II. Regional Assessments

E. Region E - Humid Southeast Assessment

1. Executive Summary

Region E. Humid Southeast

This module of the Organophosphate (OP) cumulative risk assessment focuses on risks from OP uses in the Humid Southeast (area shown to right). Information is included in this module only if it is specific to the Humid Southeast, or is necessary for clarifying the results of the Humid Southeast assessment. A comprehensive description of the OP cumulative assessment comprises the body of the main document; background and other supporting information for this regional assessment can be found there.

This module focuses on the two components of the OP cumulative assessment which are likely to have the greatest regional variability: drinking water and residential exposures. Dietary food exposure is likely to have significantly less regional variability, and is assumed to be nationally uniform. An extensive discussion of food exposure is included in the main document. Pesticides and uses which were considered in the drinking water and residential assessments are summarized in Table II.E.1 below. The OP uses included in the drinking water assessment generally accounted for 95% or more of the total OPs applied in that selected area. Various uses that account for a relatively low percent of the total amount applied in that area were not included in the assessment.

Table II.E.1. Pesticides and Use Sites/Scenarios Considered in Humid Southeast Residential/Non-Occupational and Drinking Water Assessment

Pesticide	OP Residential Use Scenarios	OP Drinking Water Scenario Uses
Acephate	Golf Courses, Ornamental Gardens	Peanuts, Cotton, Tobacco
Bensulide	Golf Courses	None
Chlorpyrifos	None	Corn, Peanuts, Tobacco
DDVP	Pest Strips	None
Dimethoate	None	Cotton
Disulfoton	Ornamental Gardens	Cotton

Pesticide	OP Residential Use Scenarios	OP Drinking Water Scenario Uses
Ethoprop	None	Tobacco
Fenamiphos	Golf Courses	None
Malathion	Home Fruit & Vegetable Gardens, Ornamental Gardens, Public Health	None
Phorate	None	Cotton, Peanuts
TCVP	Pet Uses	None
Terbufos	None	Corn
Tribufos	None	Cotton
Trichlorfon	Golf Courses, Lawn Applications	None

This module will first address residential exposures. The residential section describes the reasons for selecting or excluding various use scenarios from the assessment, followed by a description of region-specific inputs. Detailed information regarding the selection of generic data inputs common to all the residential assessments (e.g., contact rates, transfer coefficients, and breathing rate distributions, etc.) are included in the main document.

Drinking water exposures are discussed next. This will include criteria for the selection of a sub-region within the Humid Southeast to model drinking water residues, followed by modeling results, and finally characterization of the available monitoring data which support use of the modeling results. This assessment accounted for all OP uses within the selected location that are anticipated to contribute significantly to drinking water exposure.

Finally a characterization of the overall risks for the Humid Southeast region is presented, focusing on aspects which are specific to this region.

In general, the risks estimated for the Humid Southeast show a similar pattern to those observed for other regions. Drinking water does not contribute to the risk picture in any significant way at the upper percentiles of exposure. At these higher percentiles of exposure, residential exposures are the major source of risk - in particular inhalation exposure. These patterns occur for all population sub-groups, although potential risks appear to be higher for children than for adults regardless of the percentile considered.

2. Development of Residential Exposure Aspects of Humid Southeast Region

In developing this aspect of the assessment, the residential exposure component of Calendex was used to evaluate predicted exposures from residential uses. Except for golf course uses, this assessment is limited to the home as are most current single chemical assessments. The residential component of the assessment incorporates dermal, inhalation, and non-dietary ingestion exposure routes which result from applications made to residential lawns (dermal and non-dietary ingestion), golf courses, ornamental gardens, home fruit and vegetable gardens, public health uses, and indoor uses (pet uses and pest strips). These scenarios were selected because they are expected to be the most prominent contributors to exposure in this region. Additional details regarding the selection of the scenario-pesticide pairs can be found in Part I of this document. OPP believes that the majority of exposures (and all significant exposures) in this region have been addressed by the scenarios selected.

The data inputs to the residential exposure assessment come from a variety of sources including the published, peer reviewed literature and data submitted to the Agency to support registration and re-registration of pesticides. Generic scenario issues and data sources are discussed in Part I of this report. However, a variety of additional region-specific ancillary data was required for this assessment of the Humid Southeast. This information includes region-specific data on pesticide application rates and timing, pesticide use practices, and seasonal applications patterns, among others. The Gaant chart shown in Figure II.E.1 displays and summarizes the various region-specific residential applications and their timing (including repeated applications) over the course of a year which were used in this assessment. Specific information and further details regarding these scenarios, the Calendex input parameters, and the pesticides for which these scenarios were used are presented in Table II.E.2 which summarizes all relevant region-specific scenarios.

Table II.E.2. Use Scenarios and Calendex Input Parameters for Humid Southeast Residential Exposure Assessment

Chemical	Use Scenario	Application Method	Amt. Applied lb ai/A	Max. No./ Frequency Of Apps.	App. Schedule	% Use LCO	% Use HO	% Users	Residue Persistence (Days)	Routes of Exposure
Acephate	Golf Course	NA	5	1/yr	Mar.-Oct. 12-42 wks.	100	--	1	10	dermal(p)
	Ornamental	hand pump sprayer	0.9-2	4/yr, 2 wks. Between Apps.	Mar.-Oct. 12-44 wks.	--	100	6	1	inhalation(a), dermal(a)
Bensulide	Golf Course	NA	12.5	2/yr, 30 wks. Between Apps.	Apr.-May and Sept.-Oct.	100	--	4	14	dermal(p)
DDVP	Pest Strip	closet strip	NA	16 wks., Regular App. Schedule	Jan.-Dec. 1-52 wks.	--	100	2	120	inhalation(p)
		cupboard strip	NA	16 wks., Regular App. Schedule	Jan.-Dec. 1-52 wks.	--	100	2	120	inhalation(p)
Disulfoton	Ornamental	granular	8.7	3/yr, 6 wks. Between Apps.	Apr.-Nov. 14-45 wks.	--	100	2	1	inhalation(a), dermal(a)
Fenamiphos	Golf Course	NA	10	1/yr	Apr.-Nov. 14-48 wks.	100	--	1	2	dermal(p)
Malathion	Ornamental	hand pump spray	0.9-2	2/yr, 2 wks. Between Apps.	Apr.-Nov. 14-48 wks.	--	100	4	1	inhalation(a), dermal(a)
	Public Health	aerial and ground	NA	10/yr, 2 wks. Between Apps.	Apr.-Nov. 14-48 wks.	100	--	14	2	oral(p), dermal(p)
	Vegetable Garden	hand pump sprayer	1.5	5/yr, 2 wks. Between Apps.	Apr.-Nov. 14-48 wks.	--	100	1	1 7	inhalation(a), dermal(a)(p)
TCVP	Pet Aerosol	aerosol spray	2.4×10^{-5}- 3.3×10^{-5} lb ai/lb dog	3/yr, 8 wks. Between Apps.	Apr.-Sept. 14-35 wks.	--	100	5	1 32	inhalation(a), oral(p), dermal(a)(p)

Chemical	Use Scenario	Application Method	Amt. Applied lb ai/A	Max. No./ Frequency Of Apps.	App. Schedule	% Use LCO	% Use HO	% Users	Residue Persistence (Days)	Routes of Exposure
	Pet Powder	shaker can	4.6×10^{-5}- 5.5×10^{-5} lb ai/lb dog	3/yr, 8 wks. Between Apps.	Apr.-Sept. 14-35 wks.	--	100	5	1 32	inhalation(a), oral(p), dermal(a)(p)
	Pet Spray	hand pump sprayer	2.0×10^{-5}- 2.2×10^{-5} lb ai/lb dog	3/yr, 8 wks. Between Apps.	Apr.-Sept. 14-35 wks.	--	100	5	1 32	inhalation(a), oral(p), dermal(a)(p)
Trichlorfon	Golf Course	NA	8	1/yr	Jul.-Nov. 27-45 wks.	100	--	1	2	dermal(p)
	Lawn Granular	rotary spreader	8	1/yr	Jul.-Nov. 27-45 wks.	8	92	1	1 2	inhalation(a), oral(p), dermal(a)(p)
	Lawn Spray	NA	8	1/yr	Jul.-Nov. 27-45 wks.	100	--	2	2	oral(p), dermal(p)

(a) = applicator exposure
(p) = post application exposure
Note: For applicator dermal exposure, the residue persistence is 1 day.

Figure II.E.1 Residential Scenario Application and Usage Schedules for Humid Southeast Region (Region E)

<table>
<tr><th>January</th><th>February</th><th>March</th><th>April</th><th>May</th><th>June</th><th>July</th><th>August</th><th>September</th><th>October</th><th>November</th><th>December</th></tr>
<tr><td></td><td></td><td colspan="8">Acephate Golf</td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="8">Acephate Ornamental Spray</td><td></td><td></td></tr>
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<tr><td colspan="12">DDVP Pest Strip (Closet)</td></tr>
<tr><td colspan="12">DDVP Pest Strip (Cupboard)</td></tr>
<tr><td></td><td></td><td></td><td colspan="8">Disulfoton Ornamental Granular</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="8">Fenamiphos Golf</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="8">Malathion Ornamental Spray</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="8">Malathion Public Health</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="8">Malathion Vegetable Spray</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="6">TCVP Aerosol Spray</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="6">TCVP Powder</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="6">TCVP Hand Pump Spray</td><td></td><td></td><td></td></tr>
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a. Dissipation Data Sources and Assumptions

i. Acephate

A residue dissipation study was conducted on Bahia grass in Florida with multiple residue measurements collected over a period of 10 days after treatment (Days 0, 1, 2, 3, 5, 7, and 10 days). For each day following application, a residue value from a uniform distribution bounded by the low and high measurements for each day was selected. No half-life value or other degradation parameter was used, with current assessment based instead on the time-series distribution of actual residue measurements.

ii. Bensulide

A residue dissipation study was conducted with multiple residue measurements collected for up to 14 days after treatment. For each day following application, a residue value from a uniform distribution bounded by the low and high measurements was selected (the day zero distribution consisted of measurements collected immediately after application and 0.42 day after treatment). No half-life value or other degradation parameter was used, with the current assessment based instead on the time-series distribution of actual measurements. Residues measured at day 7 were assumed to be available and to persist to day 10 and day 10 measurements to persist to day 14

iii. Malathion

A residue dissipation study was conducted with multiple residue measurements collected up to 7 days after treatment in Pennsylvania. This was used for vegetable gardening in Regions A, D, E, F, and G. A value selected from a uniform distribution bounded by the low and high measurements was used for each day after the application. Since the study was conducted at a one pound ai per acre treatment rate, the residues were adjusted upwards by a 1.5 factor to account for the 1.5 pound ai per acre rate for vegetables.

iv. Trichlorfon

Residue values from a residue degradation study for the granular and sprayable formulations were collected for the “day of” and “day following” the application. This was used for the lawn post-application exposure scenarios. For dermal exposure scenarios, a uniform distribution bounded by the low and high residue measurements was used, with these residue values adjusted upwards to simulate the higher active ingredient concentrations in use (i.e., adjusted to 0.5% and 1% for granular and sprayable formulations respectively). These distributions also reflect actual measurements including those based on directions to water in the product. These values were multiplied by a value selected from a uniform distribution bounded by 1.5 and 3 to account for wet hand transfer for assessing non-dietary ingestion for children.

3. Development of Water Exposure Aspects of the Humid Southeast Region

Because of the localized nature of drinking water exposure, the water exposure component of this assessment focused on a specific geographic area within the region. The Humid Southeast region includes those portions of the Southern Seaboard and Eastern Upland regions located east of the Mississippi River. The selection process considers OP use and relative potencies of those OP pesticides and the location, nature, and vulnerability of the drinking water sources. The methods used to identify a specific location within the region are described in the main document (Section I.E). The following discussion provides the details specific to this regional assessment for drinking water exposure with respect to cumulative exposure to the OP pesticides. The discussion centers on four main aspects of the assessment: (1) the selection of the specific location in eastern North Carolina for the drinking water assessment for the region, (2) predicted cumulative OP concentrations in surface water for those OP-crop uses included in this regional assessment, (3) a comparison of the predicted concentrations used in the regional assessment with monitoring data for the region, and (4) a summary of water monitoring data used for site selection and evaluation of the estimated drinking water concentrations for the region.

a. Selection of Eastern North Carolina for Drinking Water Assessment

An evaluation of OP usage, drinking water sources, vulnerability of those sources to OP pesticide contamination, and available monitoring data indicates that (1) surface water sources of drinking water are likely to be more vulnerable than ground water sources, and (2) a surface water assessment based in eastern North Carolina will represent one of the more vulnerable sources of drinking water in the region. This area includes Pitt, Martin, Edgecombe, Greene, and Lenoir counties in eastern North Carolina.

In the preliminary cumulative risk assessment, this eastern North Carolina site represented a vulnerable surface water source of drinking water for the Southern Seaboard while a site in western North Carolina, dominated by OP use on orchards, represented the Eastern Uplands. The preliminary OP cumulative distributions in drinking water were similar for both regions. A Coastal Plain watershed in eastern North Carolina was selected based on total OP use, the RPFs of those OP pesticides used in each area, and a comparison of available monitoring data in the vicinity of the scenario sites.

Total OP usage is relatively high in the Coastal Plain portion of the region and low in the Piedmont Upland and Appalachian Mountain portions. In 1997, approximately 7 million pounds (ai) of OPs were applied to agricultural crops.

Cotton (29% of total OP use in the region), tobacco (19%), corn (14%), peanuts (12%), and alfalfa (14%) accounted for nearly 90% of OP usage in the region (Table II.E.3). Other OP-use crops in the region include fruit orchards (peaches and apples) and pecans.

Table II.E.3. General overview of OP usage in the Humid Southeast Region.

Crops	Primary Production Areas	Total Pounds Applied	Percent of Total OP Use
Cotton	Throughout the coastal plain	2,431,000	29
Tobacco	NC and SC coastal plain, KY	1,646,000	19
Corn	Throughout the region, with the highest acreage in the NC and SC coastal plain	1,231,000	14
Peanuts	GA Coastal Plain	1,027,000	12
Alfalfa	Throughout the region	1,148,000	14
Fruit Orchard	Peaches in GA coastal plain; apples in NC Piedmont	309,000	4
Pecans	Primarily in GA; some extending north to NC	221,000	3
		8,500,000	95

Source: NCFAP, 1997.

OP use in the region is concentrated in the coastal plain, with the highest intensities of use in eastern North Carolina and southern Georgia (Figure II.E.2). OP use on cotton and corn occur throughout the coastal plain. Use on tobacco is primarily in the North Carolina and South Carolina portion of the coastal plain and in Kentucky. Use on peanuts, peaches, and pecans is concentrated in the Georgia portion of the coastal plain. OP use on apples extends into the upland portions of the region, along the Piedmont and ridge and valley areas.

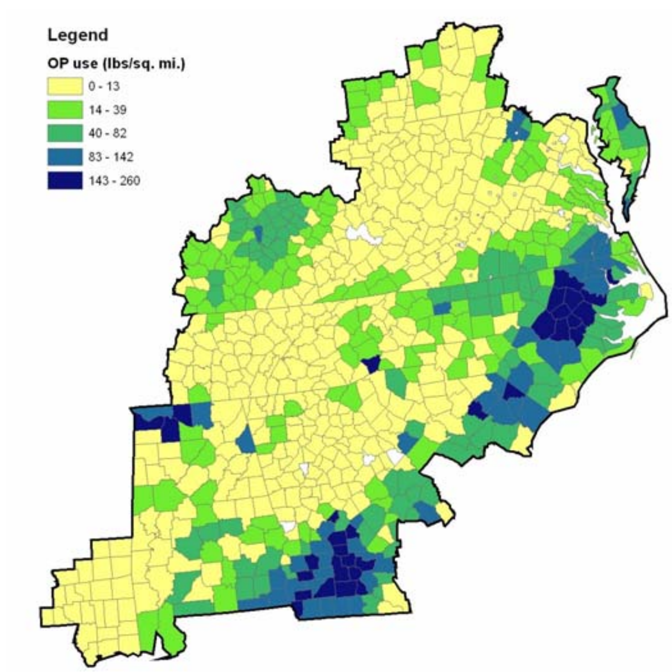

Figure II.E.2. Total OP usage (pounds per area) in the Humid Southeast Region (source: NCFAP, 1997).

Surface water sources of drinking water are common in the western portion of the region, in the Piedmont and Appalachian uplands (Figure II.E.3). The vulnerability of surface water sources of drinking water to runoff is generally greater in the upland regions, increasing from north to south within the region. The more runoff-vulnerable watersheds in the uplands generally coincide with low OP use areas (compare with Figure II.E.2). Occurrence of surface water intakes within high OP use areas is largely confined to the coastal plain in North Carolina and South Carolina. No surface-water sources of drinking water appear in the high-use area of the Georgia coastal plain.

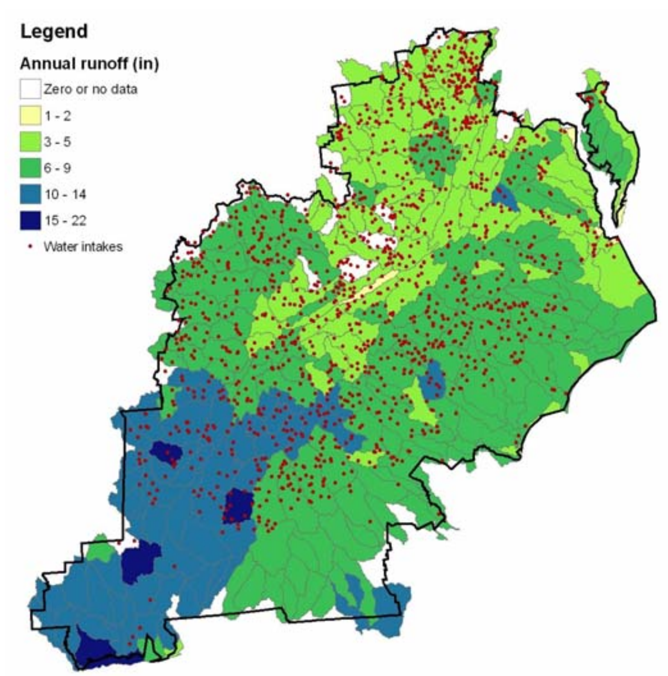

Figure II.E.3. Locations of surface water intakes of drinking water in relation to average annual runoff in the Humid Southeast Region.

A large number of people living on the Coastal Plain derive drinking water from domestic wells in unconsolidated, surficial aquifers which are vulnerable to contamination. The Coastal Plain widens from north to south in this region. Ground water is the main source of drinking water in much of southern Alabama, southern Georgia, and eastern South Carolina. Surficial aquifers provide drinking water in coastal South Carolina and southeastern Georgia. These areas, which have a high pesticide leaching potential (Figure II.E.4), are underlain in parts by the Floridan aquifer and the less productive Southeastern Coastal Plain aquifer system (see http://capp.water.usgs.gov/gwa/ch_g/jpeg/G008.jpeg).

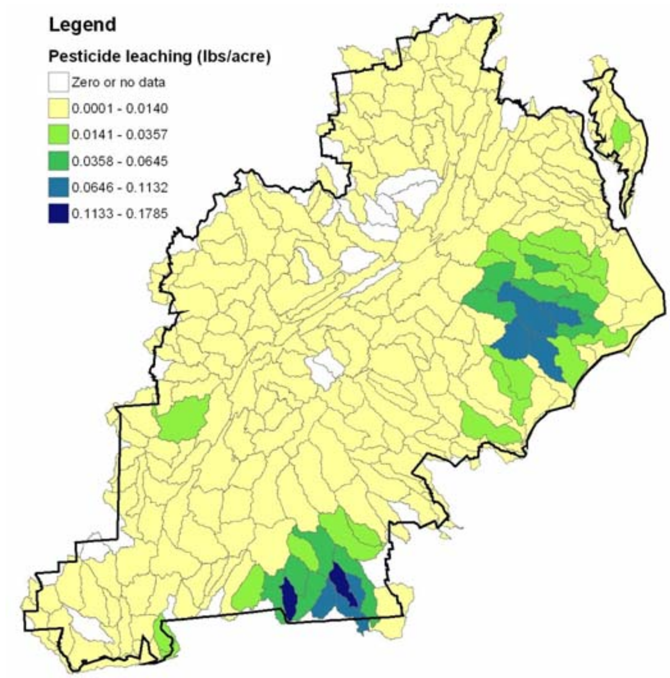

Figure II.E.4. Vulnerability of ground water resources to pesticide leaching in the Southeast Region, adapted from USDA (Kellogg, 1998)

The Floridan aquifer is a highly productive carbonate rock (e.g. limestone) aquifer which is an important source of drinking water in Alabama, Georgia, South Carolina, and Florida. 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).

The Southeastern Coastal Plain aquifer is most important as a drinking water source in the inner portion of the Coastal Plain. It is separated from the unitl also overlying Floridan by a clayey confining unit in Alabama and western Georgia, which serves to retard recharge from the Floridan. This unit also retards potential contamination from the surface. It is most productive away from the coast, where it is comprised of less sand and more clay.

Ground water is also an important source of drinking water on the Delmarva Peninsula, and in parts of coastal Virginia and North Carolina. Thick layers of sediment in this region (about 10,000 feet at Cape Hatteras, North Carolina) overlie bedrock similar to that exposed in the Piedmont physiographic province. These sediments were deposited as layers of sand overlain by finer sediments as the ocean advanced and retreated over the area. As a result, 11 aquifers comprise the Coastal Plain sediments in these states, separated by nine clay and silt confining units.

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 vulnerable.

The high OP use area in eastern North Carolina and a smaller area in eastern South Carolina have the potential to impact vulnerable surface water sources of drinking water. The high OP use area in southern Georgia is located in an area where ground water is the predominant source of drinking water. Although available monitoring data are not extensive, they indicate that surface water sources of drinking water are likely to be more vulnerable than ground water sources. Based on the weight of evidence, OPP identified the coastal plain watershed in eastern North Carolina as representative of the more vulnerable areas within the Humid Southeast region. The surface-water exposure assessment should be considered a conservative surrogate for the portion of the population deriving its drinking water from ground water.

In eastern North Carolina (Pitt, Martin, Edgecombe, Greene, and Lenoir counties), OP use on cotton, tobacco, and corn accounted for more than 80 percent of total agricultural use (Table II.E.4).

Table II.E.4. OP use on agricultural crops in eastern North Carolina (Pitt, Martin, Edgecombe, Greene, and Lenoir Counties), Southeast Region.

OP Usage/ Agricultural Crops				Cropland Acreage, Assessment Area	
Crop Group	**Crops**	**OP Usage x 1000 lb**	**Percent of Total OP Use**	**Acres x 1000**	**Pct of total Cropland**
Cotton	Cotton	70	40	209	39
Corn	Corn	33	19	62.5	12
Tobacco	Tobacco	41	23	27	5
Peanuts	Peanuts	11	6	30	6
				328.5	62

Pesticide use based latest data collected by USDA National Agricultural Statistics Service (NASS). Acreage estimates based on NC Department of Agriculture and Consumer Services. Details on the sources of usage information are found in Appendix III.E.8.

b. Cumulative OP Concentration Distribution in Surface Water

The Agency estimated drinking water concentrations in the Southeast regional cumulative assessment using PRZM-EXAMS with input parameters specific to eastern North Carolina. Table II.E.5 summarizes pesticide use information used in this regional assessment. Chemical-, application- and site-specific inputs into the assessments are found in Appendices III.E.5-7. Sources of usage information can be found in Appendix III.E.8. Based on the latest available USDA National Agricultural Statistics Service (NASS) usage data, these OP-use combinations represent roughly 87 percent of agricultural use of OP pesticides in these counties.

Since the preliminary OP cumulative assessment was released in December 2001, fenamiphos uses have been voluntarily canceled. Thus, fenamiphos use on cotton has been dropped from the revised assessment for this region.

Table II.E.5. OP-Crop combinations and application information for the Humid Southeast Region assessment.

Chemical	Crop/ Use	Pct. Acres Treated	App. Rate, lb ai/A	App Meth/ Timing	Application Date(s)	Range in Dates (most active dates)
Terbufos	Corn	38	1.14	Ground; Planting	April 17	Apr1-May20 (Apr 10-Apr 25)
Chlorpyrifos	Corn	8	1.17	Ground; Planting	April 17	Apr1-May20 (Apr 10-Apr 25)
Acephate	Cotton	16	0.27	Ground; Foliar	June 11	May 1-Jul 21
Dimethoate	Cotton	2	0.1	Ground; Foliar	May 1, Jun 11	May 1-Jul 21
Phorate	Cotton	4	0.9	Ground; Planting	May 10	Apr21-Jun8 (May 1-May 20)
Tribufos	Cotton	39	0.46	Ground; Harvest	Oct 19	Sep27-Dec15 (Oct 7-Nov 15)
Disulfoton	Cotton	11	0.66	Ground; Planting	May10	Apr21-Jun8 (May-May 20)
Acephate	Peanuts	5	0.47	Ground; Planting-Foliar	May25	Apr28-Jun21
Chlorpyrifos	Peanuts	25	0.63	Ground; Foliar	July 7	Jun15-Aug1
Phorate	Peanuts	20	0.91	Ground; Planting	May 18	Apr28-Jun2 (May 8-May 28)
Acephate	Tobacco	70	0.75	Ground; Foliar	June 30	May15-Aug15
Chlorpyrifos	Tobacco	25	2.3	Ground; Planting	May 16	Apr 18-Jun 2 (May 7-May 25)
Ethoprop	Tobacco	6(5.5)	5.2	Ground; Planting	May 16	Apr 18-Jun 2 (May 7-May 25)

Table II.E.6 summarizes the estimated concentrations of OPs in surface water in eastern North Carolina. Only acephate and terbufos (total residues) had estimated maximum concentrations greater than 1 ppb.

Table II.E.6. Predicted percentile concentrations of individual OP pesticides and of OP cumulative distribution, Southeast Region.

Chemical	Crop/Use	Concentration, ug/L (ppb)						
		Max	99th	95th	90th	80th	75th	50th
Acephate	Cotton, Peanut, Tobacco	1.7e+00	4.3e-02	3.1e-03	7.0e-04	2.1e-05	1.8e-06	1.7e-08
Chlorpyrifos	Corn, Peanut, Tobacco	2.6e-01	9.9e-02	5.6e-02	3.8e-02	2.2e-02	1.8e-02	5.8e-03
Dimethoate	Cotton	7.4e-02	1.2e-02	2.7e-03	1.0e-03	2.3e-04	7.7e-05	9.1e-07
Disulfoton (total residues)	Cotton	4.3e-02	2.8e-02	1.6e-02	1.2e-02	7.8e-03	6.5e-03	3.4e-03
Ethoprop	Tobacco	2.2e-01	1.4e-01	4.8e-02	2.9e-02	1.5e-02	1.2e-02	4.9e-03
Methamidophos	Acephate degradate	2.1e-01	5.2e-03	1.7e-04	9.8e-06	4.5e-08	1.4e-08	4.2e-10
Phorate (total residues)	Cotton, Peanut	6.6e-01	3.9e-02	1.7e-03	4.7e-05	2.1e-09	1.4e-11	1.0e-12
Terbufos (total residues)	Corn	1.5e+00	4.0e-01	1.1e-01	3.9e-02	6.5e-03	1.6e-03	1.2e-04
Tribufos	Cotton	2.4e-02	1.6e-02	1.1e-02	9.6e-03	7.8e-03	7.3e-03	5.4e-03
OP Cumulative Concentration in Methamidophos Equivalents		3.8e+00	1.1e+00	3.6e-01	1.6e-01	6.5e-02	4.9e-02	1.8e-02

Figure II.E.5 displays 35 years of predicted OP cumulative concentrations for the Humid Southeast drinking water assessment. Cumulative OP concentrations, in methamidophos equivalents, exceeded 2 ppb twice in the 35 years of weather patterns, and generally remained less than 1 ppb.

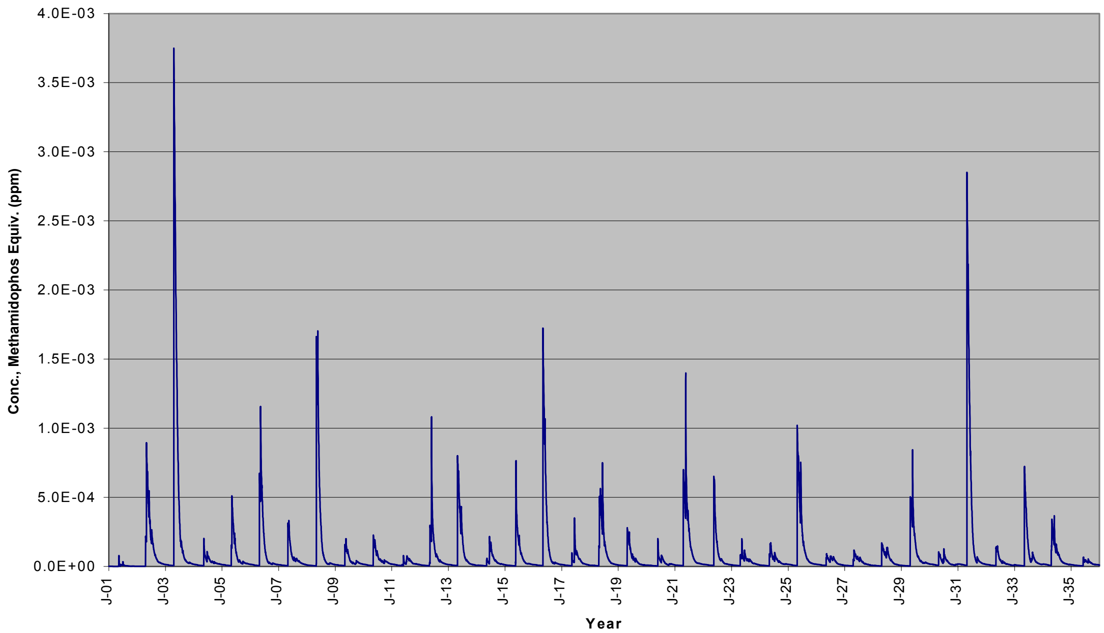

Figure II.E.5. Cumulative OP distribution in water in the Southeast Region, 35 years of weather patterns.

Figure II.E.6 overlays all 35 years of predicted values in the same year span. The highest peak concentrations occurred in mid-April, when runoff-producing rainfall occurred shortly after OP applications to corn. The later in the season the runoff events occurred in a given year, the lower the peak concentrations.

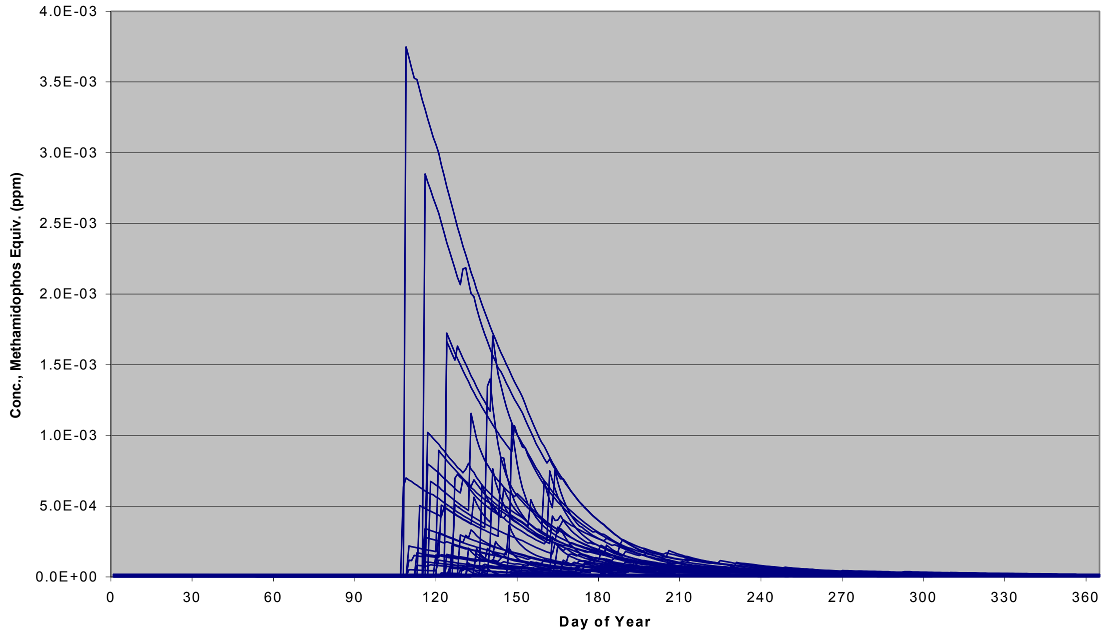

Figure II.E.6. Variations in yearly patterns of cumulative OP concentrations in water in the Southeast Region (35 years of varying weather patterns).

Figure II.E.7 shows the relative contributions of individual OPs to the estimated cumulative OP load over a three-year span. Terbufos, applied to corn, was the primary component in the peak seen in Year 16. In the subsequent years, when runoff-producing rainfalls did not occur until later in the season, a variety of OPs contributed to the cumulative OP load, including acephate, disulfoton, and phorate. The terbufos and phorate contributions reflect total residues of the parent OP and the sulfoxide and sulfone transformation products. These relative contributions reflect both individual chemical concentrations in water and the relative potency factor of each of the OP chemicals found in the water.

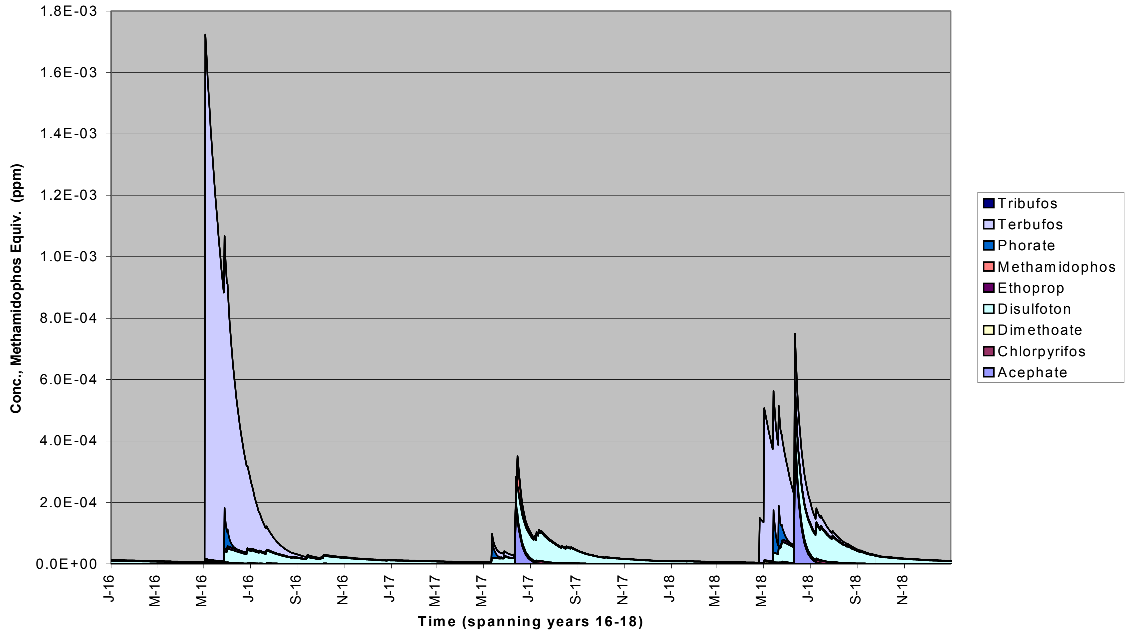

Figure II.E.7. Cumulative OP distribution spanning 3 years (16-18) in Southeast Region, showing relative contributions of individual OPs in methamidophos equivalents.

The impact of the RPF of the OP pesticides on the cumulative load can be seen by comparing Figure II.E.7 with II.E.8, which shows individual OP concentrations without the RPF. The estimated peak acephate concentrations in years 17 and 18 were greater than estimated peak terbufos concentrations in year 16, or in subsequent years. However, when the RPF was factored in (0.08 for acephate and 0.85 for terbufos), the terbufos contribution, in methamidophos equivalents, was greater than that of acephate and the relative sizes of the cumulative OP peaks reversed between years 16 and 18.

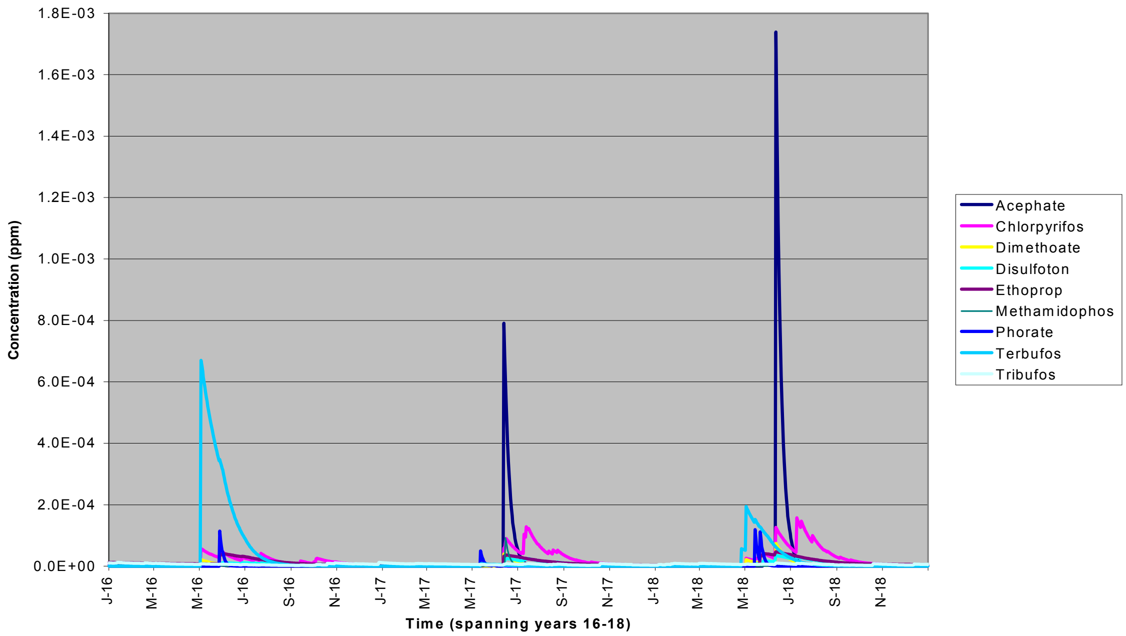

Figure II.E.8. Concentrations of selected OPs spanning 3 years (16-18) in the Southeast Region. Contrast with Figure II.E.7 for effect of relative potency on cumulative OP concentration.

c. A Comparison of Monitoring Data with Modeling Results

The **Albemarle-Pamlico Drainage Basin (ALBE) NAWQA** study unit, located primarily in the Piedmont and Coastal Plain physiographic provinces of southeastern Virginia and northeastern North Carolina, includes the area identified as a vulnerable watershed for the OP cumulative assessment. The NAWQA study included chlorpyrifos, disulfoton, ethoprop, phorate, and terbufos in its monitoring program.

Chlorpyrifos was detected in 14% of agricultural streams, at a maximum of 0.058 ug/l, roughly equivalent to the estimated 95th percentile concentration. The estimated concentrations and measured concentrations in the ALBE agricultural streams were within a factor of 10 of each other at the 90th and greater percentiles. Ethoprop was detected in 4% of all samples, with a maximum detection of 0.8 ug/l in an agricultural stream, greater than the estimated peak of 0.2 ug/l. Phorate was detected in little more than 1% of samples, with a maximum concentrations of about 0.03 ug/l, roughly equivalent to the 99th percentile estimated concentration. Terbufos was detected in a single mixed land-use sample at 0.01 ug/l, slightly less than the 90th percentile estimated concentration.

In evaluating these comparisons, it is important to realize that the estimated cumulative OP concentrations used in the exposure assessment represent concentrations that would occur in a reservoir, and not in the streams and rivers represented by the NAWQA sampling. The sampling frequency of the NAWQA study (sample intervals of 1 to 2 weeks apart or less frequent) was not designed to capture peak concentrations, so it is unlikely that the monitoring data will include true peak concentrations. The main document provides a characterization of what the water exposure estimates represent and includes an analysis of the factors that most influence these estimated concentrations.

The Tar River Reservoir, included in the USGS-EPA reservoir monitoring study, is located in the eastern coastal plain of North Carolina. While the watershed is representative of tobacco/peanut cropping (Blomquist et al, 2001; Appendix III.E.3), weather patterns during the sampling period represented unusual extremes. Drought conditions persisted in the first sampling year through September 1999. In September, Hurricane Floyd moved through North Carolina, creating flood conditions in the reservoir. USGS did not extend sampling into the second year at Tar River. Thus, any comparisons need to be placed in context with these unusual conditions. Diazinon, detected in 50% of the raw water samples from the reservoir, was not included in the OP-crop combinations for the OP cumulative assessment. Fenamiphos sulfone, the only other OP detected in the reservoir, occurred in 10% of raw water samples and 20% of treated water samples. Measured fenamiphos sulfone concentrations in the treated water samples (0.01-0.016 ug/L) were similar to 90^{th} percentile concentrations of total fenamiphos residues in untreated water estimated in the preliminary assessment (12/01). However, because fenamiphos is being voluntarily cancelled, OPP did not include it in the revised cumulative assessment.

d. Summary of Available Monitoring Data for the Southeast Region

Available water monitoring which included analysis for OPs includes four NAWQA studies, and several State monitoring programs.

The **Albemarle-Pamlico Drainage Basin (ALBE) NAWQA** study unit is located primarily in the Piedmont and Coastal Plain physiographic provinces of southeastern Virginia and northeastern North Carolina. Nearly equivalent portions of the population derived drinking water from surface water and ground water in 1990, with one-third of the population drawing water from domestic wells.

Shallow wells (< 50 feet) in unconsolidated surficial aquifers were sampled because they were most likely to be vulnerable to contamination. Several public supply wells were also included to see if pumping drew contamination from the surficial wells. Diazinon was detected in 7% of ground-water samples, and chlorpyrifos in a single ground-water sample. The USGS Circular 1157 indicates that both were detected in the agricultural (corn-soybean) land-use study, but does not indicate whether some of the diazinon detections occurred in the Virginia Beach urban land-use study. The maximum concentration of diazinon in ground water was about 0.1 ug/l. The single detection of chlorpyrifos was <0.01 ug/l.

Diazinon (9.5%) and chlorpyrifos (13.9%) were the OPs most frequently detected in agricultural streams, although both were more often detected in mixed land-use streams. Diazinon, which was not included in the suite of chemicals for this regional assessment, was detected at a maximum concentration of 0.11 ug/l in these streams, and chlorpyrifos at a maximum of 0.058 ug/l, roughly equivalent to the estimated 95th percentile concentration. Malathion was detected in 7.7% of all samples, with a maximum detection of 0.055 ug/l. Ethoprop was detected in 4.4% of all samples, with a maximum detection of 0.8 ug/l in an agricultural stream, greater than the estimated peak of 0.2 ug/l. Phorate and azinphos methyl were detected in little more than 1% of samples each, with maximum concentrations of about 0.03 ug/l. Terbufos was detected in a single mixed land-use sample at 0.01 ug/l. Surface water was collected at four intensive sampling sites, and 66 other stream sites sampled one to six times in the study.

The **Apalachicola-Chattahoochee-Flint River Basin (ACFB) NAWQA** study site extends from north of Atlanta along the Georgia-Alabama border through the Florida panhandle to the Gulf of Mexico. The northern portion of the study unit is in the Piedmont physiographic province, and the southern portion in the Coastal Plain. Ninety-three percent of the population in the Piedmont derived drinking water from surface water in 1990, while surface water and ground water served nearly equivalent populations in the Coastal Plain. Nearly half of the ground water in the basin was supplied by the vulnerable, karst limestone, Upper Floridan aquifer.

Pesticides were most frequently detected in the karst recharge areas of the Upper Floridan aquifer, but OPs were rarely detected. USGS Circular 1164 indicates that chlorpyrifos and terbufos were both detected once at about 0.01 µg/l, but the dataset available on the study unit world wide web page does not include these detections. Diazinon was detected twice in the urban land-use study. Malathion was detected once in the agricultural land-use study at a concentration of 0.011 µg/l.

Diazinon, chlorpyrifos, and malathion were frequently detected in this study unit, but almost exclusively in urban or suburban stream samples. Malathion was detected in an urban stream with a maximum concentration of 0.14 µg/l. Ethoprop was detected twice in urban or suburban streams, and once in an agricultural stream (maximum concentration 0.021 µg/l). Azinphos-methyl, disulfoton, and terbufos were detected once each in urban or suburban streams, at concentrations of 0.018 µg/l or less.

The **Potomac River Basin (POTO) NAWQA** study unit is comprised of parts of Virginia, West Virginia, Maryland, Pennsylvania and the District of Columbia. Surface water is the dominant source of drinking water in this basin, although nearly 800,000 people in the basin relied on domestic wells in 1990.

Surface-water sites included for intensive sites sampled 24 times a year for two years in agricultural and urban areas. Twenty-three tributaries with watersheds of greater than 100 square miles were sampled once each, and 25 to 39 tributaries with smaller basins were sampled once each for three years. Diazinon was the most detected OP, found in 24% of samples, with a maximum concentration of 1.4 ug/l. Chlorpyrifos was detected in 8% of samples, with a maximum concentration of 0.041 ug/l. Methyl parathion was detected in 2% of samples, but some portion of these detections might be due to orchard uses (which has since been cancelled). Malathion, ethoprop and azinphos methyl were also detected in fewer than 5% of samples.

Ground-water was sampled one time from each of 48 wells in the Piedmont and physiographic province from the Washington DC metropolitan area through central Maryland. Another 54 agricultural and 3 forest region wells were sampled once each to the west in the Valley and Ridge physiographic region. Chlorpyrifos is described as an important agricultural chemical in the Potomac River Basin, with use on corn, alfalfa and apples. It was detected in two ground-water samples, with a maximum concentration of about 0.05 ug/l. Diazinon was detected in ground water three times, with a maximum concentration of about 0.01 ug/l, and malathion once at <0.005 ug/l. Neither is listed as a major agricultural chemical in the region.

The **Santee River Basin and Coastal Drainages (SANT) NAWQA** study unit includes much of South Carolina, and extends into southwestern North Carolina. Eighty-six percent of drinking water in this region is from rivers and reservoirs, although rural regions which are not on public supply rely on domestic wells. In the north of the study unit, the relatively undeveloped land in the Blue Ridge physiographic province has little affect on water quality. However, development is more extensive in the Piedmont, and the rivers which provide drinking water are well-regulated, as 85% of water use is for the production of energy. Toward the coast, slow-moving rivers in the Coastal Plain run through marshland and row-crop farmland.

Analysis for pesticides was included in intensive (3 sites) and fixed-site (13 sites) surface water studies over a range of land uses, and at 16 urban sampling sites. Chlorpyrifos, diazinon, and malathion were the only OPs detected more than once. All three were detected in more than half of urban samples, but only chlorpyrifos (60%) was detected in more than 10% of agricultural samples. Chlorpyrifos was detected at a maximum concentration of 0.03 µg/l in an agricultural stream, and malathion at 0.216 in an urban stream. Methyl parathion was detected once in an urban stream at 0.013 µg/l.

Ground-water studies included single samples from 90 public supply, domestic, irrigation, and industrial wells from throughout the study unit. Thirty wells each were sampled from the Piedmont, Sandhills, and Floridan aquifers. Of the three, the Sandhills is the most vulnerable, as the Piedmont and Floridan underlie weathered bedrock and a clay confining layer, respectively. An agricultural land use study included single samples from 30 wells in row-crop areas, and an urban land-use study included single samples from 30 wells in commercial and residential areas.

Diazinon was detected in a single agricultural well at around 0.005 µg/l, and in a well from the Sandhills aquifer at about 0.06 µg/l. Chlorpyrifos and diazinon were detected in 2 and 3 urban wells, respectively. No other OPs were detected in ground water.

Only a few states in the Southern Seaboard region have included OP pesticides in their monitoring program (See Appendix III.E.2 for details on the state monitoring programs). In **Delaware**, chlorpyrifos was detected at a concentration of 0.75 ppb (LOD of 0.22 ppb) in a single domestic well screened between 33 and 38 feet. This detection resulted from the state's Pesticide Management Program and is included in the report, "The Occurrence and Distribution of Several Agricultural Pesticides in Delaware's Shallow Ground Water" , 2000: http://www.udel.edu/dgs/pub/RI61.pdf

In **North Carolina**, none of sixteen OPs (acephate, azinphos methyl, chlorpyrifos, diazinon, dimethoate, disulfoton, ethoprop, fenamiphos, fonofos, malathion, mevinphos, parathion, phorate, phosmet, terbufos, trichlorfon) were detected in 1 to 25 wells in its "Interagency Study of the Impact of Pesticide Use on Ground Water in North Carolina," which took place between 1991 and 1995. A separate study of domestic wells resulted in a single detection of diazinon at 0.55 ppb. It is not clear if this was the result of domestic use.

4. Results of Cumulative Assessment

Analyses and interpretation of the outputs of a cumulative distribution rely heavily upon examination of the results for changing patterns of exposure. Briefly, the cumulative assessment generates multiple potential exposures (i.e., distribution of exposures for each of the 365 days of the year) for each hypothetical individual in the assessment for each of the 365 days in a year. 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 throughout the entire year. Each of these generated exposures is internally consistent – that is, each generated exposure appropriately considers temporal, spatial, and demographic factors such that "mismatching" (such as combining a winter drinking water exposure with an exposure that would occur through a spring lawn application) is precluded. In addition, a simultaneous calculation of MOEs for the combined risk from all routes is performed, permitting the estimation of distributions of the various percentiles of total risk across the year. Results are displayed as MOEs with the various pathways, routes, and the total exposures arrayed across the year as a time series (or time profile). Any given percentile of these (daily) exposures can be selected and evaluated as a function of time. That is, for example, a 365-day series of 95th percentile values can be arrayed, with 95th percentile exposures for each day of the year (January 1, January 2, etc) shown. The result can be regarded as a "time-based exposure profile" in which periods of higher exposures (evidenced by low 'Margins of Exposure') and lower exposures (evidenced by high 'Margins of Exposure') can be discerned. Patterns can be observed and interpreted and exposures by different routes and pathways (e.g., dermal route through lawn application) observed and compared. Abrupt changes in the slope or levels of such a profile 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 exposure profile indicates that exposure from a given source or combination of sources is stable across time and the sources of risk may be less obvious. Different percentiles can be compared to ascertain which routes or pathways tend to be more significant contributors to total exposure at various total exposure levels for different subgroups of the Humid Southeast output distribution (e.g, those at the 95th percentile vs. 99th percentiles of exposure).

Figures III.N.2-1 through III.N.2-8 in Appendix N present the results of this cumulative risk analysis for Children, 1-2 years for a variety of percentiles (95, 99, 99.5, and 99.9) of the output distribution for the Humid Southeast for two averaging periods (one and seven days). Figure III.N.2-9 through Figure III.N.2-16 present these same figures for Children 3-5. Appendix III.N.3 presents the ungraphed data/output for Adults 20-49 and Adults 50+. The following paragraphs describe, in additional detail, the exposure profiles for each of these age groups for the 99.9th and 95th percentiles. Briefly, these figures present a series of time courses of exposure (expressed as MOEs) for various age groups at various percentiles of exposure. For example, for the 95th percentile MOEs for children 1-2 years old, the 95th percentile (total) exposure for children 1-2 is estimated for each of the 365 days of the year, with each of these (total) exposures – expressed in terms of MOEs – arrayed as a function of time. The result is a "time course" (or "profile") of exposures representing that portion of the Humid Southeast output distribution at the 95th percentile exposures throughout the year. In addition, the MOEs are shown for each pathway or route (e.g., oral ingestion through food, oral ingestion through hand-to-mouth activity, inhalation, dermal, etc.) for each of a variety of percentiles. This discussion represents the unmitigated exposures (i.e., exposures which have not been attempted to be reduced by discontinuing specific uses of pesticides) and no attempt is made in this assessment to evaluate potential mitigation options. The following paragraphs describe the findings and conclusions from each of the assessments performed.

a. Children 1-2 years old

Single Day Analysis (Figure III.N.2-1 through Figure III.N.2-4): At the 99.9th percentile, total MOEs are generally in the range of ~10 to 60. These total exposures are comprised mainly of inhalation exposures through residential uses of DDVP pest strips. At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips occurs. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. Although there are increases in drinking water concentrations near Julian day 110 which corresponds to April application of terbufos to corn, drinking water does not contribute to substantial exposure at any percentile examined and MOEs through this route remain above 100 throughout the year. Similarly, for all the percentiles examined (95th through 99.9$^{th)}$, oral hand-to-mouth- and dermal exposures are also apparent in the exposure profile during summer and fall portions of the year, but are small and are responsible for MOEs of generally greater than 1000 throughout the year.

Seven Day Rolling Average Analysis (Figure III.N.2-5 through Figure III.N.2-8): At the 99.9th percentile, total MOEs are generally in the range of ~ 20 to 60. These total exposures are comprised virtually exclusively of inhalation exposures through residential uses of DDVP pest strips. At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips is seen. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. Although there are increases in drinking water concentrations near Julian day 110 as described above, drinking water at at all percentiles examined (95th through 99.9th) does not contribute to substantial exposure with MOEs remaining above 100 throughout the year. Similarly, oral hand-to-mouth- and dermal exposures are also apparent in the exposure profile during summer and fall portions of the year, but are small and are responsible for MOEs at all percentiles examined which remain greater than 1000 throughout the year.

b. Children 3-5 years old

Single Day Analysis (Figure III.N.2-9 through Figure III.N.2-12): At the 99.9th percentile, total MOEs for Children 3-5 are generally in the range of ~ 15 to 60. These total exposures are comprised mainly of inhalation exposures through residential uses of DDVP pest strips. At the 95th percentile, total MOEs are well above 100, and no exposure through the use of DDVP pest strips is seen. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. While there are increases in drinking water concentrations near Julian day 110 as described above, drinking water at all percentiles examined (i.e., 95th through 99.9th) does not contribute to substantial exposure. Similarly, oral hand-to-mouth- and dermal exposures are also apparent in the exposure profile during summer and fall portions of the year, but are small and are responsible for MOEs of generally greater than 1000 throughout the year.

Seven Day Rolling Average Analysis (Figure III.N.2-13 through Figure III.N.2-16): At the 99.9th percentile, total MOEs are generally in the range of ~40 to 70. Inhalation exposures through residential uses of DDVP pest strips are almost exclusively responsible for these exposures. At the 95th percentile, total MOEs are well above 100, and there is no exposure through the use of DDVP pest strips. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. The remaining exposure pathways do not contribute to significant exposure. Specifically, exposures through drinking water remain relatively low with MOEs never becoming less than 200 throughout the year at all percentiles examined (95th through 99.9th) and dermal and oral hand-to-mouth responsible for MOEs that remain greater than 1000 throughout the year at these percentiles.

c. Adults, 20-49 and Adults 50+ years old

Single Day Analysis (Appendix III.N.3) At the 99.9th percentile, total MOEs range from ~ 30 to 160. Inhalation exposures from the residential use of DDVP pest strips are responsible for a major fraction of this exposure. At the 95th percentile, total MOEs are well above 100, and there is no exposure through the use of DDVP pest strips. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. Other exposure routes – specifically drinking water and dermal – do not contribute to significant exposures at any of the percentiles examined (95th through 99.9th) and are responsible for MOEs that remain above 200 throughout the year.

Seven Day Rolling Average Analysis (Appendix III.N.3) At the 99.9th percentile, total MOEs range from ~ 90 to 200. Inhalation exposures from the residential use of DDVP pest strips are the major contributor to these exposures. At the 95th percentile, total MOEs are well above 100, and there is no exposure through the use of DDVP pest strips. It is important to express these exposures as a *range* of MOEs because there may be variability across seasons. Other exposure routes – namely drinking water and dermal – do not contribute to significant exposures and are responsible for MOEs that remain greater than 300 throughout the year.