



# Department of Pesticide Regulation



Mary-Ann Warmerdam  
Director

## MEMORANDUM

Arnold Schwarzenegger  
Governor

TO: Worker Health and Safety Branch Staff **HSM-07005**

FROM: Joseph P. Frank, D.Sc., Senior Toxicologist *(original signed by J. Frank)*  
Worker Health and Safety Branch  
(916) 324-3517

APPROVED BY: Susan Edmiston, Chief *(original signed by S. Edmiston)*  
Worker Health and Safety Branch

DATE: September 20, 2007

SUBJECT: METHOD FOR APPROXIMATING CONFIDENCE LIMITS FOR UPPER  
BOUND AND MEAN EXPOSURE ESTIMATES FROM THE PESTICIDE  
HANDLERS EXPOSURE DATABASE (PHED)

---

*This Health and Safety Memorandum (HSM) HSM-07005 supercedes HSM-02037 dated, September 27, 2002.*

### Policy Memo

The purpose of this memorandum is to document and adopt methods to be utilized by Worker Health and Safety (WHS) staff for estimating exposure when using the Pesticide Handlers Exposure Database (PHED). This memo presents the basic instructions for calculating long- and short-term exposure estimates using PHED. The statistical basis and justification for the method are explained in Powell (2007 and 2002).

### Background

The Worker Health and Safety Branch normally uses the arithmetic mean of measured daily exposures, obtained by monitoring workers or others, as the exposure statistic to represent long-term exposure. For short-term exposures, the 95<sup>th</sup> percentile of the measurements is typically used to estimate an upper-bound or worst-case exposure. When the exposure data are from the Pesticide Handler Exposure Database (PHED, 1995), 90% upper confidence limits (UCL) on the mean and 95<sup>th</sup> percentile are used in place of the mean and percentile themselves. This is done in order to account for some of the uncertainty associated with the use of generic data whose relevance to the target exposure scenario cannot be fully addressed.

Since September 2002, WHS exposure assessors have used the method put forth in HSM-02037 (Powell, 2002) to approximate upper confidence limits on estimates of long-term and short-term exposure from PHED. In 2005, the Department of Pesticide Regulation (DPR) received comments on the methods described in HSM-02037 from the Agricultural Handler Exposure Task Force (AHETF), the Outdoor Residential Exposure Task Force (ORETF), and the



Agricultural Reentry Task Force (ARTF). The Task Forces agreed in principal with the WHS approach. However, they did not agree with some of the specific statistical approaches. After consideration of Task Force comments and suggestions, WHS scientists concluded that several changes would indeed improve on the current methods.

Powell (2007) summarizes key discussion points that led to WHS conclusions and recommendations.

### How to calculate exposures when using PHED

#### *Standard PHED scenarios*

Exposure assessors should use UCLs to predict both long- and short-term exposures when using PHED. UCLs for the PHED scenarios are presented in the WHS surrogate exposure guide (Beauvais *et al.*, 2007). For all exposure scenarios presented in the guide, exposure assessors should use the UCLs presented. Note that UCLs should be reported with three significant figures.

#### *Other PHED scenarios*

If a PHED subset is created for a scenario not included in the surrogate exposure guide (Beauvais *et al.*, 2007), its UCLs can be calculated by taking the arithmetic mean exposure, obtained from PHED, and multiplying by the appropriate value from the table in Appendix I (from Table 5 of Powell, 2007). The appropriate value depends on  $n$ , the number of replicates for the route of exposure.

Dermal nonhand exposure is the sum of the exposures for several body parts that may have different  $n$ . The effective  $n$  ( $n_e$ ) for dermal nonhand exposure is found using the following formula (Eq. 7 from Powell, 2007):

$$n_e \approx \frac{\sum_{i=1}^K M_i^2}{\sum_{i=1}^K \frac{M_i^2}{n_i}} .$$

In this formula,  $K$  is the number of body parts summed for dermal nonhand exposure.  $M_i$  and  $n_i$  are the arithmetic mean exposure and the number of replicates for the  $i^{th}$  body part. The result is rounded to a whole integer.

To illustrate this method using the data for Scenario 1 of the surrogate exposure guide (Fig. 1-1 below), the UCLs for dermal nonhand exposure would be calculated as follows:

1. Find the arithmetic mean of dermal nonhand exposure:
  - a) Sum the mean exposures for all body parts excluding the hands and feet ("Mean" column in PHED summary output). Here,  $12.1008 + 49.7781 + \dots + 4.046 = 620.8998$ .
  - b) Foot exposure is calculated as 0.52 times lower leg exposure ( $0.52 \times 4.046 = 2.10392$ ) and added to the mean ( $620.8998 + 2.10392 = 623.0037$ ).
  - c) Round the mean to three significant figures (623).

**Figure 1-1. Summary of Results from the PHED Dermal Subset for Scenario 1**

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES					
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	Subset Name : S1DERMAL.MLOD
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	

2. Calculate the effective number of replicates ( $n_e$ ) using the following equation (Eq. 7 in Powell, 2007):

$$n_e \approx \frac{\sum_{i=1}^K M_i^2}{\sum_{i=1}^K \frac{M_i^2}{n_i}}$$

$$\text{Here, } n_e = \frac{\frac{12.1008^2}{24} + \frac{49.7781^2}{24} + \dots + \frac{4.046^2}{28}}{\frac{12.1008^2}{24} + \frac{49.7781^2}{24} + \dots + \frac{4.046^2}{28}} = \frac{88314.199}{2690.712} = 32.8219,$$

which is rounded to 33.

3. The arithmetic mean exposure of 623 is multiplied by values selected from Appendix I for  $n = 33$ :
- a) UCL for short-term exposure =  $623 \times 3.349 = 2086.427$ ; round to 2,090.
  - b) UCL for long-term exposure =  $623 \times 1.204 = 750.092$ ; round to 750.

Thus, in this illustration, the estimate of short-term dermal nonhand exposure is 2,090 µg/lb AI and the estimate of long-term exposure is 750 µg/lb AI.

Calculation of hand and inhalation UCLs is more straightforward since both the arithmetic mean exposure and  $n$  come directly from the PHED summary output.

UCLs are reported separately for hand, dermal nonhand, inhalation and total exposure. Those for hand, dermal nonhand and inhalation are calculated using the Table 5 multipliers. Each UCL should be reported with three significant figures. The UCL for total exposure is obtained by summing the rounded UCLs for hand, dermal nonhand and inhalation exposure, then rounding the sum to three significant figures.

### References

- Beauvais, S., Powell, S. and Zhao, W. 2007. Surrogate Handler Exposure Estimates for Use in Assessments by the California Department Of Pesticide Regulation. Report no. HS-1826. Sacramento, CA: Worker Health and Safety Branch, Department of Pesticide Regulation.
- PHED. 1995. Pesticide Handlers Exposure Database, Version 1.1. Prepared for the PHED Task Force: Health Canada, U.S. EPA and the American Crop Protection Association, by Versar, Inc., Springfield, VA.
- 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, September 20, 2007. Sacramento, CA: Worker Health and Safety Branch, Department of Pesticide Regulation.
- Powell, S. 2002. Approximating confidence limits for upper bound and mean exposure estimates from the Pesticide Handlers Exposure Database (PHED V1.1). Memo No. HSM-02037, September 27, 2002. Sacramento, CA: Worker Health and Safety Branch, Department of Pesticide Regulation.

### Appendix I

#### Multipliers of arithmetic mean exposure to obtain 90% upper confidence limits (UCL) for the arithmetic mean and the 95<sup>th</sup> percentile of exposure using PHED<sup>a</sup> (from Table 5, Powell 2007)

<i>n</i>	UCL for 95th %ile	UCL for mean	<i>n</i>	UCL for 95th %ile	UCL for mean	<i>n</i>	UCL for 95th %ile	UCL for mean
3	5.149	1.852	37	3.314	1.192	71	3.157	1.135
4	4.741	1.705	38	3.307	1.189	72	3.154	1.134
5	4.482	1.611	39	3.299	1.186	73	3.151	1.133
6	4.299	1.546	40	3.292	1.184	74	3.148	1.132
7	4.163	1.497	41	3.285	1.181	75	3.146	1.131
8	4.056	1.458	42	3.279	1.179	76	3.143	1.130
9	3.969	1.427	43	3.273	1.177	77	3.141	1.129
10	3.897	1.401	44	3.266	1.175	78	3.138	1.128
11	3.836	1.379	45	3.261	1.172	79	3.136	1.128
12	3.784	1.361	46	3.255	1.170	80	3.133	1.127
13	3.739	1.344	47	3.249	1.168	81	3.131	1.126
14	3.699	1.330	48	3.244	1.166	82	3.129	1.125
15	3.663	1.317	49	3.239	1.165	83	3.127	1.124
16	3.631	1.306	50	3.234	1.163	84	3.124	1.123
17	3.602	1.295	51	3.229	1.161	85	3.122	1.123
18	3.576	1.286	52	3.225	1.159	86	3.120	1.122
19	3.552	1.277	53	3.220	1.158	87	3.118	1.121
20	3.530	1.269	54	3.216	1.156	88	3.116	1.120
21	3.510	1.262	55	3.211	1.155	89	3.114	1.120
22	3.491	1.255	56	3.207	1.153	90	3.112	1.119
23	3.474	1.249	57	3.203	1.152	91	3.110	1.118
24	3.458	1.243	58	3.199	1.150	92	3.108	1.118
25	3.443	1.238	59	3.196	1.149	93	3.106	1.117
26	3.428	1.233	60	3.192	1.148	94	3.105	1.116
27	3.415	1.228	61	3.188	1.146	95	3.103	1.116
28	3.402	1.223	62	3.185	1.145	96	3.101	1.115
29	3.391	1.219	63	3.181	1.144	97	3.099	1.114
30	3.379	1.215	64	3.178	1.143	98	3.098	1.114
31	3.369	1.211	65	3.175	1.141	99	3.096	1.113
32	3.358	1.208	66	3.171	1.140	100	3.094	1.113
33	3.349	1.204	67	3.168	1.139	101	3.093	1.112
34	3.340	1.201	68	3.165	1.138	102	3.091	1.111
35	3.331	1.198	69	3.162	1.137	103	3.089	1.111
36	3.322	1.195	70	3.159	1.136	104	3.088	1.110

a UCLs are calculated separately for hand, dermal nonhand, and inhalation exposures. The value of the UCL is the arithmetic mean exposure from the PHED output multiplied by the multiplier above corresponding to the number of replicates for that exposure type. For dermal nonhand exposure, *n* is calculated using the equation on p. 2 of this memorandum.