and dividing by the corresponding MOE in the previous table. For example, Table 18a shows that a fixed wing application of one pound per acre at ten feet has a MOE of 207 (upper left part of previous table). The equivalent air concentration for this MOE is 100 × 23.7 ÷ 207 = 11.4 μg/m^3, as shown in the upper left part of this table. The equivalent air concentrations used to derive setback distances are highlighted.

		Equivalent Air Concentration (μg/m^3)		
Boom Height	**Distance From Application (feet)**	**1 pound/acre**	**2 pounds/acre**	**4 pounds/acre**
High, 50 inches above target	25	11.4	17.3	26.3
	50	10.5	15.4	22.6
	75	9.8	14.0	20.1
	100	9.3	13.0	18.1
	150	8.5	11.6	15.4
	200	8.0	10.5	13.5
	250	7.5	9.7	11.9
	300	7.2	9.0	10.7
	500	6.2	7.2	7.9
	1000	4.8	5.0	5.1
Low, 20 inches above target	25	11.4	17.2	26.0
	50	10.4	15.4	22.6
	75	9.8	14.0	19.9
	100	9.3	13.0	18.1
	150	8.5	11.5	15.3
	200	7.9	10.5	13.4
	250	7.5	9.7	11.9
	300	7.2	9.0	10.7
	500	6.2	7.2	7.9
	1000	4.8	4.9	5.1