I. Preliminary OP Cumulative Risk Assessment

D. Residential OP Cumulative Risk

1. Introduction

The Office of Pesticide Programs (OPP) has used the calendar based model (Calendex) to address the temporal aspects of the residential use of pesticides in 13 distinct geographic regions throughout the United States. These regions, based on major crop growing areas and their influence on surface and ground water, also present an opportunity to consider the unique climate patterns, pest patterns and potential socioeconomic patterns that influence residential pesticide use and expected exposure.

Calendex allows the OPP to delineate the critical timing aspects of seasonal uses of Organophosphate (OP) insecticides that result in exposure to pesticides. Calendex also enables OPP to identify potential co-occurrences from multiple sources. This includes the exposure from home lawn and garden treatments, pesticides used on golf courses and exposures made by governmental entities for the control of public health pests such as wide area mosquito sprays.

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 the Agency's Exposure Factors Handbook (USEPA, 1997a). In this assessment, the full range of exposure values expressed as uniform, log-normal or cumulative distributions are used rather than relying solely on measures of central tendency. The statement of risk used in this assessment is the margin of exposure, a unitless value representing a ratio of a Point of Departure value in route specific toxicity studies and estimates of human exposure. While the dietary and drinking water assessment address the oral exposure route, the residential assessment considers the dermal and inhalation exposure routes as well as the oral route based on the mouthing behavior of young children.

EPA registered labels, while useful for establishing site/pest relationships and recommendations for applications, cannot provide the temporal aspects of regional pesticide use. Thus, OPP has relied on other sources of pesticide use information, including pesticide use survey data and information available in State Cooperative Extension Service publications. Survey data were used to identify information such as frequency of applications, the type of application equipment used, and the type clothing worn while making those applications. State Cooperative Extension Service recommendations were used to establish regional windows of pesticide applications based on the observed appearance of insects such as white grubs on lawns. For example, the timing for the treatment of white grubs occurs during early June in southern Texas (Region 1-Fruitful Rim

TX) and mid-August in areas such as New York (Northern Crescent Region 2).

2. Scope of Regional Assessments

The residential and drinking water assessments were developed for 13 distinct geographic Agricultural Production Regions (Figure 1). EPA included nine OP pesticides with residential uses and potential for significant exposures in its assessment. Not included in the cumulative assessment were certain OP uses that result in low exposure, uses for which risk mitigation actions have been taken, and pet care product uses.

Two OP pesticides are currently registered for use on pets, tetrachlorvinphos (shampoo/dip) and DDVP (flea collars). EPA did not have sufficient data on exposure for these uses to include them in a calendar-based probabilistic assessment. The screening level assessments for these uses indicate risks of concern. OPP is identifying exposure data needs for these uses to refine the assessments. OPP needs data on the fate of the pesticide on the fur and skin of the animal and data on transfer of the pesticide during the contact with humans. The exposure assessment for these products also needs to take into account the frequency of pesticide use on pets and the transfer of residues from the pet to the residential surfaces.

Other OP uses were not included because they resulted in low exposures or because their single chemical REDs showed low risk. These low exposure uses include ant baits, paint additives and post application residential exposure from sod farm application of pesticides. Ant baits are contained inside enclosed packages. The treatment of individual fire ant mounds has very low applicator exposure and the reentry or significant play on fire ant mounds is unlikely. Low exposure is expected also because the treatments often take more than one day to produce results.

In case of paint additives, the diazinon additives in outdoor paints result in low potential for exposure because of the complexity of the paint/pesticide matrix as well as the dilution of airborne concentrations in the outdoor environment For sod farm uses, post application exposure is mitigated by rapid dissipation of residues, residues removal during harvesting (cutting, rolling or stacking) and transportation. Installation of the sod requires considerable site preparation which is followed by watering in, further lowering potential for significant exposure in a post application scenario. OPP believes that children are unlikely to enter the lawn area immediately following the sod installation.

Finally, for wide-area public health treatments the more significant uses such as fenthion, malathion and naled were included. Chlorpyrifos use for mosquitoes was not included because very low exposures were estimated in the single chemical, screening level assessment.

3. Residential Scenarios

The Residential Scenarios addressed in this document represent critical OP uses that have the potential for significant exposure or risk when considered in a cumulative assessment. These are:

- ❏ Lawn care and golf course applications,
- ❏ Home gardens,
- ❏ Wide area Public Health sprays,
- ❏ Indoor crack and crevice sprays, and
- ❏ Impregnated pest strips.

a. Lawns and Golf Course Treatments

Five OPs have registrations allowing applications to residential lawns and/or golf course fairways, greens and tees. Of the five pesticides, three may be applied by homeowners as well as by professional lawn care operators (LCO) to residential lawns. These pesticides are bensulide, trichlorfon, and malathion. Bensulide is an herbicide used to control germinating weeds and trichlorfon is labeled for insects such as white grubs, which damage turf when present in significant numbers. Both of these pesticides need to be watered in for effective control. Malathion, while having label rates for some turf insects, is primarily applied as surface sprays to control nuisance pests such as fleas.

On golf courses acephate is used for surface feeding insects, like the chinch bug, which invade primarily warm season grasses such as St. Augustine grass. Trichlorfon is used for sub surface or thatch dwelling insects such as white grubs. Bensulide is used for germinating weeds such as crabgrass on fairways, greens and tees. Fenamiphos is uses as a nematicide and is also watered in. Malathion was also listed as a pesticide used on golf courses (Doane's and GolfTrak, 1998-1999). Although it is not clear why or how it was used, for this assessment we have assumed that since it is applied as a surface spray it would be used to control surface feeding pests such as the chinch bug. Finally, OPP has learned recently that the malathion golf course use is no longer supported by the registrant.

b. Home Gardens

The home garden scenarios include ornamental and edible food gardens (including home fruit orchards). Due to the wide variety of plant/pest relationships that can exist in any given region, it was assumed that applications could be made throughout the growing season for a given area. The chemicals acephate and disulfoton are insecticides that have systemic properties and appear to be more widely recommended in the cooperative extension publications. However, in most cooperative extension services malathion continues to be recommended for aphids. In addition to use on ornamental gardens, malathion is also registered for use on home vegetable gardens and orchards.

c. Public Health Uses

Residential exposure from aerial and ground based applications for the control of public health pests made by regional or state personnel was addressed in this assessment. Malathion, fenthion and naled are applied to control mosquitoes. Fenthion is also applied to control black flies.

d. Indoor Uses

Dichlorvos(DDVP) is the sole OP pesticide with indoor registrations. DDVP is used as a crack and crevice spray and is formulated as a pesticide impregnated pest strip for the control of flying insects. Crack and crevice sprays are typically defined as applications made along baseboards, to interior wall voids, and behind kitchen appliances and cabinetry. In the past, DDVP was normally formulated with other relatively longer persisting OPs to provide immediate knock down of the pests present at the time of the application. Normally, these pesticides were diazinon and chlorpyrifos, which are no longer registered or are being phased out. Although it is not clear what the future use of this pesticide will be, for the purpose of this assessment OPP assumed DDVP will be applied as a routine (monthly) crack and crevice treatment. The use of the impregnated pest strips to control flying insects was assumed to be seasonal.

4. Exposure Routes 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 oral route of exposure to pesticides used in residential settings is considered in this assessment for children two to six years old but not for adults. Dermal route of exposure is considered for both children and adults, however the calculation for children is adjusted by the appropriate surface area to body weight ratio. Children are considered in a separate group from adults because of the potential for additional exposures that result from their mouthing behavior and a higher skin surface area to body weight ratio. OPP acknowledges that there is very limited data on exposure to the very young children, under two years old. Thus this age group was not included in the assessment. In general children older than six have a similar surface area to body weight ratios to adults and also no longer exhibit mouthing behavior such as placing hands and /or objects into the mouth.

Oral ingestion via hand-to-mouth activity of children is the only oral route of exposure considered in the residential portion of this assessment. Ingestion of soil and mouthing of grass are not considered because these pathways had little impact on the exposure assessment when they were addressed in the individual OP risk assessments.

Dermal and inhalation routes of exposure for the adults making pesticide applications were considered for the three lawn care OP pesticides (Trichlorfon, Malathion, and Bensulide). The dermal route of exposure was considered for the post-application scenario, for adults and children following applications made by household members or professional lawn care operators (LCOs). In addition, for this scenario, the oral route of exposure was considered for children. For the pesticide DDVP, only the inhalation pathway was assessed. This is because there is a limited potential for significant exposure via the other routes. DDVP's high volatility limits its residence time on skin surfaces thus making the dermal and subsequent oral routes of exposure unlikely.

Dermal and inhalation routes of exposure were considered for adult residents applying OP pesticides to ornamental gardens (Acephate, Disulfoton, Malathion) and to home vegetable gardens and orchards (Malathion). For the ornamental gardens, post application exposure was not considered because the contact is expected to be minor and of limited duration. For the home vegetable garden and orchard dermal route of exposure was considered for adults harvesting and performing other maintenance activities that may involve significant contact with the foliage.

Dermal route of exposure was considered for adults and children potentially exposed to public health sprays made by state or local governments for the control of mosquitoes in the south (Regions 2, 6, 9, 11 and 12). This route of exposure was also considered for mosquitoes and black flies in Region 2. Oral route of exposure for children in these Regions was also considered for these uses.

Inhalation route of exposure was considered for the indoor crack and crevice use of DDVP because of it's volatility. Inhalation route of exposure was also considered for the DDVP use in the impregnated pest strips designed to control it's release into indoor air.

Dermal route of exposure was considered for the potential post application exposure to adults.

5. Data Sources

Three types of data are considered in this assessment: pesticide use data, residue levels/residue contact data, and exposure factors. Pesticide use information is critical to establish windows of potential exposure when using a calendar based exposure model. This information is needed to predict what pesticide will be used, amount of pesticide used, whether the applicator will be a professional or not, when will the application be made, how many times will the pesticide be applied and for how long. This type of information is needed together with chemical residue fate, residue contact data and exposure factors to predict the potential for co-occurrence of exposure events in aggregate and cumulative assessments. Other data such as frequency of applications, types of application equipment used and types of clothing worn while making the applications are also used in developing exposure scenarios. Residue levels and residue contact data are used to define the sources and magnitude of exposure from human contact. Residence time of the pesticide in the environment is also assessed using residue levels and residue contact data. Exposure factors such as duration of time spent in an area, whether the exposure is occurring indoors or outdoors, whether on the lawn or golf course, are critical for estimating exposures to a given substance. Breathing rate is a specific exposure factor that was used in the assessment of the indoor inhalation exposure to DDVP.

Table I.D-1 Pesticides and Use Scenarios Considered in the Residential/Non-Occupational Regional Assessments

Pesticide	Lawn Care	Golf Course	Home Gardens Edible Foods and Ornamentals	Public Health	Indoor Uses Crack and Crevice No Pest Strip
Acephate	None	Used in Regions (4), (5), (6), (9), (11), (12)	Edible Foods: None Ornamentals: All Regions	None	None
Bensulide	Used in Regions (4), (6), (11)	All Regions Except (9), (10)	Edible Foods: None Ornamentals: None	None	None
DDVP	None	None	Edible Foods: None Ornamentals: None	None	All Regions
Disulfoton	None	None	Edible Foods: None Ornamentals: All Regions	None	None
Fenamiphos	None	Used in Regions (4), (5), (6), (7), (11), (12)	Edible Foods: None Ornamentals: None	None	None
Fenthion	None	None	Edible Foods: None Ornamentals: None	Used in Regions (9), (12)	None
Malathion	All Regions	Used in Regions (4), (5), (6), (11), (12)	Edible Foods: All Regions Ornamentals: All Regions	Used in Regions (2), (4), (6), (9), (11), (12)	None
Naled	None	None	Edible Foods: None Ornamentals: None	Used in Regions (2), (12)	None
Trichlorfon	All Regions	All Regions Except (10), (12)	Edible Foods: None Ornamentals: None	None	None

a. Use Information

Several references were used to determine the application timing for lawn care pesticides and to estimates of the number of pesticide users. To determine the percent of households that employ professional lawn care operators (LCO), the Agency used the 1996-1997 National Gardening Survey (Butterfield, 1997) conducted by the Gallup polling organization. For the preliminary assessment, for specific chemicals, regional percent of lawns treated were taken from the National Home and Garden Pesticide Use Survey (NHGPUS) (USEPA, 1992). The use of trichlorfon was not widely reported in the NHGPUS therefore, Kline Professional Markets data were used.

An important variable for estimating pesticide 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 ft^2. It should be noted that this variable is very difficult to quantify. 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.

OPP selected a uniform distribution of lot sizes ranging from 500 to 15,000 ft^2. This range considers smaller lawns for residences such as town houses. Information in a survey conducted by the Outdoor Residential Exposure Task Force also indicates that many pesticide users make spot treatments of insecticides. This is particularly appropriate for the control of nuisance pests such as fleas on lawns. The upper bound of 15,000 ft^2 (~1/3 acre) appears reasonable given the type of application equipment assumed to be used by residential applicators, hose end sprayers and rotary granule spreaders. Information on timing of applications for pesticides were obtained from Representative Cooperative Extension Service publications.

b. Exposure Factors

Cumulative distributions of durations on lawns of up to two hours were used to address adult exposure on lawns. These data are presented in Table15-64 in EPA's Exposure Factors Handbook. However, OPP notes that the percentiles above the 95^{th} have the same values (121 minutes). A similar cumulative distribution was given for children ages one to four. However, 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 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.

c. Residue Levels and Residue Contact Data

Scenario-specific residential exposure data inputs are described in Table I.D-2.

6. Lawn Care Exposure Data

a. Lawn Applicator Dermal and Inhalation Exposure Data

Residential applicator exposure was assessed for two types of end-use product formulations, liquid sprays and granular formulations. Dermal and inhalation routes exposure data generated by the Outdoor Residential Exposure Task Force (ORETF) were used. For granular formulations, exposure data from volunteers using a push-type rotary spreader to apply dacthal were used. For sprayable formulations exposure data based on volunteers using a garden hose-end sprayer to apply diazinon were used. Volunteers participating in these exposures studies were adult non-professionals that use pesticides on their own lawns and gardens. Many of the volunteers selected as subjects in these studies are members of garden clubs. All volunteers made their applications without specific instruction from the study investigators.

Table I.D-2 Scenario-Specific Residential Exposure Data Inputs

Parameter	Value	Assumptions	Input Format	Data Source
Unit Exposure			Uniform Distribution	ORETF (Merricks, 1997)
-inhalation	0.002-0.0142 mg/lb ai handled	hand pump sprayer		
	0.0044 -8.29 mg/lb ai handled	hand garden duster		
-dermal	7.99 -354.4 mg/lb ai handled	hand pump spray		
	7.99-1375.4 mg/lb ai handled	hand garden duster		
range includes wearing short pants and short sleeved shirt to long pants and long sleeved shirt for hand pump sprayer and hand garden duster				
Hand Pump Sprayer				
Area Treated	500-2000 ft^2	median home 2250 ft^2 assumed all one floor, with 2.5-8 ft. ornamental bed perimeter	Uniform Distribution	US Census
Application Rate	label directions	rate per gallon treating 500-1000 ft^2	Uniform Distribution	(Merricks, 1997)
Treatments per Season	1-4	two-week intervals (on average based upon survey and label directions)	Uniform Distribution	ORETF
Time Spent in Garden	0.083 -1 hour		Uniform Distribution	ORETF
Transfer coefficients	100 -5,000 cm^2/hr	activities=harvesting and maintenance of edible food crops. Accounts for a wide variety of gardens	Log Normal Distribution	(Korpalski and Bruce, 2000)
Malathion on Edible Food Crops/Gardens and Home Orchards				
Area treated	135-8000 ft^2		Log Normal Distribution	ORETF with the National Garden Survey

Parameter	Value	Assumptions	Input Format	Data Source
Number of applications	1-5	1 app.=32.6%, 2 app.=36.5%, 3 app.=14.3%, 4 app.=12.2%, 5 app. =4.4%		ORETF with the National Garden Survey

Parameter	Value	Assumptions	Input Format	Data Source
Ornamental Granular Incorporated Treatment-Disulfoton 14 -40 weeks				
Unit Exposure				
-inhalation	0.00001 mg/lb ai	Based on LOQ	point value	(Merricks, 2001)
-dermal	0.0034 -0.356 mg/lb ai	range includes wearing short pants and short sleeved shirt to long pants and long sleeved shirt	uniform distribution	(Merricks, 2001)
Application rate	label		point value	
Frequency of application	1-3	1 app.=63%, 2 app.=32%, 3 app.=5% at six-week intervals		ORETF with the National Garden Survey
DDVP-Crack and Crevice and Strips				
Unit exposure-inhalation	0.72-2.499 mg/lb ai	surrogate individuals using pressurized spray, ventilation rate 17 l/min	Uniform Distribution	PHED records 05211A01-0521E03
Amount used	0.000625- 0.005625 lb		Uniform Distribution	label
Exposure Duration	0-24 hours	Time spent indoors at all locations=for children 1-4 years and adults 18-64 years	Cumulative Distribution	Exposure Factors Handbook, table 5-131
Breathing Rate Multiplier	1 (=at rest) to 2 (=moderate activity)		Uniform distribution	Exposure Factors Handbook, table 5-14
Post-application airborne concentration	0.0754 - 0.548 mg/m^3		Uniform distribution	Gold and Holcslaw,1985
Pest strips	0.11-0.005 mg/m^2 over 90 days	samples taken at 1, 7, 14, 28, 56, and 91 day intervals	uniform distribution for each sample period	Collins,1973

The granular study includes of 30 volunteers applying 50 pounds of product to treat 10,000 ft^2 of turfgrass. For the hose-end use, 30 volunteers applied pesticides using a hose-end sprayer that required pouring the pesticide into the hose-end device attached to a garden hose. These same volunteers also used a hose-end device that is available with the pesticide already in it. This product is referred to as “ready to use.” Exposure data from these studies can be used to generate normalized values expressed as milligrams exposure per pound of active ingredient of a pesticide and are referred to as Unit Exposures (UE). Unit exposures can be developed for various clothing scenarios that consider individuals wearing long pants and long sleeved shirts, short pants and short sleeved shirts. A survey conducted by Doane and Gallup (Johnson et al., 1999) on behalf of the ORETF identified 55% of those who treat their lawns wear short sleeved shirts while applying liquid formulations and 70% wore short sleeved shirts while applying granular formulations. Likewise, 38% reported wearing short pants while applying liquid formulations and 32% wore short pants while applying granular formulations.

The unit exposure values derived from the studies and used in this assessment for the granular formulations are dermal (0.02-7.6 mg/lb ai handled) and inhalation (0.00019-0.0096 mg/lb ai). The unit exposures for the hose-end sprayers are dermal 0.017-49 mg/lb ai handled) and inhalation (0.007-0.089 mg/lb ai handled). From these data, two uniform distributions were developed. One included exposures of the ready-to-use and “mix your own” hose-end sprayers and the other distribution for the granular spreader. The uniform distributions also considered that the applicants wore short-pants and short sleeved shirts to long pant and long sleeved shirts, which is consistent with survey data from the ORETF. A uniform distribution is characterized by one in which each value within the range has an equal probability. A uniform distribution is useful to address uncertainty when using relatively small data sets, in particular when considering that the magnitude of exposure can be influenced by behavior (neat vs. sloppy), conditions (windy vs. calm) and the potential range of clothing that can be worn.

b. Post-application Dermal and Non-Dietary Exposure Data

i. Dermal Exposure-Residue Contact Data

There are three exposures studies used to assess post application dermal exposure to individuals reentering treated lawns. These studies represent dermal exposure values of young children exposed to a non-toxic substance performing unscripted activities and dermal exposure values of adults exposed to pesticides while performing structured activities. These structured activities were designed to mimic the activities of young children. These proprietary studies were performed by volunteers exposed to lawns treated with granular and liquid formulations of a pesticide and reported in the literature as Vaccaro et al., 1996, “The Use of Unique Study Design to Estimate Exposure of Adults and Children to Surface and Airborne Chemicals.” In the two structured activity studies, dermal exposure values and/or internal doses were obtained via biological monitoring of urinary metabolites of pesticides. Internal doses were back calculated assuming dermal absorption values and standard body surface areas and normalized as hourly exposures (µg/hr). These hourly exposures were used to develop transfer coefficients (TCs).

A study specific to young children was used to add to the range of transfer coefficients for children two to five (Black, 1993). In this study children performed unscripted activities on turfgrass treated with a non-toxic substance used as a whitening agent in fabrics (Black,1993). The subjects of the study were 14 children aged four to nine years old. Dermal exposure was measured by fluorescent measurement technology described in Fenske et al., 1986. Measurements of various body parts were expressed as µg/body part (e.g., hand, face etc and as concentration (µg/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.

Briefly, transfer coefficients (cm^2/hr) are developed by dividing the hourly dermal exposure(µg/hr) obtained by an activity such as the scripted activities discussed above and the lawn residue commonly referred to as turf transferable residues (TTR) (µg/cm^2). This simple method is used to relate dermal exposure to residues that may be measured on lawns. Residue strength primarily is influenced by application rate but can be confounded by the residue collection method. None of the dermal exposure studies used to estimate hourly exposure in the above studies used the Turf Transferable Residue (TTR) method in the chemical specific residue dissipation studies for the individual OP's. Therefore, for this assessment the transfer coefficients were developed by assuming a transfer efficiency of 1% for sprayable formulations and assuming a transfer efficiency of 0.5% for granular 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.

The values of 0.5 and 1% are within the range of efficiency for the existing chemical specific TTR data. To account for the additional uncertainty of assuming a certain transfer efficiency to develop the transfer coefficients, TTR data having transfer efficiencies lower than 1% and 0.5% were adjusted upwards to make up the difference in efficiency. If the transfer efficiency of the TTR data was higher than 0.5% and 1% for granular and sprayable formulations respectively, they were not adjusted.

For a more detailed discussion of the relationship of transfer coefficients and TTRs please refer to 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.

The children performing the unstructured activities in Black 1993 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)

In Vaccaro, adults performed, for a period of four hours, structured activities as follows:

- Picnicking

- Sunbathing

- Weeding

- Playing frisbee

- Playing touch football.

The Vaccaro data were used to develop uniform distributions for adults. Both Black and Vaccaro data were combined to develop a uniform distribution for the children (ages two to five). Uniform distributions were selected to address the uncertainty in the types of activities that may be representative of exposure experienced by the general population after a lawn treatment.

The post application adult transfer coefficient is 1930-13200 cm^2/hr (Vacarro et al., 1996) with a uniform distribution. The post application dermal transfer coefficient for children is 700-16,000 cm^2/hr with a uniform distribution (MRID 441617-01 and 430420-01 and reported in Vacarro et al., 1996 and Black, 1993). The fate of pesticides applied to turf is a key variable for assessing post application exposure. As noted above, turf transferable data (TTR) are available for all the OPs registered on turf. Where available, regional specific TTR data were used. These data are based on the highest use rate permitted on the label.

ii. Non-Dietary Exposure Data Hand-to-Mouth Behavior

Surrogate data to evaluate non-dietary ingestion through hand-to-mouth behavior in young children consists of observations reported in Reed et al., 1999. This study addressed the mouthing behavior and other observations of children, ages three to six at day care (n=20) and children ages two to five at home (n=10). 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. The children were video taped and the frequency of hand-to-mouth events were enumerated after the taping.

The observations reported by Reed 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 following paragraphs.

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.

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., 1999. The TTR methods used in the study had similar efficiencies as the chemical specific lawn residue data (TTR data) used in this assessment.

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 percent contribution to total exposure via non-dietary ingestion continues to be difficult to quantify. This includes the variables discussed above as well as issues regarding 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.

7. Home Garden Applicator and Post Application Exposure Data

Proprietary data were used to estimate dermal and inhalation exposure of individuals applying OPs to ornamental gardens, vegetable gardens and home orchards. For disulfoton, chemical specific data measuring exposure of individuals using a shaker can of disulfoton granules to the soil around roses followed by soil incorporation is available. A study of volunteers applying carbaryl to shrubs and trees using a small tank sprayer was used to assess exposure while applying acephate and malathion to ornamentals. This study and a similar study of individuals applying a dust formulation of carbaryl to vegetable gardens was used for malathion.

Post application exposure while harvesting or performing post application maintenance activities in home gardens and orchards was assessed using a wide range of transfer coefficients to account for the diversity of gardens and types of activities. 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). Timing aspects of gardening activities were based on information available in representative state cooperative extension service publications. Chemical specific dislodgeable residue data collected from studies performed in California and Pennsylvania were used for the western and eastern regions respectively. Regional use data for the above chemicals was based on information available in the National Home and Garden Pesticide Use Survey and Kline Professional Markets Reports (1997-1998).

8. Golf Courses Post Application Exposure Data

The potential dermal exposure of individuals playing golf on treated golf courses was estimated using chemical specific turf residue data, and surrogate dermal exposure data. The surrogate data used to derive transfer coefficients were based on two measurements of four individuals playing golf on two golf courses treated with chlorothalonil (Ballee, 1990), and the exposure of golfers (four volunteers) to flurprimidol (Moran et al., 1987). For the both studies, an assumed transfer efficiency of 1% was used to calculate the transfer coefficients, since all the golf courses were treated with spray-able formulations. Based on these two studies, a uniform distribution of 200 to 760 $\mu g/cm^2$ was estimated.

To establish the percent of individuals playing golf two values were used. In a 1992 survey conducted by the Center for Golf Course Management it was reported that an average of 12.2% of the population plays golf. To determine the likelihood of playing golf on a treated golf course, percent of golf courses treated data provided by Doane's GolfTrak (1998-1999) was used. These data indicated anywhere from 5 to 75% of golf courses are treated with a given OP.

The exposure duration for individuals playing golf was fixed at a time of four hours for all chemicals except bensulide in which the use at times can be limited to treatment of tees and greens. For bensulide, a uniform distribution of two to four hours was used. The four-hour value was taken from the about mentioned 1992 study.

9. Public Health Post Application Exposure Data

Assessment of post application exposure to public health sprays was conducted in a manner similar to the method used to assess post application exposure to lawn chemicals. That is, exposures to residues on lawns were estimated using the same dermal transfer coefficients, hand to mouth variables, and duration of time spent on the lawn. What differs is the source strength of the residues deposited on the lawn from the public health sprays. The amount of residues that may fall on the lawn can be predicted from the application rate for the various public health sprays and the application specifics, such as equipment type and spray nozzle settings. The percent of the application rate that is deposited on lawns following ground applications of public health sprays is based on a study by Tieze, et al. (1995) which measures the percent of the mosquito sprays that is deposited on lawns following ground applications. These deposition values ranged from 3.8 to ~5%. The percent of the application rate that is deposited on lawns following aerial applications were calculated using the spray drift model AgDrift which were reported in the individual risk assessments for malathion, naled and fenthion. These values ranged from approximately 15 to 30%. To address the uncertainty regarding the percent of use by ground equipment and or aerial equipment, a uniform distribution for deposition of 3.8 to 30% was used. Inhalation exposure was not addressed since there are no refined models to address this scenario. It is also expected that infinite dilution based on the outdoor location mitigates this exposure.

Further estimates of lawn residues were based on the chemical specific transfer efficiency of malathion (up to 2.2%) and naled (up to 1.5%). Although there are no chemical specific data for fenthion, estimates of residue and fate were based on the malathion TTR data since malathion and fenthion have very similar formulations, vapor pressures and molecular weights.

Timing aspects and estimates of percent of use are based on conversations with representatives of Florida Mosquito Abatement Districts (Whichterman) Florida A&M (Dukes) and Dr. Burke of Health Canada (Black Fly). For other regions having public health spray uses, a spray schedule of once every two weeks was assumed for the summer season.

10. Indoor Uses Inhalation Exposure Data

The remaining OP pesticide registered for indoor use is DDVP. It is used as a crack and crevice spray and is available as resin impregnated pest strips. Exposure while handling the impregnated pest strips is considered minimal. Inhalation exposure while using pressurized sprays as a crack and crevice was evaluated using data available in the Pesticide Handlers Exposure Database (PHED). Post application inhalation exposure was estimated for adults and children using breathing rate values and cumulative distributions of durations of time spent inside homes coupled with DDVP air concentration data from Gold et al., 1983 and Collins et al., 1973. These studies present air concentration data for crack and crevice sprays and the impregnated pest strips respectively.

Use information for the number of households using DDVP indoors was taken from the National Home and Garden Pesticide Use Survey, 1991 for indoor use as well as for pest strips. Monthly treatments were assumed for the crack and crevice sprays and the use of pest strips was limited to the summer season for the northern regions and spring and summer for the southern regions. This is based on information available in the Nonoccupational Pesticide Exposure Study showing significant seasonal differences in air concentration data between Jacksonville Florida and Springfield Mass.

11. In Summary

In summary, this assessment relied upon the best available data from all sources that could be identified. Sources included chemical specific and task force generated data, as well as data from the scientific literature. When available, regional distinct residue dissipation data were used for the lawn and garden uses.