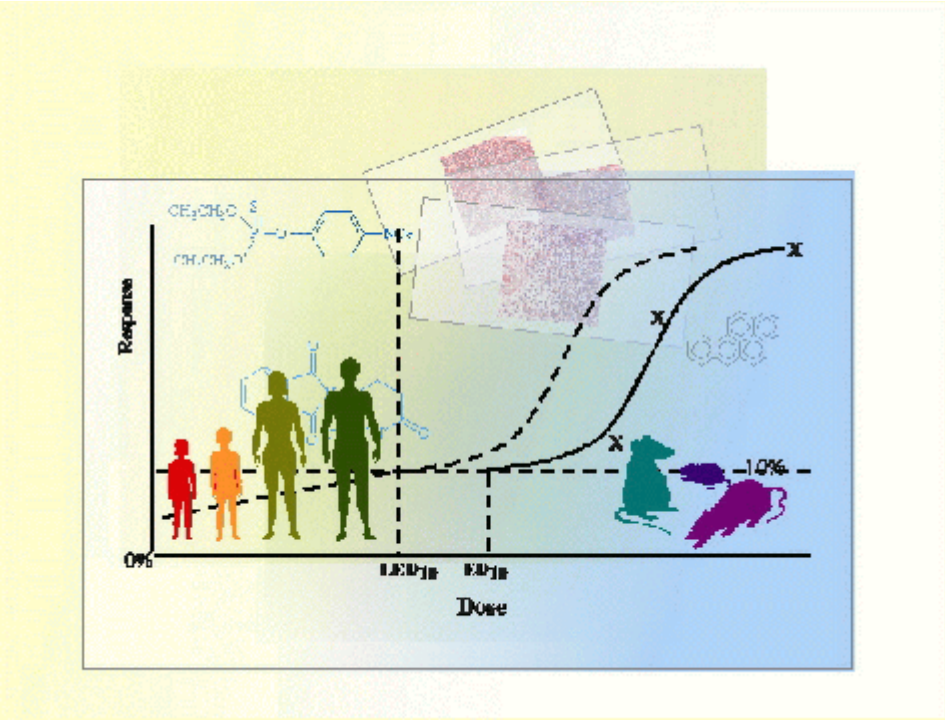
ESTIMATION OF CUMULATIVE EXPOSURE FROM N-METHYL CARBAMATE PESTICIDES:

A Case Study of 10 N-Methyl Carbamates



U.S. Environmental Protection Agency
Office of Pesticide Programs
Health Effects Division
February 18 , 2005

List of Acronyms

CHAD	Consolidated Human Activity Database
CRA	Cumulative Risk Assessment
CSFII	USDA's Continuing Survey of Food Intake by Individuals
DEEM-FCID	Dietary Exposure Evaluation Model
DFR	Dislodgeable Foliar Residue
EFED	Environmental Fate and Effects Division
FDA	Food and Drug Administration
FIFRA	Federal Insecticide, Fungicide, Rodenticide Act
FR	Federal Register
LCO	Lawn Care Operator
LOAEL	Lowest Observable Adverse Effect Level
LOQ	Limit of Quantification
MOE	Margin of Exposure
MRID	Master Record Identification Number
NASS	National Agricultural Statistics Survey
NHGPUS	National Home and Garden Pesticide Use Survey
NMC	N-Methyl Carbamate
NMC CRA	N-Methyl Carbamate Cumulative Risk Assessment
OP CRA	Organophosphorus Pesticide Cumulative Risk Assessment
OPP	The EPA's Office of Pesticide Programs
ORETF	Outdoor Residential Exposure Task Force
PCO	Pest Control Operator
PDP	Pesticide Data Program
PoD	Point of Departure
PRZM-EXAMS	Pesticide Root Zone Model- Exposure Analysis Modeling System
REJV	Residential Exposure Joint Venture
RPF	Relative Potency Factor
SAP	Scientific Advisory Panel
SOP	Standard Operating Procedure
TDS	Total Diet Study
TTR	Turf Transferable Residues
UE	Unit Exposure

Table of Contents

I. Introduction 8
II. Background and Overview 11
III. Relative Potency Factors 16
IV. Cumulative Risk From Pesticides in Foods 17
A. Method of Estimation of Cumulative Dietary Risk 17
B. Selection of Oral Relative Potency Factors 17
C. Dietary (Food) Residue Input Data for Dietary Risk Assessment 17
D. Manipulation of Residue Data for Exposure Assessment 18
1. Generation of Cumulative Equivalent Residue ($Residue_{IE}$) 19
a. N-methyl Carbamate Food Residue Database 20
b. Generation of Exposures 21
c. Assumptions 21
E. Food Consumption Data 24
F. Estimation of Acute Exposure Using DEEM-FCID™ Software 24
G. Results 24
H. Characterization of Food Exposure 25
I. Summary 27
V. Cumulative Exposure from Carbamate Pesticides in Drinking Water 64
A. Problem Formulation 64
1. Drinking Water Exposure Estimates Required for the Carbamate Cumulative Assessment 65
2. Nature of Carbamate Exposure in Drinking Water Sources 66
3. Summary 69
B. Analysis Plan 70
1. Estimating Carbamate Exposure in Surface Water Sources of Drinking Water 70
2. Estimating Carbamate Exposure in Ground Water Sources of Drinking Water 72
3. Regional Screening Approach for Drinking Water Exposure Assessment 73
C. Analysis Methods 75
1. N-methyl Carbamate Properties 75
2. Identifying Regional Exposure Scenarios 75
3. Regional Usage 76
4. Surface Water Exposure Assessment 77
5. Ground Water Exposure Assessment 80
D. Carbamate Cumulative Drinking Water Exposures: Case Study Results 81
1. Description of the Regions and Site Assessment Areas 81
2. Estimated Cumulative Distribution in Surface Water 87
3. Estimated Cumulative Distribution in Ground Water 89
E. Characterization of Drinking Water Exposures in the Case Study 89
1. What Each Regional Site Represents 90
2. What the Models Represent 91
3. What the usage information represents 92
VI. Residential NMC Cumulative Risk 94

A. Introduction 94
B. Scope of Regional Assessments 94
C. Residential Scenarios 95
D. Exposure Routes/Scenarios Considered 97
E. Data Sources 98
F. Exposure Scenarios 99
1. Lawn Care Exposure Scenarios 99
a. Lawn Applicator Dermal and Inhalation Exposure 99
b. Lawn Post-application Dermal Exposure 101
c. Lawn Non-Dietary Hand-to-Mouth Behavior Exposure 104
2. Home Garden Applicator and Post Application Exposure Scenarios 107
a. Applicator Exposure 107
b. Post-Application Exposure 108
3. Indoor Crack and Crevice Scenarios 108
a. Applicator Exposure 108
b. Post-Application Exposure 109
4. Pet Use Scenarios 110
a. Post-Application Exposure 110
b. Oral (Hand-to-Mouth) Post-Application Exposure 112
VII. The Multi-Pathway Cumulative Assessment 114
A. Attributes of the Case Study 114
B. Results 115
1. Children, 1-2 years 115
2. Children 3-5 years 116
3. Adults, 20-49 years 117
VIII. Comparison of DEEM/Calendex, Lifeline, and CARES Results 123
A. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure Estimates through the Food Pathway 123
B. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure Estimates through the Water Pathway 128
C. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure Estimates through the Food + Water Pathway 129
IX. Conclusions 130
X. References 133
Appendix 1 139
A.1.1 Overview of Co-occurrence and Aggregate Exposure 139
A.1.2 Residential Exposure Joint Venture (REJV) Data 140
A.1.3 The National Home and Garden Pesticide Use Survey (NHGPUS) & Pest Use Factors (UF) 147
A.1.4 Accounting for Residential Use & Co-occurrence in Models 149
Appendix 2 155
A.2.1 Overview of Lifeline Model 155
A.2.2.a Relative Potency Factors & Conversions for Oral/Inhalation Exposures 159
A.2.2.b Application Rates & Applicator Modifying Factors 159
A.2.2.c Applicator Unit Exposure (CDFs) 163
A.2.2.d Post-Application Oral Modifying Factors (OMF) 165

A.2.3 Lifeline 'Built-In' Distributions 167
A.2.4 Lifeline Tapwater Concentrations 168

List of Tables

Table 1. Summary Information Regarding the NMC pesticides and the Uses, Routes, and Pathways included in the NMC CRA 12
Table 2. Processing Factors Used in Cumulative Dietary Exposure Assessment 29
Table 3. Permissible Crop Translations for Pesticide Monitoring Data 62
Table 4. Summary of Probabilistic Analysis of Distribution of the Cumulative Dietary Exposures In Three Populations from Use of N-methyl carbamate Chemicals on Food Crops 63
Table 5. N-methyl carbamate use patterns and availability of national monitoring data65
Table 6. Summary of carbamate detections in the USGS NAWQA study, 1991-2001 (provisional data published by USGS in 2003). 67
Table 7. Summary of Chemical B detections in ground water monitoring data collected from available ground water monitoring data. 68
Table 8. Regional drinking water exposure sites and dominant carbamate uses. 83
Table 9. Predicted percentile concentrations of individual carbamates and RPF-adjusted cumulative distributions in the surface water scenario sites. 87
Table 10. Specific Exposure Routes and Pathways/Scenarios 97
Table 11. Triangular Distributions Used for Chemical A 100
Table 12. Transfer Coefficients (cm^2/hr) for Dermal Exposure to Lawn Uses for Children 1-6 Years of Age 103
Table 13. Transfer Coefficients (cm^2/hr) for Dermal Exposure to Lawn Uses for Adults 18 Years of Age and Older 104
Table 14. Post-Application Transfer Coefficients for Dermal Exposure to Pet Fur Residues (Empirical Distribution)1 112
Table 15. Estimated Exposures from Food Only (mg/kg) 124
Table 16. Major Food Contributors at Upper Percentile (99.9th) 127
Table 17. Estimated Exposures from Water Only (mg/kg-day) 128
Table 18. Estimated Exposures from Food+Water 129

List of Figures

Figure 1. Carbamate cumulative risk assessment regions for drinking water exposure assessment. 74
Figure 2. Locations of the regional surface water exposure sites for the carbamate cumulative assessment 76
Figure 3. Southeast, Florida, and Mid-south Regions with carbamate usage and location of drinking water exposure sites. 82
Figure 4. Location of surface water intakes in relation to carbamate usage and runoff vulnerability in the southeastern US. 84
Figure 5. Location of high carbamate use areas in relation to predominant ground water sources of drinking water. 85
Figure 6. Estimated cumulative carbamate distribution in surface water at the five regional scenario sites. 88
Figure 7. Seasonal trend in cumulative carbamate concentrations in surface water in the Southeast Region (30 years of weather). Each line represents the time series over a single year. 89
Figure 8. NMC Pesticide Cumulative Assessment Regions 95
Figure 9. Time-based Exposure Profile for Children 1-2 at the 95th Percentile 118
Figure 10. -based Exposure Profile for Children 1-2 at the 99th Percentile 118
Figure 11. -based Exposure Profile for Children 1-2 at the 99.9th Percentile 119
Figure 12. Time-based Exposure Profile for Children 3-5 at the 95th Percentile 119
Figure 13. Time-based Exposure Profile for Children 3-5 at the 99th Percentile 120
Figure 14. Time-based Exposure Profile for Children 3-5 at the 99.9th Percentile 120
Figure 15. Time-based Exposure Profile for Adults 20-49 at the 95th Percentile 121
Figure 16. Time-based Exposure Profile for Adults 20-49 at the 99th Percentile 121
Figure 17. Time-based Exposure Profile for Adults 20-49 at the 99.9th Percentile 122

I. Introduction

The passage of the Food Quality Protection Act (FQPA) in August 1996 led the Office of Pesticide Programs (OPP) to develop methodology to evaluate the risk from exposure to more than one pesticide acting through a common mechanism of toxicity. As defined in FQPA, those pesticides that induce adverse effects by a common mechanism of toxicity must be considered jointly. In other words, the exposures of concern are to include all relevant routes and sources based upon the use patterns of the pesticides in question. This multi-chemical, multi-pathway risk is referred to as cumulative risk.

The Agency's first step in developing a cumulative risk assessment was to develop methodologies and guidance on determining whether two or more chemicals share a common mechanism of toxicity. The reader is referred to the document, *Guidance for Identifying Pesticide Chemicals and Other Substances that Have a Common Mechanism of Toxicity* (1/29/99) for additional information on this topic (see http://www.epa.gov/fedrgstr/EPA-PEST/1999/February/Day-05/6055.pdf). Further guidance on conducting cumulative risk assessment was provided by EPA in 1999 and 2002. *The Guidance on Cumulative Risk Assessment of Pesticide Chemicals That Have a Common Mechanism of Toxicity* (1/14/02, see http://www.epa.gov/pesticides/trac/science/cumulative_guidance.pdf) and its precursor document *General Principles for Performing Aggregate Exposure and Risk Assessments* (10/29/99, see http://www.epa.gov/pesticides/trac/science/aggregate.pdf) describe aspects of the exposure assessment that must be accounted for in developing an integrated cumulative risk assessment. Specifically, these guidance documents state that the cumulative assessment must account for temporal aspects of exposure such as those related to the time of year during which applications resulting in exposures are likely to occur, the frequency of application and period of re-application. In addition, these documents state that the assessment must appropriately consider demographic factors and patterns.

Based in part on the principles and suggested practices contained in the above guidance documents, the first cumulative risk assessment completed by the Agency was for the organophosphorus (OP) class of pesticides. EPA completed a revised cumulative risk assessment for these pesticides in June 2002 (USEPA 2002). In this assessment, OPP developed and demonstrated in detail the methods, parameters, and issues that should be considered in estimating cumulative risk associated with common mechanism pesticides by multiple pathways of exposure. Various aspects of the hazard and dose-response assessment and the exposure analyses were presented to both the SAP and the public for comment numerous times over the course of several years. Both the SAP and the public provided helpful and insightful comments and ideas which were incorporated into the revised documents.

Following completion of the Cumulative Risk Assessment for the OP pesticides and in accordance with the requirements of FQPA, OPP is currently developing a cumulative risk assessment for the N-methyl carbamate (NMC) class of pesticides. The common mechanism determination for the chemicals in this group was based on the shared structural characteristics and similarity and their shared ability to inhibit

acetylcholinesterase (AChE) by carbamylation of the serine hydroxyl group located in the active site of the enzyme. Following maximal inhibition of cholinesterase, recovery typically occurs rapidly (minutes to hours). Subsequent to this determination of the N-methyl carbamate pesticides as a Common Mechanism Group (CMG)[1], EPA announced in a February 4, 2004 Federal Register Notice that the following 10 NMC pesticides would be part of the Common Assessment Group (CAG)[2], and were to be included in an N-methyl carbamate cumulative risk assessment:

- ❑ Aldicarb/Aldoxycarb
- ❑ Carbaryl
- ❑ Carbofuran
- ❑ Formetanate HCl
- ❑ Methiocarb
- ❑ Methomyl
- ❑ Oxamyl
- ❑ Pirimicarb
- ❑ Propoxur
- ❑ Thiodicarb

This CAG will be the second class or grouping of pesticides for which the Agency performs a cumulative risk assessment. These carbamates all display ChE-inhibiting activity, have current active registrations, and are expected to contribute to the carbamate cumulative risk assessment through quantitatively meaningful exposure scenarios.

The present document is a case study which uses the Relative Potency Factor (RPF) approach to perform a cumulative exposure assessment of the N-methyl carbamate CAG. This RPF approach was previously used in the OP CRA in which 24 OP pesticides were evaluated for total cumulative risk. Briefly, the RPF approach involves expressing the sum total of pesticide concentrations in terms of the index chemical by adjusting each component concentrations by that chemical's relative potency. The sum total concentration is expressed in "ppm of index chemical equivalents." This case study uses the same general Relative Potency Factor approach as was used in the OP assessment. In addition, this case study incorporates similar data-use policies and science-based assumptions as was used in the OP assessment to permit evaluation of potential cumulative risk. The case study is presented to help elicit and focus discussion and, as such, is not intended necessarily to reflect any final

---

[1]A Common Mechanism Group (CMG) is a defined as a group of two or more chemicals which display a Common Mechanism of Toxicity. That is, they cause a common toxic effect to human health by the same, or essentially the same, sequence of major biochemical events. A more detailed description of this can be found in the background document to the December 3, 2004 Scientific Advisory Panel and in the document *Guidance for Identifying Pesticide Chemicals and Other Substances that Have a Common Mechanism of Toxicity* (1/29/99)

[2]A Cumulative Assessment Group (CAG) is a subset of the CMG for which the Cumulative Risk Assessment will be performed. This CAG may not include all chemicals grouped by a common mechanism of toxicity since not all chemicals in the CMG should be included in the quantitative cumulative risk assessment due, e.g., to low hazard potential or the existence of only minor exposure scenarios.

regulatory judgments or future regulatory decisions and should be viewed as a first exploratory step in assessing the cumulative risk associated with the NMC class of pesticides. As such, the NMC carbamate pesticide names are coded with letters (A through J) and exposure equivalents (expressed in terms of the index chemical) are provided rather than Margins of Exposure (MOE's). Additional data and refinements will be incorporated prior to release of the preliminary cumulative risk assessment. Future regulatory actions may not reflect the exact combination of data use conventions present in this case study.

The current document is presented in 9 Sections. Section I is this general introduction. Section II presents additional, more detailed background information and briefly reviews some of the basic steps involved in quantitatively assessing the potential human risk associated with the NMC pesticides. The following section, Section III, presents an overview of the Relative Potency Factor method in this assessment. The next three sections (Section IV, V, and VI) focus on each of the major pathways (food, drinking water, and residential, respectively) including a discussion of assumptions, data inputs and inter-relationships of data exposures. Each of these pathways has unique issues relating to availability of data, scale, and interpretation of results. Results of each aspect of the assessment are discussed in each of these sections with particular attention to how they reflect potential exposures to the population and what might be inferred with regard to significant exposure pathways/scenarios. Section VII of the document examines the results of combining estimates of risk from all sources of exposure and further discusses the interpretation of the outputs with respect to identification of the most significant pathways and scenarios. The results in this section were generated by the DEEM/Calendex software. These same analyses were also performed with both LifeLine and CARES software and a comparison of results between the three models are presented in Section VIII of the document. The final section of the document, Section IX, provides summary information, concluding remarks, and next steps. Several Appendices are attached which provide additional details and background material for this case study.

It should be remembered that the cumulative assessment is intended to serve as a pointer toward major sources of risk likely to accrue due to the use of a variety of pesticides with a common mechanism of toxicity, with regulatory decision making based upon the many detailed aspects of the single-chemical, aggregate risk assessment. Because of the coalescing of many data sets into a single assessment, reducing the likelihood of compounding conservative assumptions and over-estimation bias becomes very important in constructing the cumulative risk assessment. As a result, OPP has chosen to work with those data which most closely reflect likely exposures and not to incorporate those data which are inherently conservative by their nature (e.g., field trial data which incorporate maximum application rates and minimum pre-harvest intervals). Specifics relating to these decisions are presented in the next section of this document as well as the individual pathway-specific chapters.

II. Background and Overview

There are a number of steps involved in quantitatively assessing the potential human risk associated with the NMC pesticides. The complex series of evaluations involve hazard and dose response analyses; assessments of food, drinking water, and residential/non-occupational exposures; and risk characterization. These steps have been reviewed and assessed in the previously referenced guidance documents. Several key steps include:

- ❑ Selection of the pesticides, pesticide uses, routes, and pathways from the full common mechanism group of NMCs with exposure and hazard potential to include in the quantitative estimates of risk.

- ❑ Determination of the relative toxic contribution of each NMC; selection of an Index Chemical to use as the point of reference to standardize the toxic potenticies of each NMC; and establishment of a baseline (or reference) value to use to estimate potential risk for the group;

- ❑ Estimation of the risks associated with all pertinent pathways of exposure in a manner that is both realistic and reflective of variability due to differences in location, time, and demographic characteristics of the exposed groups;

Subsequent additional key steps not covered in this case study but which will be covered in the Preliminary Assessment include identification of the specific scenarios which contribute to risk and characterization of the confidence in the results and the uncertainties encountered in the assessment. Each of the above three steps is discussed briefly below:

STEP 1

The first step involves the selection of pesticides, pesticide uses, routes, and pathways which will be included in the NMC CRA. This information is summarized in Table 1 below for the NMC included in this assessment. Additional, more detailed information regarding these selections is provided in each of the subsequent chapters and in the February 4, 2004 Federal Register Notice[3].

[3] See Federal Register dated February 4, 2004 (Volume 69, Number 23 Page 5340-5344

Table 1. Summary Information Regarding the NMC pesticides and the Uses, Routes, and Pathways included in the NMC CRA

Pesticide	Pesticide Uses	Pesticide Pathways			Pesticide Routes		
		Food	Drinking Water	Residential	Oral	Dermal	Inhalation
A	Ag crops	X	X		X		
	Lawn			X	X	X	X
	Garden			X		X	X
	Ornamentals/Trees			X		X	X
	Pet collar			X	X	X	
B	Ag crops	X	X		X		
C	Ag crops	X	X		X		
D	Ag crops	X	X		X		
E	Ag crops	X	X		X		
F	Ag crops	X	X		X		
G	Ag crops	X			X		
	C&C			X	X	X	X
	Pet collars			X	X	X	
H	Ornamental/Trees			X		X	X
I	Ag crops	X	X		X		
J	Ag crops	X			X		

STEP 2

The second step of the process involves selection of an Index Chemical to use as the point of reference to standardize the toxic potencies of each NMC and the subsequent determination of the relative toxic contribution of each NMC. For the N-methyl carbamates, one of these NMC chemicals will be selected as the index chemical and toxic potencies of the remaining chemicals will be assigned relative to this index chemical. Briefly, the RPF approach uses the index chemical as the point of reference for comparing the toxicities of the NMC compounds. Relative potency factors (i.e., the ratio of the toxic potency of a given chemical to that of the index chemical) are used to convert exposures of all chemicals in the group into exposure equivalents of the index chemical

STEP 3

The next step in the process involves estimation of the risks associated with all pertinent pathways, routes and scenarios of exposure in a manner that is realistic, internally consistent, and appropriately reflective of variability due to differences in location, time, and demographic characteristics of the exposed groups. Three key pathways of exposure to NMC pesticides – dietary pathways of food and drinking water and the non-dietary pathway from exposure in residential and other non-occupational settings—were included in this assessment; critically important in a cumulative risk assessment is the estimation of the combined (or cumulative) risks associated with joint exposures via all three routes (oral, dermal, and inhalation) in a manner which is consistently calculated and considers these exposures in a probabilistic manner to avoid compounding conservatisms. Evaluation of chemical use profiles (through scenario-building exercises) is an important component of this step and allows for the identification of exposure scenarios that may overlap, co-occur, or vary between chemicals as well as

for the identification of populations of concern. Each of these pathways is discussed briefly below with an emphasis placed on important overarching decisions and summary points regarding the scope of the assessment for this case study. More detailed discussion is presented in each of the three topic sections (food, drinking water, and residential):

Food

The cumulative assessment considers the food contribution of each of the 10 N-methyl carbamates as they occur in PDP data and in PDP-translated data[4]. The food component of the NMC cumulative risk assessment is considered to be highly refined because it is based on residue monitoring data from the USDA's Pesticide Data Program In addition, the food component of the assessment incorporates actual consumption data from USDA's Continuing Survey of Food Intake by Individuals (CSFII), 1994-96/1998. In this survey, 20,607 individual participants were interviewed over two non-consecutive days. The data were supplemented by the 1998 survey of 5,559 additional children from birth through 9 years of age. The CSFII provides a detailed representation of the food consumption patterns of the U.S. population across all age groups, during all times of the year, and across the 50 states.

The PDP data provide a very reliable estimate of pesticide residues in the major children's foods. They also provide direct measures of co-occurrence in foods that are monitored in the program. Only those foods that were directly monitored by PDP or translated from those that were directly monitored by PDP. No attempt was made to adapt field trial data for use in the assessment because the samples reflect highest label rates, shortest allowable pre-harvest interval and are taken at the farm gate. PDP implicitly reflects actual application rates, time in the chain of commerce, proportion of the crop imported, and proportion of the crop treated. In addition, PDP was specifically designed to emphasize in their sampling program foods disproportionately consumed by children. This is the same methodology and data source as was used in the OP Cumulative Risk Assessment

PDP samples with non-detectable residues were included in this assessment as "zero" values.[5] In addition, only residue data from composite samples were utilized in this assessment. For those foods not monitored by PDP, similar commodities that are measured by PDP served as surrogate data sources. This approach is considered to be reasonable and generally sound given that it is based on the concept that families of commodities with similar cultural practices and insect pests are likely to have similar pesticide use patterns and residue levels. This was the same methodology as was used in the OP Cumulative Risk Assessment.

---

[4]The preliminary cumulative risk assessment will additionally include or consider FDA monitoring data, FDA Total Diet Study data, and/or market basket data, where appropriate. OPP's experience with the OP CRA suggests that inclusion of this additional data will not markedly change the results that are generated using only PDP and PDP-translated data.

[5]The alternative approach of assigning values for non-detectable residues (for example, ½ LOD) is believed to have only negligible impart at the upper percentiles of exposure. This assumption will be tested in the expected of the Preliminary NMC Cumulative Risk Assessment this summer.

Drinking Water

The drinking water exposure component of this case study is based on PRZM-EXAMS modeling of a SE portion of North Carolina and, for purposes of this case study, considers only exposures through surface water.[6] This area is meant to be representative of SE region of U.S.[7] The geographic scale was limited to reflect a coherent area likely to have common pesticide use patterns based upon pest pressure and climate. This limitation is important in that OPP is assuming that potential water residues within this area reflect a constant pattern of use both in the urban and agricultural setting. Similarly, OPP is assuming that this geographic area is sufficiently restricted such that residential uses of pesticides will reflect common pest pressure with similar climatic conditions such that the outcome of the assessment should be relevant across the entire area. This modeling represents OPP's state of the art approach to estimating drinking water concentrations because it is based on probabilistic modeling that considered the full range of data and not a single high-end estimate. The analyses conducted here used the weighted sum (accounting for the Relative Potency Factors) of the estimated concentrations for each pesticide to produce an estimated total concentration (expressed in index-chemical equivalents). The estimated residues in water represent typical pesticide uses and reflect seasonal variations in cropping and NMC uses. The contribution to exposure from water was limited to surface water exposures (as generated by PRZM-EXAMS) to those N-methyl carbamates used in the geographic region of interest; potential contributions from ground water sources were not included in this Case Study, but – as appropriate – will be included in the Preliminary N-methyl carbamate cumulative risk assessment.[8] The assessment focuses on areas in this region where combined NMC exposure is likely to be the highest in the region as a result of total NMC usage, each NMC's relative toxicity, and vulnerability of drinking water sources. They are considered representative of exposures from typical NMC usage in one of the more vulnerable surface watersheds in this region.

It is not known to what degree the pesticides of interest actually co-occurred in drinking water sources and the analysis here attempted to account for these co-occurrences by using use and usage data from a variety of sources (NASS, Doane's, etc.). The co-occurrence of NMC residues in water is primarily estimated from modeling based on local use/usage information specific to the southeast portion of North Carolina. Monitoring data are not available consistently enough to be the sole basis for the assessment, but are (and will be) used to corroborate to the degree possible the modeling results.

---

[6]The SAP is being asked during Session 3 to review and comment upon issues associated with ground water. In the preliminary cumulative risk assessment consideration will be given to both surface and ground water sources of drinking water.

[7]The preliminary cumulative risk assessment for the NMC CAG will be performed for each region,

[8] Day 3 of the February 2005 SAP meeting is reserved for considering these drinking water issues. EFED will be addressing a number of issues – including the appropriate ground water models – in this SAP.

Residential

The residential component of the assessment reflects indoor crack and crevice, lawn care, home garden, and pet collar uses for the three NMCs that have these registered residential uses and are used in the SE region of the U.S. These exposure scenarios may result in potential exposure via the oral (via hand-to-mouth activity in children), dermal, and inhalation routes. The assessment incorporates and reflects seasonal variations in pesticide use patterns and opportunities for exposure specific to and consistent with that region, and is based on a probabilistic approach in which a number of data sources (e.g., REJV (Residential Exposure Joint Venture, NHGPUS (National Home and Garden Pesticide Use Survey), as well as label use information and professional judgment) were used to define how pesticides are used, how quickly they dissipate, how people may come into contact with pesticides, and the length of time people might be exposed based on certain activities (e.g., playing on a treated lawn).

III. Relative Potency Factors

A key component of the cumulative hazard assessment is to select an endpoint pertinent to the common mechanism of toxicity that can be used to quantify cumulative risk. *N*-methyl-carbamates exert their neurotoxicity by inhibiting acetylcholinesterase (AChE) by carbamylation of the serine hydroxyl group located in the active site of the enzyme. Following inhibition, recovery occurs rapidly. As described in the guidance document for cumulative risk assessment (USEPA, 2002), comparisons of toxic potency should be made using a uniform basis of comparison, by using to the extent possible a common response, species, and sex for all the exposure routes of interest. Humans may be exposed to the *N*-methyl-carbamates through food, drinking water, and in and around residences. Therefore, the potency of *N*-methyl-carbamates needs to be determined for the oral, dermal, and inhalation routes of exposure.

As rat is most commonly used species in toxicology studies with the N-methyl-carbamate pesticides and peak AChE inhibition is the effect of interest, acute neurotoxicity studies in the rat provide the most appropriate dataset. Cholinesterase inhibition in the blood and brain compartments are typically measured in toxicology studies submitted to the EPA for pesticide registration. Data from male and female rats have been collected. Data was extracted from oral acute studies for all the *N*-methyl-carbamates. Any available dermal and/or inhalation data were extracted for those pesticides with residential exposures.

To determine relative potency, a chemical from the NMC compounds is first selected to serve as the index chemical. Then, the relative potency factor (RPF) for a specific chemical is calculated by dividing the common toxicity endpoint for the specific chemical of interest by common toxicity endpoint of the index chemical.

The cumulative risk assessment guidance document states that the index chemical should be selected based on the availability of high quality dose-response data for the common mechanism endpoint and that it acts toxicologically similar to other members of the common mechanism group. A point of departure (PoD) is a point estimate on the index chemical's dose-response curve that is used to extrapolate risk to the exposure levels anticipated in the human population. Thus, any error or uncertainty in an index chemical's PoD value will be carried forward in the cumulative risk estimates. For the cholinesterase-inhibiting *N*-methyl-carbamate pesticides, the ideal index chemical should exhibit high quality dose-response data in blood and brain for both sexes of a single species for all exposure routes of interest. Dose-response modeling is preferred over the use of NOAEL/LOAELs (i.e., no or low observed adverse effect levels) for determining relative potency and calculating PoDs. NOAELs and LOAELs do not necessarily reflect the relationship between dose and response for a given chemical, nor do they reflect a uniform response across different chemicals.

During Session 1 of the February 15-18, 2005 SAP meeting, EPA will present its proposed empirical dose-response modeling procedure to the SAP. In the event that revisions are necessary, RPFs and PoDs are not provided in the current case study.

IV. Cumulative Risk From Pesticides in Foods

The exposure assumptions for these assessments, which are described in the following discussion, are similar to those that were used for the OP CRA. These assessments are intended as a conceptual basis for deliberations and are not to be interpreted as representing the Agency's recommended procedure for conducting cumulative assessments or as demonstrating a dietary risk assessment intended for regulatory purposes.

A. Method of Estimation of Cumulative Dietary Risk

Dietary exposure was estimated using the Dietary Exposure Evaluation Model software and incorporating the Food Commodity Intake Database (DEEM-FCID™). A joint distributional analysis was conducted by combining representative data on concentrations of 10 N-methyl carbamate pesticides on foods with distributions of anticipated consumption of these foods by different segments of the U.S. population. The primary advantage of a joint distribution analysis is that the results are in the form of a simultaneous analysis (i.e., a distribution) of exposures that demonstrate both best-case and worst-case scenarios of exposure.

B. Selection of Oral Relative Potency Factors

Ten chemicals were included in this N-methyl carbamate cumulative assessment group. These chemicals were selected based on their occurrence in the PDP monitoring data collected between the years 1994 and 2002. Exposure estimates provided in Section VII of this document are RPF-adjusted (i.e., expressed in mg/kg of index –chemical equivalents).

C. Dietary (Food) Residue Input Data for Dietary Risk Assessment

Anticipated concentrations of Chemicals A through J in foods were based on residue monitoring data collected by the PDP. These data are available for downloading from the PDP internet site (http://www.ams.usda.gov/science/pdp/). For this case study we used data collected from 1994 through 2002. The selection of commodities and chemicals analyzed by PDP varies from one year to the next but most of the N-methyl carbamate pesticides of concern were analyzed throughout this period and the foods selected for analysis generally reflect high consumption items for children. Data from other sources were also used in the OP Cumulative Risk Assessment. These include FDA monitoring data and the FDA Total Diet Study. In the case of the OP Cumulative Risk Assessment, greater than 95% of the anticipated dietary consumption of foods by children was covered by these sources of residue data with the PDP data accounting for greater than 85% of the anticipated consumption. We intend to consider these other sources of data for the Preliminary N-methyl Carbamate Risk Assessment and include a similar analysis of the proportion of food consumption by children covered by available residue sources. It is anticipated

that the coverage for carbamates will be as complete, if not more so, than for the coverage of the OPs.

The analyses of N-methyl carbamates by PDP are summarized on their web site. The 65 food forms in the PDP data with analytical data between 1994 and 2002 were used as the source of residue data for their matching food forms in the DEEM-FCID software (CSFII consumption data). Food processing factors were applied to specific chemical/commodity pairs to extend these data for use on cooked and processed food/food forms in the analysis. Table 2 shows the food forms of commodities monitored by PDP included in the food exposure assessment along with chemical specific processing factors to translate these residue values to food forms not included in PDP. The factors are intended to adjust residues in foods for changes that can occur in food preparation procedures such as cooking, canning, curing, and drying. Processing factors are based on the submitted processing studies, published data, or logical calculations in the absence of submitted studies (e.g., estimates based on loss of water in drying fruits). The absence of a processing factor in Table 2 indicates that either no residues were detected in that chemical/food form combination or there is no registered use for that chemical/food form combination.

As was done with the OP pesticides in the OP CRA, the PDP residue data were further extended to other commodities identified as reasonable for translation of pesticide residue data per OPP/HED SOP 99.3 (USEPA, 1999); see Table 4.

D. Manipulation of Residue Data for Exposure Assessment

Commonly, the following equation is used for estimating exposure and risk from a single chemical:

- Exposure = Residue X Consumption

In the case of cumulative exposure assessment, the residue term in the first equation is changed to Index Equivalent Residue.

The calculated cumulative residue is a simple arithmetic addition of residues of different chemicals that have different toxicities (potency) and therefore simple addition of their residues is not appropriate. For that reason, the amount of residue of each chemical is adjusted by multiplying by a ***Relative Potency Factor (RPF)*** to get the equivalent residue of an index chemical. This new calculated residue is termed ***Index Equivalent Residue (Residue$_{IE}$)*** and the exposure value resulting from combining Residue$_{IE}$ and consumption is termed ***Index Equivalent Exposure (Exposure$_{IE}$)***. The new central equation for exposure will then become:

$$\text{Exposure}_{IE} = \text{Residue}_{IE} \text{ X Consumption}$$

The following discussion explains in more detail how this was accomplished for this case study.

1. Generation of Cumulative Equivalent Residue ($Residue_{IE}$)

To determine a given one-day cumulative oral exposure to multiple N-methyl carbamate chemicals, first an Index Equivalent Residue ($Residue_{IE}$) for each residue value is calculated. On a given PDP sample, each residue value is multiplied by any applicable processing factor (PF) for that chemical on the food sample of interest and the Relative Potency Factor (RPF) for the same chemical to express it as an $Residue_{IE}$ for that chemical; this is step 1.

Step 1: $\mathbf{Residue_{IE}\ (per\ chemical\ n) = Residue\ X\ PF_n\ X\ RPF_n}$

The cumulative $Residue_{IE}$ for all chemicals detected on one PDP sample will then be the sum of all the $Residue_{IE}$ for all the chemicals on that sample; this is step 2.

Step 2: $\mathbf{Cumulative\ Residue_{IE} = \sum Residue_{IE}}$ (per PDP sample)

For example, given 100 samples of apples and 10 N-methyl carbamates, there will be generated 10 $Residue_{IE}$ values for each sample; hence a total of 100 * 10 = 1000 $Residue_{IE}$ values from step 1. In step 2, each set of 10 $Residue_{IE}$ for a sample is summed to generate a cumulative $Residue_{IE}$ per one sample; hence 100 cumulative $Residue_{IE}$ points for 100 samples of apples are generated.

By summing on a sample-by-sample basis, the potential for capturing any co-occurrence on the same commodity is enhanced. Another very important advantage of this approach is that, using appropriate record keeping (see next section), the complete history of each cumulative residue value in the exposure assessment can be potentially traced back to its origins. All of the sample collection and analytical information associated with a given PDP sample and all arithmetic adjustments incorporated in producing a $Residue_{IE}$ can be traced in the process of sensitivity analysis or critical food commodity contribution analysis.

a. N-methyl Carbamate Food Residue Database

The data manipulations necessary to prepare the PDP residue data for input into the risk equation are in principle very simple; however, the task of performing these calculations for multiple chemicals and food commodities is problematic. The residue data used in this case study consist of over 583,000 records of analytical data and sample information. The processing factors account for several thousand additional records of information. For this reason, and in anticipation of the need to make multiple uses of the data, to keep track of them, and work backward from the cumulative assessment results to determine contributors, all the data manipulation were conducted using relational database techniques. The N-methyl Carbamate food residue database is based on the same design as the one used for the OP Cumulative Risk Assessment. The database consists of, among other things, four major data tables:

1 Residue data table: over 583,000 records containing essentially all of PDP sample and analyses data for N-methyl carbamate pesticides for the years 1994-2002.

2 Processing factor data table: containing all relevant processing factors for specific food form/chemical combinations. (Table 2 in this document is extracted from these data).

3 RPF Table: containing the relative potency factors for all chemicals of interest.

4 Translation Table: providing bridging links between PDP commodity codes, such as *AP*, and all corresponding DEEM-FCID food forms, such as *Apple, fruit with peel; Uncooked; Fresh or N/S; Cook Meth N/S*. This table allows the assignments of translation of data between PDP commodities also, such as cantaloupe data to watermelon food forms

These four tables are linked through common fields, including pesticide codes and commodity codes. Calculation queries are coded into the database so that all the pertinent PDP samples records can be extracted, each calculation outlined above can be performed, and the results can be sorted and output in various formats for further analysis.

A cumulative residue calculation query performs the two-step process described earlier, extracting the various parameters needed from the four tables described above. The calculation is

performed on all of the food samples that are of interest and the results are compiled in text files containing the cumulative distributions for each food commodity of interest.

Each text file contains a header with sample information (number of values, number of detects, number of zeros, average of residues) and all of the cumulative residue values for a single food form, sorted in descending order.

By maintaining all of the calculation inputs in separate tables in the database, it is possible to repeat the above process with new inputs by simply replacing or adding data to the appropriate table. For example a specific chemical can be omitted from the entire process by assigning it a value of zero in the RPF table. Specific chemical/commodity combinations can be selectively omitted by entering a zero value for that pair in the processing factor table.

b. Generation of Exposures

The cumulative $Residue_{IE}$ values (text files described in the previous section) are treated as distributions of representative residues and linked to all appropriate food forms; cumulative residue values are then randomly picked and combined with a consumption record to generate a single exposure value which is termed $Exposure_{IE}$. This process (Monte Carlo in nature and conducted by DEEM-FCID software) is repeated many times per each consumption record to generate a distribution of exposure values. This process has been described in public documents and proceedings of the FIFRA Science Advisory Panel (*HTTP://www.epa.gov/oscpmont/sap/2000/#february*).

c. Assumptions

The assumptions in this cumulative assessment case study, which are summarized below, are essentially identical to those used for the OP Cumulative Risk Assessment.

The input residue data were drawn from the PDP data base. The PDP program tests different commodities for various pesticides in 10 states throughout U.S. The residue data of 1994 to 2002 were used in this assessment. The following assumptions were made in the process:

1) Although PDP has started single-unit sampling for limited crops (apples and pears) since 1998, only the residue data from composite samples were utilized in this assessment for the sake of simplicity. A single composite sample may contain several individual serving of some foods; it is

implicitly assumed that all these single servings in a composite sample have residues no more or less than the composite residue (average value). For purposes of the present example, it is assumed that residues reported on composite homogenates adequately reflect the residues in any given single serving contained in that homogenate. Therefore, no attempt was made to "decomposite" residue values to simulate residues that might be present in the single servings contained in the PDP composite sample.

2) Although PDP uses multi-residue methods to simultaneously analyze various pesticides on a crop sample, occasionally, for various reasons, there are no entries for some pesticides on some samples. In such instances, it was assumed that those pesticides with no entries had zero residues.

3) All residue analyses are subject to the limitations of the sensitivity of the analytical methods. Many of the samples analyzed are reported as being below the limit of reliable detection of the analytical method. It is usual practice in Agency assessments to assume that residues in non-detectable samples are present at ½ the limit of detection (LOD) of the analytical method in samples that were potentially harvested from treated fields. Thus, for purposes of estimating residues in samples reported as <LOD, a proportion of the samples equal to the estimated percent crop treated is assigned a residue level of ½ LOD and the remaining samples, which are assumed to come from untreated crops, are assigned a residue value of zero. This procedure becomes problematic for a cumulative assessment. It is not enough to simply estimate the percent crop treated for each of the pesticides in the cumulative assessment; it is also important to consider the potential for co-occurrence of residues of multiple residues on the same crop. A strength of the present example is that it accounts for co-occurrences in single samples if they are detectable. In the case of the OP pesticides we assessed the impact of incorporating ½ the LOD for non-detects in the cumulative assessment. The food portion of the OP assessment was conducted using the two extreme default assumptions: all non-detects = 0, and all non-detects = ½ LOD for the chemical with the greatest number of detectable residue findings. The most prevalent detected chemical was chosen because it is reasonable to assume that chemical would also have the greatest number of residues below the limit of detection. The result of this comparison confirmed that the assumption of zero values for all non-detects did not significantly impact on the results at the higher end of the

cumulative exposure distributions. It is our judgment that similar results will be found in the case of the N-methyl carbamates although we have not tested this at this time; such testing is anticipated to be performed for the preliminary assessment to be released in the spring of 2005.

4) The sample-by-sample method of summing of residues relied on the PDP sampling procedures to adequately capture the temporal and geographic variations in uses of pesticides. This procedure recognizes that the PDP sampling protocols are designed in such a way as to reflect the foods available to the public for consumption in different regions of the country and throughout the year.

5) This assessment uses residue data collected over a nine year period, 1994 through 2002. The primary reason for this is to maximize the number of food commodities in the assessment but this raises issues of lack of co-occurrence. Co-occurrence in the food is important from the standpoint of all the food consumed in the same time period. It is not readily obvious if it is appropriate to model exposure based on bananas grown in 1994 and apples grown in 1998. A related choice in selection of residue data was to include all available data for a given commodity from this time period. This includes data sets that span a time period of at least one year to 4 years data. Future assessments could readily restrict these data to the most recent one or two years.

6) In chemical specific dietary exposure assessments the Agency routinely translates residue data from one food commodity to related ones if the pesticide use patterns are similar on these commodities (HED SOP 99.3, Margaret Stasikowski, 3/26/99). For example, data on cantaloupes is often used as surrogate data for watermelons and other melons. For a cumulative assessment, in which a grower has a choice of several chemicals from the cumulative assessment group, these translations of data become more difficult to make. In the current case study, translations of the residue data were made using the surrogation scheme in HED SOP 99.3 in order to ensure representation of the maximum number of commodities possible. The cross walk between crops is presented in Table 3.

E. Food Consumption Data

For this assessment food consumption is being modeled on the USDA CSFII, 1994 to 1998. The consumption survey is included as an integral component of the DEEM-FCID software. The CSFII 1994-1998 contains survey data on 20,607 participants interviewed over two discontinuous days. It contains a supplemental children's survey conducted in 1998 in which an additional 5,459 children, birth through 9 years old, were added to the survey.

DEEM-FCID™ also has integrated new USDA/EPA recipes for conversion of foods reported eaten in the survey to food commodities on which residue data are available. These recipes, which are available to the public, replace proprietary recipes used in previous versions of DEEM.

In this case study separate assessments were conducted on three segments of the population as represented in the CSFII 1994-1998. The current assessment reports on children one to two years old, children three to five years old and all adults between the ages of twenty and forty-nine.

F. Estimation of Acute Exposure Using DEEM-FCID™ Software

Residue distribution files, or average residue values for highly blended commodities, were input in the DEEM-FCID™ software for a Monte Carlo analysis.

The Monte Carlo analysis was conducted by an iterative process of multiplication of residue concentrations on foods, expressed in index chemical equivalents, by one-day consumption of these foods, as reported by all individuals in CSFII. This process used all individuals reporting in the consumption survey for both days of the survey and the exposures were calculated as mg/kg body wt/day.

The use of DEEM for dietary exposure analysis has been described in the presentation of our previous dietary assessments of the OP pesticides to the panel. The detailed functioning of the program has also been described in a previous SAP presentation (*Dietary Exposure Evaluation Model (DEEM™) and DEEM™ Decompositing Procedure and Software*) available on the previously referenced FIFRA Scientific Advisory Panel website.

G. Results

Table 4 summarizes the results of a cumulative dietary exposure assessment for N-methyl carbamates on food commodities. Exposures are presented for three age groups: Adults 20-49 years, children 1-2 years, and children 3 -5 years. The summary results are provided for three points in the distribution of exposures estimated, i.e., at the 95th percentile, 99th percentile, and 99.9th percentile of exposure. These exposure values are expressed in terms of index-chemical equivalents.

H. Characterization of Food Exposure

OPP's cumulative guidance document describes the importance of timeframes of exposure (e.g., When does exposure occur? What is the exposure duration?) the toxic effect (e.g., What are the time to peak effects and the time to recovery? How quickly is the effect reversed?) when developing cumulative assessments (USEPA, 2002). Since recovery from AChE inhibition caused by the N-methyl carbamates is relatively rapid (within minutes to hours), it may be important to consider the intra-day timing of exposure events. For example, if the exposure events within a day are distributed sufficiently far apart in time so that significant recovery of AChE activity occurs between any two exposure events, then summing of these exposure events over an entire 24 hour period may not be appropriate and may overestimate the potential risk of the chemical. Ideally, a sophisticated model such a PBPK/PD model could be used to account for the dynamic nature of exposure and rapid recovery of AChE inhibition. However, the tools and data necessary to perform such an analysis are not yet available to EPA for performing a cumulative risk assessment. It is, however, still important to characterize, to the extent possible, the timing of anticipated exposures to N-methyl carbamates. The following text describes an approach for characterizing exposures from food only. EPA is soliciting comment from the SAP on conceptual and specific aspects of this approach. As EPA continues to develop its cumulative risk assessment, similar analyses may be appropriate for the water and/or residential pathways.

The DEEM/Calendex, Lifeline, and CARES models all use FCID to estimate food consumption. This database is derived from the CSFII survey data. The records in the CSFII capture detailed information not only about the identity and amount of foods consumed, but also about the timing of each eating occasion within a 24 hour period. However, when used in the DEEM/Calendex, Lifeline, and CARES models, food exposures are summed over a 24-hour period and thus reflect daily (24 hour) exposures. To the extent that a day's eating occasions leading to high total daily exposure are close together in time such that minimal AChE recovery occurs between eating occasions (i.e., exposure events), the approach used in this case study which sums eating events over a 24 hour period provides reasonable estimates of risk. To the extent that eating occasions leading to high total daily exposures are widely separated in time such that substantial AChE recovery occurs between eating occasions, the estimated risks under the approach used in this case study may be overstated and a more sophisticated approach that accounts for intra-day eating patterns, and the recovery of AChE between exposure events, might be more appropriate.

OPP has begun an examination of the exposure patterns for records that lie at the high end of exposure distribution. This is an attempt at determining the degree to which high-end exposures in the NMC CRA can be attributed to specific eating occasions (within a day) that occur either closely spaced in time or widely separated by time by looking at actual individual eating occasions as recorded in the CSFII daily diaries. For each Monte Carlo run conducted with DEEM, it is possible to save a portion of the exposure records from any desired

high end portion of the exposure distribution (e.g, 99 to 100th percentile). Each high-end exposure record contains, among other things, the identification of the specific individual in the CSFII that was drawn and the FCID food commodities reported eaten by that individual containing residues of the chemical(s) being assessed. The FCID database files include a recipe file that can be used to relate these food commodities (for example, wheat flour) to a food that might be reported as eaten in the CSFII survey (for example a slice of bread). Therefore, it is possible to link one of these DEEM output records with the CSFII and determine what the individual reported eating in that day that contained the food commodity listed in the DEEM (FCID) exposure record. Since the CSFII contains the reported eating occasions for that person by time of day it is possible to determine if a given DEEM exposure record was the result of one or more eating events and the reported time of day for those eating events.

A systematic analysis of daily exposure records is planned for the preliminary NMC CRA. The initial investigation described below is part of the case study being presented during the last session of the SAP meeting. This following text is designed to provide background material to the SAP panel to comment on the concepts, approach, and any preliminary conclusions. Activities and observations made to date with this case study can be summarized as follows:

1. A DEEM CEC (critical exposure commodity) report was collected from a Monte Carlo run conducted for children 3-5 years old. This report summarizes and saves individual exposure records falling in a user-selected percentile range at the upper end of the exposure distribution. At this point, a number of individual records have been selected from the interval of 99.5th percentile to the 100th percentile of the distribution.

2. EPA initially examined 65 records: the top 44 daily exposure records in the distribution along with 21 more records drawn at equally spaced intervals across the range from the 100th down to the 99.95th percentiles. This examination indicated that:

   - ❑ 64% of these high end exposure records were associated with only one eating occasion within the day
   - ❑ 31% percent of the daily records represented the sum of 2 eating occasions
   - ❑ 5 percent were due to 3 eating occasions
   - ❑ 1 record had 4 eating occasions
   - ❑ No records were found with more than 4 eating occasions on a given day.

These records represent the top 0.05% of the records (i.e., 99.95th to 100th percentiles). These results suggest that a significant fraction of the records associated with the highest exposures are due to a single eating occasion.

In order to determine if these patterns continue into a range of eating records representing lower (but still high) exposures, a second set of daily consumption records from the CSFII was examined. Specifically, another 37 records were selected from the interval representing individuals between the 99.5th percentile and the 99.51th percentile of the distribution. In this interval, a similar daily eating pattern was observed:

- 68% were the result of single eating occasions within a day
- 24% represented two eating occasions within a day
- 8% represented three eating occasions
- No records were found with 4 or more eating occasions on a given day
- In those cases where the daily record represented two or three eating occasions, the median time between eating occasions was 4.5 hours, and ranged from a minimum time of 1 hour and the maximum time of 12¼ hours

These observations are subject to confirmation through a more systematic analysis for the preliminary NMC CRA. However, assuming that subsequent, more detailed and extensive analyses provide confirmation of these preliminary observations and analyses, OPP believes that the sizable fraction (i.e., > ca. 2/3) of daily records contributing to the upper tail of the food exposure distribution represent single eating occasions. For those records where exposure to N-methyl carbamates occurs at a single eating occasion, the approach for estimating food exposure used in this case study is appropriate. Moreover, as the number of records with eating events of 3 or more make up a small fraction of high end exposure records, summing food exposures over a 24 hour period is not likely to grossly overestimate the cumulative risk to the food pathway. It is unlikely that a more sophisticated, temporal-based approach which better accounts for temporal separation of eating/exposure events will result in substantial changes in OPP's risk estimates.

I. Summary

The cumulative dietary exposure due to the use of N-methyl carbamate chemicals on food crops was assessed using residue monitoring data collected by PDP. One of the NMC pesticides was selected as the index chemical and the residue values for the other N-methyl carbamate chemicals were converted to index chemical equivalents by the Relative Potency Factor method. Residue data were collected on approximately 65 food commodities monitored by PDP

between the years of 1994 and 2002. Food processing factors were applied to specific chemical/commodity pairs to extend these data for use on more food forms. The PDP residue data were further extended to other commodities identified as reasonable for surrogation of pesticide residue data per HED SOP 99.3

The residue data were compiled as distributions of cumulative residues of index chemical equivalents that were, after adjustment for processing, summed on a sample-by-sample basis. These residue distributions were combined with a distribution of daily food consumption values *via* a probabilistic procedure to produce a distribution of potential exposures for three subpopulations in the CSFII (children 1-2, children 3-5, and adults 20-49 years). The results of this assessment are shown in Table 4.

Table 2. Processing Factors Used in Cumulative Dietary Exposure Assessment

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Apple, dried	Cooked; Dried; Cook Meth N/S	2.58		1	1	1			1		
	Cooked; Fresh or N/S; Baked	2.58		1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	2.58		1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	2.58		1	1	1			1		
Apple, dried – babyfood	Cooked; Dried; Cook Meth N/S	2.58		1	1	1			1		
Apple, fruit with peel	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Cooked; Fresh or N/S; Fried	1		1	1	1			1		
	Uncooked; Cured etc; Cook Meth N/S	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
Apple, juice	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Dried; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1		1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Fried	1		1	1	1			1		
	Cooked; Fresh or N/S; Fried/baked	1		1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1		1	1	1			1		
Apple, juice – babyfood	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Dried; Cook Meth N/S	1		1	1	1			1		
Apple, peeled fruit	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Dried; Boiled	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Fried	1		1	1	1			1		
	Cooked; Frozen; Baked	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
Apple, peeled fruit- babyfood	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
Apple, sauce	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1		1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Cooked; Frozen; Baked	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Apple, sauce – babyfood	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
Apricot	Cooked; Canned; Cook Meth N/S	1							1		
	Cooked; Dried; Boiled	1							1		
	Cooked; Fresh or N/S; Baked	1							1		
	Cooked; Fresh or N/S; Fried	1							1		
	Cooked; Frozen; Baked	1							1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1							1		
Apricot- babyfood	Cooked; Canned; Cook Meth N/S	1							1		
Apricot, dried	Cooked; Fresh or N/S; Baked	1							1		
	Uncooked; Dried; Cook Meth N/S	1							1		
Apricot, juice	Cooked; Canned; Cook Meth N/S	1							1		
	Cooked; Frozen; Baked	1							1		
	Uncooked; Dried; Cook Meth N/S	1							1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1							1		
	Uncooked; Frozen; Cook Meth N/S	1							1		
Apricot, juice- babyfood	Cooked; Canned; Cook Meth N/S	1							1		
Arugula	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Asparagus	Cooked; Canned; Boiled	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Boiled	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Banana	Cooked; Canned; Cook Meth N/S			1			1		1		
	Cooked; Fresh or N/S; Baked			1			1		1		
	Cooked; Fresh or N/S; Boiled			1			1		1		
	Cooked; Fresh or N/S; Fried			1			1		1		
	Cooked; Frozen; Fried			1			1		1		
	Uncooked; Dried; Cook Meth N/S			1			1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S			1			1		1		
	Uncooked; Frozen; Cook Meth N/S			1			1		1		
Banana- babyfood	Cooked; Canned; Cook Meth N/S			1			1		1		
	Cooked; Dried; Cook Meth N/S			1			1		1		
	Cooked; Fresh or N/S; Baked			1			1		1		
Banana, dried	Cooked; Dried; Cook Meth N/S			1			1		1		
	Cooked; Fresh or N/S; Baked			1			1		1		
	Uncooked; Dried; Cook Meth N/S			1			1		1		
Banana, dried- babyfood	Cooked; Dried; Cook Meth N/S			1			1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Barley, bran	Cooked; Dried; Boiled					1	1		1		
	Cooked; Dried; Cook Meth N/S					1	1		1		
	Cooked; Fresh or N/S; Baked					1	1		1		
Barley, flour	Cooked; Canned; Cook Meth N/S					1	1		1		
	Cooked; Dried; Baked					1	1		1		
	Cooked; Dried; Boiled					1	1		1		
	Cooked; Dried; Cook Meth N/S					1	1		1		
	Cooked; Dried; Fried					1	1		1		
	Cooked; Fresh or N/S; Baked					1	1		1		
	Cooked; Fresh or N/S; Boiled					1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S					1	1		1		
	Cooked; Fresh or N/S; Fried					1	1		1		
	Cooked; Fresh or N/S; Fried/baked					1	1		1		
	Cooked; Frozen; Cook Meth N/S					1	1		1		
	Uncooked; Dried; Cook Meth N/S					1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S					1	1		1		
	Uncooked; Frozen; Cook Meth N/S					1	1		1		
Barley, flour- babyfood	Cooked; Canned; Cook Meth N/S					1	1		1		
	Cooked; Dried; Baked					1	1		1		
	Cooked; Dried; Cook Meth N/S					1	1		1		
	Cooked; Fresh or N/S; Baked					1	1		1		
Barley, pearled barley	Cooked; Canned; Boiled					1	1		1		
	Cooked; Canned; Cook Meth N/S					1	1		1		
	Cooked; Dried; Baked					1	1		1		
	Cooked; Dried; Boiled					1	1		1		
	Cooked; Dried; Cook Meth N/S					1	1		1		
	Cooked; Fresh or N/S; Baked					1	1		1		
	Cooked; Fresh or N/S; Boiled					1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S					1	1		1		
	Cooked; Frozen; Baked					1	1		1		
Barley, pearled barley- babyfood	Cooked; Canned; Cook Meth N/S					1	1		1		
Bean, lima, succulent	Cooked; Canned; Boiled					1			1		
	Cooked; Canned; Cook Meth N/S					1			1		
	Cooked; Fresh or N/S; Boiled					1			1		
	Cooked; Fresh or N/S; Cook Meth N/S					1			1		
	Cooked; Fresh or N/S; Fried					1			1		
	Cooked; Frozen; Baked					1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Frozen; Boiled					1			1		
Bean, snap, succulent	Cooked; Canned; Boiled					1			1		
	Cooked; Canned; Cook Meth N/S					1			1		
	Cooked; Dried; Boiled					1			1		
	Cooked; Fresh or N/S; Baked					1			1		
	Cooked; Fresh or N/S; Boiled					1			1		
	Cooked; Fresh or N/S; Boiled/baked					1			1		
	Cooked; Fresh or N/S; Cook Meth N/S					1			1		
	Cooked; Fresh or N/S; Fried					1			1		
	Cooked; Frozen; Baked					1			1		
	Cooked; Frozen; Boiled					1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S					1			1		
Bean, snap, succulent- babyfood	Cooked; Canned; Cook Meth N/S					1			1		
Beet, garden, roots	Cooked; Canned; Boiled	1				1			1		
	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Cured etc; Cook Meth N/S	1				1			1		
	Cooked; Dried; Boiled	1				1			1		
	Cooked; Dried; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Beet, garden, roots- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
Broccoli	Cooked; Canned; Boiled	1				1			1		
	Cooked; Dried; Boiled	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Cooked; Frozen; Boiled	1				1			1		
	Cooked; Frozen; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Broccoli- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Brussels sprouts	Cooked; Fresh or N/S; Boiled	0.1				1			1		
	Cooked; Frozen; Boiled	0.1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Cabbage	Cooked; Canned; Boiled	0.1				1			1		
	Cooked; Canned; Boiled/baked	0.1				1			1		
	Cooked; Canned; Cook Meth N/S	0.1				1			1		
	Cooked; Cured etc; Boiled/baked	0.1				1			1		
	Cooked; Cured etc; Cook Meth N/S	0.1				1			1		
	Cooked; Dried; Boiled	0.1				1			1		
	Cooked; Dried; Cook Meth N/S	0.1				1			1		
	Cooked; Fresh or N/S; Baked	0.1				1			1		
	Cooked; Fresh or N/S; Boiled	0.1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	0.1				1			1		
	Cooked; Fresh or N/S; Fried	0.1				1			1		
	Cooked; Frozen; Baked	0.1				1			1		
	Uncooked; Cured etc; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Cantaloupe	Cooked; Canned; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Carrot	Cooked; Canned; Boiled	1		1		1			1		
	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Cooked; Dried; Boiled	1		1		1			1		
	Cooked; Dried; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
	Cooked; Fresh or N/S; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Fried	1		1		1			1		
	Cooked; Frozen; Baked	1		1		1			1		
	Cooked; Frozen; Boiled	1		1		1			1		
	Cooked; Frozen; Cook Meth N/S	1		1		1			1		
	Uncooked; Cured etc; Cook Meth N/S	1		1		1			1		
	Uncooked; Dried; Cook Meth N/S	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Carrot- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
Carrot, juice	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Casaba	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Cauliflower	Cooked; Canned; Cook Meth N/S	1				1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Cured etc; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Cooked; Frozen; Boiled	1				1			1		
	Uncooked; Cured etc; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Celery	Cooked; Canned; Boiled	1		1		1			1		
	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Cooked; Cured etc; Cook Meth N/S	1		1		1			1		
	Cooked; Dried; Boiled	1		1		1			1		
	Cooked; Dried; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
	Cooked; Fresh or N/S; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Fried	1		1		1			1		
	Cooked; Fresh or N/S; Fried/baked	1		1		1			1		
	Cooked; Frozen; Baked	1		1		1			1		
	Uncooked; Cured etc; Cook Meth N/S	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Celery- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
Celery, juice	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Cherry	Cooked; Canned; Cook Meth N/S	1		1					1		
	Cooked; Fresh or N/S; Baked	1		1					1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1					1		
	Cooked; Fresh or N/S; Fried	1		1					1		
	Cooked; Frozen; Baked	1		1					1		
	Cooked; Frozen; Fried	1		1					1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1					1		
	Uncooked; Frozen; Cook Meth N/S	1		1					1		
Cherry- babyfood	Cooked; Canned; Cook Meth N/S	1		1					1		
Cherry, juice	Cooked; Canned; Cook Meth N/S	1		1					1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Cook Meth N/S	1		1					1		
	Uncooked; Dried; Cook Meth N/S	1		1					1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1					1		
	Uncooked; Frozen; Cook Meth N/S	1		1					1		
Cherry, juice- babyfood	Cooked; Canned; Cook Meth N/S	1		1					1		
Chicken, liver	Cooked; Canned; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Baked	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Fried	1	1	1	1	1	1		1	1	
	Cooked; Frozen; Baked	1	1	1	1	1	1		1	1	
Chicken, meat byproducts	Cooked; Canned; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Canned; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Cured etc; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Dried; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Dried; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Baked	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Fried	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Fried/baked	1	1	1	1	1	1		1	1	
	Cooked; Frozen; Baked	1	1	1	1	1	1		1	1	
Chicken, meat byproducts- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1	1		1	1	
Corn, sweet	Cooked; Canned; Boiled	1				1	0.75		1		
	Cooked; Canned; Cook Meth N/S	1				1	0.75		1		
	Cooked; Fresh or N/S; Baked	1				1	0.75		1		
	Cooked; Fresh or N/S; Boiled	1				1	0.75		1		
	Cooked; Fresh or N/S; Boiled/baked	1				1	0.75		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	0.75		1		
	Cooked; Fresh or N/S; Fried	1				1	0.75		1		
	Cooked; Frozen; Baked	1				1	0.75		1		
	Cooked; Frozen; Boiled	1				1	0.75		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
Corn, sweet- babyfood	Cooked; Canned; Cook Meth N/S	1				1	0.75		1		
Cucumber	Cooked; Canned; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	0.75		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Uncooked; Cured etc; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Dandelion, leaves	Cooked; Fresh or N/S; Boiled	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Endive	Cooked; Fresh or N/S; Boiled	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Grape	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Frozen; Cook Meth N/S	1				1			1		
Grape, juice	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Dried; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Uncooked; Dried; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Frozen; Cook Meth N/S	1				1			1		
Grape, juice- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Grape, raisin	Cooked; Canned; Cook Meth N/S	2.17				1			1		
	Cooked; Dried; Boiled	2.17				1			1		
	Cooked; Dried; Cook Meth N/S	2.17				1			1		
	Cooked; Fresh or N/S; Baked	2.17				1			1		
	Cooked; Fresh or N/S; Boiled	2.17				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	2.17				1			1		
	Cooked; Fresh or N/S; Fried	2.17				1			1		
	Cooked; Frozen; Baked	2.17				1			1		
	Uncooked; Dried; Cook Meth N/S	2.17				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	2.17				1			1		
Grapefruit	Cooked; Canned; Cook Meth N/S	1	1		1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1		1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1		1	1			1		
Grapefruit, juice	Cooked; Canned; Cook Meth N/S	1	1		1	1			1		
	Cooked; Fresh or N/S; Baked	1	1		1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1		1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1		1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1		1	1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Honeydew melon	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Frozen; Cook Meth N/S	1		1		1	1		1		
Horseradish	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Cured etc; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Lemon	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Lemon, juice	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Dried; Boiled	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Fried	1	1	1	1	1			1		
	Cooked; Frozen; Baked	1	1	1	1	1			1		
	Uncooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Lemon, juice- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
Lemon, peel	Cooked; Canned; Cook Meth N/S	1.16	1	1	1	1			1		
	Cooked; Dried; Cook Meth N/S	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1.16	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1.16	1	1	1	1			1		
Lettuce, head	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Lettuce, leaf	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Lime	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
Lime, juice	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Cured etc; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1	1	1	1	1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Lime, juice- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
Nectarine	Uncooked; Fresh or N/S; Cook Meth N/S	1			1	1			1		
Oat, bran	Cooked; Dried; Baked	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1				1	1		1		
	Uncooked; Dried; Cook Meth N/S	1				1	1		1		
Oat, flour	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
Oat, flour- babyfood	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
Oat, groats/rolled oats	Cooked; Dried; Baked	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Boiled	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1				1	1		1		
	Cooked; Frozen; Baked	1				1	1		1		
	Uncooked; Dried; Cook Meth N/S	1				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
Oat, groats/rolled oats- babyfood	Cooked; Canned; Cook Meth N/S	1				1	1		1		
Okra	Cooked; Canned; Boiled	1				1			1		
	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Frozen; Boiled	1				1			1		
	Cooked; Frozen; Cook Meth N/S	1				1			1		
	Uncooked; Cured etc; Cook Meth N/S	1				1			1		
Orange	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
Orange, juice	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Frozen; Baked	1	1	1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Orange, juice- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
Orange, peel	Cooked; Canned; Cook Meth N/S	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1.16	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1.16	1	1	1	1			1		
Parsley, dried leaves	Cooked; Canned; Boiled	1				1			1		
	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Dried; Boiled	1				1			1		
	Cooked; Dried; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Parsley, dried leaves- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
Parsley, leaves	Cooked; Canned; Boiled	1				1			1		
	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Dried; Boiled	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Boiled/baked	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Parsnip	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Pea, pigeon, succulent	Cooked; Canned; Boiled	0.15				1			1		
	Cooked; Dried; Boiled	0.15				1			1		
	Cooked; Fresh or N/S; Boiled	0.15				1			1		
Pea, succulent	Cooked; Canned; Boiled	0.15				1			1		
	Cooked; Canned; Cook Meth N/S	0.15				1			1		
	Cooked; Fresh or N/S; Baked	0.15				1			1		
	Cooked; Fresh or N/S; Boiled	0.15				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	0.15				1			1		
	Cooked; Fresh or N/S; Fried	0.15				1			1		
	Cooked; Frozen; Baked	0.15				1			1		
	Cooked; Frozen; Boiled	0.15				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1.15				1			1		
	Uncooked; Frozen; Cook Meth N/S	1.15				1			1		
Pea, succulent- babyfood	Cooked; Canned; Cook Meth N/S	0.15				1			1		
Peach	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Fried	1		1	1	1			1		
	Cooked; Frozen; Baked	1		1	1	1			1		
	Cooked; Frozen; Fried	1		1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1		1	1	1			1		
Peach- babyfood	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
Peach, dried	Cooked; Dried; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1		1	1	1			1		
Peach, juice	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Peach, juice- babyfood	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
Peanut, butter	Cooked; Canned; Cook Meth N/S	1	1	1		1			1		
	Cooked; Dried; Cook Meth N/S	1	1	1		1			1		
	Cooked; Fresh or N/S; Baked	1	1	1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1		1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1		1			1		
Chicken, liver	Cooked; Canned; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Baked	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Fried	1	1	1	1	1	1		1	1	
	Cooked; Frozen; Baked	1	1	1	1	1	1		1	1	
Chicken, meat byproducts	Cooked; Canned; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Canned; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Cured etc; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Dried; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Dried; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Baked	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Fried	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Fried/baked	1	1	1	1	1	1		1	1	
	Cooked; Frozen; Baked	1	1	1	1	1	1		1	1	
Chicken, meat byproducts- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1	1		1	1	
Corn, sweet	Cooked; Canned; Boiled	1				1	0.75		1		
	Cooked; Canned; Cook Meth N/S	1				1	0.75		1		
	Cooked; Fresh or N/S; Baked	1				1	0.75		1		
	Cooked; Fresh or N/S; Boiled	1				1	0.75		1		
	Cooked; Fresh or N/S; Boiled/baked	1				1	0.75		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	0.75		1		
	Cooked; Fresh or N/S; Fried	1				1	0.75		1		
	Cooked; Frozen; Baked	1				1	0.75		1		
	Cooked; Frozen; Boiled	1				1	0.75		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Corn, sweet- babyfood	Cooked; Canned; Cook Meth N/S	1				1	0.75		1		
Cucumber	Cooked; Canned; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	0.75		1		
	Uncooked; Cured etc; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Dandelion, leaves	Cooked; Fresh or N/S; Boiled	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Endive	Cooked; Fresh or N/S; Boiled	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Grape	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Frozen; Cook Meth N/S	1				1			1		
Grape, juice	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Dried; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Uncooked; Dried; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Frozen; Cook Meth N/S	1				1			1		
Grape, juice- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Grape, raisin	Cooked; Canned; Cook Meth N/S	2.17				1			1		
	Cooked; Dried; Boiled	2.17				1			1		
	Cooked; Dried; Cook Meth N/S	2.17				1			1		
	Cooked; Fresh or N/S; Baked	2.17				1			1		
	Cooked; Fresh or N/S; Boiled	2.17				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	2.17				1			1		
	Cooked; Fresh or N/S; Fried	2.17				1			1		
	Cooked; Frozen; Baked	2.17				1			1		
	Uncooked; Dried; Cook Meth N/S	2.17				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	2.17				1			1		
Grapefruit	Cooked; Canned; Cook Meth N/S	1	1		1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1		1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1		1	1			1		
Grapefruit, juice	Cooked; Canned; Cook Meth N/S	1	1		1	1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Baked	1	1		1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1		1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1		1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1		1	1			1		
Honeydew melon	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Frozen; Cook Meth N/S	1		1		1	1		1		
Horseradish	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Cured etc; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Lemon	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Lemon, juice	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Dried; Boiled	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Fried	1	1	1	1	1			1		
	Cooked; Frozen; Baked	1	1	1	1	1			1		
	Uncooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Lemon, juice- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
Lemon, peel	Cooked; Canned; Cook Meth N/S	1.16	1	1	1	1			1		
	Cooked; Dried; Cook Meth N/S	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1.16	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1.16	1	1	1	1			1		
Lettuce, head	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Lettuce, leaf	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
Lime	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
Lime, juice	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Cured etc; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Lime, juice- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
Nectarine	Uncooked; Fresh or N/S; Cook Meth N/S	1			1	1			1		
Oat, bran	Cooked; Dried; Baked	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1				1	1		1		
	Uncooked; Dried; Cook Meth N/S	1				1	1		1		
Oat, flour	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
Oat, flour- babyfood	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
Oat, groats/rolled oats	Cooked; Dried; Baked	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Boiled	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1				1	1		1		
	Cooked; Frozen; Baked	1				1	1		1		
	Uncooked; Dried; Cook Meth N/S	1				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
Oat, groats/rolled oats- babyfood	Cooked; Canned; Cook Meth N/S	1				1	1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Okra	Cooked; Canned; Boiled	1				1			1		
	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Boiled	1				1			1		
	Cooked; Frozen; Cook Meth N/S	1				1			1		
	Uncooked; Cured etc; Cook Meth N/S	1				1			1		
Orange	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
Orange, juice	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Cooked; Frozen; Baked	1	1	1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Orange, juice- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		
Orange, peel	Cooked; Canned; Cook Meth N/S	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Baked	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Boiled	1.16	1	1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1.16	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1.16	1	1	1	1			1		
Parsley, dried leaves	Cooked; Canned; Boiled	1				1			1		
	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Dried; Boiled	1				1			1		
	Cooked; Dried; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Parsley, dried leaves- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
Parsley, leaves	Cooked; Canned; Boiled	1				1			1		
	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Dried; Boiled	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Boiled/baked	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Baked	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Parsnip	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Parsnip- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Pea, pigeon, succulent	Cooked; Canned; Boiled	0.15				1			1		
	Cooked; Dried; Boiled	0.15				1			1		
	Cooked; Fresh or N/S; Boiled	0.15				1			1		
Pea, succulent	Cooked; Canned; Boiled	0.15				1			1		
	Cooked; Canned; Cook Meth N/S	0.15				1			1		
	Cooked; Fresh or N/S; Baked	0.15				1			1		
	Cooked; Fresh or N/S; Boiled	0.15				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	0.15				1			1		
	Cooked; Fresh or N/S; Fried	0.15				1			1		
	Cooked; Frozen; Baked	0.15				1			1		
	Cooked; Frozen; Boiled	0.15				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1.15				1			1		
	Uncooked; Frozen; Cook Meth N/S	1.15				1			1		
Pea, succulent- babyfood	Cooked; Canned; Cook Meth N/S	0.15				1			1		
Peach	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Fried	1		1	1	1			1		
	Cooked; Frozen; Baked	1		1	1	1			1		
	Cooked; Frozen; Fried	1		1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1		1	1	1			1		
Peach, dried	Cooked; Dried; Cook Meth N/S	1		1	1	1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1		1	1	1			1		
Peach, juice	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
Peach, juice- babyfood	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
Peach- babyfood	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
Peanut, butter	Cooked; Canned; Cook Meth N/S	1	1	1		1			1		
	Cooked; Dried; Cook Meth N/S	1	1	1		1			1		
	Cooked; Fresh or N/S; Baked	1	1	1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1		1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1		1			1		
Pear	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
	Cooked; Fresh or N/S; Baked	1		1	1	1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1	1	1			1		
Pear, dried	Cooked; Dried; Cook Meth N/S	2.58		1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	2.58		1	1	1			1		
Pear, juice	Cooked; Canned; Cook Meth N/S	0.37		1	1	1			1		
	Cooked; Dried; Cook Meth N/S	0.37		1	1	1			1		
	Cooked; Frozen; Baked	0.37		1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	0.37		1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	0.37		1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	0.37		1	1	1			1		
Pear, juice- babyfood	Cooked; Canned; Cook Meth N/S	0.37		1	1	1			1		
Pear- babyfood	Cooked; Canned; Cook Meth N/S	1		1	1	1			1		
Pepper, bell	Cooked; Canned; Boiled	1		1		1	0.75		1		
	Cooked; Canned; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Cured etc; Boiled	1		1		1	0.75		1		
	Cooked; Cured etc; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Dried; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Fried	1		1		1	0.75		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Fried/baked	1		1		1	0.75		1		
	Cooked; Frozen; Baked	1		1		1	0.75		1		
	Cooked; Frozen; Boiled	1		1		1	0.75		1		
	Cooked; Frozen; Fried	1		1		1	0.75		1		
	Uncooked; Cured etc; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Pepper, bell, dried	Cooked; Canned; Cook Meth N/S	1		1		1	1		1		
	Cooked; Dried; Boiled	1		1		1	1		1		
	Cooked; Dried; Cook Meth N/S	1		1		1	1		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
	Cooked; Fresh or N/S; Fried	1		1		1	1		1		
	Uncooked; Dried; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Pepper, bell, dried- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1	1		1		
	Cooked; Fresh or N/S; Baked	1		1		1	1		1		
Pepper, non-bell	Cooked; Canned; Boiled	1		1		1	0.75		1		
	Cooked; Canned; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Cured etc; Boiled	1		1		1	0.75		1		
	Cooked; Cured etc; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Cured etc; Fried	1		1		1	0.75		1		
	Cooked; Dried; Boiled	1		1		1	0.75		1		
	Cooked; Dried; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Fried	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Fried/baked	1		1		1	0.75		1		
	Cooked; Frozen; Baked	1		1		1	0.75		1		
	Cooked; Frozen; Cook Meth N/S	1		1		1	0.75		1		
	Uncooked; Cured etc; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Dried; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Pepper, non-bell, dried	Cooked; Canned; Boiled	1		1		1	1		1		
	Cooked; Canned; Cook Meth N/S	1		1		1	1		1		
	Cooked; Dried; Baked	1		1		1	1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Dried; Boiled	1		1		1	1		1		
	Cooked; Dried; Cook Meth N/S	1		1		1	1		1		
	Cooked; Fresh or N/S; Baked	1		1		1	1		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
	Cooked; Fresh or N/S; Fried	1		1		1	1		1		
	Cooked; Frozen; Baked	1		1		1	1		1		
	Uncooked; Dried; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Pepper, non-bell- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1	0.75		1		
Pineapple	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
	Cooked; Fresh or N/S; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
	Cooked; Frozen; Baked	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Pineapple, dried	Uncooked; Dried; Cook Meth N/S	1		1		1			1		
Pineapple, juice	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
	Cooked; Fresh or N/S; Boiled	1		1		1			1		
	Cooked; Frozen; Baked	1		1		1			1		
	Uncooked; Dried; Cook Meth N/S	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
	Uncooked; Frozen; Cook Meth N/S	1		1		1			1		
Pineapple, juice- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1			1		
Pineapple- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1			1		
Plantain	Cooked; Dried; Boiled	1		1		1	1		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
	Cooked; Fresh or N/S; Fried	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Plantain, dried	Cooked; Fresh or N/S; Fried	1		1		1	1		1		
Plum	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Frozen; Baked	1				1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Plum, prune, dried	Cooked; Dried; Cook Meth N/S	0.15				1			1		
	Uncooked; Dried; Cook Meth N/S	0.15				1			1		
Plum, prune, fresh	Cooked; Dried; Boiled	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Plum, prune, fresh- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Plum, prune, juice	Cooked; Dried; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Plum, prune, juice- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Plum- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Plum- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Potato, chips	Cooked; Fresh or N/S; Baked	0.04	0.62	1		1	1		1		
	Cooked; Fresh or N/S; Fried	0.04	0.62	1		1	1		1		
Potato, dry (granules/ flakes)	Cooked; Dried; Boiled	0.4	0.15	1		1	1		1		
	Cooked; Dried; Cook Meth N/S	0.4	0.3	1		1	1		1		
	Cooked; Fresh or N/S; Baked	0.4	0.3	1		1	1		1		
	Cooked; Fresh or N/S; Boiled	0.4	0.3	1		1	1		1		
	Cooked; Fresh or N/S; Fried	0.4	0.19	1		1	1		1		
	Cooked; Fresh or N/S; Fried/baked	0.4	0.19	1		1	1		1		
	Cooked; Frozen; Baked	0.4	0.3	1		1	1		1		
Potato, dry (granules/ flakes)- babyfood	Cooked; Canned; Cook Meth N/S	0.4	0.3	1		1	1		1		
Potato, flour	Cooked; Canned; Boiled	1	1	1		1	1		1		
	Cooked; Canned; Cook Meth N/S	1	1	1		1	1		1		
	Cooked; Cured etc; Baked	1	1	1		1	1		1		
	Cooked; Cured etc; Boiled	1	1	1		1	1		1		
	Cooked; Cured etc; Cook Meth N/S	1	1	1		1	1		1		
	Cooked; Cured etc; Fried	1	1	1		1	1		1		
	Cooked; Dried; Baked	1	1	1		1	1		1		
	Cooked; Dried; Boiled	1	1	1		1	1		1		
	Cooked; Dried; Cook Meth N/S	1	1	1		1	1		1		
	Cooked; Dried; Fried	1	1	1		1	1		1		
	Cooked; Fresh or N/S; Baked	1	1	1		1	1		1		
	Cooked; Fresh or N/S; Boiled	1	1	1		1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	1	1	1		1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1		1	1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Fried	1	1	1		1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1	1	1		1	1		1		
	Cooked; Frozen; Baked	1	1	1		1	1		1		
	Cooked; Frozen; Boiled	1	1	1		1	1		1		
	Cooked; Frozen; Cook Meth N/S	1	1	1		1	1		1		
	Cooked; Frozen; Fried	1	1	1		1	1		1		
	Uncooked; Dried; Cook Meth N/S	1	1	1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1		1	1		1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1		1	1		1		
Potato, flour- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1		1	1		1		
	Uncooked; Dried; Cook Meth N/S	1	1	1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1		1	1		1		
Potato, tuber, w/o peel	Cooked; Canned; Boiled	2.5	0.5	1		1	0.06		1		
	Cooked; Canned; Cook Meth N/S	1	0.5	1		1	0.06		1		
	Cooked; Cured etc; Boiled	2.5	0.5	1		1	0.06		1		
	Cooked; Cured etc; Fried	0.04	0.62	1		1	0.06		1		
	Cooked; Dried; Boiled	2.5	0.15	1		1	0.06		1		
	Cooked; Dried; Fried	0.04	0.19	1		1	0.06		1		
	Cooked; Fresh or N/S; Baked	1.2	1	1		1	0.06		1		
	Cooked; Fresh or N/S; Boiled	2.5	0.5	1		1	0.06		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1		1	0.06		1		
	Cooked; Fresh or N/S; Fried	0.04	0.62	1		1	0.06		1		
	Cooked; Frozen; Baked	1.2	1	1		1	0.06		1		
	Cooked; Frozen; Fried	0.04	0.62	1		1	0.06		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1		1	1		1		
Potato, tuber, w/o peel- babyfood	Cooked; Canned; Cook Meth N/S	1	0.5	1		1	0.06		1		
Potato, tuber, w/peel	Cooked; Fresh or N/S; Baked	1.2	1	1		1	1		1		
	Cooked; Fresh or N/S; Boiled	2.5	0.5	1		1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1		1	1		1		
	Cooked; Fresh or N/S; Fried	0.04	0.62	1		1	1		1		
Poultry, other, liver	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1	1		1	1	
Poultry, other, meat byproduct	Cooked; Fresh or N/S; Baked	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1	1		1	1	
Pumpkin	Cooked; Canned; Baked	1		1		1	0.75		1		
	Cooked; Dried; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Baked	1		1		1	0.75		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	0.75		1		
Radish, roots	Cooked; Fresh or N/S; Fried	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Rice, bran	Cooked; Dried; Cook Meth N/S	0.4				1	1		1		
	Cooked; Fresh or N/S; Baked	0.4				1	1		1		
	Cooked; Fresh or N/S; Fried/baked	0.4				1	1		1		
	Uncooked; Dried; Cook Meth N/S	0.4				1	1		1		
Rice, bran- babyfood	Cooked; Canned; Cook Meth N/S	0.4				1	1		1		
Rice, brown	Cooked; Dried; Baked	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Boiled	1				1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried	1				1	1		1		
	Cooked; Frozen; Baked	1				1	1		1		
	Cooked; Frozen; Cook Meth N/S	1				1	1		1		
Rice, brown- babyfood	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
Rice, flour	Cooked; Canned; Boiled	1				1	1		1		
	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Cured etc; Baked	1				1	1		1		
	Cooked; Cured etc; Boiled	1				1	1		1		
	Cooked; Cured etc; Cook Meth N/S	1				1	1		1		
	Cooked; Cured etc; Fried	1				1	1		1		
	Cooked; Dried; Baked	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Boiled	1				1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried	1				1	1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Fried/baked	1				1	1		1		
	Cooked; Frozen; Baked	1				1	1		1		
	Cooked; Frozen; Boiled	1				1	1		1		
	Cooked; Frozen; Cook Meth N/S	1				1	1		1		
	Cooked; Frozen; Fried	1				1	1		1		
	Uncooked; Dried; Cook Meth N/S	1				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Uncooked; Frozen; Cook Meth N/S	1				1	1		1		
Rice, flour- babyfood	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Uncooked; Dried; Cook Meth N/S	1				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
Rice, white	Cooked; Canned; Boiled	0.03				1	1		1		
	Cooked; Canned; Cook Meth N/S	0.03				1	1		1		
	Cooked; Dried; Boiled	0.03				1	1		1		
	Cooked; Dried; Cook Meth N/S	0.03				1	1		1		
	Cooked; Dried; Fried	0.03				1	1		1		
	Cooked; Fresh or N/S; Baked	0.03				1	1		1		
	Cooked; Fresh or N/S; Boiled	0.03				1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	0.03				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	0.03				1	1		1		
	Cooked; Fresh or N/S; Fried	0.03				1	1		1		
	Cooked; Frozen; Baked	0.03				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	0.03				1	1		1		
	Uncooked; Frozen; Cook Meth N/S	0.03				1	1		1		
Rice, white- babyfood	Cooked; Canned; Cook Meth N/S	0.03				1	1		1		
Rye, grain	Cooked; Dried; Baked	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Boiled	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried	1				1	1		1		
Soybean, flour	Cooked; Canned; Boiled	1	1			1	1		1		
	Cooked; Canned; Cook Meth N/S	1	1			1	1		1		
	Cooked; Cured etc; Cook Meth N/S	1	1			1	1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Cured etc; Fried	1	1			1	1		1		
	Cooked; Dried; Baked	1	1			1	1		1		
	Cooked; Dried; Boiled	1	1			1	1		1		
	Cooked; Dried; Cook Meth N/S	1	1			1	1		1		
	Cooked; Dried; Fried	1	1			1	1		1		
	Cooked; Fresh or N/S; Baked	1	1			1	1		1		
	Cooked; Fresh or N/S; Boiled	1	1			1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	1	1			1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1			1	1		1		
	Cooked; Fresh or N/S; Fried	1	1			1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1	1			1	1		1		
	Cooked; Frozen; Baked	1	1			1	1		1		
	Uncooked; Dried; Cook Meth N/S	1	1			1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1			1	1		1		
	Uncooked; Frozen; Cook Meth N/S	1	1			1	1		1		
Soybean, flour- babyfood	Cooked; Canned; Cook Meth N/S	1	1			1	1		1		
	Cooked; Dried; Cook Meth N/S	1	1			1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1			1	1		1		
	Uncooked; Dried; Cook Meth N/S	1	1			1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1			1	1		1		
Soybean, oil	Cooked; Canned; Cook Meth N/S	0.005	1			1	1		1		
	Cooked; Dried; Baked	0.005	1			1	1		1		
	Cooked; Fresh or N/S; Baked	0.005	1			1	1		1		
	Cooked; Fresh or N/S; Boiled	0.005	1			1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	0.005	1			1	1		1		
	Refined; FF N/A; Cook Meth N/S	0.005	1			1	1		1		
	Uncooked; Dried; Cook Meth N/S	0.005	1			1	1		1		
Soybean, oil- babyfood	Refined; FF N/A; Cook Meth N/S	0.005	1			1	1		1		
Soybean, seed	Cooked; Canned; Boiled	1	1			1	1		1		
	Cooked; Canned; Cook Meth N/S	1	1			1	1		1		
	Cooked; Dried; Baked	1	1			1	1		1		
	Cooked; Dried; Boiled	1	1			1	1		1		
	Cooked; Dried; Cook Meth N/S	1	1			1	1		1		
	Cooked; Dried; Fried	1	1			1	1		1		
	Cooked; Fresh or N/S; Baked	1	1			1	1		1		
	Cooked; Fresh or N/S; Boiled	1	1			1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	1	1			1	1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Cook Meth N/S	1	1			1	1		1		
	Cooked; Fresh or N/S; Fried	1	1			1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1	1			1	1		1		
	Cooked; Frozen; Baked	1	1			1	1		1		
	Uncooked; Cured etc; Cook Meth N/S	1	1			1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1			1	1		1		
Soybean, soy milk	Cooked; Canned; Cook Meth N/S	1	1			1	1		1		
	Cooked; Dried; Boiled	1	1			1	1		1		
	Cooked; Dried; Cook Meth N/S	1	1			1	1		1		
	Cooked; Fresh or N/S; Baked	1	1			1	1		1		
	Cooked; Fresh or N/S; Boiled	1	1			1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1			1	1		1		
	Cooked; Fresh or N/S; Fried	1	1			1	1		1		
Spinach	Cooked; Canned; Boiled	1				1	1		1		
	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Boiled	1				1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried	1				1	1		1		
	Cooked; Frozen; Baked	1				1	1		1		
	Cooked; Frozen; Boiled	1				1	1		1		
	Cooked; Frozen; Cook Meth N/S	1				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
Spinach- babyfood	Cooked; Canned; Cook Meth N/S	1				1	1		1		
Squash, summer	Cooked; Canned; Boiled	1		1		1	0.75		1		
	Cooked; Cured etc; Cook Meth N/S	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Fried	1		1		1	0.75		1		
	Cooked; Frozen; Baked	1		1		1	0.75		1		
	Cooked; Frozen; Boiled	1		1		1	0.75		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Squash, summer- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1	0.75		1		
Squash, winter	Cooked; Canned; Boiled	1		1		1	0.75		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1	0.75		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1	1.75		1		
	Cooked; Fresh or N/S; Fried	1		1		1	0.75		1		
	Cooked; Frozen; Boiled	1		1		1	0.75		1		
Squash, winter- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1	0.75		1		
Strawberry	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Dried; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Cooked; Frozen; Cook Meth N/S	1				1			1		
	Cooked; Frozen; Fried	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Frozen; Cook Meth N/S	1				1			1		
Strawberry, juice	Cooked; Canned; Cook Meth N/S	1				1			1		
	Cooked; Dried; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Baked	1				1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Cooked; Fresh or N/S; Fried	1				1			1		
	Uncooked; Dried; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
	Uncooked; Frozen; Cook Meth N/S	1				1			1		
Strawberry, juice- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Strawberry- babyfood	Cooked; Canned; Cook Meth N/S	1				1			1		
Sweet potato	Cooked; Canned; Boiled	1	0.5	1		1			1		
	Cooked; Canned; Boiled/baked	1	0.5	1		1			1		
	Cooked; Fresh or N/S; Baked	1	1	1		1			1		
	Cooked; Fresh or N/S; Boiled	1	0.5	1		1			1		
	Cooked; Fresh or N/S; Boiled/baked	1	0.5	1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1		1			1		
	Cooked; Fresh or N/S; Fried	1	0.62	1		1			1		
Sweet potato- babyfood	Cooked; Canned; Cook Meth N/S	1	0.5	1		1			1		
	Cooked; Fresh or N/S; Baked	1	1	1		1			1		
Swiss chard	Cooked; Fresh or N/S; Boiled	1				1			1		
Tangerine	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
Tangerine, juice	Cooked; Canned; Cook Meth N/S	1	1	1	1	1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Baked	1	1	1	1	1			1		
	Uncooked; Dried; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1			1		
	Uncooked; Frozen; Cook Meth N/S	1	1	1	1	1			1		
Tomato	Cooked; Canned; Boiled	1		1		1			1		
	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Cooked; Cured etc; Boiled	1		1		1			1		
	Cooked; Dried; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
	Cooked; Fresh or N/S; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Fried	1		1		1			1		
	Cooked; Fresh or N/S; Fried/baked	1		1		1			1		
	Cooked; Frozen; Baked	1		1		1			1		
	Cooked; Frozen; Boiled	1		1		1			1		
	Uncooked; Cured etc; Cook Meth N/S	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Tomato, dried	Cooked; Dried; Baked	1		1		1			1		
	Cooked; Dried; Boiled	1		1		1			1		
	Cooked; Dried; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
	Cooked; Fresh or N/S; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Fried/baked	1		1		1			1		
	Uncooked; Dried; Cook Meth N/S	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Tomato, dried- babyfood	Cooked; Fresh or N/S; Baked	1		1		1			1		
Tomato, juice	Cooked; Canned; Boiled	0.52		1		1			1		
	Cooked; Canned; Cook Meth N/S	0.52		1		1			1		
	Cooked; Fresh or N/S; Baked	0.52		1		1			1		
	Cooked; Fresh or N/S; Boiled	0.52		1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	0.52		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	0.52		1		1			1		
Tomato, paste	Cooked; Canned; Boiled	1		1		1			1		
	Cooked; Canned; Cook Meth N/S	1		1		1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Dried; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
	Cooked; Fresh or N/S; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Fried	1		1		1			1		
	Cooked; Frozen; Baked	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Tomato, paste- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1			1		
Tomato, puree	Cooked; Canned; Boiled	1		1		1			1		
	Cooked; Canned; Cook Meth N/S	1		1		1			1		
	Cooked; Cured etc; Boiled	1		1		1			1		
	Cooked; Dried; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Baked	1		1		1			1		
	Cooked; Fresh or N/S; Boiled	1		1		1			1		
	Cooked; Fresh or N/S; Boiled/baked	1		1		1			1		
	Cooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
	Cooked; Fresh or N/S; Fried	1		1		1			1		
	Cooked; Frozen; Baked	1		1		1			1		
	Frozen; Fried/Baked	1		1		1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1			1		
Tomato, puree- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1			1		
Tomato- babyfood	Cooked; Canned; Cook Meth N/S	1		1		1			1		
Triticale, flour	Cooked; Dried; Boiled	0.1				1	1		1		
	Cooked; Dried; Cook Meth N/S	0.1				1	1		1		
	Cooked; Fresh or N/S; Baked	0.1				1	1		1		
Turkey, liver	Cooked; Fresh or N/S; Baked	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1	1		1	1	
Turkey, meat byproducts	Cooked; Canned; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Canned; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Cured etc; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Cured etc; Fried	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Baked	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Boiled	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1	1	1	1		1	1	
	Cooked; Fresh or N/S; Fried	1	1	1	1	1	1		1	1	

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Frozen; Baked	1	1	1	1	1	1		1	1	
Turkey, meat byproducts- babyfood	Cooked; Canned; Cook Meth N/S	1	1	1	1	1	1		1	1	
Turnip, roots	Cooked; Fresh or N/S; Boiled	1				1			1		
	Cooked; Frozen; Boiled	1				1			1		
	Uncooked; Cured etc; Cook Meth N/S	1				1			1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1			1		
Watermelon	Uncooked; Cured etc; Cook Meth N/S	1		1		1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Watermelon, juice	Uncooked; Fresh or N/S; Cook Meth N/S	1		1		1	1		1		
Wheat, bran	Cooked; Dried; Baked	1.03				1	1		1		
	Cooked; Dried; Boiled	1.03				1	1		1		
	Cooked; Dried; Cook Meth N/S	1.03				1	1		1		
	Cooked; Dried; Fried	1.03				1	1		1		
	Cooked; Fresh or N/S; Baked	1.03				1	1		1		
	Cooked; Fresh or N/S; Boiled	1.03				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1.03				1	1		1		
	Cooked; Fresh or N/S; Fried	1.03				1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1.03				1	1		1		
	Cooked; Frozen; Baked	1.03				1	1		1		
	Uncooked; Dried; Cook Meth N/S	1.03				1	1		1		
Wheat, flour	Cooked; Canned; Boiled	0.1				1	1		1		
	Cooked; Canned; Cook Meth N/S	0.1				1	1		1		
	Cooked; Cured etc; Baked	0.1				1	1		1		
	Cooked; Cured etc; Boiled	0.1				1	1		1		
	Cooked; Cured etc; Cook Meth N/S	0.1				1	1		1		
	Cooked; Cured etc; Fried	0.1				1	1		1		
	Cooked; Dried; Baked	0.1				1	1		1		
	Cooked; Dried; Boiled	0.1				1	1		1		
	Cooked; Dried; Cook Meth N/S	0.1				1	1		1		
	Cooked; Dried; Fried	0.1				1	1		1		
	Cooked; Fresh or N/S; Baked	0.1				1	1		1		
	Cooked; Fresh or N/S; Boiled	0.1				1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	0.1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	0.1				1	1		1		
	Cooked; Fresh or N/S; Fried	0.1				1	1		1		
	Cooked; Fresh or N/S; Fried/baked	0.1				1	1		1		
	Cooked; Frozen; Baked	0.1				1	1		1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Frozen; Boiled	0.1				1	1		1		
	Cooked; Frozen; Cook Meth N/S	0.1				1	1		1		
	Cooked; Frozen; Fried	0.1				1	1		1		
	Cooked; Frozen; Fried/baked	0.1				1	1		1		
	Uncooked; Cured etc; Cook Meth N/S	0.1				1	1		1		
	Uncooked; Dried; Cook Meth N/S	0.1				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	0.1				1	1		1		
	Uncooked; Frozen; Cook Meth N/S	0.1				1	1		1		
Wheat, flour- babyfood	Cooked; Canned; Cook Meth N/S	0.1				1	1		1		
	Cooked; Dried; Baked	0.1				1	1		1		
	Cooked; Dried; Cook Meth N/S	0.1				1	1		1		
	Cooked; Fresh or N/S; Baked	0.1				1	1		1		
	Uncooked; Dried; Cook Meth N/S	0.1				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	0.1				1	1		1		
Wheat, germ	Cooked; Dried; Boiled	0.65				1	1		1		
	Cooked; Dried; Cook Meth N/S	0.65				1	1		1		
	Cooked; Fresh or N/S; Baked	0.65				1	1		1		
	Cooked; Fresh or N/S; Boiled	0.65				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	0.65				1	1		1		
Wheat, grain	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Baked	1				1	1		1		
	Cooked; Dried; Boiled	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Baked	1				1	1		1		
	Cooked; Fresh or N/S; Boiled	1				1	1		1		
	Cooked; Fresh or N/S; Boiled/baked	1				1	1		1		
	Cooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Cooked; Fresh or N/S; Fried	1				1	1		1		
	Cooked; Fresh or N/S; Fried/baked	1				1	1		1		
	Cooked; Frozen; Baked	1				1	1		1		
	Cooked; Frozen; Fried	1				1	1		1		
	Uncooked; Fresh or N/S; Cook Meth N/S	1				1	1		1		
	Uncooked; Frozen; Cook Meth N/S	1				1	1		1		
Wheat, grain- babyfood	Cooked; Canned; Cook Meth N/S	1				1	1		1		
	Cooked; Dried; Cook Meth N/S	1				1	1		1		
Yam, true	Cooked; Fresh or N/S; Boiled	1	0.5	1		1			1		

Commodity	Foodform	Chemical									
		A	B	C	D	E	F	G	H	I	J
	Cooked; Fresh or N/S; Cook Meth N/S	1	1	1		1			1		

Table 3. Permissible Crop Translations for Pesticide Monitoring Data

Commodity Analyzed	Commodity translated to...	Comments
Potato	Subgroup 1-C	
Carrot	Subgroup 1-A or 1-C	
Head Lettuce	Cabbage, Chinese cabbage Napa (tight headed varieties), Brussels sprouts, radicchio	All have a head morphology best represented by lettuce. All are in Subgroup 5-A except radicchio (4-A).
Broccoli	Cauliflower, Chinese broccoli, Chinese cabbage bok choy, Chinese mustard, kohlrabi	Broccoli better represents these heading, thickly stemmed and/or more branching cole crops than spinach does.
Spinach	Subgroup 4-A, Subgroup 5-B and Subgroup 4-B (except celery and fennel unless a strong case can be made)	Celery and fennel typically are excluded since residues may be higher in these crops due to the whorled, overlapping petioles which may retain spray residues.
Green Bean	Subgroups 6-A and 6-B	
Soybean	Subgroup 6-C	
Tomato or bell pepper	Group 8	All are fruiting vegetables[2].
Cucumber	Subgroup 9-B	All are cucurbit vegetables; residues in melon and pumpkin expected to be lower because of removal of rind
Cantaloupe or Winter squash	Subgroup 9-A and pumpkin	
Orange	Group 10	Fruit will be peeled before analysis by PDP.
Apple or Pear	Group 11	All are pome fruits.
Peach	Group 12, except cherries (sweet and tart)	All are stone fruits.
Grape	Kiwifruit	Based on similar cultural practices.
Wheat	Group 15, except corn, rice, or wild rice	All are small grain crops or closely related thereto
Milk	Meat	Metabolism study must indicate that residues in meat, fat, and meat-by-products will likely be equal to or lower than residues in milk. If dermal use is allowed on beef cattle, then it must be permitted and used on dairy cattle as well.

[1] The reviewer should take special note of the requirement that the use scenarios be similar among translatable commodities. The mode of application (e.g., foliar, preplant) should be the same. The label application rates and preharvest intervals should be similar. The percent of crop treated also should be similar (or lower for the crop in the "translated to" column). All residues of concern should be measured or accounted for including conjugates. Tolerances and field trial residues are to be similar, as well. The reviewer should also check with the Biological and Economic Analysis Division (BEAD) to insure that use scenarios are similar, and that agricultural practices do not differ substantially.

[2] The reviewer should be careful in checking for comparable residue levels because of weight differences in tomatoes and peppers.

Table 4. Summary of Probabilistic Analysis of Distribution of the Cumulative Dietary Exposures In Three Populations from Use of N-methyl carbamate Chemicals on Food Crops

	95th Percentile	99th Percentile	99.9th Percentile
	Exposure (mg/kg body wt/day)	Exposure (mg/kg body wt/day)	Exposure (mg/kg body wt/day)
Children (1-2 years)	0.003073	0.025199	0.210519
Children (3-5 years)	0.002758	0.021769	0.177165
Adults (20-49)	0.000746	0.005951	0.056145

V. Cumulative Exposure from Carbamate Pesticides in Drinking Water

The Food Quality Protection Act (FQPA) of 1996 requires the Agency to assess the risks from different pesticides having a common mechanism of action, focusing on the likelihood that a person will be concurrently exposed to multiple pesticides from multiple sources (food, drinking water, and residential uses). Ideally, data to support the drinking water portion of this exposure would provide information on multiple pesticides, and their transformation products, collected from sufficient drinking water sources throughout the U.S. and at a sufficient frequency to reflect the spatial and temporal patterns of pesticide occurrence in water. The great diversity of geographic-, climatic-, and time-dependent factors that affect pesticide contamination in water creates unique challenges in characterizing drinking water exposure. The Office of Pesticide Programs (OPP) must rely on both available monitoring data and modeling to develop sufficient data for use in the exposure assessment.

Because of similarities in use (both groups are insecticides), hazard endpoints (acute – short term – endpoints), and exposure requirements (estimates of peak concentrations and time-series distributions), the Agency will use the same methods for estimating surface water exposure in the carbamate drinking water assessment as it did for the organophosphate (OP) cumulative risk assessment (CRA). These methods have already been presented to the FIFRA Science Advisory Panel (FIFRA SAP, 2002). This case study provides a summary of those methods used in the OP CRA as they apply specifically to the N-methyl carbamates included in this cumulative assessment group. In addition to being found in surface water, the N-methyl carbamates are likely to reach ground-water sources of drinking water. In order to assess the potential impacts of carbamate residues in ground water on the drinking water assessment, OPP is evaluating the capability of three ground water models to estimate carbamate concentrations. This evaluation is presented to the SAP as a separate document.

This case study provides preliminary results of estimated drinking water exposures from surface water in the southeastern US. Based on an assessment of carbamate use patterns and relative runoff vulnerabilities of the US, the Agency expects these drinking water exposures to represent the high-end of anticipated cumulative carbamate exposures in surface water sources of drinking water.

A. Problem Formulation

The approach for assessing drinking water exposure accounts for the fact that pesticide concentrations found in drinking water are not random, but are in large part determined by the amount, method, timing and location of pesticide application, the physical characteristics of the watersheds and/or aquifers in which the community water supplies (CWS) or private wells are located, and other environmental factors (such as rainfall) which cause the pesticide to move from the location where it was applied. The choice of data and tools to estimate the drinking water exposure component of cumulative exposure depends upon both the questions to be answered and the expected exposure in water.

1. Drinking Water Exposure Estimates Required for the Carbamate Cumulative Assessment

For the N-methyl carbamate group, the toxicity endpoint of concern results from short-term exposure (acute effects). To adequately characterize the potential impacts of pesticide residues in drinking water, the estimated residue concentrations need to reflect a sufficient reporting frequency in time to capture peak concentrations. Because pesticide loads tend to move in relatively quick pulses in flowing water, the frequency sufficient to reliably capture peak concentrations is on the order of daily sampling.

The drinking water exposure assessment needs to account for the potential for any or all of the carbamates included in the cumulative assessment group (Table 5) to occur together in drinking water sources. To realistically estimate exposures, the assessment must take into account those factors (crop uses, pest pressures, timing of application, etc.) which determine whether more than one carbamate pesticide can occur together in time and place. Although multiple carbamate pesticides may be registered for use on the same site, they may not necessarily be used at the same time. While monitoring data could provide real-time estimates of co-occurrence, it needs to be able to account for all of the potential carbamates used in the monitoring area, be of sufficient frequency to reflect the pulse nature of pesticide exposures, and span sufficient years to capture the yearly variability in use and weather patterns.

Table 5. N-methyl carbamate use patterns and availability of national monitoring data

Pesticide	Use pattern likely to result in water exposure?	Availability of national water monitoring data?
Chemical A	Yes (agricultural and residential uses)	Yes: NAWQA, Reservoir monitoring
Chemical B	Yes (agricultural uses)	Yes: NAWQA, Reservoir monitoring; state monitoring
Chemical C	Yes (agricultural uses)	Yes: NAWQA, Reservoir monitoring
Chemical D	Yes (agricultural uses)	No
Chemical E	Yes (agricultural uses)	Yes: NAWQA, Reservoir monitoring
Chemical F	Yes (agricultural uses)	Yes: NAWQA, Reservoir monitoring; state monitoring
Chemical G	No (indoor uses)	Some limited NAWQA monitoring
Chemical H	Limited impact due to limited use	Some limited NAWQA monitoring
Chemical I	Yes (agricultural uses)	No
Chemical J	Limited impact due to indoor uses, limited outdoor use	No

In order to meet the FQPA requirement of “reasonable certainty of no harm”, the drinking water exposure assessment must balance between reflecting actual use in the field and accounting for year-to-year variations due to weather, fluctuating pest pressures, and other use / environmental factors in order to provide a realistic potential high-end exposure.

2. Nature of Carbamate Exposure in Drinking Water Sources

This section briefly summarizes the nature of expected carbamate exposure in drinking water sources based in individual chemical assessments (aggregate exposure), available water monitoring data, and published literature on the potential impact of conventional drinking water treatment processes on carbamates in water.

Re-registration eligibility documents (REDs) or Interim REDs (IREDs) are available for five of the pesticides included in the carbamate cumulative assessment group (available on the USEPA OPP web site at http://cfpub.epa.gov/oppref/rereg/status.cfm?show=rereg); risk assessments are underway for three additional carbamates. These individual assessments indicate that seven of the carbamates listed in Table 5 – Chemicals A, B, C, D, E, F, and I – have the potential to reach drinking water sources based on use and chemical fate and transport properties. All seven are likely to reach surface water sources of drinking water via runoff or sediment transport, and have been detected in monitoring studies. Two carbamates – Chemicals B and F – are likely to reach and persist in ground water sources of drinking water, especially in shallow aquifers. This has been confirmed in a number of monitoring studies. Three other carbamates – Chemicals A, C, and E – may also reach ground water, but are not likely to persist. Detections of these chemicals in ground water are infrequent.

The most extensive source of national water monitoring data for pesticides is the US Geological Survey (USGS) National Water Quality Assessment (NAWQA) program, which includes seven of the carbamates in its list of pesticides (Table 6). The NAWQA program focuses on ambient water rather than drinking water sources, is not specifically targeted to pesticide use areas, and are not sampled frequently enough to provide reliable estimates of peak pesticide concentrations. However, the program does provide a good understanding on a national level of the expected occurrence of pesticides in flowing water bodies that may be representative of drinking water sources. The monitoring data are better indicators of the nature of occurrence of pesticides with widespread use rather than pesticides that are limited to a few crops or pests. A detailed description of the pesticide monitoring component of the NAWQA program is available on the NAWQA Pesticide National Synthesis Project (PNSP) web site (http://ca.water.usgs.gov/pnsp/).

A summary of the first cycle of NAWQA monitoring from 1991 to 2001 indicates that the seven carbamate pesticides included in the monitoring study were not frequently detected in the NAWQA study units (Table 6). Chemicals A and F were the most frequently detected carbamate pesticides in streams and ground water, reflecting the broader use patterns of these particular insecticides. In most instances, maximum reported detections of the carbamates were in the single parts per billion

or sub-parts per billion range. OPP obtained carbamate-specific monitoring data through the NAWQA Data Warehouse (a link is available from the PNSP web site referenced above), current through November 5, 2004. While these data have not been analyzed for this case study, a limited, preliminary evaluation noted reported concentrations as high as 25 to 35 ug/l for Chemicals A, E, and F.

As expected, co-occurrence of carbamates in the monitored water samples reflects use patterns. Chemicals A and F are the most common carbamates occurring together in the NAWQA sampling; up to three different carbamates have been detected in the same surface water samples in the NAWQA study units. Although less commonly observed, more than one carbamate was also detected in a small number of ground water samples.

Table 6. Summary of carbamate detections in the USGS NAWQA study, 1991-2001 (provisional data published by USGS in 2003).

Pesticide	Agricultural Land Use			Mixed Land Use			*Urban Land Use*		
	% detect	Max conc, ug/L	95th %ile conc	% detect	Max conc, ug/L	95th %ile conc	% detect	Max conc, ug/L	*95th %ile conc*
Surface Water Monitoring 1									
Chemical A	9.2%	5.2	nd	15.4%	0.5	nd	43.8%	5.2	*0.3*
Chemical B	0.2%	0.5	nd	0%	Nd	nd	0%	nd	*nd*
Chemical C	0.8%	0.2	nd	0%	Nd	nd	0%	nd	*nd*
Chemical E	1.6%	0.7	nd	0.3%	0.3	nd	0%	nd	*nd*
Chemical F	9.6%	7.0	0.04	3.3%	0.7	nd	2.1%	0.1	*nd*
Chemical G	0.2%	0.1	nd	0.2%	0.2	nd	0.2%	0.3	*nd*
Chemical H	0.1%	0.1	nd	0%	Nd	nd	0%	nd	*nd*
Ground Water Monitoring 2									
Chemical A	0.4%	0.02	nd	0.8%	0.5	nd	1.6%	0.03	*nd*
Chemical B	0.3%	1.8	nd	0.1%	0.1	nd	0%	nd	*nd*
Chemical C	0.8%	2.1	nd	0.1%	0.03	nd	0.2%	0.3	*nd*
Chemical E	0.1%	0.04	nd	0.1%	0.1	nd	0.2%	0.4	*nd*
Chemical F	1.6%	1.3	nd	0.4%	0.2	nd	0.7%	0.09	*nd*
Chemical G	0.1%	0.06	nd	0.1%	0.06	nd	0.2%	0.3	*nd*
Chemical H	0%	nd	nd	0.1%	0.03	nd	0%	nd	*nd*

1 Martin et al, 2003; http://ca.water.usgs.gov/pnsp/pestsw/Pest-SW_2001_Text.html
2 Koplin & Martin, 2003; http://ca.water.usgs.gov/pnsp/pestgw/Pest-GW_2001_Text.html

NAWQA and other surface-water monitoring programs show that pesticide concentrations in surface water are highly variable in location and in time. This is particularly true for insecticides, such as the carbamates, where usage is often in response to specific pest pressures, which are likely to be concentrated in some areas but not in others and in some years but not necessarily every year. In addition to variable use patterns, carbamate concentrations in surface water are influenced by local soil, hydrology, and weather patterns and by the timing of rainfall events in relation to use.

While Chemical B has not been detected frequently or in high concentrations in ground water in the NAWQA program, extensive monitoring by others (the registrant, state and local governments, universities) shows widespread contamination of ground water where Chemical B has been used. In the aggregate exposure assessment for Chemical B (IRED scheduled for 2006), OPP contrasted the entire body of ground water monitoring data, much of which occurred during the late 1980s, with monitoring data since 1990 (Table 7). During that time, label changes were incorporated to restrict use from certain areas.

While the extent of Chemical B contamination in ground water is less today than it was in previous decades, it is also less well characterized in most areas. In addition, total Chemical B residues (primarily the transformation products) can persist in ground water for years or decades after use. Twenty years after Chemical B use on Long Island, NY, was halted, Chemical B residues are still the most frequently detected pesticide compounds in ground water (Suffolk County Dept. of Health Services, 2000).

Table 7. Summary of Chemical B detections in ground water monitoring data collected from available ground water monitoring data.

Region	All ground water monitoring			Monitoring data since 1990		
	max conc (ug/L)	95th %ile (ug/L)	70th %ile (ug/L)	max conc (ug/L)	95th %ile (ug/L)	70th %ile (ug/L)
Northwest	183	58.7	1.0	2.1	0.8	0.6
Southwest	44	22.8	7.8	7.2	7.1	6.7
Northern Great Plains	65	46.3	7.9	65	52.9	9.5
Lower Midwest	N/A	N/A	N/A	N/A	N/A	N/A
North-central	111	38	10	83	24.2	6.8
Northeast	187.2	40.1	13.4	187.2	24.5	8.0
Southeast and Mid-south	602	27.7	5.3	21	20.3	3.6
Florida	55.2	25	8.3	55.2	25.6	8.5

A similarly extensive body of ground water monitoring data exists for Chemical F. Like Chemical B, the extent of monitoring for Chemical F in ground water has decreased in recent years, so current impacts are not as well documented. However, several inferences can be drawn from the body of studies. Targeted ground water monitoring studies show a clear pattern of Chemical F movement into ground water, with maximum detections in the same range as that reported for Chemical B. Because transport to ground water typically takes longer than transport to surface water, measured concentrations of Chemical F in ground water may represent usage that occurred years before the samples were collected. As with Chemical B, Chemical F will also persist in ground water for long periods of time after use has been discontinued. This is particularly true for slightly acidic to acidic ground water because Chemical F is stable to hydrolysis (the major route of degradation in ground water) at pH values of 6.0 or less.

EPA' s preliminary review of available scientific and technical literature indicates that conventional water treatment processes such as coagulation, sedimentation, and conventional filtration generally do not affect removal or transformation of most pesticides, including the N-methyl carbamates. While powdered activated carbon (PAC), granular activated carbon (GAC), and reverse osmosis can be effective in removing many pesticides, they are not widely used in community water systems (CWS). Chemical softening processes can facilitate chemical transformations of some pesticides, including those carbamates that hydrolyze rapidly at alkaline pH values. However, softening is not employed at every CWS. These results were published in the Federal Register in October 2001, along with an interim policy for considering the impacts of drinking water treatment in drinking water exposure assessments under FQPA (USEPA, 2001). The registrant has submitted studies on the effect of drinking water treatment on Chemical E and Chemical C; these studies have not been reviewed for this case study. For the cumulative assessment, the Agency will qualitatively consider the impacts of conventional drinking water treatment on specific carbamate pesticides in CWS water supplies. However, the Agency must also consider raw water concentrations for private ground water wells since these private wells generally do not include any form of treatment.

3. Summary

The goal of the drinking water exposure assessment is to provide estimates of distributions of N-methyl carbamate residues (concentrations in drinking water) for use in probabilistic exposure assessment that account for:

- daily and seasonal variations in residues over time due to time of application(s) and runoff/leaching events (surface water concentrations are expected to be more variable in time than ground water concentrations)
- year-to-year variations due to weather patterns, pest pressures, and use
- variability in residues from place to place, resulting from the source and nature of drinking water and from the regional / local factors (soil, geology, hydrology, climate, crops, pest pressures, usage) that affect the vulnerability of those sources
- the potential for co-occurrence of more than one N-methyl carbamate in location and time only when this is likely to happen

B. Analysis Plan

Risk is a function of both hazard and exposure, and estimation of the exposure portion for drinking water requires data on concentrations of the pesticides in the drinking water and consumption of drinking water for different demographic populations on a daily basis. Drinking water is locally derived and concentrations of pesticides in source water fluctuate over time and location for a variety of reasons. Pesticide residues in water fluctuate daily, seasonally, and yearly as a result of the timing of the pesticide application, the vulnerability of the watershed to pesticide runoff, spray drift and leaching, and changes in the weather. Changes in concentrations also result from the method of application, the location and characteristics of the sites where a pesticide is used, the climate, and the type and degree of pest pressure.

Given the data needs and the number of variables that can affect the outcome of the predictive model, it is apparent that the development of daily distributions of concentrations of co-occurring carbamates in drinking water for various regions of the US is far-reaching in scope and complexity. While monitoring data provide a picture of the expected occurrence of carbamate pesticides in drinking water, the data alone are not sufficient for use in the cumulative drinking water exposure assessment. This section describes the planned approach to estimate cumulative carbamate residues in drinking water using models and evaluating the estimates against available monitoring data.

Based on the needs of the probabilistic cumulative exposure assessment and the information gained from an assessment of monitoring data, OPP designed a drinking water assessment that provides multiple years of daily residue concentrations from drinking water sources in eight regions across the country. Because of similarities between the N-methyl carbamates and the organophosphate (OP) pesticides with regard to hazard endpoints and expected occurrence in surface water, the Agency will use the same approach it used in the OP CRA for estimating drinking water exposure from surface water. Unlike the OP pesticides, the carbamate pesticides have been detected in ground water sources of drinking water. Thus, the Agency is developing methods to estimate carbamate residues in ground water sources of drinking water.

1. Estimating Carbamate Exposure in Surface Water Sources of Drinking Water

While the available monitoring studies provide a profile of carbamate occurrence in water, the same limitations identified in the OP CRA also preclude basing the carbamate cumulative water exposure assessment solely on monitoring:

- ❑ The monitoring studies were not designed to characterize daily concentration profiles and are not robust enough to provide daily

distributions; the frequency is not sufficient to capture peak or near-peak concentrations

- The studies have not been conducted over a period of time sufficient to characterize year-to-year fluctuations due to weather, use, pest pressures, etc.
- While the NAWQA study units coincide with a number of high carbamate-use areas, not all of the major carbamate use areas have monitoring data
- Lack of monitoring for some compounds make it difficult to completely assess co-occurrence
- Monitoring provides a snapshot in time and does not reflect recent mitigation actions, such as lower application rates and fewer applications or cancellation of certain uses or chemicals, initiated for individual chemicals during the risk management phase.

As with the OP CRA, OPP is using available monitoring (particularly the USGS NAWQA and Reservoir Monitoring studies, state monitoring programs, and industry-conducted studies) in the carbamate cumulative drinking water assessment. Because the NAWQA monitoring covers a number of areas of the country, it can help characterize the spatial variation in exposures and identify potential areas of concern. Taken in context with known carbamate usage, weather patterns, and soil/hydrologic conditions, monitoring will be used to evaluate modeled exposure estimates.

In a case study for the OP CRA, the Agency used a developmental version of the USGS Watershed Regression for Pesticides (WARP) model to estimate concentrations of two OP pesticides in drinking water sources. The panel noted that shortcomings in the available data (particularly pesticide usage) and in the model's estimation capabilities (described below) limited the Agency's ability to use the WARP model presented to them in the cumulative exposure assessment for multiple pesticides (FIFRA SAP, 2000).

Since then, the USGS has completed development of the WARP model for atrazine (Larson et al, 2004). While the USGS is currently working on a multi-pesticide model and is investigating potential methods for estimating peak concentrations and providing temporal distributions of pesticide concentrations in water, those improvements are not ready yet. In its current state, the WARP model cannot address the requirements of the carbamate CRA:

- In present state of development (published model for atrazine), WARP is not yet capable of estimating concentrations for multiple chemicals (though a multiple chemical model is being evaluated)

- Because it is a regression model, it carries a number of the same limitations as monitoring data

- The model falls short of peak estimates because it is intended to estimate up to the 95th percentile annual concentration, which means that roughly 18 days out of every year will have greater concentrations

- Does not provide a daily distribution and, thus, cannot adequately separate estimated concentrations that are not likely to occur together in time.

Therefore, as with the OP CRA, the Agency will estimate the daily drinking water exposure from surface water sources using the simulation models PRZM (Pesticide Root Zone Model) and EXAMS (EXposure Analysis Modeling System). PRZM/EXAMS modeling using a drinking water reservoir allows the Agency to:

- Account for potential co-occurrence of carbamates by modeling all uses in a region/area

- Combine daily time series over multiple years (using 30 years of recorded weather data) to account for year-to-year variations in weather and to separate peak concentrations that are not likely to occur together

- Can estimate peak concentrations (on a daily time step); adjustments to pesticide use inputs (“typical” rates, frequencies) can reflect estimated concentrations in a “typical” year

- Model vulnerable surface water sources in regions to reflect spatial variations in crops, use, weather, soil, hydrology

- Adjust for crop area, acres treated

2. Estimating Carbamate Exposure in Ground Water Sources of Drinking Water

As noted in the problem formulation, a number of the carbamates included in this assessment have been detected in ground water. For the same reasons mentioned above for surface water, the existing body of ground water monitoring is not sufficient to serve as the basis for cumulative ground water exposure estimates. Monitoring does indicate that more than one carbamate may occur together in ground-water. While

carbamate concentrations in ground water are affected by pesticide use, rainfall, and soil conditions, the response time between an application / leaching event and detection in ground water is not as rapid as it is for surface water. Thus, carbamate concentrations are less likely to fluctuate as drastically in ground water as they do in surface water and less frequent time steps may be adequate to characterize ground water exposures. However, carbamate residues are likely to linger for longer periods in ground water, particularly in slightly acidic to acidic ground waters where the carbamates tend to be more persistent. Cumulative exposure is likely to reflect past as well as current uses.

The Agency uses the Screening Concentrations In GROund Water (SCI-GROW) model in its initial screening estimates of individual pesticide concentrations in ground water sources of drinking water (a description of the model is available through the OPP Water Models web site at http://www.epa.gov/oppefed1/models/water/index.htm). Pesticide concentrations estimated by SCI-GROW represent high-end exposure values because the model is based on ground-water monitoring studies which were conducted by applying pesticides at maximum allowed rates and frequency to vulnerable sites (i.e., shallow aquifers, sandy, permeable soils, and substantial rainfall and/or irrigation to maximize leaching). The model provides a single estimated concentration which is used for both short-term and longer-term exposures. This model does not provide time-series estimates and is not designed to estimate concentrations other than the peak estimates it provides.

Currently, EPA does not have a more refined ground water model for estimating pesticide exposures in ground water sources of drinking water. Recently, the USGS evaluated the capabilities of a number of existing ground water models. Based in the results, EPA considered three models – LEACHM, RZWQM, and PRZM – for predicting ground water concentrations. EPA has evaluated the USGS comparisons and the data requirements of these models, in addition to evaluations done by the FIFRA Environmental Model Validation Task Force in order to select a model for use in the carbamate CRA. This evaluation is being presented to the SAP in Session 3 for consideration and feedback.

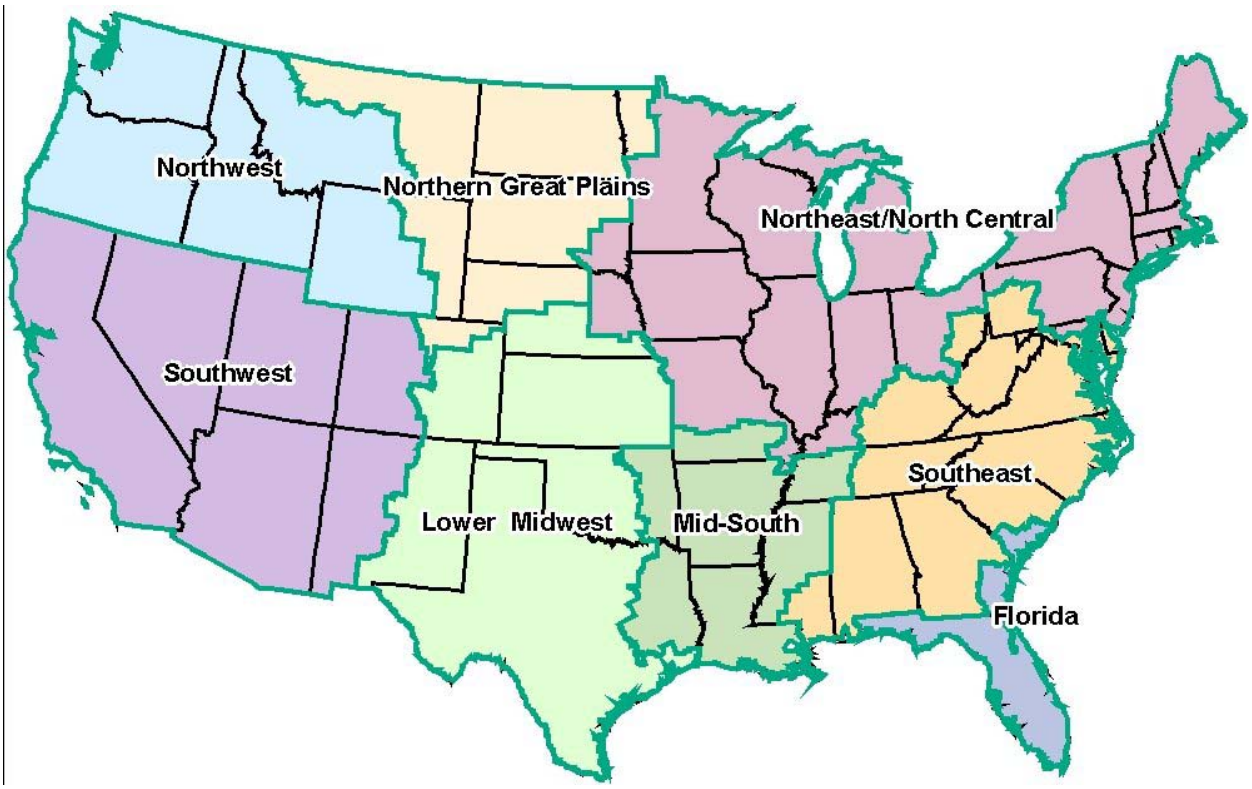
3. Regional Screening Approach for Drinking Water Exposure Assessment

As with the OP CRA, the Agency is using a regional approach as a first step in addressing the impacts of regional and localized variability in site, environmental, and management practices that affect pesticide concentrations in water. OPP adapted a modification of the USDA Farm Resource Region map (Heimlich, 2000) as a framework for focusing the cumulative assessment (Figure 1). By providing general groupings according to similarities in key environmental factors affecting runoff and leaching, such as precipitation, irrigation practices, and soil types, these

farm resource regions provide a framework for identifying one or more locations which represent an area of the greatest concern for drinking water exposure in each region. In this way, the Agency chose a set of locations to represent drinking water sources throughout the US.

Within the regions, drinking water exposure will vary locally due to pesticide use, agricultural practices, nature and vulnerability of drinking water sources, and weather patterns. Thus, the water exposure assessment focused on one or more specific geographic areas within each region in a manner that would be realistically protective of all sites within the region. OPP selected locations in each region where carbamates in drinking water sources are likely to be of greatest concern based on total carbamate use and vulnerability of the drinking water sources. If carbamate levels in water from these vulnerable sites are not major contributors to the total regional cumulative exposure, then the Agency can reasonably conclude that drinking water exposures will not be a concern in other, less vulnerable, portions of the region. If drinking water exposure from one or more of these vulnerable sites is a significant contributor to the total cumulative exposure, then additional assessments may be necessary to characterize the extent of the potential exposure.

Figure 1. Carbamate cumulative risk assessment regions for drinking water exposure assessment.



C. Analysis Methods

A detailed description of the methods used for estimating cumulative pesticide concentrations in surface water sources of drinking water can be found in the Water OP Cumulative Risk document for the OP CRA (USEPA OPP, 2002). This section provides a brief description of the methods of analysis in order to provide context for understanding case study results.

1. N-methyl Carbamate Properties

The predicted persistence and movement of each of the carbamate pesticides in the environment are based on environmental fate and transport studies submitted by the pesticide registrants as a requirement of registration and/or re-registration. Inputs for the water models are based on the individual chemical assessments. Model inputs have not been provided for this case study since the focus of the study is on the methods for cumulative exposure assessment and not the individual chemical properties. Such inputs will be documented in the preliminary risk assessment.

2. Identifying Regional Exposure Scenarios

The selection of a specific location for regional drinking water assessments involves several steps. First, OPP identified the high carbamate usage areas within each region. To account for the differences in toxicities among the carbamates, OPP adjusted the county-level estimates of pounds of each carbamate by their respective relative potency factors before summing the total pounds of carbamate use. Thus, the adjusted usage map reflects the areas of greatest use of the most potent of the carbamates.

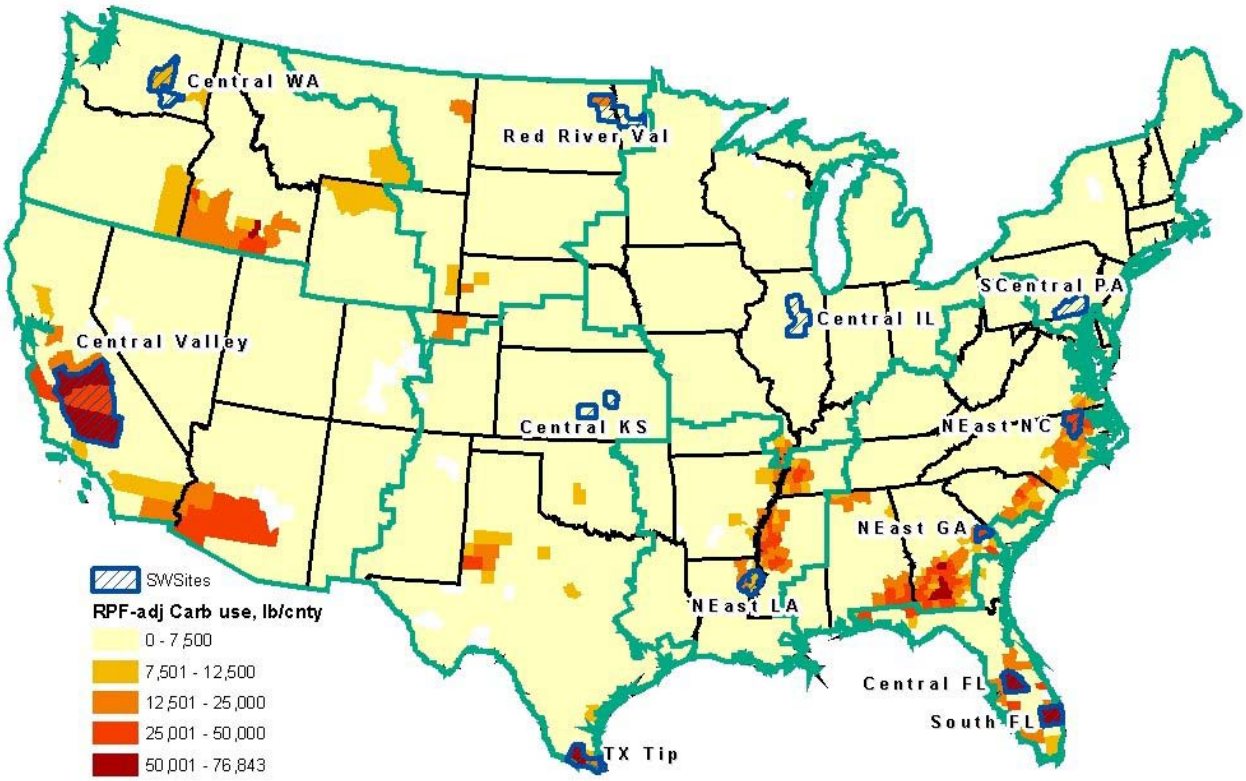
Next, OPP identified the types of drinking water sources in each high usage area. The Agency used a spatial dataset that describes water use for all the counties in the continental US (USGS, 1998) to determine the dominant source of drinking water – (1) public supply served by surface water, (2) public supply served by ground water, or (3) domestic self-supplied drinking water (primarily private wells). The Agency focused its regional assessments on high carbamate usage areas that coincided with either surface-water or ground-water sources of drinking water.

The final step in choosing a location is to assess the vulnerability of drinking water sources within the high usage area within the region. For surface water sources of drinking water, OPP compared relative vulnerabilities of the areas based on average-annual runoff, average 2-month runoff (beginning of the growing season), and average soil loss, as developed by the USDA Natural Resources Conservation Service (Kellogg et al, 1997). For ground water sources of drinking water, OPP compared

relative ground water vulnerabilities of the high carbamate use areas based on a variety of sources, including Nolan et al (2002), USGS NAWQA reports, and USGS Ground Water Atlases.

Figure 2 shows the locations of the regional surface water exposure scenarios selected for the carbamate drinking water exposure assessment. The Central FL site also serves as the initial ground water exposure scenario location. Data was collected from each county- or multi-county area to represent the cropping patterns, carbamate usage, soil, hydrologic, and weather conditions for the surface watersheds or aquifers associated with the drinking water supplies.

Figure 2. Locations of the regional surface water exposure sites for the carbamate cumulative assessment



3. Regional Usage

The regional exposure areas of interest consist of multi-county areas that encompass the vulnerable drinking water source in high carbamate use areas. OPP collected information on the target crops, estimated carbamate usage, and timing of application for these multi-county areas.

The drinking water exposure assessments require information on crop use, pounds applied, application rate, number of applications, percent of crop treated, and application timing. Much of this information is

not easily available or does not exist at the geographic scale needed for the exposure assessment. OPP used the best available information to provide the best regional estimates for the carbamate pesticide-crop combinations that actually occur in scenario areas. Because county-level pesticide usage data is based on surveys and is uneven in quality, OPP created county clusters that surrounded the initial scenario areas shown in Figure 2. The Agency also used multiple data sources and multiple years of data to improve the robustness of the use data.

For each regional scenario site, OPP used USDA National Agricultural Statistics Service (USDA NASS) and Doane's databases to estimate usage (acres planted, total pounds used, percent of crop treated, application rate, and number of applications) for each carbamate and crop reported in the use cluster. Usage was averaged for the years 1998 through 2002. The Agency identified those carbamate-crop uses that accounted for at least 95% of the total carbamate usage in the scenario area.

Usage data (application rates, frequency, area treated) represent the mean for the area over the 5-year period. As noted in the characterization section, this will result in underestimates of those times when more intense pest pressures result in higher rates and/or greater acres treated and in overestimates for those times when pest pressures are minimal or absent. As with the OP CRA, the Agency plans to conduct sensitivity analyses to characterize the uncertainty based on using average usage data.

Once the crop / chemical combinations were identified in a given area, OPP used USDA crop profiles and typical planting/harvesting dates and various other sources to identify most likely windows of application for each carbamate use. Typically, all the carbamates discussed here target multiple pests or ones that can occur multiple times during a given crop's growing season, so applications often occur over a broad time period. For the case study, OPP systematically selected the beginning of the most active window for the initial application date of each carbamate. Where multiple applications were identified, the Agency spread those evenly over the most active window.

4. Surface Water Exposure Assessment

For each of the regional surface water exposure scenarios, EPA used its paired PRZM and EXAMS models for an index, or reference, reservoir to estimate a distribution of daily drinking water concentrations that could be used for multiple chemicals over several years of predictions across the country. PRZM-EXAMS estimates concentrations in a small drinking water reservoir in a primarily agricultural watershed. PRZM-EXAMS has the capability of predicting water concentrations over a number of years based on collected historical weather data for the sites

which are being modeled. A detailed description of the models is available from the OPP Water Models web site (http://www.epa.gov/oppefed1/models/water/index.htm).

The PRZM component of the model is designed to predict the concentration of a pesticide dissolved in runoff waters and carried on entrained sediments from the field where a pesticide has been applied into an adjacent surface water body. Inputs to the model include specific soil properties (organic matter, water holding capacity, bulk density), site characteristics (slope, surface roughness, field geometry), pesticide application parameters (application rate, frequency, spray drift, application depth, application efficiency, application methods), agricultural management practices (erosion parameters influences by tillage practices, irrigation, crop rotation sequences), and pesticide environmental fate and transport properties (aerobic soil metabolism half-life, soil:water partitioning coefficients, foliar degradation and dissipation rates, and vapor pressure). The input parameters are specific for each carbamate-crop scenario in each region.

In addition to the pesticide-specific environmental fate properties and usage information described above, PRZM uses values for soil properties, site characteristics, and weather data that are specific to the regions of the exposure assessments. For instance, in the eastern North Carolina exposure site representing the Southeast region of the US, the cotton, peanut, and tobacco scenarios consist of properties for soils on which the crops are grown in the coastal plain of North Carolina. The weather data used in the simulations come from 30 years of weather collected at a NOAA weather station in Raleigh/Durham, just west of the scenario area.

The EXAMS component of the model is used to simulate environmental fate and transport processes of pesticides in surface water, including abiotic and biotic degradation, sediment:water partitioning, and volatilization. Currently, OPP is using an index reservoir as the benchmark surface water body for drinking water exposure assessments. The reservoir, based on Shipman City Lake in IL, is a 5.3-hectare reservoir (reserve normal capacity of 144,000 m3) with a 172.8-hectare (427 acre) watershed.

The PRZM-EXAMS model is used in individual chemical aggregate assessments to predict a reasonable high end screening concentration. This is done by using health-protective assumptions (maximum label application rates, 100% of the crop is treated, national percent crop area estimate) in order to determine whether the Agency can reliably conclude a reasonable certainty of no harm from pesticide exposures in drinking water. However, the cumulative assessment focuses on the probability or likelihood of concurrent exposure to multiple pesticides from food, water, and residential use. It is unlikely that the exposure to the highest (peak)

concentrations for multiple carbamates in a use area will occur at the same time. Thus, the cumulative assessment uses average application rates, average numbers of applications, and estimates of acres treated. The implications of these assumptions are discussed in the risk characterization section.

PRZM is a field-scale model, while the cumulative water assessment focuses on watershed-scale impacts (i.e., the contributions of multiple carbamate uses on multiple crops occurring in multiple fields in a watershed). As with the OP CRA, the Agency used PRZM to model multiple fields in a watershed. While this approach provides a more realistic depiction of multiple chemical usage in a watershed, it still has limitations. PRZM can simulate multiple fields, but provides no spatial context for those fields. It also assumes that the runoff from each of those fields goes into the reservoir.

To adapt PRZM for this watershed approach, OPP must adjust the estimated pesticide concentrations generated for each crop-carbamate combination to account for the portion of the watershed that is treated by a particular carbamate. This was done with a cumulative adjustment factor (CAF) in a three step process:

(1) The carbamate-crop combination was modeled with PRZM/EXAMS, using the region-specific usage, application timing, soil, site, and weather data. The result is a time-series of daily pesticide concentrations in a reservoir spanning a 30-year period.

(2) Each daily concentration is adjusted by the fraction of the watershed that is in the crop being modeled. This is done by dividing the acres of crop grown in the multi-county region by the total acres in that region (percent crop area).

(3) The daily concentrations are then adjusted by the fraction of acres of the crop treated by the particular carbamate. This is done by dividing the acres of crop treated by the total crop acres in the multi-county region (percent crop treated).

The resulting CAF-adjusted concentrations for each crop-carbamate combination must be converted to a concentration equivalent for an index chemical. Once this is done, the concentrations can be combined into a single set of daily cumulative concentrations (spanning multiple years) for each region. The concentrations were normalized to an index equivalent by multiplying each of the daily concentrations by the relative potency factor (RPF) for the respective carbamate pesticide. This normalized output for each crop-carbamate combination was summed day by day to give a single time series of potential combined water residues for the region. The resulting carbamate cumulative drinking water exposure is provided as a cumulative daily time series over 30 years.

In summary, within each region, a residue file was generated by PRZM-EXAMS for each crop-carbamate combination which was reported in the county or counties selected for assessment. This day-by-day residue file was modified by the CAF specific to that crop-carbamate combination and the relative potency factor for that pesticide. Then, the modified residue files for all crop-carbamate combinations for that location were summed across days to give a distribution of combined daily residues in drinking water.

5. Ground Water Exposure Assessment

EPA is evaluating three models for use in the carbamate cumulative risk assessment to estimate carbamate concentrations in ground water sources of drinking water. Based on the results of the evaluation (presented to this SAP in a separate session) and recommendations of the SAP, the Agency will use one of the models to estimate potential exposure of carbamates in drinking water derived from ground water.

In addition to the criteria EPA used to evaluate the suitability of the models for estimating pesticide concentrations in ground water (comparisons to monitoring, availability of inputs for the model, ease of use, maintenance, etc.), the models must also address the needs of the cumulative exposure assessment. Despite some differences in the nature of pesticide exposure in ground water as compared to surface water, the requirements of a ground water exposure assessment are similar. These requirements will be addressed in the ground water exposure assessment as follows:

- **Variations in Residues Over Time:** Pesticide residues in ground water are likely to fluctuate less drastically than residues in surface water; however, the model estimates will need to provide a concentration time series.

- **Variations in Residues Over Location:** As with the surface water assessment, EPA will focus on regional ground water sources of drinking water that are expected to be among the most vulnerable to carbamate contamination based on soil, geology, hydrology, climate, crops, pest pressures, and usage. For the preliminary assessment, EPA focused on central Florida, based on carbamate use, drinking water source, and expected aquifer vulnerability.

- **Co-occurrence:** USGS monitoring shows that co-occurrence of carbamates, though infrequent, does occur in ground water. Therefore, EPA will estimate ground water concentrations for multiple carbamate pesticides in ground water as their use is reflected in the regional ground water sites.

Unlike surface water exposure, in which pesticide residues dissipate quickly because of flow, the ground water exposure assessment needs to address background residues present from previous use. As noted, available monitoring shows that Chemical B and Chemical F can persist in slightly acidic to acidic ground water for years after use has been reduced or eliminated. The Agency is considering three possible approaches:

- at one extreme, assume no background residues (drinking water exposures would reflect only what is estimated by modeling), i.e, all residues in GW are "fresh";
- at the other extreme, assume a baseline background concentration (based on available monitoring), with model estimates as additions and no decline;
- in between, include the background levels with model estimates, but provide an estimate of decline in residues over time (estimate based on long-term trends in monitoring)

The resulting cumulative distributions from ground water will be converted to an index chemical based on the relative potency (RPF) and, then summed for a cumulative ground water distribution.

D. Carbamate Cumulative Drinking Water Exposures: Case Study Results

For this case study, EPA focused the drinking water exposure assessment on the southeastern US, covered by the Florida, Southeast, and Mid-south regions (Figure 3). EPA estimated carbamate cumulative distributions in surface water from five sites in the three regions (Figure 3 and Table 8), based on total carbamate usage (adjusted for relative potency), location of surface water intakes of drinking water, and relative vulnerabilities of those intake watersheds to runoff. Because the distribution from the northeastern North Carolina site had the highest concentrations and frequencies of pulse loads, OPP used that distribution in the cumulative exposure assessment in this case study. Thus, the case study would reflect the impacts of drinking water exposure (surface water sources) from the most vulnerable scenario modeled in the mid-south and southeastern portion of the country.

1. Description of the Regions and Site Assessment Areas

The Southeast region includes the eastern coastal plain, piedmont, and Appalachian ridge and plateaus, extending from the Delmarva Peninsula south to the gulf coast of Alabama and Mississippi. The dominant carbamate use in this area occurs along the coastal plain from southeastern Virginia to southeastern Alabama (Figure 3). The dominant

carbamate uses in the region are on cotton, peanuts, tobacco, and pecans (Table 8).

The Florida region encompasses all of Florida, and extends through coastal Georgia into southernmost South Carolina. The high-use areas are in southern Florida, around Palm Beach County and to the south, and in central Florida, around Polk County (Figure 3). In central Florida, the dominant carbamate uses are on citrus; in southern Florida, the dominant uses are on citrus, sweet corn, sugarcane, and vegetables (Table 8).

The Mid-south region includes the lower Mississippi River valley from southern Missouri southward and the Ozark Mountain regions. The high-use areas occur on either side of the Mississippi River, in western Tennessee, eastern Arkansas, northeastern Louisiana, and northwestern Mississippi (Figure 3). The dominant use in this region is on cotton, corn, and sorghum (Table 8).

Figure 3. Southeast, Florida, and Mid-south Regions with carbamate usage and location of drinking water exposure sites.

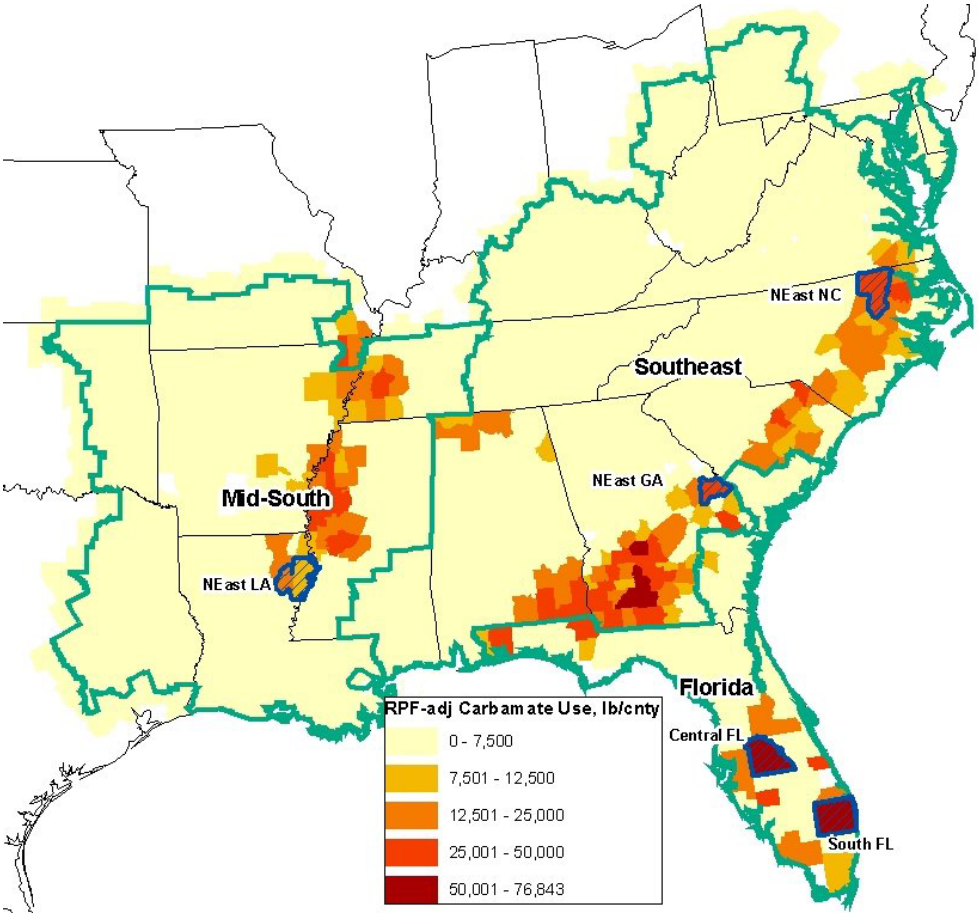


Table 8. Regional drinking water exposure sites and dominant carbamate uses.

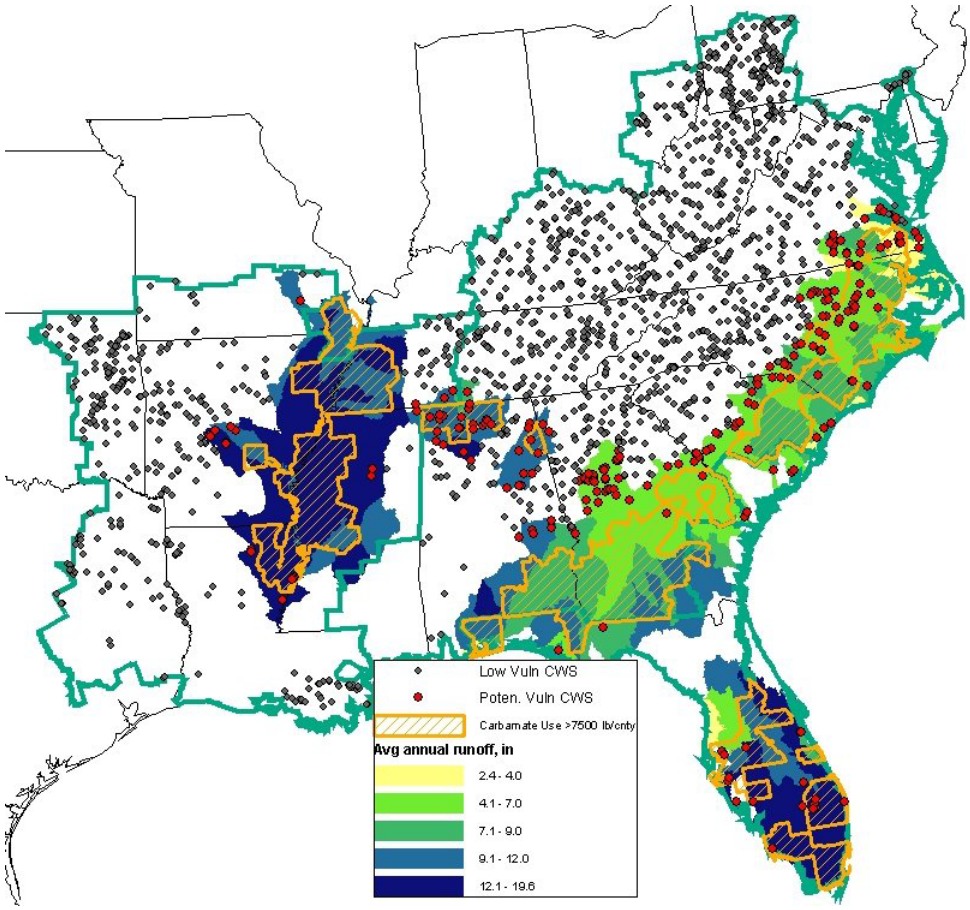
Region	Exposure scenario sites	Dominant carbamate use crops	Dominant carbamates
Southeast	Northeast NC (SW), eastern GA (SW)	Cotton, peanuts, tobacco, pecans	Chemicals A, B, C
Florida	South FL (SW), central FL (SW, GW)	Citrus, sweet corn, sugarcane, cucumber, pepper	Chemicals A, B, C, E, F, I
Mid-south	Northeast LA (SW)	Cotton, corn, sorghum	Chemicals B, C, F, I

The predominance of surface water sources of drinking water in the Southeast, Florida, and Mid-south regions occur where total carbamate use is low (Figure 4). Surface water intakes within the high carbamate use areas of the Southeast region are largely confined to the western side of the coastal plain, with more intakes to the north, in Virginia, North Carolina and South Carolina. The watersheds that are most vulnerable to runoff in the high carbamate use area tend to occur in areas where ground water is the dominant source of drinking water. EPA selected sites in northeastern North Carolina and eastern Georgia to represent the northern and southern ends of the high carbamate use areas in the coastal plain that coincide with surface water sources of drinking water.

Few surface water sources of drinking water occur in the Florida Region. However, the surface water intakes in central and southern Florida are located in high carbamate-use areas that are particularly vulnerable to runoff (Figure 4). EPA selected two sites in Florida where surface water intakes occurred in high-runoff, high carbamate use areas. The central FL site represented dominantly citrus uses; at the southern FL site, carbamate use on vegetables, citrus, sugarcane, and sweet corn accounted for more than 95 percent of agricultural usage of carbamate pesticides.

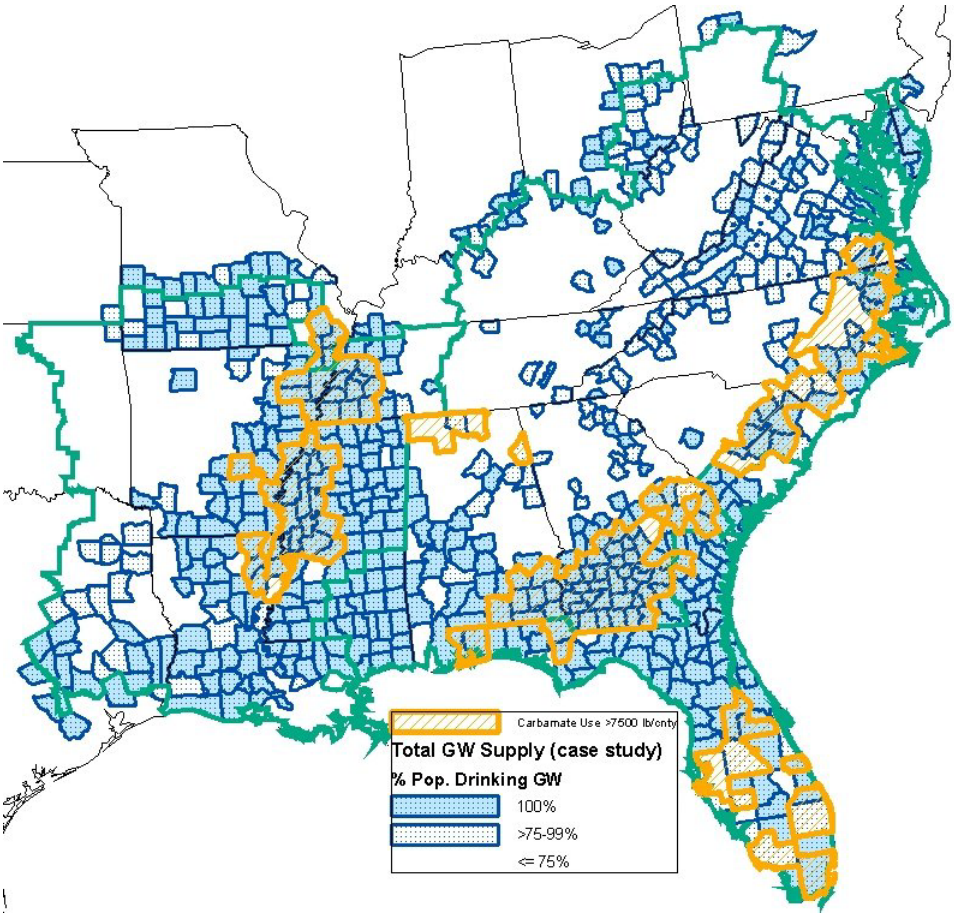
The high use area of the Mid-south has few surface water intakes, but includes the most vulnerable runoff watersheds. The Agency chose a high-use, high-runoff site in northeast Louisiana, where the intakes are surrounded by crops, with cotton, corn, and sorghum representing the dominant carbamate uses. Transport of pesticides in surface water here is complicated by levees on the Mississippi River and a system of drainage canals.

Figure 4. Location of surface water intakes in relation to carbamate usage and runoff vulnerability in the southeastern US.



The majority of the population living in the high carbamate use areas of the Southeast, Florida, and Mid-south regions obtains drinking water from ground water sources (Figure 5). In many of the counties in the high use areas, most of the drinking water comes through public ground water supplies, particularly in the Mid-south and Florida regions. In general, private wells tend to be more vulnerable to pesticide contamination than public supply wells because they are more likely to be shallower, tap into the surficial aquifers, and receive no treatment. However, the vulnerability of aquifers supplying drinking water vary greatly across and within the regions.

Figure 5. Location of high carbamate use areas in relation to predominant ground water sources of drinking water.



The high carbamate use areas in the Southeast and Florida regions overlay three major aquifers:

(1) A surficial aquifer consisting of beds of sand and shells, sand and gravel that provides drinking water in southeastern Georgia and coastal South Carolina (http://capp.water.usgs.gov/gwa/ch_g/jpeg/G008.jpeg). It also provides drinking water for private supplies in these states and Florida. Domestic wells in this aquifer are likely to be more vulnerable to pesticide contamination than wells extending into the protected, underlying aquifers.

(2) the Floridan aquifer, a highly productive carbonate rock (e.g. limestone) aquifer which is an important source of drinking water in Alabama, Georgia, South Carolina and Florida (USGS Hydrologic Investigations Atlas 730-G). In some places, the recharge areas of the Floridan aquifer can be highly vulnerable karst regions while, in areas such as southeastern Georgia, the Floridan is confined by at least 100 feet of fine sediments, which reduces the likelihood of direct contamination from the surface (NAWQA Apalachicola-

Chattahoochee-Flint River Basin study report and http://capp.water.usgs.gov/gwa/ch_g/jpeg/G055.jpeg).

(3) The Southeastern Coastal Plain aquifer is most important as a drinking water source in the inner Coastal Plain. It is separated from the overlying Floridan by a clayey confining unit in Alabama and western Georgia, which serves to retard recharge and potential contamination from the Floridan aquifer and the surface (http://capp.water.usgs.gov/gwa/ch_g/jpeg/G008.jpeg).

Ground water is also an important source of drinking water in the high carbamate use areas of coastal Virginia and North Carolina, where layers of sand are separated by clay and silt confining units into eleven aquifers. Domestic wells drawing from the unconfined surficial aquifer will be the most vulnerable to contamination. Domestic or public supply wells drawing from deeper confined aquifers are less so.

Ground water is the major source of drinking water for a significant part of the Mid-south region, north of Baton Rouge, LA, and south of western Tennessee. Ground water is derived predominantly from confined or semi-confined aquifers which underlie the entire Mississippi embayment. Significant amounts of water are also drawn from younger alluvium which occurs at the surface or under 10 to 50 feet of relatively recently deposited silt and clay. Although the alluvial aquifer is mostly used for irrigation, there is some domestic use for drinking water. The structure of the aquifer system, and the presence of multiple confining layers, reduces the likelihood of drinking-water contamination for large sections of the Mid-south region. In general, while carbamate contamination is possible, ground-water contamination with pesticides is less likely in this region than in most of the rest of the nation.

Based on total carbamate use, general aquifer characteristics, and information on relative vulnerability of the surficial aquifers to contamination from agricultural chemicals (Nolan et al, 2002), EPA selected the central Florida area (around Polk County) to use in its evaluation of ground water models for use in estimating drinking water concentrations for the carbamate cumulative case study. The results are discussed in a separate document presented to the SAP on the results of that evaluation.

2. Estimated Cumulative Distribution in Surface Water

The Agency estimated drinking water concentrations for individual carbamate pesticides and for the cumulative carbamate load (reflecting concentrations of an index chemical) for the five surface water scenario sites in the three regions included in this case study. The greatest estimated cumulative carbamate concentrations in drinking water were predicted for the northeastern NC site in the Southeast region (Table 9).

Table 9. Predicted percentile concentrations of individual carbamates and RPF-adjusted cumulative distributions in the surface water scenario sites.

Scenario site	Chemical	Crops	Concentration in ug/L 1					
			Max	99th	95th	90th	75th	50th
Southeast/ Northeast NC	B	Cotton, peanuts	1.5	0.6	0.3	0.1	0.05	0.02
	Cumulative Exposure		190	78	34	18	6.6	2.0
Southeast/ Eastern GA	A	Pecans	0.05	0.01	0.004	0.002	<0.001	<0.001
	B	Cotton, peanuts	0.4	0.2	0.09	0.04	0.01	0.003
	Cumulative Exposure		54	29	11	5.5	1.4	0.4
Florida/ South FL	B	Citrus	0.02	0.01	0.003	0.002	<0.001	<0.001
	C	Pepper, citrus, cucumber	0.1	0.02	0.006	0.003	0.001	<0.001
	E	Sweet corn, pepper, cucumber	0.6	0.3	0.2	0.1	0.07	0.03
	F	Sweet corn, sugarcane, cucumber	0.8	0.2	0.08	0.04	0.007	0.001
	I	Sweet corn	0.06	0.007	0.003	0.001	<0.001	<0.001
	Cumulative Exposure		26	6.8	3.6	2.4	1.1	0.4
Florida/ Central FL	A	Citrus	0.1	0.03	0.009	0.005	<0.001	<0.001
	B	Citrus	0.5	0.2	0.09	0.04	0.01	0.004
	C	Citrus	0.05	0.008	0.002	<0.001	<0.001	<0.001
	Cumulative Exposure		66	29	11	5.5	1.9	0.5
Mid-south / Northeast LA	B	Cotton	0.8	0.4	0.09	0.04	0.007	0.001
	E	Cotton	0.4	0.1	0.04	0.02	0.006	0.002
	F	Cotton, corn, sorghum	0.3	0.2	0.07	0.04	0.01	0.002
	I	Cotton	0.08	0.03	0.007	0.001	<0.001	<0.001
	Cumulative Exposure		103	48	12	5.1	1.3	0.2

1 Concentrations for individual chemicals are not adjusted for relative potencies while the cumulative exposure concentrations have been adjusted to index chemical concentrations.

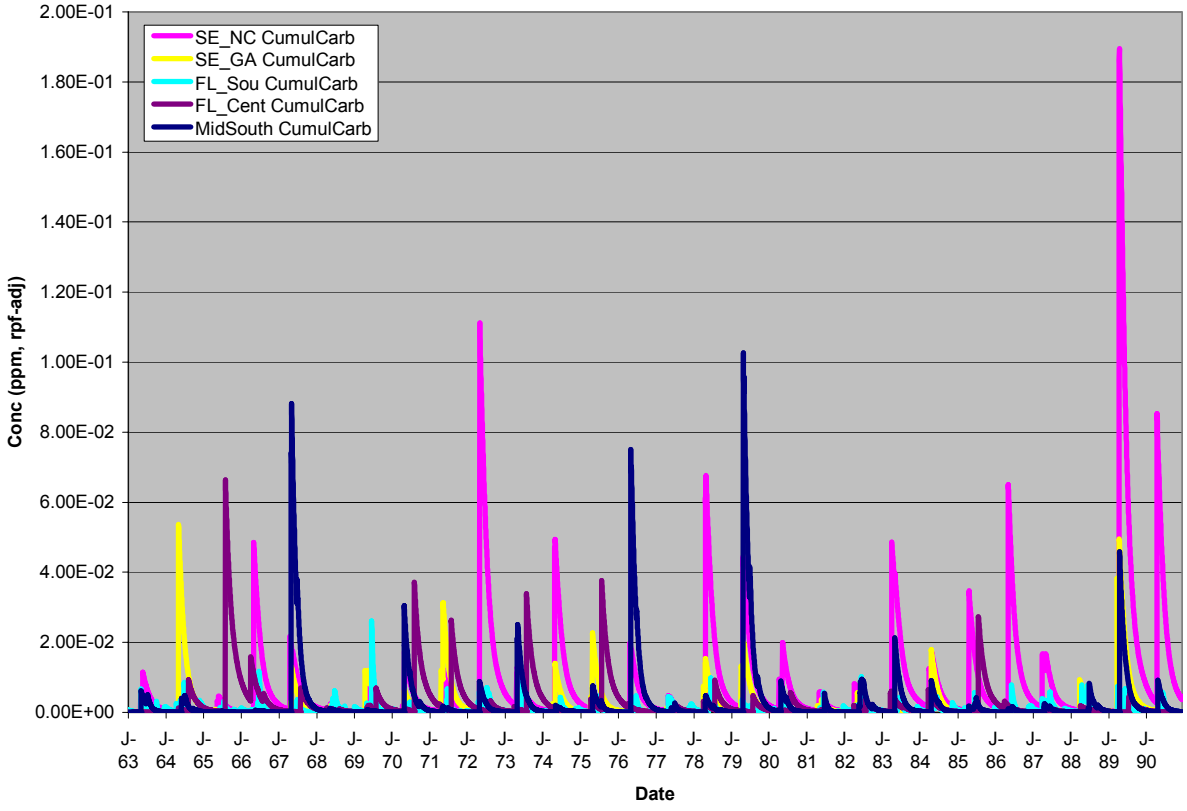
The concentrations in Table 9 for the individual carbamates represent the estimated combined exposure from all of the crops modeled for that particular pesticide. Individual carbamate exposures have not been adjusted for relative potency while the cumulative carbamate exposure in each region reflects the relative potency adjusted concentrations.

Estimated concentrations of the individual carbamate pesticides in each of the regional surface water scenario sites were in the sub-parts per billion

range. Only Chemical B reached a maximum concentration in the single parts per billion in the northeast NC site.

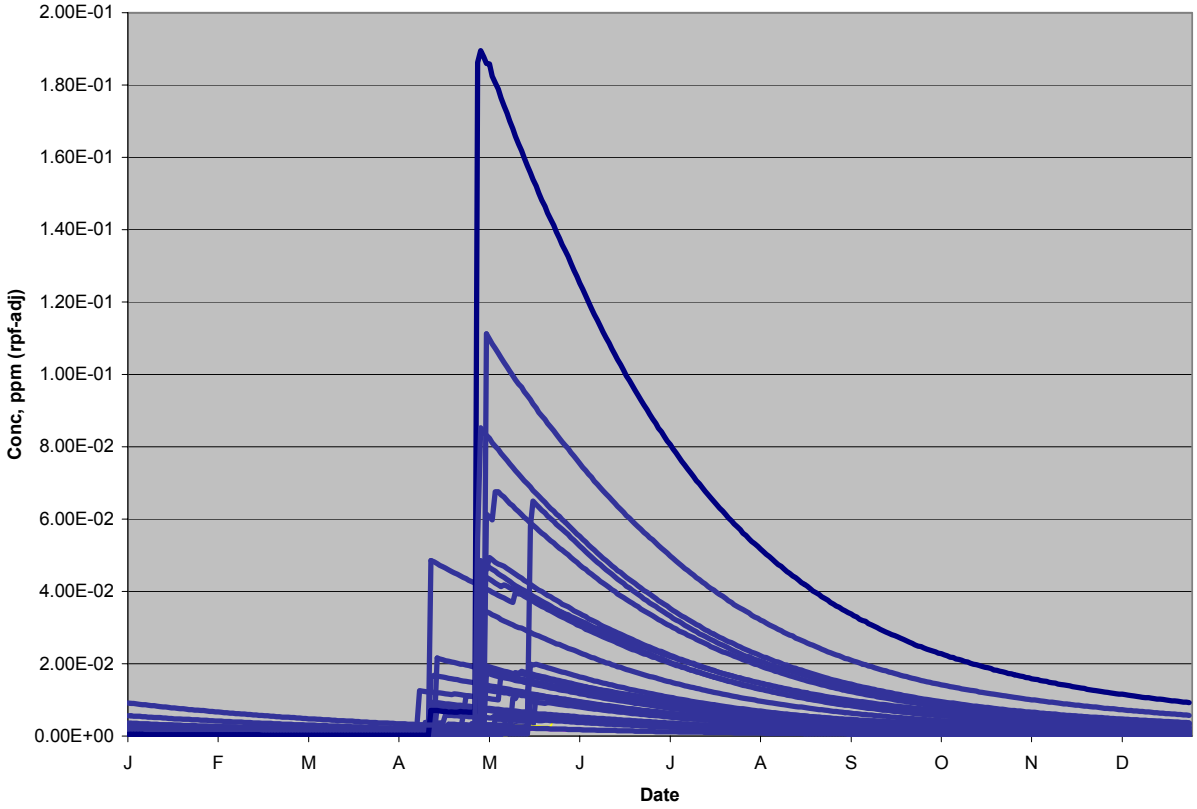
Figure 6 illustrates the year-to-year variability in predicted cumulative carbamate concentrations in surface water sources of drinking water. For the exposure assessment, pesticide usage (amount, frequency, timing) was held constant so the variations reflect the range in variability in pesticide concentrations based on weather patterns over time.

Figure 6. Estimated cumulative carbamate distribution in surface water at the five regional scenario sites.



The seasonal trend of pesticide exposure for the northeastern NC scenario site is illustrated in Figure 7. The aggregated cumulative exposure to humans will reflect this seasonal pattern, with the greatest exposures from drinking water occurring in late spring and summer (May-July), dropping to negligible levels during the rest of the year.

Figure 7. Seasonal trend in cumulative carbamate concentrations in surface water in the Southeast Region (30 years of weather). Each line represents the time series over a single year.



3. Estimated Cumulative Distribution in Ground Water

The estimated cumulative carbamate distribution in ground water will be derived using one of the models presented in a separate document submitted to the SAP. Depending on the recommendations of the SAP, EPA will use one or more of the models discussed in the evaluation paper to generate estimated concentrations over time for combined carbamates in ground water sources of drinking water.

E. Characterization of Drinking Water Exposures in the Case Study

The regional water exposure assessments are designed to represent exposures from typical carbamate usage conditions at one of the more vulnerable surface watersheds in the region. Each regional assessment focuses on areas where combined carbamate exposure is likely to be among the highest within the region as a result of total carbamate usage, adjusted for relative potencies, and vulnerability of the drinking water sources. In this manner, OPP is confident that if the regional cumulative risk assessment finds that exposure in water is not a significant contributor to the overall carbamate exposure, it will not be a significant contributor in less vulnerable areas in the region. However,

because the assessment is based on typical usage, it is not a high-end estimate of pesticide exposure at that vulnerable site.

In this case study, the surface water exposure site in northeastern North Carolina had the highest predicted carbamate cumulative concentrations of the five sites for which predicted concentrations were generated. When the drinking water component was combined with the food and residential exposure routes in the cumulative assessment, the highest seasonal exposures from surface water sources of drinking water were approximately an order of magnitude less than those estimated for food or for the total carbamate exposure from all routes. For most of the year, predicted exposures from drinking water were much lower.

Although a detailed comparison of the estimated concentrations from individual carbamates with available monitoring has not been done for this case study, very preliminary comparisons indicate that this assessment is by no means worst case or unrealistic. The estimated peak concentrations for Chemicals B, C, and E were similar to the maximum detections reported in the USGS NAWQA program. Estimated peaks for Chemicals A and F were roughly an order of magnitude less than the maximum reported detections from NAWQA. A more extensive comparison of estimated carbamate concentrations with monitoring data will be conducted for the preliminary carbamate cumulative risk assessment to be released in 2005.

The discussion that follows characterizes the results of the regional water exposure distributions, and identifies assumptions and approaches to the assessment that might impact the level of certainty in the results.

1. What Each Regional Site Represents

Each region in the assessment is represented by a geographic area with the highest apparent potential for cumulative exposure to carbamates in drinking water. This was done by identifying drinking water source in each geographic area where relatively high usage of multiple carbamate pesticides coincided with watershed or aquifer properties that would facilitate the movement of pesticides to the drinking water source.

Because the selection process took into account the relative potencies of the carbamates pesticides, the sites used for the initial drinking water exposure estimates are biased toward the areas in which the more toxic carbamates are used. Since the purpose of the assessment is to identify the impact from multiple carbamates occurring in water in the same area, the area(s) selected for the assessment do not necessarily represent the highest exposure of a single chemical, but rather the highest multiple carbamate exposure within the region. Since pesticide use may vary from year to year and cropping and usage patterns may change, some areas in other parts of the region may have greater water exposure in a given year.

2. What the Models Represent

For the surface water sources of drinking water, OPP used PRZM/EXAMS to predict pesticide concentrations in a small reservoir. This modeling approach makes certain assumptions regarding the nature of the drinking water source, the watershed, and year-to-year variability.

The reservoir used for the exposure assessment is based on the specific geometry (watershed and reservoir size) of an actual reservoir (Shipman City) in the Midwestern US. As such, it may best represent potential transport to similar drinking water sources in high rainfall areas such as the midwest and eastern U.S. It may not so well represent reservoirs in drier parts of the west, where inflow and outflow are artificially managed. In addition, while the reservoir scenario will not necessarily reflect short pulses of higher concentrations found in flowing rivers and streams, long-term average concentrations in a reservoir may be greater than in streams because of differences in the residence time for water in these water bodies.

PRZM is not a basin-scale model, but a field-scale model which estimates edge-of-field pesticide loads in runoff from a 172.8-hectare watershed into a 5.3-hectare reservoir (144,000 m3 volume) simulated by EXAMS. PRZM does not explicitly account for the relative contributions of each field to the reservoir. OPP used a cumulative adjustment factor (a combination of the regional percentage of the total watershed area in crops with carbamate uses and the percentage of acres treated by each carbamate on each crop) to adjust the resulting reservoir concentrations calculated by EXAMS. Further information on the assumptions involved in applying Percent Crop Area (PCA) factors for drinking water assessments of individual pesticides can be found in the science policy paper, "Applying a Percent Crop Area Adjustment to Tier 2 Surface Water Model Estimates for Pesticide Drinking Water Exposure Estimates" (USEPA, 2000).

PRZM does not account for location in the watershed: all fields are assumed to be uniformly distributed within the watershed, with runoff going directly into the reservoir. Each crop use simulated in PRZM assumes that the entire area of the watershed planted in the crop consists of a single soil. In each of the regions, OPP used actual soil data from local soils on which the crops are grown. When possible, the soil selected for each scenario was a benchmark soil that was prone to runoff (classified as hydrologic group "C" or "D" soils). While OPP attempted to simulate soils that might be prone to runoff, the emphasis in developing the scenarios was to choose important local soils for which sufficient data are available, and which are know to be used to grow the crops of interest. These soils may not represent those most prone to runoff, but afford reasonable certainty that the simulation represents local soil conditions. While an assessment using a single soil assumes that each part of the

watershed will be equally vulnerable to runoff, areas of higher and lower runoff vulnerability will exist in an actual watershed.

Because the application rates, frequencies, and timing are held constant, the PRZM/ EXAMS simulations over multiple years evaluate the impact of the variability in precipitation on the amount of pesticide that reaches surface water. Because weather data spanning 30 years is available for many locations across the country, PRZM/ EXAMS can account for pesticide runoff from a wide range of weather patterns not otherwise possible with monitoring studies that span relatively few years. The age of the data (1961 to 1990) limits OPP's ability to compare of the modeling output to more recent monitoring data.

Weather data files for PRZM are available for weather stations across the country. The weather station nearest to the county or counties used for the simulations was chosen for the cumulative assessment. To the extent that precipitation in these counties over the period of record might have been greater or less than that recorded at the nearest weather station, runoff for that area may have been over- or underestimated by PRZM.

3. What the usage information represents

Typical application rates and frequencies for each carbamate pesticide on each crop were generated by taking the average (spanning multiple years) of agricultural chemical usage surveys. This assumes that all applications were made at this typical or average rate and that frequencies of applications were constant year to year. The assessment considered only yearly variations in weather, and not variations in application rates. Thus, using these typical application rates and frequencies may underestimate water concentrations in years when pest pressure is higher than in our reported years and may overestimate in years when lower amounts of pesticide is used. The usage data was generally not sufficient to conduct a probabilistic assessment over a distribution of actual application rates.

In the OP cumulative risk assessment, the agency compared cumulative OP distributions estimated using the average application rates with those estimated using maximum label rates. The difference in estimated cumulative distributions between all typical and all maximum rates ranged from no difference in all but the lowest percentiles in Florida to a factor of 2 to 4 times greater at the higher percentiles (95th and above) in the Southeast and Mid-south Regions (USEPA OPP, 2002). EPA plans to conduct a similar comparison for the carbamate assessment.

The regional percent crop area (PCA) factors are based on a large area: the size of the hydrologic units (average > 1000 square miles) used

generally span multiple counties and may contain several watersheds that supply drinking water intakes. These regional PCAs represent the aggregation of crop areas from county-level NASS data and assume that the cropping area is uniformly distributed. However, cropping intensity is variable and smaller watersheds, including those capable of supporting drinking water supplies, may have a much higher percentage of crop land than the rest of the large basin.

The typical application rates and percent acres treated are derived from state-level data and assume uniform use practices across the state. Indeed, an uneven distribution of application rates and percent acres treated is expected in response to differing pest pressures. This assumption will underestimate areas where pest pressures may dictate a higher percentage of acres treated in a given year; similarly, it will overestimate areas where low pest pressures will require fewer acre treatments.

OPP used crop profiles and other relative crop production publications to establish a window for the application date of the pesticide on a particular crop. This window doesn't necessarily reflect the range over which a pesticide will be applied in a particular year, but captures the year-to-year variation in the application dates over time. Thus, in any given year, the timing of application may be clustered within a shorter time-frame than suggested by the application window. However, because of weather and other environmental factors, the timing of intensive pest pressure and/or pesticide application may vary across the window.

The date of application can have an effect on the predicted concentrations generated by PRZM/EXAMS, depending on how near in time the pesticide application coincides with rainfall events in any given year. OPP evaluated the impact varying the dates of application across the application window on the OP cumulative distribution (US EPA OPP, 2002). The impact of varying dates of application was most evident at the extremes in the distributions. The ratio in maximum concentrations between the lowest and highest estimates was a factor of 5 to 6. For 99th and lower percentiles, the differences were not as dramatic, with the ratio between lowest and highest values generally two or less. This analysis only looked at the cumulative OP distribution and did not evaluate variations in individual chemical distributions.

In the absence of data to show otherwise, OPP assumed that all of the pesticide applied on a particular crop is done on the same date. While this may be an unreasonable assumption for a large watershed, it is not unrealistic for the size of the watershed used in this assessment. This assumption may result in higher peaks, but similar overall average concentrations than if applications are spread out over time. The resulting estimate of exposure may result in a small overestimation bias in the results that will be greater in large than in small watersheds.

VI. Residential NMC Cumulative Risk

A. Introduction

The EPA's Office of Pesticide Programs (OPP) uses calendar based models (Lifeline, CARES and Calendex™) to assess aggregate or cumulative exposures by incorporating the dietary route with other exposure pathways taking into account the temporal aspects of the residential use of pesticides and the geographic influences of agricultural pesticide use impacting regional drinking water sources. The NMC cumulative risk assessment will involve 8 geographic regions throughout the continental United States (see Figure 8).

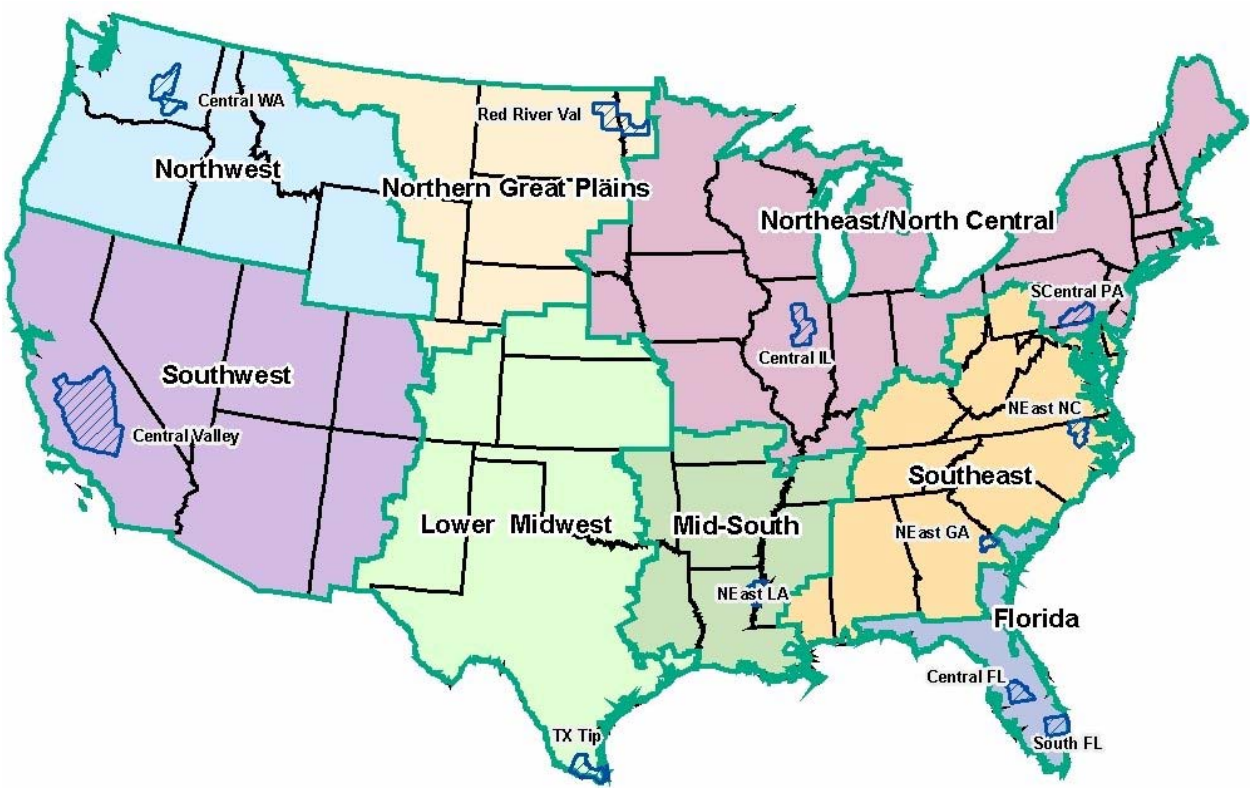
In nearly all cases, the residential exposure scenarios were developed using proprietary residue and exposure data. Exposure factors such as breathing rates and durations of time spent indoors or outdoors were taken from various sources including the Agency's Exposure Factors Handbook (USEPA, 1997a). For the majority of residential uses considered in this assessment, the full range of exposure values – expressed as uniform, log-normal, triangular, or cumulative distributions - are used, where appropriate, rather than relying on point estimates. While the dietary and drinking water assessment address only the oral exposure route, the residential assessment considers the dermal and inhalation exposure routes as well as the oral route, which is based on the mouthing behavior of young children.

In the OP CRA, the temporal aspects of residential pesticide applications were evaluated by relying on information provided in registered labels, survey data such as the National Home and Garden Pesticide Use Survey (NHGPUS) and publicly available information provided by State Cooperative Extension Services. These information resources were comprehensively used to identify information such as frequency of applications and the seasonal appearance of target pests. In the NMC CRA, EPA relied on a national pesticide usage diary survey delineating day of application of registered pesticide products. This longitudinal survey also captures incidences of co-occurrence of residential uses of the same pesticide or similar pesticides on the same day. The survey was conducted by the National Family Organization on behalf of the Residential Exposure Joint Venture (REJV). Additional details regarding this survey and the specific REJV survey data used in this case study is presented in Appendix 1.

B. Scope of Regional Assessments

There are three NMC pesticides for consideration in this cumulative assessment. Chemical A has foliar applications to lawns, fruit trees, vegetable and flower gardens, and ornamental trees and shrubs. Chemical A also has registrations of impregnated pet collars. Chemical G has registered uses as an indoor crack and crevice spray and impregnated pet collars. Chemical H has soil treatments for the control of slugs and snails in and around ornamental plants.

Figure 8. NMC Pesticide Cumulative Assessment Regions



C. Residential Scenarios

The Residential Scenarios addressed in this document represent critical NMC uses that have the potential for significant exposure or risk when considered in a cumulative assessment. A brief description of each of these is provided below:

- **Lawn care applications:**

  Chemical A (adult applicator and adult and child post application exposure)

  Chemical A may be applied by homeowners or by professional lawn care operators (LCO). There are granular and spray-able formulations that can be made by consumers using push-type spreaders and hose-end sprayers respectively.

- **Home gardens:**

  Chemical A (adult applicator and post application exposure)

  The home garden scenarios include ornamental and gardens. Chemical A may be applied as a spray or a dust to vegetable gardens and

ornamental flowers by using a small hand duster. It may also be sprayed to fruit trees and ornamentals (flowers, trees and shrubs) using a small hand held pump sprayer or hose-end sprayer. A small hand held pump sprayer may also be used to spray vegetable gardens.

- **Pet Collars:**

Chemical A (adult and child post application exposure)

Chemical G (adult and child post-application exposure)

Chemical A and G are also formulated as impregnated pet collars. Post application exposure to the collar is also expected to be lower than conventional sprays or dips due to a smaller area being treated (area around the neck rather than the whole body).

- **Indoor Crack and Crevice Sprays:**

Chemical G (adult applicator and adult and child post application exposure)

Chemical G is registered as a crack and crevice spray. Uses include sprays being made to cracks and crevices inside households typically along baseboards and to small areas behind cabinets and under appliances. For this assessment, it is assumed that spray-able formulations (e.g., wettable powders) may be applied by professional pest control operators (PCO). Consumers may make crack and crevice treatments using hand-held pressurized spray cans.

- **Ornamentals/Trees:**

Chemical A (adult applicator exposure)

Chemical H (adult applicator exposure)

Chemical A may be applied to ornamentals and trees. Chemical A may be applied as a dust to ornamental flowers by using a small hand duster. It may also be sprayed to fruit trees and ornamentals (flowers, trees and shrubs) using a small hand held pump sprayer or hose-end sprayer. A small hand held pump sprayer may also be used to spray vegetable gardens.

Chemical H may be applied to the soil in and around ornamentals used in a can as a bait.

D. Exposure Routes/Scenarios Considered

The routes of exposure considered in this cumulative assessment varied depending on certain application and post-application exposure activities which were determined to be age group-specific. The specific exposure routes and pathways/scenarios which were considered in this NMC assessment are summarized in Table 10 and described in additional detail below:

Table 10. Specific Exposure Routes and Pathways/Scenarios

Scenario	Population	Applicator			Post Application		
		Oral	Dermal	Inhalation	Oral	Dermal	Inhalation
Lawn/Turf	Adults		X	X		X	
	Children 1-2				X	X	
	Children 3-5				X	X	
Home Garden	Adults		X	X		X	
	Children 1-2						
	Children 3-5						
Indoor (c&c)	Adults		X	X		X	X
	Children 1-2				X	X	X
	Children 3-5				X	X	X
Pet Collars	Adults					X	
	Children 1-2				X	X	
	Children 3-5				X	X	
Ornamental Plants and Trees	Adults		X	X			
	Children 1-2						
	Children 3-5						

<u>Oral Route of Exposure:</u> Oral ingestion via hand-to-mouth activity of children was the only oral route of exposure considered in the residential portion of this assessment. Specifically, oral hand-to-mouth ingestion was considered only for the age group Children 1-2 and 3-5 for their activities on treated lawns and through indoor crack and crevice and pet collar uses. OPP acknowledges that there are very limited data on exposure to young children; in general, however, children ages six and older no longer exhibit mouthing behavior to the degree seen in younger children such as placing hands and /or objects into the mouth. In addition, while OPP recognizes that non-dietary pathways other than through hand-to-mouth activities do exist such as ingestion of soil and mouthing of grass, these latter two pathways are not considered because they had little impact on the exposure assessment when they were addressed in the individual chemical risk assessment.

Dermal Route of Exposure: The dermal route was assessed for adults applying consumer pesticide products to lawns and gardens and ornamental plants and trees as well as an indoor crack and crevice spray. The post-application dermal route of exposure was considered for both children and adults for assessing the lawn, indoor crack and crevice and pet uses. The dermal route was also assessed for adults reentering treated home gardens and having contact with ornamentals and trees. Children are considered in a separate group from adults because of the potential for additional exposures that result from a higher skin surface area to body weight ratio. In general children six and older have a surface area to body weight ratios that are similar to adults.

Inhalation Route of Exposure: The inhalation route of exposure was considered for adults and children. Specifically, inhalation exposure is for assessed for adults applying pesticide formulations to lawns, to home gardens and ornamental plants and trees, and as indoor crack and crevice sprays. Inhalation is also being assessed for adults and children living in households treated with Chemical G as a crack and crevice spray.

E. Data Sources

Three basic types of data were considered in this assessment: pesticide use data, residue concentration and dissipation/decay data, and residue contact and exposure factor data. Together, this information can be used to predict the potential for co-occurrence of exposure events in aggregate and cumulative assessments. These data are described in more detail below.

Pesticide Use Data: A variety of survey data were used to determining the use and timing of applications. These details are presented in Appendix 1.

Residue Concentration Data: Residue concentration data and associated pesticide decay/dissipation parameters are used to define the sources and magnitude of exposure resulting from human contact with foliar resides in home gardens, orchards, and lawns. Chemical A used a 9 day half-life that with residues set to zero 30 days after application. Chemical G employed a linear rate of degradation which was set to “0” 6 days after application (i.e., 16% degradation per day).

Exposure Factor (Contact) Data: Exposure factors such as the amount of time spent in an area, whether the exposure is occurring indoors or outdoors, and whether the residue source is a golf course or a lawn (and if the latter, its size) are critical for estimating exposures to a given substance.

For example, an important variable for estimating home-owner applicator exposure is the size of the lawn. OPP considered the average and median lawn sizes reported in a journal article by Vinlove and Torla (1995). The means and medians were ~13,000 ft2. However, the authors noted problems interpreting the data since it is based primarily on low income houses and consists of

adjustments of the lot size by the house's foundation (footprint) only. The data do not consider other structures such as decks or other green space such as gardens, which can reportedly reduce the lot size by up to 50%. Similar lawn sizes were noted in an extensive survey conducted by the Outdoor Residential Exposure Task Force (ORETF) with similar problems encountered with respect to confounding variables such as decks and other green spaces. For this assessment, OPP used a uniform distribution for lawn size bounded by 1000 ft2 and 20000 ft2. For spot treatments of lawns, OPP assumed a uniform distribution for treated area bounded by 100 ft^2 and 1000 ft^2, with application rates distributed uniformly between 2 and 4 lb ai/A, 2 and 8 lbs ai/A, and 4 and 8 lbs ai/A for dust liquid handwand, and liquid hose-end sprayers, respectively.

Another important variable for addressing post-application exposure from home lawn treatment is the duration of time spent on lawns. In this NMC CRA, cumulative distributions of durations on lawns of up to two hours were used to address adult exposure on lawns. These data are presented in Table 15-64 in EPA's Exposure Factors Handbook; however, OPP notes that the percentiles above the 95th have the same values (121 minutes). A similar cumulative distribution was given for children ages one to four. In order to be protective of children and to address the uncertainty of the upper percentiles of the exposure factor data, OPP selected a cumulative distribution from the Exposure Factor Handbook's Table 15-80 with a bound of 3.5 hours for children. This distribution represents the amount of time spent outdoors rather than just on lawns. This adjustment allows for additional time that children may spend outdoors (such as parks and schools) where there is potential for additional contact with treated turf.

F. Exposure Scenarios

This assessment considered a variety of exposure scenarios for consumer applicators and consumer post-application exposures. Each of these is described in additional detail below.

1. Lawn Care Exposure Scenarios

a. Lawn Applicator Dermal and Inhalation Exposure

Only Chemical A has registered lawn uses and all lawn exposure scenarios were performed for this chemical only. There are three formulations of Chemical A that are available for lawn use: granular formulations, dust formulations, and liquid sprayable formulations. However, exposures from the granular formulation were not used in this case study since exposure values from the hose-end sprayers are higher than for the rotary granular spreaders and are thus considered to be a conservative estimate of residential applicator exposure to Chemical A. Both dermal and inhalation exposure routes were considered. Exposure data from a hose-end sprayer residential applicator study was used to generate

normalized values expressed as milligrams exposure per pound of active ingredient of a pesticide handled (referred to as unit exposures, or UE). Total exposure is calculated as the produce of the UE (either dermal or inhalation) the application rate, and the lawn size. Volunteers participating in these exposures studies were adult non-professionals who use pesticides on their own gardens and lawns. Many of the volunteers selected as subjects in these studies were members of garden clubs. All volunteers made their applications without specific instruction from the study investigators. Unit exposures estimated from these studies cover various clothing scenarios that range from wearing short pants and short sleeved shirts, to long pants and long sleeved shirts. The triangular distributions used for unit exposures for the lawn applicator scenarios for Chemical A are shown in Table 11:

Table 11. Triangular Distributions Used for Chemical A

Application Method	Exposure Route	Unit Exposure Distribution (mg/lb ai)	Comments
Hose-End Sprayer	Dermal	T(0.017, 0.53,33)	This distribution used ONLY for lawn scenario
	Inhalation	T(0.0006, 0.015,0.088)	
Liquid Handwand	Dermal	T(7.99, 29.89, 354.4)	These distributions also used for home vegetable and ornamental/tree scenarios
	Inhalation	T(0.002, 0.0025, 0.0142)	
Dust Shaker/Powder	Dermal	T(7.99, 104.5, 1375)	These distributions also used for home vegetable and ornamental/tree scenarios
	Inhalation	T(0.00044, 0.72, 8.29)	

NOTES:
- ❑ T(x, y, z) represents a triangular distribution with a minimum value of "x", a most likely value of "y", and a maximum value of "z". For the preliminary assessment, OPP will be conducting a further, more detailed investigation of the distributional forms of these unit exposures and will likely be replacing these triangular distributions with lognormal distributions.
- ❑ Information derived from studies conducted by ORETF (Outdoor Residential Exposure Task)

For application rates, a uniform distribution bounded by the low and high and low application rates of 2 to 8 pounds per acre was used. For lawn size, OPP selected a uniform distribution of lot sizes ranging from 500 to 20,000 ft^2. The lower end of this range considers smaller lawns for residences such as town houses. Information in a survey conducted by the ORETF also indicates that many pesticide users make spot treatments of insecticides. The upper bound of 20,000 ft^2 (~ ½ acre) appears reasonable given the type of application equipment assumed to be used by residential applicators.

b. Lawn Post-application Dermal Exposure

The fate of pesticides applied to turf, and subsequent human contact, is a key variable for assessing post-application dermal exposure and can be an important exposure pathway to consider as part of a cumulative assessment. This exposure pathway was evaluated here in the NMC Cumulative Risk Assessment by using data from a number of available studies (described in more detail below). Briefly, post-application dermal exposure (mg pesticide) is calculated by multiplying the transfer coefficient (cm^2/hr) derived from literature and other studies by the time spent on the lawn (hr) and the residue concentration on the lawn (mg/cm^2). For this assessment, the transfer coefficient and the time spent on lawns were represented by a distribution of values while the residue concentration on the lawn was represented by a time series of concentration values (which accounted for residue degradation over time and incorporated the relevant half-lives or decay coefficients).

The transfer coefficients used in this equation were developed by dividing the hourly dermal exposure (µg/hr) obtained from a set of activities in the dermal exposure studies by the measurement commonly referred to as turf transferable residues (TTR) (µg/cm^2). Deposition estimates (a.i. per acre) were assumed to have a TTR transferable efficiency of 1 percent. This corresponds to the transfer efficiency of 1.2 percent observed in the Chemical A TTR dissipation study. Transfer efficiency is derived by dividing the measured TTR (µg/cm^2) by deposition (µg/cm2) times 100. Again, since none of the dermal exposure studies used to estimate hourly exposure in the above chemical specific residue studies permitted direct calculation of the TTR, the transfer coefficients for this assessment were developed by assuming a transfer efficiency of one percent for spray formulations. This was done for two reasons:

- To make use of available dermal exposure measurements in the above studies which are not influenced by TTR method, and

- To make use of the available residue dissipation data for which there are no corresponding dermal exposure transfer coefficients

A more detailed discussion of the relationship of transfer coefficients and TTRs can be found in the "Overview of Issues Related to the Standard Operating Procedures for Residential

Exposure Assessment" presented to the FIFRA Scientific Advisory Panel on September 21, 1999.

Using the above-indicated calculation methodology, several exposure studies were used to assess post application dermal exposure to individuals reentering treated lawns. Separate studies are available, and used, for children and adults. These studies are described in additional detail below]:

Children's Exposure: A study by Black (1993) investigated dermal exposure values of young children who were exposed to a non-toxic substance used to represent a spray application scenario. In this study, children performed unscripted activities on turf treated with a non-toxic substance used as a whitening agent in fabrics. The subjects of the study were 14 children aged four to nine years old. The children performing the unstructured activities were provided toys and were observed in the treated area for a period of one half hour. Activities recorded included the following classifications:

- Upright (standing, walking, jumping and running)
- Sitting (straight-up, cross legged, kneeling, crouching and crawling)
- Lying (prone or supine)

Dermal exposure was measured by fluorescent measurement technology described in Fenske et al., (1986). Measurements on various body parts were expressed as ug/body part (e.g., hand, face, etc.) and as concentration (ug/cm^2). These concentrations were normalized to represent the surface area of children three to four years of age for use with a standardized body weight of 15 kg. Standard surface area values were taken from the Agency's Exposure Factors Handbook. The transfer coefficients which were estimated from this study are shown in Table 12.

Table 12. Transfer Coefficients (cm^2/hr) for Dermal Exposure to Lawn Uses for Children 1-6 Years of Age

2844
3594
3776
4051
4103
4357
4902
6812
8395
8746
9119
9885
10713
16008

A lognormal distribution was used to fit these transfer coefficients values and an arithmetic mean and standard deviation for each distribution was calculated[9]. Specifically (for children's exposures) the NMC cumulative assessment used a distribution for the transfer coefficient represented by a lognormal distribution with an arithmetic mean of 7265 cm^2/hr and a standard deviation of 4621 cm^2/hr . The lognormal distribution was truncated at the calculated 99th percentile of the distribution (i.e., 23,769 cm^2/hr for the spray application in order to avoid a distribution which contained values that were well-beyond those that are deemed reasonable.)

Adult Exposures: In a second study (Vaccaro, 1993) in which a granular formulation was used, eight adults performed structured activities intended to mimic a child's activities including walking/running, sleeping, crawling, and sitting on turf.

The subjects performed these activities for a period of four hours beginning four hours after the turf had dried. Turf had been treated earlier with a sprayable form of chlorpyrifos and exposure was estimated in the study by monitoring the amount of a chlorpyrifos metabolite – excreted over the following period of 6 days. This method directly measures internal dose and was used to back-calculate a generic "to the skin" transfer coefficient by using chemical specific dermal absorption data for chlorpyrifos (Nolan et al., 1993. These data are presented below in Table 13:

[9]See Appendix 3 of "Guidance for Submission of Probabilistic Human Health Exposure Assessments to the Office of Pesticide Programs [draft dated 11/4/98] available at http://www.epa.gov/docs/fedrgstr/EPA-PEST/1998/November/Day-05/6021.htm for more information.

Table 13. Transfer Coefficients (cm^2/hr) for Dermal Exposure to Lawn Uses for Adults 18 Years of Age and Older

3348
6770
7217
8779
9895
11243
13169
13243

A lognormal distribution was used to fit these transfer coefficients values and an arithmetic mean and standard deviation was calculated. Specifically (for these adult exposures), the NMC cumulative assessment used a distribution of values for the transfer coefficient characterized by a lognormal distribution with an arithmetic mean of 9,784 cm^2/hr and a standard deviation of 5,515 cm^2/hr for the spray application. The lognormal distribution was truncated at the calculated 99th percentile of the distribution (i.e., 28,907 cm^2/hr.

c. Lawn Non-Dietary Hand-to-Mouth Behavior Exposure

The assessment also incorporated exposure from hand-to-mouth activity by children on lawns. Briefly, exposure through this pathway is calculated as the product of the following factors: hand-to-mouth contact frequency (hr-1), surface area of inserted hand parts (cm^2), saliva extraction efficiency (unitless), wet hand adjustment factor (unitless), and hours spent on lawn (cumulative distribution).[10]

Surrogate data to evaluate non-dietary ingestion through hand-to-mouth behavior in young children consist, in part, of observations reported in Reed et al., 1999 concerning the

[10]The cumulative distribution used for hours spent on lawn by children was obtained from the Exposure Factors Handbook and represents a cumulative distribution for "do-ers" only, i.e., a cumulative distribution for only those children that reported spending at least SOME time on the lawn (i.e., it does not consider that some children on any given day DO NOT spend time on the lawn). Thus, the cumulative distribution assumes that some time is spent on the lawn by each child. To the extent that this overestimates time spent on the lawn, this overestimates exposure by this pathway. On the other hand, this cumulative distribution for time spent on the lawn is not stratified by season. To the extent that children spend time on the lawn during the seasons which applications occur, this may underestimate exposure. On balance, however, OPP believes that the distribution used is a reasonable, yet conservative estimate of time spent on the lawn during the relevant portions of the year.

frequency of hand-to-mouth activity. This study addressed the mouthing behavior and other observations of children situated indoors, ages three to six at day care (n=20) and children ages two to five at home (n=10). The children were video taped and the frequency of hand-to-mouth events was enumerated after the taping. The hourly frequencies of the hand-to-mouth events reported were a mean of 9.5 events per hour, a 90th percentile of 20 events per hour and a maximum of 26 events per hour. These data were used to construct a triangular distribution to represent the frequency of hand to mouth activity bounded by a low value of 0 events/hr, a most likely value of 20 events/hr and a high value of 26 events/hour.[11]

The observations reported by Reed, and discussed above, are based on children in real world settings. However, they provide little information regarding the characterization of the hand-to-mouth event, residue transfer efficiency, or extraction efficiency of the residues on the hands by saliva during the mouthing event. For these values, additional assumptions and studies to address the transfer efficiency of turf residues by wet hands are needed. Variables addressing this exposure pathway are discussed in the below:

- Based on previous conversations with the SAP, each hand-to-mouth event has been estimated to equal one to three fingers or 6.7-20 cm^2 per event. To account for the fact that a child may touch nothing between successive events, and the fact that the event may not result in insertion of fingers at all (Kissel et al., 1998), a uniform distribution of 0 to 20 cm^2 per event was assigned. The Agency is aware of additional data addressing this factor and will consider it upon further analysis and availability in the published literature.

- Hands wet from saliva are reportedly more efficient at residue transfer than dry hands. A uniform distribution of transfer efficiency multipliers of 1.5 to three times was selected to address the increased efficiency of wet hands. Wet hands had higher transfer efficiencies than dry hands and other TTR methods addressed in a study performed by Clothier et al., 2000. The TTR methods used in the study had similar efficiencies as the chemical specific lawn residue data (TTR data) used in this assessment.

[11]This error was noted during the QA/QC phase of this assessment. In the preliminary cumulative risk assessment, a triangular distribution with a low value of 0 events/hr, a most likely value of 9.5 events/hr. and a high value of 26 events/hour will be considered

- To address the removal of residues from the hands by saliva during the mouthing event several studies were considered. The removal efficiency of residues on hands by saliva and other substances (e.g., ethanol) suggests a range of removal efficiencies from 10% to 50% (Geno et al., 1995; Fenske and Lu 1994; Wester and Maibach 1989; Kissel et al., 1998). Thus a uniform distribution of 10% to 50% was used in this assessment.

- The time spent on the lawn was estimated as a cumulative distribution ranging from 0.25 hours to 3.5 hours. This data was obtained from the Exposure Factors Handbook and represents children aged 1 to 4 years old. To be protective of children and to address the uncertainty of the upper percentiles of the exposure factor data, OPP selected a cumulative distribution from Exposure Factors Handbook Table 15-80 with a bound of 3.5 hours for children. This distribution represents the amount of time spent outdoors. This allows for the time that children spend outdoors not only at home but also in parks and near schools.

Assessing exposure through the non-dietary ingestion pathway is difficult due, in part, to issues associated with measurement of the above-discussed variables as well as issues associated with the utility of using children's hand-to-mouth frequencies based on indoor activities for outdoor exposure scenarios. There are also differences in mouthing behavior based on active and quiet play with increased mouthing likely to be during activities of quiet play. Limited data evaluated by Groot et al., 1998 suggests there can be longer durations of mouthing activities for children aged six to 12 months (exceeding 160 minutes per day) than children 18 to 36 months (up to 30 minutes per day). However, children in this age group are not likely to be engaged in the higher post application lawn activities which OPP is currently modeling. Additional data for very young children (under the age of two) are needed in addition to delineating the frequency differences between hand-to-mouth events for children engaged in active and quiet play. The Agency recognizes this is an evolving field of study and that additional research is also needed to evaluate the distribution of behaviors across different age ranges with a view towards the influence of factors such as socioeconomic status. Additional data have been collected addressing the frequency of hand-to-mouth events and surface area of the hand that is mouthed. These data are being considered to see if there is any significant impact on this assessment.

2. Home Garden Applicator and Post Application Exposure Scenarios

Chemical A has registered uses on both home gardens and ornamental plants/trees. This assessment includes scenarios for chemical A using dust formulations (hand/shake), and liquid hand wand. While there are other possible application methods for use on these sites, these two were selected based on use and exposure considerations. There are no special application methods for chemical A use on trees that lead to different exposures from its use on ornamental plants. This assessment also includes bait use of Chemical H on ornamental plants.

a. Applicator Exposure

As described for dermal lawn applicator exposure, dermal exposures to applicators in home garden scenarios were similarly calculated as the product of the Home Garden Unit Exposure (mg/lb ai handled), application rate (lbs ai/ft^2), and area treated (ft^2). For vegetable gardens, the area treated was entered as a lognormal distribution (arithmetic mean=135 ft^2, arithmetic standard deviation=1.2 ft^2, and maximum = 8000 ft^2); these dimensions are based on data from the National Garden Survey. For ornamental plants/trees, the area treated was entered as a uniform distribution (minimum 10 ft^2, maximum 2000 ft^2).[12]

The application rates for home gardens were entered as uniform distributions. For the dust scenario, the application rates on home gardens and ornamentals/trees ranged from 0.5 lbs/acre to 2 lbs/acre. For the liquid hand wand scenario, the application rates on both home gardens and ornamentals/trees ranged from 4 lbs/acre to 8 lbs/acre. For ornamental/tree use of chemical H, the application rates were inputted as a single value of 0.2 lbs/1000 sq ft (~8.7 lbs/acre).

The Unit Exposures (UE) for the dust (shake/pour) and liquid hand wand scenarios for chemical A use on vegetable gardens and ornamentals/trees are the same distributions used for the lawn scenario (See Table 11). The UE for chemical H were based on surrogate chemical data. The surrogate data consist of dermal and inhalation measurements of individuals using granular products - a lognormal distribution with an arithmetic mean of 0.18 mg/lb ai, an arithmetic standard deviation of 0.29 mg/lb ai, and maximum value of 1.31 mg/lb ai was used for dermal exposure, and triangular

[12] In the Lifeline model, the size of the vegetable garden is built into the model using the same National Garden Survey data. See Attachment 2.

distribution with a minimum of 0, a most likely value of 0.0065 mg/lb ai, and maximum value of 0.013 mg/lb ai was used for inhalation exposure.

b. Post-Application Exposure

Post-application exposure while harvesting or performing post application maintenance activities in home gardens were assessed using a range of transfer coefficients to account for the diversity of activities. Post application exposure was estimated as the product of a transfer coefficient (cm^2/hr), time spent in the activity (hrs), dislodgeable residue concentration (mg/cm^2).

For chemical A use on home gardens, the transfer coefficient was characterized as a uniform distribution ranging from 370 to 740 cm^2/hr to reflect a range of tasks for gardeners. The time spent harvesting or performing post-application maintenance activities was represented by a uniform distribution ranging from 0.167 hr/day to 1 hr/day. These estimates of time spent in the garden performing post application activities (as well as the frequency of applications) were based on survey data performed by the Outdoor Residential Exposure Task Force (ORETF). The dislodgeable foliar residues (expressed in mg/cm^2) were calculated as a fraction (10% dislodgeable) on the application rates.[13]

3. Indoor Crack and Crevice Scenarios

The only NMC registered for indoor use is chemical G. Chemical specific data are available to assess its use as an indoor crack and crevice treatment applied (for the purposes of this assessment) as either as a pressurized spray (aerosol) by consumers, or as a liquid spray by licensed pesticide control operators (PCO).

a. Applicator Exposure

For this assessment, adult applicator exposures were developed for individuals using the pressurized formula of Chemical G. For this case study, homeowners were assumed to apply between 10% and 50% (uniform distribution) of a 16 ounce aerosol can (0.5% ai) during a single event; this was represented by a uniform distribution for total amount (ai) applied, U (0.008,0.04).[14] The Dermal Unit

[13] The 10% provides similar DFRs as used in the RED, J.Dawson; that was based on surrogate data – ARTF – cabbage. In their CARES assessment, the registrant for chemical A used 1.1% dislodgeable, Day=7.

[14] For the Calendex assessment, we do not explicitly model which rooms were treated, the total area, and the application rates. The applicator exposure algorithm requires only total amount applied - the area treated, and application rates are not needed to calculate applicator exposure. In the Lifeline model, the

Exposures were entered as a uniform distribution bounded by 6 mg ai/oz applied and 16 mg/oz applied.

b. Post-Application Exposure

There was limited data to assess this use. Specifically, air concentration data and dermal contact deposition data presented in MRID 343325601. Air concentration data following liquid crack and crevice sprays were also presented as a uniform distribution with respective minimums and maximums of 0.001-0.007 mg/m3. Breathing rates used are as follows: ages 0-3 (0.5 m3/hr), ages 4-6 year olds (0.6 m3/hr), 7-12 year olds (0.8 m3/hr), and adults 13+ (1.0 m3/hr). For this case study, we did not calculate MET_TIME values from the NHAPS diaries as used in the OP CRA. These point values generally correspond to light activities. Time spent was specified as a uniform distribution, with a minimum with a minimum of 1 hr/day and a maximum of 6 hrs/day.[15]

Estimating post application dermal and incidental oral (htm) exposures for the crack and crevice sprays is difficult due to the variability of the residue data collected on the deposition coupons situated in various locations throughout the treated homes. Also, the treatments are largely meant to be made to inaccessible areas of the house. Dermal exposure is based on a study conducted by Vaccaro 1991 in which adults (wearing swim suits) crawled on treated carpets for a period of 4 hours. A normalized value of 16,700 cm^2/hour is used for durations of up to 8 hours. The Agency is considering other data in which biological monitoring samples following crack and crevice uses were collected. These studies suggest substantially lower internal doses when compared to the Vaccaro data which were based on immediate contact with carpets following a broadcast application. The differences in internal doses are likely to be associated with the obvious differences in treatment strategies (broadcast vs. along walls and under cabinets) and amounts of chemical applied to a given household. In the Vaccaro study, 0.127 grams of a.i. were applied, in the crack and crevice studies, 0.002 to 0.42 grams of a.i. were applied (Byrne, 1998, Krieger, 2001, Hore 2003). In addition, the original deposition data collected in the Chemical G crack and crevice study was supplemented with additional measurements comparing deposition

specific rooms treated are determined by the NHGPUS data, and the room dimensions (area treated) are also into the model's 'Knowledge Tables'; these dimensions are based on various data, including the American Housing Survey. Attachment 2 provides further description of the Lifeline model.

[15]There are various published breathing rates based on various approaches (direct measurement, estimated from daily activities, etc). Considering the activities conducted in the primary locations of use/exposure (kitchen, bathrooms), the breathing rates used here are consistent with those ranges; See Exposure Factors Handbook, Volume I, Table 5-14, p 5-16.

values and hand rubbed across the same treated surfaces. The current assessment is considered a screen and may be refined if needed.

For dermal exposure these deposition values were specified as a uniform distribution, between 0.0003-0.0007 ug/cm^2.[16] The transfer coefficients were specified as a point estimates for adults (16700) and for children ages 1-12 (6000). Ingestion of residues collected by wet hands and removed by subsequent mouthing is estimated as described above in post application exposure to lawn treatments. The only difference is the use of a 10 percent transferable rate rather than 5 percent, which is captured in the adjustment for wet hands (uniform distribution, minimum value of 1.5, maximum value of 3).

4. Pet Use Scenarios

The Cumulative Risk assessment also considered exposures through the use of two flea collar products for Chemicals A and G. Applicator exposure was not directly considered in this assessment since it is expected to be minimal when compared to the post application exposure assumptions which include contact with the collar and respective fur residues.

a. Post-Application Exposure

Post-application dermal exposure scenarios were considered to be applicable to both adults and children while post-application non-dietary oral exposure scenarios (oral hand-to-mouth) were assumed to apply only to children ages 1-6 years old. Chemical specific pet fur residue was used for Chemical A and Chemical G. Frequency, timing, and probability of collar treatments are also incorporated in the Cumulative Risk Assessment.

Dermal Post-Application exposure (to adults and children) was calculated as the product of Residue concentration (mg/cm^2), the Transfer Coefficient (in cm^2/hr), and the Time spent (in hrs/day). A further description of each of these terms is presented below:

Residue Concentration (mg/cm^2: The residue concentration on fur was derived from a study of transferable residues from dogs treated with a flea collar using carbaryl as the active ingredient.

[16] To model dermal contact, an assumption that 10% of the deposited residues presented in the aforementioned study are transferable during dermal contact based on data presented in Clothier 1999. In that study wet hands were pressed onto treated carpets and hard floors to estimate the transfer efficiency of three compounds. The 10 percent value is the highest and is based on the hard surface efficiency (carpets had a maximum of 5% transfer efficiency).

This study evaluated the quantity of carbaryl removed (by petting) from dogs of various sizes and hair lengths for a period of up to 7 days after placement of the collars. A 16 percent carbaryl collar was placed on the dogs and the dogs were petted for 2 ten minute periods on each sampling day by a person wearing a pair of white cotton gloves which were collected for analysis. A separate set of gloves was used for each 10 minute interval but they were combined for analysis so each daily residue measurement per animal represents that removed by 20 minutes of petting. Residues measured on Day 0 (4 hours after treatment) ranged from 0.0004178 mg to 0.0003978 mg/cm^2. These residues were assumed to be available on a daily basis since this is a collar product designed to emit residues throughout it active period (~1 to 3 months). These values were used as point estimates.

Transfer Coefficient (cm^2/hr): The Transfer Coefficient used in this assessment of dermal post-application exposures to adults and children was derived from a carbaryl groomer exposure study in which sixteen different veterinary personnel treated/handled eight dogs each, over a two to five hour time period. These transfer coefficients are presented in Table 14 for adults and children and were derived assuming an average transfer efficiency of 2.97% from the previous OP CRA. For the NMC CRA, the data were used directly to generate an empirical distribution for the dermal transfer coefficient which was selected to range from 179 to 4741 cm^2/hr for adults and from 66 to 1752 cm^2/hr for children. These empirical distributions were used for both Chemicals A and G.

Table 14. Post-Application Transfer Coefficients for Dermal Exposure to Pet Fur Residues (Empirical Distribution)1

Groomer µg exposure	Duration: hrs	µg/hr	ai deposited µg/cm^2*	Dislodged: 2.97 % efficiency assumed / µg/cm^2	Transfer Coefficient (adults) cm^2/hr	Transfer Coefficient (children) cm^2/hr /3
8796	2.88	3054	37.5	1.114	2742	1016
6199	2.58	2403	31.0	0.921	2610	967
1408	3.07	459	18.6	0.552	831	308
2914	2.48	1175	36.4	1.081	1087	403
5667	3.08	1840	32	0.950	1936	717
2527	3.18	795	19	0.564	1409	522
2,348	2.93	801	15.9	0.472	1696	628
2961	2.72	1089	7.75	0.230	4731	1752
1135	4.03	282	14.8	0.440	642	238
14872	3.88	3833	28.8	0.855	4481	1660
1026	3.17	324	16.6	0.493	657	243
13490	4.05	3331	56.98	1.692	1968	729
4275	4.92	869	25	0.743	1170	433
4461	3.45	1293	42.25	1.255	1030	382
1511	3.03	499	8.87	0.263	1894	702
777	3.00	259	48.6	1.443	179	66
				Average	1817	673

1 Source Carbaryl Groomer Exposure Study (activity - wash/dip/groom). Each vet tech treated/handled 8 dogs: held small dogs w/arms and torso; some dogs climbed on person's shoulders while grooming etc.
2 Average transfer efficiency 2.97% =(powder (0.62%) + aerosol (3.3%) +pump spray (5%))/3; .
3 The transfer coefficients derived from this study were adjusted by an allometric scaling factor based on the relative size of children to adults to derive an appropriate transfer coefficient for children Adult:Child surface area ratio - 2.7:1 (avg. Adult 3169: avg child 1174)
*The amount ai per dog was measured in the study along with the animal's weight. The suface areas of the dogs were estimated using an equation for estimating mammal surface area described in the Wildlife Exposure Factors Handbook.

Time Spent (hrs/day): Finally, the time spent in this activity was assumed to follow a triangular distribution with minimum value of 0.0333 hours, a most likely value of 0.108 hours, and a maximum value of 1.025 hours (as per Freeman et al, JEAEE, 2001, 11:501-509).

b. Oral (Hand-to-Mouth) Post-Application Exposure

Post-application exposure through the oral (hand-to-mouth) route was also assessed for children ages 1-6. Specifically, exposures through the hand-to-mouth route were calculated as the product of the residue value (mg/cm^2), saliva removal efficiency, adjustment for wet hands, the finger surface area (cm^2), the frequency of events (hr-1), and the time spent (hrs/day). Surface finger area (per event) was assumed to follow a uniform distribution bounded by 0 and 20 cm^2. The frequency of events was assumed

to follow a triangular distribution with a minimum value of 0.4 hr-1, a most likely value of 9.5 hr-1, and a maximum value of 26 hr-1. For the amount of residues transferred to children's hands and removed during mouthing, a saliva removal efficiency of 10 to 50 percent was used (expressed as a uniform distribution). The time spent with the pet was assumed to follow the same distribution described above for dermal post-application exposures

VII. The Multi-Pathway Cumulative Assessment

As demonstrated in previous chapters of this case study, sufficient data and methods exist to produce detailed, time-dependent estimates of exposure to more than one pesticide by the same pathway (e.g. food, drinking water, or residential). In addition, exposure can be calculated on a route-specific pathway basis as demonstrated for the residential scenarios which incorporate inhalation, dermal and oral components of exposure. Using the same calendar-based approach, it is possible to combine the exposures from the food, water, and residential pathways. To develop a cumulative exposure assessment that is highly descriptive of the likely interactions of the three pathways of exposure -- food, drinking water, and residential -- the contributions from each pathway must be calculated simultaneously for every exposed individual for every day reflected during the time frame of the exposure estimate. In other words, the dietary (food + drinking water) estimate for all pesticides likely to be encountered by an individual on a particular day must be calculated. The exposures from residential uses must also be calculated and the combination of these sources of exposure combined for each individual in the assessment. This process is repeated for each individual's exposure on each simulated day in the cumulative risk assessment. Maintaining the relationship between the residential and dietary portions of the pesticide exposure is an important aspect of the assessment in order to ensure that all estimated sources for a given individual are normalized for the same gender, body weight and time of year.

A. Attributes of the Case Study

The current case study focuses on estimating the potential exposure to 10 N-methyl carbamate pesticides in food and drinking water and from residential uses. The assessment is limited in geographic scope to the Southeast area of the U.S.. This limitation was placed on the assessment to ensure that the water and residential components of the assessment would reflect a coherent set of pesticide uses likely to be. Understanding the likelihood of co-occurrence of pesticide uses is critical to developing a reasonable estimate of total cumulative risk. In the absence of direct measures of co-occurrence, overlapping exposures must be extrapolated from use data.

Integrated cumulated exposure assessments were conducted for the age groups of Children 1-2 years of age, Children 3-5 years, and Adults 20-49 years. These three groups were chosen to emphasize the effects of differences in behavior and food consumption patterns on estimating the risk from exposure to pesticides. The assessments reflect the same assumptions about use scenarios, timing of exposures and exposures to pesticides in food and water as used in the previous pathway specific assessments. An entire year of exposure is simulated.

The food component of the cumulative assessment contains as many commodities as could reasonably be extrapolated from the available PDP monitoring data. This component of the assessment is regarded as highly refined and reflective of exposures likely to be encountered by the U.S.

population. The water component of the assessment has been conducted such that the exposure component is conservative in nature in the sense that the assessment focused on high usage areas with expected high concentrations. The residential component of the assessment is also regarded as refined and generally reflective of exposures likely to be encountered by the U.S. population.

B. Results

Analyses of the outputs of a cumulative distribution rely heavily upon examination of the results for changing patterns of exposure. To this end, graphical presentation of the data provides a useful method of examining the outputs for patterns. Abrupt changes in the slope of an exposure curve may indicate some combination of exposure conditions resulting in an altered risk profile due to a variety of factors. Factors may include increased pest pressure and subsequent home pesticide use, or increased use in an agricultural setting that may result in increased concentrations in water. Alternatively, a relatively stable slope indicates that exposures from a given source or combination of sources is stable across time and the sources of risk may be less obvious.

Because multiple calculations for each individual in the CSFII population panel are conducted for each day of the year, a distribution of daily exposures is available for each route and source of exposure across the entire year. Since these exposures are estimated for each day of a calendar year, the exposure estimates can be displayed as a time series of exposure percentiles. As demonstrated in the graphical presentations of analytical outputs for this section, results are displayed as exposures expressed in terms of index-chemical equivalents with the various pathway- and route –specific exposures arrayed across the year.

Estimates of cumulative exposures from 10 N-methyl carbamates associated with exposure through foods, drinking water, and residential uses are presented for three different percentiles in Figure 9, Figure 10, and Figure 11 for Children 1-2 years old, Figure 12, Figure 13, and Figure 14 for Children 3-5 years old and in Figure 15, Figure 16, and Figure 17 for Adults, 20-49 years old. The contributions of each of the major routes of exposure and the likely sources of those exposures are discussed in previous sections of this case study. Graphical presentations are limited to the 95th, 99th, and 99.9th percentiles because these high end exposure are of most interest to the Agency.

1. Children, 1-2 years

The results of the total cumulative exposure assessment for Children, 1-2 years old expressed in index chemical – equivalents are presented in Figure 9, Figure 10, and Figure 11. Each of these is described in additional detail below.

95th Percentile - The significant source of pesticide exposure to pesticides at this percentile of exposure is through the food pathway. (Figure 9). The food component of the assessment was stable across time with an exposure that was about 0.003 mg/kg (expressed in index chemical equivalents) across the year. During a short period from day 130 to 160, exposures through drinking water exceed that of food and total exposures (food + drinking water) approach 0.01 mg/kg. Exposures for the remaining pathways (inhalation and dermal) do not occur at this percentile.

99th Percentile - At this percentile, the exposures from food sources were about 0.02 mg/kg and comprise the "bulk" of total exposure. Exposures from oral non-dietary ingestion (i.e., hand-to-mouth) were somewhat lower than this and generally ranged from ca. 0.001 to 0.01 (Figure 10). Exposures associated with drinking water generally ranged from 0.002 to 0.01 mg/kg with the highest exposures occurring during days 130 to 180. Exposures associated with the dermal and inhalation routes appear for the first time here and always less than ca. 0.01 with inhalation exposures never exceeding 0.0001 mg/kg.

99.9th Percentile – At the 99.9th percentile, exposures through the food pathway generally ranged from ca. 0.2 to 0.5 mg/kg (Figure 11). Oral non-dietary exposure (hand-to-mouth) and dermal exposures generally range from 0.01 to 0.1 mg/kg. While for the majority of the year exposures associated with drinking water remained less than 0.005 mg/kg, exposures during Days 100 to 250 ranged up to ca. 0.02 mg/kg. In all cases, exposures through this pathway were always at least an order of magnitude smaller than seen through the food pathway. Dermal exposures generally ranged up to ca. 0.2 mg/kg during the first 120 days of the year and remained near 0.03 during the remainder of the year. Exposures associated with inhalation remained at less than ca. 0.001 throughout the year.

2. Children 3-5 years

The results of the total cumulative assessment for Children, 3-5 years old are presented in Figure 12, Figure 13, and Figure 14 for the 95th, 99th, and 99.9th percentiles, respectively. These are discussed below.

95th Percentile – Total cumulative exposure at this percentile ranges from ca. 0.004 to 0.01 mg/kg. The significant contributor to total cumulative exposure is exposure to pesticides through the food pathway (Figure 12) with fairly stable exposures of ca. 0.03 mg/kg. During a short period near to day 130, exposures associated with drinking water exceed that contributed by food. As with Children 1-2 years old, inhalation and dermal exposures do not occur at this percentile.

99th Percentile - At this percentile, the exposures from food sources generally remained ca. 0.03 mg/kg and are essentially similar to total exposure since the food pathway predominated. Exposures from oral non-dietary ingestion (i.e., hand-to-mouth) were somewhat lower than this and generally ranged from ca. 0.001 to 0.01 mg/kg (Figure 13). Exposures associated with drinking water varied from ca. 0.00015 to 0.01 with the highest exposures occurring during days 120 to 180. Exposures associated with the dermal exposure range from 0.0005 to 0.006 mg/kg and inhalation routes appear for the first time here and always are less than 0.0001 mg/kg.

99.9th Percentile – At the 99.9th percentile, the total exposure (all pathways) generally ranged up to ca 0.3 mg/kg and this was nearly all contributed by exposure through the food pathway (Figure 14). Dermal exposures ranged from 0.01 to 0.1 mg/kg and oral non-dietary exposures (hand-to-mouth) were generally consistent throughout the year at ca. 0.03 mg/kg. While for the majority of the year exposures associated with drinking water remained less than 0.005 mg/kg, exposures during Days 100 to 250 went at high as ca. 0.02 mg/kg. In all cases, exposures through this pathway were always at least an order of magnitude smaller than seen through the food pathway. Dermal exposures generally ranged between 0.02 and 0.1 mg/kg during the first 120 days of the year and remained near 0.02 mg/kg during the remainder of the year. Exposures associated with inhalation never exceeded ca. 0.0005 throughout the year.

3. Adults, 20-49 years

The results of the total cumulative assessment for adults, 20-49 years old are presented in Figure 15, Figure 16, and Figure 17 for the 95th, 99th, and 99.9th percentiles, respectively. These are discussed below

95th Percentile - Exposures from food range from ca. 0.0007 mg/kg of index chemical while those from water range from ca. 0.0001 to ca 0.002 mg/kg (Figure 15). At this percentile, there are no exposures through the inhalation or dermal routes.

99th Percentile – Exposures through the food pathway are generally about 0.005 mg/kg (Figure 16). Exposures associated with drinking water begin to show a sharp increase at about Day 100, and approach and even equal that of food from days 120 to 140. During the remainder of the year, they go as low as 0.0001 mg/kg. Dermal exposures are associated with MOEs of approximately 0.0003 to 0.007 and inhalation exposures are less than 0.0001 mg/kg throughout the year.

99.9th Percentile – Exposures from food range from ca. 0.03 to 0.1 mg/kg of index chemical while those from dermal contacts range from ca. 0.01 to ca. 0.03 mg/kg (Figure 17). Exposures through drinking water range from ca. 0.002 mg/kg to ca. 0.01 mg/kg. Inhalation exposures are generally constant throughout the year at 0.0001 mg/kg.

Figure 9. Time-based Exposure Profile for Children 1-2 at the 95th Percentile

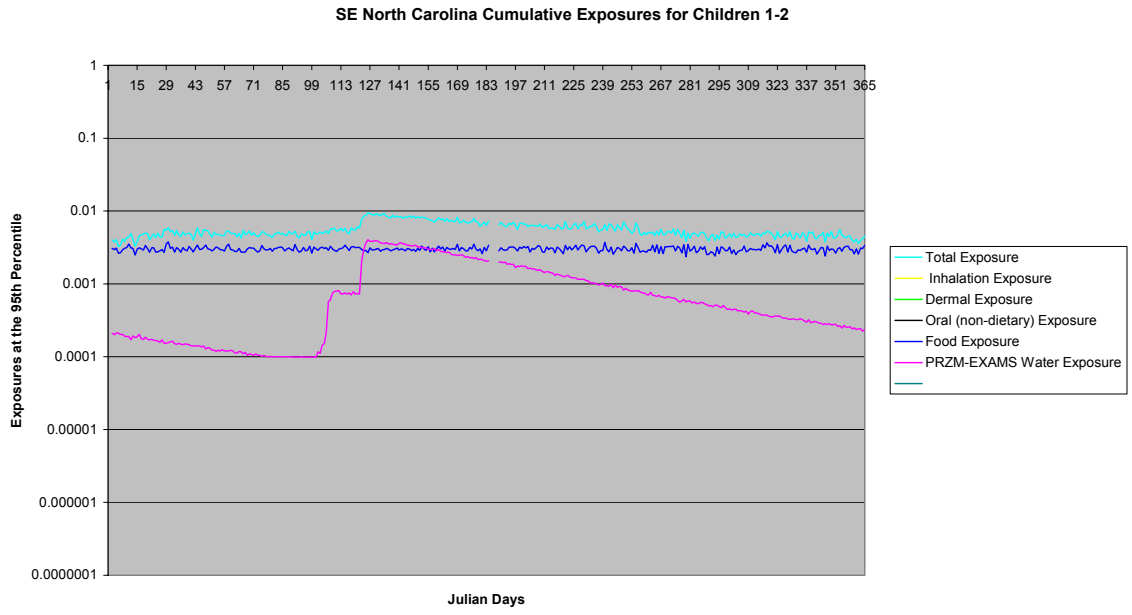


Figure 10. -based Exposure Profile for Children 1-2 at the 99th Percentile

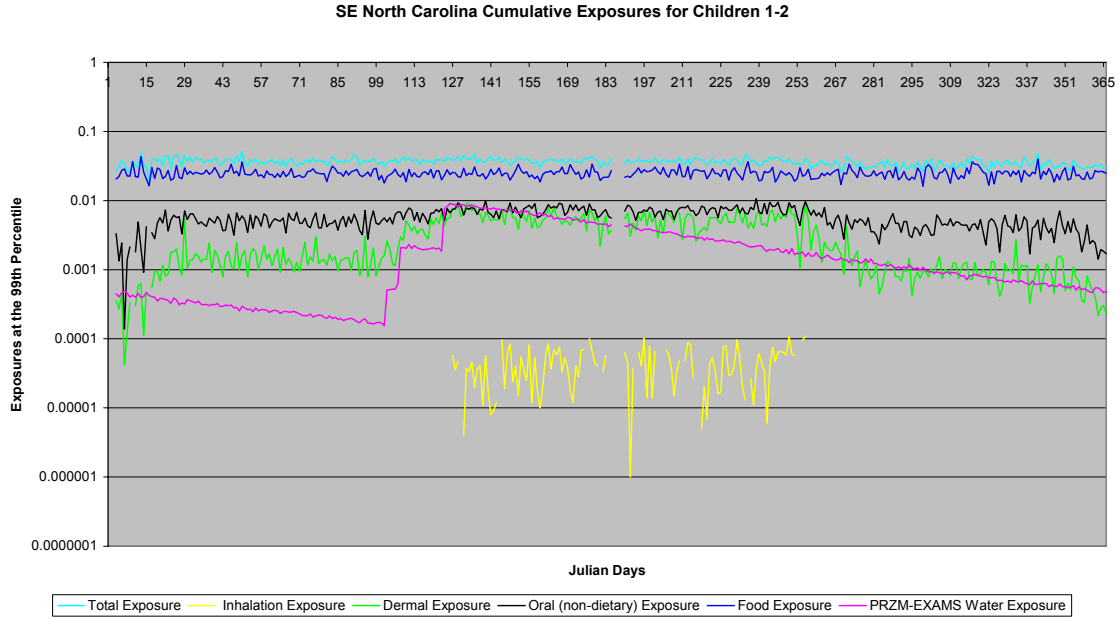


Figure 11. -based Exposure Profile for Children 1-2 at the 99.9th Percentile

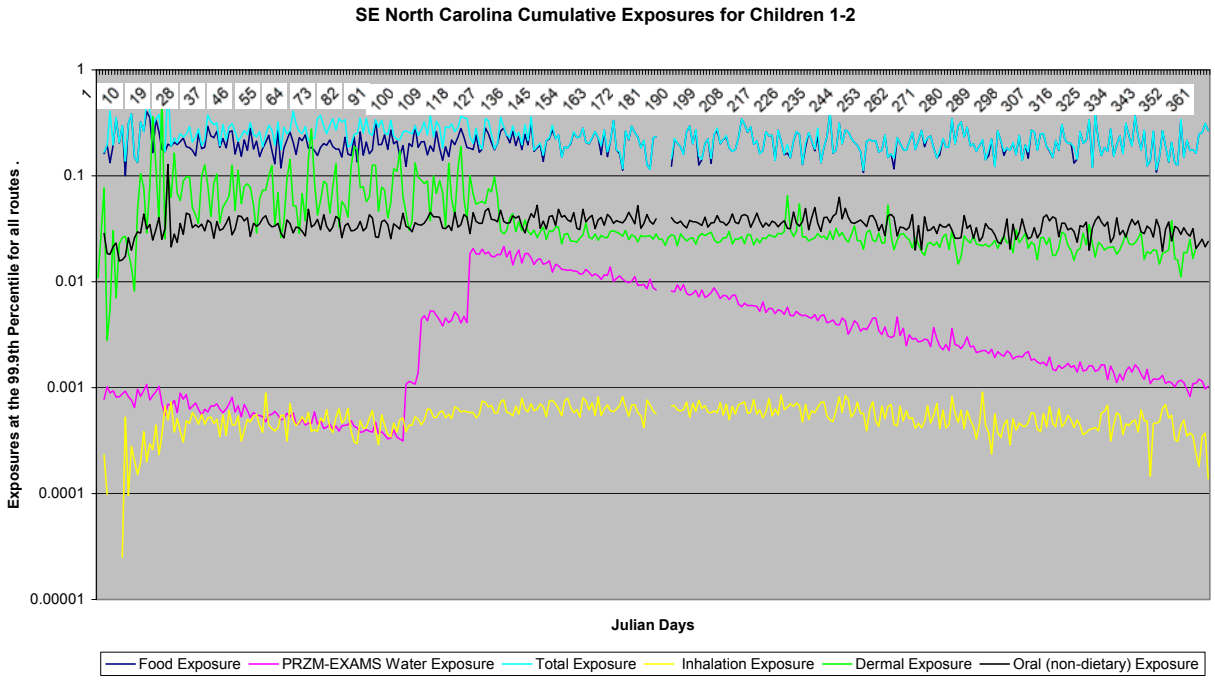


Figure 12. Time-based Exposure Profile for Children 3-5 at the 95th Percentile

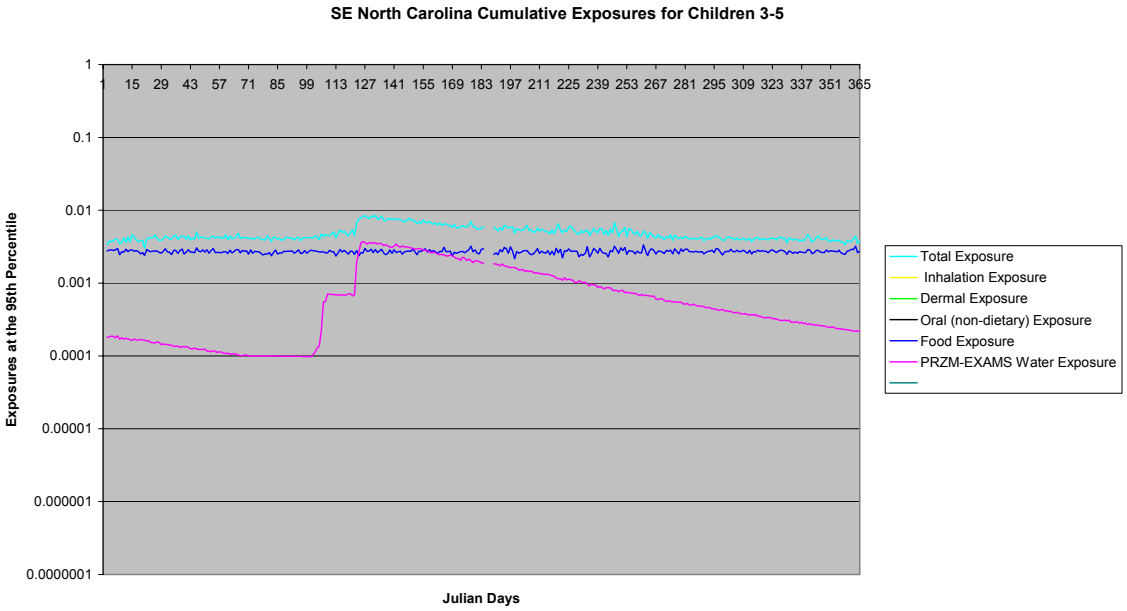


Figure 13. Time-based Exposure Profile for Children 3-5 at the 99th Percentile

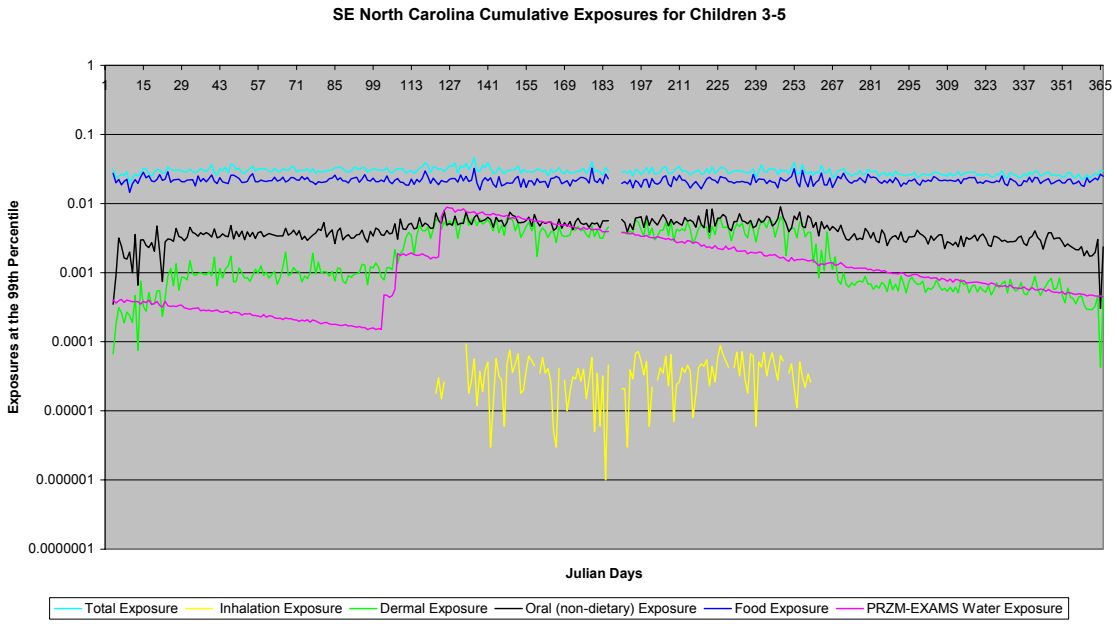


Figure 14. Time-based Exposure Profile for Children 3-5 at the 99.9th Percentile

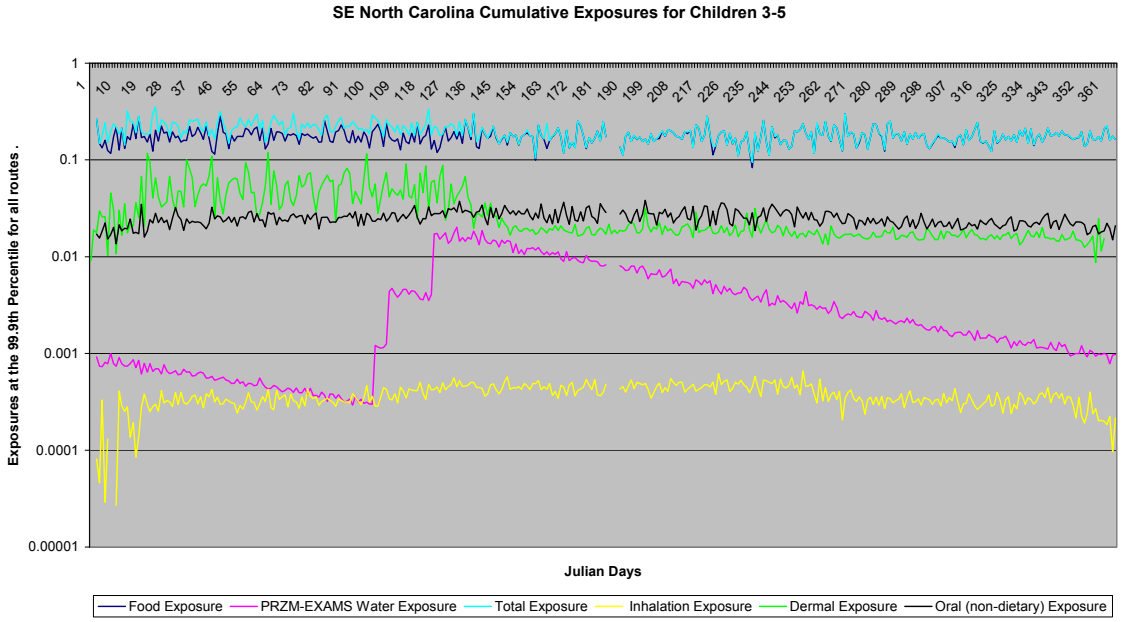


Figure 15. Time-based Exposure Profile for Adults 20-49 at the 95th Percentile

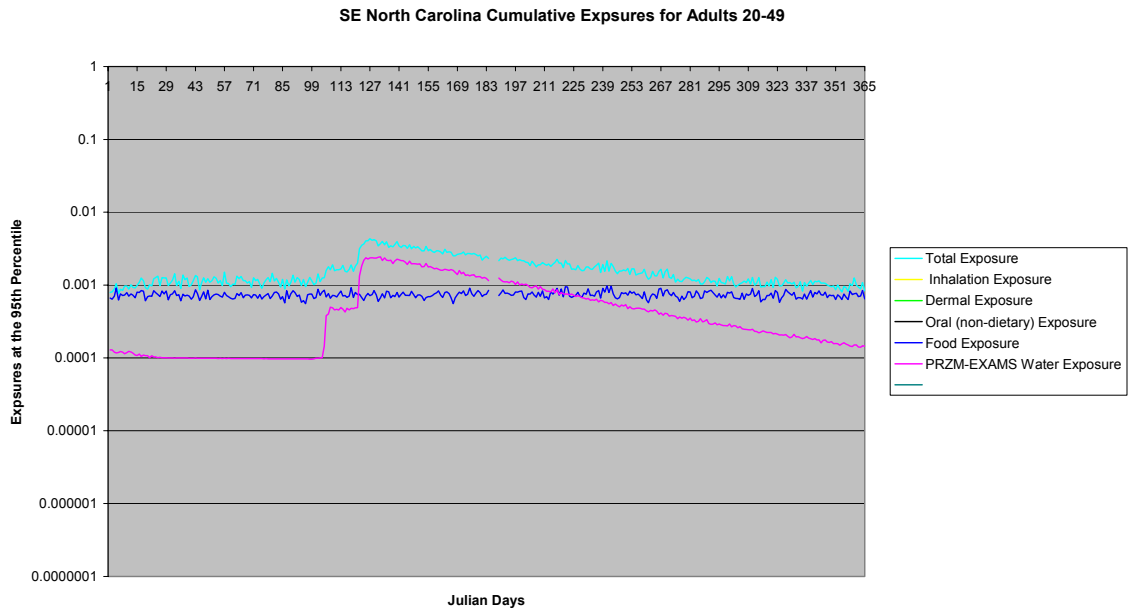


Figure 16. Time-based Exposure Profile for Adults 20-49 at the 99th Percentile

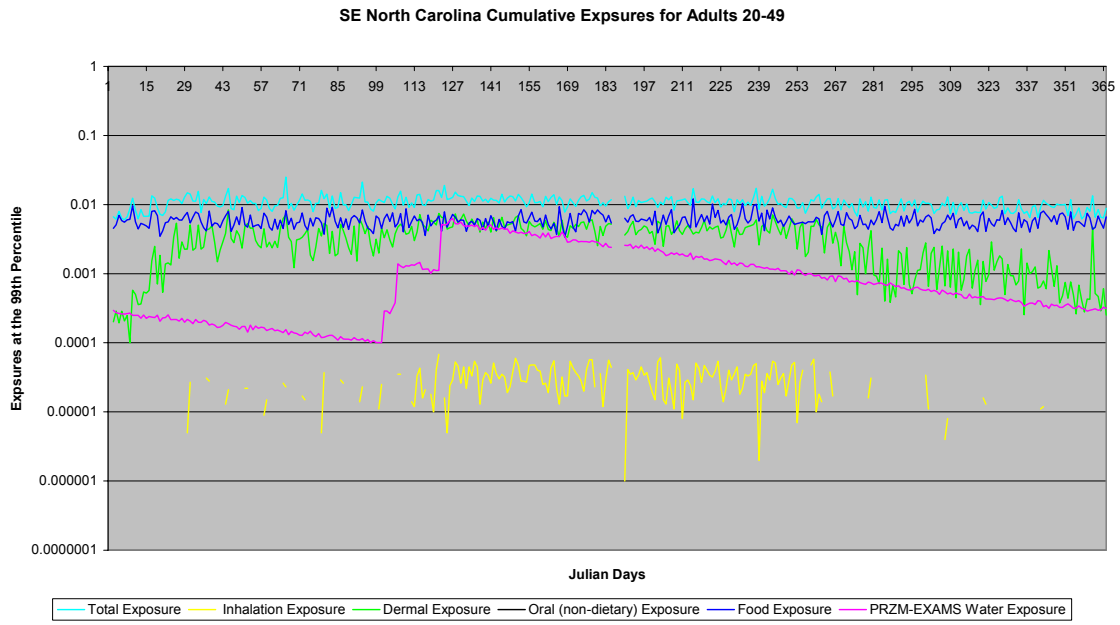
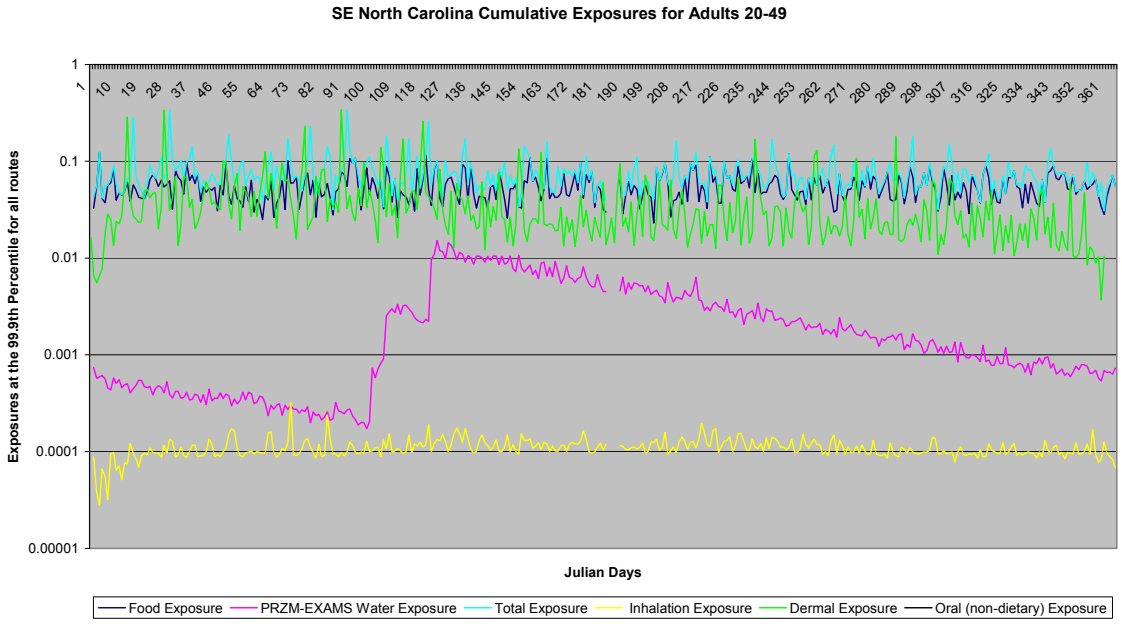


Figure 17. Time-based Exposure Profile for Adults 20-49 at the 99.9th Percentile



VIII. Comparison of DEEM/Calendex, Lifeline, and CARES Results

Sections IV, V, and VI of this case study focused on the output and results from the DEEM/Calendex program, emphasizing the food, drinking water, and residential pathways, respectively. Section VII of the document provided an integrated discussion of the results, and again focused on the output of the DEEM/Calendex model.

OPP also performed this same analysis using the Lifeline and CARES models.[17] This section of the case study reviews and compares the results from all three models.

A. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure Estimates through the Food Pathway

Estimated Exposures

Table 15 presents the results for the three models for food residues alone for the children and adult subpopulations that were considered in this case study. As indicated in the table, the three models provided comparable results at the 95th, 99th, and 99.9th percentiles.

[17]Due to time constraints, OPP was able to include only a food + water component using all three (DEEM/Calendex, CARES, and Lifeline) models. OPP was not able to include the residential component of the cumulative assessment using Lifeline or CARES but expects to include all three pathways using all three models when it releases the preliminary cumulative assessment later this year.

Table 15. Estimated Exposures from Food Only (mg/kg)

	95th Percentile	99th Percentile	99.9th Percentile
Model	**Exposure (mg/kg/day)**	**Exposure (mg/kg/day)**	**Exposure (mg/kg/day)**
1 to 2 yr olds			
DEEM/Calendex	0.003073	0.025199	0.210519
CARES*	0.003115	0.025830	0.229000
Lifeline	0.002656	0.022681	0.217772
3 to 5 yr olds			
DEEM/Calendex	0.002758	0.021769	0.177165
CARES*	0.002783	0.022860	0.194300
Lifeline	0.002460	0.021103	0.178917
20 to 49 yr olds			
DEEM/Calendex	0.000746	0.005951	0.056145
CARES*	0.000876	0.007143	0.066240
Lifeline	0.000726	0.005753	0.074998

* The CARES' results are based on a subset of both the 3 - 5 yr old subpopulation (3,500 of 4,985 individuals in the Reference Population) and the 20 - 49 yr old subpopulation (3,000 of 33,538 individuals).

It is important to note that these models will not (and are not expected to) produce identical results - even for a simple set of residues – since the various food diaries are used with different expected frequencies, the models apply different weights to project simulated person-days up to the entire population, and (for LifeLine) the modeled bodyweights are used rather than the CSFII bodyweights to calculate food consumption (grams/kg bwt)[18] Since these modeling differences vary by age group and are specific to the food residues, we would not expect one model to consistently produce higher or lower estimates than another model, across all age groups, at any given percentile, or across all percentiles for any particular age group.

[18]These models were discussed during the April 29-30 SAP entitled "A Model Comparison: Dietary and Aggregate Exposure in Calendex, CARES, and Lifeline". Information and background on this SAP is available at the SAP website (www.epa.gov/scipoly/sap). These SAS model approximations produced similar predictions as the corresponding models for this case study, although the current version of these SAS models have a significant downward bias - predicting slightly lower exposures (10%-20%) than the corresponding models. Part of that bias could be reduced by modifying the current approach which entails calculating the percent of individuals at the top percentiles in 0.01% increments, and summing across these commodity statistics until the top 0.1% was reached. That procedure could be made more precise by calculating and summing the percentiles for each of those high-end exposure permutations. The SAS models also produced significantly different contributions than the actual models for potatoes w/o peel (higher), and potatoes w/peel (lower). Part of this difference appears to be due to the fact that these SAS model approximations are based on the Lifeline food recipes, rather than the FCID recipes that are used by both DEEM/Calendex and CARES. The agency is currently looking into these and other possibilities.

While model estimates vary from run to run, we can compare the predictions across these three models by using the average estimates from multiple simulations, or by increasing the number of 'iterations' or 'modeled individuals' specified at run time.[19] For the children subpopulations, the three models generally produced exposure estimates at the 99.9th percentile that were within ca. 5-10% depending upon the number of iterations or modeled individuals. In the preliminary NMC CRA report, we plan to conduct and present a more thorough review of this model uncertainty.

Major Contributors

Table 16 presents the major food contributors for each of the age groups. The first two columns present the share of total exposures among the top 0.1 percentile for the DEEM and CARES models.

The current version of Lifeline does not produce analogous major contributor reports. The last three columns in Table 16 are SAS approximations to three models, DEEM (D1), CARES (C1) and Lifeline (L1).[20] These SAS model approximations are designed to approximate

[19] DEEM and Lifeline allows the user to determine the number of simulated exposure days at run time. The agency typically runs DEEM specifying 1000 iterations per food diary and has found that this number generally produces extremely stable results at the 99.9th percentile. Lifeline allows the user to specify the number of individuals that the model simulates from birth up to age 85. The agency typically specifies 1000 individuals in a Lifeline run; but the model currently allows the user to specify as many as 10,000 individuals (which was done for this assessment). Lifeline (even with 10,000 individuals) tends to have more variability than DEEM, especially for the children subpopulations due to the relatively lower number of simulated days that an individual lives as toddlers (1 to 2 yrs old) than as an adult (20-49 yrs old), and hence, fewer number of exposure values from which the 99.9th percentiles are calculated. In principle, the simulated distribution will converge to the 'mean' distribution with an increasing number of iterations or number of individuals modeled. CARES is well a defined model, in that it performs one 365 day simulation for each of the 100,000 individuals in its reference population; the weights project these 100,000 modeled persons up to the U.S. population (245 million). The CARES results may also vary from run to run, with the infant results being relatively more stable than the 1 to 2 yr old subpopulation due to the relatively larger number of individuals in that age group (20,003 infants vs 3,367 1 to 2 yr olds).

[20] At a recent SAP (April 29-30, 2004 "A Model Comparison: Dietary and Aggregate Exposure in Calendex, CARES, and Lifeline" http://www.epa.gov/scipoly/sap/#april), the agency identified several primary factors regarding the model design: reference population, frequency of using the various food diaries, the model weights, and for the Lifeline model - the modeled bodyweights. Based on this framework, the agency developed SAS model approximations for each of these three models, and demonstrated the use of these analytical tools to predict and identify when and why the models provide different predictions. These SAS model approximations produced similar predictions as the corresponding models for this case study, although the current version of these SAS models have a significant downward bias - predicting slightly lower exposures (10%-20%) than the corresponding models for several reasons, one of which may be corrected for with relatively quick modifications. For the 1 to 2 yr old subpopulation, the SAS model anticipated CARES to have slightly higher exposures at the 99.9th percentile than DEEM or Lifeline due to its

the corresponding models, DEEM (D1), CARES (C1) and Lifeline (L1). While these SAS models underestimate the actual exposures predicted by the corresponding models, they did predict CARES to have marginally higher exposure than DEEM at the 99.9th percentiles for both the 3 to 5 yr old and 20 to 49 yr old subpopulations.[21]

relatively higher weighting of several food diaries that relatively high consumption of fresh oranges. The SAS model approximations for the Lifeline model are not very accurate due to representing bodyweights with between five and seven percentile values from which permutations of food consumption (grams food/kg bwt) were constructed – increasing the number of values required more computer memory than was available.

[21]The particular approach taken to develop these SAS model approximations enables users to compare the food diaries that tend to contribute at higher percentiles, and contrast the 'total' effective weights that each of the three models apply to these diaries – there are generally several food diaries with high consumption and one model will not have relatively higher weights than another for all of these high consumption diaries.

Table 16. Major Food Contributors at Upper Percentile (99.9th)

	Actual Results		SAS Model Approximations/1		
Foodname (RAC)	**DEEM**	**CARES**	**D1**	**C1**	**L1**
1 to 2 yr olds					
Dietary Exposure (99.9%)	0.2171	0.2290	0.1673	0.1743	0.1348
Orange	47.00%	50.47%	40.70%	47.20%	38.70%
Apple, juice	23.40%	25.11%	24.40%	25.90%	24.70%
Potato, tuber, w/o peel	9.90%	8.38%	25.40%	21.20%	22.40%
Strawberry	3.90%	1.50%	7.10%	3.40%	6.70%
Tangerine	3.50%	3.60%	-	-	-
Nectarine	2.90%	1.40%	2.50%	2.40%	2.90%
Potato, tuber, w/peel	2.50%	3.16%	-	-	-
Peach	2.30%	1.82%	-	-	-
Apple, juice-babyfood	1.50%	0.96%	-	-	-
Grapefruit	1.30%	1.88%	-	-	-
Orange, juice	0.50%	0.27%	-	-	-
Apple, fruit with peel	0.50%	0.22%	-	-	4.60%
Other RACs	0.70%	1.23%	-	-	-
3 to 5 yr olds					
Dietary Exposure (99.9%)	0.1786	0.1943	0.1387	0.1542	0.1466
Orange	49.00%	56.60%	48.80%	54.10%	49.50%
Apple, juice	12.90%	11.80%	12.70%	11.80%	12.40%
Potato, tuber, w/o peel	12.10%	8.20%	25.60%	21.00%	24.90%
Nectarine	7.50%	6.70%	6.70%	6.90%	4.20%
Tangerine	4.30%	3.90%	-	-	-
Strawberry	4.10%	3.00%	3.50%	3.60%	6.10%
Potato, tuber, w/peel	3.00%	2.20%	-	-	-
Grapefruit	2.40%	3.30%	-	-	-
Peach	1.40%	2.40%	-	-	-
Apple, fruit with peel	1.00%	1.20%	2.70%	2.70%	2.80%
Other RACs	2.00%	0.70%	-	-	-
20 to 49 yrs old					
Dietary Exposure (99.9%)	0.0561	0.0662	0.0415	0.0479	0.0592
Orange	31.50%	34.68%	30.60%	39.80%	28.30%
Potato, tuber, w/o peel	21.30%	13.82%	44.70%	27.90%	36.80%
Grapefruit	14.50%	19.83%	2.90%	14.50%	13.10%
Potato, tuber, w/peel	11.60%	7.70%	4.40%	3.50%	6.50%
Nectarine	8.30%	9.19%	11.00%	8.20%	7.30%
Strawberry	3.30%	4.70%	6.30%	3.30%	5.80%
Peach	2.10%	3.21%	-	2.80%	-
Apple, juice	1.60%	0.89%	-	-	-
Tangerine	1.40%	1.75%	-	-	-
Apple, fruit with peel	0.50%	0.45%	-	-	2.20%
Other RACs	3.50%	3.78%	-	-	-

B. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure Estimates through the Water Pathway

Table 17 presents the estimated exposures from each of the three models for water residues for the children and adult subpopulations. As was seen in the Section VII where the results for the DEEM/Calendex analyses were presented and described, exposures through water at the upper percentiles are substantially smaller than those through food.

Table 17. Estimated Exposures from Water Only (mg/kg-day)

DEEM Results			
	95th Percentile	99th Percentile	99.9th Percentile
Children (1-2 years)	0.001060	0.003081	0.008338
Children (3-5 years)	0.001016	0.002895	0.007673
Adults (20-49)	0.000658	0.001889	0.005091
CARES Results*			
	95th Percentile	99th Percentile	99.9th Percentile
Children (1-2 years)	0.001806	0.005223	0.014400
Children (3-5 years)	0.001741	0.005096	0.013770
Adults (20-49)	0.001149	0.003253	0.008941
LifeLine Results			
	95th Percentile	99th Percentile	99.9th Percentile
Children (1-2 years)	0.001102	0.003186	0.008785
Children (3-5 years)	0.001056	0.003035	0.007805
Adults (20-49)	0.000656	0.001873	0.005039

*The CARES' results are based on a subset of both the 3 - 5 yr old subpopulation (3,500 of 4,985 individuals in the Reference Population) and the 20 - 49 yr old subpopulation (3,000 of 33,538 individuals). CARES' results are based on two separate simulations; OPP plans to perform additional simulations to confirm these results.

C. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure Estimates through the Food + Water Pathway

Table 18 presents the exposure estimates from all three models when food and water exposures are cumulated.

Table 18. Estimated Exposures from Food+Water

	95th Percentile	99th Percentile	99.9th Percentile
Model	**Exposure (mg/kg/day)**	**Exposure (mg/kg/day)**	**Exposure (mg/kg/day)**
1 to 2 yr olds			
DEEM/Calendex	0.003974	0.025917	0.201512
CARES	0.004063	0.026280	0.229000
Lifeline	0.003694	0.023765	0.256842
3 to 5 yr olds			
DEEM/Calendex	0.003616	0.021834	0.174958
CARES	0.003675	0.023260	0.195100
Lifeline	0.003269	0.020827	0.218547
20 to 49 yr olds			
DEEM/Calendex	0.001414	0.006552	0.055725
CARES	0.001528	0.007237	0.066260
Lifeline	0.001174	0.006128	0.075061

* The CARES' results are based on a subset of both the 3 - 5 yr old subpopulation (3,500 of 4,985 individuals in the Reference Population) and the 20 - 49 yr old subpopulation (3,000 of 33,538 individuals). CARES' results are based on two separate simulations; OPP plans to perform additional simulations to confirm these results.

IX. Conclusions

The passage of the FQPA led the EPA's Office of Pesticide Programs to develop methodology to evaluate risk on a "cumulative" basis. Prior to FQPA, OPP assessed exposures to pesticides on a chemical- and pathway- specific basis. That is, exposures had been evaluated on a single chemical/single pathway paradigm. With the cumulative assessment requirement of FQPA, OPP began to investigate methodologies that would permit exposures to a single pesticide to be appropriately summed across pathways and routes (e.g., food/oral, water/oral, residential/dermal) and then permit exposures to pesticides with a common mechanism to be summed across chemicals.

This document is OPP's second case study developed to demonstrate one possible approach to conducting a cumulative risk assessment that combines exposures to the N-methyl carbamate pesticides across pathways, routes, and chemicals. It incorporates ideas, processes, and thoughts provided during and subsequent to previous SAP meetings dealing with a variety of related issues. The case study is presented to help elicit and focus discussion on the detailed techniques of and mechanics behind a cumulative risk assessment.

This case study uses the RPF method such that exposures are adjusted to toxic equivalents of an Index Chemical. The Calendex software, LifeLine software, and CARES software were then used to probabilistically combine these exposures across pathways and generate a cumulative exposure assessment by simultaneously estimating – on an individual-by-individual basis and for each day in the assessment – a route- and pathway- specific exposure. The resulting cumulative assessment is intended to serve as a pointer toward major sources of exposure likely to accrue due to the use of a variety of pesticides with a common mechanism of toxicity.

This case study has demonstrated that available data can be combined to conduct a cumulative risk assessment for the N-methyl carbamate pesticides. The food component of the assessment consists of the contribution of each of the 10 N-methyl carbamate pesticides as they occur in USDA's PDP pesticide monitoring database. For the drinking water component of the cumulative assessment, the assessment was geographically limited to the southeastern North Carolina area of the U.S. so as to permit a regional assessment in which use practices, patterns, and customs share a common basis and are specific to this region. The water component of the assessment uses water concentrations generated by PRZM-EXAMs which are specific to the south-eastern region of North Carolina. The residential component of the assessment reflects estimated crack and crevice, lawn, garden, and pet collar uses for 3 N-methyl carbamates with residential uses which are used in the geographic area under consideration.[22]

[22]The case study did not attempt to refine or otherwise subdivide the REJV and NHGPUS data to be more characteristic of this region of the U.S. It is intended that the preliminary cumulative risk assessment for the N-methyl carbamate pesticides will use residential inputs that are more characteristic of the specific regions of interest.

The output from the Calendex/DEEM software is presented in Section VII of this case study and illustrates, at various selected percentiles, estimated daily cumulated exposures (expressed in terms of mg/kg of index chemical equivalents) over the course of 365 days in a year. As can be seen, the display is route/pathway specific, thereby permitting the exposure analyst and risk manager to effectively evaluate and assess the various specific significant contributors to total cumulative exposure. The outputs from the other two models considered here (LifeLine and CARES) also allow similar presentation of results. Conclusions reached from analyzing the results from the case study illustrated here, for example, are as follows:

- Results of any cumulative risk assessment are sensitive to the quality and quantity of data used to generate exposure estimates. Major considerations in the current case study have been highlighted but bear repeating. A detailed estimate of exposure to pesticides in foods was possible because of the availability of a large body of data reflecting pesticide residues in foods close to the point of consumption, and with a direct measure of co-occurrence of N-methyl carbamates in foods.

- Detailed examination of the inputs into the residential exposure scenarios revealed that the quality and quantity of data available for estimating exposure contributions by chemical greatly impacted the apparent importance of each combination. In all cases, the understanding of the likely patterns of use was critical to understanding the likely exposure to each pesticide. Although OPP believes that the total exposure estimates from the residential scenarios are reasonable in magnitude, their accuracy and precision could be improved with more information concerning residues resulting from the various patterns of use and their associate probabilities.

- In the current case study the exposure estimates were generally insensitive at the upper (99+) percentiles to the water residue concentrations estimated using the PRZM-EXAMs model. The ability of the PRZM-EXAMs model to provide accurate estimates of surface water pesticides is highly dependent upon accurate information on regarding the agricultural and urban use patterns of pesticides in the geographic area of the assessment. In situations where estimated water concentrations are likely to impact the outcome of the assessment because they are greater in magnitude, the importance of developing highly descriptive predictive models will be increased and reliable information regarding co-occurrence of the pesticides of interest in water samples along with a method for incorporating this information will become of greater importance.

With this document, OPP has demonstrated an approach to combining the available data to conduct such a cumulative risk assessment for the N-methyl carbamate pesticides. It should be remembered that this case study is intended to demonstrate the concepts put forth in the cumulative risk assessment document and to provide a conceptual basis for deliberations; it should not be interpreted as representing

OPP's recommended procedure for conducting cumulative risk assessment, as demonstrating a cumulative assessment intended for regulatory purposes, or as portending any final regulatory decisions or judgments or future regulatory actions.

X. References

Black KG. 1993. "Assessment of Children's Exposure to Chlorpyrifos from Contact with a Treated Lawn." A dissertation submitted to the Graduate School-NewBrunswick Rutgers. UMI Dissertation Services.

Byrne SL, Shurdut BA, and Saunders DG. 1998. "Potential Chlorpyrifos Exposure to Residents Following Standard Crack and Crevice Treatment." Environmental Health Perspectives. 106:725-731.

Camann DE, Majumadar TK, and Geno P. 1995. "Determination of Pesticide Removal Efficiency from Human Hands Wiped with Gauze Moistened with Three Salivary Fluids." A Final Report to EPA by ManTech under Contract 68-D5-0049.

Clothier JM. 2000. "Dermal Transfer Efficiency of Pesticides from Turf Grass to Dry and Wetted Palms." Prepared for U.S. Environmental Protection Agency, National Exposure Research Laboratory, Research Triangle Park, NC.

Clothier JM. 1999b. "Dermal Transfer Efficiency of Pesticides from Carpets to Dry and Wetted Palms." Prepared for U.S. Environmental Protection Agency, National Exposure Research Laboratory, Research Triangle Park, NC.

Clothier JM. 1999a. "Dermal Transfer Efficiency of Pesticides from New, Vinyl Sheet Flooring to Dry and Wetted Palms." Prepared for U.S. Environmental Protection Agency, National Exposure Research Laboratory, Research Triangle Park, NC.

Federal Register. 2004. February; 69(23): 5340-5344.

Fenske RA, and Lu C. 1994. "Determination of Handwash Removal Efficiency: Incomplete Removal of the Pesticide Chlorpyrifos from Skin by Standard Handwash Techniques." Am Ind Hyg Assoc J. 55:425-432.

Fenske RA, Wong SM, Leffingwell JT, and Spear RC. 1986. "A Video Imaging Technique for Assessing Dermal Exposure II. Fluorescent Tracer Testing." Am Ind Hyg Assoc. 47: 771-775.

FIFRA Science Advisory Panel (OPP SAP). 2000. "Case Study of the Estimation of Risk From 24 Organophosphate Pesticides. Final report http://www.epa.gov/scipoly/sap/2000/index.htm

FIFRA Science Advisory Panel (OPP SAP). 2002. "Organophosphate Pesticides: Preliminary OP Cumulative Risk Assessment." Final report http://www.epa.gov/scipoly/sap/2002/index.htm

Freeman NCG, Jimenez M, Reed KJ, Gurunathan S, Edwards RD, Roy A, Adgate JL, Pellizzari ED, Quackenboss J, Sexton K, and Lioy PJ. 2001.
" Quantitative Analysis of Children's Microactivity Patterns. The Minnesota Children's Pesticide Exposure Study." Journal of Exposure Analysis and Environmental Epidemiology 11: 501-509.

Formoli TA. 1996. "Estimation of Exposure of Persons in California to Pesticide Products that Contain Propetamphos." HS-1731, California Environmental Protection Agency.

Geno PW, Camann DE, Harding, HJ, Villalobos K, Lewis RG. 1995. "Handwipe Sampling and Analysis Procedure for the Measurement of Dermal Contact with Pesticides." Arch Environ Contam Toxicol. 30:132-138.

Groot ME, Lekkerkert MC, and Steenbekkers LPA. 1998. "Mouthing Behaviour of Young Children–An Observational Study." Agricultural University Wageningen, Household and Consumer Studies, Wageningen, Netherlands.

Heimlich, R. 2000. Farm Resource Regions. USDA Economic Research Service No. 760. Available: http://www.econ.ag.gov/whatsnew/issues/regions

Hore P. 2003. "Pesticide Accumulation Patterns for Child Accessible Surfaces and Objects and Urinary Metabolite Excretion by Children for Two Weeks After a Professional Crack and Crevice Application." A dissertation submitted to the Graduate School-New Brunswick Rutgers.

Kellogg RL, Goss DW, et al. 1997. "Potential Priority
Watersheds for Protection of Water Quality from Nonpoint Sources Related to Agriculture.: USDA Natural Resources Conservation Service. State of the Land website. http://www.nhq.nrcs.usda.gov/land/pubs/wqpost2.html

Kissel JC, Shirai JH, Richter KY, Fenske RA. 1998. "Empirical Investigation of Hand-to-Mouth Transfer of Soil." Bull Environ Contam Toxicol. 60:379-386.

Koplin DW, and Martin JD. 2003. "Pesticides in Ground Water: Summary Statistics, Preliminary Results from Cycle I of the National Water Quality Assessment Program (NAWQA)." 1992-2001 (provisional data). http://ca.water.usgs.gov/pnsp/pestgw/Pest-GW_2001_Text.html

Krieger RI, Bernard CE, Dinoff TM, Ross JH, and Williams RL. 2001. "Biomonitoring of Persons Exposed to Insecticides Used in Residences." The Annals of Occupational Hygiene. Apr; 45 Suppl 1: 143-53.

Larson SJ, Crawford CG, and Gilliom RJ. 2004. "Development and Application of Watershed Regressions for Pesticides (WARP) for Estimating Atrazine Concentration Distributions in Streams." U.S. Geological Survey Water-Resources Investigations Report 03-4047, 68 p.

Martin JD, Crawford CG, and Larson SJ. 2003. "Pesticides in Streams: Summary Statistics; Preliminary Results from Cycle I of the National Water Quality Assessment Program (NAWQA), 1992-2001 (provisional data). http://ca.water.usgs.gov/pnsp/pestsw/Pest-SW_2001_Text.html

Nolan BT, Hitt KJ, and Ruddy BC. 2002. "Map of the Probability that Nitrate Exceeds 4 mg/L in Shallow Ground Waters of the United States, Based on the LR Model." Accessed April 13, 2004. URL:http://water.usgs.gov/lookup/getspatial?gwrisk

Nolan RJ, Rick, DL, Freshour NL, Saunders JH. 1985. "Chlorpyrifos: Pharmacokinetics in Human Volunteers." Toxicol Appl Pharmocol 73:8-15.

Outdoor Residential Pesticide Use and Usage Survey and National Gardening Association Survey. 1999. Submitted by the Outdoor Residential Exposure Task Force. D. Johnson, Stewart Agricultural Research Services, Inc. R. Thompson, DOANE Marketing Research, Inc., B. Butterfield, National Gardening Association. November 12. Vol. 8-9 of 17.

Reed KJ, Jimenez M, Freeman NCG, Lioy PJ. 1998. "Quantification of Children's Hand and Mouthing Activities" Supported by a Co-operative Agreement #CR821902 as Subcontract from Research Triangle Institute, N.C. for the National Human Exposure Assessment Study (NHEXAS).

Ross J, Fong HR, Thonsinthusak T, Margetich S, Krieger R. 1991. "Measuring Potential Dermal Transfer of Surface Pesticide Residue Generated from Indoor Fogger Use: Using the CDFA Roller Method." Chemosphere. 22:975-984.

Ross J, Fong HR, Thonsinthusak T, Margetich S, Krieger R. 1990. "Measuring Potential Dermal Transfer of Surface Pesticide Residue Generated from Indoor Fogger Use." Chemosphere. 20:349-360.

Suffolk County Dept. of Health Services. 2000. "Water Quality Monitoring Program to Detect Pesticide Contamination in Groundwaters of Nassau and Suffolk Counties, NY." December, 2000.

US EPA OPP. 2002. Organophosphate pesticides: revised cumulative risk assessment. http://www.epa.gov/pesticides/cumulative/rra-op/

U.S. EPA. Guidance on Cumulative Risk Assessment of Pesticide Chemicals That Have a Common Mechanism of Toxicity (1/14/02) Available at http://www.epa.gov/pesticides/trac/science/cumulative_guidance.pdf

U.S. EPA. Revised OP Cumulative Risk Assessment (2002) June 10. Available at: http://www.epa.gov/pesticides/cumulative/rra-op/

U.S. Environmental Protection Agency (USEPA). November 21, 2001. FR Notice OPP-00731: The Incorporation of Water Treatment Effects on Pesticide Removal and Transformation in Food Quality Protection Act (FQPA) Drinking Water Assessments. http://www.epa.gov/oppfead1/trac/science/water_treatment.pdf

U.S. Environmental Protection Agency (USEPA). 2000. Applying a Percent Crop Area Adjustment to Tier 2 Surface Water Model Estimates for Pesticide Drinking Water Exposure Estimates.

U.S. EPA (2000). Endpoint Selection and Determination of Relative Potency in Cumulative Hazard and Dose-Response Assessment: A Pilot Study of Organophosphorus Pesticide Chemicals (Available at: http://www.epa.gov/scipoly/sap/2000/september/frnotice090100.pdf)

U.S. EPA Guidance for Identifying Pesticide Chemicals and Other Substances that Have a Common Mechanism of Toxicity (1/29/99. Availalble at http://www.epa.gov/fedrgstr/EPA-PEST/1999/February/Day-05/6055.pdf).

U.S. Environmental Protection Agency. 1999. Memorandum from Margaret Stasikowski, Health Effects Division to Staff. “Translation of Monitoring Data. HED Standard Operating Procedure 99.3 (3/26/99);” March 26, 1999. Office of Pesticide Programs, Office of Prevention, Pesticides, and Toxic Substances, Washington, D.C.

U.S. EPA (1999). Overview of Issues Related to the Standard Operating Procedures for Residential Exposure Assessment. Presented to the EPA Scientific Advisory Panel for the meeting on September 21, 1999. U.S. EPA, Arlington, VA.

U.S. EPA General Principles for Performing Aggregate Exposure and Risk Assessments (10/29/99), see http://www.epa.gov/pesticides/trac/science/aggregate.pdf)

U.S. EPA (1997) Exposure Factors Handbook (EFH). Office of Research and Development. EPA/600/002Fac.

U.S. EPA.(1997) Standard Operating Procedures for Residential Exposure Assessment. Office of Pesticide Programs, U.S. EPA, Arlington, VA

U.S. EPA (1990) Nonoccupational Pesticide Exposure Study (NOPES). Final Report. Washington, D.C. Office of Research and Development, U.S. Environmental Agency.

U.S. Geological Survey. 2004. The National Water Quality Assessment (NAWQA) Pesticide National Synthesis Project (PNSP). http://ca.water.usgs.gov/pnsp/

U.S. Geological Survey. 1998. Water Use in the United States http://water.usgs.gov/lookup/getspatial?ofr99-78_cowu95

Vaccaro JR, Nolan RJ, Hugo JM, Pillepick JL, Murphy PG, and Bartels MJ. 1991. "Evaluation of Dislodgeable Residues and Absorbed Doses of Chlorpyrifos to Crawling Infants Following Indoor Broadcast Applications of a Chlorpyrifos-Based Emulsifiable Concentrate." Sponsor: DowElanco, Indianapolis, IND, Industrial Hygiene Research & Technology; Performing Laboratory: The Dow Chemical Company, Midland, MI, Laboratory Project Study ID: DECO-HEH2.1-1-182(95).

Vacarro JR, Nolan RJ, Murphey PF, and Berbrich DB. 1996. "The Use of a Unique Study Design to Estimate Exposure to Adults and Children to Surface and Airborne Chemicals." ASTM STP 1287. Tichenor BA, Ed., American Society of Testing and Materials. pp. 166-183.

Vinlove, F.K.; Torla, R. 1995. "Comprehensive Estimation of U.S. Home Lawn Area." Journal of Turfgrass Management 1(1):83-97.

Wester RC, and Maibach HI. 1989. "Dermal Decontamination and Percutaneous Absorption." In: Percutaneous Absorption. 2nd ed. R. Bronaugh and H.I. Maibach, editors. New York: Marcel Dekker, pp 335-342.

Zartarian VG, Ferguson AC, and Leckie JO. 1997. "Quantified Dermal Activity Data from a Four-Child Pilot Field Study." J. Expo. Anal. Environ. Epidemiol. 7(4): 543-552.

Zartarian VG, Streicker J, Rivera A, Cornejo C.S, Molina S, Valadez OF, and Leckie JO. 1995. "A Pilot Study to Collect Micro-Activity Data of Two-to Four-Year-Old Farm Labor Children in Salinas Valley, California." J. Expo. Anal. Environ. Epidemiol. 5(1): 21-34.

MRID 410547-02: Dean, V.C. (1998) Exposure of Mixer/Loader-Applicators to Propoxur During Mixing/Loading and Application of Baygon 70 WP Insecticide as a Crack and Crevice & Limited Surface Treatment in Residences.

MRID 410547-03: Knarr, R.D. (1988) Exposures to Propoxur of Residents of Homes Treated with Baygon 70% WP.

MRID 410547-05: Knarr, R.D. (1987) Exposure of Applicators to Propoxur During Residential Applicators of an Aerosol Spray Containing 1% Propoxur.

MRID 444598-01: Merricks D.L., (1997) Carbaryl mixer/loader/applicator study during application of RP-2 Liquid (21%). Sevin ® Ready to Use Insect Spray or Sevin® 10 dust to home garden vegetables.

MRID 445185-01: Carbaryl Mixer/Loader/Applicator Exposure Study during Application of RP-2 Liquid (21%) to Fruit Trees and Ornamental Plants. Agrisearch Study No. 1518.. Report dated January 23, 1998. Author D. Larry Merricks, Ph.D., Sponsor: Rhone Poulenc Ag Company

MRID 44518501 (Carbaryl application to trees and shrubs study): Applications of Sevin Liquid® Carbaryl insecticide [RP-2 liquid (21%)]

MRID 44658401: Exposure of Commercial Pet Groomers During Application of Adams Carbaryl Shampoo.

MRID 448026-01: Korpalski S.J., Bruce E.D., (2000) Agronomic and Statistical Clustering of Agricultural Reentry Transfer Coefficients. Agricultural Reentry Task Force (ARTF).

MRID 449722-01: Outdoor Residential Exposure Task Force (ORETF) Handler Studies (hose-end sprayers)

MRID 450059-11: Dislodgeable Foliar Residues (DFR) Dissipation Data Following Application of Carbaryl to Tobacco.

MRID 451143-01: Turf Transferable Residue Data for Carbaryl Applied to Turfgrass in Georgia.

Appendix 1

A.1.1 Overview of Co-occurrence and Aggregate Exposure

Table A.1.1 depicts the 11 residential use scenarios and the exposures to applicators and children (post-application), by route. Applicator exposure occurs for all uses, except pet collars. Post-application exposure to children (ages 1-6) may occur for broadcast applications made to lawns, pet collars, and indoor crack and crevice treatments. Adults and youths (ages 13-19) may also receive post-application exposure from garden treatments.

Table A.1.1 Potential Exposures from Residential Uses, By Scenario and Route /1

AI	Site	Formulation-Application Method	Applicator (Adults)	Post-Application		
				Adults	Youth	Children
A	Lawn	Liquid hose-end spray	D,I	D	D	D,O
A	Lawn	Liquid handwand	D,I			
A	Lawn	Dust pour/shake	D,I			
A	Vegetable Gardens	Liquid handwand	D,I	D	D	
A	Vegetable Gardens	Dust pour/shake	D,I	D	D	
A	Ornamentals/Trees	Liquid handwand	D,I			
A	Ornamentals/Trees	Dust pour/shake	D,I			
A	Pets	Pet Collar		D	D	D,O
G	Pets	Pet Collar		D	D	D,O
G	Indoors	Crack and Crevice	D,I	D,I	D,I	D,I,O
H	Ornamentals/Trees	Ornamentals/Trees	D,I			

1/ D=Dermal, I=Inhalation, O=Incidental Oral (hand-to-mouth)

It is possible to obtain exposures on multiple occasions in various locations. For the 11 residential scenarios in this risk assessment, only pets have the possibility of being treated with multiple chemicals (two different pet collar products). While we do not have a formal definition of co-occurrent use, we do note an important distinction between exposures to the applicator and post-application exposures to children, youths and adults. For applicators, the use of one product (or multiple products) on multiple sites on the same day leads to co-occurrent exposure on that day. If the exposure duration of concern is less than or equal to one day, then these applications need to be made on the same day; applications made on subsequent days are not relevant (unless a PBPK model is used). For post-application exposures, applications to different sites (lawn, indoors) do not need to occur on same day for residues to be present, and children (or adults) to have co-occurrent exposures on the same day.

In modeling residential use, we want to know the number of households affected by multiple scenarios (numerous permutations) and how close in time those households made the various applications. Ideally, if we had numerous detailed pesticide use diaries, then we could model residential pesticide use patterns by assigning a (12 month) diary to each individual. The Residential Exposure Joint Venture (REJV) survey data most closely fits that need. At this time, none of the models have been modified to empirically utilize the REJV data.[23] In the sections below, we briefly describe how the

[23] The REJV companies have been working to match the CARES Reference Population with the REJV households. As done in Lifeline (per NHGPUS), a few other tasks need to be addressed (e.g., matching

three probabilistic models currently account for exposures from residential pesticide uses.

A.1.2 Residential Exposure Joint Venture (REJV) Data

General Overview[24]

The Residential Exposure Joint Venture (REJV) enlisted a panel of households to collect pesticide use data over a 12 month period. An initial screening survey was sent to over 100,000 panel members managed by the market research firm, National Family Opinion (NFO) Research. Of the 70,427 individuals that returned the screening survey, about 47,274 (67%) reported applying pesticides during the past year. Some respondents who indicated that they apply pesticides and who also expressed interest in participating in the survey were recruited to record monthly pesticide use diaries. Approximately 1200 households provided the full 12 months of pesticide use diaries.[25]

At the beginning of the 12 month survey period, these participants were asked to locate and record all pesticide products in and around their homes. The respondents were provided numerically labeled stickers, and they were asked to affix one sticker to each product so that each product had a unique identification number (e.g., two cans of Raid might be identified as products #1 and #2, respectively). In addition, the respondents were asked to provide an estimate of how full each of the products were: (1) Have Not Used Yet, (2) 76%-99%, (3) 51%-75%, (4) 26%-50%, (5) 1%-25%. This inventory questionnaire was filled out on three occasions: at the beginning of the survey period (5/1/01), after six months (11/1/01), and at the end of the survey (4/30/02). The product inventory sheets also contained a field for the products' EPA Registration Number. The EPA Registration Number identifies the specific product, enabling one to obtain any relevant information on that product label (which participants did not provide). The REJV obtained relevant data, in particular, the active ingredients and corresponding

---

REJV sites - kitchen, bathroom, etc. - to the CARES' scenarios), but in principle, the REJV data may be empirically used by these models in assessing residential exposures.

[24]The REJV consist of approximately 8 member companies whom sponsored, and oversaw the residential pesticide use study. One of the member companies provided the descriptive statistics in a formal submission, "Assessment of Chemical A Residential Use Patterns Using the Residential Exposure Joint Venture (REJV) Database, Data Requirement OPPTS 875.1000 - Occupational and Residential Exposure Test Guidelines, Chemical A: Occupational and Residential Exposure Assessment And Recommendations for the Reregistration Eligibility Document". Subsequent spreadsheet files "CARES_Chemical A_Inputs_21Nov02.XLS", updated: 16Dec02, 23Jan03, 28Jan03) present statistics from the complete 12 month REJV survey (May 2001 through April 2002).

[25] For the 1200 households that provided 12 months of pesticide use diaries, the NFO developed the weights to ensure that the ending sample was representative of the overall U.S. population on the following criteria: (1) geographical region, (2) household income, (3) household size, (4) Age of head of household, (5) Market Size (e.g., MSA) of city/township, (6) presence of kids. The weights range from 0.3 to 3.0, and sum up to 1200. These weights do not account for under-representation of African-Americans, or those of Hispanic origin. These weights were developed after the registrant submitted the paper (footnote 1). The estimates developed by the registrant assumed that these 1200 households (users) represent 67% of the total households (population), and that the remaining 33% do not apply any pesticides.

percentages, from the Pesticide Product Inventory System (PPIS) data base, and appended these data to the REJV Inventory Table.

At the end of each of month, the respondents were asked to fill out and send a monthly pesticide product application diary to NFO.[26] The application record contains the following information:

- ❑ Application Date
- ❑ Name of Pesticide Product
- ❑ Pesticide ID
- ❑ Where/On Whom The Product Was Applied (Site)
- ❑ Who Applied The Pesticide Product
  - o Gender (M/F)
  - o Age
- ❑ If Any Household Members were Present:
  - o Applicator Only
  - o Child 1-6 years old
  - o Child 7-12 years old
  - o Child 13-17 years old
  - o Other Adult 18+
- ❑ If the Product was Used Up
- ❑ If the Product was Disposed of After Use

The Application Table contains approximately 30,000 are valid application records. A valid application is an application that was made by a homeowner with a pesticide product that was in the product inventory table. The following discussion present some descriptive statistics compiled from the REJV data.

[26] The respondents were also asked to fill out and send a pesticide product purchase sheet to record any new products purchased that month.

Residential Use of the NM CRA – Scenarios[27]

Table A.1.2 presents the 17 lawn and garden scenarios (+1 pet scenario) developed by the registrant for chemical A based on Residential Joint Exposure Venture (REJV) data. We reduced the number of residential scenarios that we developed for chemical A from 17 to 7 based on several factors: (1) these scenarios reflect a relatively high use of chemical A for each of three sites (lawn, vegetables, ornamentals/trees) as reported in the REJV data, and (2) are conservative with respect to expected exposure. With regards to pesticide use, dust and handwand applications generally were the most frequently reported product-formulation uses (REJV) for these lawn and garden sites (turf, vegetables, ornamentals and trees). These two use patterns were retained since the REJV data also indicate a significant amount of co-occurrent use patterns for households applying either a handwand or dust formulation to multiple sites (i.e., turf, garden and ornamental plants).

The Ready-To-Use (RTU) spray scenarios were not developed for this assessment since it generally leads to lower exposure than the other application methods (dust, handwand, hose-end) due to relatively lower amounts applied. While RTU scenarios have higher unit exposure values, the applicator exposure is generally lower due to lower amounts applied. For example, for lawn uses, RTU products have higher upper range dermal unit exposure values than Hose-end applications (557 mg/lb ai versus 73 mg/lb ai). But upper range exposures from RTU products are lower since RTU products are designed for spot treatments and the amounts are applied are lower due to lower application rates (0.6 lbs ai/acre versus 8 lbs ai/acre), and area treated (<1000 sq ft versus up to 20,000 sq ft).

For turf, a Hose-end application scenario was developed to address the homeowners that treating large areas (up to 20,000 sq ft) using this more efficient method. As noted, while treating such a large area with dust, handwand or RTU products may provide higher exposure, such a scenario is unlikely due to feasibility considerations. Hose-end application methods were not modeled for vegetable, ornamental and tree uses since they are not as frequently used on those sites (REJV), and since handwands generally provide higher exposures than hose-end due to higher Dermal Unit Exposure values.

[27] These estimates were developed before NFO developed the sampling weights for the 1200 households (footnote 3). The estimates developed by the registrant assumed that the households represented 67% of the total households (population), and that the remaining 33% do not apply any pesticides. Use from all 6000 households were included.

Table A.1.2 Residential Use of Chemical A, REJV/1

Scenarios	EPA Scenarios	Formulation-Application Method	# Apps	Derived proportion	Pct of Households
Lawns					
1	1	Dust	82	90%	0.8%
2		RTU Spray	9	10%	
		Lawn Care – Subtotal (Spot)	91	100%	
3	2	Hose-end Spray	11	21%	0.2%
4	3	Handwand Spray	26	50%	0.2%
5		Granular Push Spreader	7	13%	
		Other	8	15%	
		Lawn Care – Subtotal (Broadcast)	52	100%	
		Lawn Care - Total	143		1.2%
Vegetable Gardens					
6	4	Dust	447	69%	2%
7		RTU Spray	33	5%	
8		Hose-end Spray	13	2%	
9	5	Handwand Spray	136	21%	2%
		Other	21	3%	
		Vegetable - Total	650	100%	4.12%
Ornamental Plants					
10	6a	Dust	370	61%	2%
11		RTU Spray	78	13%	
12		Hose-end Spray	24	4%	
13	7a	Handwand Spray	120	20%	2%
		Other	19	3%	
		Ornamentals – Total	611	100%	4.84%
Trees					
14	6b	Dust	18	12%	
15		RTU Spray	21	14%	
16		Hose-end Spray	4	3%	
17	7b	Handwand Spray	101	69%	
		Other	2	1%	
		Tree Care – Total	146	100%	1.12%
Pets					
18	8	Pet Collars	166	100%	0.5%

/1 "Evaluation of Potential Aggregate Human Health Risks Associated with Agricultural and Consumer Uses of Chemical A", Submitted to US EPA in support of Chemical A.

Finally, use on ornamentals and tree care was grouped as one site based on several considerations: (i) these uses have the same Unit Exposure values for each application method, (ii) there are no post-application scenarios for either ornamental plants or trees, and (iii) Lifeline does not explicitly account for use on trees. The information lost in grouping these two sites together is the total area treated (amount applied), but we do not have good information on area treated and the amount applied per given event.

Defining Scenarios & Grouping Data

Like many consumer product surveys, the REJV data is imperfect. For example, we assume that homeowners apply liquid concentrate formulations of chemical A (i.e., 21.3% concentration, 23%, 27%, etc) using either a hose-end sprayer or a handwand. The survey respondents reported using those application methods/equipment, as well as other methods that do not obviously match with such products (Application Method = aerosol spray, fogger, etc.) Such responses may be errors due to incorrect reporting, data entry, and/or misuse of a product. A careful review of the data may enable one to make educated guesses at QCing those application records. The rules for using and assigning application records will affect the calculated pesticide use statistics – such as those presented in the Table A.1.2.

Co-Occurrent Uses of the N-Methyl Carbamates

Figure A.1.1 is a bubble plot (Gaant chart) depicting use of chemical A over the 12 month period (Months 1-12, Jan-Dec). The size of the bubbles represent the percent of households that apply chemical A to the respective sites. Based on the REJV data, approximately 1.2% of all households applied chemical A to lawns; with 0.22% of all households making applications during both May and June. Similarly, 4.1% of all households applied chemical A to vegetable gardens; with over 1% of all households making an application during May, June and July and 5% of all households applied chemical A to ornamental plants/trees. Figure A.1.1 suggests that the likelihood of applying chemical A to multiple sites is higher during May and August since much of the use occurs during these months. The next two sections present further description on how CARES and Calendex account for co-occurrent use patterns.

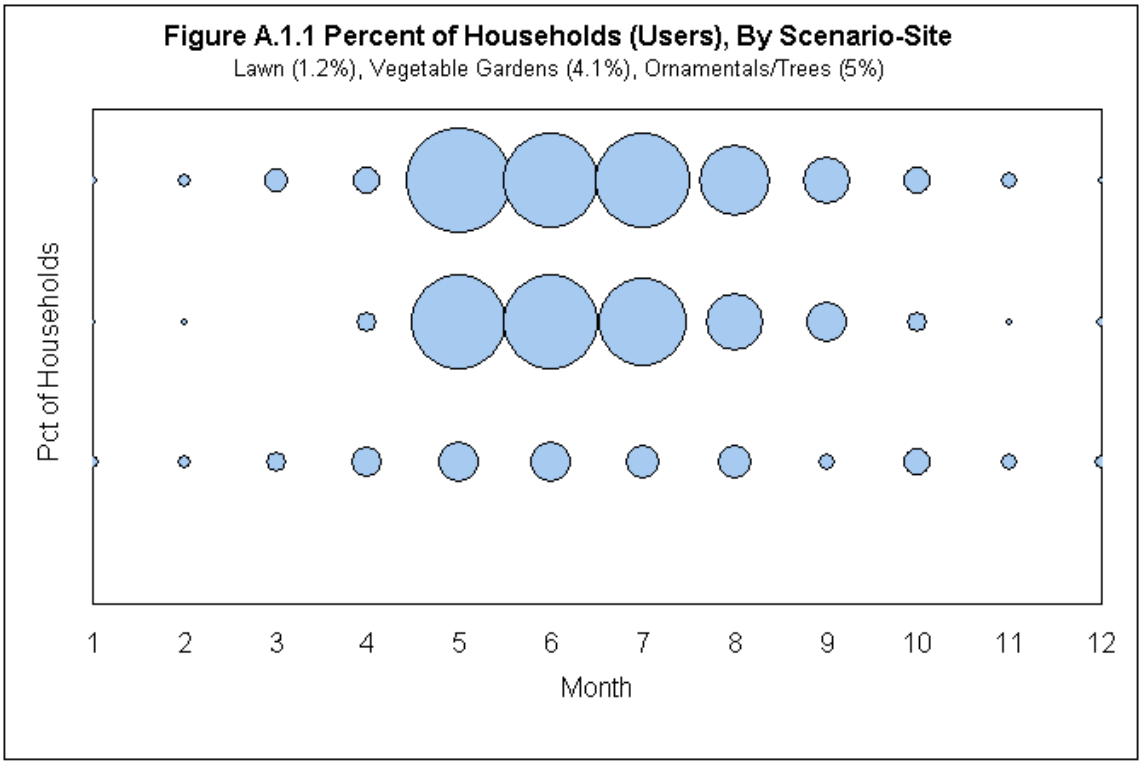


Table A.1.3 presents the Percent of Households that Apply Pesticides to the various sites as calculated from the REJV data and used by the registrant for chemical A uses. These estimates were broken down by formulation-application method previously. The registrant calculated the temporal distributions (month, day of week) over all product formulations-application methods for chemical A. Table A.1.4 presents the average number of applications made by the households (users), and the treatment interval between applications as specified in CARES.

Table A.1.3 Chemical A Percent of Applications, By Month, Day of Week

	Lawn	Vegetables	Ornamentals	Trees	Pets
PHT	1.2%	4.1%	5.0%	1.2%	0.5%
Month of Year					
January	2.1%	0.2%	0.3%	0.0%	0.0%
February	2.8%	0.2%	0.5%	0.0%	2.0%
March	5.5%	0.0%	1.5%	0.0%	2.0%
April	10.3%	1.7%	2.1%	8.8%	8.0%
May	18.6%	26.9%	28.1%	30.6%	32.0%
June	18.6%	28.4%	23.0%	23.1%	24.0%
July	12.4%	24.8%	22.4%	23.8%	12.0%
August	12.4%	10.3%	13.2%	0.9%	6.0%
September	4.1%	5.7%	5.6%	3.4%	2.0%
October	7.6%	1.4%	2.3%	0.0%	12.0%
November	3.5%	0.3%	1.0%	9.3%	0.0%
December	2.1%	0.3%	0.2%	0.0%	0.0%
Day of Week					
Sunday	22.9%	11.4%	15.2%	9.7%	20.6%
Monday	12.5%	12.7%	13.9%	12.5%	12.5%
Tuesday	9.0%	16.4%	12.9%	16.7%	6.3%
Wednesday	11.8%	14.5%	13.9%	14.6%	25.0%
Thursday	10.4%	13.7%	13.4%	15.3%	8.5%
Friday	18.1%	13.1%	13.5%	13.9%	12.5%
Saturday	15.3%	18.2%	17.3%	17.4%	14.6%

Table A.1.4 Chemical A Average Number of Applications, Treatment Intervals, By Scenario

Scenario (Site-Formulation-AppMethod)	Average Number of Applications	Treatment Interval (Days)
Lawn-Dust	2	7
Lawn-Liquid-HES	1	30
Lawn-Liquid-Handwand	2	30
Vegetables-Dust	1	30
Vegetables-Liquid-Handwand	2	30
Ornamentals/Trees-Dust	1	30
Ornamentals/Trees-Liquid-Handwand	1	30
Pet-Collar	1	15

A.1.3 The National Home and Garden Pesticide Use Survey (NHGPUS) & Pest Use Factors (UF)

General Overview

The US EPA contracted the Research Triangle Institute to design and conduct the National Home and Garden Pesticide Use Survey (NHGPUS). Technical details of the survey are available in two published reports.[28] Approximately 2,078 housheholds were contacted and provided detailed information regarding pesticide use practices. These households, located in 58 counties in 29 states, were selected from a stratified probability sample. The survey data contains demographic information regarding type of dwelling (single family, multi-family), location (urban/rural), household structure (age & gender of individuals), as well as household characteristics (presence of lawn, vegetable garden, ornamental plants, etc.), and general pesticide use questions (e.g., Did homeowner employ the services of a Lawn Care Operator or Pest Control Operator during the last year?). The survey was conducted through in-person interviews at the respondents' homes. The respondents and the survey taker located all pesticide products in and around the home (the storage locations and whether it was child secured were also recorded). For each product, a series of questions were asked regarding the households' use of that product(s) during the past 12 months:

- site(s) applied
- primary target pest(s)
- total number of applications made during last 12 months (responses coded in discrete intervals: {0,1,2,3-6,7-12,13-50, }
- application method(s)
- primary applicator(s) – household member(s)
- safety precautions taken (PPEs)

The responses to these questions are the primary data in the NHGPUS pesticide product use table. The National Home and Garden Pesticide Use Survey provides information on specific sites (e.g., D-2 = Kitchen) that a product was used to treat for specific pests. The NHGPUS total number of applications made to various classes of sites (e.g., A, B, C, D, E, F).[29]

[28] National Home and Garden Pesticide Use Survey, Final Report, Volume I: "Executive Summary, Results, and Recommendations," and Volumne II: "Survey Design, Implementation, and Analysis Methods", prepared by Research Triangle Institute, Roy W. Whitmore, et.al., for U.S. Environmental Protection Agency, Office of Pesticide Programs, March 1992.

[29] Some assumptions are needed to use this information on total applications made to sites (D,E,F) to estimate the number of applications made to each specific site (D-1,D-2, D-3, etc).

Table A.1.5 NHGPUS Application Site List (CARD B)

Code	Site Description
A-1	PERSON
B-1	CAT OR DOG OR THEIR BEDDING, KENNEL, OR RUN AREA
C-1	HOUSE PLANTS OR GREENHOUSE
D-1	FABRIC (such as laundry, carpets, linens, upholstery, drapes)
D-2	KITCHEN
D-3	BATHROOM
D-4	BEDROOM, LIVING ROOM, NURSERY, OR DEN
E-1	DETACHED STRUCTURES (such as detached garage, shed, workshop, other detached room)
E-2	OTHER INSIDE AREAS (such as attached garage, attic, basement, crawlspace, utility room, workshop, other inside space or attached room)
F-1	LAWN
F-2	EDIBLE FRUIT OR NUT TREES OR GRAPE VINES
F-3	OTHER FOOD CROPS (such as tomatoes, vegetables, berries, melons)
F-4	ROSES
F-5	OTHER ORNAMENTALS (such as non-food trees, shrubs, vines, flowers)
F-6	OTHER OUTSIDE AREAS (such as walls, driveway, patio, deck, fence, or roof, including air treated by fogging)

Table A.1.6 NHGPUS based Estimates on the Percent of Households Applying Chemical A, By Site

Site	Percent of Households Applying, By Region			
Chemical A	Northeast	Midwest	South	West
Lawn	0.46%	0.87%	1.68%	2.05%
Fruit/Nut Trees or Vine	0.94%	0.58%	0.72%	1.36%
Garden	2.10%	3.14%	2.68%	2.40%
Roses	3.05%	1.89%	1.33%	3.07%
Other Ornamentals	3.53%	2.21%	2.93%	3.31%
Other Outside Areas	0.46%	0.34%	0.48%	2.18%
Chemical G	Northeast	Midwest	South	West
Kitchen	6.7%	7.0%	11.2%	9.0%
Bathroom	2.8%	5.1%	6.8%	5.4%
Bedroom, Living Room	3.1%	4.4%	4.7%	2.1%
Detached Structure (Indoor)	1.0%	1.3%	1.8%	1.1%
Other Inside Areas	3.8%	4.2%	2.8%	3.6%
Pet or Bedding/Kennel Area	0.5%	1.1%	0.5%	1.5%
Chemical H	Northeast	Midwest	South	West
Other Ornamentals	*	0.2%	*	*

Comparison of Pesticide Use Data - General Population of Users

In addition to the REJV statistics for chemical A, the registrant also presented the Agency a study on homeowner use of chemical A on lawns and gardens.[30] Table 1 indicated that those estimates are consistent with data from other surveys. The 1990

[30]'Product A Usage Study', prepared by P.K. Data, Inc., for Rhone-Poulenc, Inc, October 22, 1998.

EPA National Home and Garden Pesticide Use Survey (NHGPUS) estimated that about 1% of all households applied chemical A to lawns, while the chemical A Usage Study indicates a somewhat higher percentage (~8%). These figures are not directly comparable since each study focused upon different population groups. The NHGPUS covered all households, the REJV study covered pesticide users, and the chemical A study covered households that had a private yard and were active in doing yard work. The participants in the latter two studies were more likely to apply pesticides than the general population. Table 1 indicates that about 74% of all households were eligible for participation in the REJV study, and about 40% were eligible to participate in the chemical A study.

Table A.1.7 Household Characteristics For 3 Residential Pesticide Use Surveys /1

Have Lawn or Yard for Private Use?	Applied Pesticides (Herbicide, Insecticide or Fungicide)			Not Apply Pesticide Anywhere	All Households
	Outdoor Only	Indoor and Outdoor	Indoor Only		
Yes	10% (a)	30% (a)	23%	17%	80%
No	<1%	1%	10%	9%	20%
Total	10% (b)	31% (b)	33% (b)	26%	100%

1/ Based primarily on the NHGPUS data. The notation (a) -denotes individuals qualifying for the Chemical A study; (b) - denotes individuals qualifying for the REJV survey. The NHGPUS survey covered all households. If 1% of all households applied chemical A to lawns, then we would anticipate approximately 2.5% (=1%/40%) of the households in the Chemical A study, and 1.3% (=1%/74%) of the households in the REJV study to apply chemical A to lawns.

A.1.4 Accounting for Residential Use & Co-occurrence in Models

CARES

For each residential use scenario, CARES requires the following pesticide use data:

- ❑ Percent of Households that Apply Pesticide (PHT) (Table A.1.2)
- ❑ Month - Percent of Total Applications (Table A.1.3)
- ❑ Day of Week - Percent of Total Applications (Table A.1.3)
- ❑ Average Number of Applications/Year (Table A.1.4)
- ❑ Days Between Application (Table A.1.4)

In addition to the above statistics, CARES also requires the user to input a Co-Occurrence Matrix. This matrix accounts for correlations across residential use scenarios. Table A.2.3 presents the Co-occurrence matrix that was calculated from the REJV data and used by the registrant in their CARES assessment. The co-occurrence matrix is not a correlation matrix, and therefore, it is not symmetric. The matrix is read by row, as follows (for the first row): “For a modeled individual in which the Lawn was treated, there is a 11.7% chance that the garden was also treated on the same day, a 31% chance that ornamental plants were treated on the same day, and a 3.4% chance

that trees were treated on the same day, and a 3.4% chance that pets were treated on the same day." The zeros in the diagonal cells indicate that use occurred on that site.

Table A.1.8 Chemical A Scenario Co-occurrence Probability Matrix

	Lawn	Vegetables	Ornamental Plants	Trees	Pets
Lawn	0.000	0.117	0.310	0.034	0.034
Vegetables	0.026	0.000	0.230	0.068	0.011
Ornamental Plants	0.072	0.248	0.000	0.076	0.008
Trees	0.034	0.306	0.320	0.000	0.000
Pets	0.100	0.120	0.080	0.000	0.000

The CARES Event Generator uses all of the descriptive statistics and the co-occurrence matrix to generate a pesticide use profile for each modeled individual. CARES outputs the calendar dates for all application events for each modeled individual – allowing the user to check how closely the model reproduces the pesticide use scenarios as reported in the REJV diaries (or other pesticide use data).

Calendex

The Calendex model requires users to input similar pesticide use statistics to model pesticide exposures. The following data are inputted into Calendex's 'Application Schedule':

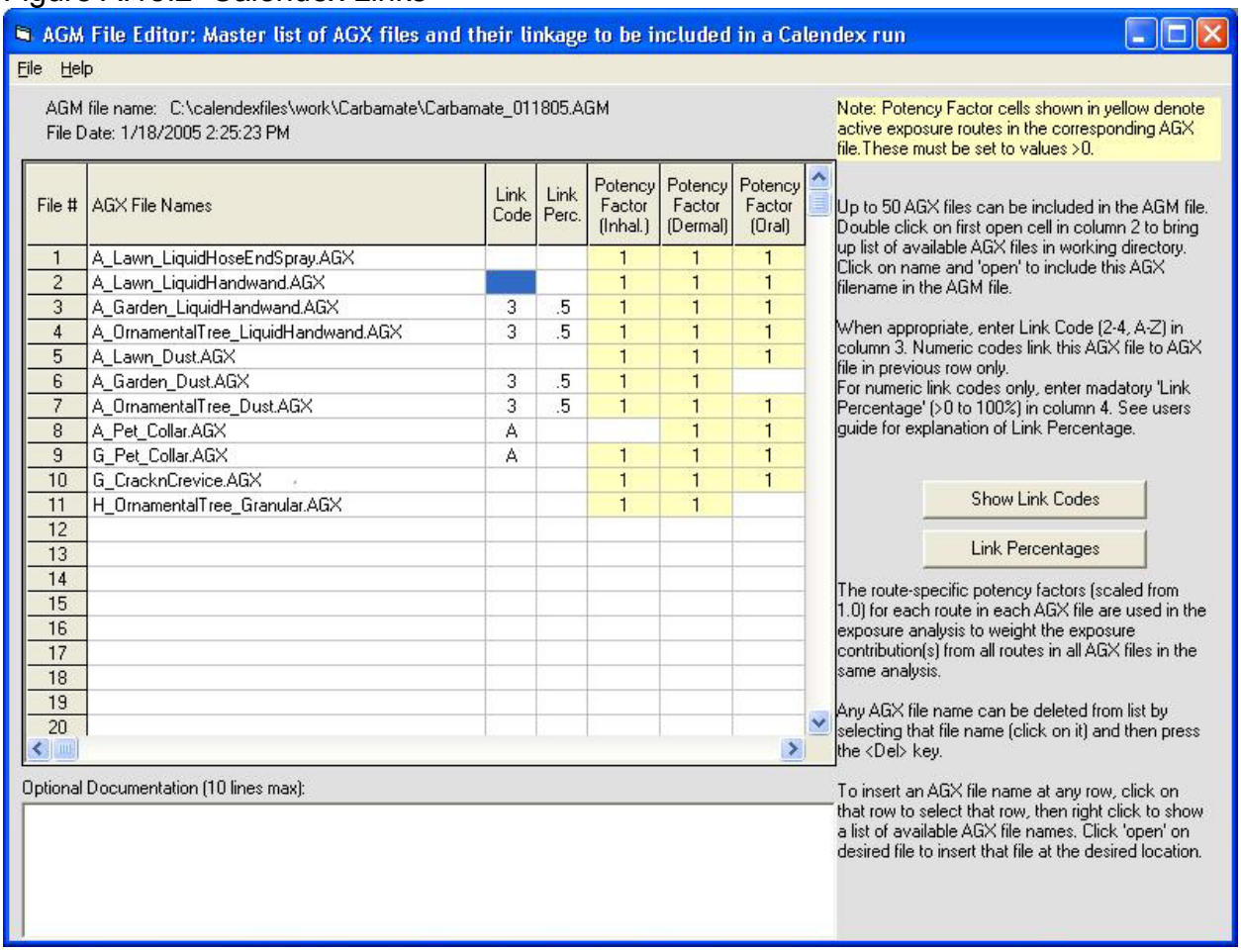
- ❑ Percent of Households Applying Pesticide (Table A.1)
- ❑ Day or Week of 1st application (Tables A.1.3)
- ❑ Number of Applications/Year (Table A.1.4)
- ❑ Number of Days (Weeks) to successive applications (Similar to Table A.1.4)

In addition to these statistics, Calendex allows the user to specify 'Linkages' between scenarios. On terminology, the pesticide use statistics for each scenario are located in a unique 'AGX' file. The AGX file also points to contact files and residue files each of the relevant routes (oral, dermal, inhalation); these files contain the corresponding 'contact' (time spent, transfer coefficient, etc.) exposure factors. There are four types of linkages which may be specified in the Calendex 'AGM' file, as depicted in Figure A.2.3.a. The numeric codes link the application(s) from one AGX file to the applications in the AGX file located immediately above. Code '2' forces an identical application schedule for this AGX file as calculated for the previous AGX file for any given individual. Code '3' is similar to Code '2', but forces the same date for the first application of the year only. Code '4' forces the application of this AGX file when the previous AGX file is used, but application schedules (numbers and dates) are independent.

The alphabetic codes: 'A', 'B', 'C', etc. define mutually exclusive (ME) treatments. There are two pet collar products, one containing chemical 'A' and the other containing

chemical 'G'. Linking these two files with the same alphabetic code forces Calendex to select at most only one of the two scenarios for each individual.

Figure A.18.2 Calendex Links



File #	AGX File Names	Link Code	Link Perc.	Potency Factor (Inhal.)	Potency Factor (Dermal)	Potency Factor (Oral)
1	A_Lawn_LiquidHoseEndSpray.AGX			1	1	1
2	A_Lawn_LiquidHandwand.AGX			1	1	1
3	A_Garden_LiquidHandwand.AGX	3	.5	1	1	1
4	A_OrnamentalTree_LiquidHandwand.AGX	3	.5	1	1	1
5	A_Lawn_Dust.AGX			1	1	1
6	A_Garden_Dust.AGX	3	.5	1	1	
7	A_OrnamentalTree_Dust.AGX	3	.5	1	1	1
8	A_Pet_Collar.AGX	A			1	1
9	G_Pet_Collar.AGX	A		1	1	1
10	G_CracknCrevice.AGX			1	1	1
11	H_OrnamentalTree_Granular.AGX			1	1	
12						
13						
14						
15						
16						
17						
18						
19						
20						

In Figure A.1.2, the three liquid handwand scenarios (as well as the three dust scenarios) of chemical A on lawn, gardens and ornamentals/trees are linked via code '3', with a link percentage of 50. The two pet collar scenarios (chemical A and chemical G) are also linked via the mutually excluseive alphabetic code 'A'. Although only one linkage may be made with a particular scenario, the Calendex links provide for a wide range of correlations across existing scenarios.

Lifeline & NHGPUS' Target Pests

Many of the application events reported in the NHGPUS (and REJV) were with products that are no longer marketed, and/or are no longer currently registered for use. While the use of particular products change over time, there is more constancy in pests problems (cockroaches, ants, termites, etc) that homeowners are faced with and for which they apply pesticides. Anticipating such changes in the homeowner pesticide markets, the Lifeline developers did not use the chemical specific information available in the NHGPUS data. Rather, the NHGPUS data on pests treated, by site (indoor-

kitchen, bathroom, etc.), and the number of applications made during the last 12 months (year) were extracted, and pesticide 'diaries' were created from these data to estimate a homeowners' probability of applying a particular product to each site/location on any given day.

Table A.1.9 Lifeline Pest Use Factors, Based on NHGPUS Data

Chemical/Site	A	A	A	A	G	G	H
PESTNAME	Lawn	Garden	Orn / Tree	Pet	Indoor	Pet	Orn / Tree
ANY OTHER ANTS	1.2%	23.9%	6.7%		15.7%	29.6%	
BEES, HORNETS, WASPS	2.3%				15.7%	9.6%	
BROADLEAF WEEDS		8.7%	5.0%				
COCKROACHES					12.1%	14.4%	
FABRIC INSECT PESTS					2.9%		
FIRE ANTS	3.1%	34.4%	15.3%		13.6%		
FLEAS	6.7%	63.7%	24.7%	6.5%	1.8%	1.8%	
FLIES, GNATS, WIDGETS				2.8%	4.4%	2.3%	
GRASS-LIKE WEEDS		16.4%	5.4%		18.0%		
MICE, RATS					2.9%		
MILDEW, MOLD, BACTERIS, VIRUS			3.9%		0.0%	1.4%	
MOSQUITOES				1.8%	4.1%		
OTHER MAMMALS		50.1%					
OTHER PEST				7.0%			
OTHER WOOD-DESTROYING INSECTS		24.6%	13.6%		29.1%		
PLANT DISEASES	5.5%	7.3%	8.0%		5.6%		
PLANT-CHEWING INSECTS	8.6%	24.3%	19.6%	100%	7.0%		
PLANT-CHEWING OR PLANT SUCKING INSECTS	4.8%	32.4%	8.4%	75.2%			
PLANT-SUCKING INSECTS AND MITES	6.7%	18.8%	11.3%	34.7%	1.6%	17.2%	
SLUGS, SNAILS	13.4%	9.2%	15.8%				4.6%
SOIL-DWELLING INSECTS, NEMATODES	1.3%	13.1%	13.8%				
SPIDERS, CRICKETS, SOWBUGS/PILLBUGS, MILLIPIDES, CENTIPIDES	4.1%	29.3%	6.5%		10.6%	6.5%	
STORED FOOD INSECT PESTS					10.2%		
TERMITES					5.9%		
TICKS, CHIGGERS	5.5%			8.1%	2.2%	1.9%	

Table A.1.9 presents the pest 'Use Factors' for each chemical applied to each site. These statistics were calculated directly from the NHGPUS data, and were entered into Lifeline (rkg file). The pest use factors (UF) are comparable to market shares; they do not represent the percent of households treating the site to control for the respective pests (For more details, see Lifeline Technical Manual, p 5-46). Therefore, while chemical 'A' accounted for 63.7% of the applications made to gardens to control 'Fleas' on gardens, there were few applications made to this site for that intended purpose – the 32.4% share for 'Plant-chewing or plant sucking insects' accounts for more use than the larger share of the 'flea' market.[31]

For each modeled individual, Lifeline draws a particular NHGPUS pesticide 'diary' to model residential pesticide use. If the diary indicates that the pest was treated in one of the Microenvironment (ME) Classes (lawn, garden, ornamental plants, indoors, pets), then the Lifeline model uses the corresponding number of applications that the household reportedly made to calculate the probability that an application was made on any given day. For individuals living in the southern states, the probabilities were calculated based on use occurring during a 365 day season. For individuals living in northern states, the probabilities were calculated based on use during the spring and summer seasons (approximately 183 days). (Technical Manual, page 5-51, 5-52)

To further illustrate how Lifeline uses the NHGPUS records, approximately 1.44 million households reported making an application of one or more pesticide products to their garden to treat for 'Plant-chewing or plant sucking insects'. Approximately 467,000 households (32.4% of the total applications) reported applying 'A' to gardens to treat for this target pests. The NHGPUS survey was based on a projected 84.5 million households in the U.S., therefore, approximately 0.55% (0.00552=0.467/84.5) of all households applied 'A' to gardens to treat for this particular pest. Based on the NHGPUS data, we anticipate that approximately 0.55% of all modeled individuals in Lifeline will draw a NHGPUS diary in which gardens were treated to control for 'Plant-chewing or plant sucking insects', based on the corresponding UF (32.4%). For any particular diary treating for that pest, a corresponding number of applications were made, from which the probabilities of applying 'A' on any given day are calculated – all days during the use season have equal probability of treatment. Similar calculations are made for other pests that may be listed in that NHGPUS diary. Overall, between 2% to 3% of all households will apply 'A' to gardens to treat for various pests (Table A.1.6).

Co-occurrence in NHGPUS

Since Lifeline empirically utilizes the NHGPUS data, co-occurrence in use and exposure is built into the Lifeline model to the degree that some homeowners (NHGPUS diaries) reported applying a pesticide product to treat for the various pests in the corresponding sites. Based on the approach taken by the Lifeline developers, as long as the NHGPUS diary reported using a product to control for similar target pests, the possibility exists

[31]Since chemical 'A' has three formulations applied to 'Lawn', as an approximation, these pest use factors can be apportioned using the overall percent of households applying (Table A.1.1); or use factors can be calculated for each product-formulation used on lawns. The agency is evaluating different approaches.

that modeled co-occurrence from chemicals' A, G, and H could occur even though that particular NHGPUS did not use products containing those three chemicals to the respective sites. Similarly, the modeled use of a NHGPUS diary that did report using products containing A, G and H to the respective sites may not necessarily result in modeled use of those products (at any point during the year) since Lifeline assigns only a daily probability, and no assurance is made that the product will be used at some point throughout the year.[32]

Using More Recent Pesticide Use Data (e.g., REJV) in Lifeline

Although Lifeline uses the NHGPUS data to generate pesticide use events, its use of the NHGPUS data enables it to utilize other data sources (such as the REJV) to account for updated use patterns. For example, if pesticide use has increased (or decreased) since the NHGPUS was conducted, then one can adjusts the Use Factors proportionately. A spreadsheet summarizing use (by target pest-site) among the 2,078 households can provide a quick update on the overall percent of households applying that chemical to that site based the new adjusted target pest 'Use Factors' to check that the percentages have increased to the desired levels. While co-occurrence remains based on the use patterns reported by the NHGPUS participants, this use of the NHGPUS data enables modelers to adjust the pest use factors to better reflect more recent pesticide use patterns.

[32]Different approaches that may have been taken by the Lifeline developers to incorporate the NHGPUS data could influence the likelihood of modeled co-occurrence.

Appendix 2

A.2.1 Overview of Lifeline Model

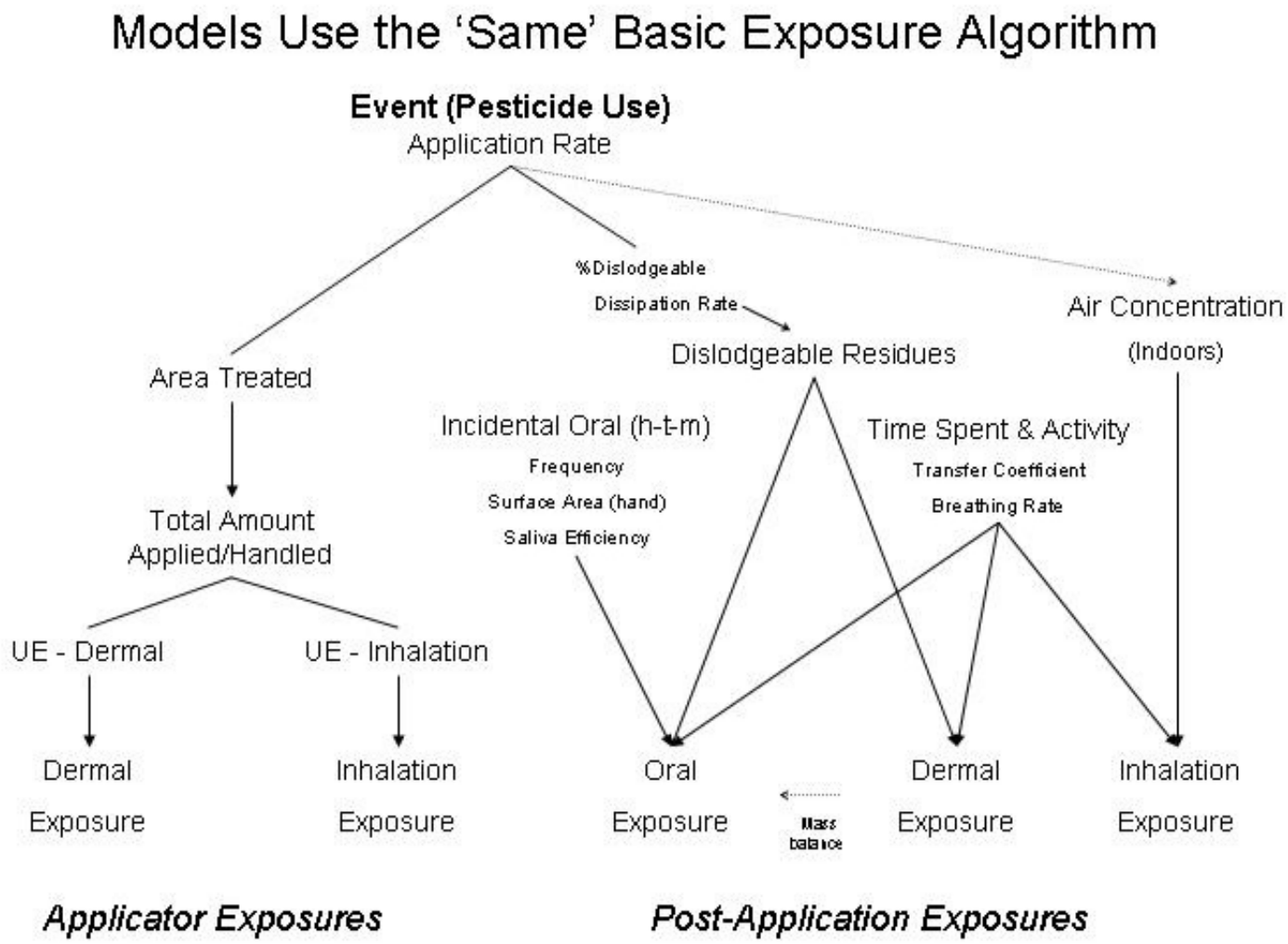
The various models may produce different estimates in either a single product use scenario assessment or a cumulative exposure assessment due to differences in the data inputs used and/or differences in how the various models use these data. With regard to any given scenario, DEEM/Calendex, LifeLine, and CARES all use similar basic algorithms to estimate exposure for various residential uses (Figure 1).[33] However, LifeLine differs from Calendex and CARES in that much of these exposure data are incorporated or already "built in" its model design. For example, housing characteristics such as lawn size, the number rooms, and source of tapwater (community water supply, private well, other) are extracted from the American Housing Survey (AHS). The probability of a pesticide application is determined by the Target Pest(s), corresponding Pest Use Factors, and the household pesticide use diary selected from the US EPA National Home and Garden Pesticide Use Survey (NHGPUS). The US EPA National Human Activity Pattern Survey (NHAPS) data is used to determine the locations and associated activities that a modeled individual pursues throughout the day. Such empirical use of the time use diaries enable Lifeline to determine both the time spent in a treated area (kitchens, bathrooms, yard-outside areas, etc.), as well as the specific activities performed. These activities, in turn determine the appropriate transfer coefficient(s) and breathing rate(s) which are calculated by the LifeLine using anthropomorphic models of the individuals' bodyweights, body surface areas, and basal metabolic rates.

All of the exposure data resources used by Lifeline are publicly available, and some have been used to calculate distributions for exposure factors used in this assessment. For example, distributions on time spent (outdoors) are taken from the EPA Exposure Factors Handbook, via the NHAPS survey – which is embedded in the Lifeline model. The decision to embed a particular data set into a model should not greatly affect the model's predictions to the extent that alternative data provide similar distributions of the various exposure factors. That is not to say that the two approaches produce the same results since modeling assumptions that are required to empirically incorporate data from such diverse sources can and do affect predicted exposures. From the experience we have in evaluating the various models, it appears that these effects are relatively less important than the residue values – if residues (air and/or surface) are relatively large, then exposure/risks will be comparatively large across these models.

It is difficult to make general statements regarding the effect (direction) that each model's design assumption has upon the model's predictions. However, these data are

[33]The CARES' mass balance algorithm calculating incidental oral (htm) exposure for toddlers differs from the standard algorithm used by EPA/HED in that the total residues on the toddlers' hand is a fraction of their total dermal residues, and this amount is apportioned across each event, based on the assumed exposure duration (hours) and number of events per hour. The EPA/HED algorithm assumes that the residues are fully replenished after each htm event, and therefore, total incidental oral exposures tend to be higher under this algorithm (dependent upon dermal TC).

embedded into the Lifeline model in a reasonable and consistent manner that provides for logical consistencies with respect to modeling aggregate exposure.


Models Use the 'Same' Basic Exposure Algorithm
Event (Pesticide Use)
Application Rate
%Dislodgeable
Dissipation Rate
Air Concentration
(Indoors)
Dislodgeable Residues
Area Treated
Incidental Oral (h-t-m)
Frequency
Surface Area (hand)
Saliva Efficiency
Time Spent & Activity
Transfer Coefficient
Breathing Rate
Total Amount
Applied/Handled
UE - Dermal
UE - Inhalation
Dermal
Exposure
Inhalation
Exposure
Oral
Exposure
Mass
balance
Dermal
Exposure
Inhalation
Exposure
Applicator Exposures
Post-Application Exposures

For example, a homeowner is assumed to apply a certain amount of pesticide from which both his inhalation and dermal exposures are calculated. In contrast, Calendex may allow applicators to have inhalation and dermal exposures based on different amounts applied.[34] Similarly, for post-application exposure, the toddler is assumed to spend a certain amount of time from which dermal, inhalation and incidental oral (htm) exposures are calculated. And across the various residential uses, the total duration of exposure for any individual (time spent indoors + yard) will not exceed 24 hours, in contrast to both Calendex and CARES.

With regard to aggregating exposures across scenarios, the models employ different methods to account for co-occurrent use, as Appendix 1 illustrated. Therefore, even though the same pesticide use data may be available for use in all of these models, the models will utilize these data differently, and, as a result, provide slightly different estimates of aggregate exposure. While Lifeline embeds the NHGPUS data to define pesticide use patterns, its use of the target pest information (rather than specific products/chemicals applied), enable the user to utilize the REJV data to generate Pest Use Factors to account for overall use.

The current version of Lifeline contains several limitations that require users to make modifications to some of the data inputs in order to incorporate into the assessment a variety of probabilistic refinements and adjustments. These limitations include: (i) Lifeline accepts only a single point estimate for many exposure factors (e.g., application rate, hand-to-mouth activities), and where it does allow for distributions (Unit Exposure), the user needs to input a custom Cumulative Distribution Function (lognormal & triangular distributions need to be converted in Crystal Ball or @Risk), and (ii) RPFs cannot be entered for different chemicals. Section A.2.2 describes the modifications to the input data that were made to account for these limitations. Section A.2.3 describes some distributions of exposure factors that are embedded or 'built-in' to the Lifeline model. Section A.2.4 presents the Pest Use Factors for the residential scenarios. Section A.2.5 presents the tapwater concentration distributions that were used for this assessment.

[34]Calendex has separate data entry screens (dialog boxes) to input exposure factors for each of the three routes (incidental oral, dermal, inhalation); so the total amount applied (or application rate, area treated) are inputted twice if applicators have both inhalation and dermal exposure. To calculate the applicator's dermal and inhalation exposure, Calendex will draw a (independent and) random variable for the amount applied (or for both the application rate and area treated if those are specified separately) for each of those two routes. So the calculation of dermal exposure may be based on 1 lb ai applied, while the calculation of inhalation exposure may be based on 2 lbs ai applied. For applicator exposures, this shortfall is muted to some extent since the dermal route accounts for most exposure - even after accounting for differences in the route PODs. Calendex also has three different sets of data entry screens for each of the post-application exposure routes. For example, since toddlers may obtain both dermal and incidental oral exposure from treated turf, two separate (independent) random values for time spent in the treated area are drawn for calculating dermal and oral exposures. Therefore, the post-application exposure may be based on one our duration for dermal exposure and two hours duration for incidental oral.

A.2.2.a Relative Potency Factors & Conversions for Oral/Inhalation Exposures

The current version of Lifeline (version 2.0) does not permit specification of separate relative potency factors (RPFs) for different chemicals. Following the methodology used in Lifeline Organophophate Cumulative Risk Assessment (LL OP CRA), one accounts for the differences in RPFs by adjusting the application rates. Thus, application rates are specified in, for example, index chemical equivalent lbs per acre. This procedure is somewhat analogous to the pre-calculations that are made for food residues. For residential uses, there is an added complexity in that there are several potential exposure routes (oral, dermal and inhalation), each of which may have a different RPF. Since there is only one application rate for a given pesticide, each rate is entered in dermal equivalents using the Dermal-RPFs for the respective chemicals. The Dermal-RPF was chosen since all of these residential uses have some dermal exposure (applicator and/or post-application). For example, if a pesticide were to have a RPF of 2 and it was applied at 3 times the rate of the reference or index chemical, its application rate would be adjusted to 6 lbs of index-chemical equivalents per acre which would appropriately consider both its increased potency (relative to the index chemical) and its higher application rate. Since the application rates are inserted as 'Dermal-equivalents', subsequent conversions/adjustments must be made to properly weigh any oral or inhalation exposures for that chemical-product. Again, following the LL OP CRA, 'Dermal-to-Oral (DTO) and 'Dermal-to-Inhalation' (DTI) conversion factors were calculated and used to make these adjustments

No adjustments are needed for the Index Chemical's product application rates and the DTO and DTI are thus both 1 since the reference chemical (and the Oral, Dermal, and Inhalation RPF's are all equal to 1 (by definition), To illustrate how the application rates and DTO/DTIs are used, assume that a chemical has an application rate of 1 lb ai/acre and a dermal RPF of 0.025. Converting this rate into 'Dermal-equivalents' entails multiplying the application rate of 1 lb ai/acre by the Dermal-RPF of 0.025, and entering the application rate of the chemical as 0.025 lbs /acre (=1 x 0.025) which is expressed in dermal equivalents of the index chemical. Any dermal exposure based on this application rate can be summed with the dermal exposures from the index chemical since they are expressed in the same units As noted, adjustments for potential inhalation and oral (hand-to-mouth) exposures are done in a manner similar to this, but are made in different places in the LifeLine software for applicator and post-applicator exposures While these adjustments require careful accounting by the user , the net result is that the exposures from each route take into account the respective RPFs for the chemical of interest.

A.2.2.b Application Rates & Applicator Modifying Factors

Table A.2.1 presents the ranges of application rates in typical units (lbs ai/Acre) used by Calendex and EPA Standard Operating Procedures for the 8 residential lawn and garden scenarios. Lifeline requires the application rates to be entered in metric units (mg/m^2) to match with the areas that the model calculated for each household (e.g.,

lawn size is expressed in m^2). Since Lifeline only allows a single value to be entered for application rates, the upper values of these ranges were selected and converted into dermal equivalents. This conversion does not affect the chemical which is selected as the index chemical since it is the reference chemical with (by definition) an RPF of 1).

The distributions in total amount applied lead to variations in applicator exposure. The Applicator Modifying Factor can be used to account for these variations due to distributions in application rates and, for ornamentals, area treated. The area treated for lawns and vegetable gardens are already incorporated into Lifeline as part of its standard calculational algorithms but the area treated for ornamental plants is fixed at 2000 sq ft. Since Lifeline has this as a fixed value, the Applicator Modifying Factors (AMF) for ornamental uses also need to adjusted to account for variable area treated, (here, U(10, 2000) sq ft). The AMF distributions for Lawn_Liquid Hose End Spray was calculated using Crystal Ball™ by simply drawing random variables from the Uniform distribution, U(0.5,1), to account for the distribution in application rates, U(4,8), that may occur as a fraction of the upper bound value (8 lbs ai/acre) entered into Lifeline. Similarly, the AMF distributions for both Lawn_Liquid Handwand and Lawn_Dust were calculated based on a Crystal Ball™ simulation of random variables from the Uniform distribution, U(0.25,1) to account for distribution in application rates for those two formulations-application methods, U(2,8), and U(0.5,2), respectively. For chemical H use on ornamentals, the AMF was calculated based on a Crystal Ball™ simulation of the product of two random variables, one to account for the variation in application rates, U(0.5,1), and one to account for the variability in area treated, U(0.005,1).

For the Indoor Crack and Crevice scenario described in Table A.2.2, we assume that 1-16 oz aerosol can of chemical G may treat approximately 750 sq ft (7 oz fogger can treat 15'x22'x8', 300 sq ft room, EPA Reg No., 4822-180.). This is approximately 453,592 grams applied over 69.7 m2, or an application rate of 6510 mg product/m2, or 163 mg product/m2 in dermal equivalents. This application rate, together with the product concentration of 0.5%, are entered into the LifeLine software. Based on study data, the indoor surface residues from Crack and Crevice treatments for chemical G ranged from U(0.0003,0.0007) mg/cm2. To obtain this amount, we converted the application rate in terms of mg ai/cm2 – not in the dermal equivalents, and back calculated the fraction dislodgeable needed to obtain the product's indoor surface residues. The lower bound value for transferable residues (0.0003 mg/cm2) is obtained with a 9.2% dislodgeable, while the upper bound (0.0007 mg/cm2) is obtained with 21.5% dislodgeable. These values are presented in the table above for confirmatory purposes – the Application rates are entered into Lifeline in dermal equivalents, and the model calculates the transferable residues based on these parameters – also in dermal equivalents. The AMF is not needed for this scenario since the application rate is a single point estimate, and the area treated is determined by Lifeline (AHS).

Table A.2.1 Application Rates (Dermal equivalents) & Applicator Modifying Factors								
Chemical	A	A	A	A	A	A	A	H
Site	Turf	Turf	Turf	Vegetable Gardens	Vegetable Gardens	Ornamental & Trees	Ornamental & Trees	Ornamental& Trees
Formulation - Application Method	Liquid HoseEnd	Liquid Handwand	Dust pour/shake	Liquid Handwand	Dust pour/shake	Liquid Handwand	Dust pour/shake	Granular pour/shake
App Rate-Range (lbs ai/Ac)	U(4,8)	U(2,8)	U(2,4)	U(2,8)	U(0.5,2)	U(2,8)	U(0.5,2)	U(2,4)
App Rate-High End (lbs ai/Ac)	8	8	4	8	2	8	2	8
App Rate (mg ai/m2)	897	897	448	897	224	897	224	448
Dermal RPF	1	1	1	1	1	1	1	0.07
App Rate in Dermal Equivalents	897	897	448	897	224	897	224	31
Applicator Modifying Factor								
App Rate-AMF	U(.5,1)	U(.25,1)	U(.5,1)	U(.25,1)	U(.25,1)	U(.25,1)	U(.25,1)	U(.5,1)
Area Treated-NM CRA (sq ft)	U(1000,20000)	U(100,1000)	U(100,1000)	LogNormal	LogNormal	U(10,2000)	U(10,2000)	U(10,2000)
Area Treated-Lifeline	CDF(100,20000)	CDF(100,1000)	CDF(100,1000)	NGS	NGS	2000	2000	2000
Area Treated-AMF	-	-	-	-	-	U(.005,1)	U(.005,1)	U(.005,1)
AMF - Cum Distribution								
0	0.500	0.250	0.500	0.250	0.250	0.002	0.002	0.003
10	0.548	0.329	0.548	0.329	0.329	0.055	0.055	0.073
50	0.746	0.626	0.746	0.626	0.626	0.276	0.276	0.360
75	0.872	0.808	0.872	0.808	0.808	0.459	0.459	0.542
90	0.949	0.926	0.949	0.926	0.926	0.638	0.638	0.702
95	0.975	0.964	0.975	0.964	0.964	0.737	0.737	0.781
99	0.995	0.992	0.995	0.992	0.992	0.878	0.878	0.894
100	1.000	1.000	1.000	1.000	1.000	0.993	0.993	0.995

1/ Unit Conversion: 1 lbs ai/Ac = 112.08 mg ai/m2.

Table A.2.2 Application Rates for Indoor Crack & Crevice	
Chemical	G
Site	Indoors
Formulation – Application Method	Aerosol CracknCrevice
App Rate (mg product/m2)	6510
Dermal RPF	TBD
App Rate (mg product/m2) in Dermal Equivalents	163
Pct of AI (0.5%)	0.5%
App Rate (mg ai/cm2) – not in dermal equivalents	0.00325
Fraction Dislodgeable (soft surfaces)	0.092
Indoor Surface Residues (soft surfaces)	3.0E-4
Fraction Dislodgeable (hard surfaces)	0.215
Indoor Surface Residues (hard surfaces)	7.0E-4

Lifeline allows the user to apply different fraction dislodgeable values to soft and hard surfaces. By default, the Lifeline model assumes the following indoor locations to have soft surfaces (bedrooms, living room, dining room, den, other, halls/stairs/closets), and the following indoor locations to have hard surfaces (kitchen, bath, cellar, garage). The dislodgeable residues will differ depending upon the location treated and where the individual receives his/her exposure. The lower value (0.092) was used in this case study for soft surfaces and the higher value (0.215) was used for hard surfaces.

For pet collars (no applicator exposure), the transferable residues are not directly related to any 'application rate' in Calendex & CARES. Parameters for this scenario are presented in Table A.2.3. The current version of Lifeline does not have a pet collar algorithm that is structurally different from the pet flea/tick treatment scenarios. Therefore, the user must specify an 'application rate' for collars, and the model will calculate pet transferable residues based on this rate and the percent dislodgeable. This case study assumes that the pet collar is applied to a 30 lb dog having a total body surface area of 5985 cm^2.[35] The percent dislodgeable required to obtain the Pet Transferable Residues (0.00171 mg ai/cm^2) reported in the pet collar studies for chemical A was back calculated from the estimate of the amount ai applied (5902 mg ai), and the surface area of the pet (5985 cm^2) . The application rate for chemical G pet collars are adjusted according to the respective Dermal-RPFs.

[35]Lifeline allows the product to be applied to either a 30 lb dog or a 10 lb cat, with total body surface areas of 5985 cm2 and 2931 cm2, respectively. The surface areas are based on the Wildlife Exposure Factors Handbook model: SA = 12.3x(Weight(grams))^(0.65). See Lifeline Technical Manual, p 6-13.

Table A.2.3 Application Rates for Pet Collars

Chemical	A	G
Site	Pet	Pet
Formulation - Application Method	Collar	Collar
Application Amount (lbs ai/30 lbs dog)	0.013	0.013
Application Amount (mg ai/30 lbs dog)	5902	5902
Dermal RPF	TBD	TBD
Application Rate (mg ai) - Dermal Equiv	5902	148
Total Surface Area (cm2/30 lbs dog)	5985	5985
Application Rate (mg ai/cm2)	0.9861	0.025
% Dislodgeable	0.00173	0.00173
Pet Transferable Residues (mg ai/cm2)	0.00171	4.28E-5

A.2.2.c Applicator Unit Exposure (CDFs)

Table A.2.4 presents the Cumulative Distribution Functions (CDFs) for the various Unit Exposure (UE) distributions. Since Lifeline allows only custom CDFs, the lognormal distributions for the Unit Exposures used in Calendex and CARES were converted to Cumulative Distributions using Crystal Ball™. The Inhalation UEs also take into account the DTI factor, which are relevant for uses of chemicals G and H, as explained in Section A.2.2.a. For the dust or liquid handwand applications, the UE distributions are the same for all lawn and garden sites (turf, vegetable gardens, ornamental plants/trees). The differences across these sites in either the application rates and/or area treated are accounted for in the Applicator Modifying Factors. The pet collar scenarios do not have any significant applicator exposure.

Table A.2.4 Unit Exposures for Lawn (Turf) & Garden Scenarios

Chemical	A	A	A	H	G
Site	Turf	Turf, Veg, Orn/Tree	Turf, Veg, Orn/Tree	Orn/Tree	Indoor Crack & Crevice
Formulation - Application Method	Liquid Turf HoseEnd	Liquid Handwand	Dust (pour/shake)	Granular (pour/shake)	Aerosol
DTI	NA	NA	NA	30.3	12.8
Inhalation Unit Exposure (ng/lb ai)					
0%	987	2,002	29,851	904,489	2.23
10%	10,320	2,846	767,744	23,262,633	3.23
50%	25,175	5,683	2,710,422	82,125,797	7.57
75%	37,052	8,179	4,377,205	132,629,322	10.19
90%	47,721	10,438	5,854,360	177,387,112	11.78
95%	53,072	11,538	6,574,577	199,209,695	12.30
99%	59,999	13,001	7,514,642	227,693,649	12.68
100%	66,000	14,200	8,290,000	251,187,000	12.80
Dermal Unit Exposure (ug/lb ai)					
0%	30	8,434	12,233	12,233	6.00
10%	1,920	35,668	128,402	128,402	7.02
50%	9,977	116,254	439,497	439,497	11.01
75%	16,638	186,037	719,587	719,587	13.52
90%	22,581	249,681	966,069	966,069	15.02
95%	25,653	278,023	1,087,979	1,087,979	15.48
99%	29,865	318,986	1,249,319	1,249,319	15.88
100%	33,000	354,400	1,375,420	1,375,420	16.00

A.2.2.d Post-Application Oral Modifying Factors (OMF)

Table A.2.5 presents the Oral Modifying Factor (OMF) cumulative distributions used for the Lifeline scenarios that have post-application incidental oral exposures. The OMF is a product of several random variables. As noted above, Lifeline does not allow distributions for various incidental oral hand-to-mouth activities. Therefore, the OMF is used to account for variation in these, and possibly other factors. First, the activity description files allow the user to input single values for the HTM frequency parameter of 20 events/hour in contrast to the assumed triangular distribution of T(0.4,9,25.7); a Triangle distribution, T(0.02,0.45,1.285) accounts for the variability in events (0.02=0.4/20, 0.45=9/20, 1.285=25.7/20). Also, a uniform distribution, U(0,1), accounts for variability in hand surface area placed in the mouth, which the Lifeline parameter of 20 cm2; a uniform distribution, U(0.1,0.5), accounts for variability in saliva efficiency, and a uniform distribution, U(1.5,3), accounts for variability due to wet hands.

There are some differences in the OMF across these four scenarios. First, the DTO factor is applied to account for the RPF from the oral route versus the dermal route – which the application rates wereentered. For the Hose-end lawn scenario, the OMF also includes variability in application rates, from the single value of 8 lbs ai/acre that was used (converted to dermal equivalents), to the U(4,8) lbs ai/acre that was modeled in Calendex. Such variability in application rates was not applicable for the pet and indoor crack and crevice scenarios.

Table A.2.5 Oral Modifying Factors				
Chemical	A	A	G	G
Site	Turf	Pet	Pet	Indoor Crack & Crevice
Formulation - Application Method	Liquid Turf HoseEnd	Collar	Collar	Aerosol
HTM Frequency: LL(20 event/hr)=>T(0.4,9,25.7)	T(0.02,0.45,1.285)	T(0.02,0.45,1.285)	T(0.02,0.45,1.285)	T(0.02,0.45,1.285)
HTM Hand Surface Area, LL(~20 cm2)=>U(0,20)	U(0,1)	U(0,1)	U(0,1)	U(0,1)
HTM Saliva Efficiency, LL (.5)=>U(.1,.5)	U(.2,1)	U(.2,1)	U(.2,1)	U(.2,1)
HTM Wet Hands, LL(1)=>U(1.5,3)	U(1.5,3)	U(1.5,3)	U(1.5,3)	U(1.5,3)
Time Spent, LL(1)=>T(0.0333,0.108,1.025)	-	T(0.0333,0.108,1.025)	T(0.0333,0.108,1.025)	-
Application Rate, L(8)=>U(4,8)	U(.5,1)	-	-	-
DTO	1	1	56.7	56.7
OMF-Percentiles				
0%	0.000	0.000	0.00	0.00
10%	0.016	0.006	0.34	1.34
50%	0.105	0.043	2.43	8.00
75%	0.210	0.098	5.63	15.70
90%	0.344	0.188	10.88	25.85
95%	0.446	0.266	15.05	33.55
99%	0.700	0.451	26.87	49.21
99.9%	1.002	0.691	42.04	69.44
100%	1.355	0.956	59.93	87.93

For the pet collar scenarios, Lifeline does not use the NHAPS diaries to determine time spent in contact with treated pets (due to lack of specificity in activities). The model allows the user to input a single value (1 hour), which is assumed to occur in addition to the NHAPS diaries (the 24 hour constraint is 'exceeded', but the time use diaries do not capture multi-tasking activities, i.e., watching television and petting a dog). The time spent playing with pets, T(0.033,0.108,1.025), was based on videography data and the variability in this exposure factor (versus 1 hour) is captured by the corresponding triangular distribution. For the turf and indoor crack scenarios, Lifeline uses the NHAPS records to account for time spent in those treated areas, respectively.

Lifeline does not have an adjustment term to account for variability in application rates for post-application dermal exposure. Therefore, specifying the upper bound application rates would provide a conservative estimate of post-application dermal exposure in Lifeline. Alternatively we could have inputted different application rates (lower, mean, upper) to evaluate the sensitivity of this option; but it is hoped that future versions of Lifeline will allow for distributions for application rates so as to obviate the need to conduct such alternative assessments.

A.2.3 Lifeline 'Built-In' Distributions

As noted above, Lifeline assigns a normalized transfer coefficient and an activity class, or metabolic equivalent (MET) for each NHAPS activity. Those assignments are needed to calculate post-application dermal exposure and inhalation exposure, respectively, for the time use diaries. These assumptions are presented in Tables A.2.6 and A.2.7, below. The specific activities that are assigned to these classes may be looked up in the activity description file (Preliminary assumptions_11.acd). These are the same values that were used in the Lifeline OP CRA. In the preliminary assessment, we intend to present the list of NHAPS activities for each of these categories (dermal and inhalation), as well as the unweighted distributions that the Lifeline model will draw upon for comparisons with the distributions used in the other models (e.g., comparison of transfer coefficient distribution used based on study data).

Table A.2.6 Normalized (Body Surface Area) Transfer Coefficients

Activity	Age 1-6 yrs	Age 6-85 yrs
Sleep & Bathing	0	0
Low Dermal Activities	0.43	0.19
Moderate Dermal Activities	0.66	0.49
High Dermal Activities	2.4	0.74

Table A.2.7 Activity Factors (MET) for Specific Activity Levels

Activity Level	Resting Breathing Rate Multiplier
Rest	1
Sedentary	1.2
Light Activity	2
Moderate Activity	4
Heavy Activity	10

A.2.4 Lifeline Tapwater Concentrations

The current version of Lifeline accounts for drinking water exposure in a different manner than Calendex and CARES. Table A.2.8 presents the cumulative distributions, by season, for tapwater concentrations in the Southeast region. Based on our experience using the Lifeline tapwater module these percentiles are adequately refined so as to capture the PRZM-EXAMS distribution of drinking water concentrations, i.e., increasing the number of percentiles will not significantly affect the results.

Table A.2.8 Lifeline Tapwater Concentrations (ppm) by Season, Southeast

	Season			
Pctile	Fall	Spring	Summer	Winter
0%	1.33E-04	4.13E-05	3.53E-04	5.49E-05
5%	2.29E-04	1.17E-04	6.63E-04	9.72E-05
10%	3.26E-04	3.09E-04	9.79E-04	1.33E-04
15%	4.29E-04	4.76E-04	1.24E-03	1.75E-04
20%	5.84E-04	7.02E-04	1.67E-03	2.46E-04
25%	7.28E-04	1.36E-03	2.16E-03	3.08E-04
30%	9.05E-04	1.76E-03	2.62E-03	3.80E-04
35%	1.11E-03	2.23E-03	3.13E-03	4.51E-04
40%	1.33E-03	3.38E-03	3.67E-03	5.38E-04
45%	1.55E-03	4.49E-03	4.34E-03	6.14E-04
50%	1.78E-03	6.13E-03	5.15E-03	7.06E-04
55%	2.06E-03	8.24E-03	6.12E-03	8.03E-04
60%	2.41E-03	1.06E-02	7.20E-03	9.28E-04
65%	2.81E-03	1.24E-02	8.38E-03	1.06E-03
70%	3.41E-03	1.51E-02	9.85E-03	1.22E-03
75%	4.04E-03	1.87E-02	1.19E-02	1.48E-03
80%	4.77E-03	2.82E-02	1.48E-02	1.76E-03
85%	5.75E-03	3.76E-02	1.82E-02	2.14E-03
90%	7.04E-03	4.64E-02	2.28E-02	2.67E-03
95%	9.94E-03	6.72E-02	3.24E-02	3.85E-03
96%	1.11E-02	7.80E-02	3.53E-02	4.37E-03
97%	1.27E-02	9.16E-02	4.00E-02	4.97E-03
98%	1.44E-02	1.07E-01	4.76E-02	5.59E-03
99%	1.81E-02	1.44E-01	6.06E-02	7.13E-03
99.9%	2.37E-02	1.86E-01	8.35E-02	8.93E-03
100%	2.44E-02	1.90E-01	8.64E-02	9.17E-03
Mean	3.03E-03	1.70E-02	9.44E-03	1.16E-03