5.0 Residential Exposure Assessment

Approach

The residential exposure assessment performed in this report is based on the same data and exposure input assumptions used in the EPA assessment of cumulative residential exposures dated June 11, 2002 (June 11 assessment). The residential assessment does not; however, completely follow the June 11 assessment. There are three reasons for this. First, LifeLine™ allows the use of data that cannot be used in the software used in the June 11 assessment. For example, LifeLine™ tracks the time spent indoors and on lawns and the activities the individual performs. These activities can be related to breathing rates and to dermal transfer rates. Therefore, activity-specific values for breathing rates and dermal transfer rates are used in this assessment. Second, many assumptions in the June 11assessment for inputs are not used in this assessment since these data are derived in LifeLine™ from actual survey data. Such factors include:

- Size of gardens and lawns;
- Durations of time spent on lawns and indoors
- The types of activities performed on lawns and indoors;
- The fraction of the population that golf as a function of age, gender, and income; and
- The gender of the individual applying the pesticide.

Third, in a few instances LifeLine™ Version 2.0 requires the use of a single value while the software used in the earlier assessment allows the use of a distribution. In these instances the LifeLine™ assessment has used the upper bound values of the input distributions.

Often, the use of distributions for multiple inputs of a specific dose model for a specific product and route of exposure in the June 11 assessment has been addressed by combining the distribution into a single distribution using simple Monte Carlo models. Appendix C and D describe the development of these input distributions.

LifeLine™ Version 2.0 Input Files

All of the data on residential exposures is entered into LifeLine™ using two files OPcumulative.rkg and OPcumulative.acd. OPcumulative.rkg contains the compound and product specific information. The data on these inputs are stored in two sets of files. The first file includes the data on the toxicology of the index chemical Methamidophos. These data consist of the three “points of departure” for oral, dermal and inhalation exposures. For additional information, see section 2.0 of this report. A printout of OPcumulative.rkg and OPcumulative.acd are given in Appendix E and F of this report.

The second set is the data on each of the pesticide/products. These data include information of factors such as:

- Application rates;
- Transfer Efficiencies;
- Unit Exposures;
- Dissipation rates;
- Modifying factors, and
- Data related to the probability and frequency of use.

OPcumulative.acd contains data on age- and activity- specific exposure related behaviors. These data are independent of the pesticide/product and are applied to all of the pesticides equally. These data include the inputs for following factors:

- Dermal transfer coefficients;
- Frequency of hand to mouth events;
- Fraction of hand placed in the mouth;
- Replenishment; and
- Data related to inhalation rates.

All of the inputs are related to specific ages and to specific NHAPS activities. See the LifeLine Technical Manual for additional information.

Data Used in the Residential Assessment

This section presents a summary of the data used in the input files for LifeLine™. A detailed description of how the residential inputs and assumptions are used in the LifeLine™ software can be found in the Technical Manual for LifeLine™. In this report, data are divided by the location of the use of the pesticide product. These locations include: lawns (turf), ornamentals and vegetable gardens, golf, indoor environments, and pets.

Lawns (Turf) Related Products

Pesticide exposures associated with lawns occur as the result of three types of pesticide products; homeowner-applied pesticides, commercially applied pesticides, and public health use pesticide. The homeowner-applied pesticides have the potential to cause applicator and post-application exposures. The commercially applied and public health uses only result in post-application exposures.

Pesticide-Specific Information for Lawn-Related Products

The following tables present the pesticide/product specific data used in the assessment of pesticide exposures from lawn-related products. Tables 5.1 and 5.3 present both the values of the pesticide application rates that are actually entered in LifeLine and also the values of the factors used to derive the application rates. Most of these factors are consistent with the factors considered in the June 11 assessment; however, the dermal to oral (DTO) and dermal to inhalation (DTI) factors are new concepts created for this assessment. DTO and DTI are factors

that convert the compound specific doses to the correct Methamidophos equivalent doses. In this assessment, the residues are converted to Methamidophos equivalents using the compound-specific dermal RPFs. When the route of exposure is oral or inhalation, the RPF for those routes should be used. Therefor an additional conversion factor is required. The DTO is defined as the ratio of the oral to the dermal RFP for the pesticide (given in Table 2.1). For example the Fenthion DTO is 0.33/ 0.015 or 19.8. DTI is defined as the ratio of the inhalation to dermal RPF.

Tables 5.2, 5.4, and 5.5 present the data on the probability of the use of pesticide in a household. For products applied by the homeowner, the data are in terns of the use factors for specific pests identified in the National Home and Garden Pesticide Use Survey[1] (NHGPUS). Pesticides applied by commercial applicators are expressed in terms of the regional probability that a person using a lawn care service will in a given year apply a specific pesticide product. Finally, probability of use for the public use pesticide is the probability that a house with a lawn will receive spray drift.

Table 5.1. Compound-Specific Data for Public Health Use Pesticides

	Fenthion	Malathion	Naled
Application Rate (mg/m^2)	19.8	19.8	7.5
RPF-Dermal Route	0.05	0.05	0.230
Application Rate in Dermal Equivalents (mg/m^2)	0.99	0.99	1.725
Transfer Efficiency	0.010	0.010	0.010
Percent Daily Decline	50%	50%	100%
Frequency of Application (App./month)	1.3	2	2
Dermal To Oral (DTO) Factor	19.8	0.018	1

Table 5.2. Percent of Residential Lawns Affected by Spray Drift from Public Health Uses of Pesticides

	Region			
Pesticide	**West**	**Midwest**	**Northeast**	**South**
Fenthion	0	0.001	0	0.016
Malathion	0.036	0.382	0.367	0.284
Naled	0.005	0.185	0.189	0.053

[1]US Environmental Protection Agency, 1992. *National Home and Garden Pesticide Use Survey*. Prepared by the Research Triangle Institute for the Office of Pesticides and Toxic Substances, Biological and Economic Analysis Branch.

Table 5.3. Compound-Specific Data Used in LifeLine™ for Lawn Products (Homeowner and Commercially Applied)			
	Bensulide	Trichlorfon Liquid	Trichlorfon Granular
Application Rate (lb/a)	12.5	8	8
Application Rate (mg/m^2)	1401	897	897
RPF-Dermal Route	0.0045	0.023	0.023
Application Rate in Dermal Equivalents (mg/m^2)	6.3	20.6	20.6
Transfer Efficiency	0.0049	0.0037	0.0037
Turf Transferable Residue in Dermal Equivalents (mg/m^2)	0.031	0.076	0.076
Percent Daily Decline	30%	96%	96%
Dermal to Oral (DTO) Factor	2	0.39	0.39
Dermal to Inhalation (DTI) Factor	1*	-	11

*There is no RPF for Bensulide; therefore, no change was made in the RPF.

Table 5.4. Fraction of Households Using Commercial Lawn Care Product			
Region	Bensulide	Trichlorfon - Liquid	Trichlorfon - Granular
West	0	0.02	0.002
Midwest	0	0.02	0.002
Northeast	0	0.02	0.002
South	0.01	0.02	0.001

Table 5.5. Use Factors for Homeowner Applied Lawn Pesticides		
	Bensulide	Trichlorfon - Granular
NHGPUS Pest Category	GRASS-LIKE WEEDS	GRASS-LIKE WEEDS
Use Factor	0.15	0.15

Applicator Exposures (Home Owner Applied Pesticides)

Applicator exposures occur as a result of dermal and inhalation exposures. The doses from these exposures are determined using estimates of the amount applied and the route specific "unit exposures."

In LifeLine™ Version 2.0 the applicator's dermal dose is determined using the following formula:

$$Dermal\,Dose = \frac{UE_D \times AR \times TA \times C}{BW}$$

where, UE_D is the unit exposure value for dermal exposures (ug/lb of AI), AR is the application rate in Methamidophos equivalents (mg/m^2), TA is the treated area (m^2), C is a unit conversion factor, and BW is the applicator's body weight (kg).

The dermal unit exposure value for lawn products is assumed to be a truncated log normal distribution. This distribution was taken from EPA's June 11 assessment. See Appendix C for additional information on how this distribution was entered into LifeLine™.

The application rate is a single value and is in units of Methamidophos equivalents established using the dermal RPF. Thus, the resultant dose will be in units of Methamidophos equivalents per kg. The value of the treated area is calculated by the LifeLine™ software based on data sampled from the American Housing Survey. Information on how this data is developed can be found in the Technical Manual for LifeLine. As with the June 11 Assessment the size of the lawn is capped at $15{,}000ft^2$.

In LifeLine™ 2.0 the applicator's inhalation dose is calculated using the following formula:

$$InhalationDose = \frac{UE_I \times AR \times DTI \times TA \times C}{BW}$$

where, UE_I is the unit exposure value for inhalation exposures (ng/lb of AI), AR is the application rate in Methamidophos equivalents mg/m^2, DTI is a factor that adjusts dose to reflect the inhalation RPF rather than dermal RPF, the TA is the treated area, C is a unit conversion factor, and BW is the applicator's body weight.

The inhalation unit exposure value used for lawns is a uniform distribution. This distribution was taken from EPA's June 11 assessment. See Appendix C for additional information on how the distribution was entered into LifeLine™.

The application rate is a single value and is in units of Methamidophos equivalents. Thus, the resultant dose will be in units of Methamidophos equivalents per kg. However, this conversion is performed using the dermal RPF. This conversion is not appropriate for the determination of inhalation doses. Therefore, an additional factor Dermal to Inhalation (DTI) factor has been added to the dose calculation. The DTI is defined as the ratio of each chemical's inhalation RPF to the dermal RPF. In the case of Bensulide there is no inhalation RPF and the value of DTI is assumed to be 1.0[2].

[2]In the June 11 Assessment, EPA demonstrated that the estimates of cumulative risks are not measurably affected by any reasonable value for the inhalation RPF for Bensulide since inhalation exposures for this chemical result in very low doses to the applicator.

Post Application Exposures

Post application exposures happen to both adults and children. Adults are exposed as a result of dermal contact. Children six years or less of age are exposed as a result of both dermal and hand to mouth exposures.

In LifeLine™ version 2.0 dermal exposure is modeled as a function of the individual's age, activity, activity duration, and surface area. As discussed in the LifeLine™ Technical Manual the doses from dermal exposures are defined as:

$$DermalDose = \sum_{i} TC_i' \times SA \times ET_i \times AR \times TE$$

where, TC_i' is the surface area normalized transfer coefficient for the i^{th} activity performed on the lawn, SA is the individual's surface area, ET_i is the exposure time (duration) for the i^{th} activity performed on the lawn, AR is the application rate of the pesticide, and TE is the transfer efficiency.

Table 5.6 present the values used for TC'. These values were taken from the range of values of TC specified in the June 11 assessment. The value of TC' was assumed to be zero for children less than one year of age. Table 5.7 presents the categories in the National Human Activity Pattern Survey (NHAPS).

Table 5.6. Body Weight Normalized Transfer Coefficients (hr^{-1})

Activity	Ages (1-6)	Ages 6-85
Sleep & Bathing	0	0
Low Dermal Activities	0.43	0.19
Moderate Dermal Activities	0.66	0.49
High Dermal Activities	2.4	0.74
Playing golf	-	0.042
Playing with Pets	0.10	0.10
Gardening	-	0.28

Table 5.7. Dermal Potential of Different Activities Tracked in NHAPS		
High Dermal -Activities	Moderate Dermal -Activities	Low Dermal-Activities
active sports	animal care	art
exercise	baby care	attending fulltime school
games	bars/lounges	breaks
indoor playing	car repair/maintenance	computer use
music/drama/dance	car repair/services	conversations
outdoor playing	child care	domestic crafts
outdoor recreation	child/youth/family	govt financial services
sports event	cleaning house	hobbies
	clothes care	homework
	dressing, etc	letters/writing/paperwork
	entertainment	magazines, etc
	food cleanup	movies/videos
	food preparation	other classes
	main job	other education
	help and care	other organization
	helping/teaching	professional union
	medical care-child	radio
	na activities	reading books
	other household work	reading newspaper
	other repair services	records/tapes
	other repairs	special interest
	other services	talking/reading
	other social	thinking/relaxing
	outdoor cleaning	tv
	parties	unemployment
	plant care	using library
	religious groups	
	visiting	
	volunteer helping	
	child care	
	errands	
	medical appointments	
	shopping for clothes/hh items	
	shopping for food	
	travel to/from work	
	travel, passive leisure	
	religious practices	
	second job	

Surface area of each individual is determined by LifeLine™ from the height and weight, gender, and ethnicity of the individual. The process for estimating the surface area is described in the LifeLine™ Technical Manual. The exposure time, or duration, of the NHAPS activity is taken

from the appropriate NHAPS survey record by LifeLine™. The values for the application rate and the transfer efficiencies are taken from the inputs for the modeling performed in the June 11 assessment. The transfer efficiencies were calculated from the ratio of the applied rate to the turf transfer residue (TTR). In most instances a range of values is given for TTR. When a range is given, the ratio is calculated based on the upper end of the range.
LifeLine™ also requires information on the rate of decline of the dislodgeable residues over time. This rate is expressed in terms of a percent decline per day. EPA staff provides estimates of the daily rate of decline for Malathion, Fenthion, and Naled. Appendix D presents the derivation of the rates of decline for the remaining pesticides.

Oral exposures occur because of incidental hand to mouth behavior. The dose from this exposure is determined using the following equation:

$$OralDose = \frac{\sum_i AR \times TE \times ET_i \times MF_i \times FH_i \times HSA \times R_i \times OMF}{BW}$$

where, MF_i is the mouthing frequency associated with the i^{th} NHAPS activity that occurs on the turf during a day, FH_i is the average fraction of the child's hand placed in the mouth during the i^{th} NHAPS activity, HSA is the total surface area of one of the child's hand, R_i is the replenishment factor associated with the i^{th} NHAPS activity, and OMF is the oral modifying factor.

In the June 11 assessment, EPA used uniform distributions for four factors mouthing frequency, hand area, the effect of wet hands, and the saliva removal efficiency. In this assessment a single value of 20 events per hour is used for mouthing frequency for all NHAPS activities (except sleeping). LifeLine™ does not enter a specific number for the area of the hand that a child enters into his or her mouth. Instead a fraction of the hand is entered. LifeLine™ develops an estimate of the total size of both the child's hands that is consistent with the height and weight of the child. This total hand area is then multiplied times the hand fraction to estimate the area entered into the mouth. The fraction of a typical 2-3 year old total hand area (both hands) that corresponds to 20 cm^2 is approximately 0.06. The value of 0.06 was assumed to apply to all NHAPS activities. The value of R_i is set at 1 for all activities.

The Oral Modifying Factor (OMF) is a "catch all term" that can be a single value or a distribution. In this assessment the OMF is used to enter a distribution that reflects:

- The variation in the MF;
- The variation in the FH;
- The range of values for the saliva dislodgeability factor;
- The variation in transfer due to wet hands; and
- The pesticide-specific dermal to oral (DTO) factor.

Appendix C describes the distribution of the OMF factor and the basis for deriving the distribution.
The Wet hand factor is described by EPA as a modification that accounts for the enhanced uptake

of residues by wet hands. The saliva dislodgeability factor refers to the ability of saliva to extract the pesticide from a child's hand. The pesticide-specific DTO factor is a factor that corrects the dose estimate for the use of the dermal RPF in the derivation of AR. The DTO is defined as the ratio of the oral RPF to the Dermal RPF for a pesticide.

Ornamentals and Gardens

Exposure to ornamentals occurs during the application of products. Application of product results in both dermal and inhalation exposures. No post application exposures occur.

Compound-Specific Data Used in the Assessment of Ornamentals

The following tables present the information on the use rates and compound-specific data on exposures.

Table 5.8. Residue Data Used in LifeLine™ Ornamentals and Garden Products

	Acephate	Disulfoton	Malathion (Ornamentals)	Malathion (Gardens)
Application Rate (lb/a)	2	8.7	2	1.5
Application Rate (mg/m^2)	224	975	224	168
RPF-Dermal Route	0.0075	1.41	0.050	0.05
Application Rate in Dermal Equivalents (mg/m^2)	1.7	1370	11.2	8.4
Dermal to Inhalation Factor	82.7	14	0.2	0.2

Acephate and malathion (ornamentals) have application rates that ranges from 0.9 to 2.0 lb/a. This range is reflected in the distribution of modifying factors used in the applicator and garden post application assessments. See Appendix C.

Table 5.9. Use Factors for Homeowner Applied Ornamental and Garden Pesticides	
Pesticide/NHGPUS Pest Categories	Use Factor
Acephate/Ornamentals	
Spiders, Crickets, Sow/Pillbugs, Milli/Centipides	0.083
Plant-Sucking Insects and Mites	0.076
Plant-Chewing or Plant-Sucking Insects	0.039
Plant-Chewing Insects	0.07
Flies, Gnats, Widgets	0.085
Disulfoton/Ornamentals	
Soil-Dwelling Insects, Nematodes	0.121
Plant-Sucking Insects and Mites	0.161
Plant-Chewing or Plant-Sucking Insects	0.031
Plant-Chewing Insects	0.054
Plant Disease	0.056
Other Wood-Destroying Insects	0.136
Other Pest	0.341
Cockroaches	0.229
Malathion/Ornamentals	
Spiders, Crickets, Sow/Pillbugs, Milli/Centipedes	0.075
Soil-Dwelling Insects, Nematodes	0.033
Plant-Sucking Insects and Mites	0.118
Plant-Chewing or Plant-Sucking Insects	0.081
Plant-Chewing Insects	0.099
Mosquitoes	0.226
Flies, Gnats, Widgets	0.079
Malathion/Gardens	
Spiders, Crickets, Sow/Pillbugs, Milli/Centipides	0.177
Soil-Dwelling Insects, Nematodes	0.127
Plant-Sucking Insects and Mites	0.115
Plant-Chewing or Plant-Sucking Insects	0.113
Plant-Chewing Insects	0.077
Flies, Gnats, Widgets	0.337
Fire Ants	0.328

Applicator Exposures

Applicator exposures for gardens and ornamentals occur because of dermal and inhalation exposures. The equations used for estimating applicator doses are the same as those for lawns. However, the treated area for ornamentals is not automatically generated but LifeLine™ in the way that Lawn sizes are generated. The area treated is entered as a single value of 186 m^2 (2,000 ft^2) and the variation is entered separately as an applicator exposure modifying factor. Thus, for Disulfoton the modifying factor is uniform distribution with a minimum value of 0.005 and a

maximum value of 1.0. The product of this value times the point estimate of 186 m^2 (2,000 ft^2) is equivalent to entering a uniform distribution between 0.96 m^2 (10 ft^2) and 186 m^2 (2,000 ft^2).

In the case of Malathion and Acephate the application rates of the pesticides also vary. For these compounds the maximum application rate is used alone with the maximum area treated. The modifying factor for these pesticides is a distribution that reflects the variation in the value of both the area treated and the application rate. Appendix C describes the process used in developing the distributions for the modifying factors.

The area treated for gardens is automatically calculated by LifeLine™. Thus, there is no need to enter a value for area treated.

Garden Post Application Exposures

Garden post application exposures occur because of the cultivation and harvesting activities that occur in a garden following the application of a pesticide. The only exposure pathway is dermal and children under the age of 18 are not assumed to enter gardens. The dermal post application exposures use the same equations as the dermal post application exposures for lawns. The value of TC' for garden-specific activities can be found in Table 5.6. The Rate of decline in malathion was determined by fitting the data on dislodgeable foliar residues to a first order rate of decline, see Appendix B.

Golf

Exposure to pesticides used on golf courses is limited to post application dermal exposures to golfers. Assessing dermal exposures to pesticides used on golf courses require data on

- The amount of pesticide applied (AR)
- The Transfer Efficiency (TE)
- Rate of daily decline of the dislodgeable residue (percent decline per day)
- The number of applications in a year.

Table 5.10 presents the values used for each of the pesticide products. Table 5.11 presents the frequency for the use of the products.

Table 5.10. Residue Data Used in LifeLine™ Golf Course Products								
	Application Rate							
Pesticide and Use	lb/a	mg/m^2	RPF-Dermal Route	Application Rate Dermal Equivalents (mg/m^2)	Transfer Efficiency	Turf Transferable Residue in Dermal Equivalents (mg/m^2)	Percent Daily Decline	Applications Frequency (Applications/y)
Acephate	5	560	0.01	4.2	0.0116	0.049	45%	2
Bensulide	12.5	1401	0.0045	6.3	0.00485	0.032	30%	2
Fenamiphos	116	13002	0.05	650.1	0.000927	0.603	98%	1
Trichlorfon	8	897	0.023	20.6	0.0037	0.076	96%	1

Table 5.11. Fraction of Golf Courses Treated				
	Region			
Pesticide	West	Midwest	Northeast	South
Acephate	0.007	0.015	0.005	0.299
Bensulide	0.168	0.063	0.066	0.23
Fenamiphos	0.041	0.004	0.003	0.048
Trichlorfon	0.063	0.702	0.715	0.097
* Probability that a golf course will use the product during the modeled year.				

Modeling the Probability and Frequency of Golfing Exposures

The probability of golfing is not equivalent across different demographic groups. Golfers tend to be college educated, older, and male (NGF, 2001). LifeLine™ defines each individual based on race, income quartile, gender, and age. LifeLine™ uses this data to define the probability of an individual playing golf and the frequency of playing golf at different ages.

Based on data reported by National Golf Foundation (NGF, 2001) the following model of golfing was developed. First, golfers are defined in terms of the following four categories:

- Junior,
- Occasional,
- Moderate, and
- Avid golfers.

Second, the probability of an individual falling into one of the categories or being defined as a non-golfer is performed in the following steps. First, all children below the age of 12 are assumed to be non-golfers. Surveys performed by NGA show that golfing is not a regular activity in individuals until age 12.

All golfers between the ages of 12 and 18 are defined as junior golfers. The probability of becoming a junior golfer at age 12 is a function of the gender and the income level of the individual. The probabilities of being a junior golfer are given in Table 5.12.

Table 5.12. Probability of Becoming a Junior Golfer at Age 12		
Gender	**SES Quartile**	**Probability**
Male	1	0.037
Male	2	0.054
Male	3	0.065
Male	4	0.099
Female	1	0.008
Female	2	0.012
Female	3	0.015
Female	4	0.023

Data from the NGF survey suggests that the fraction of junior golfers are relatively constant from ages 12-17. As a result, LifeLine™ assumes that once becoming a junior golfer the individual will remain a junior golfer.

Third, at age 18, all junior golfers are assumed to move onto one of three adult categories of golfing: occasional, moderate, and avid. The probability of becoming one of the three categories will be different for each of the eight combinations of gender and (parental) income. Table 5.13 gives each of the probabilities for being placed in one of the adult categories.

Table 5.13. Probability of a Junior Golfer Entering One of the Three Adult Categories of Golfers				
Gender	**SES Quartile**	**Occasional**	**Moderate**	**Avid**
Male	1	0.422	0.296	0.282
Male	2	0.389	0.304	0.307
Male	3	0.389	0.335	0.276
Male	4	0.371	0.339	0.29
Female	1	0.629	0.194	0.176
Female	2	0.609	0.2	0.192
Female	3	0.608	0.219	0.173
Female	4	0.597	0.222	0.181

Fourth, since the number of adult golfers is larger than the number of junior golfers, a certain portion of non-golfers will take up golf at age 18. Thus, at age 18 a small percentage of non-golfers are assigned to one of the three golfing categories based on the gender and SES category. Table 5.14 give the probability of different types of individuals taking up golf.

Table 5.14. Probability of Non-Golfer becoming a Golfer at Age 18				
Gender	**SES Quartile**	**Occasional**	**Moderate**	**Avid**
Male	1	0.006	0.0042	0.004
Male	2	0.0016	0.0013	0.0013
Male	3	0.0068	0.0058	0.0048
Male	4	0.0118	0.0108	0.0092
Female	1	0.0042	0.0013	0.0012
Female	2	0.003	0.001	0.0009
Female	3	0.0058	0.0021	0.0017
Female	4	0.0097	0.0036	0.0029

Once individuals become adult golfers they are assumed to remain in the same categories over time.

Using this approach LifeLine™ defines if an individual is a non-golfer or a junior, occasional, moderate, or an avid golfer on each year of their lives. This assignment will reflect the income and gender of the individual.

The golfers in these categories have different frequencies of playing golf. Based on the NGF survey the following are the average numbers of rounds for the four categories of golfers:

Table 5.15. Rounds Per Year by Gender and Category of Golfing		
	Male	Female
Junior	15.4	9.9
Occasional	3.2	2.8
Moderate	14	13.7
Avid	68	63.7

Once the assignment of the golfing categories is established, the frequency reported by category and gender can be taken from Table 5.15. The daily probability of playing golf is estimated based on the following formula:

If the day falls in the warm portion[3] of the year:

$$DP_G = A_G / (FY * 365)$$

If the day falls in the cool portion of the year then:

[3] The warm and cool portions of the year are tracked by LifeLine™ as a function of the region the in which the person resides. The warm season is defined as year round for the South, from mid-spring to mid-fall for the Northeast and Midwest and Spring, Summer, and Fall for the West. For additional information, see the LifeLine™ Technical Manual.

$$DP_G = 0$$

where, DP_G is the probability of going golfing on a given day, A_G is reported number of games played for the persons golf category, and FY is the fraction of the year that is warm.

Under this approach and individual is allowed to play on consecutive days.

LifeLine™ assumes that the typical golf game requires four hours to play. If the product is used on greens, tees, and fairways, the golfer is assumed to be exposed for the entire four hours. If the product is only used on tees and greens then the golfer is assumed to be exposed for two hours.

Determination of Dermal Exposure

Pesticide exposures occur as the result of dermal contact with turf. The doses from these exposures are modeled using the same equation as the post-application lawn exposures. Table 5.6 gives the value of TC' for golfing.

Indoor Exposures: Pest Strips

The only indoor use of OP pesticides included in this assessment are the DDVP pest strips. These strips are placed in closets and cupboards and result in airborne residue concentrations in the residence. No exposures are assumed to occur during the placement of the strips. Post-application exposures are assumed to be limited to inhalation of airborne residues. The residues in air are assumed to occur throughout the home. Airborne residues are anticipated to decline over time as the residue in the strips is depleted. The pest strips are assumed to be replaced every sixteen weeks (112 days). These assumptions are consistent with the assumptions used in the June 11 assessment of DDVP pest strips.

In order to assess the exposure to airborne residues using LifeLine™ Version 2.0, two inputs are required; the initial concentration in the home and the rate that the residue concentrations decline over time. The software then models the decline in airborne levels using a simple first order decay model:

$$C_t = C_0 e^{-kt}$$

where, C_t in the concentration at time t, C_0 is the concentration at some reference time (t=0), k is the first order decay constant (hr^{-1}) and t is the number of hours since the reference time.

Data on the air concentrations associated with the use of the products is taken from the study Collins and DaVries (1973)[4]. These measurements are modified to reflect the change in the size

[4] Collins, R. D. and DeVries, D. M.(1973) Air Concentrations and Food Residues from Use of Shell's No-Pest Insecticide Strip. Bull. Environ. Contamin. Toxicology. 9(4):227-233.

of the DDVP pest strips and the FQPA adjusted RPF for inhalation. The results are the equivalent Methamidophos air concentrations associated with each of the two pest strips. The data were converted using the following formula:

Methamidophos Equivalent Residue Concentration = C * RPF * F

where, C is the original value reported by Collins and DaVries (1973), RPF is the inhalation RPF for DDVP, and F is the reduction factor that accounts for the larger strips used in the 1973 study. The value of inhalation RFP for DDVP is 2.03. The values of F for the 21 g and the 5.25 g strips are 0.26 and 0.066. In this analysis, half of the homes are assumed to use larger strips and the second half the smaller strips. Table 5.16 gives the raw data from Collins and DaVries (1973) Table 5.17 give the values of the equivalent residues for each of the two sizes of the pest strips.

Table 5.16. DDVP Airborne Residue Levels (ug/l) As Reported in Collins and De Vries (1973)

	Days Since Application					
Residence	1	7	14	28	56	91
1	0.02	0.02	0.02	0.005	0.005	0.005
2	0.08	0.07	0.07	0.05	0.005	0.02
3	0.04	0.03	0.03	0.01	0.01	0.005
4	0.02	0.02	0.01	0.005	0.005	0.005
5	0.05	0.02	0.02	0.01	0.005	0.005
6	0.11	0.06	0.02	0.03	0.01	0.005
7	0.11	0.05	0.06	0.02	0.02	0.005
8	0.02	0.02	0.02	0.01	0.005	0.005
9	0.01	0.01	0.02	0.005	0.005	0.005
10	0.07	0.09	0.06	0.04	0.02	0.02
11	0.05	0.04	0.02	0.02	0.005	0.005
12	0.05	0.07	0.02	0.03	0.01	0.005
13	0.07	0.08	0.04	0.04	0.02	0.005
14	0.08	0.05	0.04	0.03	0.01	0.005
15	0.04	0.02	0.02	0.02	0.005	0.005

Table 5.17. Data on Initial Airborne Concentrations for Small and Large Strips in Methamidophos Equivalents (Using the Inhalation RPF)			
Residence	Day 1	Day 1-Small Strip	Day 1-Large Strip
1	0.02	0.00132	0.0052
2	0.08	0.00528	0.0208
3	0.04	0.00264	0.0104
4	0.02	0.00132	0.0052
5	0.05	0.0033	0.013
6	0.11	0.00726	0.0286
7	0.11	0.00726	0.0286
8	0.02	0.00132	0.0052
9	0.01	0.00066	0.0026
10	0.07	0.00462	0.0182
11	0.05	0.0033	0.013
12	0.05	0.0033	0.013
13	0.07	0.00462	0.0182
14	0.08	0.00528	0.0208
15	0.04	0.00264	0.0104

The input format for the initial concentrations used in LifeLine™ is a cumulative distribution. This distribution was defined by the Excel percentile function applied to the 30 residue values (15 large strips and 15 small strips). Note this approach is equivalent to the assumption in the EPA June 11, assessment where it was assumed that there was an equal probability of using the small and larger strips. Table 5.18 gives the percentiles and corresponding Methamidophos residue values for the input distribution.

Table 5.18. DDVP Airborne Residue Data at 24 h (mg/m^3)		
Quantile	Raw Data (mg/m^3)	Converted Data (Using Inhalation RPF)
0	0.00066	0.0013
0.1	0.00132	0.0027
0.25	0.0033	0.0067
0.5	0.00524	0.0106
0.75	0.013	0.0264
0.9	0.0208	0.0422
1	0.0286	0.0581

The rate of daily decline in LifeLine™ is modeled using a first order decay rate. The rate of decline, k, was estimated using the following process.

As discussed above the concentration at a time t is given by:

$$C_t = C_0 e^{-kt}$$

rearranging the equation gives

$$-\ln (C_t / C_0) = kt$$

The slope of the line formed by plotting $-\ln (C_t / C_0)$ against t, will give the value of k. The best value of k can be found by using a simple linear regression model constrained to pass through the origin.

To perform this analysis, we assumed that the data from the 24 h measurements could be used as a measure of the initial concentration (C_0). The air data from the 15 houses reported in Collins and DeVries (1973) are divided by the concentrations at 24 hours (C_0) and the resulting normalized concentrations C_t/C_0 were averaged to give a single value of C_t/C_0 for each time. The number of hours since the initial measurement was defined at t. The natural logs of the ratios were taken and plotted against t. Table 5.16 presents the initial concentrations (C_t), the normalized concentrations (C_t / C_0), the mean of the normalized concentrations across houses at various times (t), and the natural logs of the means are given in Table 5.19. Figure 1 presents a plot of $-\ln (C_t / C_0)$ against t and the slope and R^2 of the least squares the regression line. As the plot shows, the data fit a first order decay model very well and the linear regression has an R^2 of 0.90. The value of k is 0.00096 hr^{-1}.

Table 5.19. Ratio of DDVP Airborne Residue Levels to Initial Measurements (C_t/C_{24})

	Hours Since Initial Measurement (t)					
Residence	0	144	312	648	1320	2160
1	1.00	1.00	1.00	0.25	0.25	0.25
2	1.00	0.88	0.88	0.63	0.06	0.25
3	1.00	0.75	0.75	0.25	0.25	0.13
4	1.00	1.00	0.50	0.25	0.25	0.25
5	1.00	0.40	0.40	0.20	0.1	0.10
6	1.00	0.55	0.18	0.27	0.09	0.05
7	1.00	0.45	0.55	0.18	0.18	0.05
8	1.00	1.00	1.00	0.50	0.25	0.25
9	1.00	1.00	2.00	0.50	0.5	0.50
10	1.00	1.29	0.86	0.57	0.29	0.29
11	1.00	0.80	0.40	0.40	0.1	0.10
12	1.00	1.40	0.40	0.60	0.2	0.10
13	1.00	1.14	0.57	0.57	0.29	0.07
14	1.00	0.63	0.50	0.38	0.13	0.06
15	1.00	0.50	0.50	0.50	0.13	0.13
-ln(Average)	0	0.160	0.359	0.908	1.591	1.768

Determining Inhalation Exposures

LifeLine™ determines inhalation exposures based on the average airborne concentration of DDVP, the duration of exposure, the specific activities performed, and the inhalation rate. The dose from this route of exposure is determined using the following equation:

$$InhalationDose = \frac{\sum_i AC \times IR_i \times ET_i \times LC}{BW}$$

where, AC is the airborne concentration of DDVP, IR_i is the inhalation rate associated with the i^{th} activity the individual performs in the home on the day, ET is the time spent in the i^{th} activity, and LC is lung clearance.

The inhalation rate of individuals is defined by the individual's age, gender, body weight, and activity specific inhalation rates. The process used for defining the inhalation rates is described in detail in the LifeLine™ Technical Manual. Essentially the approach uses the equations proposed by Layton (1993) to establish a resting breathing rate. This resting breathing rate is multiplied times an activity factor to give the activity-specific breathing rate. Table 5.20 presents the categories and the activity factors.

Figure 5.1 DDVP Airborne Data Plot of -ln(C0/Ct) versus t (Time Since Inital Measurement)

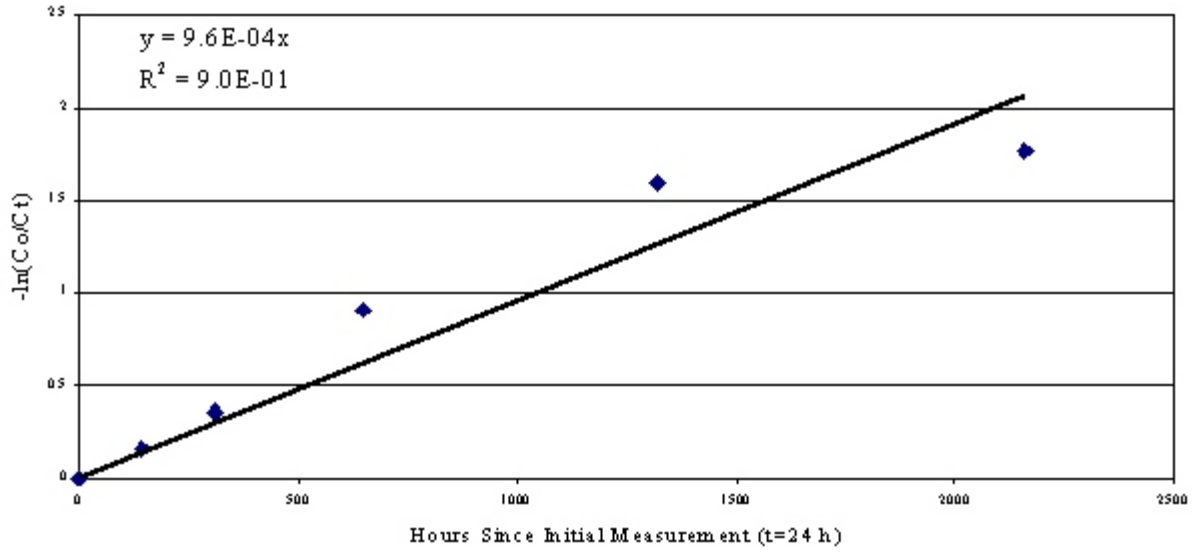

Table 5.20. Activity Factors for Specific Activity Levels	
Activity Level	**Resting Breathing Rate Multiplier**
Rest	1
Sedentary	1.2
Light Activity	2
Moderate Activity	4
Heavy Activity	10

Data on the relationship between breathing rates and NHAPS activities is given in Table 5.21.

Table 5.21. Assignment of NHAPS Activities into the Five Breathing Rate Categories				
Heavy	Moderate	Light	Sedentary	Rest
active sports	animal care	art	bathing, etc	Sleeping Napping
exercise	baby care	attending fulltime school	computer use	
	car repair/maintenance	bars/lounges	conversations	
	car repair/services	breaks	eating	
	child care	child care	govt financial services	
	child/youth/family	domestic crafts	homework	
	cleaning house	dressing, etc	letters/writing/paperwork	
	clothes care	entertainment	magazines, etc	
	games	errands	movies/videos	
	indoor playing	food cleanup	personal care services	
	music/drama/dance	food preparation	personal hygiene	
	other household work	help and care	radio	
	other repair services	helping/teaching	reading books	
	other repairs	hobbies	reading newspaper	
	other services	main job	records/tapes	
	outdoor cleaning	medical appointments	talking/reading	
	outdoor playing	medical care	thinking/relaxing	
	outdoor recreation	medical care-child	tv	
	sports event	na activities		
		other classes		
		other education		
		other organization		
		other social		
		parties		
		plant care		
		professional union		
		religious groups		
		religious practices		
		second job		
		shopping for clothes/hh items		
		shopping for food		
		special interest		
		travel to/from work		
		travel, passive leisure		
		unemployment		
		using library		
		visiting		
		volunteer helping		

The time spent in specific activities is taken from NHAPS activity pattern records. The lung clearance (or inhalation absorption fraction) is set at 1.0.

Exposure to Pesticide Products Applied to Pets

Pesticide products applied to pets causes both applicator and post application exposures. The applicator exposures occur by both inhalation and dermal routes of exposure. Postapplication exposures occur for both adults and children. Children aged six and under are exposed by dermal and oral routs of exposure. Children above the age of six and adults are assumed only to be exposed by the dermal route. Only one OP pesticide is used on pets (TCP). However, the pesticide is used in three products, a powder, pump spray, and aerosol.

Compound and Product Specific Data Used in the Assessment of Pet Related Exposures

The following tables present the product specific data for three pet products containing TCVP. Note TCVP is also contained in other pet products that treat dogs and products that treat cats. However, in the June 11 assessment EPA concluded that it was only necessary to focus on the aerosol, spray, and powder. To compensate for not including the other pet products EPA increased the values of the use factors.

Table 5.22. Residue Data Used in LifeLine™ for Pet Products

Pesticide and Use	Application Rate (mg/30 lb dog)	RPF-Dermal Route	Application Rate in Dermal Equivalents (mg/30 lb dog)	Transfer Efficiency	Transferable Residues (mg/30 lb dog)	Percent Daily Decline
TCVP-Aerosol	450	0.002	0.9	0.026	0.023	21%
TCVP-Spray	300	0.002	0.6	0.072	0.043	21%
TCVP-Powder	750	0.002	1.5	0.0033	0.0050	21%

Table 5.23. Use Factors for TCVP Products

	NHGPUS Pest Category	
Product	Fleas	Ticks and Chiggers
TCVP-Aerosol	0.3	0.3
TCVP-Spray	0.3	0.3
TCVP-Powder	0.3	0.3

Determination of Applicator Exposures

Determination of applicator exposure for pets is performed using the same approach as other homeowner applied products. In the June 11 assessment, EPA used distributions for:

1. The dermal and oral unit exposures;
2. The amount of TCVP applied per lb of dog;
3. The weight of the dogs; and
4. The number of dogs treated on a single day.

These distributions were combined to produce the distributions for each product given in Table. 5.24. The process used to create these distributions is described in Appendix C.

Table 5.24. Cumulative Distribution of Applicator Exposures that Reflects Variation in Unit Exposures, Amount of TCVP applied, Size of Dog, and Number of Dogs

	Powder		Pump Spray		Aerosol	
Percentile	Dermal (ug/lb ai applied to single dog weighing 30 lbs)	Inhalation (ng/lb ai applied to single dog weighing 30 lbs)	Dermal (ug/lb ai applied to single dog weighing 30 lbs)	Inhalation (ng/lb ai applied to single dog weighing 30 lbs)	Dermal (ug/lb ai applied to single dog weighing 30 lbs)	Inhalation (ng/lb ai applied to single dog weighing 30 lbs)
0	0	0	0	0	0	0
10	0.000002	0.000001	0.000005	0.000006	0.000005	0.000006
50	0.00001	0.000012	0.000024	0.000062	0.000022	0.000057
75	0.000021	0.000035	0.000050	0.000143	0.000045	0.000129
90	0.000039	0.000082	0.000095	0.000279	0.000086	0.000249
95	0.000055	0.000131	0.000132	0.000402	0.00012	0.000364
99	0.000107	0.000275	0.000244	0.000744	0.000217	0.00067
100	0.000405	0.000598	0.000760	0.0017	0.000848	0.001884

Post Application Exposures

Post application exposure from use of pet products occurs to both children and adults. Dermal exposures occur to both children and adults. Oral exposures are limited to children aged six and under.

Dermal exposures are determined by a measure of the transferable residue on the pet and a pest specific surface area normalized dermal transfer rate. The measure of the transferable residue is determined by taking the amount of TCVP applied to a 30 lb dog and dividing it by the surface area of the animal. The surface area is estimated using the equation:

$$SurfaceArea = 12.3 \times PetWeight^{0.65}$$

where, Surface Area is in cm^2 and pet weight is in g. For a 30 lb dog this corresponds to 6,000 cm^2.
This surface concentration is multiplied by the transferable fraction of TCVP for each product. The transferable fraction is taken from the application rate and measurements of TCVP transferred in studies of TCVP products reported in the June 11 assessment. The values for the application rate and the transferable fraction are presented in Table 5.22. The transferable residues for all TCVP products decline with a half life of three days this corresponds to a daily percent decline rate of 21%.

In the June 11 assessment the dermal transfer rate for pets was estimated to be 1174 cm^2/h. This corresponds to a surface normalized transfer coefficient (TC') of 0.1 h^{-1}.

Oral exposures to pet residues are estimated using the same approach as for oral exposures to residues on turf. The inputs to the dose equation are the transferable residue values, the durations of interaction with the pet, frequency of contacts with the pet that are followed by a mouthing event, fraction of the hand placed in the mouth, and the dislodgeability of the residues by saliva. In the June 11 assessment EPA defined distributions for these terms. As described in Appendix C these factors and the Dermal To Oral (DTO) factor are combined to yield the product-specific sets of distributions given in Table 5.25. These distributions are entered as the oral modifying factor for each product.

Table 5.25. Distribution for Variation in Hand Area, Frequency of Mouthing Events, Duration, and DTO Factor

Percentile	Powder	Pump Spray	Aerosol
0	0	0	0
1	0.00330	0.00312	0.00284
5	0.0226	0.0214	0.0194
75	0.0510	0.0483	0.0442
90	0.0980	0.0936	0.0858
95	0.137	0.130	0.119
99	0.235	0.225	0.201
100	0.483	0.446	0.45