UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460
OFFICE OF
PREVENTION, PESTICIDES, AND
TOXIC SUBSTANCES

DP Barcodes: D291466
PCCode:056801
Date: July 14, 2003

MEMORANDUM:

SUBJECT: Response to Phase 5 Comments on the Interim Reregistration Eligibility Decision (IRED) Document for Carbaryl

To: Anthony Britten, PM Team Reviewer
Michael Goodis, Product Manager
Special Review and Reregistration Division (7508C)

FROM: R. David Jones, Ph.D., Senior Agronomist
Thomas Steeger, Ph.D., Senior Biologist
Environmental Risk Branch IV
Environmental Fate and Effects Division (7507C)

THRU: Elizabeth Behl, Chief
Environmental Risk Branch IV
Environmental Fate and Effects Division (7507C)

The Environmental Fate and Effects Division (EFED) has reviewed the comments received during Phase 5 of the reregistration process for carbaryl. In general, environmental fate comments focused primarily on urban runoff and monitoring data while the ecological effect comments focused primarily on the effects of carbaryl on beneficial insects (honey bees) and on the Section 24c (Special Local Needs) use of carbaryl to control burrowing shrimp in oyster culture. Comments have been paraphrased below and EFED's response to the issues being raised follow.

California Regional Quality Control Board (Reference Number 20) **The County Sanitation Districts of Los Angeles County** (Reference Number 32; Reference Number 45); **California Stormwater Quality Association** (Reference Number 28)

Comment: Based on two references from journal articles prepared by the United States Geological Survey (Gilliom *et al.,* 1999; Hoffman *et al.,* 2000), the commenter asserted that "*Carbaryl is commonly detected in urban surface water at concentrations known to cause adverse effects to aquatic ecosystems"*

EFED Response: As noted in the references, and cited in the EFED science chapter in support of the interim reregistration eligibility decision (IRED), carbaryl is frequently found in urban streams with 44% of samples showing detects in 8 urban streams (Hoffman *et al. 2000).* Gilliom *et al. (1999)* indicates that insecticides were detected in NAWQA monitoring more frequently in urban streams than in agricultural streams, and that

carbaryl was the second most frequently detected insecticide. The Gilliom *et al.* (1999) paper indicates that concentrations of some insecticides exceeded aquatic life criteria, but does not specify carbaryl as one of those compounds. Hoffman *et al.* did conclude that carbaryl exceeded a Canadian aquatic life criterion in 10% of the study samples; however, it is worthwhile investigating this criterion and what the exceedance of this criterion means. The value cited in these two papers was 0.2 $\mu g\ L^{-1}$ and is a value set by Environment Canada for the protection of aquatic life (Environment Canada, 1999.) Environment Canada sets aquatic life criteria by selecting the no-observed adverse effect concentration (NOAEC) from a chronic toxicity test for the most sensitive species and dividing this value by a factor of ten (Environment Canada, 1999). Thus, it would appear that Environment Canada based their aquatic life criteria on the same chronic test used by the EPA, which had similar results, *i.e.*, the 21-day chronic toxicity test using *Daphnia magna* which had a NOAEC of 1.5 $\mu g\ L^{-1}$. While use of the aquatic life criteria as an 'action level' to protect aquatic ecosystems is an appropriate use of these criteria, they should not be interpreted as a demonstration of adverse effects to aquatic environments, since we do not have reason to expect effects at one tenth the concentration that caused no observable adverse effects in the most sensitive tested species.

Comment: U.S. EPA deleted discussion of urban uses from revised risk assessment

***EFED Response**:* NAWQA data relevant to effects of urban uses on surface water resources are discussed on pages 12 and 13 of the EFED IRED chapter. Detailed discussion on the terrestrial assessment are in Appendix F to the EFED Chapter.

Comment: Risk Quotients may be 100 or 1000 times higher than U. S. EPA estimates.

EFED Response: EFED would be pleased to consider any data which show the risk is 100 to 1000 times higher than was estimated using the data which were available at the time the assessment was written. The references provided do not contain such data.

Comment: The Districts are particularly concerned about uses of carbaryl with direct routes of exposure to the sewer system. Several pet shampoos containing carbaryl are currently registered by the EPA. In normal usage, all of the carbaryl in these pest shampoos will be released to sewer systems.

***EFED Response**:* Liquid and dust pet uses (including pet shampoos) are being voluntarily cancelled by the registrant.

Comment: Assessing urban surface water risks is feasible.

***EFED Response**:* EFED has assessed monitoring data relevant to the urban uses in its IRED chapter. It is worth noting, however, that because water monitoring samples are collected only infrequently in time, the peak concentrations for carbaryl at any location are unlikely to be detected and therefore acute exposure will generally be underestimated using monitoring data. Because carbaryl degrades rapidly, it is particularly difficult for monitoring studies to capture the high concentrations that may occur. EFED is aware that the Office of Water is currently developing an urban scenario for the Castro Valley in California to assess exposure to copper derived from brake pad dust. The model being used, *i.e.*, Hydrologic Simulation Program in Fortran (HSPF), must be highly calibrated and may not be suitable as a pesticide assessment tool without substantial monitoring data in the basin for calibration purposes and without good information on the distribution of non-agricultural pesticide use within the watershed. In addition, OPP needs to be able to identify and model sites which would be expected to be high exposure sites relative to all urban basins and there is no assurance that the Castro Valley scenario would meet that criteria. We will continue to stay

abreast of model developments in this area, but have concluded that the best estimate of exposure to carbaryl in urban area at the present time is provided by the monitoring described in the EFED risk assessment. Current monitoring data do not show any risk exceedences for carbaryl, but these data are likely to underestimate the true exposure. Modeling tools and data needed to estimate upper-bound estimates of carbaryl resulting from urban uses are at a developmental stage.

G. Fred Lee & Associates (Reference Number 14)

Comment: This situation is yet another example of the inadequate approach that is used by the US EPA OPP in evaluating the potential environmental hazards of pesticides. The registration of pesticides for agricultural and urban use does not include an evaluation of whether stormwater runoff from an area which has received the pesticide could lead to diminished water quality. A single runoff event, such as the one we encountered because we happened to be sampling at the time, could have a significant adverse impact on aquatic life-related beneficial uses of the tributary streams and Upper Newport Bay.

EFED Response: The Office of Pesticide Programs (OPP) has been using models (e.g. Pesticide Root Zone Model [PRZM], Exposure Analysis Model System [EXAMS], Generic Estimated Environmental Concentration [GENEEC], FQPA Index Reservoir Screening Tool [FIRST]) which fully consider impacts of storm water runoff and spray drift on water resources since 1991. Tier 2 modeling using PRZM and EXAMS considers the possible impacts from all storms that occur in a weather record of 30 years, so infrequent high-magnitude storms and interactions between application timing and storm occurrence can be more fully considered in the assessment. Because the modeling approaches can capture the exposure due to these infrequent events, and can also simulate pesticides which are not yet registered, the Agency considers modeling approaches a critical component of its aquatic and drinking water exposure assessments. OPP currently does not have the capability to model the hydrology for urban watersheds and consequently cannot generate upper-bound estimates of carbaryl or other urban-use pesticides using modeling tools, as it can for agricultural pesticide uses. We will continue to stay abreast of model developments (including in other parts of the Agency) in this area, but have concluded that the best estimate of exposure to carbaryl in urban area at the present time is provided by the monitoring described in the EFED risk assessment. Modeling tools and usage data needed to estimate upper-bound estimates of carbaryl resulting from urban uses are currently at a developmental stage.

National Resources Defense Council (Document Number 39)

Comment: The water assessment did not consider non-agricultural sources of carbaryl, a total of 40% of carbaryl by weight, and the dominant source of surface water carbaryl pollution.

EFED Response*:* Monitoring data for carbaryl in urban watersheds (non-agricultural use) are described and used in risk assessment in the main EFED RED chapter (pages 12 and 13). Carbaryl has been found in urban watershed in concentrations up to 3.2 $\mu g\ L^{-1}$ and is found much more frequently in urban than in agricultural watersheds, with detection in roughly 45% of the samples. However, the concentrations detected in urban drainages are not high enough to exceed level of concern thresholds for either human health through drinking water or for fish. Exceedances of risk thresholds for aquatic invertebrates might be expected based on this data, but these data indicate that those concentrations would occur infrequently. EFED acknowledges that having the capability to model urban uses would greatly strengthen our assessments in that area. (See comments on modeling urban uses above.).

Comment: The acute drinking water level of concern (DWLOC) for combined food and water exposure exceed acceptable levels.

EFED Response: The commenter is correct in noting that the DWLOC is exceeded for carbaryl. Consequently, the assessment was refined beyond the screening level using an approach that uses combined food and water in a more fully probabilistic manner, similar to what was done by the Agency in the OP cumulative assessment. This approach uses the full time series from the aquatic model simulations for carbaryl and was peer reviewed by the Agency's FIFRA Scientific Advisory Panel (SAP). This approach is more fully described in the revised health effects division chapter. The additional model simulations to support this assessment are attached (**Appendix B**)

Comment: Carbaryl poses unacceptably high risks to mammals and aquatic animals; all granular uses are unsafe for mammals.

EFED Response: The NRDC is correct that the EFED chapter indicates acute risk LOCs are exceeded for mammals on all 40 registered uses of granules (RQ range 0.99 - 21). However, except in cases of unusually high rain events, granular formulations tend to reduce the runoff potential of carbaryl into aquatic habitats due to the slow release of active ingredient from the granules. Since the risk assessment for aquatic animals was based on nongranular formulations, it is not possible to gauge the extent to which exposure will be reduced as granular formulations are used in place of liquid/dust formulations. The Agency believes that the voluntary cancellation of a number of uses and proposed mitigation measures for the remaining uses will reduce potential risks to nontarget animals.

Comment: EPA must ensure that the Agency's actions do not jeapardize endangered species.

EFED Response: The EFED chapter identifies risks to endangered/threatened terrestrial and aquatic animals and discusses previous biological opinions rendered by the U. S. Fish and Wildlife Service on carbaryl. Additionally, the Agency has already developed a consultation package for the National Marine Fisheries Service on listed Pacific salmon and steelhead and is committed to fulfilling its responsibilities to consult with the Services under the Endangered Species Act.

Comment: Carbaryl is highly toxic to honey bees.

EFED Response*:* The NRDC is correct in asserting that the EFED chapter states that carbaryl is highly toxic to beneficial insects and that bee kill incidents have been associated with some uses of carbaryl. However, many bee kill incidents so not contain sufficient detail to clearly implicate carbaryl (see the response to comments from Runquist Law Office [Reference Number 37], Jeffrey Anderson [Reference Number 29], and Steve Ellis [Reference Number 42] regarding bee issues below). EFED has recommended that additional studies be conducted to determine whether chronic exposure to carbaryl impacts bee hives. With this additional information, EFED may be able to make more reliable recommendations to mitigate the potential effects of carbaryl on honey bees.

Nahcotta Oyster Farm (Reference Number 12)

Comment: The comments indicate that the 200-ft aerial application buffer and 50-ft ground application buffer for controlling burrowing shrimp in oyster culture are inadequate and that carbaryl cannot be contained within the immediate application site due to tidal movement. As a result of tidal movements across treated

areas, lethal effects of carbaryl have been observed in adjacent oyster beds extending more than 1,000 feet from the application site.

EFED Response: Appendices E1 through E3 of the EFED Environmental Fate and Ecological Risk Assessment for the Interim Reregistration Eligibility Decision on Carbaryl provides an overview of the Section 24c Special Local Needs use of carbaryl to control burrowing shrimp in Willapa Bay/Grays Harbor, Washington. EFED acknowledges that acute mortality of animals is likely in the immediate application area and that carbaryl is likely to drift to nontarget areas due to tidal movements within the bay. However, based on the data that were available for review, EFED believes that carbaryl concentrations will be substantially reduced at nontarget sites given the large tidal flux that Willapa Bay undergoes.

It is EFED's understanding that the growers have established a memorandum of agreement with various stakeholders in the area to examine both chemical and nonchemical alternatives for carbaryl and that the growers have also recently agreed to phase out the use of carbaryl completely within 12 years. Additionally, it is EFED's understanding that Willapa Bay oyster growers have recently agreed to a settlement that establishes substantial buffers around the Nachotta oyster farm; these buffers are intended to reduce the likelihood of carbaryl drift into this area (personal communication, Bill Dewey, Taylor Shellfish Co., 2003). EFED encourages stakeholders to communicate their concerns to the growers to reach a mutually acceptable agreement to reduce carbaryl drift to properties adjoining treatment sites.

Runquist Law Office (Reference Number 37); Jeffrey Anderson (Reference Number 29); Steve Ellis (Reference Number 42); Steve Ellis (Reference Number 43)

Comment: Beekeepers in Minnesota have expressed concern that the use of carbaryl on hybrid poplar plantations is resulting in a significant loss of bee hives. The beekeepers maintain that carbaryl (Sevin XLR Plus®) cannot be safely used on poplar plantations where blooming weeds are present and that the label should specifically exclude this use.

EFED Response: The Minnesota Department of Agriculture has provided the Agency copies of all of their investigative reports on bee kill incidents reportedly associated with carbaryl use on hybrid poplar plantations. EFED has reviewed these materials and has summarized the results of that review in a recent memo (see attached memo dated 6.30/03; DP Barcode D291468). While the Agency has data to support label language indicating that carbaryl is highly toxic to beneficial insects on an acute exposure basis, there are no data to evaluate concerns that carbaryl can be potentially transported back to the hive on pollen where it then exerts chronic effects that impact bee colony survival. Although beekeepers in the vicinity of poplar plantations believe they have experienced substantial losses due to the use of carbaryl, there are only circumstantial data to implicate carbaryl. EFED has recommended that research be initiated to evaluate the potential of carbaryl to be transported back to the hives and to determine whether residues are high enough to result in chronic effects. Without sufficient data to support restrictive label language, it is difficult for the Agency to impose such restrictions. When data are available, the Agency will evaluate the results and determine whether the label language needs to be adjusted.

John Kepner; Beyond Pesticides (Reference Number 40)

Comment: Although Mr. Kepner raises a number of issues, three were relevant to EFED. These included the comments that 1) EPA doesn't consider estrogenic potential of carbaryl in risk assessment, 2) EPA must incorporate increased carbaryl [residential] use due to phase out of chlorpyrifos and diazinon, and 3) EPA

must consult with the services on endangered species in accordance with the consent decree between the Agency and Californians for Alternatives to Toxics relative to endangered salmonids.

EFED Response: With regard to carbaryl's "estrogenic" potential, the EFED chapter states that "there are data indicating that carbaryl exposure may impact endocrine-mediated processes in both aquatic and terrestrial" and the chapter provides details on the studies used to support this concern. As Mr. Kepner has noted, the chapter also states that when the appropriate screening and/or testing protocols have been developed, "it is recommended that carbaryl be subjected to additional screening and/or testing to better characterize effects related to endocrine disruption." Therefore, the risk characterization of carbaryl does identify carbaryl's potential to act on endocrine-mediated processes and recommends that this uncertainty be addressed when the appropriate testing protocols have been developed.

With respect to endangered species, the Agency is committed to initiating consultations with the National Marine Fisheries Service (NMFS) on endangered anadromous salmonids. As the chapter states, the Agency submitted a consultation package on endangered Pacific Coast salmonids in April 2003. Additionally, the Agency is currently engaged in discussions with the U. S. Fish and Wildlife Service and the NMFS to develop a mutually acceptable and efficient process for conducting future consultations.

With respect to EPA having to account for shifts in the extent to which carbaryl will occupy the residential market, it is not possible for the Agency to quantify this unknown. While several organophosphates are being phased out, alternative pesticides will likely include carbaryl; however, the extent to which carbaryl will be used is unknown. Alternatives are represented by both existing and emerging products that the consumer preferences will determine. At this point, it is not possible for the Agency to reasonably quantify future use patterns for the purposes of risk assessment.

Literature Citations

Environment Canada. 1999. *Canadian Water Quality Guidelines for the Protection of Aquatic Life.* Ottawa, Ontario.

Gilliom, R. J., J. E. Barbash, D. W. Kolpin, and S. J. Larson. 1999. Testing Water Quality Pollution. *Environmental Science and Technology* **33**:164A.

Hoffman, Ryan S., Paul D. Capel, and Steven J. Larson. 2000. Comparison of pesticides in eight urban streams. *Environmental Toxicology and Chemistry.* **19**:2249-2258.

Attachment A: Review of Minnesota Bee Incident Investigations

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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D P Barcodes: D 291468

PCCode:056801
Date: July 1, 2003

MEMORANDUM:

SUBJECT: Review of Minnesota Department of Agriculture and Minnesota District Court Information Materials Related to Bee Kill Incidents and Carbaryl Use on Hybrid Poplar Plantations

To: Anthony Britten, PM Team Reviewer
Michael Goodis, Product Manager
Special Review and Reregistration Division (7508C)

FROM: Thomas Steeger, Ph.D., Senior Biologist
Environmental Risk Branch IV
Environmental Fate and Effects Division (7507C)

THRU: Elizabeth Behl, Chief
ERB IV/EFED (7507C)

The Environmental Fate and Effects Division (EFED) has reviewed information forwarded by Mr. Paul M. Liemandt of the Minnesota Department of Agriculture (MDA) regarding investigations of [alleged] bee kill incidents. The materials represented copies of MDA correspondence/closure letters to Minnesota beekeepers regarding beekeeper complaints of [alleged] bee mortalities due to the use of carbaryl (Sevin XLR Plus®) in hybrid poplar plantations to control cottonwood leaf beetle (*Chrysomela scripta*). Poplar plantations in the vicinity of the bee kills were operated primarily by International Paper Company and in some cases were maintained by the Minnesota Department of Natural Resources. In general, investigations conducted by the MDA concluded that the plaintiffs did not have sufficient data to support claims that carbaryl was responsible for reduced numbers of bees in commercial colonies in close proximity to poplar plantations. Although in at least one instance, carbaryl use on poplars was associated with the loss of a significant number of hives, the investigation indicated that the hives had been inadvertently sprayed when the spraying protocols were not adequately followed.

According to court records, in most of the bee kill incidents, carbaryl was applied by licensed applicators following label instructions. Additionally, carbaryl applications were conducted at night to minimize impacts to beneficial insects. The defendants (International Paper and the Minnesota Department of Natural Resources) argued beekeepers in Minnesota were experiencing difficulties with their hives prior to 1998 when carbaryl use was initiated on poplar plantations and that carbaryl residues have not been detected in the majority of incidents investigated. Furthermore, the defendants indicated that other pesticides, *e.g.* methyl parathion and coumaphos, may have been responsible for bee kills rather than carbaryl.

Plaintiffs have argued that they have suffered financial losses due to the impact of carbaryl and that failure of state investigators to detect carbaryl residues is likely due to poor sample collection methodology or inadequate levels of detection. The plaintiff's testimony suggests that carbaryl residues may not dry sufficiently on plants and residues are carried back to the hive on pollen. Although no data are provided to support their claim, beekeepers testified that carbaryl residues in the hives impact the survival of young bees. Declining bee survival is reportedly interpreted by the bees to indicate that the queen is impaired and that she must be eliminated.

Although EFED has data indicating that carbaryl is highly toxic to bees on an acute exposure basis, there are no data currently available on the chronic effects of carbaryl exposure on bees. Therefore, it is not possible to EFED to comment on the potential for carbaryl to be transported back to the hive or at what concentration effects on bees are likely. EFED therefore recommends that a chronic honey bee study be initiated to evaluate the sublethal effects of carbaryl; this study requirement is similar to one recently suggested for the registration of clothianidin. The honey bee study should evaluate the effects of carbaryl on the hive over time and should include but not necessarily be limited to the following criteria: **a)** an evaluation of two complete life cycles (~130 days) including egg, larvae, adult stages, and mortality of the honey bee colony; **b)** an evaluation of the exposure and effects to the queen during these life cycles; **c)** provide carbaryl residue analysis of the stored nectar, honey, and pollen at the beginning of the study, at periodic time intervals during the study and at the end of the study; and **d)** the study must include replicated data with statistical comparison to controls.

While it is clear that some Minnesota beekeepers believe they are experiencing bee mortality due to the use of carbaryl on poplar plantations, there are insufficient data to clearly implicate carbaryl with the majority of recent bee kill incidents in the state. The current label contains a bee warning; however, in order for EFED to determine whether more restrictive label language is warranted to protect bees, chronic bee toxicity data are necessary. If risk managers require additional information regarding EFED's recommendation for additional studies, please do not hesitate to contact me.

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ADDENDUM **June 30, 2003**

SUBJECT: Final Report of Carbaryl EEC's for Drinking Water, additional simulations
DB Barcode: D288455
PC Code: 056801

TO: Anthony Britten,
Chemical Review Manager,
Reregistration Branch 3
Special Review and Reregistration Division

FROM: R. David Jones, Ph.D., Senior Agronomist
Environmental Risk Branch 4

THROUGH: Elizabeth Behl, Chief
Environmental Risk Branch 4
Environmental Fate and Effects Division

This is an addendum to the final report for revised estimated environmental concentrations (EEC's) in surface water for the use of carbaryl on selected crops. This addendum provides additional EEC's that more fully describe the variation in exposure across the landscape. This has been done by adding additional two addition crops, peaches and pecans, and adding estimates for citrus in California to the estimates for citrus in Florida. These additional simulations are provided to more fully characterize exposure to carbaryl residues in drinking water from a variety of uses and (for the citrus use) to provide exposure estimates representing a variety of alternative scenarios (maximum application rates, application methods, application intervals)which could mitigate the predicted dietary risks from food plus water from the Florida citrus use. The additional exposure estimates further refine the risk and help localize the risk by identifying other crops that have high exposure, but do not fill the risk cup, (pecan, peaches, and apples) and by identifying locations where citrus is grown where the exposure is lower than Florida. These refinements will help segregate where risk mitigation practices may be necessary from those locations and crops where the risk is not expected to be exceeded. In addition to the EEC's, additional characterization of the exposure due to urban use has been included.

The EEC's in Table 1 represent the 90 percentile exposure value for carbaryl use on representative crops. These EEC's are based on the maximum use patterns allowed on each label as described below.

Table 1. EEC's for the 'maximum' use patterns for carbaryl on selected agricultural crops. Scenario with the highest EEC's (Florida citrus) are shaded.		
Crop	Acute EEC	Chronic EEC
	---------- μg L^{-1} carbaryl ----------	
Apples (PA)	94.7	3.3
Citrus 1 (CA)	100.0	4.71
Citrus 2 (CA)	87.9	3.37
Citrus (FL)	410.4	18.6
Peaches (GA)	44.9	2.05
Pecans (GA)	48.2	2.16

A more complete description of rationale and effects of these changes is provided below. The revised EEC's for the maximum use pattern are in Table 1. A complete list of EEC's for all use patterns is in Table 6. The estimate for apples revises the maximum use pattern from 2 lb $acre^{-1}$ to 3 lb $acre^{-1}$ in accordance with the actual maximum label practice. The maximum use pattern for citrus is 7.5 lb $acre^{-1}$ with a 20 lb $acre^{-1}$ seasonal total, which was previously modeled with 4 applications of 5 lb $acre^{-1}$. To better reflect the exposure which may result from this use pattern, this pattern was simulated with 4 applications of 7.5 lb $acre^{-1}$ in California, a total of 22.5 lb $acre^{-1}$ per year, and with two application of 7.5 lb $acre^{-1}$ and one application of 5 lb $acre^{-1}$ in Florida. A use pattern with a single high application (16 lb $acre^{-1}$) to citrus was not modeled previously and has been added here as "Citrus 2 (CA)" in Table 1.

Models

These estimates were calculated using PRZM version 3.12 dated May 24, 2001 and EXAMS version 2.98.04 dated July 18, 2002. These models were run in the EFED PRZM EXAMS shell, PE3 version 1.2, dated October 15, 2002. The shell also processed the output from EXAMS to estimate the 1 in 10 year return values reported here. In addition, time series of daily values for thirty years were output and have been provided for use in more refined dietary exposure assessment. A list of the input files used to generate these EEC's is in the Appendix. In some cases, runs with two different application rates were run and then recombined using Excel spreadsheets. The summary statistics for these runs were estimated manually. Florida citrus simulation 13 (2 applications of 7.5 lb $acre^{-1}$ and one application of 4 lb $acre^{-1}$ with 14 day interval applied by spray blast) was modeled by Dirk Young rather than R. David Jones. The PE4 shell (see below) was used for this simulation rather than PE3.

It is worth noting that the Office of Pesticide Programs is aware of an error in the current modeling system that results in the "peak" EEC's reported actually representing not instantaneous peak concentrations, but 24-hour mean concentrations on the day the peak occurs. The OPP is currently taking corrective action, but revisions had not completed QA review prior to initiation of this analysis. For the case of carbaryl, this likely results in an approximately five percent underestimation of the peak. However, this error is certainly covered by other substantial conservatisms which are inherent in these estimates. A new version of the post-processing and shell software "PE4" has now been approved by OPP for use and fixes these errors. It was

not used here in order to maintain consistency with the previous carbaryl simulations but will be used for any future efforts.

Scenarios

EEC's were calculated for 5 crops which include those which are the major use sites for carbaryl. These sites are: apples, citrus, field corn, sweet corn, and sugar beets. The scenario for apples is in Lancaster County, Pennsylvania and represents a Elioak silt loam soil, Hydrologic Group C soil. The Florida scenario for citrus is in Collier and Hendry Counties Florida and represents a Wabasso sand soil. The California citrus scenario is in Fresno County and uses a Exeter loam soil in Hydrologic Group C. The peach scenario is in Peach County and has a Greenfield fine sandy loam soil in Hydrologic Group B. The pecan scenario is in Mitchell and Dougherty Counties and uses a Greenville fine sandy loam in Hydrologic Group C.

Use Patterns

The use patterns for each crop were adapted from the carbaryl labels to represent the maximum use patterns. The input parameters used to represent these use patterns are in Table 2. In cases where a minimum re-application interval was specified on the label this value was used in the maximum application pattern. In cases when no minimum interval is specified, a interval of 3 days was used. The OPP currently has no written guidance for this assumption However, three days is a reasonable minimum retreatment interval, given that scouting and evaluation of efficacy would have to occur before another treatment is undertaken. This minimum value has been used by OPP for Tier 2 modeling in the absence of guidance for 10 years. Metadata for each scenario is described in EFED, 2002b. As noted above, the apples and Florida citrus practices replace those for simulations in the document which this is an addendum

Table 2. Maximum use patterns for carbaryl application on selected crops based on the EPA label.

Crop	Single App. Rate (lb acre^{-1})	Number of Applications	Application Interval	Application Method	Date of First Application
Apples 1	3	5	3 days	aerial	June 1
Citrus: CA - 1	7.5, 5[1]	3	3 days	aerial	April 30
Citrus: CA - 2	16	1	NS	aerial	April 30
Citrus: FL - 3	7.5, 5[1]	3	3 days	aerial	April 30
Citrus: FL - 4, 5[3]	10	2	14	aerial	April 30
GA peaches	4.945	3	7 days	aerial	June 1
GA pecans[2]	5	3	7 days	aerial	April 15

1) Maximum single application of 7.5 lb acre^{-1}, 20 lb acre^{-1} per season, modeled as 3 applications of 7.5 lb acre^{-1}.
2) Four application per season are allowed for pecans, but only 15 lb acre^{-1} each year, or three applications at the maximum rate.
3) This use pattern was used to estimate EEC's for with both the default PCA of 0.87 and the provisional regional PCA for Florida of 0.38.

Several addition use patterns have been simulated in order to support risk management decisions and identify appropriate and sufficient mitigation practices. These are listed in Table 3. In all these additional simulations, aerial application, which is allowed on the label, has been replaced with spray blast, which is the most commonly used application method for orchard crops. Spray blast tends to result in much less drift than aerial application. Several of these simulations, namely Apples 2, Citrus 4, Citrus 9, Pecans 2 and 3 are the maximum application practice with the change to spray blast only. Apples 3 includes a reduction in the number of applications to three and an increase in the application interval to 14 days. According to analysis of usage data by BEAD (personal communication), this would represent a practice which is greater than 90% of the actual carbaryl use on apples. Citrus 7 and Pecans 4 are also use patterns that would represent approximately a ninetieth percentile according to BEAD. Citrus 11 and Pecans 3 do not represent different use patterns but reflect the use of a provisional regional PCA. This PCA is further described in the results section. Aerial application is represented by using a spray drift efficiency of 0.16 and an application efficiency of 0.95 while air blast is represented by values of 0.064 and 0.99 for these parameters respectively

Table 3. Selected use patterns for carbaryl application for evaluating mitigation practice effects on carbaryl in drinking water.

Crop	Single app. Rate (lb acre^{-1})	Number of Applications	Application Interval	Application Method	Date of First Application
Apples - 2	3	5	14 days	spray blast	June 1
Apples - 3	3	3	14 days	spray blast	June 1
Citrus (CA) 6	16	1	--	spray blast	April 1
Citrus (CA) 7	12	1	--	spray blast	April 1
Citrus (CA) 8	8	1	---	spray blast	April 1
Citrus (CA) 9	7.5, 5[1]	3	14 days	spray blast	April 30
Citrus (FL) 10,11[2]	7.5, 5[1]	3	14 days	spray blast	April 30
Citrus (FL) 12	4	2	14 days	spray blast	April 30
Citrus (FL) 13[2]	7.5, 4[1]	3	14 days	spray blast	April 30
Pecans 2, 3[2]	5	3	7 days	spray blast	April 15
Pecans 4	2.5	2	10 days	spray blast	April 15

1) Two applications at 7.5 and 1 application a 5 lb acre^{-1}. For Citrus 13, the third application was 4 lb acre^{-1}.
2) This use pattern was used to estimate EEC's for with both the default PCA of 0.87 and the provisional regional PCA for Florida of 0.38.

Table 3. EEC's for carbaryl application to selected crops for evaluating mitigation practice effects on carbaryl in drinking water. The default PCA of 0.87 was used unless otherwise noted.

Use Site/ application method	1 in 10 year Peak ($\mu g\ L^{-1}$)	1 in 10 Year Annual Mean	Maximum	percent over 100 $\mu g\ L^{-1}$	percent over 6 $\mu g\ L^{-1}$
	---------- $\mu g\ L^{-1}$ ----------				
Apples maximum	94.7	3.3	158	0.08	8.6
Apples - 2	86.6	3.2	153	0.08	8.3
Apples - 3	67.0	2.1	141	0.03	4.2
Citrus (CA) max 1	100	4.7	118	0.29	12.1
Citrus (CA) max 2	87.9	3.4	91.3	0.00	10.1
Citrus (CA) 6	34.6	1.3	35.8	0.00	6.6
Citrus (CA) 7	26.0	1.0	26.9	0.00	5.8
Citrus (CA) 8	17.3	0.66	17.9	0.00	4.1
Citrus (CA) 9	22.7	1.6	23.9	0.00	12.0
Citrus (FL) max 3	410.4	18.6	2085	13.4	16.2
Citrus (FL) max 4[1]	646.8	23.3	854	1.65	18.0
Citrus (FL) max 5[2]	237.9	8.6	373	0.68	14.3
Citrus (FL) 10[1]	395.0	19.1	602	13.4	18.9
Citrus (FL) 11[2]	172.8	7.0	322	0.52	9.6
Citrus (FL) 12[2]	108.7	3.8	141	0.10	3.6
Citrus (FL) 13[2]	204	6.7	263	0.38	9.7
Peaches - max	44.9	2.0	249	0.07	8.4
Pecans - max 1[1]	182.4	8.5	201.8	0.64	14.0
Pecans 2[1]	159.9	7.0	194.0	0.39	12.4
Pecans 3[2]	69.8	3.1	84.7	0.00	6.6
Pecans 4	21.0	0.94	109	0.03	5.6

1 Calculated with default PCA of 0.87
2 Calculated with provisional default regional PCA for Florida watersheds of 0.38

Chemical Parameters

The chemistry input parameters were identical to those used in the simulations in the original memorandum document to which this is an addendum.

Results and Characterization

EEC's were calculated as described above and then adjusted for percent cropped area (PCA), based on OPP guidance (OPP, 2000). EEC's are in Table 3. In most cases, the default PCA of 0.87 was used, but for Florida citrus and Georgia pecan simulations, an additional set of EEC's was generated using a provisional default regional PCA of 0.38 (Table 3). The PCA represents the maximum amount of agricultural land in any watershed at the 8 digit hydrologic unit code (HUC) scale in the HUC 2 watershed area containing Florida. This regional PCA was calculated in a similar manner to that for the national default PCA, and these regional default PCA's were used in the OP cumulative assessment. The OPP is currently considering a policy for using regional default PCA's as a regular part of drinking water exposure assessment. For all the crops simulated in this assessment, the default PCA for all agricultural land of 0.87 was used. As before, the citrus scenario with the maximum use pattern is recommended in estimating EEC's for Tier II drinking water assessment.

A Tier II EEC uses a single site which represents a high exposure scenario for the use of the pesticide on a particular crop or non-crop use site. The weather and agricultural practice are simulated at the site over multiple (in this case, 30) years so that the probability of an EEC occurring at that site can be estimated. Sites are selected to represent a site which is more vulnerable than 90% of the sites which are used for growing the crop on a nationwide basis. Sites are currently selected to meet this standard by best professional judgement. For each simulation, the exposure of interest, either the annual peak or mean, is identified for each year. These 30 values are sorted and the single point estimate is selected by identifying the value that would be expected to recur once every 10 years. For these simulations, this specific value is linearly interpolated from between the third and fourth highest annual values.

These values are greater than those that would be expected to be found in the environment primarily for three reasons. First, we have used the default PCA of 0.87, as the PCA for citrus in Florida. The default PCA is the maximum proportion of agricultural land found in any basin in the country, In fact, the actual PCA in Florida is probably closer to one-third this value, although a precise estimate is not available at this time. Secondly, the percent crop treated has been assumed to be 100%. In fact, according to BEAD (Hernandez, 2002), the percent crop treated for different citrus crops ranges for 1.5 to 6%, depending on the crop. Thirdly, since the labels have not specified maximum number of applications, the maximum practice modeled is substantially greater than that which is usually used in practice. In particular, the rate per acre and the number of treatments per season is often less than that allowed on the label. In addition, the interval between applications (when there is more than one) is usually longer than has been simulated for the maximum use pattern. This third factor has been addressed in this assessment, and is reflected in the EEC's from the 'average' and maximum reported use patterns from Table 3 and 4.

In addition to the point estimate EEC's for drinking water exposure described above. We have provided the time series of concentrations for the entire duration of the simulation for the different citrus scenarios. These series of estimates are intended for use in a more full of the whole range dietary exposure for carbaryl and are being combined with pesticide residues in food using the DEEM model. While making fuller use of the whole time series for drinking water exposure is expected to improve the description of the dietary risk, using the time series for water in combination with the distribution of food residues and

consumption patterns normally used in DEEM substantially alters the interpretation of the risk represented by the output of the model because the drinking water component introduces a time component which is not present in the food and consumption data - any time component in the data is ignored by DEEM. Technically, the food and consumption distributions are assumed to be 'stationary' with respect to time and location, that is the distributions are always the same at any point in time and any location in the United States. This is a reasonable assumption for food residues and consumption, but not a reasonable one for pesticide residues in drinking water which are expected to vary by orders of magnitude with both time and location. The difference in interpretation can be best illustrated by describing how the interpretation differs when the different exposure components dominate the exposure profile. When food (other than water dominates the exposure and the drinking water contribution is negligible, an exceedance of the 99.9% threshold implies that one person in 1000 across the whole U. S. population is above the threshold each day. If drinking water dominates and food contributions are negligible, an exceedance of the 99.9% means that the entire population provided drinking water from a facility represented by scenario, are expected to exceed the risk once every 1000 days, a little less that once every three years. When both water and food sources make significant contributions to exposure, a more detailed analysis of the structure of the data is necessary to determine the nature of the risk. Depending on the structure of the risk, regulating on the 99.9 percentile in a manner similar to that used previously may not provide a intended level of safety similar to that which is provided by using DEEM with food only and the DWLOC approach with water.

Beyond the three major factors which are described above, there are a number of other factors inherent in the modeling can affect the accuracy and precision of this analysis including the selection of the high exposure scenarios, the quality of the input data, the ability of the models to represent the real world, and the number of years that were modeled.

Scenarios that are selected for use in Tier 2 EEC calculations are ones that are likely to produce large concentrations in the aquatic environment. It should represent a site that really exists and would be likely to have the pesticide in question applied to it. It should be extreme enough to provide conservative estimates of the EEC, but not so extreme that the model cannot properly simulate the fate and transport processes at the site. Currently, sites are chosen by best professional judgement to represent sites which generally produce EEC's larger than 90% of all sites use for that crop. The EEC's in this analysis are accurate only to the extent that the site represents this hypothetical high exposure site.

The quality of the analysis is directly related to the quality of the input parameters. In general, the fate data for carbaryl are good. The paucity of soil and aquatic metabolism data is the main limitation of the data set. Because metabolism values are set to the upper 90% confidence limit of the mean, the EEC's will be conservative to the extent we are uncertain of the true central tendency of the metabolism data. Additional metabolism data would greatly increase our confidence, and likely reduce our EEC estimates. As noted above, using best estimates for "average" application practice rather than the standard upper bound estimates reduced the EEC from 125 $\mu g\ L^{-1}$ to 78.9 $\mu g\ L^{-1}$. This indicates that the quantity and quality of the metabolism data can substantially effect the estimates.

The models themselves represent a limitation on the analysis quality. While the models are some of the best environmental fate estimation tools available, they have significant limitations in their ability to represent some processes. Spray drift is estimated as a straight 16% of the application rate reaching the reservoir for each application. In actuality, this value should vary with each application from zero when the wind blows away from the reservoir to perhaps as high as 20%. A second major limitation of the models is the lack of validation at the field level for pesticide runoff. While several of the algorithms (volume of runoff water, eroded sediment mass) are well validated and well understood, there is less confidence that PRZM 3.12

well represents the amount of pesticide transported in runoff events. Some validation efforts undertaken by the pesticide industry and under review by the Agency indicate that PRZM gives reasonable estimates of pesticide extraction into runoff, but validation of the runoff portion of PRZM is not extensive. Another limitation of the models used is their inability to handle within-site variation (spatial variability), lack of crop growth algorithms, and an overly simple soil water transport algorithm (the "tipping bucket" method). A final limitation is that only thirty years of weather data were available for modeling at each site. Consequently there is approximately a 1-in-20 chance that the true 10% exceedance EEC's are larger than the maximum EEC in the calculated in the analysis. If the number of years of weather data could be increased it would increase the confidence that the estimated value for the 1-in-10 year exceedance EEC was close to the true value.

Drinking Water and Aquatic Exposure Issues Related to Urban Usage

BEAD has indicated that as much as 50 percent of carbaryl usage is in residential and 'urban' uses. The OPP currently does not have the capability to model the hydrology for urban watersheds and consequently cannot generate upper-bound estimates of carbaryl or other urban-use pesticides, as it can for agricultural pesticide uses. As noted in the main EFED RED chapter, monitoring data for carbaryl in urban watersheds does exist and carbaryl has been found in urban watershed in concentrations up to 3.2 $\mu g\ L^{-1}$ and is found much more frequently than in agricultural watersheds, with detection in roughly 45% of the samples. However, these concentrations detected in urban drainages are not high enough to exceed level of concern thresholds for either human health through drinking water or for fish. Exceedances of risk thresholds for aquatic invertebrates might be expected based on this data, but these data indicate that would occur infrequently.

It is worth noting, however, that because monitoring data samples are collected only infrequently in time, the peak concentrations for carbaryl at any location are unlikely to be detected and therefore acute exposure will generally be underestimated using monitoring data. Because carbaryl degrades rapidly, it is particularly difficult to capture the high concentrations that occur by monitoring. We are aware that the Office of Water is currently developing a urban scenario for the Castro Valley in California in order to assess exposure to copper derived from brake pad dust. The model being used, HSPF, must be highly calibrated and may not be suitable as a pesticide assessment tool without substantial monitoring data in the basin for calibration purposes and without good information on the distribution of non-agricultural pesticide use within the watershed. In addition, OPP needs to be able to identify and model sites which would be expected to be high exposure sites relative to all urban basins and there is no assurance that the Castro Valley scenario would meet that criteria. We will continue to stay abreast of model developments in this area, but have concluded that the best estimate of exposure to carbaryl in urban area at the present time is provided by the monitoring described in the EFED risk assessment. Monitoring data exists that do not show any risk exceedances for carbaryl, but they are likely to underestimate the true exposure. Modeling tools and data needed to estimate upper-bound estimates of carbaryl resulting from urban uses are at a developmental stage.

For aquatic risk concerns, it is worth noting that risks due to pesticides are not likely to be the greatest threat to wildlife in urban basins. Urban watersheds are beset by many other environmental threats including scouring due rapidly increasing flows during storms, sediment load, and thermal problems due loss of canopy and heating of storm water on pavement. As noted above, occasional exceedances of some aquatic life risks are expected to occur for carbaryl, but the risks are in most cases going to be outweighed by these other stressors in urban watersheds.

Literature Citations

Environmental Fate and Effects Division. 2002b. Pesticide Root Zone Model (PRZM) Field and Orchard Crop Scenarios: Standard Procedures for Conducting Quality Control and Quality Assurance. http://www.epa.gov/oppefed1/models/ water/qa_qc_documentation_ver2.htm/

Appendix
Input Files for Estimating Drinking Water Exposure for Total Carbaryl Residues.

Table C-1. Input files archived for azinphos methyl applied to pome fruits.

File Name	Date	Description
W03813.dvf	July 3, 2002	weather data for the Georgia peach scenario
W12842.dvf	July 3, 2002	weather data for Florida citrus scenario
W14637.dvf	July 3, 2002	weather data for Pennsylvania apple scenario
W23155.dvf	July 3, 2002	weather data for the California citrus scenario
W93805.dvf	July 3, 2002	weather data for the Georgia pecan scenario
Cacitrus.txt	October 12, 2002	California citrus scenario parameters for PE3 shell
Gapeaches.txt	October 12, 2002	Georgia peaches scenario for the PE3 shell
GApecans.txt	May 23, 2003	Georgia pecans scenario for the PE3 shell
Flcitrus.txt	October 12, 2002	Florida citrus scenario parameters for PE3 shell
PAapple.txt	October 12, 2002	Pennsylvania apple scenario parameters for PE3 shell
Input Data Files for specific simulations (.PZR extension)		
Cacits13	May 16, 2003	maximum national use pattern, aerial California
Cacits14	May 16, 2003	California maximum use pattern
Cacits15	June 3, 2003	California max use pattern, spray blast
Cacits16	June 3, 2003	California 1 app, 12 lb, spray blast
Cacits17	June 3, 2003	California 1 app, 8 lb, spray blast
Cacits 18	June 3, 2003	California national max use pattern, spray blast, part 1
Cacits19	June 3, 2003	California national max use pattern, spray blast, part 2
FLCits12	June 3, 2003	Florida national max use pattern, aerial, part 1
FLCits13	June 3, 2003	Florida national max use pattern, aerial, part 2
FLCits14	June 3, 2003	Florida national max use pattern, 14 day interval, sb, part 1
FLCits15	June 3, 2003	Florida national max use pattern, 14 day interval, sb, part 2
FLCits16	June 3, 2003	Florida, 2 apps 4 lb, 14 day interval, spray blast
FLCits17	June 12, 2003	Florida 7.5x2, 4x1, 14 day interval, spray blast
FLCits20	June 20, 2003	Florida 2 apps, 10 lb acre, 14 day interval, spray blast
GApech00	May 16, 2003	Georgia peaches, maximum use pattern
GApecn00	May 27, 2003	Georgia pecans, maximum use pattern
GApecn01	June 5, 2003	Georgia pecans, maximum pattern, but spray blast
GApcn02	June 5, 2003	Georgia pecans, 2.5 lb two times, 10 day interval SB
PAAppl06	June 3, 2003	apples, replacement maximum use
PAAppl07	June 3, 2003	apples, replacement maximum use pattern, SB
PAAppl08	June 3, 2003	apples, 3 lb, 3 applications, spray blast

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