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April 29, 1993

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Dear Dr. Till and Mr. Donnelly:

APPROACH FOR CALCULATING POPULATION DOSES USING THE CIDER COMPUTER CODE

Ref. 1: CDC/Battelle Contract No. 200-92-0503 (CDC) Milestone 12.

This letter is provided to complete the referenced milestone as defined by the Technical Steering Panel (TSP) at its meeting on January 8, 1993. Within this milestone, the Battelle Hanford Environmental Dose Reconstruction Project (HEDR) is to describe the capability for using HEDR computer codes to calculate population doses.

Defining the Assessment Question

To provide a description of how such doses could be calculated, it is necessary to state the assessment question that the dose result would answer. We have identified several possible interpretations of the concept of "population dose". The assessment question we consider here is the one most commonly addressed in environmental health physics assessments:

What is the total collective thyroid dose, in person-rad, that a specific group of people received over a given time period?

The answer to this question will have only one true, but unknown, value. Monte Carlo techniques should be used to estimate the uncertainty of the calculated population dose. Examples of specific groups of people could be the residents of a specific geographical (e.g., HEDR) or political (e.g., Franklin County, Washington) domain or a Native American tribe. Should the assessment question change, the approach to the calculation would also change - however, we believe that the HEDR tools are appropriate for answering other population-related questions as well.

This assessment question may be addressed using the HEDR-developed individual dose calculation tool CIDER with no modification to either the code itself or to its DESCARTES-derived database.

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Dose Calculation Process

The process for calculating population doses is conceptually simple, as illustrated in Figure 1. The process may be considered to consist of six, sometimes repeated, steps.

Step 1. As part of the initial assessment question, a particular population must be specified (e.g., who comprises the population of interest?)

Step 2. The population of interest is subdivided into a number of reasonably homogeneous constituent groups. The members of these groups should have similar exposure patterns. In practice, this means that the groups should be of similar ages (i.e., infants and adults should probably be considered separately) and have similar food sources and consumption rates. Each group is then represented by an idealized "representative individual" - an "averaged" person with characteristics that describe the salient features of the constituent group. The overall level of accuracy of the population dose estimate is directly dependent on the level of detail of this step. (In the extreme case, this could expand to every individual in the population.)

From this step, two parallel efforts are necessary. The first, step 3, is to select a suite of input parameters for each of the representative individuals. These input parameters should have been considered in the preceding step defining and differentiating the groups - they now must be quantified, with appropriate ranges on their distributions. Simultaneously, step 4, the absolute number of people fitting this description must be estimated. We assume that the groups may inhabit more than one of the CIDER calculational node locations. Therefore, the input parameters for a representative individual will be used for dose estimates at more than one node. The number of people fitting this description for each node must be estimated. We assume that there will be some uncertainty about the total number of people fitting the representative description, and their spatial distribution, so this is also assumed to be a stochastic selection process.

Using the input parameters defined in the prior steps, the dose distributions for each type of representative individual at each node are calculated using the CIDER code, step 5. This is the exact process the CIDER code was designed for - the procedure is the same as that for estimating dose for any specific individual.

Finally, step 6, the product of dose and number of people is formed for each combination of location and representative individual, and the total population dose in person-rad is obtained. Because the doses and population estimates are both uncertain, this process must be repeated for each realization of dose and number of people exposed. A simple post-processor may be required to speed the final assembly of the results. For small groups or for small geographic areas, a simple spreadsheet should suffice to keep track of intermediate data. For more comprehensive calculations, a statistical data-management tool such as SAS® is advisable.

Table 1 illustrates a hypothetical calculation for N node locations, with I representative individual types, performed for R realizations (probably usually 100 realizations would be used from the CIDER output). For each realization, the sum of the products of dose and number of people is shown in the last column of the table. The distribution of these sums defines the uncertainty about the estimated population dose.

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Accuracy and Reliability of Result

The calculation of population dose would be a relatively straight-forward application of the tools provided by the HEDR project. The accuracy and reliability of the calculated result depends on the care with which the parameters describing the constituent groups within the population are developed. Some of this information is needed by the CIDER code, such as

- definition of constituent groups based upon age, sex, consumption, and food source
- definition of representative individuals
- average consumption rates by age and sex.

The remaining information would be needed for the final summation, particularly

- population distribution by age, sex, and food source
- population at each spatial node.

Presentation of Final Result

The final population dose result could be expressed as a single value with its uncertainty, as a box plot, or as a complimentary cumulative distribution function. We performed this general process for the HEDR Phase I summary report, (although we did not describe it in this way - the population dose was actually the area under the curve presented in the Phase I report).

Questions or comments concerning this information should be addressed to me at the above phone number or Mr. B. A. Napier, Chief Scientist, (509) 375-3896.

Very truly yours,

W.T. Till for DBS

Dillard B. Shieler, Manager
Hanford Environmental
Dose Reconstruction Project

DBS:ban:prc

Enclosures:

Logic of Process (box diagram)
Conceptual Model (example calculation matrix)

cc: See attached distribution list

FIGURE 1. Population Dose Process Logic Diagram

TABLE 1. Conceptual Representation of a Population Dose Calculation

Realization	Location (Node) 1						Location (Node) 2						...	Location (Node) N						
	Type 1		Type 2		Type 1		Type 1		Type 2		Type 1		...	Type 1		Type 2		Type 1		
	D_	#_	D_	#_	D_	#_	D_	#_	D_	#_	D_	#_	...	D_	#_	D_	#_	D_	#_	
1	4.2	36	23	1	55	23	2	99	-	-	45	78	...	4	23	14	7	23	9	9876
2	3.9	37	28	2	49	22	2	87	-	-	51	82	...	3	22	19	8	24	8	9994
3	5.6	32	25	1	53	24	2	91	-	-	59	80	...	5	21	17	7	29	9	9106
...																				
R	6.8	35	31	3	44	19	3	97	-	-	57	79	...	6	19	16	9	30	7	9204

The table is incremented for N nodes, I individual types, and R realizations. D indicates the dose (rad) estimated for this individual type, location, and realization, and # indicates the number of such individuals estimated for this location and realization. The SUM indicates the sum of the products of the dose times the number of individuals (person-rad) for each type and location across each realization. The distribution of the sums is the distribution about the estimated population dose. The dash (-) illustrates that it is unnecessary to estimate doses for individual type/location combinations for which there were no people. Ellipses (...) indicate that the table can continue for as many locations, individual types, and realizations as desired.

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