SURROGATE HANDLER EXPOSURE ESTIMATES FOR USE IN ASSESSMENTS BY THE CALIFORNIA DEPARTMENT OF PESTICIDE REGULATION

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By

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ABSTRACT

Most pesticide active ingredients (AIs) have a wide variety of handler exposure scenarios. Although numerous studies have been conducted to monitor handler exposure to various compounds, relatively little AI-specific exposure data are available. In an attempt to partly bridge these data gaps, the Pesticide Handlers Exposure Database (PHED) was created from multiple studies in which exposure was monitored during specific handler activities, including mixing, loading, application with several types of equipment, and flagging during aerial applications. For the activities covered in PHED, an assumption is made that handler exposure is primarily a function of the physical parameters of handling during the mixing, loading and application processes, rather than the chemical properties of an AI. This assumption, considered valid for most AIs (exceptions include AIs with high vapor pressure, such as fumigants), allows PHED to be used as a generic database to estimate handler exposures.

To ensure that estimates derived from PHED are consistent across exposure assessments by the California Department of Pesticide Regulation (DPR), this document contains default scenario-specific exposure estimates based on PHED. In addition, DPR's approach to using PHED data is explained.

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INTRODUCTION

Persons mixing, loading and applying pesticides, flaggers, or anyone otherwise involved in a pesticide application (e.g., cleaning equipment following a pesticide application) are referred to collectively as "handlers." Most pesticide active ingredients (AIs) have a wide variety of handler exposure scenarios, or combinations of task, formulation type, and equipment. Rarely is there sufficient chemical-specific data available to estimate exposure for all scenarios. Even when chemical- and task-specific worker exposure studies are available, they cannot cover all application rates, application methods and protective clothing/personal protective equipment (PPE) combinations. Gaps often exist in data used to estimate handler exposure.

The Pesticide Handlers Exposure Database (PHED, 1995) is a computerized database containing monitoring data on inhalation and dermal exposures for pesticide handlers performing mixing, loading, application and flagging tasks, primarily in support of agricultural pesticide applications. PHED was developed by the U.S. Environmental Protection Agency (U.S. EPA), Health Canada and the American Crop Protection Association to provide non-chemical-specific pesticide handler exposure estimates for specific handler scenarios. It combines exposure data from multiple field monitoring studies of different AIs. Although many handler scenarios exist, a limited number of application methods and formulation types are included in PHED. Scenarios included in PHED were largely determined by the scope of adequately reported exposure monitoring studies available for inclusion in this publicly accessible database. Most handler exposure monitoring studies measure exposures during mixing, loading, and application. Few studies monitor other activities such as equipment cleaning and repair (van Hemmen, 1992). Thus, these activities are not covered in PHED.

Major Assumptions for Using PHED

The use of non-chemical-specific (or "generic") exposure estimates is based on two main assumptions, that exposure of handlers performing these tasks is primarily a function of the pesticide application method/equipment and formulation type rather than the physical-chemical properties of the specific AI, and that exposure is proportional to the amount of AI handled (Reinert *et al.*, 1986; Versar, 1992). These assumptions are supported by comparisons of exposure across several studies with multiple AIs (Rutz and Krieger, 1992; van Hemmen, 1992; U.S. EPA, 1996).

Exceptions to these assumptions are known. For example, volatile compounds such as fumigants are not well represented by PHED, as data contained in PHED are based on sampling of liquid aerosols and granular compounds rather than vapors or gases (van Hemmen, 1992). Although the point at which volatility (or vapor pressure) begins to substantially affect handler exposure has not been specifically investigated, the California Department of Pesticide Regulation (DPR) assumes that PHED should not be used to estimate exposure for AIs with vapor pressure above approximately 1×10^{-4} mmHg. The North American Free Trade Agreement (NAFTA) Technical Working Group on

Pesticides has suggested that for exposure assessment purposes, 1 x 10^{-4} kPa (equivalent to 7.5 x 10^{-4} mmHg) is the limit above which pesticides are considered to be volatile in outdoor uses in the temperature range 20 – 30°C (Norman, 2005).

How PHED Is Used

Four parent data files are included in PHED: (1) mixer/loader (MIXLD.file, with 556 records); (2) applicator (APPL.file, with 715 records); (3) mixer, loader, and applicator (MLAP.file, with 349 records); and (4) flagger (FLAG.file, with 92 records). From these parent files or from their user-defined subsets, exposure estimates for the hand, skin, and inhalation can be calculated. Instructions for use of PHED are given in the PHED Reference Manual (Versar, 1992).

An exposure assessor using PHED selects a subset of the data having the same or a similar application method and formulation type as the target scenario. Selection of subsets involves making multiple choices, and subsets generated by different users may give different exposure estimates. For many years, exposure assessments from U.S. EPA have contained estimates from their PHED Surrogate Exposure Guide (U.S. EPA, 1998), developed by U.S. EPA for the use of agency exposure assessors, which ensures consistency in the use of data from PHED (U.S. EPA *et al*., 2007). However, the DPR approaches PHED differently than U.S. EPA. First, as explained in U.S. EPA's policy for use of PHED data (U.S. EPA, 1999): "Once the data for a given exposure scenario have been selected, the data are normalized (i.e., divided by) by the amount of pesticide handled resulting in standard unit exposures (milligrams of exposure per pound of active ingredient handled). Following normalization, the data are statistically summarized. The distribution of exposure values for each body part (i.e., chest upper arm) is categorized as normal, lognormal, or "other" (i.e., neither normal nor lognormal). A central tendency value is then selected from the distribution of the exposure values for each body part. These values are the arithmetic mean for normal distributions, the geometric mean for lognormal distributions, and the median for all "other" distributions. Once selected, the central tendency values for each body part are composited into a "best fit" exposure value representing the entire body." In other words, U.S. EPA uses various central tendency estimates (often the geometric mean or median, as PHED data rarely follow a normal distribution), while DPR believes the arithmetic mean is the appropriate statistic regardless of the sample distribution (Powell, 2003). Second, DPR uses a 95th percentile upper-bound estimate for short-term exposure estimates, while U.S. EPA uses a central tendency estimate for all exposure durations. Third, DPR calculates 90% upper confidence limits (UCLs) for both upper bound and mean exposures, while U.S. EPA does not. Thus, rather than rely on U.S. EPA (1998), DPR exposure assessors use estimates from subsets documented in Appendix I, which include adjustments in accordance with DPR policy.

DPR's approach to PHED was initially described by Powell (2001) as a method by which 95th percentile upper-bound and 90% UCLs could be approximated through multiplying PHED arithmetic mean results by constants, called "multipliers." These multipliers were derived from basic statistical relationships, and were chosen such that smaller sample sizes would have larger multipliers, reflecting the greater uncertainty associated with

smaller sample sizes. DPR's approach has been refined since the initial policy memo of Powell (2001). The first change, documented by Powell (2002), was to substitute an estimate of the 90% UCL on the 95th percentile upper bound, in recognition of the fact that the upper-bound estimate has an uncertainty; in Powell (2001), only the uncertainty in the mean estimate was addressed.

Powell (2007) further refined DPR's approach to PHED in two ways, by using different statistical assumptions to derive the multipliers for the 90% UCLs on both the mean and the 95th percentile, and by using a different method to determine the effective sample size for each dermal subset (previously, the median sample size in each dermal subset had been used). The exposure rates given in Appendix I were calculated according to this approach, which was briefly summarized in a policy memo by Frank (2007).

Finally, a note about terminology: U.S. EPA (1998) used the term "replicates" to refer to "observations for a specific body location." However, because observations in PHED originate in multiple studies conducted under a variety of conditions, the term, "replicate," is not quite accurate. Furthermore, the term is also commonly used to refer to an individual in an exposure monitoring study, potentially causing confusion. In this document, each specific body part for which exposure was monitored in a study is referred to as an "observation." The term "record" is used, following PHED (1995), to refer to all observations made on an individual during a monitoring interval (the same individual can be monitored more than once, resulting in multiple records).[1]

PHED SUBSET SELECTION CRITERIA

Selection criteria used to create each subset are shown in Appendix I for each scenario. For each scenario, subsets were generated separately for inhalation, hand, and dermal exposures. Criteria used to generate subsets are discussed below.

Data Quality Specification

Data quality grades were the first criteria used in selecting subsets for each scenario. Data quality grades reported in PHED are based on Quality Assurance (QA) data provided in exposure study reports. Grades A and B are high-quality grades, with lab recoveries of 90-110% and 80-110%, respectively (field recoveries range 70-120% and 50-120%); grade C represents moderate quality, with lab and field recoveries of 70-120% and 30-120%, respectively; grade D represents poor quality, with lab recovery of 60-120% and field recovery that is either in the range of 30-120% or missing; E is the lowest quality grade, and is assigned to PHED data that do not meet basic quality assurance (U.S. EPA, 1998).

When PHED was created, these data quality grades were assigned to four categories of data, "dermal uncovered," "dermal covered," "hand," and "airborne." The first two

[1] U.S. EPA has proposed the term, "monitoring unit" to refer to an individual during a monitoring interval (U.S. EPA *et al.*, 2007). Although that term is not used in this document it might be preferred over "records" in exposure assessment documents.

categories refer to fortified material from patch dosimeters or whole-body dosimeters used to monitor dermal exposure on most of the body; material from the dermal dosimeters is fortified with the AI used in the study as a QA measure. In some studies, some or all of the fortified dosimeter QA samples were covered with cloth to protect the fortified material from sunlight; these "covered" QA samples were intended to match conditions of dosimeters under at least one layer of clothing. Similarly, "uncovered" QA dosimeter samples were intended to match conditions of dosimeters attached to the outermost layer of clothing or worn outside all other clothing. The "hand" category refers to hand washes or glove dosimeters used to estimate hand exposure. Head exposures are considered by PHED to be based on patch dosimeters, even in cases where head exposure was monitored with face and neck wipes rather than a patch dosimeter; thus, the data quality grade assigned to head exposure in each study is grouped with "dermal covered" or "dermal uncovered."

Hand and Inhalation Data Subsets

Data quality grades for hand and inhalation observations were specified for subsets used to estimate hand and inhalation exposures. Two goals guided the use of data quality grades when subsetting: to include the highest quality data possible and to have an effective sample size of at least 15 observations. The target sample size of 15 was selected because it corresponds to the minimum sample size recommended "to obtain a reasonable cross-section of the variation of individual exposure values," in U.S. EPA guidance for exposure monitoring (U.S. EPA, 1987, 1996).

Subsets were prepared in a stepwise manner, using the following priority:

1. **High confidence subset:** If possible, a subset was selected to contain only data of grade A or B quality, with at least 15 observations.
2. **Medium confidence subset:** If the first subset contained fewer than 15 observations, another subset was selected to contain data of grade A, B or C quality.

If neither of the subsets generated according to the above criteria contained at least 15 observations, then a subset with fewer than 15 observations was used; this is a low confidence subset.

Dermal Data Subsets

To specify data quality grades in both "dermal uncovered" and "dermal covered" fields, preliminary subsets containing high and high-medium data quality were created from each of the four parent data files (dermal data have two fields in which data quality can be specified, whereas hand and inhalation data each have a single field). Scenario-specific dermal subsets were generated from the appropriate preliminary dermal subset, using the stepwise method described for hand and inhalation data.

Because different body parts in a dermal subset could have different numbers of observations, the effective number of observations (N) in the dermal subset was estimated as a weighted harmonic mean of the observations for the body parts in the

dermal subset. The harmonic mean is the reciprocal of the arithmetic mean of the reciprocals of the body part N's. Each body part N was weighted by the square of the arithmetic mean exposure for the body part, which gave greater weight to the N's for body parts with higher exposures. The method for determining the effective sample size is described in Powell (2007).

Confidence in Scenario Data Sets

Of the 28 scenarios described in Appendix I, eleven contain high-confidence subsets. Two scenarios contain subsets with E-grade data, and the other 15 contain some C-grade data. Thirteen scenarios have at least some body parts with fewer than 15 observations.

Data graded D or E were not used in subsets, except in scenarios 8 and 26. In Scenario 8 inhalation and hand data were both E-grade; dermal data were C-grade. In Scenario 26, hand data were E-grade.

Test Material Specification

Formulation (Liquid Type or Solid Type)

For mixer/loader scenarios that involved liquids, all liquid types were selected (i.e., all liquid formulations were grouped together in creating subsets). In contrast, solid types were each treated separately in mixing/loading scenarios, with one exception. Scenario 3 (also Scenario 3A) is marked as applying to both dry flowables and wettable powders, although all records in this scenario involved handling wettable powders. As no data are available for dry flowables in water soluble packaging, this scenario may also be used for dry flowables; dry flowables are typically less dusty than wettable powders, so handler exposure is expected to be no greater than with wettable powder.

For applicators, two solid types, dry flowables and wettable powders, were grouped with liquids as both are dissolved in water before application and applied as solutions. Granules are not mixed with water or other solvent before application. None of the scenarios includes dust as a formulation type; in spite of the fact that dust is an option in PHED, there are no data in PHED for handlers of dusts.

Package Type

Package type is a choice available only for mixer/loader and mixer/loader/applicator data. Types of packaging available in PHED include bag, can, bottle, and water soluble packet. The package type was not specified for scenarios in Appendix I, except for water soluble packet in Scenarios 3 and 3A.

Task Specification

Mixing Procedure

Choices for mixing procedures in PHED include open (i.e., open pour) and two types of closed systems. “Open pour” mixing is defined as follows (Franklin and Worgan, 2005):

> Mixing the active pesticide ingredient with other substances such as water in an open environment (such as mixing in an open container), as opposed to a closed environment and/or loading the pesticide (or mixture containing the pesticide) into application equipment in an open environment (such as pouring the pesticide into an unsealed opening.

California regulation defines a closed system as follows (California Code of Regulations Title 3 (3 CCR), Section 6000 (3 CCR 6000)):

> "Closed system" means a procedure for removing a pesticide from its original container, rinsing the emptied container and transferring the pesticide product, mixtures and dilutions and rinse solution through connecting hoses, pipes and couplings that are sufficiently tight to prevent exposure of any person to the pesticide or rinse solution. Rinsing is not required when the pesticide is used without dilution. The system's design and construction shall meet the director's closed system criteria.

The director's closed system criteria are available as an attachment to Donahue and Andrews (1998). Closed systems are either pump- or gravity-fed; both types were selected in closed-system mixing/loading scenarios.

Application Method

Applicator subsets include the general type of equipment used. PHED includes 21 types of application methods, plus one listed as "other". Not all application methods were used in subset generation.

More than one application method was selected for some scenarios, if the methods were anticipated to give similar applicator exposures. For example, aerial fixed wing and aerial rotary wing were combined to yield exposure estimates for aerial applicators (pilots), and for applicators using groundboom equipment, data from groundboom tractor and groundboom truck were combined.

Cab Type

PHED allows four choices of cab/cockpit types: open, closed with open window, closed with closed window, closed with filtered air. These were grouped as follows:

- Open cab/cockpit. Open cab or closed cab with open window.
- Closed cab/cockpit. Closed cab with closed window or closed cab with filtered air.

EXPOSURE CALCULATION PARAMETERS

Once the PHED subsets were generated for each scenario, the inputs for exposure calculations were entered according to standard DPR practice. Selections made at each exposure menu in PHED are summarized in this section.

Exposure Menu Selections

Exposure Algorithm
PHED provides options to calculate dermal and inhalation exposures separately or together. DPR calculated hand, dermal and inhalation exposures separately using the hand, dermal and inhalation subsets constructed for each scenario. Dermal and hand exposures were both calculated using the dermal exposure algorithm.

Method of Normalization
Exposures were normalized by pound of AI handled, rather than by hour worked, because the total work-time spent within each handling task is not as well defined. In Appendix I, exposures are expressed as micrograms per pound of AI handled (i.e., µg/lb AI handled). Exposures are generally expressed in these units within the U.S. because product labels typically give use directions in English units such as pounds, gallons, and quarts (for liquid products, the unit of measure is converted to lbs AI). For convenience, Appendix II summarizes exposures from all 28 scenarios in µg/kg AI handled.

Inhalation Rate
PHED allows the user to either accept the program default rate of 25 L/min or to enter another value. In preparing the scenarios in Appendix I, DPR used a default inhalation rate of 16.7 L/min (1.0 m^3/hr), assuming that the typical handler work-hour consists primarily of light activity. Default inhalation rates used by DPR for various activity levels are documented in Andrews and Patterson (2000).

Type of Clothing Worn
PHED allows choosing among several types of clothing for the purpose of calculating dermal exposure. Choices are "no clothes," which uses data from outer patches and dosimeters only; "normal work clothing," which includes data from patches under single layers of clothing; and "protective clothing," which includes data from patches under coveralls or under coveralls and clothing. Normal work clothing was specified unless insufficient observations were available.

Once normal work clothing is selected, PHED allows additional clothing and glove choices, including long-and short-sleeved shirts and gloves or no gloves. Long-sleeved shirt and long pants were specified for most scenarios, depending on available data. For three scenarios (8, 19, and 26), there were not enough observations for any clothing combination except "no clothes." Exposures were estimated for handlers with and/or without gloves, depending on whether sufficient observations were available for each choice.

Head Patches Used
Choices are to use actual head patches only, to use estimated head patches only, or to use both. (Head exposure can be estimated from face, neck and/or shoulder patches when no actual head patches are present.) To increase the number of observations, both actual and

estimated head patches were included. Although inclusion of estimated patches might result in less accurate head exposure estimates, in most scenarios (with airblast as a notable exception) head exposure is minimal compared to exposure estimates calculated for other body regions; thus, the error in most cases would not be substantial.

Adjustments to PHED Outputs

Once all of the selections have been entered, PHED calculates exposures and summarizes results in standardized outputs. An excerpt from the dermal exposure output was included as a figure in each scenario in Appendix I. Adjustments to the PHED outputs were made according to DPR practice, and are explained in this section.

Dermal Exposure

PHED reports dermal results (distribution of data, median, arithmetic mean, coefficient of variation, geometric mean, and number of observations) for head, front and back of neck, chest, back, upper arms, forearms, thighs, lower legs, feet and hands. PHED also reports dermal total medians, arithmetic means, and geometric means. In calculating dermal exposure, DPR subtracted hand and feet means from the arithmetic mean total reported by PHED. Hand and foot exposures were calculated as described below.

Hand Exposure

PHED includes hand exposure as a body part when calculating total dermal exposure. As hand data are associated with different QA than other dermal measures, DPR calculated hand exposure separately, using only the arithmetic mean hand exposure rate provided by PHED from the hand subset.

Foot Exposure

DPR practice in estimating dermal exposure to feet is to assume it is the same as the lower leg. Foot exposure rate estimates provided by PHED were not used in preparing scenarios in Appendix I because there are too few observations to be meaningful, and because U.S. EPA (1998) reports an error in that PHED field. A value of [0.52 x lower-leg exposure] was used in place of the foot exposure estimate given in the PHED output, because the median surface area of the feet is 52 percent of the median surface area of the lower legs (U.S. EPA, 1997). Calculation of ratio: (1,225 cm^2)/(2,370 cm^2) = 0.52

Protection Factors for Clothing and PPE

With the exception of Scenario 15, Appendix I provides exposure estimates for handlers both wearing and not wearing gloves. If sufficient numbers of actual observations (at least 15) were available for both gloved and ungloved workers in a scenario, then an additional, no-glove scenario was paired with the glove scenario. No-glove scenarios are designated with an “A” after the scenario number.

If insufficient observations were available for both glove and non-gloved handlers in a scenario, then hand exposure was adjusted with the default 90% protection factor used by DPR for gloves (Aprea *et al*., 1994). If sufficient observations were available only for

handlers not wearing gloves, then exposure of gloved hands was calculated as one tenth of the exposure of the ungloved hands. Conversely, if insufficient observations were available for workers not wearing gloves, then exposure of ungloved hands was calculated as ten times the arithmetic mean exposure of gloved hands.

For three scenarios (8, 19, and 26), the only observations available were "no clothes" (i.e., all exposure measurements were outside clothing). To estimate exposure of handlers wearing long-sleeved shirt and long pants, arithmetic mean exposures of upper arms, chest, back, forearms, thighs and lower legs (along with the calculated exposure for feet) were adjusted by a 90% protection factor for work clothing (Thongsinthusak *et al*., 1991).

Dermal Exposure for Body Parts with Missing Data

In Scenario 25, no observations were available for head or neck (front or back of the neck). A value of [0.48 x chest exposure] was added to the dermal total, assuming that the chest exposure would be the best surrogate measure for the head and neck exposure and factoring in the ratio of head and neck to chest surface areas (U.S. EPA, 1997). Calculation of ratio: $[(1{,}304\ cm^2) + (135\ cm^2) + (98\ cm^2)]/[3{,}178\ cm^2] = 0.48$

Significant Figures

All exposure estimates reported in Appendix I were rounded to three significant figures. All estimates were rounded to the same extent because the resolution of measurements within each study could not be readily determined; PHED reports results to four decimal places regardless of the resolution in the original data. DPR considers three significant figures to be a reasonable default resolution.

DPR STANDARD PHED SCENARIOS

Appendix I contains PHED outputs and tables of the subset criteria and exposure estimates for 28 handler scenarios. The scenarios are grouped into the four categories recognized by PHED: Mixer/Loader, Applicator, Mixer/Loader/Applicator, and Flagger. The tables in this section summarize information about the studies included in subsets for each scenario.

<u>Mixer/Loader</u>

There are six mixer/loader (M/L) scenarios. Table 1 lists the scenarios for M/L handling dry formulations, including wettable powder (WP), dry flowable (DF), and granular. Both WP and DF are mixed with water; granular formulations are not.

Of the four M/L scenarios summarized in Table 1, three are open pour. In contrast, Scenario 3/3A, mixing/loading a WP packaged in a water-soluble bag (also referred to as water-soluble packaging, or WSP), is not an open pour scenario. WSP is designed to be placed unopened into the pesticide mixing chamber; it dissolves after coming into contact

with water. Assuming the mixing chamber is closed following addition of the WSP, M/L exposure to the pesticide is limited.

Table 1. Summaries of PHED Subsets for Solid Mixer/Loader Scenarios [a]

Scenario No.	Scenario	Formulation [b]	Studies Included In Subsets [c]			
			Study ID	Observations	Location	Sampling Dates
1 & 1A	Open Pour Mixing/Loading	WP	1025	6	AZ/FL	11/1992-1/1993
			1000 [d]	13	CA	7-9/1990
			518	6	CA	6/1987
			517 [d]	6	CA	10/1984
			454 [e]	4	CA	12/1986
			449 [d]	3	PA	6/1981
			438	2	IN	4/1986
			437	3	IN	9/1984
			432	2	CA	9/1977
			436 [e]	4	NJ	3/1985
2 & 2A	Open Pour Mixing/Loading	DF	9008 [e]	5	Australia	6-7/1990
			1013	7	CA	5/1991
			502 [d]	3	ND/IN	5-9/1985
			460	16	CA	6/1988
3 & 3A	Mixing/Loading Water-Soluble Bag	WP	518	6	CA	6/1987
			517 [d]	3	CA	10/1984
			438	2	IN	4/1986
			437	3	IN	9/1984
4	Open Pour Mixing/Loading	G	1027 [f]	14	GA/NC	2-3/1993
			1011	25	Canada	10/1990
			1004	15	IA/NE	5/1992
			427	1	ND	10/1979
			422	2	IL	6/1981

[a] See Appendix I for subset details and exposure estimates. Scenarios with numbers ending in A are no-glove scenarios. PHED: Pesticide Handlers Exposure Database.
[b] DF: dry flowable; G: granular; WP: wettable powder.
[c] Information was determined by browsing the appropriate fields for individual observations in PHED subsets.
[d] Only dermal observations (no hand or inhalation) were taken from this study.
[e] Only hand observations (no dermal or inhalation) were taken from this study.
[f] Only inhalation observations (no hand or dermal) were taken from this study.

Table 2 lists the two scenarios for M/L handling liquids. Scenario 5/5A is an open pour M/L scenario, while Scenario 6/6A is M/L handling liquids with a closed system.

Applicator

Table 3 lists the scenarios for applicators operating ground equipment, including airblast, groundboom and right-of-way sprayer. Paired scenarios are available for open and closed cabs (or cockpits, for aerial applicators). U.S. EPA (1998) has a glossary that

defines application methods, which can be consulted for any questions about the methods reported in Tables 3 through 7.

Table 2. Summaries of PHED Subsets for Liquid Mixer/Loader Scenarios [a]

Scenario No.	Scenario	Formulation [b]	Studies Included In Subsets [c]			
			Study ID	Observations	Location	Sampling Dates
5 & 5A	Open Pour Mixing/Loading	L	9010	10	Malaysia	8/1982
			9003	4	Sri Lanka	4/1987
			9001	9	England	6/1984
			1026	15	CA	10/1991-5/1992
			1025	3	MI	6-7/1992
			1014	5	MS	8/1994
			1012	16	MD	9/1992
			1001	8	MS	9/1991
			523	16	GA	7/1987
			517 [d]	2	CA	10/1984
			471	9	MD/PA	9-10/1987
			465	6	MD	6/1985
			447	6	MS	5/1985
			446 [e]	1	MN	5/1985
			440	1	IN	6/1983
			435	5	NC/OH/VA	8/1985
			434	2	PA	6/1982
			433	2	CA	6/1982
			427	4	ND	10/1979
			426	1	KS	8/1982
			423	1	IL	6/1981
			422	2	CO	4/1981
			415 [e]	3	CA	5/1984
6	Closed System Mixing/Loading	L	1001	16	CA	9/1991
			517 [d]	1	CA	10/1984
			503	5	Canada	8/1990
			426	1	KS	8/1982
			422	4	IL	5/1981
			413 [e]	8	CA	8/1985

[a] See Appendix I for subset details and exposure estimates. Scenarios with numbers ending in A are no-glove scenarios. PHED: Pesticide Handlers Exposure Database.
[b] L: liquid (includes all five liquid types; see text).
[c] Information was determined by browsing the appropriate fields for individual observations in PHED subsets.
[d] Only dermal observations (no hand or inhalation) were taken from this study.
[e] Only hand observations (no dermal or inhalation) were taken from this study.

Table 3. Summaries of PHED Subsets for Ground Applicator Scenarios [a]

Scenario No.	Scenario	Studies Included In Subsets [b]				
		Study ID	Crop/Site	Location	Observations	Sampling Dates
9 & 9A	Airblast, Open Cab	1026	Citrus	CA	10	10/1991-5/1992
		1000 [c]	Apricots	CA	5	7/1990
		518	Grapes	CA	6	6/1987
		460	Grapes	CA	12	6/1988
		449 [d]	Apples	PA	10	6-7/1981
		435	Apples	NC/VA/OH	5	8/1985
		434	Apples	PA	2	6/1982
		433	Grapes	CA	2	6/1982
		432	Grapes	CA	2	9/1977
10	Airblast, Closed Cab	1007 [c]	Apples	OR	5	7/1991
		1000	Apricots	CA	5	7/1990
		523	Pecans	GA	16	9/1991
		460	Grapes	CA	4	6/1988
11	Groundboom, Open Cab	1025	Several	AZ/FL/MI	9	6/1992
		1008	Cotton	AZ	5	7/1989
		1000 [c]	Lettuce/Fallow	CA	10	8-9/1990
		502 [c]	Fallow/Soybean	IN/ND	3	5-9/1985
		465	Preplant	MD	3	6/1985
		454 [d]	Pistachios	CA	8	12/1986
		440	None [e]	IN	2	6/1983
		438	Turf	IN	3	4/1986
		437	Turf	IN	3	9/1984
		430	Roses	CA	1	9/1981
		427	None	ND	2	10/1979
12	Groundboom, Closed Cab	9008 [d]	Barley/Wheat	Australia	5	6/1990
		1001	Cotton	CA	8	9/1991
		427	None	ND	2	10/1979
		426	None	KS	2	8/1982
		423	None	IL	2	6/1981
		422	None	IL	2	5/1981
14 & 14A	Broadcast Spreader, Granular	1011	Preplant	Canada	29	4-5/1992
		1004	Corn	IA/MO/NE	15	10/1990
		422	None	IL	2	6/1981
16	Right-of-Way Sprayer	415	R-O-W [f]	CA	4	5/1984
		1012	R-O-W	MD	16	9/1992

[a] See Appendix I for subset details and exposure estimates. Scenarios with numbers ending in A are no-glove scenarios. PHED: Pesticide Handlers Exposure Database.
[b] Study identifiers and sampling dates were determined by browsing the appropriate fields for individual observations in PHED subsets.
[c] Only dermal observations (no hand or inhalation) were taken from this study.
[d] Only hand observations (no dermal or inhalation) were taken from this study.
[e] No specific crop or other use site was indicated for this study.
[f] R-O-W: right-of-way.

Table 4 lists the scenarios for applicators using manual methods, including spraying pesticide in an aerosol can, hand spreading bait, and applying a pesticide-containing paint with a paintbrush. Unlike most M/L and ground applicator scenarios, few studies are available for the scenarios listed in Table 4; in fact, two of the three scenarios each contain data from a single study.

Special mention is made of Scenario 28, one of the scenarios listed in Table 4. When data from the single study contained in Scenario 28 (Study ID 467) were entered into PHED, incorrect amounts of AI handled were entered for 11 of the 15 observations (U.S. EPA, 1998). Appendix III describes the corrections made to this scenario.

Table 4. Summaries of PHED Subsets for Manual Applicator Scenarios [a]

Scenario No.	Scenario	Studies Included In Subsets [b]				
		Study ID	Crop/Site	Location	Observations	Sampling Dates
13 & 13A	Aerosol Can	521	Crack/Crevice	FL	15	1/1991
		456 [c]	None [d]	MO	15	10/1988
15	Hand Spread Bait	520	Residential	FL	16	1/1991
28	Paintbrush	467	None	MD	15	11/1988

[a] See Appendix I for subset details and exposure estimates. Scenarios with numbers ending in A are no-glove scenarios. PHED: Pesticide Handlers Exposure Database.
[b] Study identifiers and sampling dates were determined by browsing the appropriate fields for individual observations in PHED subsets.
[c] Only hand observations (no dermal or inhalation) were taken from this study.
[d] No specific crop or other use site was indicated for this study.

Table 5 lists the scenarios for aerial applicators. PHED subsets can be specified for aerial applicators applying liquids with either open or closed cockpit; however, the only data available in PHED for aerial applicators applying granular formulations are for closed-cockpit applications. The most recent information available about equipment used by aerial applicators shows that open cockpits are relatively rare, but may still be used (NAAA, 2004).

Flagger

There are two aerial flagger scenarios (Table 6). The flagger subsets for aerial application of granular formulations (Scenario 8) contain data from the same two studies as for the aerial applicator.

Mixer/Loader/Applicator

There are eight mixer/loader/applicator (M/L/A) scenarios. These scenarios cover exposure of individuals who mix and load a pesticide, then apply it using the equipment identified in the scenario. Table 7 summarizes the studies included in each M/L/A scenario. All eight scenarios involve open pour mixing/loading and (with the exception of the push-type broadcast spreader, Scenario 25) hand-held application equipment. Three M/L/A scenarios each contain data from a single study.

Table 5. Summaries of PHED Subsets for Aerial Applicator Scenarios [a]

Scenario No.	Scenario	Studies Included In Subsets [b]				
		Study ID	Crop/Site	Location	Observations	Sampling Dates
17	Aerial, Liquids, Open Cockpit	1013	Rice	CA	10	5/1991
		443	Rice	AR	4	7/1982
		420 [c]	Soybeans	IL	3	7/1984
18	Aerial, Liquids, Closed Cockpit	1014	Cotton	MS	12	8/1984
		1001	Cotton	CA	8	10/1991
		503	Conifers	Canada	5	8/1990
		447	Cotton	MS	6	5/1985
		422	Preplant	Colorado	2	4/1981
		413	Cotton	CA	8	8/1985
19	Aerial, Granular, Closed Cockpit	1003	Rice	AR	9	7/1990
		448 [c]	Rice	AR	4	6/1980

[a] See Appendix I for subset details and exposure estimates. PHED: Pesticide Handlers Exposure Database.
[b] Study identifiers and other information in this table were determined by browsing the appropriate fields for individual observations in PHED subsets.
[c] Only dermal observations (no hand or inhalation) were taken from this study.

Table 6. Summaries of PHED Subsets for Flagger Scenarios [a]

Scenario No.	Scenario	Studies Included In Subsets [b]				
		Study ID	Crop/Site	Location	Observations	Sampling Dates
7	Flagger, Liquids	1013	Rice	CA	10	5/1991
		1001	Cotton	CA	16	10/1991
		422	Preplant	CO	2	4/1981
		413 [c]	Cotton	CA	8	8/1985
8	Flagger, Granular	1003	Rice	AR	16	7/1990
		448 [d]	Rice	AR	4	6-7/1980

[a] See Appendix I for subset details and exposure estimates. PHED: Pesticide Handlers Exposure Database.
[b] Study identifiers and sampling dates were determined by browsing the appropriate fields for individual observations in PHED subsets.
[c] Only hand observations (no dermal or inhalation) were taken from this study.
[d] Only dermal observations (no hand or inhalation) were taken from this study.

M/L/A scenarios are possible as well for applications involving ground equipment, and for aerial applications. In addition to M/L/A scenarios summarized in Table 7, U.S. EPA (1998) includes M/L/A scenarios for airblast and groundboom applications. However, most exposure monitoring studies conducted during ground and aerial applications monitor M/L and applicator separately and these scenarios in U.S. EPA (1998) contained very few records. Aerial, airblast and groundboom M/L/A are assumed by DPR to have exposures in the range of M/L and applicators (DPR normalizes exposure estimates to an 8-hour day, and M/L/A would mix/load part of the day, and apply for the remainder). For this reason, DPR generally does not estimate exposures for M/L/A involved in ground or aerial applications.

Table 7. Summaries of PHED Subsets for Mixer/Loader/Applicator Scenarios [a]

Scenario No.	Scenario [b]	Studies Included In Subsets [c]				
		Study ID	Crop/Site	Location	Observations	Sampling Dates
20	Backpack	1024	Greenhouse	OH	2	4/1993
		471	Poultry	VA/PA/MD	9	9-10/1987
21	High Pressure HW	1024	Greenhouse	OH	13	4-5/1993
22	Low Pressure HW, Liquids	1024	Greenhouse	OH	1	4/1993
		471	Poultry	VA/PA/MD	9	9-10/1987
		201 [d]	Lawn/shrubs/ trees	WA	70	5-8/1978
23	Low Pressure HW, WP	458	None [e]	MO	16	9-10/1985
24	Termiticide Injection	513	Foundations [f]	KS/MO	9	7-8/1988
		512	Foundations	MO	8	6/1987
25	Push-Type Broadcast Spreader	1027	Turf	NC/GA	15	2-3/1993
26	Garden Hose End Spreader	201	Lawn	WA	8	8/1978
27	Belly Grinder, Granular	1027	Turf	NC/GA	15	2-3/1993
		504	Turf	MI	9	8-9/1991
		459	Drive/sidewalk	MO	16	9-10/1988
		419 [d]	Ornamentals	CA	5	6/1984

[a] See Appendix I for subset details and exposure estimates. PHED: Pesticide Handlers Exposure Database.
[b] Abbreviations: HW = handwand. WP: wettable-powder formulation.
[c] Study identifiers and sampling dates were determined by browsing the appropriate fields for individual observations in PHED subsets.
[d] Only dermal observations (no hand or inhalation) were taken from this study.
[e] No specific crop or other use site was indicated for this study.
[f] Includes slab foundations, basements, and crawl spaces.

USING PHED SUMMARIES AND ESTIMATES

Appendix IV explains the summary statistics provided in PHED outputs. The daily external exposure rates (in µg/lb AI handled) used to calculate short-term and long-term exposure estimates are given for each scenario in Appendix I. These values are presented in the second of the two tables for each scenario.

Selection of Protection Levels for Exposure Assessments

Where Appendix I allows a choice, exposure assessors should use the scenario with the minimum level of protection (gloves/no-gloves or engineering controls) specified by any product label or regulation for the target AI. For example, the no-glove scenario should be used unless gloves are specified on labels for all products used in the scenario or unless regulations requiring gloves apply to all products that could be used in the scenario. Also, scenarios with open cab/cockpit or open mixing methods should be used, unless product labels or applicable regulations specify closed cabs or closed mixing/loading systems. A scenario based on all open-cab data may be used to estimate exposure for closed cabs, while one based on all open-pour data may be used to estimate exposure for a closed mixing/loading system; the appropriate default protection factor is then applied.

Exposure assessors should be aware of state and federal regulations that require protective clothing and engineering controls in addition to those required by product labels. For example, 3 CCR 6746 requires the use of closed mixing and loading systems for liquid formulations of toxicity category I pesticides and closed loading systems for liquid mixtures of toxicity category I dry formulations. Toxicity categories are defined in 3 CCR 6000.

The amount of an AI depositing on the skin, which is available for absorption into the body, is affected by the use of protective clothing, PPE, and engineering controls such as use of a closed system for mixing and loading a pesticide or an enclosed cab on a tractor driven by an applicator (van Hemmen, 1992). PHED allows users to create subsets containing data only from studies where specific PPE, clothing, and engineering controls were used. Appendix I contains exposure estimates for handlers wearing only a single layer of work clothing (i.e., long-sleeved shirt and long pants). No exposure estimates have been provided for workers wearing additional protection, such as coveralls or respirators. When appropriate, protection factors may be applied at the time of the assessment. U.S. EPA (1998) discusses use of protection factors with PHED.

Data Distributions Reported by PHED

As discussed in the Introduction, DPR's approach to using PHED differs from the approach of U.S. EPA. One of the ways in which the approaches differ is that DPR consistently uses the arithmetic means from PHED outputs, while U.S. EPA uses different estimates of central tendency depending on the sample distributions reported by PHED. Exposure estimates calculated by DPR and U.S. EPA can differ substantially because of this difference, as arithmetic means can in some cases be considerably greater than the corresponding geometric means and medians. To assist in discussing the impact of this difference in approach on DPR and U.S. EPA estimates for specific scenarios, Appendix V summarizes the frequency distributions reported by PHED for each subset. To determine distributions, PHED sequentially tests first for a lognormal distribution, by log-transforming the values within each subset (for dermal subsets, each body region is separately tested). If the log-transformed data fail the normal distribution test, then PHED tests the untransformed data for a normal distribution. Both tests are Kolomogrov-Smirnov tests (Versar, 1992). Data failing tests for both lognormal and normal distribution are classified by PHED as having a distribution of "other."

To allow interested readers to compare PHED-based exposure estimates generated by DPR with those generated by U.S. EPA, values from the U.S. EPA (1998) are summarized in Appendix VI.

Explanation of PHED in Exposure Assessments

Standard (or boilerplate) text to be inserted into exposure assessment documents (EADs) using PHED is given in Appendix VII. Appraisal statements for specific scenarios are given in Table 8.

Table 8. Scenario-Specific Comments for Exposure Appraisals [a]

No.	Scenario	Comment
3 & 3A	Mixing/loading water-soluble bag	This scenario may overestimate exposure for dry flowable formulations, as all handlers used wettable powder formulations, but it provides the best available exposure estimates.
8	Flagger, Granular	This scenario contains data which did not meet basic quality criteria, but were used because no other data were available.
13	Aerosol Can	All data in this scenario were from a single study, which could not be evaluated by the exposure assessor (study identifiers in PHED are confidential).
15	Hand Spread Bait	All data in this scenario were from a single study, which could not be evaluated by the exposure assessor (study identifiers in PHED are confidential).
19	Aerial Applicator, Granular	All data in this scenario were from a single study, which could not be evaluated by the exposure assessor (study identifiers in PHED are confidential).
21	High Pressure Handwand	All data in this scenario were from a single study, which could not be evaluated by the exposure assessor (study identifiers in PHED are confidential).
23	Low Pressure Handwand Handling Wettable Powder	All data in this scenario were from a single study, which could not be evaluated by the exposure assessor (study identifiers in PHED are confidential).
25	Push-Type Broadcast Spreader	All data in this scenario were from a single study, which could not be evaluated by the exposure assessor (study identifiers in PHED are confidential).
26	Garden Hose End Spreader	All data in this scenario were from a single study, which could not be evaluated by the exposure assessor (study identifiers in PHED are confidential). All applications were to turf, which involves a downward spray that might be anticipated to result in lower exposures than spraying of trees and shrubs, which can require the sprayer to be directed horizontally or even above the head, depending on the part of the plant to be sprayed. Increased spray height has been correlated with increased exposure (Leonas and Yu, 1992; van Hemmen, 1992). Therefore, exposure estimates of handlers applying to shrubs and trees may be underestimated by these data. This scenario contains data which did not meet basic quality criteria, but were used because no other data were available.
27	Belly Grinder Mixer/Loader/ Applicator, Granular	Exposure estimate for workers wearing gloves was calculated from data for ungloved workers, even though there were sufficient observations for a gloved estimate directly from PHED. However, as noted in Scenario 30 of U.S. EPA (1998), "If only grades ABC are used for the gloved data (n=15), the "gloved" hand exposure would be significantly more than the "no gloved" hand exposure ... Therefore, the estimate reported above is based on all grades in order to increase the sample size." To address this issue, U.S. EPA (1998) included E-grade data, to which in combination with the acceptable-quality gloved data resulted in a lower exposure estimate. However, DPR believes that the gloved data should not be used and chose to apply a protection factor with ungloved data to calculate an estimate for workers wearing gloves.

[a] See Appendix I for subset details and exposure estimates. PHED: Pesticide Handlers Exposure Database.

DPR POLICIES AFFECTING PHED-BASED EXPOSURE ESTIMATES

The Arithmetic Mean Is the Appropriate Statistic for Exposure Assessment

Although acknowledging that environmental concentration and exposure monitoring data are likely to be lognormally distributed (Ott, 1990), DPR believes that the arithmetic mean is the appropriate statistic to use in exposure estimates (Powell, 2003). DPR uses

the arithmetic mean exposure for intermediate- or long-term exposures because the parameter of interest for exposure assessment is the overall exposure that a person is expected to have during the averaging period. For environmental samples, the arithmetic mean concentration is the best estimate of the average mass of residue per unit of environmental medium; it is equivalent to compositing all of the samples and measuring the concentration of the mixture (Parkhurst, 1998). This is true regardless of the shape of the underlying distribution.

As explained by Krump (1998), use of the geometric mean based solely on distribution of underlying data "does not give any consideration to how the mean is to be used or interpreted in the analysis." Arguing this case, Dong (1999) pointed out that the purpose of calculating an exposure estimate is generally to compare it to some estimate of toxicity (e.g., the no-observed-adverse-effect-level) in a risk assessment. These toxicity estimates are typically based on arithmetic, rather than geometric, mean dosages administered to laboratory animals. Because of this, it would be inconsistent to compare exposure estimates based on geometric means with toxicity estimates based on arithmetic mean exposures.

Upper-Bound Estimates for Short-Term (Acute) Exposures

DPR generally uses the 95th percentile of daily exposure to estimate short-term exposure. The 95th percentile upper bound is the value such that 95% of anticipated exposures would be lower, and 5% would exceed it. DPR believes upper-bound estimates are appropriate for short-term exposures because high-end exposures are possible, and DPR has an obligation to protect all individuals exposed to pesticides as a result of legal uses. Protecting at the level of "average or typical" exposure would, by definition, suggest that many individuals (anyone with above-average exposure) could be exposed to acutely toxic concentrations.

DPR generally uses the 95th percentile of daily exposure rather than the maximum, because DPR assumes a lognormal distribution, which in theory has an indefinitely large maximum. In practice of course, exposures must have a finite maximum value because a finite amount of AI is applied. The 95th percentile is used by DPR rather than a higher percentile (e.g., 99th percentile), because the higher a percentile, the less reliably it can be estimated. Also, DPR recognizes that the assumed lognormal distribution may not exactly match the actual distribution of exposure values, and that any discrepancy from the lognormal distribution will be greatest at the upper extremes (Ott, 1990). DPR believes that the 95th percentile upper bound is a realistic exposure estimate for short durations.

Sometimes readers of exposure assessments are concerned when upper-bound estimates are considerably larger than the mean. These readers may suggest that upper-bound estimates should not be used if they are much larger than the mean, and that large differences between the mean and upper-bound estimate indicate a problem with the upper bound. However, the estimated difference between the mean and upper bound estimates for short-term exposures is irrelevant to risk assessment. It may or may not be related to the quality of the underlying data.

Evaluation of individual exposure monitoring studies shows that ranges of samples can be quite broad, and can include values that are substantially higher than sample means (e.g., Everhart and Holt, 1982; Grover *et al.*, 1986; Popendorf *et al.*, 1995; Vercruysse *et al.*, 1999). Some studies have reported sample ranges that span orders of magnitude (e.g., Wojeck *et al.*, 1981; Grover *et al.*, 1986; Hines *et al.*, 2001).

Confidence Limits for PHED Exposure Estimates

When using PHED to estimate exposure, DPR uses the 90% UCL on the 95th percentile for short-term exposure, and the 90% UCL on the arithmetic mean for intermediate- and long-term exposures. UCLs are used to account for some of the uncertainty inherent in using PHED and to increase our confidence that exposures are not underestimated.

Confidence limits define interval estimates of a parameter such as a mean. An interval estimate for a mean or upper percentile is valuable because point estimates of these parameters vary from sample to sample (Snedecor and Cochran, 1967). Thus, instead of a single-value estimate for, e.g., a population mean, a confidence interval gives a lower and upper limit for the mean. Confidence intervals are reported with the probability that a series of intervals will capture the true mean; thus a 90% confidence interval is large enough that 90% of the intervals calculated for samples from the same population will contain the true mean.

In using UCLs, DPR is effectively using one-sided upper confidence intervals. One-sided upper confidence intervals are used when it is most important that the true mean (or 95th percentile) not be underestimated. The UCL defines the upper limit of the one-sided confidence interval. The 90% UCL value is high enough that 90% of the UCLs calculated for samples from the same population will be at least as great as the true mean (or true 95th percentile).

Estimating the UCL requires knowing the mean and standard deviation of total dermal exposure. PHED reports the mean of total dermal exposure, but only the coefficients of variation for separate body regions. Insufficient information is provided to calculate the standard deviation of total dermal exposure. In order to approximate the UCLs, DPR makes the assumption that total exposure is lognormally distributed across persons and has a population (not sample) coefficient of variation of 100 percent. The method of approximation is described in Powell (2007), and uses the fact that in any lognormal distribution with a given coefficient of variation, the confidence limits are constant multiples of the arithmetic mean. The value of the multiplier depends only on sample size.

To use the approximation with PHED data, there is one multiplier for the UCL for the mean and another for the UCL for the 95th percentile. In either case, the arithmetic mean exposure is multiplied by a multiplier corresponding to the effective sample size. The exposure estimates given in Appendix I have been calculated incorporating the appropriate multipliers.

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APPENDIX I. SUMMARIES AND EXPOSURE ESTIMATES FOR STANDARD PHED SCENARIOS

This appendix provide detailed information on values used in handler exposure estimates.

For each scenario, two tables and a figure are provided.

- Table 1 gives parameters (specifications) used to generate the subsets.
- Figure 1 is a copy of the PHED "Summary Statistics" output for the dermal subset. (Appendix III explains the elements of the PHED output.)
- Table 2 summarizes calculations and presents estimates to be used in exposure assessments.

Note: All exposure rate estimates were rounded to three significant figures.

Scenario 1: Mixer/Loader, Open Pour, Wettable Powder (With Gloves)

Table 1-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Wettable powder	Wettable powder
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Hand are all Grade A or B; Airborne data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 1-1. Summary of Results from the PHED Dermal Subset for Scenario 1 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	12.1008	159.063	3.243	24
NECK.FRONT	49.7781	241.7376	1.6288	24
NECK.BACK	35.299	250.8502	.9205	24
UPPER ARMS	181.099	412.7976	15.4083	30
CHEST	155.2533	458.3228	9.6478	36
BACK	165.361	437.2647	9.8479	36
FOREARMS	12.2599	180.986	4.6336	28
THIGHS	5.7027	140.9473	2.8042	28
LOWER LEGS	4.046	120.7341	1.9477	28

[a] Subset criteria included actual and estimated head patches. All 24 head observations were actual.

Table 1-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 1 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	623	33 [e]	2,090	750
Hand (with gloves)	23.7	20	83.7	30.1
Inhalation	49.4	17	178	64.0
Total exposure	696	--	2,350	844

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 1A: Mixer/Loader, Open Pour, Wettable Powder (No Gloves)

Table 1A-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Wettable powder	Wettable powder
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Hand are all Grade A or B; Airborne data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 1A-1. Summary of Results from the PHED Dermal Subset for Scenario 1A [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	12.1008	159.063	3.243	24
NECK.FRONT	49.7781	241.7376	1.6288	24
NECK.BACK	35.299	250.8502	.9205	24
UPPER ARMS	181.099	412.7976	15.4083	30
CHEST	155.2533	458.3228	9.6478	36
BACK	165.361	437.2647	9.8479	36
FOREARMS	12.2599	180.986	4.6336	28
THIGHS	5.7027	140.9473	2.8042	28
LOWER LEGS	4.046	120.7341	1.9477	28

[a] Subset criteria included actual and estimated head patches. All 24 head observations were actual.

Table 1A-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 1A [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	623	33 [e]	2,090	750
Hand (no gloves)	9,090	12	34,400	12,400
Inhalation	49.4	17	178	64.0
Total exposure	9,760	--	36,700	13,200

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 2: Mixer/Loader, Open Pour, Dry Flowable (With Gloves)

Table 2-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B,C
Solid Type	Dry flowable	Dry flowable
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality grades for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A or B, with the exception of one dermal replicate that has Dermal Uncovered Grade C (Dermal Covered for that replicate is Grade B). Data quality grades are defined in the text and in Versar (1992).

Figure 2-1. Summary of Results from the PHED Dermal Subset for Scenario 2 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	30.5021	124.7406	11.9921	19
NECK.FRONT	13.9106	102.7059	5.8389	16
NECK.BACK	3.2942	170.3236	.7453	19
UPPER ARMS	8.3504	98.8935	6.5856	23
CHEST	8.9296	67.003	6.7856	26
BACK	6.786	73.1388	4.8789	26
FOREARMS	3.7089	66.0196	3.0986	23
THIGHS	90.2695	296.5869	11.3605	26
LOWER LEGS	17.8317	298.7707	4.2874	26

[a] Subset criteria included actual and estimated head patches. Of the 19 head observations, 16 were actual and 3 were estimated from nearby patches (Versar, 1992).

Table 2-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 2 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	193	25 [e]	664	239
Hand (with gloves)	9.74	21	34.2	12.3
Inhalation	0.655	23	2.28	0.818
Total exposure	203	--	700	252

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 2A: Mixer/Loader, Open Pour, Dry Flowable (No Gloves)

Table 2A-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B,C
Solid Type	Dry flowable	Dry flowable
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality grades for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A or B, with the exception of one dermal replicate that has Dermal Uncovered Grade C (Dermal Covered for that replicate is Grade B). Data quality grades are defined in the text and in Versar (1992).

Figure 2A-1. Summary of Results from the PHED Dermal Subset for Scenario 2A [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	30.5021	124.7406	11.9921	19
NECK.FRONT	13.9106	102.7059	5.8389	16
NECK.BACK	3.2942	170.3236	.7453	19
UPPER ARMS	8.3504	98.8935	6.5856	23
CHEST	8.9296	67.003	6.7856	26
BACK	6.786	73.1388	4.8789	26
FOREARMS	3.7089	66.0196	3.0986	23
THIGHS	90.2695	296.5869	11.3605	26
LOWER LEGS	17.8317	298.7707	4.2874	26

[a] Subset criteria included actual and estimated head patches. Of the 19 head observations, 16 were actual and 3 were estimated from nearby patches (Versar, 1992).

Table 2A-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 2A [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	193	25 [e]	664	239
Hand (no gloves)	15.8	7	65.8	23.6
Inhalation	0.655	23	2.28	0.818
Total exposure	209	--	732	263

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 3: Mixer/Loader, Water Soluble Bags Containing Wettable Powder (With Gloves)

Table 3-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Wettable powder	Wettable Powder
Package Type	Water Soluble Bag	Water Soluble Bag

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Hand are all Grade A or B; Airborne data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 3-1. Summary of Results from the PHED Dermal Subset for Scenario 3 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	3.51	165.0541	1.1942	15
NECK.FRONT	.423	155.9811	.1734	15
NECK.BACK	.2933	167.61	.0978	15
UPPER ARMS	2.619	17.2127	2.5837	6
CHEST	1.8046	83.2317	1.1207	12
BACK	1.8046	83.2317	1.1207	12
FOREARMS	1.089	17.2176	1.0743	6
THIGHS	4.9023	204.1674	1.6636	12
LOWER LEGS	1.19	86.1261	.7092	12

[a] Subset criteria included actual and estimated head patches. All 15 head observations were actual.

Table 3-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 3 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	18.3	11 [e]	70.2	25.2
Hand (with gloves)	0.056	6	0.241	0.0866
Inhalation	0.277	12	1.05	0.377
Total exposure	18.6	--	71.5	25.7

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 3A: Mixer/Loader, Water Soluble Bags Containing Wettable Powder (No Gloves)

Table 3A-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Wettable powder	Wettable Powder
Package Type	Water Soluble Bag	Water Soluble Bag

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Hand are all Grade A or B; Airborne data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 3A-1. Summary of Results from the PHED Dermal Subset for Scenario 3A [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	3.51	165.0541	1.1942	15
NECK.FRONT	.423	155.9811	.1734	15
NECK.BACK	.2933	167.61	.0978	15
UPPER ARMS	2.619	17.2127	2.5837	6
CHEST	1.8046	83.2317	1.1207	12
BACK	1.8046	83.2317	1.1207	12
FOREARMS	1.089	17.2176	1.0743	6
THIGHS	4.9023	204.1674	1.6636	12
LOWER LEGS	1.19	86.1261	.7092	12

[a] Subset criteria included actual and estimated head patches. All 15 head observations were actual.

Table 3A-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 3A [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	18.3	11 [e]	70.2	25.2
Hand (no gloves)	21.7	5	97.3	35.0
Inhalation	0.277	12	1.05	0.377
Total exposure	40.3	--	169	60.6

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 4: Mixer/Loader, Open Pour, Granular

Table 4-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Granular	Granular
Mixing Procedure [c]	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A; Airborne and Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).
[c] Loading by open pour rather than through a closed system (PHED lists as a mixing procedure).

Figure 4-1. Summary of Results from the PHED Dermal Subset for Scenario 4 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.6052	111.649	.4573	29
NECK.FRONT	1.27	114.3228	.5317	3
NECK.BACK	.1063	155.3151	.033	3
UPPER ARMS	1.067	127.0853	.768	36
CHEST	1.3555	126.3593	.9812	33
BACK	1.3555	126.3593	.9812	33
FOREARMS	.4974	128.9505	.3399	36
THIGHS	1.227	100.8068	.9099	33
LOWER LEGS	.7801	101.9997	.5622	36

[a] Subset criteria included actual and estimated head patches. All 29 head observations were actual.

Table 4-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 4 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	8.67	12 [e]	32.8	11.8
Hand (with gloves)	0.977	45	3.19	1.15
Hand (no gloves) [f]	9.77	45	31.9	11.5
Inhalation	3.45	58	11.0	3.97
Total exposure (with gloves)	13.1	--	47.0	16.9
Total exposure (no gloves)	21.9	--	75.7	27.3

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 5: Mixer/Loader, Open Pour, Liquids (With Gloves)

Table 5-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type	Emulsifiable concentrate, aqueous suspension, microencapsulated, solution, or undiluted liquid	Emulsifiable concentrate, solution
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Airborne are all Grade A or B; Hand data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 5-1. Summary of Results from the PHED Dermal Subset for Scenario 5 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	127.9871	495.5875	4.1314	122
NECK.FRONT	23.0158	362.6609	1.7263	104
NECK.BACK	15.5714	383.462	.5412	110
UPPER ARMS	157.6735	903.2036	1.4925	90
CHEST	19.0359	263.976	3.4214	90
BACK	10.8933	223.0206	1.8685	89
FOREARMS	4.4266	211.9821	.8927	84
THIGHS	16.6064	198.1742	3.9823	72
LOWER LEGS	37.8101	824.4477	1.1046	82

[a] Subset criteria included actual and estimated head patches. Of the 122 head observations, 96 were actual and 26 were estimated from nearby patches (Versar, 1992).

Table 5-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 5 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	433	99 [e]	1,340	482
Hand (with gloves)	58.2	59	186	66.9
Inhalation	2.35	85	7.34	2.64
Total exposure	494	--	1,530	552

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 5A: Mixer/Loader, Open Pour, Liquids (No Gloves)

Table 5A-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type	Emulsifiable concentrate, aqueous suspension, microencapsulated, solution, or undiluted liquid	Emulsifiable concentrate, solution
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered and Airborne are all Grade A or B; Hand data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 5A-1. Summary of Results from the PHED Dermal Subset for Scenario 5A [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	127.9871	495.5875	4.1314	122
NECK.FRONT	23.0158	362.6609	1.7263	104
NECK.BACK	15.5714	383.462	.5412	110
UPPER ARMS	157.6735	903.2036	1.4925	90
CHEST	19.0359	263.976	3.4214	90
BACK	10.8933	223.0206	1.8685	89
FOREARMS	4.4266	211.9821	.8927	84
THIGHS	16.6064	198.1742	3.9823	72
LOWER LEGS	37.8101	824.4477	1.1046	82

[a] Subset criteria included actual and estimated head patches. Of the 122 head observations, 96 were actual and 26 were estimated from nearby patches (Versar, 1992).

Table 5A-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 5A [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	433	99 [e]	1,340	482
Hand (no gloves)	21,500	53	69,200	24,900
Inhalation	2.35	85	7.34	2.64
Total exposure	21,900	--	70,500	25,400

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 6: Mixer/Loader, Closed System, Liquids

Table 6-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A
Liquid Type	Emulsifiable concentrate, aqueous suspension, microencapsulated, solution, or undiluted liquid	All emulsifiable concentrate
Mixing Procedure	Closed, mechanical pump or gravity feed	Closed

[a] Subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 6-1. Summary of Results from the PHED Dermal Subset for Scenario 6 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	1.6959	121.3279	.9508	22
NECK.FRONT	1.5225	278.5222	.2418	22
NECK.BACK	.456	280.8991	.0729	22
UPPER ARMS	1.3441	96.6967	.7988	21
CHEST	1.8416	93.4405	1.0577	16
BACK	1.8416	93.4405	1.0577	16
FOREARMS	.5474	98.5203	.3206	21
THIGHS	2.3398	81.9301	1.5773	16
LOWER LEGS	1.292	85.7276	.8778	21

[a] Subset criteria included actual and estimated head patches. All 22 head observations were actual.

Table 6-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 6 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	13.6	18 [e]	48.6	17.5
Hand (with gloves)	5.72	31	19.3	6.93
Hand (no gloves) [f]	57.2	31	193	69.3
Inhalation	0.128	27	0.437	0.157
Total exposure (with gloves)	19.5	--	68.3	24.6
Total exposure (no gloves)	70.9	--	242	87.0

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 7: Flagger, Liquids

Table 7-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate or dry flowable
Application Method	Fixed- or rotary-wing	All rotary-wing

[a] Subsets of Flagger data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A; Airborne and Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 7-1. Summary of Results from the PHED Dermal Subset for Scenario 7 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	11.3028	127.5702	5.6188	18
NECK.FRONT	.9533	134.3334	.5146	18
NECK.BACK	1.4111	215.8529	.4931	18
UPPER ARMS	3.9285	195.1025	.8284	28
CHEST	5.1065	188.8378	1.0384	26
BACK	5.1065	188.8378	1.0384	26
FOREARMS	1.802	179.5283	.3837	28
THIGHS	4.0404	308.6996	.9165	26
LOWER LEGS	2.448	305.6618	.612	28

[a] Subset criteria included actual and estimated head patches. All 18 head observations were actual.

Table 7-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 7 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	37.4	21 [e]	131	47.2
Hand (with gloves) [f]	5.97	30	2.02	0.725
Hand (no gloves)	59.7	30	20.2	7.25
Inhalation	0.200	28	0.680	0.245
Total exposure (with gloves)	43.6	--	134	48.2
Total exposure (no gloves)	97.3	--	152	54.7

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 8: Flagger, Granular

Table 8-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subset [a]	Actual characteristics of subset
Data Quality Grades [b]		
Airborne	Not specified	E
Dermal	A, B, C	C
Hand	Not specified	E
Solid Type	Granular	Granular
Application Method	Fixed- or rotary-wing	All rotary-wing

[a] Subset of Flagger data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality grades are defined in the text and in Versar (1992).

Figure 8-1. Summary of Results from the PHED Dermal Subset for Scenario 8 [a]

SCENARIO: No clothing (total deposition)

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.4875	72.3282	.3785	20
NECK.FRONT	.042	73.8095	.0328	20
NECK.BACK	.0396	97.9798	.0286	20
UPPER ARMS	1.2804	85.1687	.9177	20
CHEST	.994	73.833	.7761	20
BACK	1.278	98.0673	.923	20
FOREARMS	.4659	89.6759	.3491	20
THIGHS	1.1842	62.709	.979	20
LOWER LEGS	.7735	64.0465	.6327	16

[a] Subset criteria included actual and estimated head patches. All 20 head observations were estimated. "No clothing (total deposition)" means that exposure monitoring used patches outside of clothing.

Table 8-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 8 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	1.56	20 [e]	5.51	1.98
Hand (with gloves) [f]	0.0025	4	0.0119	0.00426
Hand (no gloves)	0.025	4	0.119	0.0426
Inhalation	0.124	4	0.588	0.211
Total exposure (with gloves)	1.69	--	6.11	2.20
Total exposure (no gloves)	1.71	--	6.22	2.23

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997). Also, upper arms, chest, back, forearms, thighs, lower legs and feet were multiplied by 0.1 for work clothing, 90% protection factor (Thongsinthusak *et al.*, 1991).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 9: Airblast Applicator, Open Cab (With Gloves)

Table 9-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate, dry flowable or wettable powder
Application Method	Airblast	Airblast
Cab Type	Open Cab or Closed Cab with Open Window	Open Cab or Closed Cab with Open Window

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 9-1. Summary of Results from the PHED Dermal Subset for Scenario 9 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	778.5762	155.5207	176.2608	42
NECK.FRONT	37.1325	147.948	12.193	38
NECK.BACK	27.8342	159.3144	8.7825	42
UPPER ARMS	42.3987	265.4846	6.4049	40
CHEST	21.8289	177.8784	5.4396	49
BACK	14.7289	174.1332	4.204	49
FOREARMS	7.4511	148.7525	2.0066	38
THIGHS	56.8344	189.968	16.9924	32
LOWER LEGS	17.2699	129.16	7.0944	32

[a] Subset criteria included actual and estimated head patches. Of the 42 head observations, 41 were actual and 1 was estimated from nearby patches (Versar, 1992).

Table 9-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 9 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	1,010	42 [e]	3,310	1,190
Hand (with gloves)	8.52	18	30.5	11.0
Inhalation	5.41	47	17.6	6.32
Total exposure	1,020	--	3,360	1,210

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 9A: Airblast Applicator, Open Cab (No Gloves)

Table 9A-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate, dry flowable or wettable powder
Application Method	Airblast	Airblast
Cab Type	Open Cab or Closed Cab with Open Window	Open Cab or Closed Cab with Open Window

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 9A-1. Summary of Results from the PHED Dermal Subset for Scenario 9A [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	778.5762	155.5207	176.2608	42
NECK.FRONT	37.1325	147.948	12.193	38
NECK.BACK	27.8342	159.3144	8.7825	42
UPPER ARMS	42.3987	265.4846	6.4049	40
CHEST	21.8289	177.8784	5.4396	49
BACK	14.7289	174.1332	4.204	49
FOREARMS	7.4511	148.7525	2.0066	38
THIGHS	56.8344	189.968	16.9924	32
LOWER LEGS	17.2699	129.16	7.0944	32

[a] Subset criteria included actual and estimated head patches. Of the 42 head observations, 41 were actual and 1 was estimated from nearby patches (Versar, 1992).

Table 9A-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 9A [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	1,010	42 [e]	3,310	1,190
Hand (no gloves)	645	22	2,250	810
Inhalation	5.41	47	17.6	6.32
Total exposure	1,660	--	5,580	2,010

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 10: Airblast Applicator, Closed Cab

Table 10-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Airborne Data Quality Grades [b]	A,B,C	A,C
Dermal and Hand Data Quality [b]	A,B	A,B
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate or dry flowable
Application Method	Airblast	Airblast
Cab Type	Closed Cab or Closed Cab with Filtered Air	Closed Cab or Closed Cab with Filtered Air

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A or B; Hand data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 10-1. Summary of Results from the PHED Dermal Subset for Scenario 10 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	9.269	186.7612	3.3373	20
NECK.FRONT	.936	96.5812	.653	20
NECK.BACK	.3795	172.6482	.1877	20
UPPER ARMS	.7469	108.6089	.5098	30
CHEST	1.2543	118.3927	.7449	30
BACK	.9112	108.604	.6219	30
FOREARMS	.726	156.3499	.3357	30
THIGHS	2.4957	315.0419	.7696	30
LOWER LEGS	.6585	107.6689	.4411	30

[a] Subset criteria included actual and estimated head patches. Of the 20 head observations, 4 were actual and 16 were estimated from nearby patches (Versar, 1992).

Table 10-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 10 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	17.7	30 [e]	62.1	22.3
Hand (with gloves)	17.3	20	61.1	22.0
Hand (no gloves) [f]	173	20	611	220
Inhalation	0.449	9	1.78	0.641
Total exposure (with gloves)	35.4	--	125	44.9
Total exposure (no gloves)	191	--	675	243

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 11: Groundboom Applicator, Open Cab

Table 11-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B,C
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate or wettable powder
Application Method	Groundboom, Truck or Tractor	Groundboom, Tractor
Cab Type	Open Cab or Closed Cab with Open Window	Open Cab or Closed Cab with Open Window

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality grades for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A or B, with the exception of one dermal replicate that has Dermal Uncovered Grade C (Dermal Covered for that replicate is Grade B). Data quality grades are defined in the text and in Versar (1992).

Figure 11-1. Summary of Results from the PHED Dermal Subset for Scenario 11 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	2.7891	136.1192	1.0464	33
NECK.FRONT	1.5763	167.9503	.3296	23
NECK.BACK	1.0063	173.5765	.2335	29
UPPER ARMS	1.6914	88.749	1.1637	32
CHEST	1.7581	98.5154	1.1329	42
BACK	3.0175	233.2361	1.3959	42
FOREARMS	2.7301	419.1055	.564	32
THIGHS	3.1255	185.5703	1.1806	33
LOWER LEGS	2.1148	172.3425	.7466	35

[a] Subset criteria included actual and estimated head patches. All 33 head observations were actual.

Table 11-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 11 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	20.9	34 [e]	69.8	25.1
Hand (with gloves) [f]	4.56	29	15.5	5.56
Hand (no gloves)	45.6	29	155	55.6
Inhalation	1.18	22	4.12	1.48
Total exposure (with gloves)	26.6	--	89.4	32.1
Total exposure (no gloves)	67.7	--	229	82.2

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 12: Groundboom Applicator, Closed Cab

Table 12-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type or Solid Type	Not specified	Emulsifiable concentrate or wettable powder
Application Method	Groundboom, Truck or Tractor	Groundboom, Tractor
Cab Type	Closed Cab or Closed Cab with Filtered Air	Closed Cab or Closed Cab with Filtered Air

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered and Dermal Covered are all Grade A; Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 12-1. Summary of Results from the PHED Dermal Subset for Scenario 12 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.2031	70.0148	.1729	16
NECK.FRONT	.0647	234.6213	.028	16
NECK.BACK	.0179	67.0391	.0153	16
UPPER ARMS	.4365	73.0355	.3707	16
CHEST	.355	0	.355	8
BACK	.355	0	.355	8
FOREARMS	.2647	118.2849	.187	16
THIGHS	1.337	50.6507	1.176	8
LOWER LEGS	1.071	93.9309	.7651	16

[a] Subset criteria included actual and estimated head patches. All 16 head observations were actual.

Table 12-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 12 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	4.66	10 [e]	18.2	6.53
Hand (with gloves) [f]	0.187	12	0.708	0.254
Hand (no gloves)	1.87	12	7.08	2.54
Inhalation	0.040	16	0.145	0.0522
Total exposure (with gloves)	4.89	--	19.1	6.84
Total exposure (no gloves)	6.68	--	25.4	9.12

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 13: Aerosol Can Applicator (With Gloves)

Table 13-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A
Application Method	Aerosol Can	Aerosol Can

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 13-1. Summary of Results from the PHED Dermal Subset for Scenario 13 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	69769.2667	124.9606	41026.2018	15
NECK.FRONT	7149.9	217.7599	2512.8897	15
NECK.BACK	2612.3533	80.9252	1995.1883	15
UPPER ARMS	5907.3	0	5907.0886	15
CHEST	7206.5	0	7206.2421	15
BACK	7206.5	0	7206.2421	15
FOREARMS	2737.4233	39.7741	2625.4536	15
THIGHS	7754.6	0	7754.3224	15
LOWER LEGS	4831.4	0	4831.2271	15

[a] Subset criteria included actual and estimated head patches. All 15 head observations were actual.

Table 13-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 13 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	118,000	15 [e]	432,000	155,000
Hand (with gloves)	1,670	15	6,120	2,200
Inhalation	1,040	15	3,810	1,370
Total exposure	121,000	--	442,000	159,000

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 13A: Aerosol Can Applicator (No Gloves)

Table 13A-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A
Application Method	Aerosol Can	Aerosol Can

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered and Hand are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 13A-1. Summary of Results from the PHED Dermal Subset for Scenario 13A [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	69769.2667	124.9606	41026.2018	15
NECK.FRONT	7149.9	217.7599	2512.8897	15
NECK.BACK	2612.3533	80.9252	1995.1883	15
UPPER ARMS	5907.3	0	5907.0886	15
CHEST	7206.5	0	7206.2421	15
BACK	7206.5	0	7206.2421	15
FOREARMS	2737.4233	39.7741	2625.4536	15
THIGHS	7754.6	0	7754.3224	15
LOWER LEGS	4831.4	0	4831.2271	15

[a] Subset criteria included actual and estimated head patches. All 15 head observations were actual.

Table 13A-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 13A [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	118,000	15 [e]	432,000	155,000
Hand (no gloves)	121,000	15	443,000	159,000
Inhalation	1,040	15	3,810	1,370
Total exposure	240,000	--	879,000	315,000

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 14: Broadcast Spreader Applicator (Closed Cab, Truck or Tractor), Granular (With Gloves)

Table 14-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Granular	Granular
Application Method	Broadcast spreader (tractor/truck/ag uses) [c]	Broadcast spreader (tractor/truck/ag uses) [c]
Cab Type [d]	Closed Cab or Closed Cab with Filtered Air	Closed Cab or Closed Cab with Filtered Air

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A; Airborne and Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).
[c] This application method is specified with this exact phrase in PHED, and is distinguished from hand-held granular spreaders used on turf.
[d] Cab type specified to eliminate 4 observations with open cab (insufficient data to estimate exposure for applicators with open cabs).

Figure 14-1. Summary of Results from the PHED Dermal Subset for Scenario 14 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.13	0	.13	27
NECK.FRONT	.015	0	.015	2
NECK.BACK	.011	0	.011	2
UPPER ARMS	.291	0	.291	30
CHEST	.355	0	.355	28
BACK	.355	0	.355	28
FOREARMS	.1335	50.4869	.1269	29
THIGHS	.4244	28.8172	.4126	27
LOWER LEGS	.2626	28.1036	.2557	29

[a] Subset criteria included actual and estimated head patches. All 27 head observations were actual.

Table 14-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 14 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	2.11	28 [e]	7.18	2.58
Hand (with gloves)	0.171	17	0.616	0.222
Inhalation	0.220	37	0.729	0.262
Total exposure	2.50	--	8.52	3.06

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 14A: Broadcast Spreader Applicator (Closed Cab, Truck or Tractor), Granular (No Gloves)

Table 14A-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Solid Type	Granular	Granular
Application Method	Broadcast spreader (tractor/truck/ag uses) [c]	Broadcast spreader (tractor/truck/ag uses) [c]
Cab Type [d]	Closed Cab or Closed Cab with Filtered Air	Closed Cab or Closed Cab with Filtered Air

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A; Airborne and Hand data are all Grade A or B. Data quality grades are defined in the text and in Versar (1992).
[c] This application method is specified with this exact phrase in PHED, and is distinguished from hand-held granular spreaders used on turf.
[d] Cab type specified to eliminate 4 observations with open cab (insufficient data to estimate exposure for applicators with open cabs).

Figure 14A-1. Summary of Results from the PHED Dermal Subset for Scenario 14A [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.13	0	.13	27
NECK.FRONT	.015	0	.015	2
NECK.BACK	.011	0	.011	2
UPPER ARMS	.291	0	.291	30
CHEST	.355	0	.355	28
BACK	.355	0	.355	28
FOREARMS	.1335	50.4869	.1269	29
THIGHS	.4244	28.8172	.4126	27
LOWER LEGS	.2626	28.1036	.2557	29

[a] Subset criteria included actual and estimated head patches. All 27 head observations were actual.

Table 14A-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 14A [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	2.11	28 [e]	7.18	2.58
Hand (no gloves)	0.326	24	1.13	0.405
Inhalation	0.220	37	0.729	0.262
Total exposure	2.66	--	9.04	3.25

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 15: Hand Spreading of Bait, Applicator (With Gloves)

Table 15-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Solid Type	Granular	Granular
Application Method	Other	Other
Study Code	Exclude 1027 [c]	520

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered are all Grade A or C; Hand data are all Grade C. Data quality grades are defined in the text and in Versar (1992).
[c] Study 1027 omitted because applications done with a Lesco spreader (identified in Applicator Make/Model field), rather than by hand. No application equipment is listed in Study Code 520 (field is blank).

Figure 15-1. Summary of Results from the PHED Dermal Subset for Scenario 15 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	5911.8638	65.7229	4628.6454	16
NECK.FRONT	788.2688	56.8973	652.267	16
NECK.BACK	500.2346	65.7229	391.6546	16
UPPER ARMS	13233.4796	65.7229	10361.0448	16
CHEST	16143.9356	65.7229	12639.7626	16
BACK	16143.9356	65.7229	12639.7626	16
FOREARMS	5502.5809	65.7229	4308.2008	16
THIGHS	17371.7842	65.7229	13601.0966	16
LOWER LEGS	10823.2582	65.7229	8473.9817	16

[a] Subset criteria included actual and estimated head patches. All 16 head observations were actual.

Table 15-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 15 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	92,000	16 [e]	334,000	120,000
Hand (with gloves)	4,660	15	17,100	6,140
Inhalation	350	16	1,270	457
Total exposure	97,000	--	352,000	127,000

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.

Scenario 16: Right-of-Way Sprayer, Applicator

Table 16-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Liquid Type or Solid Type	Not specified	All Solution
Application Method	Right-of-Way Sprayer	Right-of-Way Sprayer

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered were Grade A or C; Hand data were Grade A or B; Airborne data were all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 16-1. Summary of Results from the PHED Dermal Subset for Scenario 16 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	10389.132	222.4426	167.8616	5
NECK.FRONT	9.4125	139.336	4.7775	4
NECK.BACK	8.1702	164.4586	2.5677	4
UPPER ARMS	90.6756	111.704	59.7682	20
CHEST	105.648	119.5292	61.4217	20
BACK	103.9262	122.7038	53.7938	20
FOREARMS	42.7312	99.0744	29.3127	20
THIGHS	61.9604	379.0122	6.2685	20
LOWER LEGS	10.234	201.7921	3.5633	20

[a] Subset criteria included actual and estimated head patches. All 5 head observations were actual.

Table 16-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 16 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	10,800	5 [e]	48,400	17,400
Hand (with gloves) [f]	111	16	403	145
Hand (no gloves)	1,110	16	4,030	1,450
Inhalation	3.39	16	12.3	4.43
Total exposure (with gloves)	10,900	--	48,800	17,500
Total exposure (no gloves)	11,900	--	52,400	18,900

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 17: Aerial Applicator, Liquids, Open Cockpit

Table 17-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Liquid Type	Not specified	All emulsifiable concentrate
Solid Type	Exclude granular	none
Application Method	Fixed- or rotary-wing	All fixed-wing
Cab Type	Open Cockpit or Closed Cockpit with Open Window	Open Cockpit or Closed Cockpit with Open Window

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered, and Hand were Grade A or C; Airborne data were Grade B or C. Data quality grades are defined in the text and in Versar (1992).

Figure 17-1. Summary of Results from the PHED Dermal Subset for Scenario 17 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	4.212	118.2574	1.2438	10
NECK.FRONT	.414	143.6715	.1169	10
NECK.BACK	.3124	139.1485	.0741	10
UPPER ARMS	8.5554	109.6232	5.7532	10
CHEST	6.3065	158.1987	2.1395	17
BACK	8.7497	141.5614	3.131	17
FOREARMS	2.7901	131.7516	1.1744	17
THIGHS	9.55	157.4126	3.4718	13
LOWER LEGS	7.4494	138.0769	3.3312	10

[a] Subset criteria included actual and estimated head patches. Of the 10 head observations, 7 were actual and 3 were estimated from nearby patches (Versar, 1992).

Table 17-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 17 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	52.2	12 [e]	198	71.0
Hand (with gloves)	9.63	9	38.2	13.7
Hand (no gloves) [f]	96.3	9	382	137
Inhalation	0.573	14	2.12	0.762
Total exposure (with gloves)	62.4	--	238	85.5
Total exposure (no gloves)	149	--	582	209

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 18: Aerial Applicator, Liquids, Closed Cockpit

Table 18-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type	Not specified	All emulsifiable concentrate
Solid Type	Exclude granular	none
Application Method	Fixed- or rotary-wing	Fixed- or rotary-wing
Cab Type	Closed Cockpit, closed windows or Closed Cockpit, closed windows with filtered air	Closed Cockpit, closed windows or Closed Cockpit, closed windows with filtered air

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered, and Hand were Grade A or B; Airborne data were all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 18-1. Summary of Results from the PHED Dermal Subset for Scenario 18 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.4689	190.9362	.2178	28
NECK.FRONT	.0413	164.4068	.0239	28
NECK.BACK	.033	181.8182	.0169	28
UPPER ARMS	.3274	44.4411	.3117	16
CHEST	.355	0	.355	14
BACK	.355	0	.355	14
FOREARMS	.1452	35.124	.139	10
THIGHS	.382	0	.382	14
LOWER LEGS	.2975	54.6555	.273	16

[a] Subset criteria included actual and estimated head patches. All 28 head observations were actual.

Table 18-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 18 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	2.56	17 [e]	9.22	3.32
Hand (with gloves) [f]	0.957	36	3.18	1.14
Hand (no gloves)	9.57	36	31.8	11.4
Inhalation	0.025	15	0.0916	0.0329
Total exposure (with gloves)	3.54	--	12.5	4.49
Total exposure (no gloves)	12.2	--	41.1	14.8

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 19: Aerial Applicator, Granular, Closed Cockpit

Table 19-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	C
Solid Type	Granular	Granular
Application Method	Fixed- or rotary-wing	Fixed- or rotary-wing
Cab Type	Closed Cockpit, closed windows or Closed Cockpit, closed windows with filtered air	Closed Cockpit, closed windows or Closed Cockpit, closed windows with filtered air

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Hand, Dermal Uncovered and Dermal Covered were all Grade C. Data quality grades are defined in the text and in Versar (1992).

Figure 19-1. Summary of Results from the PHED Dermal Subset for Scenario 19 [a]

SCENARIO: No clothing (total deposition)

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	.38	77.0789	.2981	13
NECK.FRONT	.0381	74.8031	.0312	13
NECK.BACK	.0322	77.0186	.0252	13
UPPER ARMS	.8954	84.398	.6802	13
CHEST	.9012	74.767	.7392	13
BACK	1.0377	77.0839	.814	13
FOREARMS	.3909	92.9905	.2872	13
THIGHS	1.0285	61.3807	.8759	13
LOWER LEGS	.6876	63.4526	.5799	9

[a] Subset criteria included actual and estimated head patches. All 13 head observations were estimated from nearby patches (Versar, 1992). "No clothing (total deposition)" means that exposure monitoring used patches outside of clothing.

Table 19-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 19 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	0.977	12 [e]	3.70	1.33
Hand (with gloves)	0.091	9	0.361	0.130
Hand (no gloves) [f]	0.910	9	3.61	1.30
Inhalation	1.14	9	4.52	1.63
Total exposure (with gloves)	2.21	--	8.58	3.09
Total exposure (no gloves)	3.03	--	11.8	4.26

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997). Also, upper arms, chest, back, forearms, thighs, lower legs and feet were multiplied by 0.1 for work clothing, 90% protection factor (Thongsinthusak *et al.*, 1991).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 20: Backpack Mixer/Loader/Applicator, Liquid (Open Pour)

Table 20-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Liquid Type	Not specified	Solution, Microencapsulated
Application Method	Backpack	Backpack
Mixing Procedure	Open	Open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered are all Grade A or B; Hand data are all Grade C. Data quality grades are defined in the text and in Versar (1992).

Figure 20-1. Summary of Results from the PHED Dermal Subset for Scenario 20 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	345.2564	194.899	91.4483	11
NECK.FRONT	178.6391	155.1078	38.2719	11
NECK.BACK	1163.209	108.1731	611.9794	11
UPPER ARMS	10116.4827	239.4633	257.2654	11
CHEST	275.4477	170.903	65.7564	11
BACK	8918.1809	167.9854	1044.0635	11
FOREARMS	153.593	184.2219	30.0425	11
THIGHS	597.2782	282.8189	49.147	9
LOWER LEGS	425.8878	230.6324	64.6874	9

[a] Subset criteria included actual and estimated head patches. All 11 head observations were actual.

Table 20-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 20 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	22,300	11 [e]	85,600	30,800
Hand (with gloves)	9.68	11	37.1	13.4
Hand (no gloves) [f]	96.8	11	371	134
Inhalation	17.5	11	67.1	24.1
Total exposure (with gloves)	22,300	--	85,700	30,800
Total exposure (no gloves)	22,400	--	86,000	31,000

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 21: High Pressure Handwand Mixer/Loader/Applicator, Liquid (Open Pour)

Table 21-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Liquid Type	Not specified	Microencapsulated
Application Method	High pressure hand wand	High Pressure Handwand, Greenhouse/Ornamental
Mixing Procedure	Open	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered are all Grade A; Hand data are all Grade C. Data quality grades are defined in the text and in Versar (1992).

Figure 21-1. Summary of Results from the PHED Dermal Subset for Scenario 21 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	335.34	189.3598	108.1326	13
NECK.FRONT	684.7243	169.8879	240.7374	7
NECK.BACK	502.1311	169.8879	176.5408	7
UPPER ARMS	1000.3013	153.8867	353.808	13
CHEST	1220.2988	153.8867	431.6215	13
BACK	1220.2988	153.8867	431.6215	13
FOREARMS	415.9328	153.8867	147.1161	13
THIGHS	614.7471	125.9135	325.0308	7
LOWER LEGS	383.01	125.9135	202.5061	7

[a] Subset criteria included actual and estimated head patches. All 13 head observations were actual.

Table 21-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 21 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	6,580	11 [e]	25,200	9,080
Hand (with gloves)	339	13	1,270	456
Hand (no gloves) [f]	3,390	13	12,700	4,560
Inhalation	151	13	565	203
Total exposure (with gloves)	7,070	--	27,000	9,740
Total exposure (no gloves)	10,100	--	38,500	13,800

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 22: Low Pressure Handwand Mixer/Loader/Applicator, Liquid (Open Pour)

Table 22-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]		
Airborne	A,B	A, B
Dermal and Hand	A, B, C	A, B, C
Liquid Type	Emulsifiable concentrate, aqueous suspension, microencapsulated, solution, or undiluted liquid	Solution or Microencapsulated
Application Method	Low Pressure Handwand	Low Pressure Handwand
Mixing Procedure	Not specified	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality grades are defined in the text and in Versar (1992).

Figure 22-1. Summary of Results from the PHED Dermal Subset for Scenario 22 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	658.5361	136.7049	290.5017	80
NECK.FRONT	137.9226	369.6483	18.9272	80
NECK.BACK	86.3274	429.9868	14.8349	79
UPPER ARMS	111.8313	232.934	32.6211	10
CHEST	235.1875	185.929	48.9756	10
BACK	163.797	202.4421	41.5723	10
FOREARMS	40.9585	267.6492	9.412	10
THIGHS	37.9878	115.1859	27.6737	9
LOWER LEGS	66.9309	164.3135	30.0241	9

[a] Subset criteria included actual and estimated head patches. Of the 80 head observations, 10 were actual and 70 were estimated from nearby patches (Versar, 1992).

Table 22-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 22 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	1,570	35 [e]	5,230	1,880
Hand (with gloves)	10.4	10	40.5	14.6
Hand (no gloves) [f]	104	10	405	146
Inhalation	22.8	10	88.9	31.9
Total exposure (with gloves)	1,600	--	5,360	1,930
Total exposure (no gloves)	1,700	--	5,720	2,060

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 23: Low Pressure Handwand Mixer/Loader/Applicator, Wettable Powder Formulations

Table 23-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Solid Type	Wettable powder	Wettable powder
Application Method	Low Pressure Handwand	Low Pressure Handwand
Mixing Procedure	Not specified	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne, Dermal Uncovered, Dermal Covered are all Grade C; Hand data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 23-1. Summary of Results from the PHED Dermal Subset for Scenario 23 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	2636.0019	179.0708	1267.5067	16
NECK.FRONT	756.6675	296.038	176.9167	16
NECK.BACK	151.0809	73.0526	109.8324	16
UPPER ARMS	494.7182	36.3833	463.0868	16
CHEST	700.3928	71.0002	603.0781	16
BACK	611.7981	38.4089	569.1622	16
FOREARMS	448.2142	146.8857	287.9792	16
THIGHS	5126.2967	165.785	2440.9362	16
LOWER LEGS	458.983	52.9223	410.828	16

[a] Subset criteria included actual and estimated head patches. All 16 head observations were actual.

Table 23-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 23 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	11,600	16 [e]	42,100	15,100
Hand (with gloves)	3,430	15	12,600	4,520
Hand (no gloves) [f]	34,300	15	126,000	45,200
Inhalation	1,040	16	3,780	1,360
Total exposure (with gloves)	16,100	--	58,500	21,000
Total exposure (no gloves)	46,900	--	172,000	61,700

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 24: Termiticide Injection Mixer/Loader/Applicator, Liquids

Table 24-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B	A,B
Liquid Type	Not specified	All Aqueous Suspension
Application Method	Termiticide Injection	Termiticide Injection
Mixing Procedure	Not specified	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered are all Grade A or B; Airborne and Hand data are all Grade A. Data quality grades are defined in the text and in Versar (1992).

Figure 24-1. Summary of Results from the PHED Dermal Subset for Scenario 24 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	81.6171	176.1534	16.2653	17
NECK.FRONT	316.4232	315.0398	14.0868	17
NECK.BACK	1.7839	175.6657	.6259	17
UPPER ARMS	9.7228	101.2424	5.6498	17
CHEST	13.4274	110.0429	7.7291	17
BACK	6.9538	91.0926	4.3841	17
FOREARMS	16.6838	102.2351	9.714	17
THIGHS	768.7862	188.4758	162.7054	17
LOWER LEGS	52.374	77.4787	36.2681	17

[a] Subset criteria included actual and estimated head patches. All 17 head observations were actual.

Table 24-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 24 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	1,290	17 [e]	4,650	1,670
Hand (with gloves)	254	17	915	329
Hand (no gloves) [f]	2,540	17	9,150	3,290
Inhalation	1.75	17	6.30	2.27
Total exposure (with gloves)	1,550	--	5,570	2,000
Total exposure (no gloves)	3,830	--	13,800	4,960

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of bare hands is calculated as ten times exposure of gloved hands.

Scenario 25: Push (Scotts)-Type Broadcast Spreader Mixer/Loader/Applicator, Granular

Table 25-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Solid Type	Granular	Granular
Application Method	Broadcast spreader, Scotts type	Broadcast spreader, Scotts type
Mixing Procedure	Not specified	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered, Dermal Covered, and Hand were Grade C; Airborne data were all Grade B. Data quality grades are defined in the text and in Versar (1992).

Figure 25-1. Summary of Results from the PHED Dermal Subset for Scenario 25 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)				0
NECK.FRONT				0
NECK.BACK				0
UPPER ARMS	322.4862	141.6077	200.2811	15
CHEST	393.411	141.6077	244.3291	15
BACK	393.411	141.6077	244.3291	15
FOREARMS	134.0922	141.6077	83.2784	15
THIGHS	397.8912	119.3712	198.8172	15
LOWER LEGS	247.9008	119.3712	123.8704	15

[a] Subset criteria included actual and estimated head patches. No head observations in subset.

Table 25-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 25 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	2,190	15 [e]	8,020	2,880
Hand (with gloves) [f]	243	15	890	320
Hand (no gloves)	2,430	15	8,900	3,200
Inhalation	5.83	15	21.4	7.68
Total exposure (with gloves)	2,440	--	8,930	3,210
Total exposure (no gloves)	4,630	--	16,900	6,090

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area and by addition of default head and neck value of 0.48 x (value for chest); ratio of surface areas (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 26: Garden Hose End Sprayer Mixer/Loader/Applicator, Open Pour

Table 26-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C (except hands; not specified)	C or E
Liquid Type	Not specified	All Solution
Application Method	Garden-hose-end sprayer (residential)	Garden-hose-end sprayer(residential)
Mixing Procedure	Not specified	All open

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Airborne and Dermal Uncovered were all Grade C. Hand data were all Grade E. Data quality grades are defined in the text and in Versar (1992).

Figure 26-1. Summary of Results from the PHED Dermal Subset for Scenario 26 [a]

SCENARIO: No clothing (total deposition)

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	520.6988	82.6901	393.5742	8
NECK.FRONT	73.8637	118.0917	44.7307	8
NECK.BACK	53.1781	122.7107	28.7246	8
UPPER ARMS	902.5729	50.5155	800.8678	8
CHEST	1748.1087	118.0916	1058.6268	8
BACK	1716.2031	122.7107	927.0225	8
FOREARMS	594.5486	116.5038	339.8912	8
THIGHS	1778.8308	64.8833	1526.4968	8
LOWER LEGS	1098.8758	50.0588	965.4128	8

[a] All 8 head observations were estimated from nearby patches (Versar, 1992). "No clothing (total deposition)" means that exposure monitoring used patches outside of clothing.

Table 26-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 26 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	1,460	8 [e]	5,920	2,130
Hand (with gloves) [f]	4,840	8	19,600	7,060
Hand (no gloves)	48,400	8	196,000	70,600
Inhalation	13.4	8	54.3	19.5
Total exposure (with gloves)	6,310	--	25,600	9,210
Total exposure (no gloves)	49,900	--	202,000	72,700

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997). Also, upper arms, chest, back, forearms, thighs, lower legs and feet were multiplied by 0.1 for work clothing, 90% protection factor (Thongsinthusak *et al.*, 1991).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 27: Belly Grinder Mixer/Loader/Applicator, Granular

Table 27-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	A,B,C
Solid Type	Granular	Granular
Application Method	Broadcast spreader, belly grinder	Broadcast spreader, belly grinder

[a] Subsets of Mixer/Loader/Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered were Grade A or C; Hand data were Grade C; Airborne data were Grade A or B. Data quality grades are defined in the text and in Versar (1992).

Figure 27-1. Summary of Results from the PHED Dermal Subset for Scenario 27 [a]

SCENARIO: Long pants, long sleeves

PATCH LOCATION	MICROGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	1880.7055	188.0913	402.1796	29
NECK.FRONT	616.9102	132.1463	191.35	29
NECK.BACK	381.6992	150.612	117.46	29
UPPER ARMS	3675.8344	145.6315	631.9432	45
CHEST	5559.0338	164.0897	983.8566	44
BACK	4484.9596	145.5984	740.016	45
FOREARMS	2745.8288	308.5469	318.7088	45
THIGHS	3645.2817	149.0803	797.0017	45
LOWER LEGS	1780.0866	134.3576	335.439	45

[a] Subset criteria included actual and estimated head patches. All 29 head observations were actual.

Table 27-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 27 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	25,700	44 [e]	83,900	30,200
Hand (with gloves) [f]	634	23	2,200	792
Hand (no gloves)	6,340	23	22,000	7,920
Inhalation	80.7	40	266	95.5
Total exposure (with gloves)	26,400	--	86,400	31,100
Total exposure (no gloves)	32,100	--	106,000	38,200

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

Scenario 28: Paintbrush Applicator

Table 28-1. Description of Pesticide Handlers Exposure Database (PHED) Subsets [a]

Parameter	Specifications used to generate subsets [a]	Actual characteristics of resulting subsets
Data Quality Grades [b]	A,B,C	B,C
Application Method	Paintbrush	Paintbrush

[a] Subsets of Applicator data in the Pesticide Handlers Exposure Database (PHED). Parameter descriptions are from screens displayed in the PHED program.
[b] Data quality for Dermal Uncovered and Dermal Covered were Grade C; Hand data were Grade B; Airborne data were Grade C. Data quality grades are defined in the text and in Versar (1992).

Figure 28-1. Summary of Results from the PHED Dermal Subset for Scenario 28 [a]

SCENARIO: Long pants, long sleeves, no gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	10899.2607	189.0617	3127.282	15
NECK.FRONT	3203.592	167.6246	785.9412	15
NECK.BACK	105.4937	172.9478	39.0046	15
UPPER ARMS	1432.5736	215.8231	538.4358	15
CHEST	7948.0003	238.318	1051.7277	15
BACK	1509.1287	206.7452	561.6448	15
FOREARMS	11935.561	152.0554	4285.5991	15
THIGHS	352.0512	19.0136	343.7148	15
LOWER LEGS	219.3408	19.0136	214.1469	15

[a] Subset criteria included actual and estimated head patches. All 15 head observations were actual. For 11of the 15 records, the amount handled was incorrectly recorded in the database; these were corrected in a spreadsheet.

Table 28-2. PHED Data from Dermal, Hand, and Inhalation Subsets and Calculated Exposure Rates for Scenario 28 [a]

Exposure Category	Mean Subset Exposure Rate (µg/lb AI handled)	Number of Observations in Subset	Short-Term Exposure Rate (µg/lb AI handled) [b]	Long-Term Exposure Rate (µg/lb AI handled) [c]
Dermal (non-hand) [d]	21,700	15 [e]	80,300	28,200
Hand (with gloves) [f]	20,000	15	74,000	26,000
Hand (no gloves)	200,000	15	740,000	260,000
Inhalation	197	15	729	256
Total exposure (with gloves)	41,900	--	155,000	54,500
Total exposure (no gloves)	222,000	--	821,000	288,000

[a] Results from subsets of Mixer/Loader data in the Pesticide Handlers Exposure Database (PHED), and upper confidence limits (UCL) for mean and 95th percentile (%ile) calculated from these results. The amount entered into PHED was incorrect for 11 of the 15 reps; the data were corrected and re-calculated. All values rounded to three significant figures.
[b] UCL for 95th %ile exposure = 1/SQRT(2)*MEAN*EXP{Z(0.95)*0.8326 + Z(0.90)*0.8326/SQRT(n)}; Equation 5 in Powell (2007).
[c] UCL for arithmetic mean exposure = MEAN*EXP{Z(0.90)*0.8326/SQRT(n)}; Eq. 6 in Powell (2007).
[d] Dermal total includes addition of default feet value of 0.52 x (value for lower legs); ratio of feet/lower leg surface area (U.S. EPA, 1997).
[e] Effective sample size for number of dermal observations was estimated as the harmonic mean, weighted by the squared mean dermal exposure.
[f] Gloves assumed to provide 90% protection (Aprea *et al.*, 1994); exposure of gloved hands is calculated as one tenth exposure of bare hands.

APPENDIX II. SUMMARY OF EXPOSURE ESTIMATES IN METRIC UNITS

Table II-1. Scenario Totals (µg/kg AI handled) [a]

No.	Scenario [b]	ST D (gl) [c]	LT D (gl) [c]	ST D (ng) [c]	LT D (ng) [c]	ST Inh [c]	LT Inh [c]
1	M/L, Open Pour WP	4,780	1,720	NA [c]	NA	392	141
1A	M/L, Open Pour WP (NG)	NA	NA	80,300	29,000	392	141
2	M/L, Open Pour DF	1,540	553	NA	NA	5.02	1.80
2A	M/L, Open Pour DF (NG)	NA	NA	1,610	578	5.02	1.80
3	M/L, WSP, WP	155	55.6	NA	NA	2.31	0.829
3A	M/L, WSP, WP (NG)	NA	NA	368	132	2.31	0.829
4	M/L, Open Pour Gr	79.2	28.5	142	51.3	24.2	8.73
5	M/L, Open Pour Liq	3,360	1,210	NA	NA	16.1	5.81
5A	M/L, Open Pour Liq (NG)	NA	NA	155,000	55,900	16.1	5.81
6	M/L, Closed Sys, Liq	150	53.7	532	190	0.961	0.345
7	Flagger, Liq	292	106	332	120	1.50	0.539
8	Flagger, Gr	12.1	4.37	12.4	4.45	1.29	0.464
9	Airblast App, OC	7,340	2,640	NA	NA	38.7	13.9
9A	Airblast App, OC (NG)	NA	NA	12,200	4,400	38.7	13.9
10	Airblast App, CC	271	97.5	1,480	533	3.92	1.41
11	Groundboom App, OC	188	67.4	495	177	9.06	3.26
12	Groundboom App, CC	41.6	15.0	55.6	20.0	0.319	0.115
13	Aerosol Can App	964,000	346,000	NA	NA	8,380	3,010
13A	Aerosol Can App	NA	NA	1,920,000	691,000	8,380	3,010
14	Broadcast Gr App	17.2	6.17	NA	NA	1.60	0.576
14A	Broadcast Gr App (NG)	NA	NA	18.3	6.57	1.60	0.576
15	Hand Spread of Bait, App	773,000	278,000	NA	NA	2,790	1,010
16	ROW Sprayer, App	107,000	38,600	115,000	41,500	27.1	9.75
17	Aerial App, Liq, OC	520	186	1,280	457	4.66	1.68
18	Aerial App, Liq, CC	27.3	9.81	90.3	32.4	0.202	0.0724
19	Aerial App, Gr	8.93	3.22	16.1	5.79	9.94	3.59
20	BP M/L/A, Open Liq	188,000	67,800	189,000	68,100	148	53.0
21	HPHW M/L/A, Open Liq	58,200	21,000	83,300	30,000	1,240	447
22	LPHW M/L/A, Open Liq	11,600	4,170	12,400	4,460	196	70.2
23	LPHW M/L/A, Open WP	120,000	43,100	370,000	133,000	8,320	2,990
24	Termiticide Inject M/L/A	12,200	4,390	30,300	10,900	13.9	4.99
25	Push-Type M/L/A, Gr	19,600	7,040	37,200	13,400	47.1	16.9
26	Garden Hose Spray M/L/A	56,800	20,200	444,000	160,000	119	42.9
27	Belly Grinder M/L/A, Gr	190,000	68,100	233,000	838,000	585	210
28	Paintbrush App	340,000	119,00	1,810,000	634,000	1,600	563

[a] Calculated from values Table 2 in each scenario: Values (in µg/lb AI handled) were multiplied by 2.2 lb/kg and rounded to three significant figures. Dermal values reported in this table are summed from hand and non-hand dermal exposure rates from Table 2 in each scenario.

[b] Abbreviations in scenario names: App = applicator; BP = backpack; CC = closed cab or cockpit; DF = dry flowable; Gr = granular formulations; HPHW = high pressure handwand; Liq = liquids; LPHW = low pressure handwand; M/L = mixer/loader; M/L/A = mixer/loader/applicator; NG = no gloves; OC = open cab or cockpit; ROW = right-of-way; Sys = system; WP = wettable powder; WSP = water soluble packaging.

[c] Abbreviations in exposure categories: D = dermal; gl = with gloves; Inh = inhalation; LT = long-term; NA = not applicable; ng = no gloves; ST = short-term.

APPENDIX III. CORRECTIONS TO SCENARIO 28

Scenario 28, Paintbrush Applicator, contains data from a single study, identified in PHED as Study ID 467. When data from this study were entered into PHED, incorrect amounts of AI handled were entered for several of the observations (U.S. EPA, 1998). Table III-1 summarizes the amounts reported in PHED for each observation, and the correct amount. As exposure is normalized by amount AI handled, exposures calculated by PHED were overestimated.

Table III-1. Amount of Active Ingredient Handled During Observations of Paintbrush Applicators [a]

Record I.D. in PHED	Total AI Applied as Reported in PHED (lb)	Total AI Actually Applied (lb) [b]	Correction Required?
0467*AA*01	0.0253	0.0253	No
0467*BB*01	0.0253	0.0253	No
0467*CC*01	0.051	0.051	No
0467*DD*01	0.0253	0.051	Yes
0467*EE*01	0.0253	0.051	Yes
0467*FF*01	0.0253	0.051	Yes
0467*GG*01	0.0253	0.051	Yes
0467*HH*01	0.0253	0.051	Yes
0467*II*01	0.0253	0.0253	No
0467*JJ*01	0.0253	0.051	Yes
0467*KK*01	0.0253	0.051	Yes
0467*LL*01	0.0253	0.051	Yes
0467*MM*01	0.0253	0.051	Yes
0467*NN*01	0.0253	0.051	Yes
0467*OO*01	0.051	0.051	Yes

[a] See details reported in Appendix I, Scenario 28. Abbreviations: AI = active ingredient; PHED = Pesticide Handlers Exposure Database.
[b] Corrected values from U.S. EPA (1998).

Figure III-1 displays a portion of the output from PHED, including arithmetic mean exposures for body parts in the dermal subset. These results require correction of amounts handled as shown in Table III-1.

Figure III-1. Summary of Results from the PHED Dermal Subset for Scenario 28 [a]

SCENARIO: Long pants, long sleeves, no gloves

PATCH LOCATION	MICROGRAMS PER LB AI SPRAYED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	10899.2607	189.0617	3127.282	15
NECK.FRONT	3203.592	167.6246	785.9412	15
NECK.BACK	105.4937	172.9478	39.0046	15
UPPER ARMS	1432.5736	215.8231	538.4358	15
CHEST	7948.0003	238.318	1051.7277	15
BACK	1509.1287	206.7452	561.6448	15
FOREARMS	11935.561	152.0554	4285.5991	15
THIGHS	352.0512	19.0136	343.7148	15
LOWER LEGS	219.3408	19.0136	214.1469	15

[a] For 11of the 15 observations, the amount handled was incorrectly recorded in the database; these were corrected in a spreadsheet.

PHED does not allow alteration of original data (Versar, 1992). Thus, corrections were done in an Excel spreadsheet using data copied from PHED (data were accessed using the

Browse/Print Values function in PHED). To verify that data were accurately transferred to the spreadsheet, arithmetic mean results were calculated and compared to those in Figure III-1. Hand and inhalation arithmetic mean exposures calculated in the spreadsheet were also verified against those calculated by PHED. This check also served to verify that data were handled in the spreadsheet according to the same rules used by PHED. For example, all dermal exposure values were reported in PHED as "combined patch data," which PHED automatically divides in half to account for the doubled patch surface area (Versar, 1992).

Table III-2 summarizes the arithmetic mean exposure for each body part, total dermal, hand, and inhalation exposures following correction. These are the basis for results reported in Table 28-2 in Appendix I. For convenience, Table III-2 also lists surface areas used by PHED for each body part (Versar, 1992). These surface areas differ slightly from ones used by DPR to calculate exposure estimates (U.S. EPA, 1997). With the exception of feet, the spreadsheet with corrected data for Scenario 28 used surface areas from PHED, for consistency with other scenarios.

Table III-2. Arithmetic Mean Exposure Estimates for Paintbrush Applicators Corrected for Amount of Active Ingredient Handled [a]

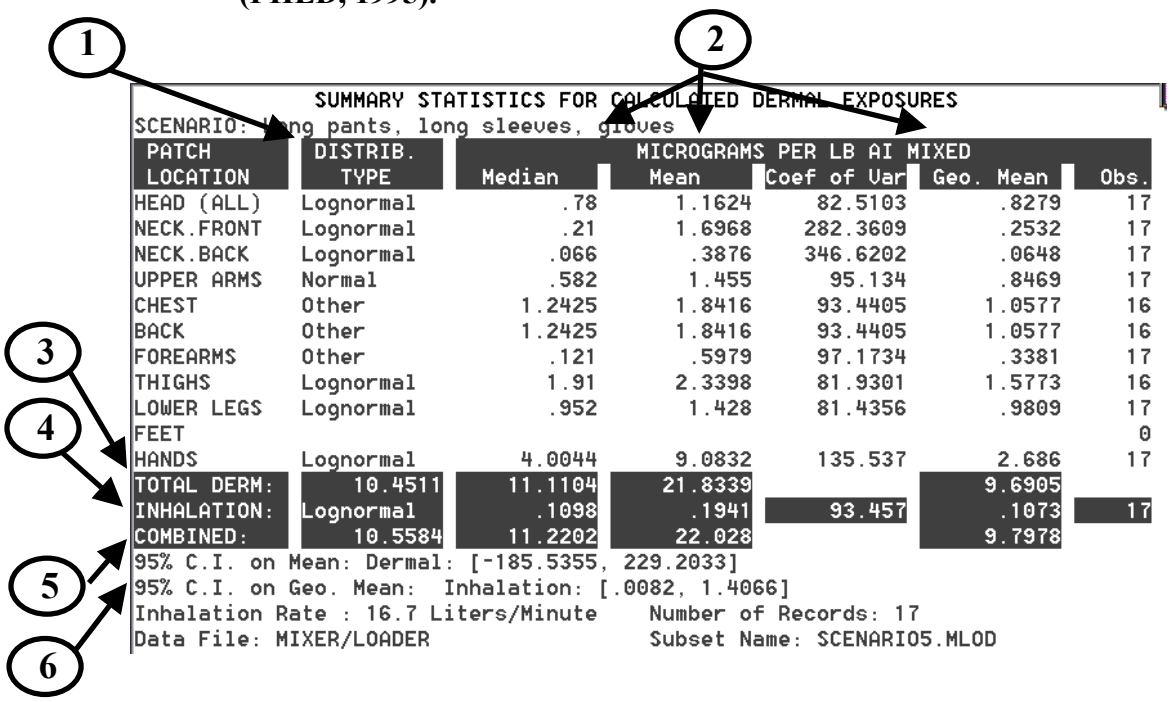
Body Part	Surface Area from PHED [b] (cm^2)	Exposure from PHED (µg/lb AI handled)	Corrected Exposure (µg/lb AI handled)	Comments
Head	1300	10899.2607	7099.7020	One missing value calculated as the mean of shoulder, chest, and back outer patches
Neck Front	150	3203.5914	2048.9338	Data from outer chest patches
Neck Back	110	105.4937	58.0542	Data from outer back patches
Upper Arms	2,910	1432.5736	781.5864	Combined inner patches
Chest	3,550	7948.0003	4062.8640	Combined inner patches
Back	3,550	1509.1287	959.2823	Combined inner patches
Forearms	1,210	11935.5620	6288.8725	Combined inner patches
Thighs	3,820	352.0512	225.2980	Combined inner patches
Lower Legs	2,380	219.3408	140.3689	Combined inner patches
Feet [c]	Not applicable	114.0757	72.9918	Calculated same way as for other scenarios
Total Dermal	20,290	37718.9299	21737.9540	
Hands	Not applicable	307656.6638	200454.8193	
Inhalation	Not applicable	307.8643	196.9882	

[a] See details reported in Appendix I, Scenario 28. Abbreviations: AI = active ingredient; PHED = Pesticide Handlers Exposure Database.
[b] Surface areas used by PHED to calculate exposure from amount on patches (Versar, 1992). These surface areas were also used to calculate corrected exposure values, for consistency with other scenarios.
[c] Feet value calculated as 0.52 x (value for lower legs); 0.52 is the ratio of feet/lower leg surface area (U.S. EPA, 1997).

APPENDIX IV. EXPLANATION OF PHED SUMMARY STATISTICS OUTPUT

The summary statistics table produced by PHED—and excerpted in each scenario in Appendix I—gives average exposure per body region (in µg/lb AI handled). The output format varies depending on whether exposures are requested for dermal, inhalation, or both. Figure IV-1 is an example output when both dermal and inhalation exposures are requested. Key features of the output are briefly discussed below.

Figure IV-1. Sample output from the Pesticide Handlers Exposure Database (PHED, 1995).



SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	DISTRIB. TYPE	MICROGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	.78	1.1624	82.5103	.8279	17
NECK.FRONT	Lognormal	.21	1.6968	282.3609	.2532	17
NECK.BACK	Lognormal	.066	.3876	346.6202	.0648	17
UPPER ARMS	Normal	.582	1.455	95.134	.8469	17
CHEST	Other	1.2425	1.8416	93.4405	1.0577	16
BACK	Other	1.2425	1.8416	93.4405	1.0577	16
FOREARMS	Other	.121	.5979	97.1734	.3381	17
THIGHS	Lognormal	1.91	2.3398	81.9301	1.5773	16
LOWER LEGS	Lognormal	.952	1.428	81.4356	.9809	17
FEET						0
HANDS	Lognormal	4.0044	9.0832	135.537	2.686	17
TOTAL DERM:	10.4511	11.1104	21.8339		9.6905	
INHALATION:	Lognormal	.1098	.1941	93.457	.1073	17
COMBINED:	10.5584	11.2202	22.028		9.7978	

95% C.I. on Mean: Dermal: [-185.5355, 229.2033]

95% C.I. on Geo. Mean: Inhalation: [.0082, 1.4066]

Inhalation Rate : 16.7 Liters/Minute Number of Records: 17

Data File: MIXER/LOADER Subset Name: SCENARIO5.MLOD

1. An assessment of the distribution of exposure values within each body region, based on a statistical test of fit (column labeled "DISTRIB. TYPE"). This column is the source for the entries in Appendix V.
2. Three estimates of central tendency exposure for each body region: the median, arithmetic mean (column "Mean") and geometric mean.
3. Four estimates of average total dermal exposure (row "TOTAL DERM"); row entries under the columns headed "Median", "Mean" and "Geo. Mean" are the sums of the respective averages over all body regions. In addition, a **composite total** is calculated by summing the averages corresponding to the distribution type selected for each body region. For body regions with lognormal distributions, the geometric mean is used; for body regions with normal distributions, the arithmetic mean is used; for body regions with "other", i.e., neither normal nor lognormal, distributions, the median is used (Versar, 1992). The composite total is the first value in the total dermal exposure row (under the DISTRIB. TYPE column).
4. Average inhalation exposure is reported in the same way as a body-region exposure.

5. Average combined dermal and inhalation exposure (row labeled "COMBINED") is given as the **composite total** (described above); the sum of dermal and inhalation medians; the sum of dermal and inhalation arithmetic means; and the sum of dermal and inhalation geometric means.
6. Ninety-five percent confidence intervals (C.I.) for arithmetic mean total dermal exposure, assuming normal distributions, and for the geometric mean of inhalation exposure, assuming a lognormal distribution.

APPENDIX V. FREQUENCY DISTRIBUTIONS FOR SUBSETS

Table V-1. Frequency Distribution of Samples Reported in PHED [a]

No.	Scenario [b]	Dermal	Hand	Inhalation	Exceptions in Dermal Subset
1	M/L, Open Pour WP	Lognormal	Lognormal	Lognormal	(No exceptions)
1A	M/L, Open Pour WP (NG)	Lognormal	Lognormal	Lognormal	(No exceptions)
2	M/L, Open Pour DF	Lognormal	Lognormal	Lognormal	Back = Other
2A	M/L, Open Pour DF (NG)	Lognormal	Lognormal	Lognormal	Back = Other
3	M/L, WSP, WP	Lognormal	Other	Lognormal	(No exceptions)
3A	M/L, WSP, WP (NG)	Lognormal	Other	Lognormal	(No exceptions)
4	M/L, Open Pour Gr	Lognormal	Lognormal	Lognormal	(No exceptions)
5	M/L, Open Pour Liq	Other	Lognormal	Other	Neck and thighs = Lognormal
5A	M/L, Open Pour Liq (NG)	Other	Lognormal	Other	Neck and thighs = Lognormal
6	M/L, Closed Sys, Liq	Lognormal	Lognormal	Lognormal	Back, chest, forearms, upper arms = Other
7	Flagger, Liq	Other	Lognormal	Normal	Head and neck = Lognormal
8	Flagger, Gr	Lognormal	Lognormal	Lognormal	(No exceptions)
9	Airblast App, OC	Lognormal	Lognormal	Other	(No exceptions)
9A	Airblast App, OC (NG)	Lognormal	Lognormal	Other	(No exceptions)
10	Airblast App, CC	Other	Lognormal	Lognormal	Head and neck = Lognormal
11	Groundboom App, OC	Lognormal	Lognormal	Lognormal	Chest = Normal. Legs and thighs = Other.
12	Groundboom App, CC	Other	Lognormal	Lognormal	Lower legs and thighs = Lognormal
13	Aerosol Can App	Other	Other	Lognormal	Head and neck = Lognormal
13A	Aerosol Can App	Other	Lognormal	Lognormal	Head and neck = Lognormal
14	Broadcast Gr App	Other	Lognormal	Lognormal	(No exceptions)
14A	Broadcast Gr App (NG)	Other	Lognormal	Lognormal	(No exceptions)
15	Hand Spread of Bait, App	Lognormal	Lognormal	Lognormal	(No exceptions)
16	ROW Sprayer, App	Lognormal	Lognormal	Lognormal	Lower legs and thighs = Other
17	Aerial App, Liq, OC	Other	Other	Lognormal	(No exceptions)
18	Aerial App, Liq, CC	Lognormal	Lognormal	Lognormal	(No exceptions)
19	Aerial App, Gr	Lognormal	Lognormal	Lognormal	(No exceptions)
20	BP M/L/A, Open Liq	Lognormal	Lognormal	Other	Chest = Normal
21	HPHW M/L/A, Open Liq	Lognormal	Lognormal	Lognormal	(No exceptions)
22	LPHW M/L/A, Open Liq	Other	Other	Other	Neck, upper arms, lower legs = Lognormal
23	LPHW M/L/A, Open WP	Lognormal	Lognormal	Lognormal	(No exceptions)
24	Termiticide Inject M/L/A	Lognormal	Lognormal	Lognormal	(No exceptions)
25	Push-Type M/L/A, Gr	Lognormal	Lognormal	Lognormal	(No exceptions, but no head/neck data)
26	Garden Hose Spray M/L/A	Lognormal	Lognormal	Lognormal	(No exceptions)
27	Belly Grinder M/L/A, Gr	Other	Lognormal	Other	Back and upper arms = Other
28	Paintbrush App	Other	Lognormal	Other	Head, neck, upper arms, forearms = Lognormal

[a] Distributions reported in PHED output. U.S. EPA policy is to select a central tendency estimate according to distribution: geometric mean for lognormal, arithmetic mean for normal, and median for other (U.S. EPA, 1999).

[b] Abbreviations: App = applicator; BP = backpack; CC = closed cab or cockpit; DF = dry flowable; Gr = granular formulations; HPHW = high pressure handwand; Liq = liquids; LPHW = low pressure handwand; M/L = mixer/loader; M/L/A = mixer/loader/applicator; NG = no gloves; OC = open cab or cockpit; ROW = right-of-way; Sys = system; WP = wettable powder; WSP = water soluble packaging.

APPENDIX VI. SUMMARY OF EXPOSURE ESTIMATES USED BY U.S. EPA

Scenarios are numbered as in Appendix I; the corresponding U.S. EPA scenario number is given afterward. Exposure estimates and accompanying notes are summarized from U.S. EPA (1998). In U.S. EPA (1998), hand exposure is included in the total estimated dermal exposure, and inhalation exposure is reported separately. The "grades" listed in each entry below refer to the data quality grades defined Versar (1992); U.S. EPA (1998) also contains a table summarizing the data quality grades.

Scenario 1 (M/L, Open Pour, WP): U.S. EPA SCENARIO 4 (WP)

Inhalation: 44 reps, ABC grades. Inhalation = 43.42 µg/lb AI handled.
No clothes: 7-24 reps, ABC grades. Dermal = 6700 µg/lb AI handled.
Single layer, no gloves: 7-45 reps, ABC grades. Dermal = 3700 µg/lb AI handled.
Single layer, gloves: 22-45 reps, ABC grades. Dermal = 170 µg/lb AI handled.

Scenario 2 (M/L, Open Pour, DF): U.S. EPA SCENARIO 1 (DF)

Inhalation: 23 reps, AB grades. Inhalation = 0.77 µg/lb AI handled.
No clothes: 7-19 reps, AB grades. Dermal = 1100 µg/lb AI handled.
Single layer, no gloves: 7-26 reps, AB grades. Dermal = 66 µg/lb AI handled.
Single layer, gloves: 16-26 reps, AB grades. Dermal = 66 µg/lb AI handled.

Scenario 3 (M/L, WP in WSP): U.S. EPA SCENARIO 5

Inhalation: 15 reps, all grades. Inhalation = 0.24 µg/lb AI handled.
No clothes: 5-15 reps, AB grades. Dermal = 39 µg/lb AI handled.
Single layer, no gloves: 5-15 reps, AB grades. Dermal = 21 µg/lb AI handled.
Single layer, gloves: 6-15 reps, all grades. Dermal = 9.8 µg/lb AI handled.
NOTE: Inner dosimeters were mostly non-detects. Gloved data are non-detect.

Scenario 4 (M/L, Open Pour, Granular): U.S. EPA SCENARIO 2

Inhalation: 58 reps, AB grades. Inhalation = 1.7 µg/lb AI handled.
No clothes: 10-59 reps, all grades. Dermal = 32 µg/lb AI handled.
Single layer, no gloves: 10-78 reps, all grades. Dermal = 8.4 µg/lb AI handled.
Single layer, gloves: 33-78 reps, ABC grades. Dermal = 6.9 µg/lb AI handled.
Coveralls, single layer, gloves: 12-59 reps, ABC grades. Dermal=3.4 µg/lb AI.

Scenario 5 (M/L, Open Pour, Liquids): U.S. EPA SCENARIO 3

Inhalation: 85 reps, AB grades. Inhalation = 1.2 µg/lb AI handled.
No clothes: 53-122 reps, AB grades. Dermal = 3100 µg/lb AI handled.
Single layer, no gloves: 53-122 reps, AB grades. Dermal = 2900 µg/lb AI handled.
Single layer, gloves: 59-122 reps, AB grades. Dermal = 23 µg/lb AI handled.

Scenario 6 (M/L, Closed System, Liquids): U.S. EPA SCENARIO 6

Inhalation: 27 reps, AB grades. Inhalation = 0.083 µg/lb AI handled.

Single layer, gloves: 16-31 reps, AB grades. Dermal = 8.6 µg/lb AI handled.

Scenario 7 (Flagger, Liquids): U.S. EPA SCENARIO 25
Inhalation: 28 reps, AB grades. Inhalation = 0.35 µg/lb AI handled.
No clothes: 17-57 reps, ABC grades. Dermal = 53 µg/lb AI handled.
Single layer, no gloves: 18-30 reps, AB grades. Dermal = 11 µg/lb AI handled.
Single layer, gloves: 6-28 reps, AB grades. Dermal = 12 µg/lb AI handled.
NOTE: Data pooled from flaggers in treatment and perimeter areas.

Scenario 8 (Flagger, Granular): U.S. EPA SCENARIO 26
Inhalation: 4 reps, E grades. Inhalation = 0.15 µg/lb AI handled.
No clothes: 4-20 reps, all grades. Dermal = 5.0 µg/lb AI handled.

Scenario 9 (Airblast Applicator, Open Cab): U.S. EPA SCENARIO 11
Inhalation: 47 reps, AB grades. Inhalation = 4.5 µg/lb AI handled.
No clothes: 22-44 reps, AB grades. Dermal = 2,200 µg/lb AI handled.
Single layer, no gloves: 22-49 reps, AB grades. Dermal = 360 µg/lb AI handled.
Single layer, gloves: 18-48 reps, AB grades. Dermal = 240 µg/lb AI handled.
NOTE: Omitted turf airblast; included tree crops and grapes only.

Scenario 10 (Airblast Applicator, Closed Cab): U.S. EPA SCENARIO 12
Inhalation: 9 reps, ABC grades. Inhalation = 0.45 µg/lb AI handled.
Single layer, gloves: 20-30 reps, AB grades. Dermal = 19 µg/lb AI handled.
NOTE: Most values were non-detects.

Scenario 11 (Groundboom Applicator, Open Cab): U.S. EPA SCENARIO 13
Inhalation: 22 reps, AB grades. Inhalation = 0.74 µg/lb AI handled.
No clothes: 17-33 reps, AB grades. Dermal = 46 µg/lb AI handled.
Single layer, no gloves: 23-42 reps, AB grades. Dermal = 14 µg/lb AI handled.
Single layer, gloves: 21-42 reps, ABC grades. Dermal = 14 µg/lb AI handled.

Scenario 12 (Groundboom Applicator, Closed Cab): U.S. EPA SCENARIO 14
Inhalation: 16 reps, AB grades. Inhalation = 0.043 µg/lb AI handled.
No clothes: 13-26 reps, ABC grades. Dermal = 10 µg/lb AI handled.
Single layer, no gloves: 16-31 reps, ABC grades. Dermal = 5.0 µg/lb AI handled.
Single layer, gloves: 12-31 reps, ABC grades. Dermal = 5.1 µg/lb AI handled.

Scenario 13 (Aerosol Can Applicator): U.S. EPA SCENARIO 10
Inhalation: 15 reps, AB grades. Inhalation = 1,300 µg/lb AI handled.
No clothes: 15 reps, AB grades. Dermal = 480,000 µg/lb AI handled.
Single layer, no gloves: 15 reps, AB grades. Dermal = 190,000 µg/lb AI handled.
Single layer, gloves: 59-122 reps, AB grades. Dermal = 81,000 µg/lb AI handled.
NOTE: Each replicate applied 0.01 lb (one can). Crack and crevice treatment.

Scenario 14 (Broadcast Spreader, Ag Uses): U.S. EPA SCENARIO 15 (open cab)
Inhalation: 5 reps, AB grades. Inhalation = 1.2 µg/lb AI handled.
No clothes: 1-5 reps, AB grades. Dermal = 39 µg/lb AI handled.
Single layer, no gloves: 1-5 reps, AB grades. Dermal = 9.9 µg/lb AI handled.

And U.S. EPA SCENARIO 16 (Closed Cab)
Inhalation: 37 reps, AB grades. Inhalation = 0.2201 µg/lb AI handled.
No clothes: 2-27 reps, AB grades. Dermal = 2.1 µg/lb AI handled.
Single layer, no gloves: 2-30 reps, AB grades. Dermal = 2.1 µg/lb AI handled.
Single layer, gloves: 2-30 reps, AB grades. Dermal = 2.0 µg/lb AI handled.
NOTE: Application equipment includes drop-type spreaders and row planters.

Scenario 15 (Hand Spreading Bait): U.S. EPA SCENARIO 17
Inhalation: 17 reps, ABC grades. Inhalation = 470 µg/lb AI handled.
Single layer, gloves: 15-16 reps, ABC grades. Dermal = 17,000 µg/lb AI handled.
NOTE: The 15 hand observations are all nondetect (LOQ = 41 µg).

Scenario 16 (Right-of-Way Sprayer): U.S. EPA SCENARIO 24
Inhalation: 16 reps, A grades. Inhalation = 3.9 µg/lb AI handled.
No clothes: 4-16 reps, ABC grades. Dermal = 1,900 µg/lb AI handled.
Single layer, no gloves: 4-20 reps, ABC grades. Dermal = 1,300 µg/lb AI handled.
Single layer, gloves: 4-20 reps, all grades. Dermal = 390 µg/lb AI handled.

Scenario 17 (Aerial Applicator, Liquids, Open Cockpit) U.S. EPA didn't estimate exposure for this scenario, only for the closed-cockpit scenario.

Scenario 18 (Aerial Applicator, Liquids, Closed Cockpit): U.S. EPA SCENARIO 7
Inhalation: 23 reps, ABC grades. Inhalation = 0.068 µg/lb AI handled.
No clothes: 20-34 reps, ABC grades. Dermal = 5.0 µg/lb AI handled.
Single layer, no gloves: 20-48 reps, ABC grades. Dermal = 5.0 µg/lb AI handled.
Single layer, gloves: 7-48 reps, all grades. Dermal = 2.2 µg/lb AI handled.

Scenario 19 (Aerial Applicator, Granular, Closed Cockpit): U.S. EPA SCENARIO 8
Inhalation: 13 reps, all grades. Inhalation = 1.3 µg/lb AI handled.
No clothes: 4-13 reps, all grades. Dermal = 4.4 µg/lb AI handled.
Single layer, no gloves: 4-13 reps, all grades. Dermal = 1.7 µg/lb AI handled.
Single layer, gloves: 9-13 reps, all grades. Dermal = 1.7 µg/lb AI handled.
NOTE: Outer patches only on thighs and lower legs. Most values were non-detects.

Scenario 20 (Backpack M/L/A, Open Pour Liquids): U.S. U.S. EPA SCENARIO 34
Inhalation: 11 reps, A grades. Inhalation = 30 µg/lb AI handled.
Single layer, gloves: 9-11 reps, ABC grades. Dermal = 2,500 µg/lb AI handled.

Scenario 21 (High Pressure HW M/L/A, Open Pour Liquids): U.S. EPA SCENARIO 35

Inhalation: 13 reps, A grades. Inhalation = 120 µg/lb AI handled.
Single layer, gloves: 7-13 reps, ABC grades. Dermal = 2,500 µg/lb AI handled.

Scenario 22 (Low Pressure HW M/L/A, Open Pour Liquids): U.S. EPA SCENARIO 32
Inhalation: 80 reps, ABC grades. Inhalation = 30 µg/lb AI handled.
No clothes: 70-80 reps, all grades. Dermal = 110,000 µg/lb AI handled.
Single layer, no gloves: 9-80 reps, all grades. Dermal = 100,000 µg/lb AI handled.
Single layer, gloves: 9-80 reps, ABC grades. Dermal = 430 µg/lb AI handled.

Scenario 23 (Low Pressure HW M/L/A, Open Pour WP): U.S. EPA SCENARIO 33
Inhalation: 16 reps, ABC grades. Inhalation = 1,100 µg/lb AI handled.
Single layer, gloves: 15-16 reps, ABC grades. Dermal = 8,600 µg/lb AI handled.

Scenario 24 (Termiticide Injection M/L/A): U.S. EPA SCENARIO 37
Inhalation: 17 reps, AB grades. Inhalation = 2.2 µg/lb AI handled.
Single layer, gloves: 17 reps, AB grades. Dermal = 360 µg/lb AI handled.

Scenario 25 (Push-Type Spreader M/L/A): U.S. EPA SCENARIO 31
Inhalation: 15 reps, B grades. Inhalation = 6.3 µg/lb AI handled.
Single layer, no gloves: 0-15 reps, C grades. Dermal = 2,900 µg/lb AI handled.

Scenario 26 (Garden Hose Spray M/L/A): U.S. EPA SCENARIO 36
Inhalation: 8 reps, ABC grades. Inhalation = 9.5 µg/lb AI handled.
No clothes: 8 reps, CE grades. Dermal = 34,000 µg/lb AI handled.

Scenario 27 (Belly Grinder M/L/A): U.S. EPA SCENARIO 30
Inhalation: 40 reps, AB grades. Inhalation = 62 µg/lb AI handled.
No clothes: 20-29 reps, ABC grades. Dermal = 210,000 µg/lb AI handled.
Single layer, no gloves: 23-45 reps, ABC grades. Dermal = 10,000 µg/lb AI handled.
Single layer, gloves: 20-45 reps, all grades. Dermal = 9,300 µg/lb AI handled.

Scenario 28 (Paintbrush Applicator): U.S. EPA SCENARIO 22
Inhalation: 15 reps, C grade. Inhalation = 280 µg/lb AI handled.
No clothes: 14-15 reps, C grade. Dermal = 260,000 µg/lb AI handled.
Single layer, gloves: 14-15 reps, ABC grades. Dermal = 180,000 µg/lb AI handled.
NOTE: PHED V1.1 incorrectly lists the amount of active ingredient handled. The correct lb AI handled for replicates 0467 CC, DD, EE, FF, GG, HH, JJ, KK, LL, MM, and NN is 0.0510 lb AI, not 0.0253 lb AI. The exposure estimates represent the recalculated (correct) values.

APPENDIX VII. BOILERPLATE TEXT FOR EXPOSURE ASSESSMENT DOCUMENTS

The following sections contain standardized text intended to be copied and pasted into the appropriate parts of any exposure assessment document that uses exposure estimates from PHED. Two undefined abbreviations are included in the text below, active ingredient (AI) and the California Department of Pesticide Regulation (DPR). These were not defined because it was assumed that the abbreviations would have been used on previous pages in the EAD. If an abbreviation has not been previously used and defined in an EAD, then its definition should be given at first use. Include any references cited in the boilerplate in the reference list of your EAD. All references cited in the boilerplate are listed at the end of each section.

Boilerplate for Exposure Assessment section

Chemical-specific data were not available for the assessment of exposure of handlers performing {*name scenarios for which PHED was used*}. Exposure estimates for these scenarios were instead derived using the Pesticide Handlers Exposure Database (PHED, 1995). PHED is a computerized database containing monitoring data from multiple studies of inhalation and dermal exposure of pesticide handlers performing mixing, loading, application and flagging tasks with a variety of AI. PHED was developed by the U.S. Environmental Protection Agency (U.S. EPA), Health Canada and the American Crop Protection Association to provide non-chemical-specific pesticide handler exposure estimates for specific handler scenarios. The user selects a subset of the data having the same or a similar application method and formulation type as the target scenario. The use of non-chemical-specific (or "generic") exposure estimates is based on two assumptions (Versar, 1992): (1) that exposure is primarily a function of the pesticide application method/equipment and formulation type and not of the physical/chemical properties of the specific AI; and (2) that exposure is proportional to the amount of AI handled (Reinert *et al.*, 1986; Versar, 1992). These assumptions are supported by comparisons of exposure across several studies (Rutz and Krieger, 1992; van Hemmen, 1992).

PHED has limitations as a generic database. It combines measurements from diverse studies involving different protocols, analytical methods and residue detection limits. Most dermal exposure studies in PHED use the patch dosimetry method of Durham and Wolfe (1962); residues (in $\mu g/cm^2$) on small patches placed on different parts of the body are multiplied by the surface area of the body part to estimate its exposure (in μg). These partial estimates are then summed to provide a total body exposure estimate. Some studies measured exposure only to selected body parts such as the hands, arms and face. As a consequence, the dermal exposure estimates for different body parts may be based on data from different studies. Further, for some handler scenarios, the number of matching observations in the PHED is so small that the possibility they do not represent well the target scenario is substantial.

In order to account for some of the uncertainty inherent in using PHED and to increase our confidence that exposures are not underestimated, DPR uses the 90% upper confidence limit (UCL) on an exposure statistic, instead of the statistic itself, when using PHED.

When using PHED to assess short-term exposure, DPR uses as the exposure estimate the 90% upper confidence limit (UCL) on the 95th percentile of daily exposure. (Confidence limits on percentiles, also called tolerance limits, are described by Hahn and Meeker (1991).) DPR believes upper-bound estimates are appropriate for short-term exposures because high-end exposures are possible and because DPR has an obligation to protect all individuals exposed as a result of legal uses of pesticides (not just individuals with "average" exposures). It is often the case that the upper bound is 3-5 times the size of the mean; this should not be surprising because in highly skewed distributions such exposures can happen.

When using PHED to assess intermediate or long-term exposure, DPR uses as the exposure estimate the 90% UCL on the arithmetic mean of daily exposure.

Estimating the confidence limit requires knowing the mean and standard deviation. PHED reports the mean of total dermal exposure, but only the coefficients of variation for separate body regions. Because the sample sizes per body region differ and because the correlations among body regions are unknown, the standard deviation of total dermal exposure cannot be calculated. In order to approximate the confidence limit for the 95th percentile, DPR makes the assumption that the population of total exposure is lognormally distributed across persons and has a coefficient of variation of 100 percent. The method of approximation is described in Powell (2007), and uses the fact that in any lognormal distribution with a given coefficient of variation, the confidence limit for the 95th percentile is a constant multiple of the arithmetic mean. The value of the multiplier depends only on sample size. These multipliers have been calculated for a large range of sample sizes (Powell, 2007); to find the UCL for a 95th percentile, arithmetic mean exposure is multiplied by a multiplier corresponding to the sample size.

The 90% UCL on the arithmetic mean of daily exposure is approximated making the same assumptions as for short-term exposure. The UCL is a multiple of the arithmetic mean (a different multiple than for the 95th percentile). These multipliers have also been calculated for a large range of sample sizes (Powell, 2007); to find the UCL for a mean, arithmetic mean exposure is multiplied by a multiplier corresponding to the sample size.

Durham, W.F. and Wolfe, H.R. 1962. Measurement of the exposure of workers to pesticides. Bulletin of the WHO 26:75-91.

Hahn, G.J., and Meeker, W.Q. 1991. Statistical Intervals: A Guide for Practitioners. New York, John Wiley & Sons, Inc.

PHED. 1995. The Pesticide Handlers Exposure Database, Version 1.1. Prepared for the PHED Task Force representing Health and Welfare Canada, U.S. Environmental

Protection Agency, and the National Agricultural Chemicals Association; prepared by Versar, Inc., 6850 Versar Center, Springfield, VA 22151.

Powell, S. 2007. Recommended Method for Approximating Confidence Limits for Upper Bound and Mean Exposure Estimates from the Pesticide Handlers Exposure Database (PHED) to Replace the Method of HSM-02037. Memo No. HSM-07004. Sacramento, CA: Worker Health and Safety Branch, California Department of Pesticide Regulation, California Environmental Protection Agency.

Reinert, J.C., Nielsen, A.P., Lunchick, C., Hernandez, O. and Mazzetta, D.M. 1986. The United States Environmental Protection Agency's guidelines for applicator exposure monitoring. Toxicology Letters 33:183-191.

Rutz. R. and Krieger, R.I. 1992. Exposure to pesticide mixer/loaders and applicators in California. Reviews of Environmental Contamination and Toxicology 129:121-139.

van Hemmen, J.J. 1992. Agricultural pesticide exposure data bases for risk assessment. Reviews of Environmental Contamination and Toxicology 126:1-85.

Vercruysse, F., Drieghe, S., Steurbaut, W. and Dejonckeere, W. 1999. Exposure assessment of professional pesticide users during treatment of potato fields. Pesticide Science 55:467-473.

Versar. 1992. PHED: The Pesticide Handlers Exposure Database reference manual. Prepared for the PHED Task Force: Health and Welfare Canada, U. S. Environmental Protection Agency, National Agricultural Chemicals Association. Springfield, VA: Versar, Inc.

Boilerplate for Exposure Appraisal section

Because chemical-specific data were not available to assess exposure of handlers performing {*name scenarios for which PHED was used*}, exposure estimates for these scenarios were derived using generic data from PHED (PHED, 1995). PHED has limitations as a generic database. It combines measurements from diverse studies involving different protocols, analytical methods and residue detection limits. Most dermal exposure studies in PHED use the patch dosimetry method of Durham and Wolfe (1962); residues (in $\mu g/cm^2$) on small patches placed on different parts of the body are multiplied by the surface area of the body part to extrapolate its exposure (in µg). These body part estimates are then summed to provide a total body exposure estimate. Some studies measured exposure only to selected body parts such as the hands, arms and face. As a consequence, the dermal exposure estimates for different body parts may be based on data from different studies. Further, for {*name of handler scenario, if applicable, for which this is the case*}, the number of matching observations in PHED is so small that the possibility they do not represent well the target scenario is substantial. In addition, exposure scenarios are incompletely characterized in the PHED database, confounding assessment of the match between a given subset and the exposure scenario it is intended to represent. Finally, the assumptions underlying the use of generic data, that exposure is primarily a function of the pesticide application method/equipment and formulation type and not of the physical/chemical properties of the specific AI, and that exposure is proportional to the amount of AI handled, may be false in some cases.

To account for some of the uncertainty inherent in using PHED and to increase our confidence that exposures are not underestimated, DPR uses the 90% upper confidence limit (UCL) on an exposure statistic instead of the statistic itself when using PHED to estimate exposure. PHED, however, does not provide all the information needed to calculate confidence limits. Estimating a confidence limit requires knowing the mean and standard deviation. PHED reports the mean of total dermal exposure, but only the coefficients of variation for separate body regions. Because the sample sizes per body region differ and because the correlations among body regions are unknown, the standard deviation of total dermal exposure cannot be calculated. In order to approximate the confidence limit for the 95th percentile, DPR makes the assumption that the population of total exposure is lognormally distributed across persons and has a population coefficient of variation of 100 percent. The method of approximation is described in Powell (2007), and uses the fact that in any lognormal distribution with a given coefficient of variation, the confidence limit for the 95th percentile (or for the mean) is a constant multiple of the arithmetic mean, the multiplier depending only on sample size. Any of these underlying assumptions could be incorrect and, to the extent they are, the UCLs would be incorrect.

Durham, W.F. and Wolfe, H.R. 1962. Measurement of the exposure of workers to pesticides. Bulletin of the WHO 26:75-91.

Powell, S. 2007. Recommended Method for Approximating Confidence Limits for Upper Bound and Mean Exposure Estimates from the Pesticide Handlers Exposure Database (PHED) to Replace the Method of HSM-02037. Memo No. HSM-07004. Sacramento, CA: Worker Health and Safety Branch, California Department of Pesticide Regulation, California Environmental Protection Agency.