APPENDIX D

BACKGROUND INFORMATION ON THE PESTICIDE HANDLERS EXPOSURE DATABASE (PHED)

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D-1.0 PESTICIDE HANDLERS EXPOSURE DATABASE (PHED) VERSION 1.1

[NOTE: This Section has been prepared by: Health Canada for the purposes of the Herbicide Use at Canadian Forces Base Gagetown Work Program - July 7, 2006.]

An exposure assessment for each occupational scenario can be developed using the Pesticide Handlers Exposure Database (PHED) Version 1.1. PHED is a generic database containing exposure data for workers mixing/loading and applying pesticides under typical, actual field conditions. It was developed by a task force consisting of representatives from the U.S. Environmental Protection Agency (U.S. EPA), Health Canada, the California Department of Pesticide Regulation, and member companies of the American Crop Protection Association.

The basic assumption underlying the use of PHED is that exposure to pesticide handlers is primarily a function of the physical parameters of the handling and application process, such as formulation type (*e.g.*, liquid versus solid), packaging type, application method, and clothing scenario, rather than of the specific chemical. PHED consists of two parts: a database of measured exposure values for workers handling pesticides and computer algorithms that are used to generate appropriate subsets of the monitored data and to statistically summarize the data. Currently, the database contains values for over 1,700 monitored individuals (replicates).

The exposure studies in PHED are passive dosimetry studies, in which the amount of pesticide deposited on clothing, skin, and in the breathing zone of the worker is measured. There are two basic types of passive dosimetry studies. One method involves wearing a whole body dosimeter (*e.g.*, coveralls) over and/or under typically worn clothing. Another method is to attach patches under and/or outside of clothing (*e.g.*, on the chest, back, upper arm, forearm, thigh, and lower leg). Patches are also attached to the front and sides of caps when estimations of exposure to the face and neck are needed, or on top of hats for head exposure. The whole body dosimeters or patches trap residues that would otherwise come into contact with clothing or skin. At the end of the exposure period, the dosimeters or patches are collected and the trapped residues are measured. The amount of pesticide recovered from a dosimeter or patch is generally reported as micrograms of pesticide per square centimeter ($\mu g/cm^2$). For patches, the patch area may be considerably less than the surface area of the body part. Thus, the amount collected is scaled to the size body part based on the ratio of the body part area to the dosimeter area. Pesticide residues on the hands are measured by analyzing the pesticide content of rinsate after washing the hands, by measuring the amount found on hand wipes used after exposure, or by calculating the amount left on cotton glove dosimeters. Personal air samplers are used to estimate the amount of pesticide in the breathing zone of workers.

The algorithms in PHED allow the user to construct exposure scenarios representative of specific uses of a chemical by selecting data from one of the four main data files contained in the system (*i.e.*, mixer/loader, applicator, flagger, and mixer/loader/applicator). PMRA and the U.S. EPA have used PHED to develop exposure tables of exposure values for the most common pesticide worker exposure scenarios, including mixing/loading of liquid formulations and application by aerial equipment. These table contain values normalised per amount of active ingredient handled so that can easily be adjusted to best represent the actual situation under consideration. The PMRA and the U.S. EPA tables are based on “best fit” values which PHED calculates by assessing the distributions of exposures for each body part (normal, lognormal or “other”) then calculating a composite exposure value representing total exposure to the entire body. Most data sets in PHED are lognormally distributed or fall into the “other” distribution category. If the distribution is lognormal, the geometric mean for the distribution is used in the “best fit” exposure value. If the data are an “other” distribution, the median value of the dataset is used in the calculation of the “best fit” exposure value. As a result, the surrogate unit exposure values that serve as the basis for this assessment generally range from the geometric mean to the median of the selected dataset.

Each study in PHED has been graded from “A” to “E” according to certain quality assurance and quality control (QA/QC) factors as indicated in the Table below.

Data Grade	% Lab Recovery	CV* for Lab recovery	% Field Recovery	% Storage Stability	Data Corrected For:***
A	90-110	.15	70-120	**	Field Recovery
B	80-110	.25	50-120	**	Field Recovery
C	70-120 70-120	.33 .33	30-120 or missing	** 50-120	Field Recovery
D	60-120	.33	**	**	Field Recovery if available; if not then storage stability, if not then lab recovery
E	**Does not meet above criteria**				

***** CV = Coefficient of Variation
****** Does not matter if available or missing
******* If a field recovery of 90% or greater is obtained, no correction of the data is necessary

Data confidence refers to both the quality and the amount of data for each PHED run. PHED runs are graded according to the quality of data within the run (A, B grade *etc.*) and the number of replicates for each run. A run is considered to have HIGH CONFIDENCE if the data are all A and B grade and if there are at least 15 replicates for each body part. A run is considered to have LOWER CONFIDENCE if the run contains C grade data and the replicates are less than 15 OR the run contains A and B grade with replicates less than 10. Health Canada does not generally use D or E grade data.

Unit exposure numbers are presented in the PHED tables for different clothing options. If PHED did not contain adequate data, clothing scenarios are calculated based on a 75% protection factor for cotton coveralls and 90% protection factor for chemical resistant gloves, chemical resistant coveralls and respirators.

As the exposure studies in PHED are older studies (pre 1995), they are based on exposure using older application equipment. While this means that PHED tends to exaggerate the exposures associated with modern equipment, which is designed to be more efficient and to keep occupational exposures to a minimum, it also means that PHED data is particularly appropriate for the types of historical risk assessments required for some of the Gagetown applications.

However, PHED is considered to generate conservative (high end) exposure estimates, even for the older applications being assessed, for reasons that include:

1. The aerial application studies in PHED, including the flagger exposure studies, are primarily based on agricultural uses. The use of these studies to estimate exposure for forest application scenarios may result in exaggerated exposures as there is no protective tree canopy effect in the agricultural studies.
2. When a chemical is not detected on a dosimeter, the PHED algorithms assume that is there at one half of the analytical limit for detecting that chemical. As many of the older studies in PHED have relatively high chemical detection limits, this can be a conservative assumption.
3. Using patches to estimate exposure, then extrapolating that exposure to the whole body assuming uniform distribution, can result in exaggerated exposure estimates.

In addition, the highest application rates and the maximum areas of land treated are often used in risk assessment calculations. Multiplying conservative parameters exponentially compounds the conservatism of the exposure estimate.

D-2.0 U.S. EPA USE OF PHED

The PHED is a database that contains voluntarily submitted empirical exposure data for workers involved in the handling or application of pesticides in the field (OPPT, 2006). The database contains data for over 2,000 monitored exposure events. The basic assumption underlying the system is that exposure to pesticide handlers can be calculated generically, based on the available empirical data for chemicals, as worker exposure is primarily a function of the formulation type and the handling activities (*e.g.*, packaging type, mixing/loading/application method, and clothing scenario), rather than chemical-specific properties. The use of generic data that does not directly address chemical properties of a herbicide is most appropriate. The experience in agriculture and forestry applications is that the formulation, the method of application, the label rate of application, the percent active ingredient, and the number of acres treated, *but not the chemical properties of the pesticide* control the amount of dermal and inhalation exposure. Thus, PHED allows exposure and risk assessments to be conducted with a much larger number of observations than would be available from a single exposure study, thus increasing the confidence in the assessment.

If chemical-specific data are available, then these data can be pooled with PHED data, or in some cases substituted for PHED data. PHED exposure estimates with data sets that describe exposure scenarios with medium or high confidence include open mixing for liquid formulations, and aerial spraying (U.S. EPA, 2000).

D-3.0 PEST MANAGEMENT REGULATORY AGENCY USE OF PHED

For aerial application, dermal and inhalation exposure estimates for mixer/loader/applicators are based on data from the PHED Version 1.1 (PMRA, 2002). PMRAs version of PHED differs from the U.S. EPA version by incorporating metric rather than imperial units of measure. When a specific application scenario does not exist in PHED or other available databases, exposure assessors estimate the quantity of pesticides use surrogate data and professional judgment.

D-4.0 FORESTRY APPLICATION OF 2,4,5-T AND 2,4-D BY HELICOPTER AND MEASURED EXPOSURES

D-4.1 Aerial Application of 2,4,5-Trichlorophenoxyacetic Acid

2,4,5-T was supplied as 4 lb acid-equivalent per gallon and formulated as propylene glycol butyl ether ester. The study was designed to evaluate worker exposure during aerial application of herbicides. All workers in crews were monitored using several methods during and after application by helicopter. Helicopter operations used an application rate of 2 lb/acre in 5 gal of water per acre. The exposure analysis employed two separate helicopter crews made up of a pilot, a mixer, a supervisor, and two flagmen. Workers, for the most part, did not wear gloves or special protective clothing. The typical attire for members of the spray crews included long trousers, shirt (long or short sleeves) and field boots (Lavy *et al.*, 1980).

Respiratory tract exposure to the 2,4,5-T ester was assessed *via* a portable air pump that drew a known volume of air to trap 2,4,5-T on a resin (XAD-2) . Air was drawn through the resin at approximately 6 to 7 L of air/h. Dermal exposure tests estimated quantity of 2,4,5-T likely to come into contact with the bare skin portions of the body. Six cellulose backed gauze patches (10 x 10 cm) were attached to the clothing (chest, back, upper arms, and upper thighs) of each worker. After analysis of patches worn during tests the total amount of 2,4,5-T detected per patch times the total skin area exposed was assumed to constitute the total dermal exposure for the activity (Lavy *et al.*, 1980).

D-4.1.1 Results

Only one of ten helicopter application crew (a flagman) showed any evidence of detectable levels of 2,4,5-T by use of air-monitoring devices suggesting low potential for inhalation exposure. Urine samples for each on the other hand showed clear evidence of exposure to 2,4,5-T for mixers, suggesting that dermal exposure was a likely source. Other members of the spray crew showed low levels, but detectable levels of exposure. Categorized by work duties, mixers received the highest internal exposures followed by helicopter pilots, supervisors and flagmen. The apparently elevated exposure experienced by one of the pilots was attributed to the fact that he maintained the spray nozzles and helped to change the spray boom before and after each sortie (Lavy *et al.*, 1980)

Table D-1 Average Levels of 2,4,5-T Detected in Air (inhalation zone), Skin (patches) and Urine Samples Following Helicopter Application of Herbicide[a]

Operation and duty	Air (breathing zone) µg/kg	Skin (mg/kg)	Urinary excretion[b] (mg/kg)
Pilot 1	nd[c]	0.11	0.005
Pilot 2	nd	nd	0.038
Mixer 1	nd	0.12	0.065
Mixer 2	nd	0.042	0.096
Supervisor 1	nd	0.024	0.004
Supervisor 2	nd	nd	0.003
Flagman 1	nd	nd	0.002
Flagman 2	nd	nd	0.001
Flagman 3	nd	nd	0.001
Flagman 4	1.03	nd	0.001

[a] Adapted from Lavy *et al.*, 1980
[b] Total excreted over a period of six days post exposure
nd not detected

D-4.2 Aerial Application of 2,4-Dichlorophenoxyacetic Acid

A second helicopter study that examined exposure to 2,4-D during forestry aerial application. This study also revealed little evidence of incidental exposure to the herbicide. Nevertheless Lavy *et al.* (1982) showed that those low levels of exposure could be further reduced by the use of protective clothing.

The objectives of the study were (1) to measure both external exposure and internal dose received by helicopter crew spraying 2,4-D in the forest, (2) to determine whether protective clothing significantly altered these measurements, and (3) to evaluate the relationship between exposure or dose and the worker's duties (Lavy *et al.*, 1982). Three different helicopter application crews (pilot, mechanic, mixer/loader, supervisor and two observers (flagmen)) were monitored during and after two herbicide applications scheduled a week apart. Crews performed their duties with two levels of clothing protection (*e.g.*, standard work clothes and Tyvek coveralls) (Lavy *et al.*, 1982). Applicators in this study were trained and certified pesticide applicators.

Respiratory exposure was estimated from the results of personal air sampling monitoring equipment. Total volume of air inhaled was assumed to be 1,740 L/h for this kind of work. Exposure was expressed as micrograms per kilogram body weight (detection limit 0.05 µg). Dermal exposure estimates were prepared from 2,4-D on denim patches located in areas adjacent to the wrist, head and neck, on a hat and other locations (detection limit 0.0037 mg). Urinary samples collected for eight days after exposure were used to estimate internal dose of 2,4-D (detection limit 0.04 mg/kg in urine) (Lavy *et al.*, 1982).

Treatments used contained 4 lb of acid equivalent 2,4-D per gallon (U.S.). The herbicide was mixed with **diesel oil** and water at a rate of 0.5 gal concentrate to 0.5 gal diesel to 9 gallons water (10 gallons final volume). This mixture was applied at 10 gallon/acre (2 lb active ingredient per acre) (Lavy *et al.*, 1982).

Batching was carried out in a mixing truck (1000 gal of spray/application for 100 acres). Mixing took from 5 to 18 minutes using a mechanical pump. Loading into the helicopter took 30-60 seconds. (When a mixing pump failed and manual transfer was required, this process took up yo an hour) (Lavy *et al.*, 1982).

D-4.2.1 Results

Estimation of respiratory exposure to 2,4-D determined from personal air monitors. Even without special clothing precautions, all but one of 18 members of the three separate teams showed no evidence of inhalation exposure to 2,4-D (17 non-detects and one mixer at 0.3 µg/kg body weight) (Lavy *et al.*, 1982)..

Estimation of dermal exposure was reduced by the use of a protective Tyvek suit (data not shown).

Table D-2 Average Levels of 2,4-D Detected in Air (inhalation zone), Skin (patches) and Urine Samples Following Helicopter Application of Herbicide[a]

Operation and duty	Air (breathing zone) µg/kg	Skin (mg/kg)	Urinary excretion[b] 2,4-D (mg/kg)
Pilot 1	nd[c]	nd	0.00179
Pilot 2	nd	0.0010	0.0557
Pilot 3	nd	0.0007	0.00206
Mechanic 1	nd	0.0023	0.00044
Mechanic 2	nd	0.0059	0.00232
Mechanic 3	nd	0.0617	0.0136
Mixer 1	nd	0.0023	0.00215
Mixer 2	nd	0.0911	0.0189
Mixer 3	0.03	0.0409	0.0337
Supervisor 1	nd	nd	nd
Supervisor 2	nd	nd	nd
Supervisor 3	nd	0.0005	0.00692
Flagman (observer)1	nd	nd	nd
Flagman (observer) 2	nd	nd	nd
Flagman (observer) 3	nd	nd	0.011
Flagman (observer) 4	nd	nd	0.00055
Flagman (observer) 5	nd	nd	nd
Flagman (observer) 6	nd	0.0005	0.0013

[a] Adapted from Lavy *et al.*, 1982
[b] Total excreted over a period of eight days post exposure
nd not detected

This study found that some crew members involved in the aerial application of 2,4-D for forestry purposes absorbed low levels of 2,4-D (the doses as indicated by urine analyses were several orders of magnitude below the no-observable-effect level determined in toxicology studies) (Lavy *et al.*, 1982).

The study also found that exposure to 2,4-D could be reduced. In particular, when mechanics, mixer-loaders, and pilots wore standard protective apparel and followed good hygienic practices there was evidence of reduced exposure. For example, wearing chemically impervious rubber gloves and using modern siphon pumps and drip-free coupling systems on transfer hoses virtually all dermal exposure was eliminated (Lavy *et al.*, 1982).

D-5.0 CONCLUSION

The experience with aerial application of herbicide to forests does not appear to contradict the information available in the PHED database. These results were also consistent with those generated in this risk assessment. It is not clear whether the use of the exposure data available from the two papers of Lavy *et al.*1980; 1982 could be usefully applied to the circumstances that prevailed at CFB Gagetown.

D-6.0 REFERENCES

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