

US EPA ARCHIVE DOCUMENT

Table of Contents

Technical Executive Summary	2
List of Acronyms	9
Table of Contents	10
List of Appendices	14
I. Preliminary N-Methyl Carbamate Cumulative Risk Assessment	21
A. Introduction	21
B. Hazard/Relative Potency Factors	26
1. Introduction	26
2. Endpoints and Toxicology Studies	27
3. Determination of Toxic Potency	32
a. Empirical Modeling: Dose-Time Response Model and Benchmark Dose Estimation	32
i. Dose-Time Response Model	32
ii. Statistical Methodology	36
b. Results: Benchmark Dose and Potency Estimation	38
4. Selection of Relative Potency Factors: Brain ChE Inhibition	45
5. Selection of the Index Chemical (Oxamyl)	48
a. Candidates for the Index Chemical	48
b. Description of the Oxamyl Database	48
6. Relative Potency Factors for the Preliminary Cumulative Risk Assessment of the N-Methyl Carbamates	50
7. Uncertainty, Extrapolation, and FQPA 10X Factors	52
8. On-going Research Efforts to Support the NMC Cumulative Risk Assessment	53
9. Summary	55
C. Cumulative Risk From Pesticides in Foods	56
1. Method of Estimation of Cumulative Dietary Risk	56
2. Selection of Oral Relative Potency Factors	56
3. Dietary (Food) Residue Input Data for Dietary Risk Assessment	56
4. Manipulation of Residue Data for Exposure Assessment	57
a. Generation of Cumulative Equivalent Residue (Residue _{IE})	58
i. N-methyl Carbamate Food Residue Database	59
ii. Generation of Exposures	60
iii. Assumptions	60
5. Food Consumption Data	63
6. Estimation of Acute Exposure Using DEEM-FCID™ Software	63
7. Results	63
8. Summary	64
D. Cumulative Risk from Carbamate Pesticides in Drinking Water	68
1. Problem Formulation	68
a. Drinking Water Exposure Estimates Required for the Carbamate Cumulative Assessment	69
b. Nature of Carbamate Exposure in Drinking Water Sources	70
c. Summary	74
2. Conceptual Model	75

a. Regional Screening Approach for Vulnerable Sources of Drinking Water	75
b. Conceptual Model for Surface Water Sources of Drinking Water	77
c. Conceptual Model for Vulnerable Ground Water Sources of Drinking Water	79
3. Analysis Plan	82
a. N-methyl Carbamate Properties	82
b. Identifying Regional Exposure Scenarios	83
c. Regional Usage	85
d. Surface Water Exposure Assessment	86
e. Ground Water Exposure Assessment	88
4. Analysis: Carbamate Cumulative Surface Water Exposure	90
5. Analysis: Ground Water Exposure	92
E. Residential NMC Cumulative Risk	100
1. Introduction	100
2. Scope of Regional Assessments	100
3. Residential Scenarios	101
a. Lawn Care	101
b. Vegetable Gardens	102
c. Ornamentals	102
d. Fruit Trees	103
e. Indoor Crack and Crevice Sprays	103
f. Pet Collars	104
g. Golf Course	104
4. Exposure Routes/Scenarios Considered	105
a. Oral Route of Exposure	106
b. Dermal Route of Exposure	106
c. Inhalation Route of Exposure	106
5. Data Sources	107
a. Pesticide Use Data	107
i. Broadcast Lawn Scenarios	107
ii. Pet Collar Scenarios	108
iii. Indoor Crack and Crevice Scenarios	108
b. Residue Concentration Data	108
6. Exposure Scenarios	109
a. Lawn Care Exposure Scenarios	109
i. Lawn Applicator Exposure	109
ii. Lawn Post-Application Dermal Exposure	113
iii. Lawn Non-Dietary Hand-to-Mouth Exposure	116
b. Vegetable Garden Exposure Scenarios	118
i. Applicator Exposure	118
ii. Post-Application Dermal Exposure	120
c. Ornamental Plants and Shrubs Exposure Scenarios	121
i. Applicator Exposure	121
ii. Post-Application Dermal Exposure	122
d. Fruit Tree Exposure Scenarios	122
i. Applicator Exposure	123
ii. Post-Application Dermal Exposure	123

e. Ornamental Garden - Snail and Slug Bait Scenarios	124
i. Applicator Exposure	124
ii. Post-Application Exposure	125
f. Indoor Crack and Crevice Scenarios	125
i. Applicator Exposure	125
ii. Post-Application Dermal Exposure	126
iii. Post-Application Inhalation Exposure	127
iv. Post-Application Oral (hand-to-mouth) Exposure	128
g. Pet Collar Scenarios	129
i. Applicator Exposure	129
ii. Post-Application Dermal Exposure	129
iii. Oral (Hand-to-Mouth) Post-Application Exposure	130
h. Golf Course Scenario	131
i. Post-Application Dermal Exposure	131
F. The Multi-Pathway Cumulative Assessment	133
1. Basic Concepts	133
2. Framing the Population-Based Assessment	134
3. Interpreting the Outputs	135
4. Attributes of the Preliminary N-Methyl Carbamate Cumulative Risk Assessment	136
a. Children, 1-2 years, Florida Coastal Ridge Ground Water	137
b. Children 3-5 years, Florida Coastal Ridge Ground Water	138
c. Adults, 20-49 years, Florida Coastal Ridge Ground Water	139
d. Adults, 50+ years, Florida Coastal Ridge Ground Water	140
e. Children, 1-2 years, North Carolina Coastal Plain Ground Water	140
f. Children 3-5 years, North Carolina Coastal Plain Ground Water	141
g. Adults, 20-49 years, North Carolina Coastal Plain Ground Water	142
h. Adults, 50+ years, North Carolina Coastal Plain Ground Water	142
i. Children, 1-2 years, North Carolina Coastal Plain Surface Water	143
j. Children 3-5 years, North Carolina Coastal Plain Surface Water	144
k. Adults, 20-49 years, North Carolina Coastal Plain Surface Water	145
l. Adults, 50+ years, North Carolina Coastal Plain Surface Water	145
G. Comparison of DEEM/Calendex, Lifeline, and CARES Results	147
1. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure and Risk Estimates through the Food Pathway	147
2. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure and Risk Estimates through the Water Pathway	149
3. Comparison of DEEM/Calendex, Lifeline, and CARES Exposure and Risk Estimates through the Food + Water Pathway	150
4. Comparison of DEEM/Calendex and CARES Exposure and Risk Estimates for Selected Residential Scenarios	150
H. Risk Characterization	151
1. Introduction	151
2. Hazard and Dose-Response Assessment	151
3. Recovery of ChE and Use of Calendex, CARES, and Lifeline Models	155
4. Dietary Assessment	160
a. Use of CSFII Data	160
b. Use of PDP Data	161

c. Data Translation from PDP	162
d. Other Sources of Residue Data	162
e. Impact of Risk Mitigation Actions	163
5. Residential Assessment	164
a. Pesticide Use Data	164
b. Pesticide Residue and Exposure Contact Data	165
i. Dermal Exposure	165
ii. Non-dietary ingestion	168
6. Characterization of Drinking Water Exposures	175
a. Ground Water Exposure	175
b. Surface Water Exposure	179
c. Usage Information	180
d. Timing of Exposure	181
7. Conclusions	182
I. Future Actions/Next Steps	186
1. Hazard Assessment	186
2. Food Exposure Assessment	187
3. Drinking Water Exposure Assessment	187
4. Residential Exposure Assessment	188
5. Risk Assessment Methodology	188
J. References	189

List of Appendices

- II. Preliminary N-Methyl Carbamate Cumulative Risk Assessment Appendices**
- A. Introduction (None)**
- B. Hazard**
1. Spreadsheet of RBC and whole/half brain AChE data (means, standard deviations) used in the Preliminary Cumulative Risk Assessment of the N-methyl carbamate pesticides
 - a. Agg Data
 - b. Padilla Data
 2. Dose-response modeling of rat RBC and brain AChE for the Preliminary Cumulative Risk Assessment of the N-methyl carbamate pesticides
 - a. Dose-Time Response Modeling of Rat Brain AChE Activity: Aldicarb Gavage Dosing
 - b. Dose-Time Response Modeling of Rat RBC AChE Activity: Aldicarb Gavage Dosing
 - c. Dose-Time Response Modeling of Rat Brain AChE Activity: Carbaryl Dermal Exposure
 - d. Dose-Time Response Modeling of Rat RBC AChE Activity: Carbaryl Dermal Dosing
 - e. Dose-Time Response Modeling of Rat Brain AChE Activity: Carbaryl Gavage Dosing
 - f. Dose-Time Response Modeling of Rat RBC AChE Activity: Carbaryl Gavage Dosing
 - g. Dose-Time Response Modeling of Rat Brain AChE Activity: Carbofuran Gavage Dosing
 - h. Dose-Time Response Modeling of Rat RBC AChE Activity: Carbofuran Gavage Dosing
 - i. Dose-Time Response Modeling of Rat Brain AChE Activity: Formetanate Gavage Dosing
 - j. Dose-Time Response Modeling of Rat RBC AChE Activity: Formetanate Gavage Dosing
 - k. Dose-Time Response Modeling of Rabbit Brain AChE Activity: Methiocarb Dermal Dosing
 - l. Dose-Time Response Modeling of Rabbit RBC AChE Activity: Methiocarb Dermal Dosing
 - m. Dose-Time Response Modeling of Rat Brain AChE Activity: Methiocarb Gavage Dosing
 - n. Dose-Time Response Modeling of Rat RBC AChE Activity: Methiocarb Gavage Dosing
 - o. Dose-Time Response Modeling of Rat Brain AChE Activity: Methomyl Gavage Dosing
 - p. Dose-Time Response Modeling of Rat RBC AChE Activity: Methomyl Gavage Dosing
 - q. Dose Response Modeling of Rabbit Brain AChE Activity: Oxamyl Dermal Dosing

- r. Dose Response Modeling of Rabbit RBC AChE Activity: Oxamyl Dermal Dosing
 - s. Dose Response Modeling of Rat Brain AChE Activity: Oxamyl Inhalation Exposure
 - t. Dose Response Modeling of Rat RBC AChE Activity: Oxamyl Inhalation Exposure
 - u. Dose-Time Response Modeling of Rat Brain AChE Activity: Oxamyl Gavage Dosing
 - v. Dose-Time Response Modeling of Rat RBC AChE Activity: Oxamyl Gavage Dosing
 - w. Dose-Time Response Modeling of Rat Brain AChE Activity: Primicarb Gavage Dosing
 - x. Dose-Time Response Modeling of Rat RBC AChE Activity: Pirimicarb Gavage Dosing
 - y. Dose-Time Response Modeling of Rabbit Brain AChE Activity: Propoxur Dermal Dosing
 - z. Dose-Time Response Modeling of Rabbit RBC AChE Activity: Propoxur Dermal Dosing
 - aa. Dose-Time Response Modeling of Rat Brain AChE Activity: Propoxur Inhalation Exposure
 - bb. Dose-Time Response Modeling of Rat RBC AChE Activity: Propoxur Inhalation Exposure
 - cc. Dose-Time Response Modeling of Rat Brain AChE Activity: Propoxur Gavage Dosing
 - dd. Dose-Time Response Modeling of Rat RBC AChE Activity: Propoxur Gavage Dosing
 - ee. Dose-Time Response Modeling of Rat Brain AChE Activity: Thiodicarb Gavage Dosing
 - ff. Dose-Time Response Modeling of Rat RBC AChE Activity: Thiodicarb Gavage Dosing
- 3. N-M-CarbamateDoseResponse (computer code, zip file)
- 4. R-packages (computer code, zip file)
- 5. Summary of AChE protocol evaluations, mixture experiments, motor activity measurements
- 6. Physiologically-Based Pharmacokinetic Modeling for the N-methyl carbamate cumulative risk assessment
- C. Food**
 - 1. Processing Factors Used in Cumulative Dietary Exposure Assessment
- D. Drinking Water**
 - 1. Summary of USGS NAWQA Monitoring for N-Methyl Carbamates
 - 2. Summary of State Monitoring for N-Methyl Carbamates
 - 3. Drinking Water Treatment Effects on N-Methyl Carbamate Pesticides
 - 4. N-Methyl Carbamate Usage Estimates
 - 5. Chemical-Specific Fate and Transport Properties Used for the Water Exposure Models
 - 6. N-Methyl Carbamate Surface Water Exposure Assessment

- 7. N-Methyl Carbamate Ground Water Exposure Assessment
- E. **Residential**
 - 1. Residential Pesticide Use Inputs from REJV Survey Data
 - 2. Residential Exposure Scenarios Appendix
- F. **Cumulative Risk**
 - 1. Temporal Exposure Profile Plot for Florida Central Ridge Ground Water
 - 2. Temporal Exposure Profile Plot for North Carolina Coastal Plain Ground Water
 - 3. Temporal Exposure Profile Plot for North Carolina Coastal Plain Surface Water
- G. **Model Comparison** (None)
- H. **Risk Characterization** (None)
- I. **Future Steps** (None)
- J. **References** (None)

List of Tables

Table ES.1. <i>N</i> -methyl Carbamate Pesticides Considered in the Preliminary Cumulative Risk Assessment.....	8
Table I.A.1 Summary Information Regarding the NMC pesticides and the Uses, Routes, and Pathways included in the Preliminary NMC CRA	23
Table I.B.1. Test guidelines/studies that contain evaluations for ChE activity.....	29
Table I.B.2. List of toxicity studies used in the Preliminary <i>N</i> -Methyl Carbamate Risk Assessment.....	31
Table I.B.3. Oral BMD ₁₀ s and BMDL ₁₀ s from rat brain and RBC ChE inhibition for the <i>N</i> -methyl carbamates ¹	40
Table I.B.4. Dermal BMD ₁₀ s, BMDL ₁₀ s, and potency estimates from rat and rabbit brain and RBC ChE inhibition for the <i>N</i> -methyl carbamates with residential/non-occupational uses	43
Table I.B.5. Inhalation BMD ₁₀ s, BMDL ₁₀ s, and potency estimates from rat brain and RBC ChE inhibition for the <i>N</i> -methyl carbamates with residential/non-occupational uses.	44
Table I.B.6. Half life for time to recovery from oral rat studies for brain and RBC ChE inhibition for the <i>N</i> -methyl carbamates.....	45
Table I.B.7. Oral, dermal, and inhalation brain BMD ₁₀ s and BMDL ₁₀ s for OXAMYL, the index chemical.	49
Table I.B.8. Relative Potency Factors for Oral, Dermal, and Inhalation routes.	50
Table I.C.1. <i>N</i> -methyl Carbamates, Code Letters and RPFs.....	64
Table I.C.2. Permissible Crop Translations for Pesticide Monitoring Data	65
Table I.C.3. Summary of Probabilistic Analysis of Distribution of the Cumulative Dietary Exposures and Risk from Use of <i>N</i> -methyl carbamate Chemicals on Food Crops	66
Table I.C.4. Relative Exposure Contribution from Foods for Children 1 To 2 Years Old (At 99.8% Risk Level and Above).....	66
Table I.D.1. <i>N</i> -methyl carbamate use patterns and availability of national monitoring data	69
Table I.D.2. Summary of carbamate detections in the USGS NAWQA study, 1991-2001 (provisional data published by USGS in 2003).....	72
Table I.D.3. Summary of aldicarb detections in ground water monitoring data collected from available ground water monitoring data.	73
Table I.D.4. Summary of <i>N</i> -methyl carbamate fate and transport properties.	83
Table I.D.5. Regional drinking water exposure sites and dominant carbamate uses. ..	84
Table I.D.6. Percentile concentrations for estimated <i>N</i> -methyl carbamate cumulative distributions in the surface water scenario sites (30-year period).....	90
Table I.D.7. Characterization of estimated regional <i>N</i> -methyl carbamate cumulative concentrations in ground water/ private wells.	96
Table I.D.8. Comparisons of modeled estimates of regional <i>N</i> -methyl carbamate cumulative distributions in ground water (30-year period).....	97
Table I.E.1 Specific Exposure Routes and Pathways/Scenarios.....	105
Table I.E.2 Lognormal Distributions of Unit Exposures Used for Carbaryl Lawn Care Scenarios	112
Table I.E.3. Lognormal Distributions of Unit Exposures Used for Carbaryl Garden, Fruit Tree, and Ornamental Scenarios	120
Table I.G.1 Estimated Exposures and Risk from Food Only	147

Table I.G.2. Estimated Exposures and Risk from Water Only (FL Groundwater).....	149
Table I.G.3. Estimated Exposures and Risk from Food and Water Combined.....	150
Table I.H.1. Input Parameters Used in the Exposure Models: Bias, Assumptions, Uncertainties, and Strengths.....	170

List of Figures

Figure I.B.1. Plot of BMD _{10s} and the 95% confidence limits for rat brain ChE inhibition for the <i>N</i> -methyl carbamates	41
Figure I.B.2. Plot of BMD _{10s} and the 95% confidence limits for rat RBC ChE inhibition for the <i>N</i> -methyl carbamates	42
Figure I.B.4. Plot of oral relative potency factors for rat brain ChE inhibition for the <i>N</i> -methyl carbamates.	51
Figure I.B.5. Plot of brain ChE measured in a seven chemical mixture of <i>N</i> -methyl carbamates.	54
Figure I.C.1. Relative Contribution of Crop/Chemical Pairs to Top 0.2 Percentile of Cumulative Distribution for Children 1-2	67
Figure I.D.1. Carbamate cumulative risk assessment regions for drinking water exposure assessment showing high carbamate use areas and regional surface water exposure sites.	77
Figure I.D.2. Conceptual model for surface water sources of drinking water illustrating how multiple carbamate uses are proportioned in the watershed.	79
Figure I.D.3. Depiction of general ground water scenario concept used for estimating pesticide concentrations in drinking water	81
Figure I.D.4. Conceptual model for handling pesticide degradation through the soil and vadose zone	81
Figure I.D.5. Location of surface water intakes (red dots) in relation to carbamate usage (high use areas outlined in orange) and runoff vulnerability (based on Kellogg et al, 1997) in the southeastern US.	91
Figure I.D.6. Variability in peak <i>N</i> -methyl carbamate concentrations in surface water from 30 years of time series in North Carolina.	92
Figure I.D.7. Location of high carbamate use areas (Thelin & Gianessi, 2000) in relation to population drinking water from private wells (USGS, 1998).	93
Figure I.D.8. Aldicarb detections in private wells related to citrus land use (orange color on map) in central FL. Land use coverage and monitoring data are from the FL DEP (FL DEP 2004, 2005).	94
Figure I.D.9. Relationship of aldicarb detections in private wells with soils with high saturated hydraulic conductivities (dark blue areas on the map).	95
Figure I.D.10. Estimated concentrations of total aldicarb residues in ground water over 30 years from citrus use in Central FL using three models.	98
Figure I.D.11. Distribution of estimated oxamyl (blue), aldicarb (pink), and cumulative (dark red) concentrations in a shallow private well in the citrus area of central FL. Cumulative concentration is in oxamyl equivalents.	99
Figure I.D.12. Comparisons of cumulative carbamate exposures in ground water from the FL central ridge (dark red), NC coastal plain (blue), and GA coastal plain (yellow) with the highest surface water exposure (pink) from NC.	99
Figure I.E.1 Pesticide Cumulative Assessment Regions	101
Figure I.F.1. Three-dimensional plot of the total MOE by day of the year and percentile of exposure	135
Figure I.H.1. Mean RBC ChE activity in cannulated adult male CD rats following a repeated oral administration of aldicarb	154
Figure I.H.2. Plot of simulation of pattern of ChE inhibition.	157

Figure I.H.3. Characterization of Food Exposure Children 3-5: number of eating occasions (sample of 8005 records from top 5 percentile exposure)	158
Figure I.H.4. Characterization of Food Exposure Children 3-5: number of eating occasions (sample of records near the 99.5th percentile)	158
Figure I.H.5. Map showing overlap between citrus areas (orange) and highly permeable soils (blue) identifying vulnerable ground water areas (dark colors) in FL central ridge.	176