Refining Pyrethroid Aquatic Exposure Assessments by Incorporating Measured Landscape and Environmental Variability using Probabilistic Approaches. IV – Comparison of Aquatic Exposure Estimates for Pyrethroid Crops based on Real-world Inputs and Standard Lower Tier Regulatory Estimated Concentrations.

PYRETHROID WORKING GROUP

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Abstract

The Pyrethroid Working Group (PWG) has conducted a probabilistic refinement of aquatic exposure estimates for agricultural uses. PWG has characterized potential vulnerabilities of the US nationwide landscape for key pyrethroid use patterns in terms of the potential for drift and runoff/erosion entry at the NHD+ catchment spatial scale in areas where the crop is currently produced, the likelihood of multiple applications all having adverse wind speeds and directions and also the potential impact of many other factors associated with well documented pyrethroid behaviors. The first two factors have been defined as numerical probability distributions which can be translated into input assumptions for USEPA standard farm pond scenario modeling using PRZM-VFSMOD-AGRO-2014 for comparison with output from EPA's standard lower tier model scenarios. The results show that the probabilistic assessments generate exposure distributions that are dominated by results from catchments with zero to low cropping densities. This, coupled with the fact that most crops are not grown extensively on extremely erosive slopes/soils, means that standard lower tier regulatory exposure estimates only reflect the upper bounds of real-world potential exposures. Additional factors related to pyrethroid behaviors mean that even these probabilistic pyrethroid model outputs over-predict likely real-world concentrations. These results are supported by monitoring data.

Background

Accompanying posters have provided background information about a) the rationale PWG developed for incorporating additional factors into a probabilistic exposure and accompanying uncertainty assessment b) the national scale landscape assessment for a wide range of crops and c) the impact of wind speed and associated weather conditions on estimations of drift load. This poster examines the cumulative effect of the national distributions of the percent cropped areas (PCA), the contribution of the variation of runoff/erosion potential and of the area of each crop treated with any pyrethroid as well as the potential impact of several sources of uncertainty on water body EECs .

Materials and Methods

The table below describes the sequential steps applied for the initial probabilistic modeling for each crop. The examples shown are for deltamethrin

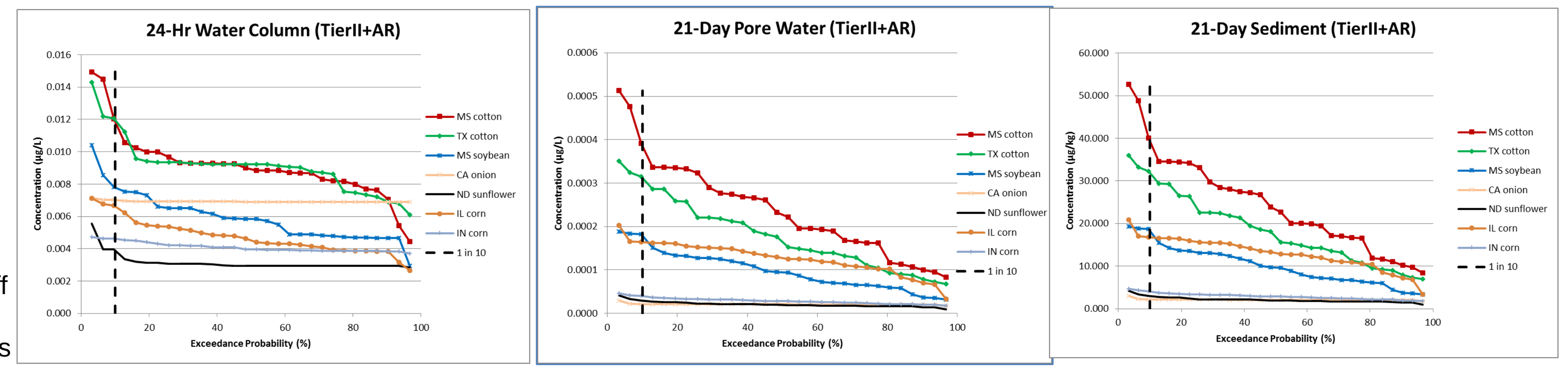
Parameter	PWG Tier II+AR	PWG Landscape Refinement 1 – LR1	PWG Landscape Refinement 2 – LR2
Model Suite	PRZM/ *VFSMOD*/ AGRO-2014**	PRZM/ VFSMOD*/ AGRO-2014*	
Application Rate	Max		
No. Applns	Max		
Appln. Sequence	*Agronomically realistic*		
Appln Interval**	Shortest for final aerial applications only		
Field/Water body half-lives	Mean		
Soil Photolysis	*On (when soil unshaded)*		
Adsorption Inputs	K_{OC-LLE} (field); $K_{OC-SPME}$ (water body)		
Ground Drift Model	*RegDisp*		
Aerial drift model	AgDRIFT® Tier 1		
Wind Speed/ towards pond	*15 mph (ground)* 10 mph (air)		
Mitigation-drop size	Medium/coarse		
Mitigation-VFS***/NSB***	10ft VFS,*25ft grnd*,150ft air		
Runoff/Erosion (R/E) Scenario	Std. Tier II	Std. Tier II	R/E Distribution across all cropped NHD+ catchments
Percent cropped Area .(PCA***)	100%	10 point geometric distribution reflecting 2012 crop PCA for combined 10-200m proximity zone	10 point geometric distribution reflecting 2012 crop PCA for separate 10-50 and 50-200m proximity zones
PTA***	100%	100%	
Probabilistic output	30 years	300 years	3330 years

*A more recent version of VFSMOD was introduced at this stage as well as a minor revision to AGRO-2014. **Intervals driven by label where specified. *** PTA – Percent treated area. NSB- No Spray Buffer. VFS- Vegetative filter strip. PCA – Percent cropped area.

Ranked Tier II+AR EECs

Basic EECs from max rate/max numbers of applications with agronomically realistic application sequences are compared here across a number of crops

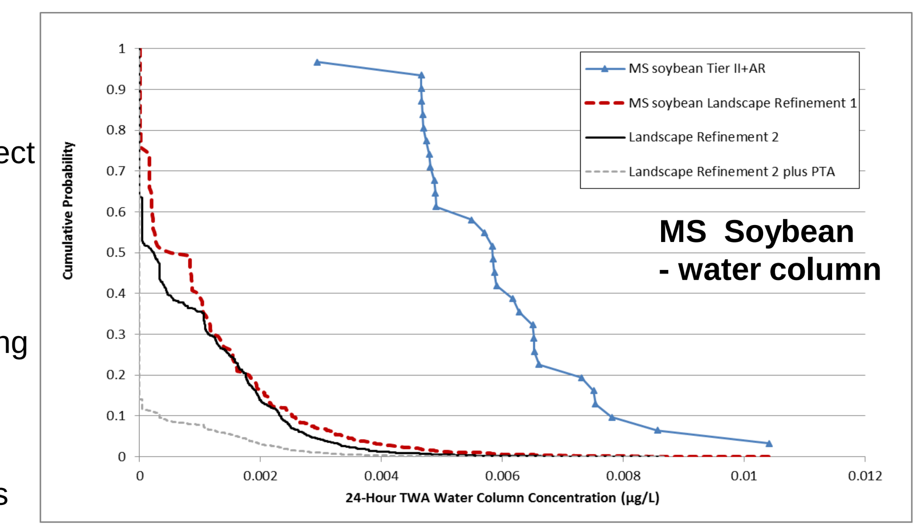
- Differences reflect EPA Tier II R/E vulnerabilities & labeled Nos. applications
- Arid area EECs largely drift driven, Humid area EEC have high contribution from runoff & erosion
- Pore water/sediment show identical patterns

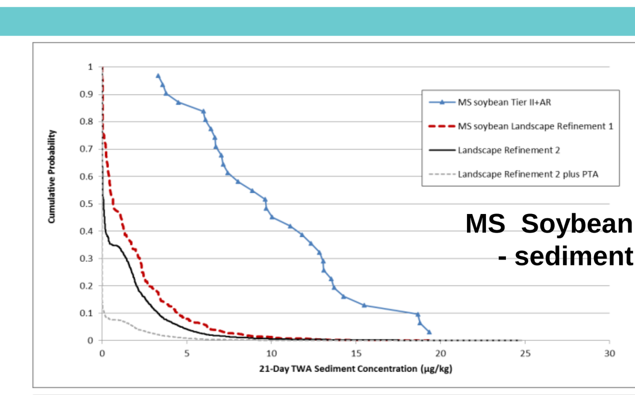


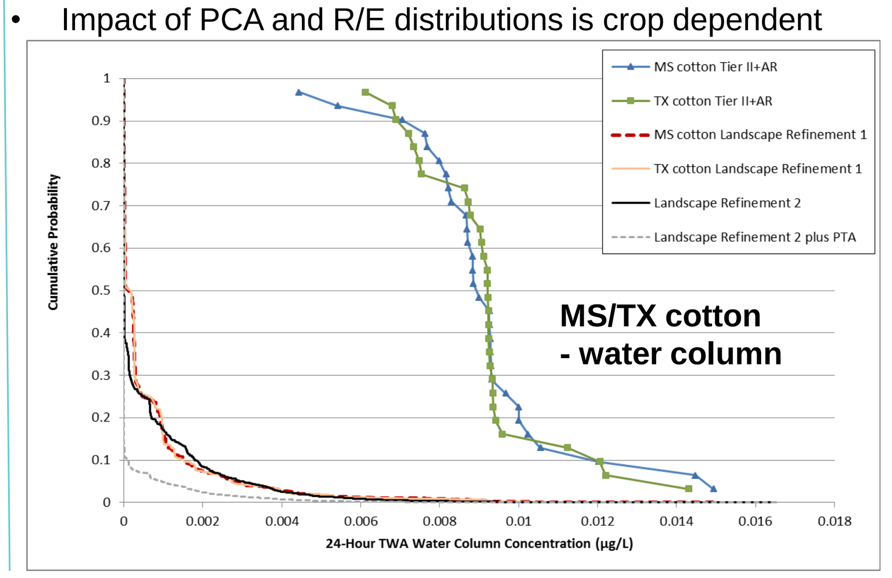
Probabilistic Modeling EECs

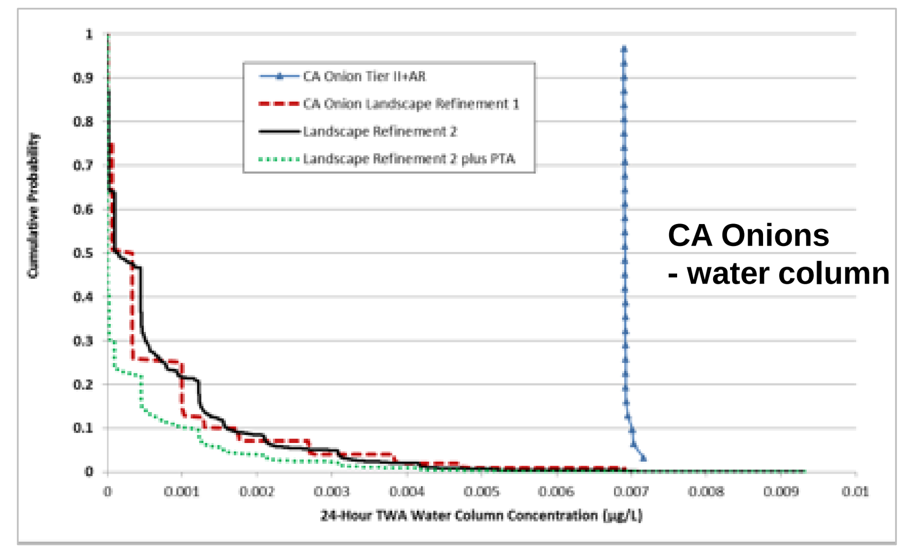
Probabilistic EECs also use max rate/max numbers of applications with agronomically realistic application sequences.

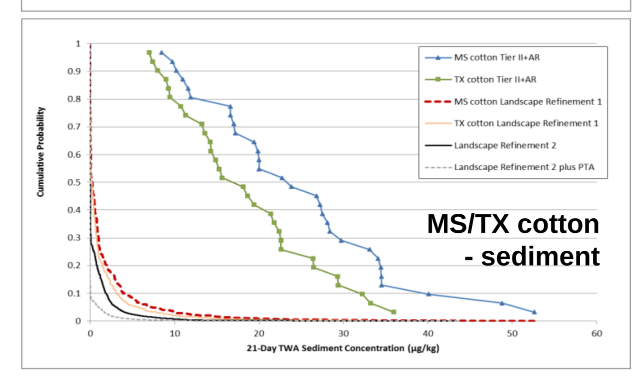
- Graphs compare Tier II+AR EECs (30 yr) with PCA only effect (LR1) and combined PCA/R/E distributions (LR2)
- The effect of incorporating the assumption that 100% of all pyrethroid applications are made with deltamethrin and applying this PTA value to the distribution from LR2.
- The incorporation of PCA distributions into standard modeling has a very significant effect on 90th centile EECs
- The R/E distribution has a lower effect on water column concentrations than PCA
- The PTA has a very significant & non-linear impact on EECs
- Impact of PCA and R/E distributions is crop dependent

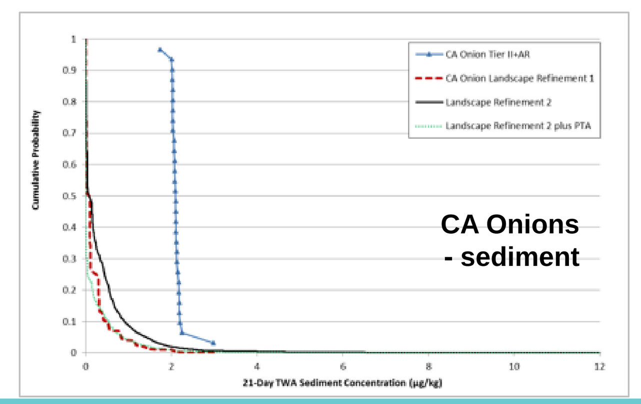












Potential Sources of EEC Uncertainty

PWG has performed a detailed assessment of the sources of uncertainty potentially impacting lower tier EECs. A list of over 70 potentially conservative, non-conservative and variable sources of uncertainty has been evaluated in detail. Two lists below indicate subsets primarily affecting either:

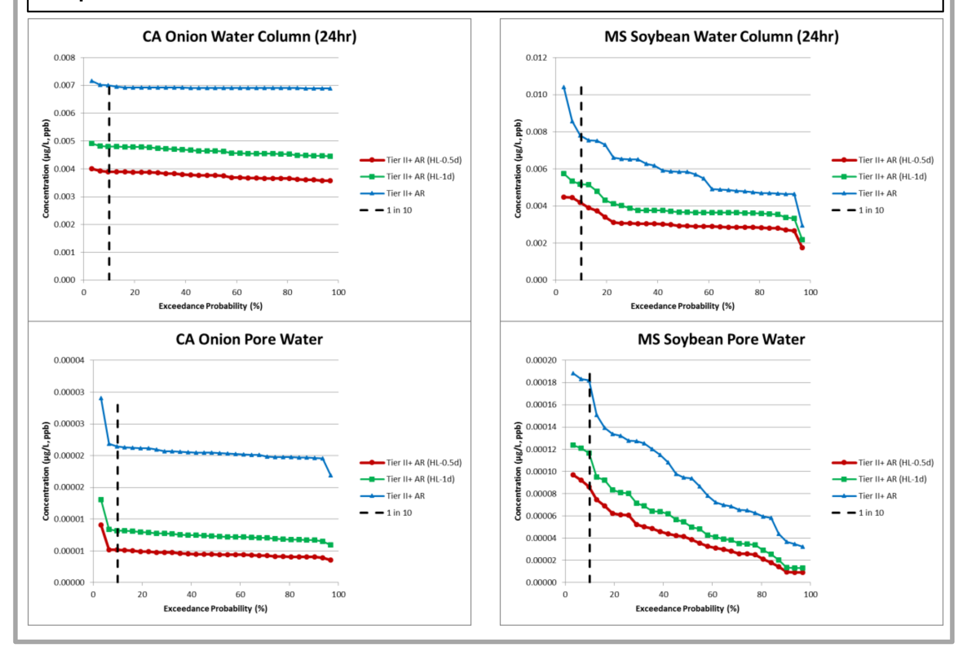
- EECs in ponds which are/will be exposed to pyrethroid entry
- The likelihood of occurrence of potentially exposed water bodies. (Note that several uncertainties in this category will ALSO potentially impact concentrations in exposed ponds)

Potential source of uncertainty	Factor (relative to Tier II+AR) [Factors >1 indicate the multiple by which EECs will be reduced]	Impacts single exposed pond scenario
Systematic uncertainties in SPME KOC model inputs.	1.25 – 1.4X due to correction factor used for model inputs.	Y
Adsorption to aq. plants/associated biofilms in water body (quantified via EXAMS-300 mg dry wt/L biomass).	13X for water column, 2X for sediment and pore water.	Y
Degradation by plant surfaces & associated biofilms.	Estimated 1.5 – 3X.	Y
Variation in number of applications made per season.	Estimated 1 – >1.5X.	Y
Variation in wind speed at time of application.	1.1 – 5X .	Y
Variation from modeled 30 year continuous cropping regimes.	1 – 1.3X.	Y
Variation in frequency of applications.	Estimated 1 – 1.2X.	Y
Incorporation of soil photolysis.	Estimated 0.7 – 1X. (i.e. if photolysis switched off, EEC ↑)	Y
Variable volume water body – evaporation.	0.7 – 1X.	Y
Variation in wind direction relative to water body.	Estimated 1 – 1.3X.	Y
Variable deposition/mixing of drift	0.5 - 2X - creates more- & less- potentially exposed areas	Y
Variable deposition/mixing of erosion	0.5-2X - creates more- & less- potentially exposed areas	Y

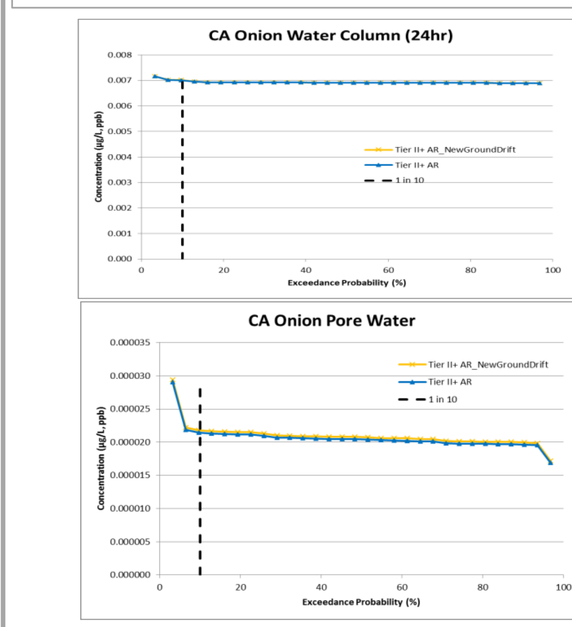
Potential source of uncertainty	Factor (relative to Tier II+AR)	Impacts probability of finding an exposed pond
Landscape refinement 1 - distribution of PCA across potentially treated watersheds	**Quantified. Typically 3-10X for sediment and water column for major crops**	Y
Landscape refinement 2 - LR1 plus full distribution of environmental vulnerabilities	**Quantified. 0.9-1.1 for water column. 0.5-2X for sediment and pore water IN ADDITION TO Landscape Refinement 1**	Y
Interception of drift by intervening vegetation.	1 – 2X.	Y
Effect of riparian buffers along water-body edges on modifying runoff/erosion.	1 – 2X (effect mainly on sediment).	Y
Variation in natural and man-made filter strip widths.	1 – 2X (effect mainly on sediment).	Y
Potential Drift deposition from >200 m.	0.7 – 1.0X.	Y
Fraction of percent of crop area treated (PTA).	Water column 5.5X, 23X & 130X. Sediment = 4X, 150X and 970X. (Onion, Soybean & Cotton) at 90th centile	Y
Fraction of catchment area draining to watershed exit (i.e., uncertainty about enclosed depressions).	Estimated 1.1X – 1.3X.	Y
Individual market share of pyrethroids nationally and by region.	3 – 100X (deltamethrin > 100X both nationally and in CA).	Y
Variation in fraction of CoI in catchment treated on the same day.	Estimated 1 – 1.8X.	Y
Variation in actual rate of pyrethroid applied (based on GfK Kynetec data).	1 – 1.15X.	Y
Variation in selection of application methods (ground/air) and subsequent handling (banding/incorporation).	0.9 – 1.3X.	Y
Variation in intervals between applications.	Estimated 1 – 1.2X.	Y
Fraction of watersheds with sediment /erosion control structures.	1 – 1.4X (regional). (effect mainly on sediment).	Y
Fraction of CoI area using conservation tillage, associated realism of LS CA and P parameters in models.	0.8 – 1.1X (effect mainly on sediment).	Y
Impact of sediment delivery ratios at field/catchment scales.	1 – 4X (effect mainly on sediment).	Y

Incorporating Additional Factors & Monitoring Database Analysis.

Using measured water body half lives from mesocosm studies (0.5 to 1d) in place of laboratory values (46d) has crop-specific impacts on Tier II+AR EEC distributions



Comparisons indicate that potential of ground spray drift loads from beyond the 10-50m proximity zones have no impact on annual maxima distributions.



High centile estimates of bulk water column concentrations from various PWG modeling steps have been compared with extensive monitoring data.

- Comparisons suggest that modeled concentrations are significantly conservative

	Modeling (ng/L)				Monitoring (ng/L)	
%ile	II+AR	LR1	LR2	CA Res[a]	Ag(n=229)	Urban(n=420)
90th	43-280	11-28	10-20	125	<RL[c]	<RL
95th	44-390	17-50	19-32	158	<RL	<RL
99th	44-470[b]	42-130	32-61	162[b]	2.8	16

Conclusions and Next Step.

Pyrethroids have unique properties that mean standard lower tier models and default input values may not be optimal. PWG has identified more suitable lower tier approaches and inputs and has also conducted refined higher tier modeling incorporating national crop-specific landscape-scale PCA and runoff/erosion vulnerability measurements which identify the likely EECs in 90th centile water bodies in cropped catchments.

- National PCA distributions have major impacts on 90th centile EECs, runoff/erosion vulnerability distributions have smaller effects.
- Magnitude of these effects is crop-specific and may differ between water column & sediment/pore water EECs.
- Incorporating conservative estimates of fraction of crop treated with any pyrethroid also has major effect on resulting EECs

In addition, PWG has conducted a detailed analysis of all potential sources of uncertainty associated with lower tier EECs and identified subsets which can be quantified by modeling or best-professional judgment. The resulting analyses:

- Will be published and are offered to the stakeholder communities for discussion and improvement
- Show that there are a wide range of factors that contribute to
  - EECs in ponds which are potentially highly exposed
  - The probability that ponds will be receive the expected loads of drift or runoff entry
- Suggest that, in many cases, the pyrethroid EECs predicted by lower tier modeling, are likely to be conservative by at least one order of magnitude
- A large pyrethroid monitoring database supports the conclusion that modeled EECs are very conservative

PWG believes that these approaches to the concept of refining lower tier exposure assessments and the resulting detailed analyses of sources of uncertainty and the associated crop-specific databases of landscape vulnerabilities measured at the NHD+ catchment level offer important new tools for exposure and sustainability assessment of all classes of agrochemicals. As such the approaches and data will benefit from evaluation by a range of stakeholders.

Acknowledgement

The Pyrethroid Working Group (PWG) is a US task force whose members include eight primary pyrethroid registrants (AMVAC Chemical Corporation, BASF Corporation, Bayer CropScience LP, Cheminova A/S, DuPont Crop Protection, FMC Corporation, Syngenta Crop Protection, LLC, Valent U.S.A. Corporation).