Regional Water Quality Control Board
Central Valley Region
Board Meeting – 8/9 June 2017

RESPONSE TO PEER REVIEW COMMENTS ON PROPOSED AMENDMENTS TO THE WATER QUALITY CONTROL PLAN FOR THE SACRAMENTO RIVER AND SAN JOAQUIN RIVER BASINS FOR THE CONTROL OF PYRETHROID PESTICIDE DISCHARGES

This document presents responses to the comments received from three peer reviewers on the May 2015 Draft Staff Report and proposed Basin Plan Amendment, as well as secondary documents. Scientific findings and conclusions that were posed to the reviewers are in bold text. Comments are numbered and shown in indented italics. Comment numbers in this document are not necessarily the same as the comment numbers provided by the commenters in their comment letters. Staff responses follow each comment in regular text. The responses identify where revisions to the Staff Report and Proposed Amendment have been made based on the comments received.

Contents

1. Kevin L. Armbrust, Ph.D., Chair and Professor, Department of Environmental Sciences, School of Coast and Environment, Louisiana State University

1. **The proposed water quality objectives are protective of the beneficial use(s) that is most sensitive to pyrethroid pesticides. The Draft Staff Report evaluates several potential water quality objectives and concludes that the acute and chronic water quality criteria derived in 2015 using the University of California - Davis methodology, are scientifically sound and are protective of beneficial uses.**

   Comment 1.1:
   The staff report identifies warm and/or cold aquatic life habitats as the beneficial uses most sensitive to impairment by pyrethroid insecticides in either water or sediment. The basis of this conclusion is that pyrethroid insecticides are reported in the scientific literature to have the highest toxicity to aquatic and sediment dwelling arthropods. The conclusions of the staff report appear to be well founded in cited literature as well as consistent with the general scientific consensus I have heard over the years in professional and regulatory meetings regarding pyrethroids. The UC Davis method that established 2015 acute and chronic water quality criteria is a logical basis for water quality objectives for these compounds as it allows the calculation of numeric standards for each of the pesticides of interest and should be low enough to be protective of the beneficial uses. I concur that the other alternative methods presented would not be as protective for beneficial uses as they had higher numeric values or were designed such that numeric values could not be developed for some of the pyrethroid insecticides of interest due to the lack of data. In many respects the UC Davis method is consistent with and mirrors the US EPA method for developing criteria but allows greater flexibility to handle data sets and the development of numeric values when full data sets required for the EPA method are not available.

Response to Comment 1.1: Comment acknowledged.

2. **The underlying method for deriving the proposed pyrethroid pesticides water quality criteria, which are proposed as water quality objectives and TMDLs, is scientifically sound. The UC-Davis Methodology and the criteria derived by this method are technically valid and scientifically sound for use as water quality objectives and TMDLs. The following procedures result in conservative criteria that are scientifically sound and protective of sensitive species, and are not overly conservative:**

   2A. The UC-Davis Methodology uses 24-96-hour toxicity data to derive acute criteria not to be exceeded over a 1-hour averaging period and longer duration chronic toxicity data to derive chronic criteria not to be exceeded over a 4-day averaging period. In addition, the most sensitive life-stage and endpoint are used among toxicity data for a given species. The use of toxicity data from longer durations than the criteria averaging period does provide conservatism

to the criteria; based on scientific evidence this is valid in order to ensure that the values are protective of all species in an aquatic ecosystem, including those for which no toxicity data is available.

Comment 1.2:

The criteria developed using the UC Davis method are attained if the averaging periods do not exceed the chronic criteria more than once every three years. This longer duration should be protective and is appropriate given the current state of the science. As stated in the staff report, the criteria are based upon toxicity to the most sensitive species tested, in this case, Hyalella azteca which notably was consistently the most sensitive species in all tests. However data was also presented in the staff report that there is evidence native (i.e., wild) populations of Hyalella do adapt to develop resistance to chronic low-level amounts of pyrethroids over time, thus laboratory based-toxicity assessments using laboratory reared organisms, and the corresponding criteria based upon them, may overestimate the potential impact on the same species in the field. While the current status of data at this point would not justify a higher criteria value, it may in the future as the database in the research of native species evolution and "ruggedness to chemical insult" continues to evolve and expand.

Response to Comment 1.2:

Comment acknowledged. The proposed Basin Plan language includes a provision that the Regional Board will review the pyrethroid pesticides numeric triggers and implementation provisions no later than 15 years after the effective date of the amendment. At this time, any new research on the ability of resident *Hyalella azteca* to adapt to pyrethroid exposure and the effects of those adaptations will be reviewed.

2B. The authors recommend using the lower 95% confidence interval of the 5th percentile or the 1st percentile of the SSD for downward adjustment of criteria. Five of the six 2015 water quality criteria derived using the UC-Davis Methodology were adjusted downward using the 1st percentile of the SSD to be protective of sensitive species in the data sets, however, using the 5th percentile would be more consistent with other methodologies.

Comment 1.3:

The downward adjustment of the criteria for bifenthrin, cyfluthrin, cypermethrin, esfenvalerate and lambda-cyhalothrin using the 1st percentile of SSD is scientifically sound based upon the UC Davis method and consistent with stated policy to provide the greatest degree of protection to the most sensitive species. In general, the major differences between using the 5th percentile vs. the 1st percentile of the SSD results in an approximate order of magnitude difference in criteria values. A great deal of conservatism is already built into the process via a maximum exceedance of the chronic criteria of once over 3 years over a 4 day averaging period and using toxicity values based upon laboratory reared organisms that appear to be more sensitive than native organisms in impacted waters. While use of the 1st percentile of the SSD is consistent with scientific knowledge, methods and practices it would appear to be overly protective based upon the conservatism already in place. Criteria values based upon the 5th percentile would be equally justified scientifically, consistent with other national *and international methods and standards as noted by the staff report, and would likely still provide adequate protection for the identified beneficial uses.*

Response to Comment 1.3:
After receiving the peer review comments regarding the use of criteria based on the 1st or 5th percentile of the species sensitivity distributions, staff has changed their recommendation. In the draft staff report that was peer reviewed the staff recommendation was to use the water quality criteria based on the 1st percentile for bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, and lambda-cyhalothrin. Following peer review, staff has changed their recommendation to water quality criteria based on the 5th percentile for all six pyrethroids.

The change in recommended values was determined after considering the peer review comments indicating that the criteria based on the 5th percentile would also be reasonably protective of aquatic ecosystems. Beyond the scientific foundation of the values, staff also recognized upon further analysis that the criteria based on the 5th percentile would be more likely to be achieved, but will still require significant reductions from all dischargers. In addition, the effects of pyrethroids will be reviewed within 15 years after adoption of the proposed Basin Plan amendment and if the criteria based on the 5th percentile do not appear to be protective of aquatic life at that time, the values can be adjusted by the Regional Board.

2C. It is scientifically sound to mix flow-through, static renewal, and static data in deriving criteria and does not introduce bias that would lead to criteria that are underprotective or overly conservative. While data from flow-through tests based on measured concentrations is preferred, using the best available data for a given species is technically valid.

Comment 1.4:
It is an acceptable scientific practice to mix data collected from flow-through, static renewal and static toxicity studies for criteria development as long as there are established metrics that dictate acceptable data quality that are applied consistently to each study. The UC Davis method uses a process that applies metrics in study evaluation, and a ranking system for selection of one study type over another (e.g. flow-through vs static; measured concentrations are preferred over nominal concentrations, etc). Studies selected for criteria development are ranked according to both relevancy and reliability and are given designations of RR (Relevant and Reliable). Studies rated as less reliable in either category are used as supplemental information. Studies rated as unreliable are not used to develop criteria.

Response to Comment 1.4: Comment acknowledged.

2D. When there are insufficient acute toxicity data to use a species sensitivity distribution to derive the acute criterion, the UC Davis methodology Phase II Report includes assessment factors that are applied to the lowest acute toxicity value in the data set in order to estimate the 5th percentile of a distribution. The assessment factors decrease as the number of available data increase because uncertainty decreases with increasing information. The assessment factors were derived by a mathematical procedure from the

USEPA guidance for the Great Lakes system using existing high quality pesticide data sets. It is recognized that assessment factors are a conservative approach for deriving water quality criteria, but when little data is available; it is scientifically sound to use a conservative approach. Similarly, the UC Davis methodology Phase II Report provides a default acute-to-chronic ratio to use for derivation of chronic criteria when too few chronic toxicity data are available to derive criteria using a species sensitivity distribution or empirical acute-to-chronic ratios for the pesticide of interest. The default acute-to-chronic ratio is based on the 80th percentile of available empirical acute-to-chronic ratios for other pesticides, following the US EPA guidance for the Great Lakes system. Use of the 80th percentile provides some conservatism to the default acute-to-chronic ratio, which is scientifically sound to account for the uncertainty in using this value for pesticides for which little to no chronic toxicity data are available.

Comment 1.5:
The use of assessment factors and also default acute-to-chronic ratios for other pesticide classes to develop criteria, while not ideal, are still scientifically sound and acceptable in the absence of high quality data for the pesticides of interest. The UC Davis method directly follows EPA guidance in this manner and thus has an established proven precedent. Ideally, the other pesticide data sets chosen would be those that are within the same class of pesticide (ie. In this case another pyrethroid). In the absence of this, pesticides chosen with the same mode of action would be a secondary selection factor.

Response to Comment 1.5:
The data sets used to calculate the assessment factors and the default acute-to-chronic ratio do include pyrethroids, but are not limited to pyrethroids or pesticides with the same mode of action. There are few robust pesticide data sets available to use in these calculations and thus far, there is not a clear trend in assessment factors and acute-to-chronic ratios based on mode of action, so all pesticide data are included.

3. **For determining attainment of water quality objectives it is scientifically sound to consider the six pyrethroid pesticides additively if more than one is detected in a water sample. Based on current information available, it is not scientifically sound to assume additive toxicity of other constituents with pyrethroid pesticides.**

Comment 1.6:
It is scientifically sound and consistent with regulatory practice to consider the six pyrethroids additively as all have the same mode of action. It is reasonable to assume that if multiple compounds are detected in a water or sediment sample, any organism in contact with that media would be equally exposed to all of them, and they would behave additively if they have the same mode of action. This is a similar approach that has been used for organophosphate and carbamate insecticides and is the basis of aggregate risk assessment under the Food Quality Protection Act of 1996, used to assess human health risk of exposure to multiple pesticides with similar modes of action across all media. In the case of pyrethroid insecticides, there is an adequate literature base to establish a line of evidence that they do indeed act additively as a mixture. It is very likely that other classes of chemicals present in impaired waters will also act additively, especially

those with a neurochemical mode of action (e.g. metals, antidepressant pharmaceuticals such as sertraline). However at this junction there is not an adequate literature basis to justify including these or other chemicals and thus I concur with the staff assessment that it is not scientifically sound to assume additivity with other constituents.

Response to Comment 1.6: Comment acknowledged.

4. **For determining attainment of water quality objectives, it is scientifically sound to use the measured or estimated freely dissolved aqueous concentrations of pyrethroid pesticides. The proposed equation to estimate freely dissolved concentrations and the default partition coefficients are scientifically sound and protective of beneficial uses.**

Comment 1.7:
There is a well-established literature basis to show that pyrethroid insecticides associate mostly with sediment and dissolved organic matter in water. In the particulate phase it is highly unlikely pyrethroids are bioavailable to aquatic organisms and the literature basis for this conclusion is relatively clear. The literature basis is not as strong to make the case that pyrethroids are not bioavailable when associated with dissolved organic matter (or dissolved organic carbon), however the literature does indicate bioavailability is significantly reduced in the presence of increasing levels of DOC/DOM. The most conservative approach would be to use whole water concentrations for attainment assessment however this would likely be overly conservative and grossly overestimate exposure. As discussed above there is already a large degree of conservatism (and therefore implicit safety) designed into the UC Davis method, thus the use of freely dissolved concentrations are appropriate, the most scientifically justified and should result in adequate protection of beneficial uses. The proposed equation to estimate freely dissolved concentrations is also scientifically sound. The default partition coefficients are also reasonable and scientifically sound to use. Attempting to collect site-specific partition coefficients is unreasonable as these are likely to be highly variable both spatially and temporally and ultimately would have a negligible change on the values determined in surface water to assess attainment, especially given the uncertainty introduced and associated with analytical measurements at sub part-per trillion concentrations (see discussion below in section 5 and "the Big Picture, part (b)").

Response to Comment 1.7: Comment acknowledged.

5. **The proposed TMDL loading capacity, allocations, margin of safety, and numeric targets are clearly described and consistent with attaining water quality objectives that are protective of the beneficial use(s) most sensitive to pyrethroid pesticides.**

Comment 1.8:
The staff recommendation is that the TMDL loading capacity be concentration-based equal to the water quality objectives. These are established using the additive formulas used to calculate criteria-normalized concentration units. These concentration-based loading capacities would equate to wasteload allocations

applicable only to the two storm-water systems stated in the report but presumably could be expanded to others as well. As these storm water systems are the only sources and there are no non-point sources in listed waterbodies within these systems, no load allocations are proposed. As the numeric criteria form the basis of all loads and subsequent allocations, which in turn are based upon the UC Davis method, these should be adequately protective of beneficial uses. Ultimately attainment will be based upon collection of adequate data to do the calculations, presumably from water-monitoring.

Unfortunately adequate methods to monitor pyrethroids consistently and accurately at the concentrations approaching criteria levels do not exist at this point in time. As analytical detection limits are higher than criteria levels any detection would constitute non-attainment, and non-detection would not necessarily guarantee attainment of criteria. Sediment toxicity testing is also proposed, presumably with the most sensitive species, Hyalella azteca as a possible indication of the presence of pyrethroids, however due to the low levels of pyrethroids that can cause toxicity and the lack of analytical methods sensitive enough to reliably confirm the presence of pyrethroids at these levels, it is hard to imagine how meaningful results would be obtained from any monitoring efforts. This issue is acknowledged in later chapters (Implementation and Monitoring) of the Staff Report as well as in the Basin Plan Amendment itself. In these chapters and the Basin Plan Amendment adequate flexibility to address these issues on a case-by-case basis appear to be in place.

Response to Comment 1.8:
For aqueous samples, analytical detection limits are currently higher than the proposed criteria levels; however, a detection will not necessarily constitute an exceedance because accounting for bioavailability may indicate that only a small fraction of the detected concentration is freely dissolved. It is a concern that a non-detect does not clearly indicate attainment of the proposed triggers, however, waiting to adopt regulations until detection limits are below these levels will not result in progress toward reducing pyrethroid loads in surface waters.

Sediment toxicity testing with *Hyalella azteca* has shown to be a sensitive indicator of pyrethroid toxicity in sediments in many studies (Holmes et al. 2008, Phillips et al. 2014). Method detection limits for sediment are typically below or approximately equal to pyrethroid concentrations that cause toxicity in sediments, so detected pyrethroid concentrations are often used as a line of evidence or indication that pyrethroids caused or contributed to observed sediment toxicity (Domagalski et al. 2010, Ensminger et al. 2011, Hladik and Kuivila 2012). Sediment toxicity testing with *Hyalella azteca* followed by pyrethroid analysis when samples exhibit toxicity is routinely used in current Regional Board regulatory programs and has proven effective at identifying sources and loading of pyrethroids to surface waters.

The Big Picture
(**a) In reading the Draft Staff Report and Draft Basin Plan Amendment language, are there any additional scientific issues that should be part of the scientific portion of the proposed rule that are not described above? If so, comment with respect to the Draft Staff Report and Draft Basin Plan Amendment.**

Comment 1.9:
The Draft Staff Report as well as the Draft Basin Plan Amendment are very well-written and comprehensive in scope. The report, assessments and conclusions are based upon state of the art science, as it exists to date. The authors are thorough in their evaluation of the scientific uncertainties that undoubtedly exist that could impact the assessment and corresponding criteria calculations. Examples of these uncertainties are additive toxicity associated with other contaminants possibly with similar or dissimilar modes of action, the existence of native Hyalella population evolutionary pyrethroid resistance likely due to chronic exposure, and bioavailability of pyrethroid residues sorbed to sediment or associated with dissolved organic matter/organic carbon. The authors clearly explain why these were addressed or not addressed in assessments and provided a current literature basis to support their conclusions. I have no other substantive comments to add in this area.

Response to Comment 1.9: Comment acknowledged.

(b) Taken as a whole, is the scientific portion of the proposed actions based upon sound scientific knowledge, methods, and practices?

Comment 1.10:
The proposed actions are based upon sound science considering only the criteria and on the basis of toxicity. However taken as a whole one cannot realistically ignore that the proposed criteria are well below the range that pyrethroid insecticides can be reliably measured in water and sediment samples for monitoring and subsequent enforcement activities. Most of the methods referenced in the papers where monitoring data were reported, and many in the referenced toxicity studies were based upon electron capture detector (ECD) methods using two-column confirmation. While this is considered an acceptable practice it is still highly prone to error especially in difficult environmental matrices as it is non-selective and not based upon structural features of the analyte. Typically the quality control demands require much higher signal-to-noise ratios to definitively state an analyte is indeed present in the matrix, and this needs to be addressed on a chromatogram-by-chromatogram basis. The papers that were referenced and monitoring data presented did not include the chromatograms or quality assurance data supporting QC criteria (as is typical in most published studies) so I am left to presume that the referenced paper's authors used expert judgment in assigning detections and their data analysis is correct. Example chromatograms supporting the Appendix C data set (Weston and Lydy, 2010) would have been useful. The challenges in detection of analytes was addressed by the Draft Report authors briefly in the monitoring section of this report however I felt this could have been more heavily reviewed and discussed further. Current research is indicating that gas chromatography coupled with triple quadrupole mass spectrometry methods incorporating negative chemical ionization (GC/MS/MS – NCI) have promise to reaching lower levels of detection, however further work will be needed in these areas. Given the amount of time before compliance will be required it is likely that sensitive methods will be available as the criteria in these reports will set the need and threshold of required analytical detection limits necessary for monitoring and compliance.

As mentioned earlier, this issue was acknowledged in both the Draft Staff Report and in the Basin Plan Amendment itself, and engagement and discussion was recommended between both the water-board and regulated entities before initiating any monitoring effort. Given the uncertainties currently existing in methods to reliably measure these analytes, the proposed actions are based upon sound scientific knowledge and practices.

Response to Comment 1.10:
Additional discussion regarding analytical methods has been added to the Surveillance and Monitoring chapter of the Draft Staff Report. This discussion focuses on the development and use of GC/MS/MS-NCI methods for pyrethroids analyses. Several California laboratories are using these methods and they may be used for monitoring related to the proposed Basin Plan Amendment if they are certified by the California Environmental Laboratory Accreditation Program (ELAP). Staff has been in contact with local laboratories and ELAP staff to discuss the potential development of more sensitive methods and to ensure that the methods are reliable and reproducible.

2. Joel R. Coats, Ph.D., Charles F. Curtiss Distinguished Professor, Department of Entomology, Iowa State University

Comment 2.1:
Conclusion 1
The acute and chronic water quality criteria developed by using the UC-Davis methodology are based on sound science; they are logical adaptations from the way the methods were utilized and criteria were developed in 2010-2011. A very broad spectrum of alternative methods were considered and carefully evaluated for their appropriateness, and the selected alternatives are well justified in the draft report. The methods selected and the rationale presented for aqueous concentration and for sediment concentrations are very clear. Specific data on K_{oc} *and toxicities for all six of the major pyrethroids being addressed contributes to confidence that fate and availability of residues of each are well understood.*

The criteria developed for the pyrethroids will protect the beneficial uses of the waterways; they will also be protective of sensitive species, without being unnecessarily conservative. One important set of information is presented in Table 5-14, which considers the six pyrethroids individually and the possible outcomes for each alternative considered. For consideration of sediment criteria, Tables 5-13 presents valuable information for equilibrium sediment guidelines. The conclusion is sustained as well as possible for sediment, considering the very limited data available for pesticides in sediment. Table 5-16 is an excellent summary of nine factors that must be considered, versus the four most appropriate alternatives for the water quality objectives.

Response to Comment 2.1: Comment acknowledged.

Comment 2.2:
Conclusion 2

There is every indication that the methodology developed by scientists at UC-Davis is scientifically sound and technically defensible. It presents a very thorough treatment of considering data quantity as well as data quality when developing guidelines for methods; the reports explain the use of toxicity data from short or long time periods, producing protection under both acute and chronic circumstances; determination of criteria that are protective of all species, including sensitive or rare ones, is a crucial tenet in this development of the water quality criteria. Their use of the species sensitivity distribution is quite logical and well documented to be appropriate for risk assessments. While it is preferable to use only data based on measured concentrations, there are distinct benefits to the use of other data (e.g., data from studies with nominal concentrations of the pesticide). The approach the authors present for use of a default acute-to-chronic ratio is valid when there is insufficient toxicity data available; the approach is conservative, but appropriate in those situations.

Physical-chemical data for a compound is extremely important in determining the fate of the chemical and the ecotoxicological effects of compounds (pyrethroids in this case). It is quite encouraging that they specifically address quantitative structure-activity relationships that can be developed for a series of related compounds, such that fate and/or toxicity can be predicted in silico, rather than needing to test every new pyrethroid molecule for all its physical-chemical properties and all of its potential ecotoxicology issues. The authors' addressing of mixtures toxicology is important, as multiple stressors occur in almost every real-world body of water. It is a complicated issue, and it is addressed specifically for pyrethroids in the next conclusion, but they lay a very solid foundation for that discussion in the Phase I document. There are also valuable discussions in the methodology documents regarding the possibilities of bioaccumulation and secondary toxicity effects, as well as the goal of protection of endangered and threatened species.

Response to comment 2.2: Comment acknowledged.

Comment 2.3:
Conclusion 3
The authors of the draft staff report make a strong case for the additive toxicity approach to evaluation of waters that contain residues of more than one pyrethroid. The concentration-addition model is definitely appropriate for utilization, based on the toxic units approach to the additive effects of multiple pyrethroid insecticides in water samples. While there are some additional effects caused by Type II pyrethroids, the principal mechanism of toxic action at the neuron's sodium channels is the same for both Type I and Type II pyrethroids.

One situation that will not be covered by the additive toxicity model is that of the insecticide synergist piperonyl butoxide co-occurring with a pyrethroid. The synergist is considered to be essentially non-toxic (and it is, compared to any pyrethroid), but it is capable of enhancing the potency of a pyrethroid. It has been used in commercial formulations for over 50 years to increase potency of natural and first-generation synthetic pyrethroids. The question is raised in the Water Quality Criteria Reports. Recently it has been added to formulations of some of the halogenated "photo-stable" pyrethroids, especially permethrin. Not much is *known about the persistence of piperonyl butoxide in the environment or about its capacity to enhance toxicity to aquatic non-target organisms, so the document appropriately does not include it in the additivity formula but mentions it as a possible confounding factor in water or sediment quality. As discussed in the highly informative individual Water Quality Criteria Reports, there is no way to predict or use any data from the presence of synergists or any other non-additive interactions in determining compliance.*

Response to comment 2.3: Comment acknowledged.

Of the six pyrethroids that are the focus of the Basin Plan amendment, few of them are found in products that also contain PBO. The majority of products containing one of the six pyrethroids of interest and PBO are used as pest repellant for domestic animals and sprays or foggers in and around commercial and domestic buildings. The one exception is permethrin, which is co-formulated with PBO in approximately 140 products, including some used on agricultural crops and for vector control, which would have a higher likelihood of off-site movement. PBO is also used in many products with pyrethrins and the photolabile pyrethroids. One study found that PBO contained in vector control spray (co-formulated with pyrethrins) resulted in synergism of pyrethroid toxicity of pre-existing pyrethroid residues in urban creeks (Weston et al. 2006). This study indicates that PBO in the environment may be an important factor for assessing environmental impacts, particularly with large-scale outdoor applications, such as occur during vector control spraying and should be considered when more information becomes available.

Comment 2.4:
Conclusion 4
The document addresses the complex question of bioavailability of pyrethroid residues in water and sediment in a relatively straightforward way, especially considering the variables involved in the disposition of pyrethroids in waters and sediments. The ideal situation would be to have measured bioavailability data for each pyrethroid in every type of surface water and every type of sediment, but in fact, little of that information is available. However, there have been major advances in the understanding of pyrethroid bioavailability in recent years. The use of freely dissolved aqueous concentrations of pyrethroids in water is the best way to develop meaningful understanding about bioavailability and uptake of pyrethroids into aquatic non-target species. The use of partition coefficients is a suitable method for estimating bioavailability in aqueous samples, including ones with organic particulates and/or dissolved organic carbon. A realistic bioavailability ratio can be obtained, and it is much more useful than such a ratio derived only from whole-water residues of the pyrethroid(s).

In the realm of sediments, the bioavailability is even more complicated. Considerable information can be generated by batch-equilibrium sorption/desorption studies with natural sediments. Koc values for sediments can provide some indication of the bioavailability of a pesticide, and there are promising techniques utilizing solid-phase micro extraction (SPME) fibers in sediment (and in water) to estimate the availability of pyrethroids to organisms living in sediments. The draft report acknowledges that the bioavailability is often complicated by organisms ingesting food items that contain residues of the pyrethroid. The individual Water Quality Criteria Reports are again very helpful; they address the question of bioavailability for each of the six pyrethroids and *discuss some of the data available for specific species in specific experimental situations.*

The draft report explains very thoroughly the process of considering all of the possible alternatives for aqueous samples and sediment samples and reaches its conclusions in a logical and quite transparent way. The criteria are likely to be protective of warm and cold beneficial uses of water/sediment systems in California.

Response to comment 2.4: Comment acknowledged.

Comment 2.5:
Conclusion 5
The recommendation of the draft report that total maximum daily loads (TMDLs) should be used for urban waters is well founded. The authors explain the logic by which that conclusion was reached, and what types and amounts of pyrethroids occur in urban wastes. The methods are well understood, and the rationale is explained clearly. The numeric targets for water-column values and for sediment values are likely to be protective of non-target organisms, including sensitive species, and if loading capacities are not exceeded, there should be no serious damage to the beneficial uses of the waters.

Response to comment 2.5: Comment acknowledged.

Comment 2.6:
Other Comments
The draft staff report, the documents on the two phases of the methodology, and the six specific documents for individual pyrethroids, all taken together, provide a thorough, carefully developed plan or proposing amendment of the Basin Plan for the Sacramento and San Joaquin Rivers. The plan will be substantially protective of all beneficial uses of the waters, including sensitive species and endangered and threatened species.

It was good that the Implementation section of the draft report addressed vector-control uses of pyrethroids, since there are many of them applied for adult mosquito control. The waste discharges from those operations are already covered under the National Pollutant Discharge Elimination System, so the report makes no further recommendations for those pyrethroids, i.e., under their use for ULV or cold fogging.

A valuable discussion of detection limits is presented in the Surveillance and Monitoring section. The major point is that some sources, e.g., Clean Water Act, list detection limits of pyrethroids from 3 to 5 orders of magnitude higher than some commercial labs or the US EPA Office of Water and Office of Science and Technology. This disparity points to a potential issue in the monitoring of the pyrethroids, depending on which laboratory and what method is used for quantification.

Response to comment 2.6: Comments acknowledged.

Additional discussion of analytical methods has been added to the Surveillance and Monitoring chapter to further address the continuing development of sensitive analytical methods for pyrethroids.

Comment 2.7:
Some specific additions and corrections:

<u>Draft Staff Report:</u>
List of Acronyms and Abbreviations, p. xi – Add POTW

Section 2, p. 25, paragraph 2 – insert "All of the Group III pyrethroids are halogenated, photo-stable chemicals, with the exception of fenpropathrin."

Section 2, p. 26, line 19 – "Broadcast treatment but not…"

Section 5, p. 51, last lines – One possible mechanism of tolerance or resistance in the H. azteca is the selection for an altered sodium channel in the neurons; this is a common mechanism in resistant insects.

Section 5.6.3.1, p. 71 – Sediment Quality Criteria (SQC)

<u>Water Quality Criteria Report for Bifenthrin:</u>
Section 15.2, p. 27, line 25 – "2. This requirement…"

Section 15.2, p. 27, lines 27-28 – "…Chironomus dilutus (order: Diptera) is from a different order than Procloeon sp. (order: Ephemeroptera)."

Response to comment 2.7: These additions and corrections have been addressed.

3. Jeffrey J. Jenkins, Ph.D., Department of Environmental and Molecular Toxicology, Oregon State University

1. **The proposed water quality objectives are reasonably protective of the beneficial uses that are most sensitive to pyrethroid pesticides.**

   Comment 3.1:
   Water Quality Objectives for the 6 pyrethroid pesticides are presented in Section 5 of the Draft Staff Report. Water quality is defined in terms of preserving or enhancing aquatic life beneficial uses (aquatic life and their habitat). Protecting against toxicity to aquatic life is considered a primary concern in preserving or enhancing aquatic life beneficial uses. To meet these qualitative objectives numeric water quality objectives (criteria) have been developed for six pyrethroid pesticides for all water bodies designated with aquatic life beneficial uses in the Sacramento River and San Joaquin River basins. Water quality criteria and supporting science for the 6 pyrethroids developed using the UC Davis methodology and contained in the March 2015 reports are scientifically sound. In addition, appropriate use of these numeric criteria can be effective in meeting qualitative water quality objectives that preserve or enhance aquatic life beneficial uses.

Response to Comment 3.1: Comment acknowledged.

2. **The underlying method for deriving the pyrethroid pesticides water quality criteria, which are proposed as water quality objectives and TMDLs, is scientifically sound.**

   Comment 3.2:
   The proposed water quality criteria and TMDLs for the 6 pyrethroid pesticides rely on the UC – Davis Methodology reported in TenBrook and Tjeerdema (2006)[1], and subsequent derivation and application of the UC-Davis methodology for specific pesticides (TenBrook et al., 2009)[2]. Evaluation of the scientific basis for the assignment of numeric targets will largely rely on the review of methodologies conducted as these reports are considered current, highly relevant, and comprehensive.

   The UC-Davis methodology used as the basis for the assignment of acute and chronic numeric targets contains the following elements in a step by step format:

[1] TenBrook, TL and RS Tjeerdema. Methodology for Derivation of Pesticide Water Quality Criteria for the Protection of Aquatic Life in the Sacramento and San Joaquin River Basins. Phase I: Review of Existing Methodologies. Report Prepared for the Central Valley Regional Water Quality Control Board. Department of Environmental Toxicology, University of California, Davis. April 2006.

[2] TenBrook, PL, AJ Palumbo, and RS Tjeerdema. Methodology for Derivation of Pesticide Water Quality Criteria for the Protection of Aquatic Life Phase II: Methodology Development and Derivation of Chlorpyrifos Criteria. Report Prepared for the Central Valley Regional Water Quality Control Board. Department of Environmental Toxicology, University of California, Davis. September 2009.

- *Guidance for collection, evaluation, and reduction of data;*
- *Species sensitivity distribution (SSD) methods to derive criteria when data are available for five representative taxa - 1) a warm water fish, 2) a fish in the family Salmonidae, 3) a planktonic crustacean – Ceriodaphnia, Daphnia, or Simocephalus, 4) a benthic crustacean, and 5) an insect (aquatic exposure).*
- *Data quality and quantity dependent SSD procedures.*
- *An assessment factor (AF) method to derive acute criteria when fewer than five acute toxicity data are available;*
- *A default acute-to-chronic ratio (ACR) to derive chronic criteria when fewer than five chronic data are available;*
- *Methods for assessing bioavailability;*
- *Methods for assessing compliance in cases of mixtures of chemicals with similar modes of toxic action and for mixtures that exhibit non-additive toxicity;*
- *Methods for quantifying relationships between toxicity and water quality parameters, such as pH and temperature;*
- *Techniques for assessing whether derived criteria might harm particularly sensitive species, lead to bioaccumulation, harm ecosystems, harm threatened and endangered species, or lead to unacceptable levels of pesticides in other environmental compartments;*
- *A template for describing final criteria in terms of magnitude, duration and frequency.*

This methodology defines a pesticide as "1) any substance or mixture of substances that is intended to be used for defoliating plants, regulating plant growth, or for preventing, destroying, repelling, or mitigating any pest, which may infest or be detrimental to vegetation, man, animals, or households, or be present in any agricultural or nonagricultural environment whatsoever, or 2) any spray adjuvant, or 3) any breakdown products of these materials that threaten beneficial uses."

The methodology prescribes appropriate endpoints for criteria derivation as those that measure survival, growth, or reproductive effects. Surrogates (i.e., LC_{50}, EC_{50}*, NOEC, LOEC, MATC) may be used if those endpoints have been linked to effects on survival, growth, or reproductive effects.*

The UC-Davis methodology employs various statistical methods, dependent on data quality and quantity, in deriving SSDs, and when data limited estimating chronic criterion using acute data. For example, details of the application of the log-logistic SSD procedure for bifenthrin are as follows:

"The log-logistic SSD procedure (section 3-3.2.2) was used for the acute criterion calculation because there were not more than eight acceptable acute toxicity values available in the bifenthrin data set (Table 2). The log-logistic SSD procedure was used to derive 5th percentile values (median and lower 95% confidence limit), as well as 1st percentile values (median and lower 95% confidence limit). The median 5th percentile value is recommended for use in criteria derivation by the methodology because it is the most robust of the distributional estimates (section 3-3). Comparing the median estimate to the

lower 95% confidence limit of the 5th percentile values, it can be seen that the first significant figures of the two values are different (0.0016419 vs. 0.0000240 ug/L). Because there is uncertainty in the first significant digit, the final criterion will be reported with one significant digit (section 3-3.2.6).

The ETX 1.3 Software program (Aldenberg 1993) was used to fit the log-logistic distribution to the data set, which is plotted with the acute values in Figure 2. This distribution provided a satisfactory fit (see Appendix A) according to the fit test described in section 3-3.2.4. No significant lack of fit was found ($\chi 2_{2n}$ = 0.1247) using the fit test based on cross validation and Fisher's combined test (section 3-3.2.4), indicating that the data set is valid for criteria derivation."

This statistical analysis, as well as all methods employed in UC-Davis methodology, demonstrates statistical rigor in the evaluation of all available toxicity values that meet data quality criteria, and is among the most robust evaluations of this type currently employed for regulatory purposes worldwide; these methods have the potential to greatly reduce uncertainty in estimating no-effect exposure levels by reducing the probability of both Type I error or false negative when there is a null hypothesis of some adverse effect, and Type II error or false positive; failure to reject the potentially false null hypothesis, i.e., no effect).

Response to comment 3.2: Comment acknowledged.

Derivation of Final Criteria Statements

Comment 3.3:
Bifenthrin
The acute criterion for bifenthrin was derived using the SSD method as at least five acceptable acute toxicity values were available and fulfilled the five taxa requirements of the SSD method. Using the log-logistic SSD procedure the resulting acute criterion, based on the median 5th percentile value, is 0.0008 ug/L. This value is considered acceptable for its intended purpose.

As chronic toxicity values from fewer than five different families were available the ACR procedure was used to calculate the bifenthrin chronic criterion. Because an ACR could not be calculated with the available data, the chronic criterion was calculated with the default ACR value of 11.4 = 0.0001 ug/L. This value is considered acceptable for its intended purpose.

However, further "sensitivity analysis" determined that this acute criterion is not protective of the sensitive species H. azteca. This determination was based on comparing the result of the SSD analysis – the median 5th percentile acute value – to the lowest acute value for H. azteca. Consequently the median 1st percentile estimate was used to derive the acute and chronic criteria, resulting in final bifenthrin criteria of acute = 0.00006 ug/L and chronic = 0.00001 ug/L. While these criteria are sufficiently conservative and deemed acceptable for the intended purpose, use of the median 1st percentile estimate of acute criterion, a less reliable estimate, is inconsistent with the derivation of other acute and chronic criteria for which there is sufficient data to use the SSD approach. Given *the premise for use of the SSD approach in the UC-Davis Methodology – a robust statistical analysis using all of the available toxicity values that meet data quality criteria – it seems arbitrary to use the median 1st percentile estimate for the sole purpose of deriving a toxicity value that is less than the H. azteca lowest acute value, a single value of unknown significance. If a goal of the SSD approach is to reduce the probability of both Type I and Type II error in estimating the acute value, use of the median 5th percentile acute value is consistent with other assessments and appropriate for its intended purpose, regardless of whether the result is greater than an independent acute value of unknown significance.*

Alternatively, if H. azteca is significantly more sensitive than taxa required for use of the SSD approach in the UC-Davis methodology, and is ultimately the driver in determining criteria, then it should be included as a required species for SSD analysis. Otherwise, the statistical power that is derived from the SSD approach for determination of water quality criteria needs careful consideration.

Response to Comment 3.3:
After receiving the peer review comments regarding the use of criteria based on the 1st or 5th percentile of the species sensitivity distributions, staff has changed their recommendation. In the draft staff report that was peer reviewed the staff recommendation was to use the water quality criteria based on the 1st percentile for bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, and lambda-cyhalothrin. Following peer review, staff has changed their recommendation to water quality criteria based on the 5th percentile for all six pyrethroids.

The change in recommended values was determined after considering the peer review comments indicating that the criteria based on the 5th percentile would also be reasonably protective of aquatic ecosystems. Beyond the scientific foundation of the values, staff also recognized upon further analysis that the criteria based on the 5th percentile would be more likely to be achieved, but will still require significant reductions from all dischargers. In addition, the effects of pyrethroids will be reviewed within 15 years after adoption of the proposed Basin Plan amendment and if the criteria based on the 5th percentile do not appear to be protective of aquatic life at that time, the values can be adjusted by the Regional Board.

Hyalella azteca is considered to fulfill the UC-Davis methodology taxa requirement of benthic crustacean. This species has been demonstrated to be the most sensitive species in the data sets for six pyrethroids. However, the UC-Davis methodology is applicable to all pesticides, not only pyrethroids, and *Hyalella azteca* has not been the most sensitive species in data sets for other classes of pesticides, thus it is not a required species for SSD analysis.

Comment 3.4:
λ-cyhalothrin
For λ-cyhalothrin The Burr Type III SSD procedure was used for the acute criterion calculation because more than eight acceptable acute toxicity values were available in the λ-cyhalothrin data set. This procedure, roughly equivalent to the Clean Water Act (CWA) National Standard methodology, the acute

criteria=0.0007 ug/L is based on the median 5th percentile acute value. This value is considered acceptable for its intended purpose.

As chronic data for only 3 of the 5 representative taxa (including a saltwater species) were available for λ-cyhalothrin, the ACR method was used to calculate the chronic criterion by pairing chronic toxicity values (MATC) with an appropriate corresponding acute toxicity value (LC_{50}) in order to calculate an ACR; the species mean ACR (SMACR) for each of the three species was calculated by dividing the acute LC_{50} value by the chronic MATC value. The final multi-species ACR was obtained by calculating the geometric mean of the three SMACR resulting in the ACR-derived chronic criterion = 0.0003 ug/L. This value is considered acceptable for its intended purpose.

However, further "sensitivity analysis" determined that this acute criterion is not protective of the sensitive species H. azteca. This determination was based on comparing the result of the SSD analysis – the median 5th percentile acute value – to the lowest acute value for H. azteca. Consequently the median 1st percentile estimate was used to derive the acute and chronic criteria, resulting in final λ-cyhalothrin criteria of acute = 0.00003 ug/L and chronic = 0.00001 ug/L. While this value is considered acceptable for its intended purpose, see discussion above regarding use of the median 1st percentile to estimate of bifenthrin acute criterion.

Response to Comment 3.4: See Response to Comment 3.3.

Comment 3.5:

Cyfluthrin

The acute criteria for cyfluthrin was derived using the log-logistic SSD method as at least five acceptable acute toxicity values were available and fulfilled the five taxa requirements of the SSD. The resulting acute criterion = 0.0008 ug/L, based on the median 5th percentile acute value.

As chronic toxicity values from fewer than five different families were available the ACR procedure was used to calculate the cyfluthrin chronic criterion. The ACRs were calculated for each of the three species by dividing the acute LC50 value by the chronic MATC value. The final multi-species ACR of 10.27 was obtained by calculating the geometric mean of the three ACR values; resulting in a chronic criterion = 0.0002 ug/L. This value is considered acceptable for its intended purpose.

However, further "sensitivity analysis" determined that this acute criterion is not protective of the sensitive species H. azteca. This determination was based on comparing the result of the SSD analysis – the median 5th percentile acute value – to the lowest acute value for H. azteca. Consequently the median 1st percentile estimate was used to derive the acute and chronic criteria, resulting in final cyfluthrin criteria of acute = 0.00007 ug/L and chronic = 0.00001 ug/L. While this value is considered acceptable for its intended purpose, see discussion above regarding use of the median 1st percentile to estimate of bifenthrin acute criterion.

Response to comment 3.5: See Response to Comment 3.3.

Comment 3.6:

Cypermethrin

As at least five acceptable acute toxicity values were available and fulfilled the five taxa requirements and more than eight acceptable acute toxicity values were available the Burr Type III SSD procedure was used to determine the median 5th percentile acute value, resulting in cypermethrin acute criterion = 0.001 ug/L. This value is considered acceptable for its intended purpose.

As chronic toxicity values from fewer than 5 different families were available the acute-to-chronic ratio (ACR) method was used to calculate the chronic criterion. While chronic toxicity data was available for one freshwater species and one saltwater, however only the saltwater species data met data quality requirements and could be paired with acute data to determine the ACR. Surrogate (default) data for cyfluthrin and λ-cyhalothrin were used to meet data requirements of the ACR method. The final multi-species ACR was obtained by calculating the geometric mean of the saltwater species with two default ACR values, resulting in a cypermethrin chronic criterion = 0.0003 ug/L. Discussion of the rationale for use of this surrogate data is missing and seems appropriate. EPA has conducted a cumulative human health risk assessment[3] in which pyrethroid relative potency factors (RPFs) are reported based on studies in mammals. A cypermethrin RPF of 0.19 indicates that it is less potent than cyfluthrin (RPF=1.15) and λ-cyhalothrin (RPF=1.63). While RPFs take into consideration both target site sensitivity and pharmacokinetics and dynamics, as the pyrethroids have a common mode of action across taxa – disruption of voltage-gated sodium channels leading to alteration of neuronal membranes and ultimately neurotoxicity – these findings suggest that the use of cyfluthrin and λ-cyhalothrin ACRs in determining the cypermethrin chronic criterion may be overly conservative while protective of aquatic life. In addition, ACRs as a function of potency should be addressed.

However, further "sensitivity analysis" determined that this acute criterion is not protective of the sensitive species H. azteca. This determination was based on comparing the result of the SSD analysis – the median 5th percentile acute value – to the lowest acute value for H. azteca. Consequently the median 1st percentile estimate was used to derive the acute and chronic criteria, resulting in final cyfluthrin criteria of acute = 0.00004 ug/L and chronic = 0.00001 ug/L. While this value is considered acceptable for its intended purpose, see discussion above regarding use of the median 1st percentile to estimate of bifenthrin acute criterion.

Response to comment 3.6:

The default ACR values do not only include data for cyfluthrin and λ-cyhalothrin, but include data from a total of 10 pesticides. ACRs are a ratio of acute to chronic toxicity for a given pesticide, and thus each individual ACR is normalized for potency to itself, and therefore ACRs already account for relative potency.

The relative potencies of pyrethroids for aquatic organisms, such as *Hyalella azteca*, may differ from the relative potencies of pyrethroids for mammals. A set of high quality

[3] http://epa.gov/pesticides/cumulative/common_mech_groups.htm#pyrethrins

and highly consistent toxicity tests were recently performed with *Hyalella azteca* and cyfluthrin and cypermethrin had nearly identical toxicity (LC_{50}=0.55 ng/L and 0.54 ng/L, respectively). Relative potency factors normalized to λ-cyhalothrin (the most sensitive for *H. azteca*) are given in Table 1.

Available data indicate that there is variability among ACRs, whether for the same chemical and different species, or for the same species and different chemical's within a class or mode of action (Raimondo et al. 2007). All of the ACR data for individual species gathered in the six pyrethroid criteria are compiled in Table 2. For *Daphnia magna*, it appears that there may be a trend of increasing ACR with decreasing relative potency, but this is a very small data set and the trend may not be statistically significant, or may only apply to this species. The two ACRs for *Pimephales promelas* also follow this trend, but for the two ACRs for *Americamysis bahia*, the trend is reversed. Overall, the data do not indicate that ACRs vary based on relative potency for pyrethroids. However, this is a very small data set, and if more ACR values are available in the future (when the Basin Plan amendment is reviewed, approximately 15 years after adoption), this topic shall be reconsidered at that time.

See Response to Comment 3.3 regarding the use of the 1st vs. 5th percentile.

Table 1. Relative potency factors (RPF) based on *Hyalella azteca* LC_{50}

Chemical	**LC_{50} (ng/L)***	**RPF (normalized to λ–cyhalothrin)**
λ-cyhalothrin	0.3	1
Bifenthrin	0.5	0.6
Cyfluthrin	0.55	0.55
Cypermethrin	0.56	0.54
Esfenvalerate	0.85	0.35
Permethrin	7.0	0.04

*Data from water quality criteria reports

Table 2. Compilation of acute-to-chronic ratios (ACRs) for six pyrethroids

Species	**Chemical**	**LC_{50} (ng/L)***	**ACR***
Americamysis bahia	Cypermethrin	4.75	6.1
Americamysis bahia	Permethrin	75	4.7
Daphnia magna	λ-cyhalothrin	13	4.9
Daphnia magna	Cyfluthrin	160	5.6
Daphnia magna	Esfenvalerate	900	14
Pimephales promelas	λ-cyhalothrin	360	8.2
Pimephales promelas	Cyfluthrin	2,490	12.4
Oncorhynchus mykiss	Cyfluthrin	251	18.9
Cyprinodon variegatus	λ-cyhalothrin	810	2.6

*Data from water quality criteria reports

Comment 3.7:
Esfenvalerate
As at least five acceptable acute toxicity values were available and fulfilled the five taxa requirements and more than eight acceptable acute toxicity values were

available the Burr Type III SSD procedure was used to determine the median 5th percentile acute value, resulting in esfenvalerate acute criterion = 0.002 ug/L. This value is considered acceptable for its intended purpose.

As chronic toxicity values for 3 different families were available, the acute-to-chronic ratio (ACR) method was used to calculate the chronic criterion. As acceptable acute and chronic data was only available for 1 species, the final multi-species ACR was obtained by calculating the geometric mean of the daphnid ACR with two default ACR values (surrogate data for cyfluthrin and λ-cyhalothrin), resulting in a esfenvalerate chronic criterion = 0.0003 ug/L. Discussion of the rationale for use of this surrogate data is missing and seems appropriate. EPA has conducted a cumulative human health risk assessment[3] in which pyrethroid relative potency factors (RPFs) are reported based on studies in mammals. An esfenvalerate RPF of 0.36 indicates that it is less potent than cyfluthrin (RPF=1.15) and λ-cyhalothrin (RPF=1.63). While RPFs take into consideration both target site sensitivity and pharmacokinetics and dynamics, as the pyrethroids have a common mode of action across taxa – disruption of voltage-gated sodium channels leading to alteration of neuronal membranes and ultimately neurotoxicity – these findings suggest that the use of cyfluthrin and λ-cyhalothrin ACRs in determining the esfenvalerate chronic criterion may be overly conservative while protective of aquatic life. In addition, ACRs as a function of potency should be addressed.

However, further "sensitivity analysis" determined that this acute criterion is not protective of the sensitive species H. azteca. This determination was based on comparing the result of the SSD analysis – the median 5th percentile acute value – to the lowest acute value for H. azteca. Consequently the median 1st percentile estimate was used to derive the acute and chronic criteria, resulting in final esfenvalerate criteria of acute = 0.0002 ug/L and chronic = 0.00003 ug/L. While this value is considered acceptable for its intended purpose, see discussion above regarding use of the median 1st percentile to estimate of bifenthrin acute criterion.

Response to comment 3.7:
See Response to Comment 3.6 regarding ACRs as a function of potency.

See Response to Comment 3.3 regarding the use of the 1st vs. 5th percentile.

Comment 3.8:
Permethrin
As at least five acceptable acute toxicity values were available and fulfilled the five taxa requirements and more than eight acceptable acute toxicity values were available the Burr Type III SSD procedure was used to determine the median 5th percentile acute value, resulting in permethrin acute criterion = 0.006 ug/L. This value is considered acceptable for its intended purpose.

As chronic toxicity values from fewer than 5 different families were available the acute-to-chronic ratio (ACR) method was used to calculate the chronic criterion. While chronic toxicity data was available for one freshwater species and one saltwater, however only the saltwater species data met data quality requirements *and could be paired with acute data to determine the ACR. Surrogate (default) data for cyfluthrin and λ-cyhalothrin were used to meet data requirements of the ACR method. The final multi-species ACR was obtained by calculating the geometric mean of the saltwater species with two default ACR values, resulting in a permethrin chronic criterion = 0.001 ug/L. Discussion of the rationale for use of this surrogate data is missing and seems appropriate. EPA has conducted a cumulative human health risk assessment[3] in which pyrethroid relative potency factors (RPFs) are reported based on studies in mammals. A permethrin RPF of 0.09 indicates that it is significantly less potent than cyfluthrin (RPF=1.15) and λ-cyhalothrin (RPF=1.63). While RPFs take into consideration both target site sensitivity and pharmacokinetics and dynamics, as the pyrethroids have a common mode of action across taxa – disruption of voltage-gated sodium channels leading to alteration of neuronal membranes and ultimately neurotoxicity – these findings suggest that the use of cyfluthrin and λ-cyhalothrin ACRs in determining the permethrin chronic criterion may be overly conservative while protective of aquatic life. In addition, ACRs as a function of potency should be addressed. However, Permethrin acute and chronic criteria are considered acceptable for their intended purpose.*

Response to comment 3.8:
See Response to Comment 3.6 regarding ACRs as a function of potency.

3. The proposed TMDL loading capacity, allocations, and margin of safety are clearly described and consistent with attaining water quality objectives that are protective of the beneficial use(s) most sensitive to pyrethroid pesticides.

Comment 3.9:
The use of urban point source discharge allocations to address pyrethroid TMDL loading capacity impairment objectives is typical and practicable. For non-point source pyrethroid discharge from agricultural lands assigning allocations is not feasible or practicable at this time. Assigning TMDL allocations for non-point source discharge from agricultural lands requires detailed spatial-temporal information on pesticide distribution and fate at the watershed scale and beyond. Effective implementation will require monitoring and modeling technologies that currently not available for this purpose, such as GIS-based ecohydrologic models that incorporate agronomic practices. However, the Clean Water Act (CWA) category 4(b) alternative, as described in Section 6.2, is a viable approach to meeting water quality objectives that are protective of the beneficial use(s) most sensitive to pyrethroid pesticides. This approach relies on sufficiently stringent provisions of the Irrigated Lands Regulatory Program, including best management practices designed to reduce surface water loading, as well as monitoring to evaluate BMP performance.

As required by the CWA, TMDLs must also include a margin of safety (MOS) to account for the uncertainty in predicting how well pollutant reduction will result in meeting water quality standards, and account for seasonal variations. As point source allocations are concentration-based (the alternative being mass-based) and water quality objectives are concentrations, a MOS is implicit regarding seasonal variations in discharge or volume of receiving waters. In addition, the

UC-Davis Methodology used to derive the criteria is sufficiently conservative to address other areas of uncertainty.

Response to comment 3.9: Comment acknowledged.

4. For determining compliance with water quality objectives it is scientifically sound and protective of beneficial uses to consider the 6 pyrethroid pesticides additively if more than one is detected in a water sample. Based on current information available, it is not scientifically sound to assume additive toxicity of other constituents with pyrethroid pesticides.

Comment 3.10:
Pyrethroid use practices and monitoring data indicate that the co-occurrence of pyrethroids in the surface waters of the Sacramento and San Joaquin Basins is likely. As the pyrethroids have shared structural characteristics and a common mode of action – disruption of voltage-gated sodium channels leading to alteration of neuronal membranes and ultimately neurotoxicity – their toxicity to aquatic life should be considered jointly. Since Bliss (1939)[4] three basic types of action for combinations of chemicals have been defined:

- *Similar action (dose/concentration addition)*
- *Dissimilar action (independent action), and*
- *Interactions (agonist, antagonist)*

Consideration of chemical mixtures with a common mode of action is of interest as the mixture may exceed an adverse effect threshold even when the individual chemicals are at concentrations that are below their threshold. The Staff Report provides a detailed appraisal of the relevant literature and concludes that the pyrethroids have a common mode of action and act jointly by dose/concentration addition. Dose/concentration addition assumes that all components in a mixture contribute to the joint effect, in proportion to their prevalence and individual potency. This implies that individual pyrethroid concentrations in a mixture should be normalized based on their potency – using LC50 values or some other endpoint to determine relative potency factors (RPF) or toxicity equivalency factor (TEF). The Staff Report implies that data was insufficient for potency normalization and that toxicity thresholds varied by no more than a factor of 2. Consequently, acute and chronic water quality objectives for the 6 pyrethroids are based on additive toxicity (normalized for individual acute and chronic criteria), as determined by equations 7 and 8 in Section 5.9. Adequate consideration of the additive toxicity of the pyrethroids jointly with the action all other co-occurring constituents is not justified given the current state of knowledge and is outside the scope of current regulations. Consequently, assumptions regarding pyrethroid additive toxicity are deemed scientifically sound and protective of beneficial uses. However, in the future the co-occurrence of the pyrethroids with other neurotoxins should be considered in the context of neurological adverse outcome pathways.

[4] Bliss, CI. 1939. The Toxicity of Poisons Applied Jointly. Annals of Applied Biology. 26 (3) 585-615

Response to comment 3.10:
The Draft Staff Report did not intend to imply that data were insufficient for potency normalization, but rather that water quality criteria should be used for the normalization instead of toxicity values (e.g., LC_{50}s). The reason for using water quality criteria for normalization is that the additivity equations are for determining attainment of the proposed numeric triggers, which are equal to the criteria.

Staff agrees that the joint toxicity of pyrethroids and other neurotoxins should be considered when more information is available. The Basin Plan language includes a provision to review the numeric triggers and implementation measures for pyrethroids no later than 15 years after the effective date of the amendment, and this topic will be reviewed at that time.

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