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Dosimetry and Health Effects Self-Teaching Curriculum

Illustrative Problems to Supplement the User's Manual for the Dosimetry and Health Effects Computer Code

Prepared by G. E. Runkle, N. C. Finley

Sandia National Laboratories

Prepared for
U.S. Nuclear Regulatory Commission

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ABSTRACT

This document contains a series of sample problems for the Dosimetry and Health Effects Computer Code to be used in conjunction with the user's manual (Runkle and Cranwell, 1982) for the code. This code was developed at Sandia National Laboratories for the Risk Methodology for Geologic Disposal of Radioactive Waste program (NRC FIN A-1192). The purpose of this document is to familiarize the user with the code, its capabilities, and its limitations. When the user has finished reading this document, he or she should be able to prepare data input for the Dosimetry and Health Effects code and have some insights into interpretation of the model output. This report represents one of a series of self-teaching curricula prepared under a technology transfer contract for the U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Division of Waste Management (FIN A-1158).

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INTRODUCTION

These sample problems are designed to illustrate the function and capabilities of the computer code that implements the concept of the Dosimetry and Health Effects Model. The problems are a supplement to the user's manual (Runkle and Cranwell, 1982) and much of the detailed background information included in the user's manual has not been repeated here. It is essential that a copy of the user's manual be readily available to gain a full understanding of the Sample Problems.

The Dosimetry and Health Effects Computer Code (DHECC) was designed to process data from the Pathways Model (Helton and Kaestner, 1981) for the scenario analysis to demonstrate the high-level waste risk assessment methodology (developed under NRC FIN No. A-1192). In addition, the code has the capability to stand alone to process limited data sets that are independent of the Pathways Model. Several user options are available to choose the input device (card deck or disk file), the input data type (concentrations and/or intakes) and the output of various intermediate and final results. These options are detailed in the user's manual. The sample problems illustrate the stand alone capability of the code, as well as the procedures for performing a complete scenario analysis. The scenario analysis includes processing data of radioactive releases to the biosphere from the groundwater transport models through the Pathways Model to determine the radionuclide concentration in the environmental media. These concentrations are used to calculate human intakes (via ingestion and inhalation) and external exposures and finally to estimate dose commitments and potential adverse health effects.

The Dosimetry and Health Effects Model is a linear model that converts curie intakes (ingestion and inhalation) and external exposure levels for various radionuclides to dose commitments (rem) and finally estimates the potential adverse health effects that may result from these exposures. For convenience of processing and storage of the data for the scenario analyses performed with the Risk Assessment Methodology, the equations to calculate the intakes from the ingestion and inhalation pathways were moved from the Pathways Model to the Dosimetry and Health Effects Computer Code (Subroutine RDCONC). Therefore, the user may choose to input the radionuclide concentrations in soil, water, sediment and well water (if the scenario includes withdrawal wells) and have the DHECC calculate intakes via ingestion and inhalation and finally, risk estimates. Or the user may input ingestion and inhalation intakes (calculated external to the DHECC) and the code will process these data to estimate adverse health effects. These input data may be read from a disk file or from a card deck.

The basic structure of the DHECC is given in Figure 1. The set of option cards determines the input device, input type, output selections, number of time steps, and the increment of each time step. A disk file (designated as Tape 1 in the code) contains a data base of 70 year intakes/70 year dose commitment factors for 170 radionuclides and 7 organs. The ICRP-2 Model (ICRP, 1959) and the basic INREM model (Killough, et al 1975) were extended using the parameters provided in Hoenes and Soldat (1977) to calculate these dose commitment factors (Runkle, et al 1981). The effects of radioactive decay and biological elimination are included in the dose conversion factors. This file is read by the code and stored in the DFING, DFINH, DFEXT arrays. The set of radionuclides that are to be considered for a particular analysis are read from the input card deck and a pointer (IPNT) is set to designate the appropriate radionuclide dependent dose conversion factors.

Data may be input from a disk file or from a card deck and may be expressed as environmental media concentrations and/or ingestion and inhalation intakes. If radionuclide concentrations are input by the RDCONC Subroutine, the code will compute the inhalation and ingestion intakes. The soil, surface water, sediment and well water (optional) concentrations are multiplied by concentration factors to determine the radionuclide level in various food sources. The ingestion pathways include milk, beef, plant, fish, invertebrate and drinking water intakes. The invertebrate intake is zero for all freshwater sources. The effects of terrestrial sources are determined with and without irrigation. If a release scenario includes a well, it is assumed that drinking water is obtained from the well withdrawal. Otherwise, drinking water and irrigation water are obtained from the surface water. These various food concentrations are combined with human uptake rates to calculate consumption from the ingestion pathways. The intakes are expressed as curies/year for each radionuclide specified in the analysis. For the inhalation pathway, the soil concentration of each radionuclide is combined with the concentration of suspended material in the air (3.5E-9 kg/m^3) to determine air concentration (Ci/m^3). The standard breathing rate is multiplied by the air concentration to determine the annual inhalation intake, expressed as curies/year.

If a user chooses to input ingestion and inhalation intakes (calculated external to the DHECC), the Subroutine RDINTK is called to read the intakes from the water based paths, land based paths with and without irrigation, and from inhalation. Also, the radionuclide concentrations in soil, surface water, sediment and air are input to calculate the external exposure.

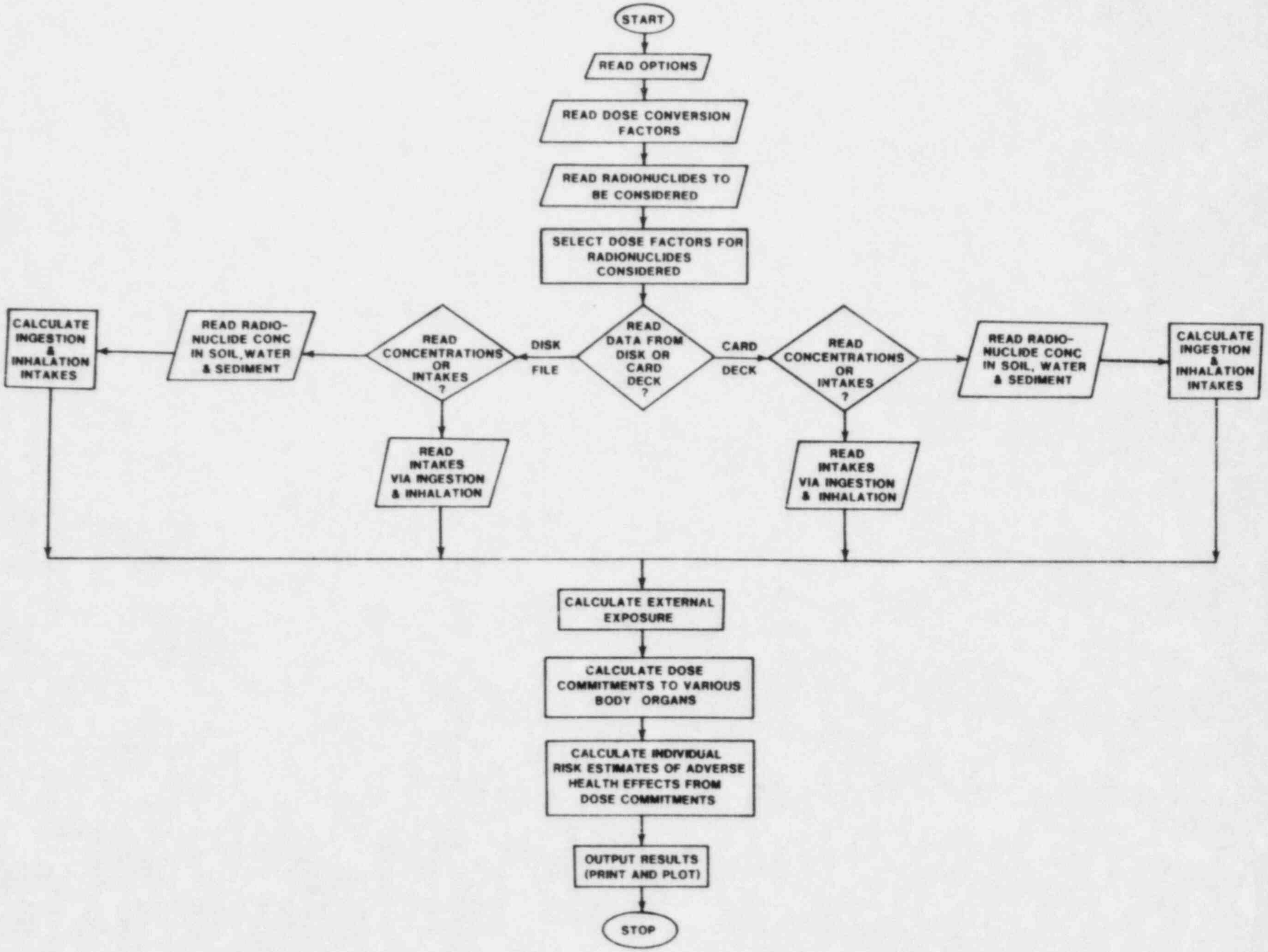

Figure 1. Flow Chart of the Dosimetry and Health Effects Computer Code -- Simple Analysis

Regardless of the input type chosen for the ingestion and inhalation intakes, the DHECC calculates the external exposure levels. The environmental media concentrations and the average exposure times to soil, surface water, sediment and air are combined to estimate external exposure levels expressed as $Ci \cdot hr/m^2$ for surfaces and $Ci \cdot hr/m^3$ for air.

To estimate risk in terms of adverse health effects, it is necessary to convert the Ci/yr values for the inhalation and ingestion pathways and the $Ci \cdot hr/m^2$ or m^3 for the external exposure to dose commitments for the various body organs. It is assumed that the individual is exposed to these environmental media for an average lifetime of 70 years. The DHECC matches these curie values for each radionuclide with the appropriate dose conversion factor and calculates the individual dose commitment in rem.

The dose commitments are combined with risk estimators for the various types of cancer to estimate the latent cancer effects that may potentially result from these dose commitments to the body organs. The risk estimators are based on the linear dose response curves from BEIR (1972). Since population statistics are always changing and our predictions extend to 10^5 years after closure of the depository, we have chosen to calculate risk to an individual. We do acknowledge that the BEIR risk factors have been derived from population statistics. For our calculations, the population fractions used in calculating risk factors, based on person-rem, have been replaced with an age fraction. The age fraction is defined as the portion of a 70 year lifetime within a given age group. This approach assumes that the individual dose rate is constant throughout the lifetime of the individual. These age fractions are similar to the population fractions and the risk estimators calculated by this method do not vary significantly from the population based estimators. These risk estimators express the conditional probability of an individual dying of cancer. In addition to the potential latent cancer estimates, the average annual dose received from the potential releases from the depository are calculated. These dose levels may be used to estimate the potential genetic and embryonic effects.

The output from the analysis is selected by the user and may consist of a printout of intermediate and final results to the line printer and/or plots of the results if the analysis involves multiple time steps and vectors. To account for the uncertainty in the input parameters to the groundwater flow and transport models, these parameters are treated as random variables having assigned ranges of values and assumed distributions (e.g., K_d, hydraulic conductivity, solubility limits). Specific values for these input parameters are then obtained using a statistical sampling procedure. A set of input values is referred to as a vector, where the components of the vector are the specific values of the input parameter obtained during one sampling procedure.

The relatively simple procedure (outlined in Figure 1) may be followed if a limited set of input parameters are to be processed, as illustrated in Sample Problems 2 and 3. However, if a more detailed analysis is needed, the flow diagram illustrated in Figure 2 is more appropriate. With this procedure, DO LOOPS are used to process decay chains to risk estimates for all radionuclides, zones, time steps and vectors. This more complex design has been used in processing the scenario analyses for the High-Level Waste Risk Assessment Methodology Development Program.

The reference site used in the analysis is detailed in Campbell, et al (1978) and the surface environment of this site consists of several zones as described in Helton and Kaestner (1981). In the scenario analysis considered in the sample problems, two zones are defined, Zone 1 and Zone 2. Zone 1 describes an area 4 km by 40 km from a point above the depository to the junction with a river (River L in the reference site). This zone is designed to display the effects of discharges to the surface environment other than at the river (e.g., well withdrawal and faults). Zone 2 is downstream from Zone 1 and takes into account environmental dilution and retardation, resuspension from soil and irrigation with river water. The only connection between these zones is the surface water compartment. The Pathways Model (Helton and Kaestner, 1981) uses a mixing cell composed of four compartments (surface water, groundwater, soil and sediment) to simulate the movement of radionuclides through the biosphere. Influences of distribution coefficients (K_d) and flow rates between the compartments are considered by this model. If the final output from the Pathways Model is the concentration of each radionuclide considered in the soil, the surface water, the sediment, and the well water (optional) at each time step, the DHECC will compute intakes for the ingestion and inhalation pathways. If the intakes are calculated in the Pathways Code, the DHECC will proceed to external exposure calculations and on to risk estimates. The more complex procedure used in the scenario analysis is demonstrated in sample Problems 4 and 5.

For the sample problems, radionuclide concentrations are considered the input data. The code calculates the ingestion and inhalation intakes to more fully demonstrate the capabilities of the DHECC. In Problem 1, a hand calculation is performed stressing the basic concepts of a single pathway. In Problem 2, assumed concentrations of ^{240}Pu and ^{236}U in the soil, surface water, and sediment are used as input to the computer code. The input deck for executing the DHECC to process this problem is detailed. Problem 3 uses the same format as Problem 2 with different input concentrations. However, the user is asked to calculate the potential risk from several pathways. In Problem 4, a single decay chain and single vector are considered for a U-tube scenario. The final risk estimates for the ingestion, inhalation, and external paths are output.

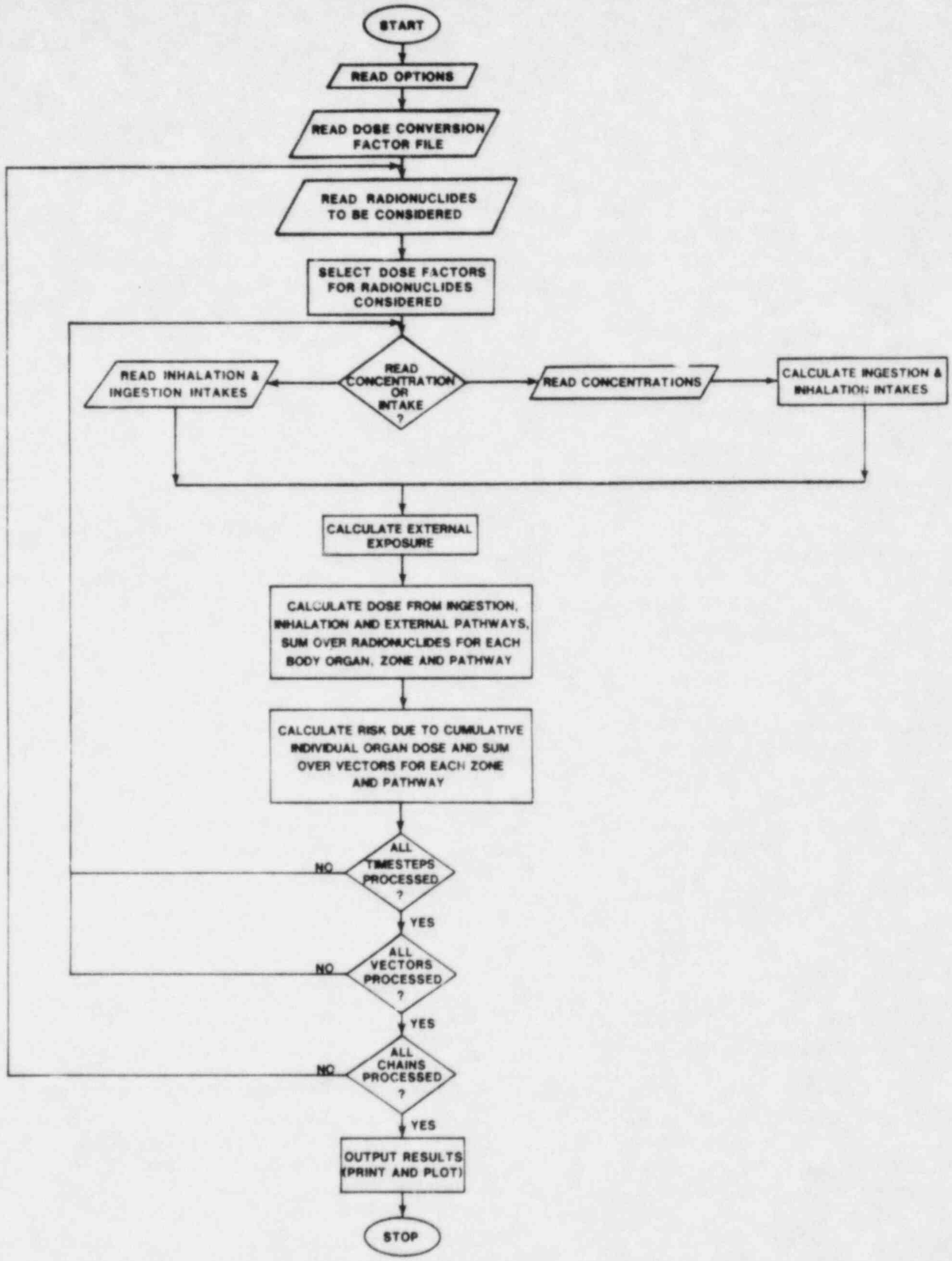

Figure 2. Flow Chart of the Dosimetry and Health Effects Computer Code -- Complex Analysis

In Problem 5, the same U-tube scenario is analyzed for five decay chains and 35 vectors. The normal output in the form of individual cancer risk curves and dose estimates for the time periods from 100 to 100,000 years post-closure are given.

SAMPLE PROBLEM 1

In this problem we are considering only the drinking water component of the ingestion pathway. The ingestion pathway usually includes the intakes from drinking water, fish, invertebrates, beef, plants, and milk. Let us assume that a surface water concentration of 2.15E-12 Ci/ℓ was calculated for ^{241}Am by the Pathways Model. We wish to estimate the potential health effects that may result from drinking this water for a 70 year lifetime. The average consumption rate of water is 370 ℓ/yr.

Intake from Drinking Water (Ci/yr) = Water Consumption Rate (ℓ/yr)

x Water Concentration (Ci/ℓ)

7.96E-10 Ci/yr = 370 ℓ/yr x 2.15E-12 Ci/ℓ

Using this curie intake, it is necessary to convert to a dose commitment expressed in rem for the various body organs by using the ingestion dose conversion factors.

DOSE COMMITMENT (70 yr)

$$\text{Intake } \frac{7.96\text{E-}10 \text{ Ci}}{\text{yr}} \times \text{Dose Factor Total Body } \frac{2.75\text{E}6 \text{ rem-yr}}{\text{Ci}} = 2.19\text{E-}3 \text{ rem}$$

$$\text{Intake } \frac{7.96\text{E-}10 \text{ Ci}}{\text{yr}} \times \text{Dose Factor Bone } \frac{4.08\text{E}7 \text{ rem-yr}}{\text{Ci}} = 3.24\text{E-}2 \text{ rem}$$

$$\text{Intake } \frac{7.96\text{E-}10 \text{ Ci}}{\text{yr}} \times \text{Dose Factor Lung } (0.0) = 0.0 \text{ rem}$$

$$\text{Intake } \frac{7.96\text{E-}10 \text{ Ci}}{\text{yr}} \times \text{Dose Factor GI TRACT } \frac{5.19\text{E}6 \text{ rem-yr}}{\text{Ci}} = 4.13\text{E-}3 \text{ rem}$$

Estimates of the individual cancer risk from these dose levels are calculated by multiplying these doses (in rem) by the appropriate risk estimators.

Type of Cancer	Individual Risk per rem	Dose (In rem)	Individual Cancer Risk
Lung	2.5E-5	0.0	0.0
Leukemia	2.9E-5	3.2E-2	9.3E-7
Stomach	1.2E-5	4.1E-3	4.9E-8
Pancreas	3.8E-6	4.1E-3	1.6E-8
Rest of GI	3.8E-6	4.1E-3	1.6E-8
Breast	2.9E-5	2.2E-3	6.4E-8
Bone	9.8E-6	3.2E-2	3.1E-7
All Other	3.6E-5	2.2E-3	7.9E-8
			1.5E-6

The 1.5E-6 value is the individual cancer risk following the intake of water having a concentration of 2.15E-12 Ci/ℓ of ^{241}Am for a 70 year lifetime. This is a conditional risk based on the assumption that the release to the surface water occurs with a probability of 1.0.

SAMPLE PROBLEM 2

In this problem we use the Dosimetry and Health Effects Computer Code and assume values for the input concentrations of soil, water, and sediment to calculate the exposures for all of the pathways to the human, and the potential health effects that may result from these exposure levels.

The two radionuclides considered in this problem are ^{240}Pu and ^{236}U. The assumed concentrations for the soil, surface water, and sediment in Zone 1 and Zone 2 are given in Table 1. The equations in Table 2 are used by the code to calculate intake from the various food sources and external exposure levels in Subroutine RDCONC. The input parameters for these equations are given in Tables 3 and 4. Many of these parameters are radionuclide dependent. After calculating the exposure levels expressed in Ci/yr or as $Ci\text{-}hr/m^2$ or $Ci\text{-}hr/m^3$ for the various pathways, it is necessary to convert the curie values to dose commitments. The dose conversion factors for ^{240}Pu and ^{236}U for ingestion, inhalation, and external exposures are given in Table 5 for various body organs. The final section of the computer code estimates the potential health effects that may result from these dose levels. The individual risk estimators for the various types of cancer are given in Table 6. By following several pathways from the input concentration to the final risk estimate (as illustrated in Problem 1), it is possible to examine all of the functions of the DHECC.

The input deck that is needed to process this sample problem with the DHECC is described in Table 7; and samples of the punched cards are shown in Figure 3. The output from the execution of this input deck is given in Table 8. Page 1 (Table 8) echoes the input parameters, selected output options, and the time steps specified. Page 2 contains a printout of the concentrations that were read from the input deck. Page 3 details the human intakes from the water based pathways and from the land based pathways with and without irrigation. Page 4 summarizes the concentrations and intakes for all the radionuclides, zones, and pathways. Page 5 gives the results of the external exposure calculations for the total body for each radionuclide and environmental media. Page 6 summarizes the external exposure results from the various pathways and radionuclides. Page 7 gives the dose commitments from the individual radionuclides for the various body organs following intakes via ingestion and inhalation. Page 8 is a summary of the dose commitments for the ingestion and inhalation pathways for all radionuclides. Page 9 gives the risk estimates for the various cancer types for the dose commitments given on Page 8. Page 10 summarizes all the estimates of risk for the various pathways for the two zones considered in this problem.

Table 1

Assumed Pathways Concentrations for Problem 2

		^{240}Pu	^{236}U
	Soil	5.28E-15 Ci/kg	1.12E-10 Ci/kg
Zone 1	Surface Water	6.21E-15 Ci/ℓ	1.18E-10 Ci/ℓ
	Sediment	3.90E-14 Ci/kg	7.38E-10 Ci/kg
	Soil	4.72E-15 Ci/kg	5.73E-10 Ci/kg
Zone 2	Surface Water	4.90E-15 Ci/ℓ	2.80E-10 Ci/ℓ
	Sediment	3.08E-14 Ci/kg	2.90E-10 Ci/kg

Table 2

BASIC EQUATIONS

Page 1

FOR VARIOUS PATHWAYS

(1) DRINKING WATER INTAKE (Ci/Yr)=WATER CONSUMPTION (370 1/Yr)

* WATER TREATMENT FACTOR (1.0) * WATER CONC. (Ci/l)

(2) FISH (Kg/Yr) = FISH CONSUMPTION (6.9 Kg/Yr)

* WATER/FISH CONC. FACTOR (CF)** *WATER CONC. (Ci/l)

**See Table 3: THESE CONCENTRATION FACTORS ARE RADIONUCLIDE DEPENDENT.

LAND WITHOUT IRRIGATION

(3) PLANT CONC. (Ci/Kg)=SOIL/PLANT CF** *SOIL CONC. (Ci/Kg)

(4) PLANT INTAKE (Ci/Yr) = PLANT CONSUMPTION (190.0 Kg/Yr)
* PLANT CONC. (Ci/Kg)

(5) MILK INTAKE (Ci/Yr) = [DAIRY COW CONSUMPTION OF
PLANTS (50 Kg/Day) * PLANT CONC. (Ci/Kg)
+ DAIRY COW DRINKING RATE PER DAY (60.0 l/Day)
* WATER CONC. (Ci/l)] * MILK/DIET CF**
* MILK CONSUMPTION RATE (110.0 l/Yr)

(6) MEAT INTAKE (Ci/Yr) = [BEEF CATTLE CONSUMPTION OF
PLANTS (50 Kg/Day) * PLANT CONC. (Ci/Kg)
+ BEEF CATTLE DRINKING RATE PER DAY (50.0 l/Day)
* WATER CONC. (Ci/l)] * BEEF/DIET CF**
* MEAT CONSUMPTION RATE (95.0 Kg/Yr)

**See Table 3:

LAND WITH IRRIGATION

(7) DEPOSITION RATE (Ci/Kg-yr) = RETAINED FRACTION ON PLANT (.25)

• WATER CONC. (Ci/l)

• [RATE IRRIGATION (300 l/m^2-yr)/PLANT DENSITY (5.2 Kg/m^2)]

(8) WEATHERING RATE (yr^{-1}) = ln2/0384 Yr (14 Day Half Life)

(9) PLANT CONC. (Ci/Kg) = [SOIL/PLANT CF** *SOIL CONC. (Ci/Kg)]

* [(DEPOSITION RATE (Ci/Kg)/WEATHERING RATE (yr^{-1})]

* {1 - [EXP -ln2/.0384 * IRRIGATION TIME (.17 yr)]}

PLANT, BEEF, MILK CONSUMPTIONS WITH IRRIGATION ARE CALCULATED USING FORMULAS 4-6 AND THE PLANT CONC. (9).

**See Table 3:

Table 2 (cont'd)

Page 4

INHALATION

(10) AIR CONC. (Ci/m^3) = SOIL CONC. (Ci/Kg)

* CONCENTRATION OF SUSPENDED MATERIAL IN THE AIR (3.5E-9 Kg/m^3)

(11) INHALATION (Ci/Yr) = AIR CONC. (Ci/m^3)

* BREATHING RATE (8000 m^3/Yr)

EXTERNAL

(12) AIR SUBMERSION = 6.13E5 Hrs (LIFETIME EXPOSURE)

* AIR CONC. (Ci/m^3)

(13) SOIL EXPOSURE = 2.04E5 Hrs (1/3 YEAR EXPOSURE FOR 70 YEARS)

* SOIL CONC. (Ci/Kg) * SOIL DENSITY (2.6E3 Kg/m^3)

* SOIL DEPTH (.025m)

(14) SEDIMENT EXPOSURE = 1.05E3 Hrs (15 Hrs/Yr FOR 70 YEARS)

* SEDIMENT CONC. (Ci/Kg) * SEDIMENT DENSITY (2.6E3Kg/m^3)

* SEDIMENT DEPTH (.025m)

(15) WATER IMMERSION = 1.05E3 Hrs (15 Hrs/Yr FOR 70 YEARS)

* WATER CONC. (Ci/l) * 1000 l/m^3

Table 3

Concentration Factors for Human Food Sources
That Appear in Subroutine RDCONC*

Radionuclide	Fish (Ci/kg per Ci/L)	Invertebrate (Ci/kg per Ci/L)	Veg/Soil (Unitless)	Diet to Milk Ci/kg/Ci/day	Diet to Meat Ci/kg/Ci/day
CM	2.5 E01	1.0 E03	2.5 E-03	5.0 E-06	2.0 E-04
AM	2.5 E01	1.0 E03	2.5 E-04	5.0 E-06	2.0 E-04
PU	3.5 E00	1.0 E02	2.5 E-04	2.0 E-06	1.4 E-05
U	2.0 E00	6.0 E01	2.5 E-03	5.0 E-04	3.4 E-04
TH	3.0 E01	5.0 E02	4.2 E-03	5.0 E-06	2.0 E-04
RA	5.0 E01	2.5 E02	3.1 E-04	8.0 E-03	3.4 E-02
NP	1.0 E01	4.0 E02	2.5 E-03	5.0 E-06	2.0 E-04
PB	1.0 E02	1.0 E02	6.8 E-02	6.2 E-04	2.9 E-04
PA	1.1 E01	1.1 E02	2.5 E-03	5.0 E-06	8.0 E-02
AC	2.5 E01	1.0 E03	2.5 E-03	5.0 E-06	5.0 E-02
CS	2.0 E03	1.0 E02	1.0 E-02	1.2 E-02	4.0 E-03
SR	3.0 E01	1.0 E02	1.7 E-02	8.0 E-04	6.0 E-04
TC	1.5 E01	5.0 E00	2.5 E-01	2.5 E-02	4.0 E-01
BI	1.5 E01	2.4 E01	1.5 E-01	5.0 E-04	1.3 E-02
PO	5.0 E02	2.0 E04	1.5 E-01	3.0 E-04	1.2 E-02
SM	2.5 E01	1.0 E03	2.5 E-03	5.0 E-06	5.0 E-03
NB	3.0 E04	1.0 E02	9.4 E-03	2.5 E-03	2.8 E-01
ZR	3.3 E00	6.7 E00	1.7 E-04	5.0 E-06	3.4 E-02
SN	3.0 E03	1.0 E03	2.5 E-03	2.5 E-03	8.0 E-02
NI	1.0 E02	1.0 E02	1.9 E-02	6.7 E-03	5.3 E-03

Taken from USNRC (1977)

*These concentration factors take into account animal uptake also.

Table 4

Ingestion, Inhalation and External Exposure Rates for an Average Individual

Ingestion Rates

Water Consumption by Humans in Zones 1 and 2	3.7 E02 l/yr
Plant Consumption by Humans in Zones 1 and 2	1.9 E02 kg/yr
Milk Consumption by Humans in Zones 1 and 2	1.1 E02 l/yr
Beef Consumption by Humans in Zones 1 and 2	9.5 E01 kg/yr
Fish Consumption by Humans in Zones 1 and 2	6.9 E00 kg/yr

Inhalation Rate

Average Air Consumption by Humans	8.0 E03 m^3/yr

External Exposure Rates

Submersion in Air	8.7 E03 hr/yr
Groundshine from Soil	2.9 E03 hr/yr*
Groundshine from Sediment	1.5 E01 hr/yr*
Immersion in Water	1.5 E01 hr/yr

*An effective depth of 0.025 m was assumed for soil and sediment.

Taken from USNRC (1977) and USDOE (1979)

Table 5

Dose Conversion Factors for ^{240}Pu and ^{236}U

(70 year intake/70 year dose commitment)

Ingestion (rem·yr/Ci)

Radionuclide	Total Body	Bone	Lung	GI Tract
^{240}Pu	9.5E5	3.9E7	0.0	4.8E6
^{236}U	3.5E6	5.5E7	0.0	4.0E6

Inhalation (rem·yr/Ci)

Radionuclide	Total Body	Bone	Lung	GI Tract
^{240}Pu	7.9E9	3.3E11	1.2E10	2.9E6
^{236}U	8.6E7	1.4E9	3.6E9	2.5E6

External (Total Body)

Radionuclide	Water	Air	Ground and Sediment
	$\left(\frac{rem \cdot m^3}{hr \cdot Ci}\right)$	$\left(\frac{rem \cdot m^3}{hr \cdot Ci}\right)$	$\left(\frac{rem \cdot m^2}{hr \cdot Ci}\right)$
^{240}Pu	1.4E-4	6.5E-2	1.3E-3
^{236}U	3.0E-6	1.2E-6	2.1E-4

Table 6

Individual Risk Estimators
(Encoded in RSKFCT Array)

Type of Cancer	Individual Risk per rem	Organ Dose Commitment Associated with this Cancer Type
Lung	2.5E-05	Lung
Leukemia	2.9E-05	Bone
Stomach	1.1E-05	GI Tract
Pancreas	3.8E-06	GI Tract
Rest of GI	3.8E-06	GI Tract
Breast	2.9E-05	Total Body
Bone	9.8E-06	Bone
All Other	3.6E-05	Total Body

Table 7

Input Data for Problem 2

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
1	Title	Alphanumeric	1-30	Left Justified
2 (Options)	NZONE*	2	1-5	Right Justified
	NVECT	1	6-10	"
	NCHN	1	11-15	"
	IWELL	0	16-20	"
	IO	0	21-25	"
	IC	0	26-30	"
	IOC	1	31-35	"
	IOI	1	36-40	"
	IOD	1	41-45	"
	IOR	1	46-50	"
	IPLT	0	51-55	"
	NTS	1	56-60	"
3	TSTP	1.E02	1-10	"
	TEND	1.E02	11-20	"
4	NRN	2	1-5	"
5	NUC(RI)**	PU240	1-10	Left Justified
	NUC(R2)	U236	11-20	"
6	SOLCNC,Rl,Zl***	5.28E-15	1-10	Right Justified
	WTRCNC,Rl,Zl	6.21E-15	11-20	"
	SEDCNC,Rl,Zl	3.90E-14	21-30	"

Table 7 (cont'd)

Input Data for Problem 2

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
7	SOLCNC,R2,Z1	1.12E-10	1-10	Right Justified
	WTRCNC,R2,Z1	1.18E-10	11-20	"
	SEDCNC,R2,Z1	7.38E-10	21-30	"
8	SOLCNC,R1,Z2	4.72E-15	1-10	"
	WTRCNC,R1,Z2	4.90E-15	11-20	"
	SEDCNC,R1,Z2	3.08E-14	21-30	"
9	SOLCNC,R2,Z2	5.73E-10	1-10	"
	WTRCNC,R2,Z2	2.80E-10	11-20	"
	SEDCNC,R2,Z2	2.90E-10	21-30	"

*Definitions are contained in Chapter 4 of Runkle and Cranwell, (1981).

**RI = radionuclide (1). . . radionuclide (NRN)

***R1 = radionuclide number 1

Z1 = zone number 1

Using the output in Table 8 and the equations, etc., defined in Tables 2-6, it is possible for the user to trace all the calculations that are performed for ^{240}Pu and ^{236}U from the intake values for the various pathways, to dose commitments to the various body organs, and finally to risk estimates.

5.73E-10 2.80E-10 2.90E-10

4.72E-15 4.90E-15 3.08E-14

1.12E-10 1.18E-10 7.38E-10

5.28E-15 6.21E-15 3.90E-14

PU240 U236

2

1.E02 1.E02

2 1 1 0 0 0 1 1 1 1 0 1

SAMPLE PROBLEM 2

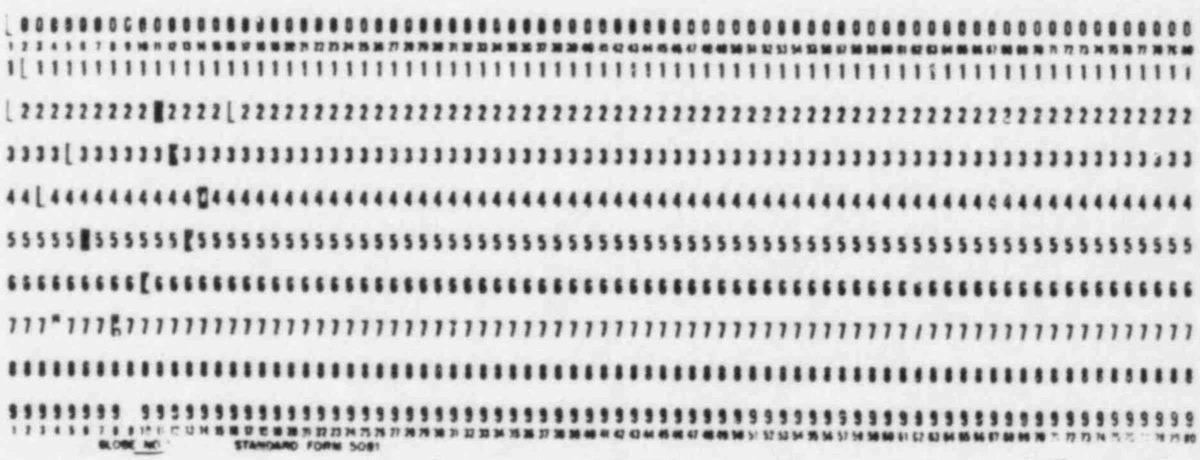

Figure 3. Display of the Input Cards for Executing the DHECC for Sample Problem 2

Table 8

Sample Problem 2 Output

Page 1

```
SAMPLE PROBLEM 2

NUMBER OF ZONES     2
NUMBER OF VECTORS     1
NUMBER OF RADIONUCLIDE CHAINS     1

INPUT IS FROM CARDS
ENVIRONMENTAL CONCENTRATIONS WILL BE INPUT

SELECTED OUTPUT OPTIONS
CONCENTRATIONS
CONCENTRATIONS AND INTAKES
DOSE
RISK

NUMBER OF DIFFERENT SIZE TIME STEPS     1
    1 TIME STEPS OF SIZE 1.000E+02 YRS WILL BE TAKEN TO 1.000E+02 YRS
TOTAL NUMBER OF TIME STEPS     1
```

Table 8 (cont'd)

Page 2

SAMPLE PROBLEM 2

VECTOR NUMBER 1 TIME 1.000E+02 YRS

CONCENTRATIONS(CI/KG OR CI/L)

ISOTOPE	ZONE	SOIL CONC	WTR CONC	SED CONC
PU240	1	5.280E-15	5.210E-15	3.900E-14
U236	1	1.120E-10	1.180E-10	7.380E-10
PU240	2	4.720E-15	4.900E-15	3.080E-14
U236	2	5.730E-10	2.800E-10	2.900E-10

Table 8 (cont'd)

SAMPLE PROBLEM 2

VECTOR NUMBER 1 TIME 1.000E+02 YRS

INTAKES VIA INGESTION(CI/YR)

		WATER BASED			LAND WITH IRRIGATION			LAND W/O IRRIGATION		
ISOTOPE	ZONE	DRKWTR	FISH	INVRT	PLANT	MILK	MEAT	PLANT	MILK	MEAT
PU240	1	2.293E-12	1.500E-13	0.	8.992E-13	1.340E-16	7.277E-16	2.508E-16	8.199E-17	4.131E-16
U236	1	4.365E-08	1.623E-09	0.	1.713E-08	6.374E-10	3.362E-10	5.320E-11	3.902E-10	1.910E-10
PU240	2	1.813E-12	1.183E-13	0.	7.095E-13	1.058E-16	5.742E-16	2.242E-16	6.469E-17	3.259E-16
U236	2	1.035E-07	3.864E-09	0.	4.080E-08	1.515E-09	7.990E-10	2.722E-10	9.279E-10	4.545E-10

Table 8 (cont'd)

SAMPLE PROBLEM 2

VECTOR NUMBER 1 TIME 1.000E+02 YRS

CONCENTRATIONS(CI/KG OR CI/L) AND INTAKES(CI/YR)

ISOTOPE	ZONE	SOIL CONC	WTR CONC	SED CONC	AIR CONC	INHALE	WTR BASED	ING/IRR	ING/NO IR	TOT ING
PU240	1	5.280E-15	5.210E-15	3.900E-14	1.848E-23	1.478E-19	2.448E-12	9.001E-13	7.458E-16	3.348E-12
U236	1	1.120E-10	1.180E-10	7.380E-10	3.920E-19	3.136E-15	4.529E-08	1.811E-08	6.344E-10	6.340E-08
PU240	2	4.720E-15	4.900E-15	3.080E-14	1.652E-23	1.322E-19	1.931E-12	7.102E-13	6.148E-16	2.642E-12
U236	2	5.730E-10	2.800E-10	2.900E-10	2.006E-18	1.604E-14	1.075E-07	4.312E-08	1.655E-09	1.506E-07

Table 8 (cont'd)

Page 5

SAMPLE PROBLEM 2

VECTOR NUMBER 1 TIME 1.000E+02 YRS

EXTERNAL EXPOSURES-TOTAL BODY(REM)

ISOTOPE	ZONE	SOIL EXP	WTR EXP	SED EXP	AIR EXP	TOT EXP
PU240	1	9.833E-11	9.129E-13	3.460E-12	7.363E-19	1.027E-10
U236	1	3.305E-07	3.680E-10	1.038E-08	2.980E-16	3.413E-07
PU240	2	8.790E-11	7.203E-13	2.733E-12	6.582E-19	9.135E-11
U236	2	1.691E-06	3.732E-10	4.077E-09	1.524E-15	1.696E-06

```
SAMPLE PROBLEM 2

VECTOR NUMBER    1      TIME 1.000E+02 YRS

TOTAL EXTERNAL EXPOSURES-TOTAL BODY(REM)

ZONE    TOT EXP

   1 3.414E-07
   2 1.696E-06
```

SAMPLE PROBLEM 2

VECTOR NUMBER 1 TIME 1.000E+02 YRS

DOSE(REM)

ISOTOPE	ORGAN	ZONE	DOSE ING	DOSE INH
PU240	TOTAL BODY	1	3.179E-06	1.170E-09
PU240	BONE	1	1.308E-04	4.813E-08
PU240	THYROID	1	0.	0.
PU240	LIVER	1	1.779E-05	6.535E-09
PU240	KIDNEYS	1	1.359E-05	5.003E-09
PU240	LUNGS	1	0.	1.810E-09
PU240	GI-LLI	1	1.589E-05	4.357E-13
U236	TOTAL BODY	1	2.189E-01	2.707E-07
U236	BONE	1	3.495E+00	4.400E-06
U236	THYROID	1	0.	0.
U236	LIVER	1	0.	0.
U236	KIDNEYS	1	3.463E-01	1.066E-06
U236	LUNGS	1	0.	1.136E-05
U236	GI-LLI	1	2.556E-01	7.837E-09
PU240	TOTAL BODY	2	2.508E-06	1.046E-09
PU240	BONE	2	1.032E-04	4.303E-08
PU240	THYROID	2	0.	0.
PU240	LIVER	2	1.404E-05	5.931E-09
PU240	KIDNEYS	2	1.073E-05	4.472E-09
PU240	LUNGS	2	0.	1.618E-09
PU240	GI-LLI	2	1.254E-05	3.895E-13
U236	TOTAL BODY	2	5.199E-01	1.385E-06
U236	BONE	2	8.300E+00	2.251E-05
U236	THYROID	2	0.	0.
U236	LIVER	2	0.	0.
U236	KIDNEYS	2	2.011E+00	5.455E-06
U236	LUNGS	2	0.	5.810E-05
U236	GI-LLI	2	6.071E-01	4.009E-08

SAMPLE PROBLEM 2

VECTOR NUMBER 1 TIME 1.000E+02 YRS

TOTAL DOSE(REM)

ORGAN	ZONE	TOT ING	TOT INH
TOTAL BODY	1	2.189E-01	2.718E-07
BONE	1	3.495E+00	4.448E-05
THYROID	1	0.	0.
LIVER	1	1.779E-05	6.635E-09
KIDNEYS	1	8.468E-01	1.071E-05
LUNGS	1	0.	1.136E-05
GI-LLI	1	2.555E-01	7.837E-09
TOTAL BODY	2	5.199E-01	1.386E-05
BONE	2	8.300E+00	2.255E-05
THYROID	2	0.	0.
LIVER	2	1.404E-05	5.931E-09
KIDNEYS	2	2.011E+00	5.459E-06
LUNGS	2	0.	5.810E-05
GI-LLI	2	6.072E-01	4.009E-08

SAMPLE PROBLEM 2

VECTOR NUMBER 1 TIME 1.000E+02 YRS

RISK

CANCER	ZONE	RISK ING	RISK INH	RISK EXT
LUNG	1	0.	2.839E-10	8.534E-12
LEUKEMIA	1	9.960E-05	1.268E-10	9.729E-12
STOMACH	1	2.940E-06	9.013E-14	3.926E-12
PANCREAS	1	9.842E-07	3.017E-14	1.314E-12
REST OF GI	1	9.842E-07	3.017E-14	1.314E-12
BREAST	1	6.304E-06	7.829E-12	9.831E-12
BONE	1	3.407E-05	4.337E-11	3.328E-12
OTHER	1	7.880E-06	9.787E-12	1.229E-11
LUNG	2	0.	1.452E-09	4.240E-11
LEUKEMIA	2	2.366E-04	6.428E-10	4.833E-11
STOMACH	2	6.982E-06	4.611E-13	1.950E-11
PANCREAS	2	2.338E-06	1.544E-13	6.529E-12
REST OF GI	2	2.338E-06	1.544E-13	6.529E-12
BREAST	2	1.497E-05	3.991E-11	4.884E-11
BONE	2	8.093E-05	2.199E-10	1.654E-11
OTHER	2	1.872E-05	4.989E-11	6.105E-11

Table 8 (cont'd)


```
SAMPLE PROBLEM 2

TOTAL RISK      ZONE    1

TIME(YRS)  RISK ING  RISK INH  RISK EXT  TOT RISK

1.000E+02 1.528E-04 4.718E-10 5.025E-11 1.528E-04


SAMPLE PROBLEM 2

TOTAL RISK      ZONE    2

TIME(YRS)  RISK ING  RISK INH  RISK EXT  TOT RISK

1.000E+02 3.628E-04 2.406E-09 2.497E-10 3.628E-04
```

SAMPLE PROBLEM 3

The design of this problem follows the same format as Problem 2 with different concentrations of the same two radionuclides. The concentrations for this problem for water, soil, and sediment are given in Table 9. Using the tables of equations, concentration factors, dose conversion factors, and risk estimators, (given in Problem 2) calculate the exposures for the following pathways through risk estimates for the specified radionuclide and zone:

(1) Calculate the external exposure from soil contaminated with ^{240}Pu in Zone 1 and estimate the individual cancer risk from this exposure.

(2) Calculate the individual cancer risk for the entire ingestion pathway in Zone 2 for ^{236}U. Assume there is irrigation with the land-based sources.

(3) Calculate the inhalation exposure expressed as rem from ^{240}Pu in Zone 2 for the four body organs.

Samples of these calculations and a computer output (similar to Table 8) are provided in Appendix A for reference by the user. The input deck for processing this problem with the DHECC is detailed in Table 10 and is shown in Figure 4.

Table 9

Assumed Pathways Concentrations for Problem 3

		^{240}Pu	^{236}U
	Soil	9.62E-13	8.43E-12
Zone 1	Surface Water	1.24E-12	9.72E-12
	Sediment	2.41E-13	1.34E-11
	Soil	8.24E-13	9.21E-12
Zone 2	Surface Water	1.04E-12	4.11E-12
	Sediment	2.31E-13	1.94E-12

Table 10

Input Data for Problem 3

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
1	Title	Alphanumeric	1-30	Left Justified
2 (Options)	NZONE*	2	1-5	Right Justified
	NVECT	1	6-10	"
	NCHN	1	11-15	"
	IWELL	0	16-20	"
	IO	0	21-25	"
	IC	0	26-30	"
	IOC	1	31-35	"
	IOI	1	36-40	"
	IOD	1	41-45	"
	IOR	1	46-50	"
	IPLT	0	51-55	"
	NTS	1	56-60	"
3	TSTP	1.E02	1-10	"
	TEND	1.E02	11-20	"
4	NRN	2	1-5	"
5	NUC(RI)**	PU240	1-10	Left Justified
	NUC(R2)	U236	11-20	"
6	SOLCNC,R1,Z1***	9.62E-13	1-10	Right Justified
	WTRCNC,R1,Z1	1.24E-12	11-20	"
	SEDCNC,R1,Z1	2.41E-13	21-30	"

Table 10 (cont'd)

Input Data for Problem 3

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
7	SOLCNC,R2,Z1	8.43E-12	1-10	Right Justified
	WTRCNC,R2,Z1	9.72E-12	11-20	"
	SEDCNC,R2,Z1	1.34E-11	21-30	"
8	SOLCNC,R1,Z2	8.24E-13	1-10	"
	WTRCNC,R1,Z2	1.04E-12	11-20	"
	SEDCNC,R1,Z2	2.31E-13	21-30	"
9	SOLCNC,R2,Z2	9.21E-12	1-10	"
	WTRCNC,R2,Z2	4.11E-12	11-20	"
	SEDCNC,R2,Z2	1.94E-12	21-30	"

*Definitions are contained in Chapter 4 of Runkle and Cranwell, (1981).

**RI = radionuclide (1). . . radionuclide (NRN)

***R1 = radionuclide number 1

Z1 = zone number 1

9.21E-12 4.11E-12 1.94E-12

8.24E-13 1.04E-12 2.31E-13

8.43E-12 9.72E-12 1.34E-11

9.62E-13 1.24E-12 2.41E-13

PU240 U236

2

1.E02 1.E02

2 1 1 0 0 0 1 1 1 1 0 1

SAMPLE PROBLEM 3

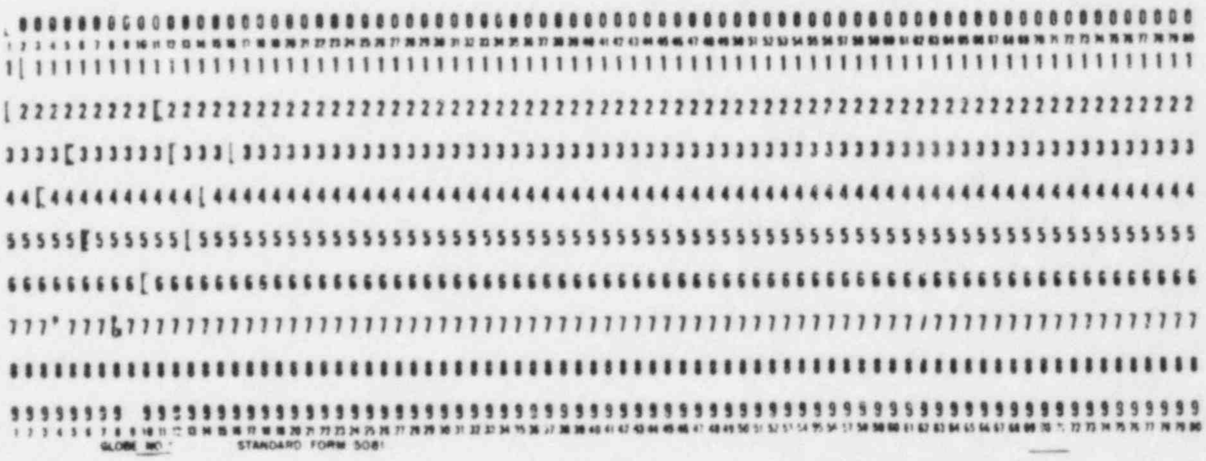

Figure 4. Display of the Input Cards for Executing the DHECC for Sample Problem 3

SAMPLE PROBLEM 4

In this problem we will consider an entire decay chain and the various results calculated by the Dosimetry and Health Effects Computer Code. For this analysis we have chosen a scenario to illustrate a U-tube effect in our reference depository. A U-tube effect could result from exploratory drill holes or mining shafts present at the time of closure or emplaced at some future time (Figure 5). Differences in hydraulic properties result in water circulating from the middle sandstone aquifer through the U-tube and returning to the middle aquifer. In this scenario, radionuclides reaching the middle aquifer are discharged to the surface at a river approximately 20 miles from the depository. In our complete analysis of a scenario, we consider four decay chains and one chain composed of single elements from fission and activation products as the radioactive inventory of the depository. However, for this sample problem we consider only one decay chain composed of the following radionuclides: ^{245}Cm, ^{241}Pu, ^{241}Am, ^{237}Np, ^{233}U, ^{229}Th, ^{225}Ra, and ^{225}Ac. Normally, the Dosimetry and Health Effects Computer Code is designed to process one chain to completion (risk estimates), then return to the beginning of the program, read a new file, and process the next chain, until all five chains are considered.

In our scenario analysis, the time span considered is 100,000 years after closure of the depository. During this time, factors such as leaching, retardation, chemical changes, and other physical/chemical properties all affect the amount of radioactive material that may potentially be released from the depository and may ultimately reach the biosphere. The time steps from 100 to 1000 years after closure are 100 year increments and from 1000 to 100,000 years the time steps are 1000 year increments. Therefore, we are considering 109 time steps in our analysis out to 100,000 years after closure for the scenario detailed above.

The Pathways Model considers the output of the geologic transport model at each time step and calculates the concentration for each radionuclide in the soil, water, and sediment. It is then assumed that these concentrations exist for the next 70 years and that there are persons living continuously in this contaminated area. Radioactive decay is assumed to occur over this period and is taken into account by the dose conversion factors. The model separates the pathway exposures into ingestion, inhalation, and external. Dose factors for the internal organs and the total body for each radionuclide considered are multiplied by the appropriate concentration level (curies) to estimate the dose in rem. These rem values are summed over all radionuclides for the individual body organs to calculate the total dose commitment from all the potential releases from the depository. Individual risk estimators for the various organs are multiplied by the organ dose commitments to estimate the

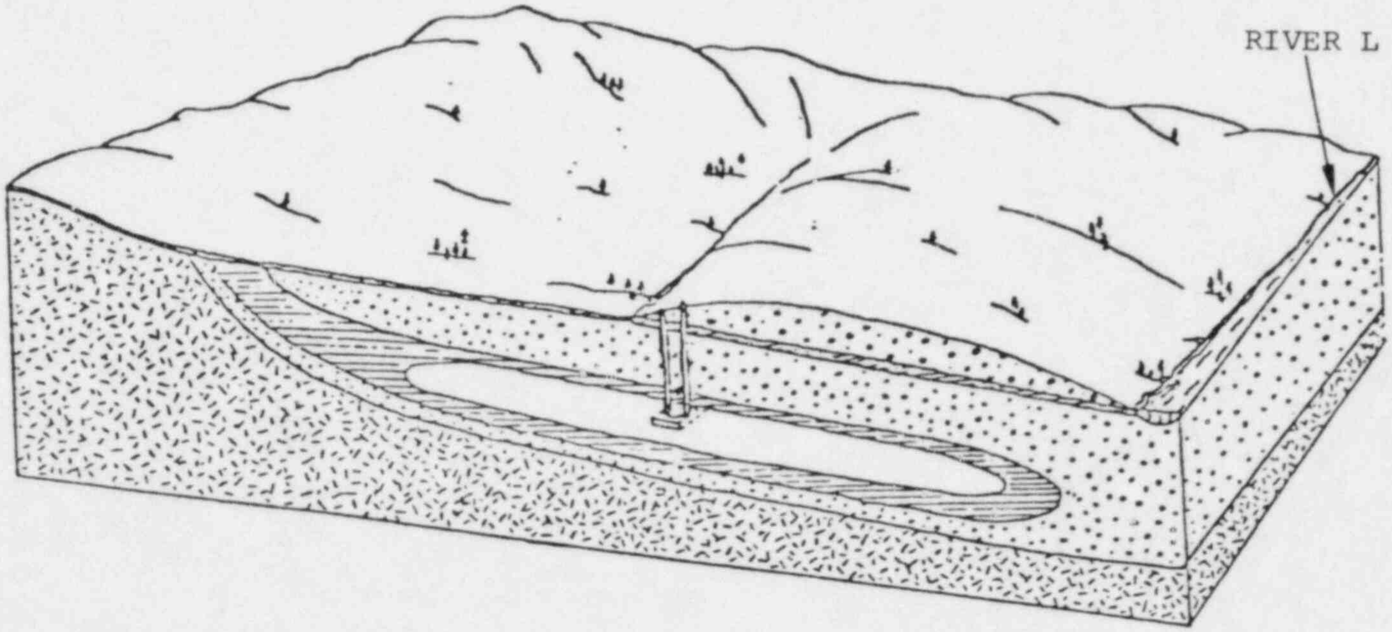

Figure 5. The Reference Depository Site Illustrating a U-tube Connecting the Depository with the Middle Sandstone Aquifer

total individual cancer risk that may result from exposure to the releases from the depository at a given time step. The time step is incremented by 100 or 1000 years and the procedure is repeated.

To account for the uncertainty in the input parameters to the groundwater flow and transport models (SWIFT and NWFT/DVM), these parameters are treated as random variables having assigned ranges and assumed distributions. A set of input values is referred to as a vector, where the components of the vector are the specific values of the input parameters obtained during one statistical sampling procedure. For most of the risk calculations performed on the various scenarios, 35 input vectors are selected. However, if sensitivity and uncertainty analyses are to be performed, additional input vectors may be required. In this sample problem we will consider only one vector (Vector #34).

In summary, Problem 4 represents the analysis of a U-tube scenario for one decay chain and one vector. The complete input file (from the Pathways Model) containing the concentrations of water, sediment, and soil for each radionuclide in Zones 1 and 2 for each time step is quite large. Therefore, as an example, we have printed the input data (concentrations) for all the radionuclides considered at time 25,000 years for Zones 1 and 2.

The input deck for Sample Problem 4 is given in Table 11 and the punched card deck is shown in Figure 6. In addition, it is necessary to associate Tape 21 with the data file written by the Pathways Model for the ^{245}Cm decay chain. Several updates are also needed to output the concentrations at the 25,000 year time step for Vector #34. These updates are given in Figure 7.

The radionuclide concentrations in the soil, surface water, and sediment at 25,000 years post closure are given in Table 12 for Zones 1 and 2.

The final output of this analysis is given in Table 13. The individual cancer risks for the ingestion, inhalation, and external pathways are given for all 109 time steps. This risk is based on the summation of the dose commitments to the various body organs from all the radionuclides considered in the analysis.

Table 11

Input Data for Problem 4

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
1	Title	Alphanumeric	1-30	Left Justified
2 (Options)	NZONE*	2	1-5	Right Justified
	NVECT	1	6-10	"
	NCHN	1	11-15	"
	IWELL	0	16-20	"
	IO	1	21-25	"
	IC	0	26-30	"
	IOC	0	31-35	"
	IOI	0	36-40	"
	IOD	0	41-45	"
	IOR	0	46-50	"
	IPLT	0	51-55	"
	NTS	2	56-60	"
3	TSTP	1.E02	1-10	"
	TEND	1.E03	11-20	"
4	TSTP	1.E03	1-10	"
	TEND	1.E05	11-20	"
5	NRN	8	1-5	"
6	NUC(R1)	CM245	1-10	Left Justified
	NUC(R2)	PU241	11-20	"
	NUC(R3)	AM241	21-30	"
	NUC(R4)	NP237	31-40	"

Table 11 (cont'd)

Input Data for Problem 4

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
6 (cont.)	NUC(R5)	U233	41-50	Left Justified
	NUC(R6)	TH229	51-60	"
	NUC(R7)	RA225	61-70	"
	NUC(R8)	AC225	71-80	"

```
CM245     PU241     AM241     NP237     U233      TH229     RA225     AC225

    8

     1.E03     1.E05

     1.E02     1.E03

    2    1    1    0    1    0    0    0    0    0    1    2

SAMPLE PROBLEM 4 SCENARIO 2-UTUBE-CHAIN2
```

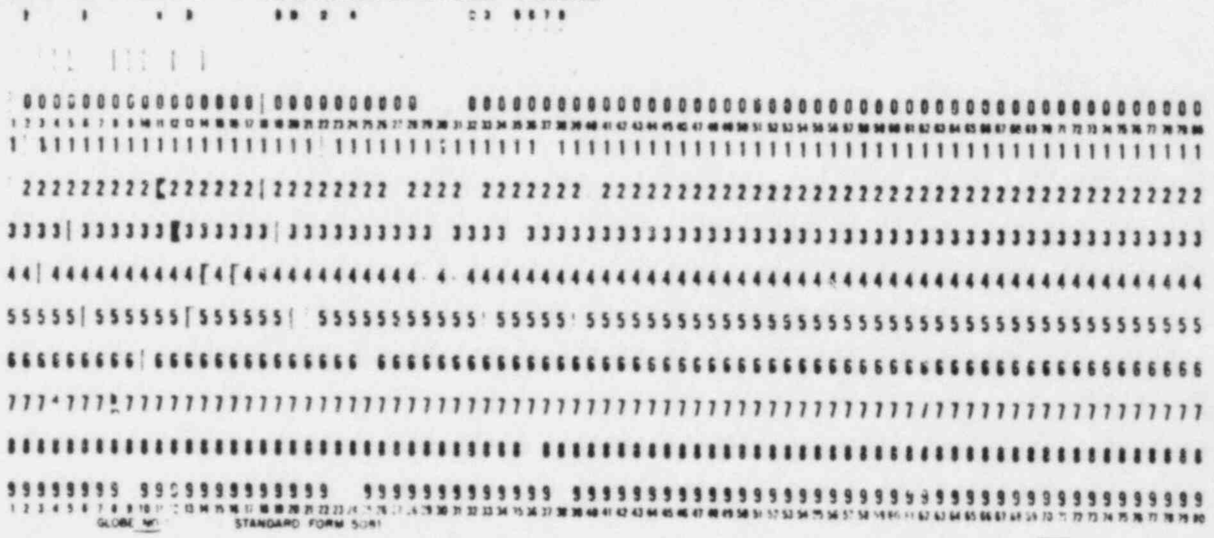

Figure 6. Display of the Input Deck for Executing the DHECC for Sample Problem 4

```
IVECT=IVEC

IVECTT=IVECT

IF(IVECT.NE.34)GO TO 42

*I RD1.237

   42 CONTINUE

*I RD1.233

      PRINT 51, TITLE,IVECTT,TIME(ITIME)

      IF(IDC.EQ.0.AND.TIME(ITIME).NE.25000.)GO TO 90

*D,RD1.246,247

*ID CHK
```

Figure 7. Display of the Update Cards for Output of the Radionuclide Concentrations at Time 25,000 Years and for the Consideration of Vector #34 Only

Table 12

Input - Radionuclide Concentrations from the Pathways Model at 25,000 Years

SAMPLE PROBLEM 4 SCENARIO 2-UTJBE-CHAIN2

VECTOR NUMBER 34 TIME 2.500E+04 YRS

CONCENTRATIONS(CI/KG OR CI/L)

ISOTOPE	ZONE	SOIL CONC	WTR CONC	SED CONC
CM245	1	0.	5.578E-15	1.767E-13
PU241	1	0.	1.146E-16	5.695E-14
AM241	1	0.	5.940E-15	1.863E-13
NP237	1	0.	1.425E-17	9.555E-18
U233	1	0.	3.161E-17	1.731E-15
TH229	1	0.	6.485E-19	8.708E-18
RA225	1	0.	6.487E-19	8.668E-18
AC225	1	0.	6.487E-19	8.643E-18
CM245	2	1.025E-13	4.403E-15	1.395E-13
PU241	2	9.821E-16	2.300E-16	4.503E-14
AM241	2	1.074E-13	4.584E-15	1.469E-13
NP237	2	3.582E-18	1.125E-17	7.532E-18
U233	2	1.008E-15	2.493E-17	1.366E-15
TH229	2	4.403E-18	5.150E-19	6.907E-18
RA225	2	4.194E-18	5.446E-19	6.876E-18
AC225	2	4.034E-18	5.367E-19	6.857E-18

Table 13

Final Output - Expressed as Individual Cancer Risk for Ingestion, Inhalation, and External Exposure Pathways

SAMPLE PROBLEM 4 SCENARIO 2-UTUBE-CHAIN2

TOTAL RISK ZONE 1

TIME(YRS)	RISK ING	RISK INH	RISK EXT	TOT RISK
1.000E+02	0.	0.	0.	0.
2.000E+02	0.	0.	0.	0.
3.000E+02	0.	0.	0.	0.
4.000E+02	0.	0.	0.	0.
5.000E+02	0.	0.	0.	0.
6.000E+02	0.	0.	0.	0.
7.000E+02	0.	0.	0.	0.
8.000E+02	0.	0.	0.	0.
9.000E+02	0.	0.	0.	0.
1.000E+03	0.	0.	0.	0.
2.000E+03	0.	0.	0.	0.
3.000E+03	0.	0.	0.	0.
4.000E+03	0.	0.	0.	0.
5.000E+03	0.	0.	0.	0.
6.000E+03	0.	0.	0.	0.
7.000E+03	0.	0.	0.	0.
8.000E+03	0.	0.	0.	0.
9.000E+03	2.184E-10	0.	2.393E-14	2.185E-10
1.000E+04	1.612E-07	0.	1.590E-11	1.612E-07
1.100E+04	4.606E-07	0.	4.400E-11	4.606E-07
1.200E+04	3.660E-07	0.	3.493E-11	3.660E-07
1.300E+04	2.878E-07	0.	2.747E-11	2.879E-07
1.400E+04	2.264E-07	0.	2.160E-11	2.264E-07
1.500E+04	1.780E-07	0.	1.699E-11	1.780E-07
1.600E+04	1.400E-07	0.	1.336E-11	1.400E-07
1.700E+04	1.101E-07	0.	1.050E-11	1.101E-07
1.800E+04	8.659E-08	0.	8.260E-12	8.660E-08
1.900E+04	6.811E-08	0.	6.496E-12	6.811E-08
2.000E+04	5.357E-08	0.	5.108E-12	5.357E-08
2.100E+04	4.214E-08	0.	4.017E-12	4.214E-08
2.200E+04	3.315E-08	0.	3.159E-12	3.315E-08
2.300E+04	2.608E-08	0.	2.484E-12	2.609E-08
2.400E+04	2.053E-08	0.	1.953E-12	2.053E-08
2.500E+04	1.616E-08	0.	1.536E-12	1.616E-08
2.600E+04	1.273E-08	0.	1.208E-12	1.273E-08
2.700E+04	1.003E-08	0.	9.503E-13	1.003E-08
2.800E+04	7.905E-09	0.	7.475E-13	7.905E-09
2.900E+04	6.237E-09	0.	5.880E-13	6.238E-09
3.000E+04	4.926E-09	0.	4.626E-13	4.926E-09
3.100E+04	3.898E-09	0.	3.641E-13	3.898E-09
3.200E+04	3.089E-09	0.	2.866E-13	3.090E-09
3.300E+04	2.454E-09	0.	2.257E-13	2.454E-09
3.400E+04	1.955E-09	0.	1.777E-13	1.955E-09
3.500E+04	1.563E-09	0.	1.401E-13	1.563E-09
3.600E+04	1.259E-09	0.	1.106E-13	1.259E-09
3.700E+04	1.014E-09	0.	8.721E-14	1.014E-09
3.800E+04	8.294E-10	0.	6.899E-14	8.295E-10
3.900E+04	6.818E-10	0.	5.466E-14	6.818E-10
4.000E+04	5.674E-10	0.	4.337E-14	5.674E-10
4.100E+04	4.776E-10	0.	3.455E-14	4.776E-10

Table 13 (cont'd)

4.200E+04	4.115E-10	0.	2.766E-14	4.115E-10
4.300E+04	3.545E-10	0.	2.217E-14	3.545E-10
4.400E+04	3.159E-10	0.	1.793E-14	3.159E-10
4.500E+04	2.808E-10	0.	1.454E-14	2.808E-10
4.600E+04	2.616E-10	0.	1.198E-14	2.616E-10
4.700E+04	2.403E-10	0.	9.897E-15	2.403E-10
4.800E+04	2.276E-10	0.	8.332E-15	2.276E-10
4.900E+04	2.189E-10	0.	7.074E-15	2.189E-10
5.000E+04	2.115E-10	0.	6.129E-15	2.115E-10
5.100E+04	2.093E-10	0.	5.379E-15	2.093E-10
5.200E+04	2.058E-10	0.	4.819E-15	2.058E-10
5.300E+04	2.037E-10	0.	4.364E-15	2.037E-10
5.400E+04	2.058E-10	0.	4.058E-15	2.058E-10
5.500E+04	2.026E-10	0.	3.750E-15	2.026E-10
5.600E+04	2.079E-10	0.	3.649E-15	2.079E-10
5.700E+04	2.065E-10	0.	3.189E-15	2.065E-10
5.800E+04	2.047E-10	0.	2.835E-15	2.047E-10
5.900E+04	2.105E-10	0.	2.919E-15	2.105E-10
6.000E+04	2.136E-10	0.	2.934E-15	2.136E-10
6.100E+04	2.190E-10	0.	3.063E-15	2.190E-10
6.200E+04	2.224E-10	0.	3.080E-15	2.224E-10
6.300E+04	2.282E-10	0.	3.169E-15	2.282E-10
6.400E+04	2.304E-10	0.	3.222E-15	2.304E-10
6.500E+04	2.343E-10	0.	3.241E-15	2.343E-10
6.600E+04	2.408E-10	0.	3.355E-15	2.408E-10
6.700E+04	2.430E-10	0.	3.407E-15	2.430E-10
6.800E+04	2.430E-10	0.	3.407E-15	2.430E-10
6.900E+04	2.548E-10	0.	3.557E-15	2.548E-10
7.000E+04	2.565E-10	0.	3.597E-15	2.565E-10
7.100E+04	2.565E-10	0.	3.597E-15	2.565E-10
7.200E+04	2.676E-10	0.	3.753E-15	2.676E-10
7.300E+04	2.700E-10	0.	3.787E-15	2.700E-10
7.400E+04	2.700E-10	0.	3.787E-15	2.700E-10
7.500E+04	2.759E-10	0.	3.925E-15	2.759E-10
7.600E+04	2.836E-10	0.	3.977E-15	2.836E-10
7.700E+04	2.836E-10	0.	3.977E-15	2.836E-10
7.800E+04	2.836E-10	0.	3.977E-15	2.836E-10
7.900E+04	2.912E-10	0.	4.157E-15	2.912E-10
8.000E+04	2.992E-10	0.	4.197E-15	2.992E-10
8.100E+04	2.992E-10	0.	4.197E-15	2.992E-10
8.200E+04	3.068E-10	0.	4.378E-15	3.068E-10
8.300E+04	3.076E-10	0.	4.382E-15	3.076E-10
8.400E+04	3.148E-10	0.	4.418E-15	3.149E-10
8.500E+04	3.160E-10	0.	4.445E-15	3.160E-10
8.600E+04	3.224E-10	0.	4.599E-15	3.224E-10
8.700E+04	3.224E-10	0.	4.599E-15	3.224E-10
8.800E+04	3.315E-10	0.	4.644E-15	3.315E-10
8.900E+04	3.337E-10	0.	4.697E-15	3.337E-10
9.000E+04	3.401E-10	0.	4.851E-15	3.402E-10
9.100E+04	3.401E-10	0.	4.851E-15	3.402E-10
9.200E+04	3.432E-10	0.	4.865E-15	3.432E-10
9.300E+04	3.523E-10	0.	4.970E-15	3.523E-10
9.400E+04	3.579E-10	0.	5.103E-15	3.579E-10
9.500E+04	3.579E-10	0.	5.103E-15	3.579E-10
9.600E+04	3.579E-10	0.	5.103E-15	3.579E-10
9.700E+04	3.625E-10	0.	5.125E-15	3.625E-10
9.800E+04	3.777E-10	0.	5.385E-15	3.777E-10
9.900E+04	3.777E-10	0.	5.385E-15	3.777E-10
1.000E+05	3.777E-10	0.	5.385E-15	3.777E-10

SAMPLE PROBLEM 5

In this problem, we will consider the complete analysis of all 5 chains and 35 vectors processed through the Dosimetry and Health Effects Model and the forms of the final output from the analysis. Again we will consider the U-tube scenario detailed in Problem 4. The time span considered is the same 100,000 years as used previously.

Instead of one decay chain, we will consider four decay chains present in the depository inventory and a fifth chain composed of fission and activation products. The heads of these four decay chains are ^{252}Cf, ^{249}Cf, ^{250}Cf, and ^{251}Cf, respectively. The ^{249}Cf chain was considered in Problem 4.

Also, we will consider 35 vectors instead of the one vector considered in Problem 4. The final output curves represent the average risk from these 35 vectors.

The input deck for executing the DHECC for this scenario analysis is given in Table 14 and is shown in Figure 8. There are no updates required since we are requesting the normal output options. Tapes 21 through 25 must be associated with the concentration data from the Pathways Model for the 5 chains that are to be considered in the analysis and the appropriate radionuclide names must be detailed in the input deck.

Several methods have been developed to illustrate the results of our analysis. These are routine output when the IPLT option = 1. In Figures 9 and 10 the individual cancer risk curves are given for a U-tube scenario in Zones 1 and 2 for our reference site. The curves represent the mean value for 35 vectors processed by the computer code. Each of these 35 vectors had a set of input parameters that were sampled from the ranges of each input variable. The ingestion pathway dominates the cancer risk with the external and inhalation pathways falling below the ingestion curve.

Another method for illustrating some of the uncertainty of our analysis is given in Figures 11 and 12. There are 35 individual points at any given time step in these scatter plots. Each point represents the risk to an individual from the set of input parameters that were sampled for that vector. In this graph, approximately 45 or less percent of the 35 values are shown with the remainder falling below the 10^{-9} level. The mean values fall within the upper range of the risk values and are represented by the solid line. The median value is below the 10^{-9} cut off.

Table 14

Input Data for Problem 5

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
1	Title	Alphanumeric	1-30	Left Justified
2 (Options)	NZONE	2	1-5	Right Justified
	NVECT	35	6-10	"
	NCHN	5	11-15	"
	IWELL	0	16-20	"
	IO	1	21-25	"
	IC	0	26-30	"
	IOC	0	31-35	"
	IOI	0	36-40	"
	IOD	0	41-45	"
	IOR	0	46-50	"
	IPLT	1	51-55	"
	NTS	2	56-60	"
3	TSTP	1.E02	1-10	"
	TEND	1.E03	11-20	"
4	TSTP	1.E03	1-10	"
	TEND	1.E05	11-20	"
5	NRN	5	1-5	"
6	NUC(R1)	PU240	1-10	Left Justified
	NUC(R2)	U236	11-20	"
	NUC(R3)	TH232	21-30	"
	NUC(R4)	RA228	31-40	"

Table 14 (cont'd)

Input Data for Problem 5

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
6 (cont.)	NUC(R5)	RA224	41-50	Left Justified
7	NRN	8	1-5	Right Justified
8	NUC(R1)	CM245	1-10	Left Justified
	NUC(R2)	PU241	11-20	"
	NUC(R3)	AM241	21-30	"
	NUC(R4)	NP237	31-40	"
	NUC(R5)	U233	41-50	"
	NUC(R6)	TH229	51-60	"
	NUC(R7)	RA225	61-70	"
	NUC(R8)	AC225	71-80	"
9	NRN	10	1-5	Right Justified
10	NUC(R1)	CM246	1-10	Left Justified
	NUC(R2)	PU242	11-20	"
	NUC(R3)	U238	21-30	"
	NUC(R4)	PU238	31-40	"
	NUC(R5)	U234	41-50	"
	NUC(R6)	TH230	51-60	"
	NUC(R7)	RA226	61-70	"
	NUC(R8)	PB210	71-80	"
11	NUC(R9)	BI210	1-10	"
	NUC(R10)	PO210	11-20	

Table 14 (cont'd)

Input Data for Problem 5

Input Card Number	Description of Parameters	Value for this Analysis	Column Number	Note
12	NRN	7	1-5	Right Justified
13	NUC(1)	AM243	1-10	Left Justified
	NUC(2)	PU239	11-20	"
	NUC(3)	U235	21-30	"
	NUC(4)	PA231	31-40	"
	NUC(5)	AC227	41-50	"
	NUC(6)	TH227	51-60	"
	NUC(7)	RA223	61-70	"
14	NRN	3	1-5	Right Justified
15	NUC(1)	SN126	1-10	Left Justified
	NUC(2)	CS137	11-20	"
	NUC(3)	TC99	21-30	"

```
SN126    CS137    TC99

    3

AM243    PU239    U235    PA231    AC227    TH227    RA223

    7

BI210    PO210

CM246    PU242    U238    PU238    U234    TH230    RA226    PB210

   10

CM245    PU241    AM241    NP237    U233    TH229    RA225    AC225

    8

PU240    U236    TH232    RA228    RA224

    5

    1.E03    1.E05

    1.E02    1.E03

    2   35    5    0    1    0    0    0    0    0    1    2

SAMPLE PROBLEM 5 SCENARIO 2 UTUBE HLW
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Figure 8. Display of the Input Cards for Executing the DHECC for Sample Problem 5

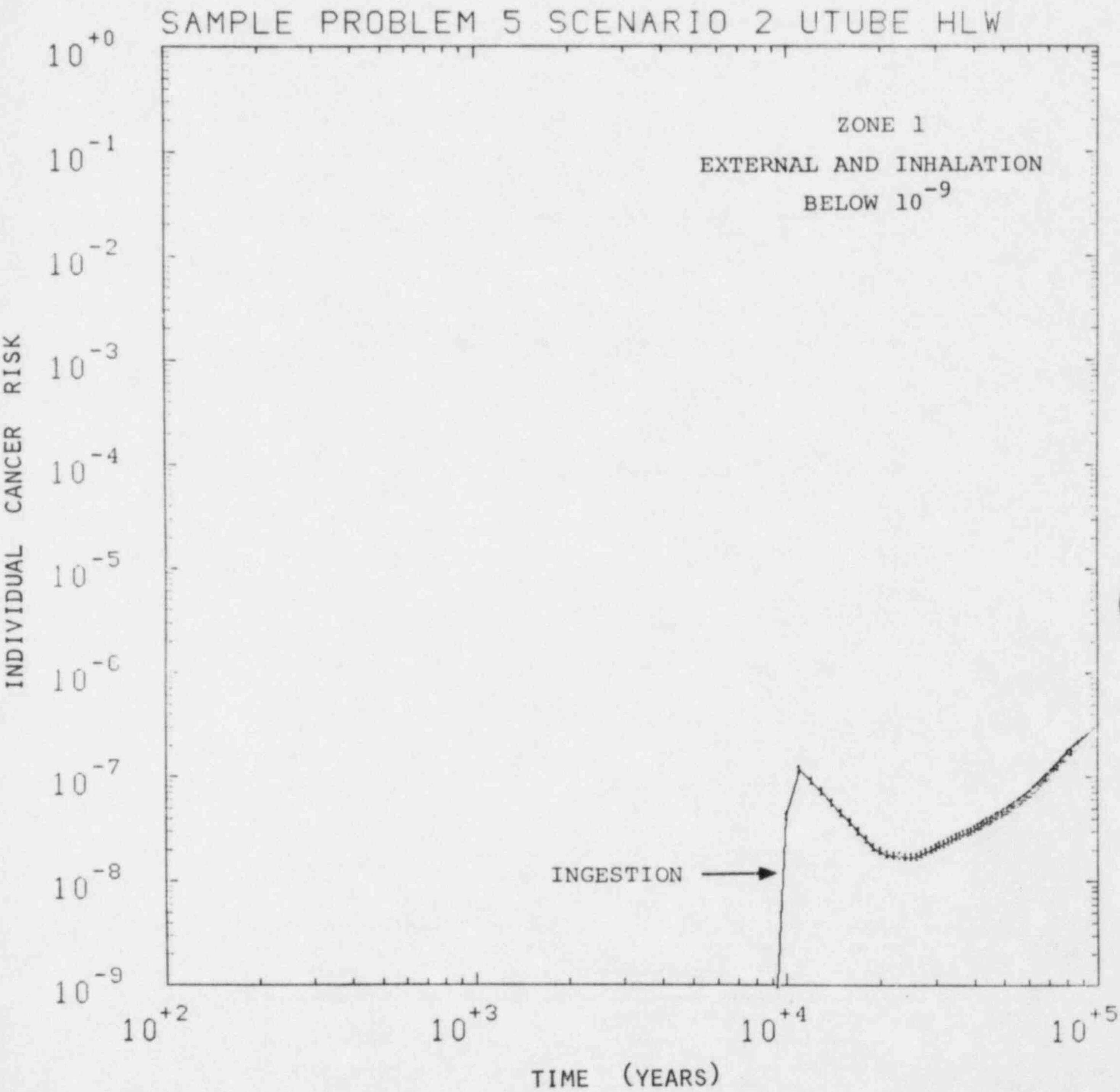

Figure 9. Conditional Probability of an Individual Dying of Latent Somatic Cancer in Zone 1

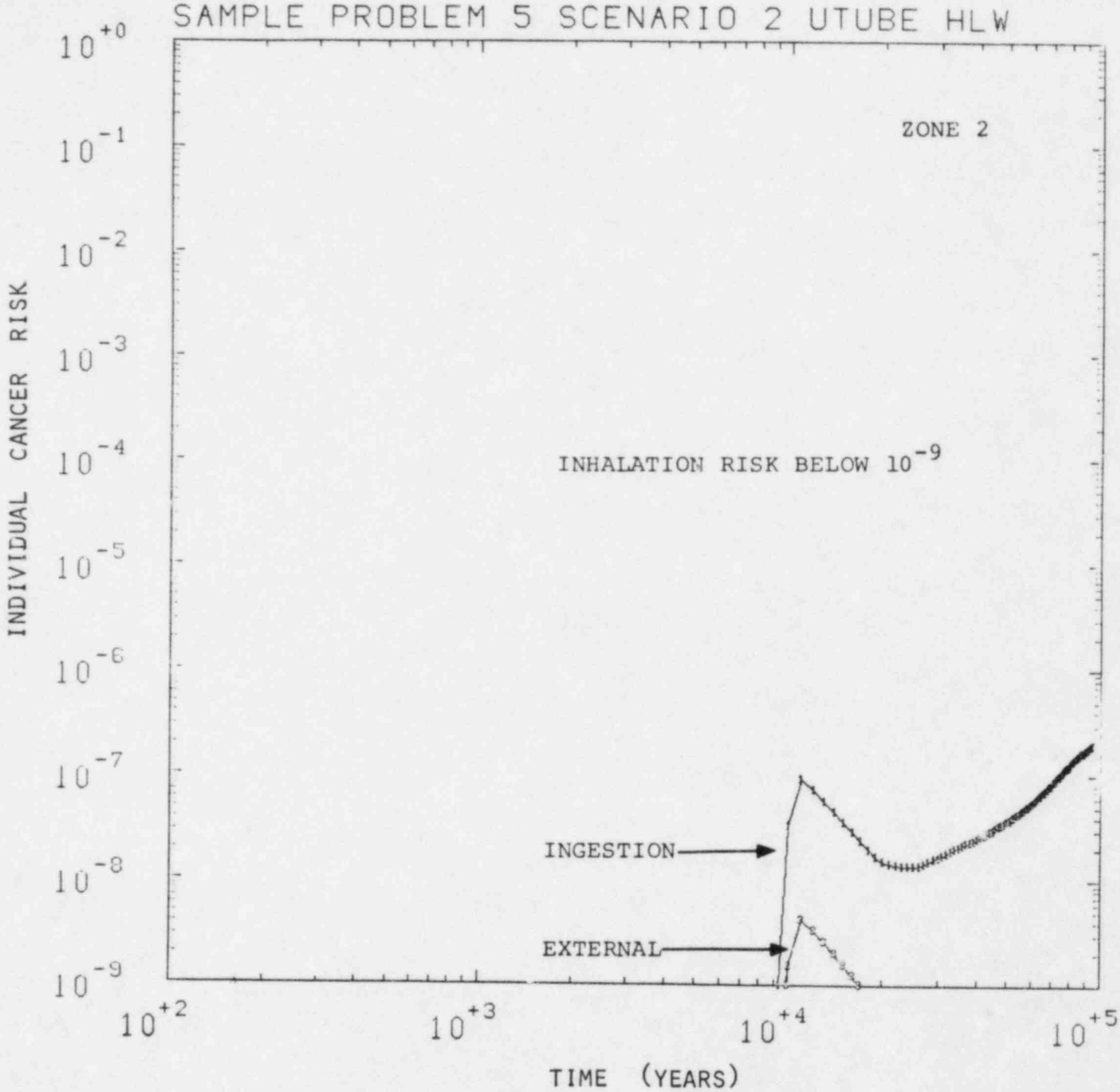

Figure 10. Conditional Probability of an Individual Dying of Latent Somatic Cancer in Zone 2

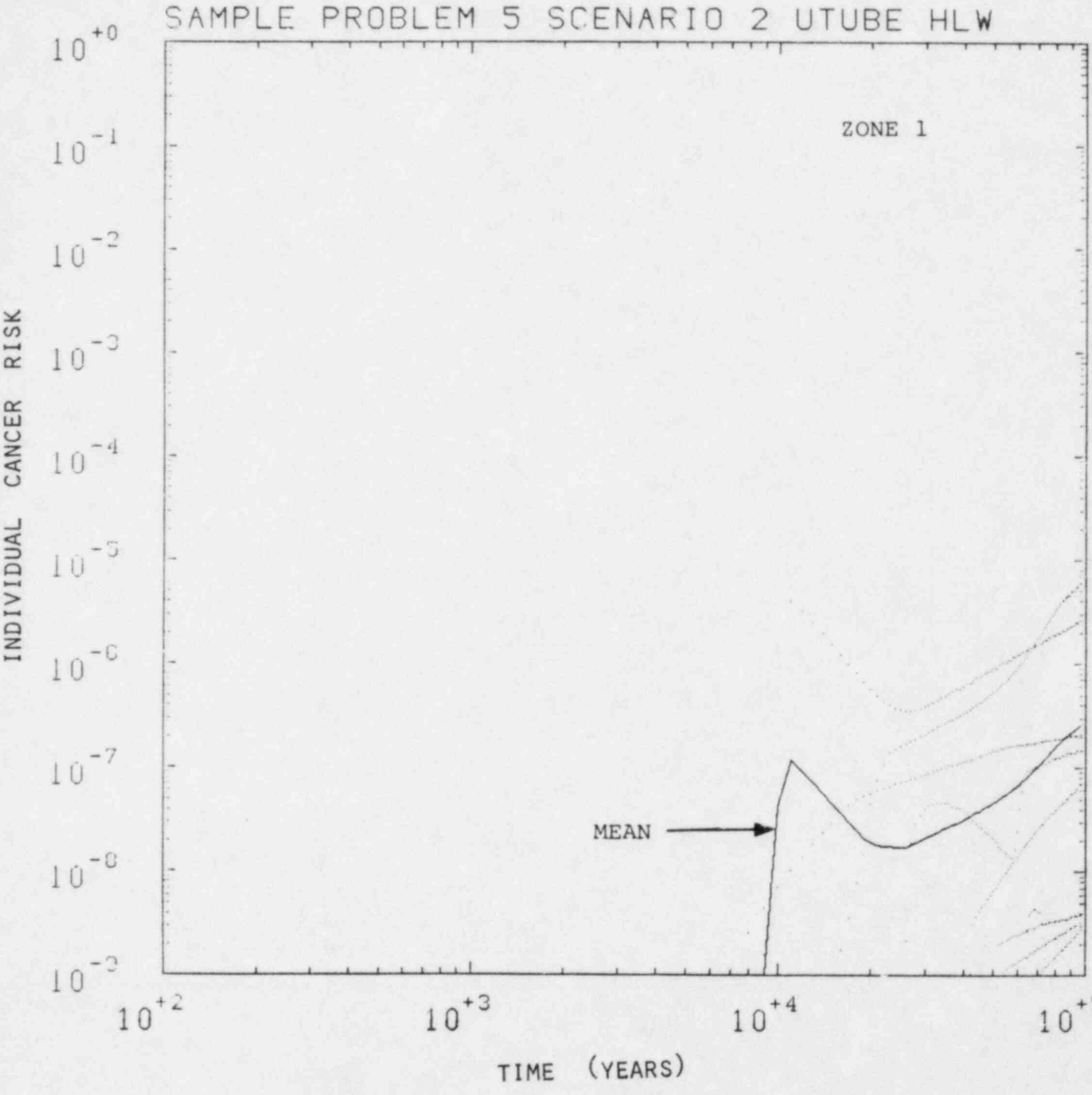

Figure 11. Individual Cancer Risk from 35 Vestors Processed by the Model at Each Time Step for Zone 1 (The dots represent the summation of the risk from the ingestion, inhalation and external paths. The solid line represents the mean value of the 35 vectors.)

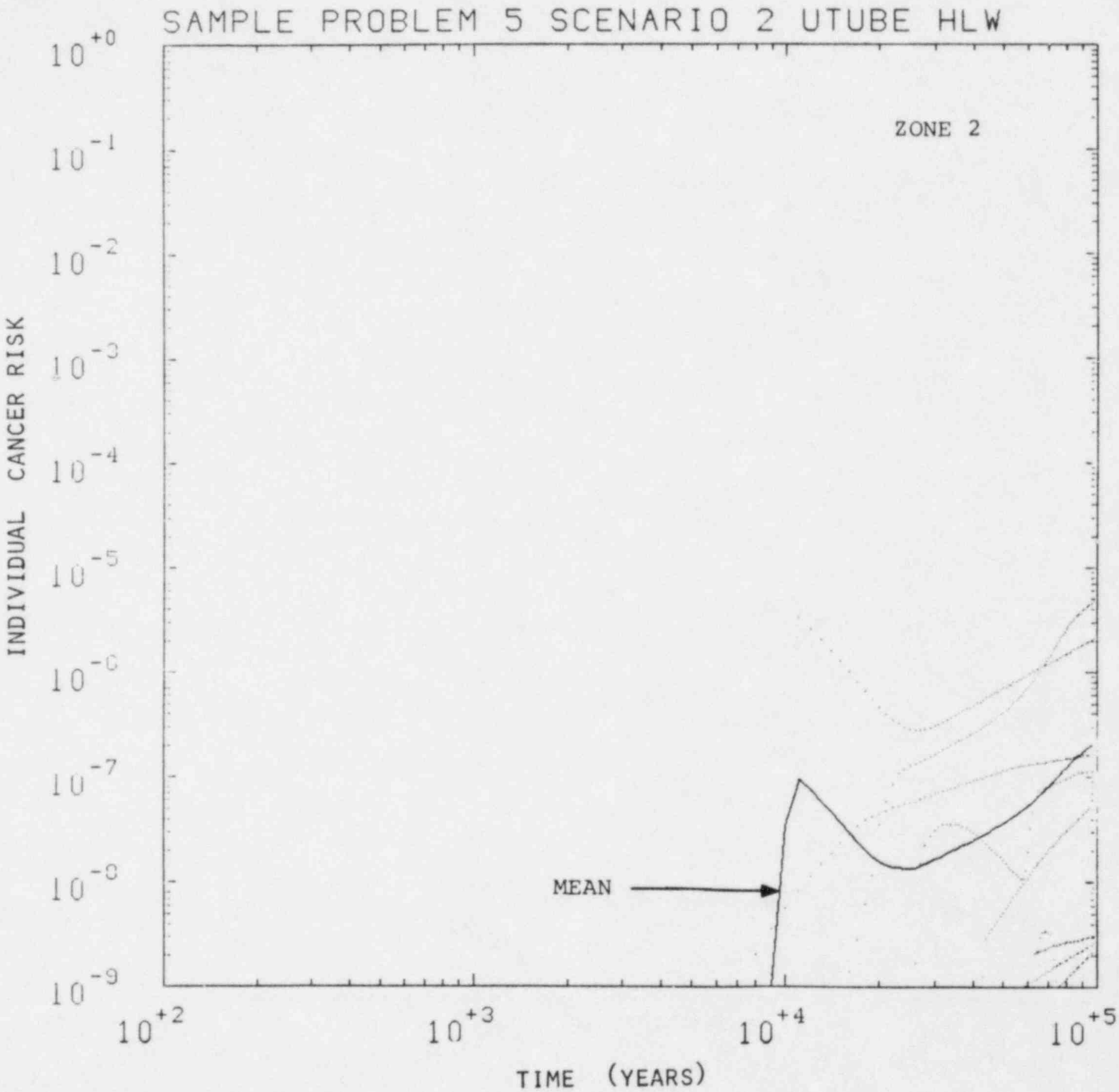

Figure 12. Individual Cancer Risk from 35 Vectors Processed by the Model at Each Time Step for Zone 2 (The dots represent the summation of the risk from the ingestion, inhalation and external paths. The solid line represents the mean value of the 35 vectors.)

In Figures 13 and 14, the average dose to an individual is given for the U-tube scenario. The dose is expressed in rem/yr and is plotted at each time step considered in the analysis. As long as the results of this plot are significantly less than 0.1 rem/yr, it is assumed that the risk of genetic effects will not be above those that occur naturally. However, genetic risk estimators may be applied to these dose levels to estimate potential genetic effects.

In addition to these plot outputs, the individual cancer risk and the total dose will be printed for all vectors considered in the analysis at each time step for each zone. The output of the individual cancer risk for this scenario analysis is given in Table 15.

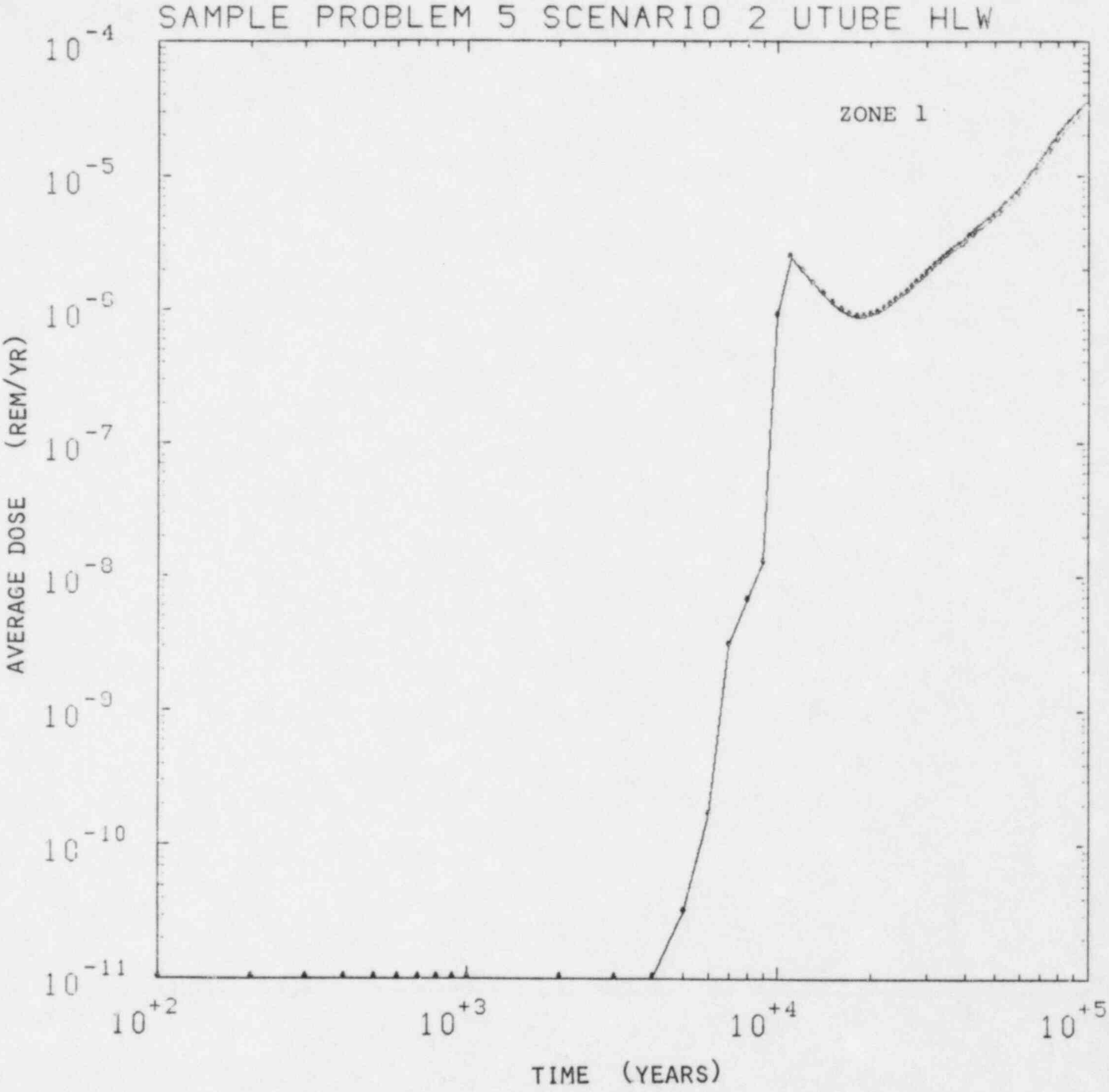

Figure 13. Average Individual Dose Expressed in rem/year at Each Time Step in Zone 1

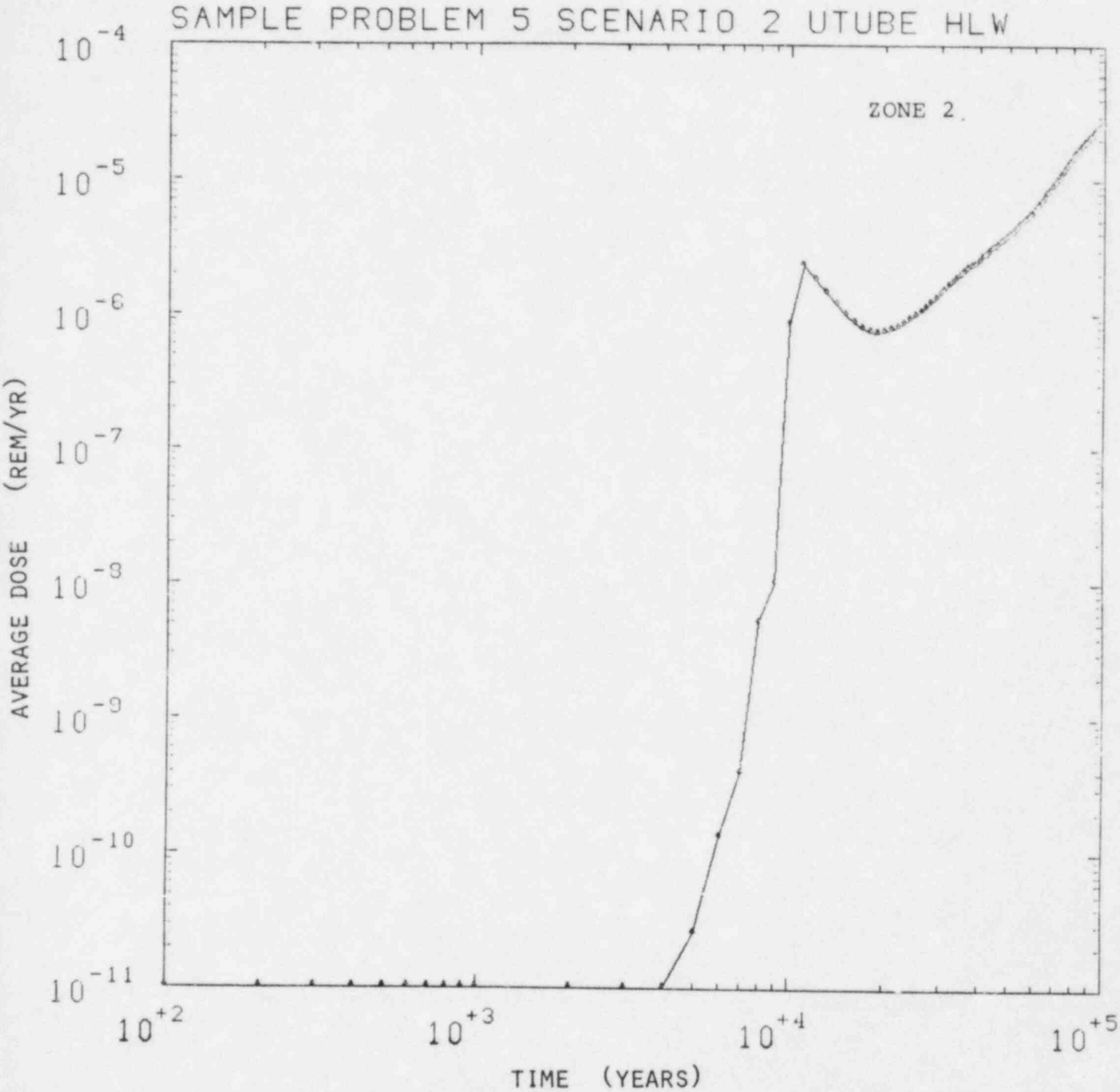

Figure 14. Average Individual Dose Expressed in rem/year at Each Time Step in Zone 2

Table 15

Final Output - Individual Cancer Risk for All Vectors at Each Time Step for Each Zone Considered in the Analysis

Page 1

SAMPLE PROBLEM 5 SCENARIO 2 UTUBE HLW

INDIVIDUAL CANCER RISK BY VECTOR ZONE 1

TIME(YRS)	RISK VECTORS									
1.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
2.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
3.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
4.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
5.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
6.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
7.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					

Table 15 (cont'd)

Page 2

8.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
9.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
1.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
2.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
3.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
4.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
5.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	3.055E-11	0.	0.					
6.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.601E-10	0.	0.					
7.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.191E-09	0.	0.					

Table 15 (cont'd)

Page 3

8.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	2.575E-09	1.243E-14	0.					
9.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	4.511E-09	1.593E-09	0.					
1.000E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	7.036E-09	1.466E-06	0.					
1.100E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.026E-08	4.051E-06	0.					
1.200E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.413E-08	3.188E-06	0.					
1.300E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.859E-08	2.500E-06	0.					
1.400E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	9.586E-16	0.	2.389E-08	1.968E-06	0.					
1.500E+04	0.	0.	6.736E-10	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	1.311E-15	0.	2.975E-08	1.556E-06	0.					
1.600E+04	0.	0.	1.774E-09	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	1.561E-15	0.	3.622E-08	1.240E-06	0.					

1.700E+04	0.	0.	3.604E-09	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	1.763E-15	6.759E-15	4.326E-08	9.983E-07	0.					
1.800E+04	0.	0.	7.910E-09	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	1.968E-15	4.411E-14	4.917E-08	8.143E-07	0.					
1.900E+04	0.	0.	1.469E-08	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2.195E-15	9.912E-14	5.301E-08	6.758E-07	0.					
2.000E+04	0.	0.	4.483E-08	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2.446E-15	1.482E-13	5.631E-08	5.725E-07	0.					
2.100E+04	0.	0.	7.564E-08	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	1.024E-12	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2.714E-15	1.502E-13	6.059E-08	4.961E-07	0.					
2.200E+04	0.	0.	1.081E-07	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	1.154E-11	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2.995E-15	1.539E-13	6.437E-08	4.410E-07	0.					
2.300E+04	0.	0.	1.416E-07	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.140E-10	0.	0.	0.	3.464E-11	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	3.287E-15	1.578E-13	6.606E-08	4.033E-07	0.					
2.400E+04	0.	0.	1.519E-07	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.329E-10	0.	0.	0.	5.464E-11	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	3.587E-15	1.578E-13	7.017E-08	3.792E-07	0.					
2.500E+04	0.	0.	1.624E-07	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.532E-10	0.	0.	0.	5.328E-11	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	3.892E-15	1.578E-13	7.203E-08	3.556E-07	0.					

Table 15 (cont'd)

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2.600E+04	0.	0.	1.705E-07	0.	0.	1.178E-12	1.769E-12	0.	0.	0.
	0.	0.	1.743E-10	0.	0.	0.	6.870E-11	0.	0.	0.
	0.	0.	0.	0.	2.153E-09	0.	0.	0.	0.	0.
	4.199E-15	1.578E-13	7.456E-08	3.564E-07	0.					
2.700E+04	0.	0.	1.794E-07	0.	0.	1.227E-12	4.012E-11	0.	0.	0.
	0.	0.	1.959E-10	0.	0.	0.	7.388E-11	0.	0.	0.
	0.	0.	0.	0.	1.916E-08	0.	0.	0.	0.	0.
	4.505E-15	1.578E-13	7.753E-08	3.584E-07	0.					
2.800E+04	0.	0.	1.890E-07	0.	0.	1.227E-12	6.663E-11	0.	0.	0.
	0.	0.	2.190E-10	0.	0.	0.	7.898E-11	0.	0.	0.
	0.	0.	0.	0.	2.906E-08	0.	0.	0.	0.	0.
	4.807E-15	1.578E-13	8.114E-08	3.653E-07	0.					
2.900E+04	0.	0.	1.992E-07	0.	0.	1.227E-12	9.314E-11	0.	0.	0.
	0.	0.	2.427E-10	0.	0.	0.	8.399E-11	0.	0.	0.
	0.	0.	0.	0.	3.528E-08	0.	0.	0.	0.	0.
	5.105E-15	1.578E-13	8.405E-08	3.768E-07	0.					
3.000E+04	0.	0.	2.102E-07	0.	0.	1.227E-12	1.210E-10	0.	0.	0.
	0.	0.	2.671E-10	0.	0.	0.	8.879E-11	0.	0.	0.
	0.	0.	0.	0.	4.020E-08	0.	0.	0.	0.	0.
	5.394E-15	1.578E-13	8.736E-08	3.914E-07	0.					
3.100E+04	0.	0.	2.222E-07	0.	0.	1.227E-12	1.489E-10	0.	0.	0.
	0.	0.	2.927E-10	0.	0.	0.	9.202E-11	0.	0.	0.
	0.	0.	0.	0.	4.355E-08	0.	0.	0.	0.	0.
	5.674E-15	1.578E-13	8.916E-08	4.089E-07	0.					
3.200E+04	0.	0.	2.348E-07	0.	0.	1.227E-12	1.771E-10	0.	0.	0.
	0.	0.	3.189E-10	0.	0.	0.	9.202E-11	0.	0.	0.
	0.	0.	0.	0.	4.510E-08	0.	0.	0.	0.	0.
	5.947E-15	1.578E-13	9.221E-08	4.285E-07	0.					
3.300E+04	0.	0.	2.475E-07	0.	0.	1.227E-12	2.069E-10	0.	0.	0.
	0.	0.	3.461E-10	0.	0.	0.	9.202E-11	0.	0.	0.
	0.	0.	0.	0.	4.564E-08	0.	0.	0.	0.	0.
	6.210E-15	1.578E-13	9.485E-08	4.496E-07	0.					
3.400E+04	0.	0.	2.594E-07	0.	0.	1.227E-12	2.367E-10	0.	0.	0.
	0.	0.	3.741E-10	0.	0.	0.	9.202E-11	0.	0.	0.
	0.	0.	0.	0.	4.556E-08	0.	0.	0.	0.	0.
	6.464E-15	1.578E-13	9.788E-08	4.723E-07	0.					

3.500E+04	0.	0.	2.706E-07	0.	0.	1.227E-12	2.666E-10	0.	0.	0.
	0.	0.	4.026E-10	0.	0.	0.	9.202E-11	0.	0.	0.
	0.	0.	0.	0.	4.551E-08	0.	0.	0.	0.	0.
	6.464E-15	1.578E-13	1.005E-07	4.959E-07	0.					
3.600E+04	0.	0.	2.821E-07	0.	0.	1.227E-12	2.973E-10	0.	0.	0.
	0.	0.	4.329E-10	0.	0.	0.	9.202E-11	0.	0.	0.
	0.	0.	0.	0.	4.546E-08	0.	0.	0.	0.	0.
	6.823E-15	1.578E-13	1.049E-07	5.207E-07	0.					
3.700E+04	0.	0.	2.942E-07	0.	0.	1.227E-12	3.276E-10	0.	0.	0.
	0.	0.	4.634E-10	0.	0.	0.	9.202E-11	0.	0.	0.
	0.	0.	0.	0.	4.299E-08	0.	0.	0.	0.	0.
	7.049E-15	1.578E-13	1.062E-07	5.460E-07	0.					
3.800E+04	0.	0.	3.071E-07	0.	4.721E-11	1.227E-12	3.598E-10	0.	0.	0.
	0.	0.	4.944E-10	0.	0.	0.	9.202E-11	0.	0.	0.
	0.	0.	0.	0.	4.187E-08	0.	0.	0.	0.	0.
	7.164E-15	1.578E-13	1.089E-07	5.723E-07	0.					
3.900E+04	0.	0.	3.210E-07	0.	3.160E-10	1.227E-12	3.873E-10	0.	0.	0.
	0.	0.	5.256E-10	0.	0.	0.	9.202E-11	2.171E-15	0.	0.
	0.	0.	0.	0.	4.030E-08	0.	0.	0.	0.	0.
	7.566E-15	1.578E-13	1.126E-07	5.722E-07	0.					
4.000E+04	0.	0.	3.356E-07	0.	5.503E-10	1.227E-12	4.148E-10	0.	0.	0.
	0.	0.	5.593E-10	0.	0.	0.	9.202E-11	6.507E-15	0.	0.
	0.	0.	0.	0.	3.835E-08	0.	0.	0.	0.	0.
	7.566E-15	1.578E-13	1.145E-07	6.124E-07	0.					
4.100E+04	0.	0.	3.510E-07	0.	7.063E-10	1.227E-12	4.411E-10	0.	0.	0.
	0.	0.	5.928E-10	0.	0.	0.	9.202E-11	1.084E-14	0.	0.
	0.	0.	0.	0.	3.627E-08	0.	0.	0.	0.	0.
	7.849E-15	1.578E-13	1.182E-07	6.531E-07	0.					
4.200E+04	0.	0.	3.675E-07	0.	1.028E-09	1.227E-12	4.668E-10	0.	0.	0.
	0.	0.	6.272E-10	0.	0.	0.	9.202E-11	1.518E-14	0.	0.
	0.	0.	0.	0.	3.412E-08	0.	0.	0.	8.937E-12	0.
	8.012E-15	1.578E-13	1.209E-07	6.549E-07	0.					
4.300E+04	0.	0.	3.852E-07	0.	3.150E-09	1.227E-12	4.925E-10	0.	0.	0.
	0.	0.	6.621E-10	0.	0.	0.	9.202E-11	1.951E-14	0.	0.
	0.	0.	0.	0.	3.156E-08	0.	0.	0.	1.555E-11	0.
	8.012E-15	1.578E-13	1.216E-07	6.941E-07	0.					

Table 15 (cont'd)

4.400E+04	0.	0.	4.034E-07	0.	3.719E-09	1.227E-12	5.180E-10	0.	0.	0.
	0.	0.	6.980E-10	0.	0.	0.	9.202E-11	4.178E-14	0.	0.
	0.	0.	0.	0.	2.913E-08	0.	0.	0.	2.217E-11	0.
	8.039E-15	1.578E-13	1.277E-07	7.364E-07	0.					
4.500E+04	0.	0.	4.218E-07	0.	4.173E-09	1.227E-12	5.435E-10	0.	0.	0.
	0.	0.	7.345E-10	0.	0.	0.	9.202E-11	7.200E-14	0.	0.
	0.	0.	0.	0.	2.762E-08	0.	0.	0.	2.879E-11	0.
	8.482E-15	1.578E-13	1.284E-07	7.417E-07	0.					
4.600E+04	0.	0.	4.406E-07	0.	4.560E-09	1.227E-12	5.690E-10	0.	0.	0.
	0.	0.	7.716E-10	0.	0.	0.	9.202E-11	1.022E-13	0.	0.
	0.	0.	0.	0.	2.618E-08	0.	0.	0.	3.495E-11	0.
	8.563E-15	1.578E-13	1.310E-07	7.790E-07	0.					
4.700E+04	0.	0.	4.607E-07	0.	4.981E-09	1.227E-12	5.948E-10	0.	0.	0.
	0.	0.	8.097E-10	0.	0.	0.	9.202E-11	1.324E-13	0.	0.
	0.	0.	0.	0.	2.476E-08	0.	0.	0.	4.085E-11	0.
	8.563E-15	1.578E-13	1.351E-07	8.225E-07	0.					
4.800E+04	0.	0.	4.822E-07	0.	5.468E-09	1.227E-12	6.207E-10	0.	0.	0.
	0.	0.	8.484E-10	0.	0.	0.	9.202E-11	1.627E-13	0.	0.
	0.	0.	0.	0.	2.336E-08	4.066E-12	0.	0.	4.675E-11	0.
	8.563E-15	1.578E-13	1.379E-07	8.315E-07	0.					
4.900E+04	0.	0.	5.051E-07	0.	5.976E-09	1.227E-12	6.466E-10	0.	0.	0.
	0.	0.	8.877E-10	0.	0.	0.	9.202E-11	2.041E-13	0.	0.
	0.	0.	0.	0.	2.208E-08	4.275E-12	0.	0.	5.264E-11	0.
	8.601E-15	1.578E-13	1.384E-07	8.661E-07	0.					
5.000E+04	0.	0.	5.302E-07	0.	6.513E-09	1.227E-12	6.727E-10	0.	0.	0.
	0.	0.	9.279E-10	0.	0.	0.	9.202E-11	2.467E-13	0.	0.
	0.	0.	0.	0.	2.091E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.029E-15	1.578E-13	1.454E-07	9.109E-07	0.					
5.100E+04	0.	0.	5.574E-07	0.	7.090E-09	1.227E-12	6.989E-10	0.	0.	0.
	0.	0.	9.685E-10	0.	0.	0.	9.202E-11	2.892E-13	0.	0.
	0.	0.	0.	0.	1.934E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.095E-15	1.578E-13	1.454E-07	9.107E-07	0.					
5.200E+04	0.	0.	5.856E-07	0.	7.710E-09	3.276E-10	2.018E-09	0.	0.	0.
	0.	0.	1.010E-09	0.	0.	0.	9.202E-11	3.318E-13	0.	0.
	0.	0.	0.	0.	1.777E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.095E-15	1.578E-13	1.479E-07	9.713E-07	0.					

5.300E+04	0.	0.	6.177E-07	0.	8.375E-09	3.568E-10	2.076E-09	0.	0.	0.
	0.	0.	1.052E-09	0.	0.	0.	9.202E-11	3.741E-13	0.	0.
	0.	0.	0.	0.	1.683E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.095E-15	1.578E-13	1.533E-07	9.712E-07	0.					
5.400E+04	0.	0.	6.518E-07	0.	9.115E-09	3.870E-10	2.133E-09	0.	0.	0.
	0.	0.	1.095E-09	0.	0.	0.	9.202E-11	4.147E-13	0.	0.
	0.	0.	0.	0.	1.596E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.095E-15	1.578E-13	1.534E-07	1.033E-06	0.					
5.500E+04	0.	0.	6.888E-07	0.	9.880E-09	4.178E-10	2.191E-09	0.	0.	0.
	0.	0.	1.138E-09	0.	0.	0.	9.202E-11	4.552E-13	0.	0.
	0.	0.	0.	0.	1.514E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.095E-15	1.578E-13	1.573E-07	1.033E-06	0.					
5.600E+04	0.	0.	7.283E-07	0.	1.069E-08	4.500E-10	2.249E-09	0.	0.	0.
	0.	0.	1.182E-09	0.	0.	0.	9.202E-11	4.958E-13	0.	0.
	0.	0.	0.	0.	1.436E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.095E-15	1.578E-13	1.573E-07	1.095E-06	0.					
5.700E+04	0.	0.	7.705E-07	0.	1.155E-08	4.828E-10	2.307E-09	0.	0.	0.
	0.	0.	1.227E-09	0.	0.	0.	9.202E-11	5.364E-13	0.	0.
	0.	0.	0.	0.	1.366E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.095E-15	1.578E-13	1.611E-07	1.095E-06	0.					
5.800E+04	0.	0.	8.168E-07	0.	1.246E-08	5.167E-10	2.364E-09	0.	0.	0.
	0.	0.	1.273E-09	0.	0.	0.	9.202E-11	5.762E-13	0.	0.
	0.	0.	0.	0.	1.375E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.249E-15	1.578E-13	1.612E-07	1.159E-06	0.					
5.900E+04	0.	0.	8.668E-07	0.	1.341E-08	5.516E-10	2.422E-09	0.	0.	0.
	0.	0.	1.319E-09	0.	0.	0.	9.202E-11	6.147E-13	0.	0.
	0.	0.	0.	0.	1.632E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.615E-07	1.159E-06	0.					
6.000E+04	0.	0.	9.201E-07	0.	1.393E-08	5.873E-10	2.480E-09	0.	0.	0.
	0.	0.	1.365E-09	0.	0.	0.	9.202E-11	6.532E-13	0.	0.
	0.	0.	0.	0.	2.466E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.655E-07	1.223E-06	0.					
6.100E+04	0.	0.	9.771E-07	0.	1.513E-08	6.245E-10	2.539E-09	0.	0.	0.
	0.	0.	1.412E-09	0.	0.	0.	9.202E-11	6.916E-13	0.	0.
	0.	0.	0.	0.	4.035E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.655E-07	1.223E-06	0.					

Table 15 (cont'd)

6.200E+04	0.	0.	1.040E-06	0.	1.637E-08	6.623E-10	2.597E-09	0.	0.	0.
	0.	0.	1.459E-09	0.	0.	0.	9.202E-11	7.301E-13	0.	8.591E-12
	0.	0.	0.	0.	5.982E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.655E-07	1.289E-06	0.					
6.300E+04	0.	0.	1.107E-06	0.	1.759E-08	7.015E-10	2.655E-09	0.	0.	0.
	0.	0.	1.507E-09	0.	0.	0.	9.202E-11	7.675E-13	0.	4.077E-10
	0.	0.	0.	0.	7.647E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.654E-07	1.289E-06	0.					
6.400E+04	0.	0.	1.179E-06	0.	1.852E-08	7.416E-10	2.714E-09	0.	0.	0.
	0.	0.	1.527E-09	0.	0.	0.	9.202E-11	8.040E-13	0.	1.064E-09
	0.	0.	0.	0.	8.604E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.697E-07	1.356E-06	0.					
6.500E+04	0.	0.	1.256E-06	0.	1.947E-08	7.826E-10	2.772E-09	0.	0.	0.
	0.	0.	1.527E-09	0.	0.	0.	9.202E-11	8.405E-13	0.	2.702E-09
	0.	0.	0.	0.	9.448E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.697E-07	1.356E-06	0.					
6.600E+04	0.	0.	1.340E-06	0.	2.047E-08	8.252E-10	2.822E-09	0.	0.	0.
	0.	0.	1.624E-09	0.	0.	0.	9.202E-11	8.770E-13	0.	3.833E-09
	0.	0.	0.	0.	9.405E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.697E-07	1.424E-06	0.					
6.700E+04	0.	0.	1.431E-06	0.	2.160E-08	8.681E-10	2.848E-09	0.	0.	0.
	0.	0.	1.681E-09	0.	0.	0.	9.202E-11	9.136E-13	0.	4.191E-09
	0.	0.	0.	0.	9.806E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.698E-07	1.424E-06	0.					
6.800E+04	0.	0.	1.528E-06	0.	2.298E-08	9.123E-10	2.874E-09	0.	0.	0.
	0.	0.	1.681E-09	0.	0.	0.	9.202E-11	9.486E-13	0.	4.340E-09
	0.	0.	0.	0.	9.808E-08	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.698E-07	1.486E-06	0.					
6.900E+04	0.	0.	1.631E-06	0.	2.436E-08	9.571E-10	2.928E-09	0.	0.	0.
	0.	0.	1.763E-09	0.	0.	0.	9.202E-11	9.832E-13	0.	4.340E-09
	0.	0.	0.	0.	1.023E-07	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.744E-07	1.510E-06	0.					
7.000E+04	0.	0.	1.744E-06	0.	2.581E-08	1.003E-09	3.014E-09	0.	0.	0.
	0.	0.	1.837E-09	0.	0.	0.	9.202E-11	1.018E-12	0.	4.214E-09
	0.	0.	0.	0.	1.028E-07	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.744E-07	1.510E-06	0.					

7.100E+04	0.	0.	1.865E-06	0.	2.710E-08	1.050E-09	3.100E-09	0.	0.	0.
	0.	0.	1.837E-09	0.	0.	0.	9.202E-11	1.053E-12	0.	4.052E-09
	0.	0.	0.	0.	1.070E-07	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.784E-07	1.598E-06	0.					
7.200E+04	0.	0.	1.992E-06	0.	2.826E-08	1.098E-09	3.144E-09	0.	0.	0.
	0.	0.	1.904E-09	0.	0.	0.	9.202E-11	1.087E-12	0.	3.214E-09
	0.	0.	0.	0.	1.067E-07	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.785E-07	1.598E-06	0.					
7.300E+04	0.	0.	2.127E-06	0.	2.934E-08	1.147E-09	3.164E-09	0.	0.	0.
	0.	0.	1.995E-09	0.	0.	0.	9.202E-11	1.120E-12	0.	2.349E-09
	0.	0.	0.	0.	1.117E-07	4.433E-12	0.	0.	5.597E-11	0.
	9.588E-15	1.578E-13	1.785E-07	1.675E-06	0.					
7.400E+04	0.	0.	2.273E-06	0.	3.047E-08	1.197E-09	3.185E-09	0.	0.	0.
	0.	0.	1.995E-09	0.	0.	0.	9.202E-11	1.153E-12	0.	1.468E-09
	0.	0.	0.	0.	1.114E-07	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.832E-07	1.689E-06	0.					
7.500E+04	0.	0.	2.425E-06	0.	3.192E-08	1.248E-09	3.216E-09	0.	0.	0.
	0.	0.	2.047E-09	0.	0.	0.	9.202E-11	1.186E-12	0.	8.335E-10
	0.	0.	0.	0.	1.114E-07	4.433E-12	0.	0.	5.697E-11	0.
	9.588E-15	1.578E-13	1.832E-07	1.689E-06	0.					
7.600E+04	0.	0.	2.583E-06	0.	3.350E-08	1.301E-09	3.249E-09	0.	0.	0.
	0.	0.	2.149E-09	0.	0.	0.	9.202E-11	1.218E-12	0.	6.679E-10
	0.	0.	0.	0.	1.165E-07	4.433E-12	0.	0.	5.697E-11	0.
	1.010E-14	1.578E-13	1.832E-07	1.781E-06	0.					
7.700E+04	0.	0.	2.747E-06	0.	3.513E-08	1.354E-09	3.283E-09	0.	0.	0.
	0.	0.	2.157E-09	0.	0.	0.	9.202E-11	1.251E-12	0.	5.908E-10
	0.	0.	0.	0.	1.166E-07	4.433E-12	1.267E-14	0.	5.697E-11	0.
	1.073E-14	1.578E-13	1.832E-07	1.781E-06	0.					
7.800E+04	0.	0.	2.918E-06	0.	3.680E-08	1.409E-09	3.321E-09	0.	0.	0.
	0.	0.	2.192E-09	0.	0.	0.	9.245E-11	1.282E-12	0.	5.908E-10
	0.	0.	0.	0.	1.224E-07	4.433E-12	2.826E-14	0.	5.697E-11	0.
	1.174E-14	1.578E-13	1.832E-07	1.873E-06	0.					
7.900E+04	0.	0.	3.092E-06	0.	3.677E-08	1.465E-09	3.360E-09	0.	0.	0.
	0.	0.	2.296E-09	0.	0.	0.	9.249E-11	1.313E-12	0.	5.908E-10
	0.	0.	0.	0.	1.221E-07	4.433E-12	4.385E-14	0.	5.597E-11	0.
	1.344E-14	1.578E-13	1.882E-07	1.875E-06	0.					

Table 15 (cont'd)

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8.000E+04	0.	0.	3.269E-06	0.	3.934E-08	1.523E-09	3.392E-09	0.	0.	0.
	0.	0.	2.321E-09	0.	0.	0.	9.253E-11	1.344E-12	0.	5.908E-10
	0.	0.	0.	0.	1.221E-07	4.433E-12	5.943E-14	0.	5.697E-11	0.
	1.615E-14	1.578E-13	1.882E-07	1.877E-06	0.					
8.100E+04	0.	0.	3.447E-06	0.	4.030E-08	1.581E-09	3.394E-09	0.	0.	0.
	0.	0.	2.339E-09	0.	0.	0.	9.256E-11	1.375E-12	0.	5.908E-10
	0.	0.	0.	0.	1.279E-07	4.433E-12	7.502E-14	0.	5.697E-11	0.
	2.242E-14	1.578E-13	1.882E-07	1.971E-06	0.					
8.200E+04	0.	0.	3.627E-06	0.	4.195E-08	1.642E-09	3.396E-09	0.	0.	0.
	0.	0.	2.445E-09	0.	0.	0.	9.260E-11	1.406E-12	0.	5.889E-10
	0.	0.	0.	0.	1.276E-07	4.433E-12	9.060E-14	0.	5.697E-11	0.
	3.166E-14	1.578E-13	1.882E-07	1.971E-06	0.					
8.300E+04	0.	0.	3.805E-06	0.	4.394E-08	1.704E-09	3.411E-09	0.	0.	0.
	0.	0.	2.488E-09	0.	0.	0.	9.263E-11	1.435E-12	0.	5.708E-10
	0.	0.	0.	0.	1.277E-07	4.433E-12	9.892E-13	0.	5.597E-11	0.
	4.476E-14	1.578E-13	1.883E-07	1.983E-06	0.					
8.400E+04	0.	0.	3.982E-06	0.	4.466E-08	1.766E-09	3.451E-09	0.	0.	0.
	0.	0.	2.489E-09	0.	0.	0.	9.267E-11	1.464E-12	0.	5.579E-10
	0.	0.	0.	0.	1.338E-07	4.433E-12	2.032E-12	0.	5.697E-11	0.
	6.294E-14	1.578E-13	1.901E-07	2.090E-06	0.					
8.500E+04	0.	0.	4.157E-06	0.	4.743E-08	1.832E-09	3.490E-09	0.	0.	0.
	0.	0.	2.596E-09	0.	0.	0.	9.270E-11	1.494E-12	0.	5.579E-10
	0.	0.	0.	0.	1.336E-07	4.433E-12	3.074E-12	0.	5.697E-11	0.
	8.760E-14	1.578E-13	1.938E-07	2.090E-06	0.					
8.600E+04	0.	0.	4.329E-06	0.	4.773E-08	1.899E-09	3.508E-09	0.	0.	0.
	0.	0.	2.658E-09	0.	0.	0.	9.274E-11	1.523E-12	0.	5.579E-10
	0.	0.	0.	0.	1.336E-07	4.433E-12	4.117E-12	0.	5.697E-11	0.
	1.235E-13	1.578E-13	1.938E-07	2.111E-06	0.					
8.700E+04	0.	0.	4.497E-06	0.	5.028E-08	1.968E-09	3.508E-09	0.	0.	0.
	0.	0.	2.658E-09	0.	0.	0.	9.277E-11	1.552E-12	0.	5.579E-10
	0.	0.	0.	0.	1.400E-07	4.433E-12	5.159E-12	0.	5.697E-11	0.
	1.726E-13	1.578E-13	1.979E-07	2.211E-06	0.					
8.800E+04	0.	0.	4.627E-06	0.	5.151E-08	2.039E-09	3.508E-09	0.	0.	0.
	0.	0.	2.749E-09	0.	0.	0.	9.281E-11	1.579E-12	0.	5.579E-10
	0.	0.	0.	0.	1.400E-07	4.433E-12	6.202E-12	0.	5.697E-11	0.
	2.354E-13	1.578E-13	1.980E-07	2.211E-06	0.					

8.900E+04	0.	0.	4.627E-06	0.	5.321E-08	2.112E-09	3.567E-09	0.	0.	0.
	0.	0.	2.830E-09	0.	0.	0.	9.284E-11	1.607E-12	0.	5.579E-10
	0.	0.	0.	0.	1.398E-07	4.433E-12	1.091E-11	0.	5.697E-11	0.
	3.148E-13	1.578E-13	1.980E-07	2.243E-06	0.					
9.000E+04	0.	0.	4.907E-06	0.	5.591E-08	2.187E-09	3.651E-09	0.	0.	0.
	0.	0.	2.830E-09	0.	0.	0.	9.287E-11	1.635E-12	0.	5.579E-10
	0.	0.	0.	0.	1.398E-07	4.433E-12	1.600E-11	0.	5.697E-11	0.
	4.131E-13	1.578E-13	2.035E-07	2.336E-06	0.					
9.100E+04	0.	0.	5.054E-06	0.	5.618E-08	2.263E-09	3.734E-09	0.	0.	0.
	0.	0.	2.905E-09	0.	0.	0.	9.288E-11	1.663E-12	0.	5.570E-10
	0.	0.	0.	0.	1.398E-07	4.433E-12	2.109E-11	0.	5.697E-11	0.
	7.255E-13	1.578E-13	2.035E-07	2.336E-06	0.					
9.200E+04	0.	0.	5.113E-06	0.	5.929E-08	2.341E-09	3.743E-09	0.	0.	0.
	0.	0.	3.005E-09	0.	0.	0.	9.292E-11	1.689E-12	0.	5.382E-10
	0.	0.	0.	0.	1.398E-07	4.433E-12	2.617E-11	0.	5.697E-11	0.
	1.074E-12	1.578E-13	2.035E-07	2.378E-06	0.					
9.300E+04	0.	0.	5.413E-06	0.	5.964E-08	2.421E-09	3.743E-09	0.	0.	0.
	0.	0.	3.005E-09	0.	0.	0.	9.296E-11	1.716E-12	0.	5.240E-10
	0.	0.	0.	0.	1.398E-07	4.433E-12	3.126E-11	0.	5.697E-11	0.
	3.128E-12	1.578E-13	2.035E-07	2.464E-06	0.					
9.400E+04	0.	0.	5.457E-06	0.	6.243E-08	2.502E-09	3.746E-09	0.	0.	0.
	0.	0.	3.052E-09	0.	0.	0.	9.296E-11	1.742E-12	0.	5.240E-10
	0.	0.	0.	0.	1.455E-07	4.433E-12	3.635E-11	0.	5.697E-11	0.
	4.004E-12	1.578E-13	2.035E-07	2.464E-06	0.					
9.500E+04	0.	0.	5.604E-06	0.	6.436E-08	2.585E-09	3.790E-09	0.	0.	5.387E-13
	0.	0.	3.174E-09	0.	0.	0.	9.303E-11	1.768E-12	0.	5.240E-10
	0.	0.	0.	0.	1.463E-07	4.433E-12	4.065E-11	0.	5.697E-11	0.
	4.999E-12	1.578E-13	2.035E-07	2.518E-06	0.					
9.600E+04	0.	0.	5.843E-06	0.	6.566E-08	2.670E-09	3.834E-09	0.	0.	9.640E-13
	0.	0.	3.182E-09	0.	0.	0.	9.307E-11	1.794E-12	0.	5.240E-10
	0.	0.	0.	0.	1.463E-07	4.433E-12	4.491E-11	0.	5.697E-11	0.
	6.147E-12	1.578E-13	2.093E-07	2.596E-06	0.					
9.700E+04	0.	0.	5.843E-06	0.	6.897E-08	2.757E-09	3.868E-09	0.	0.	1.189E-12
	0.	0.	3.222E-09	0.	0.	0.	9.311E-11	1.819E-12	0.	5.240E-10
	0.	0.	0.	0.	1.463E-07	4.433E-12	4.917E-11	0.	5.697E-11	0.
	7.449E-12	1.578E-13	2.093E-07	2.596E-06	0.					

Table 15 (cont'd)

9.800E+04	0.	0.	6.072E-06	0.	6.897E-08	2.846E-09	3.868E-09	0.	0.	1.395E-12
	0.	0.	3.335E-09	0.	0.	0.	9.315E-11	1.844E-12	0.	5.240E-10
	0.	0.	0.	0.	1.463E-07	4.433E-12	5.344E-11	0.	5.697E-11	0.
	8.892E-12	1.578E-13	2.093E-07	2.661E-06	0.					
9.900E+04	0.	0.	6.215E-06	0.	7.235E-08	2.937E-09	3.868E-09	0.	0.	1.404E-12
	0.	0.	3.362E-09	0.	0.	0.	9.316E-11	1.869E-12	0.	5.240E-10
	0.	0.	0.	0.	1.464E-07	4.433E-12	5.770E-11	0.	5.697E-11	0.
	1.048E-11	1.578E-13	2.093E-07	2.731E-06	0.					
1.000E+05	0.	0.	6.253E-06	0.	7.234E-08	3.030E-09	3.886E-09	0.	0.	1.404E-12
	0.	0.	3.383E-09	0.	0.	0.	9.322E-11	1.893E-12	0.	5.240E-10
	0.	0.	0.	0.	1.464E-07	4.433E-12	6.196E-11	0.	5.697E-11	0.
	1.221E-11	1.578E-13	2.095E-07	2.731E-06	0.					

Table 15 (cont'd)

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SAMPLE PROBLEM 5 SCENARIO 2 UTUBE HLW

INDIVIDUAL CANCER RISK BY VECTOR ZONE 2

TIME(YRS)	RISK VECTORS									
1.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
2.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
3.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
4.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
5.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
6.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
7.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
8.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					

Table 15 (cont'd)

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9.000E+02	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
1.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
2.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
3.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
4.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.					
5.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	2.496E-11	0.	0.					
6.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.255E-10	0.	0.					
7.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	3.739E-10	0.	0.					
8.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	2.065E-09	1.004E-14	0.					

Table 15 (cont'd)

9.000E+03	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	3.618E-09	1.320E-09	0.					
1.000E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	5.643E-09	1.216E-05	0.					
1.100E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	8.229E-09	3.359E-06	0.					
1.200E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.134E-08	2.643E-06	0.					
1.300E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.500E-08	2.073E-06	0.					
1.400E+04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.918E-08	1.631E-05	0.					
1.500E+04	0.	0.	5.331E-10	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2.278E-15	0.	2.389E-08	1.289E-06	0.					
1.600E+04	0.	0.	1.401E-09	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	2.711E-15	0.	2.909E-08	1.026E-05	0.					
1.700E+04	0.	0.	2.852E-09	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	3.063E-15	5.394E-15	3.475E-08	8.251E-07	0.					

Table 15 (cont'd)

1.800E+04	0.	0.	6.262E-09	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	3.419E-15	3.520E-14	3.949E-08	6.719E-07	0.					
1.900E+04	0.	0.	1.163E-08	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	3.813E-15	7.910E-14	4.257E-08	5.563E-07	0.					
2.000E+04	0.	0.	3.552E-08	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	4.249E-15	1.183E-13	4.522E-08	4.698E-07	0.					
2.100E+04	0.	0.	5.992E-08	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	8.112E-13	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	4.714E-15	1.199E-13	4.866E-08	4.058E-07	0.					
2.200E+04	0.	0.	8.567E-08	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	9.149E-12	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	5.203E-15	1.228E-13	5.171E-08	3.594E-07	0.					
2.300E+04	0.	0.	1.122E-07	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	2.745E-11	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	5.709E-15	1.259E-13	5.310E-08	3.273E-07	0.					
2.400E+04	0.	0.	1.204E-07	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	4.330E-11	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	6.231E-15	1.259E-13	5.640E-08	3.065E-07	0.					
2.500E+04	0.	0.	1.286E-07	0.	0.	0.	0.	0.	0.	0.
	0.	0.	1.210E-10	0.	0.	0.	5.015E-11	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	6.761E-15	1.259E-13	5.790E-08	2.944E-07	0.					
2.600E+04	0.	0.	1.351E-07	0.	0.	9.314E-13	0.	0.	0.	0.
	0.	0.	1.376E-10	0.	0.	0.	5.444E-11	0.	0.	0.
	0.	0.	0.	0.	1.700E-09	0.	0.	0.	0.	0.
	7.294E-15	1.259E-13	5.993E-08	2.861E-07	0.					

2.700E+04	0.	0.	1.421E-07	0.	0.	9.698E-13	3.179E-11	0.	0.	0.
	0.	0.	1.548E-10	0.	0.	0.	5.855E-11	0.	0.	0.
	0.	0.	0.	0.	1.513E-08	0.	0.	0.	0.	0.
	7.825E-15	1.259E-13	6.234E-08	2.868E-07	0.					
2.800E+04	0.	0.	1.497E-07	0.	0.	9.698E-13	5.280E-11	0.	0.	0.
	0.	0.	1.730E-10	0.	0.	0.	6.259E-11	0.	0.	0.
	0.	0.	0.	0.	2.295E-08	0.	0.	0.	0.	0.
	8.351E-15	1.259E-13	6.526E-08	2.917E-07	0.					
2.900E+04	0.	0.	1.578E-07	0.	0.	9.698E-13	7.381E-11	0.	0.	0.
	0.	0.	1.916E-10	0.	0.	0.	6.657E-11	0.	0.	0.
	0.	0.	0.	0.	2.786E-08	0.	0.	0.	0.	0.
	8.868E-15	1.259E-13	6.761E-08	3.003E-07	0.					
3.000E+04	0.	0.	1.664E-07	0.	0.	9.698E-13	9.589E-11	0.	0.	0.
	0.	0.	2.110E-10	0.	0.	0.	7.037E-11	0.	0.	0.
	0.	0.	0.	0.	3.174E-08	0.	0.	0.	0.	0.
	9.369E-15	1.259E-13	7.028E-08	3.115E-07	0.					
3.100E+04	0.	0.	1.759E-07	0.	0.	9.698E-13	1.180E-10	0.	0.	0.
	0.	0.	2.312E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.439E-08	0.	0.	0.	0.	0.
	9.857E-15	1.259E-13	7.174E-08	3.250E-07	0.					
3.200E+04	0.	0.	1.859E-07	0.	0.	9.698E-13	1.403E-10	0.	0.	0.
	0.	0.	2.518E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.562E-08	0.	0.	0.	0.	0.
	1.033E-14	1.259E-13	7.419E-08	3.404E-07	0.					
3.300E+04	0.	0.	1.960E-07	0.	0.	9.698E-13	1.639E-10	0.	0.	0.
	0.	0.	2.733E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.604E-08	0.	0.	0.	0.	0.
	1.079E-14	1.259E-13	7.636E-08	3.568E-07	0.					
3.400E+04	0.	0.	2.054E-07	0.	0.	9.698E-13	1.876E-10	0.	0.	0.
	0.	0.	2.954E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.598E-08	0.	0.	0.	0.	0.
	1.123E-14	1.259E-13	7.875E-08	3.747E-07	0.					
3.500E+04	0.	0.	2.143E-07	0.	0.	9.698E-13	2.113E-10	0.	0.	0.
	0.	0.	3.180E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.594E-08	0.	0.	0.	0.	0.
	1.123E-14	1.259E-13	8.093E-08	3.933E-07	0.					

Table 15 (cont'd)

3.600E+04	0.	0.	2.234E-07	0.	0.	9.698E-13	2.353E-10	0.	0.	0.
	0.	0.	3.415E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.590E-08	0.	0.	0.	0.	0.
	1.185E-14	1.259E-13	8.447E-08	4.128E-07	0.					
3.700E+04	0.	0.	2.330E-07	0.	0.	9.698E-13	2.593E-10	0.	0.	0.
	0.	0.	3.655E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.395E-08	0.	0.	0.	0.	0.
	1.224E-14	1.259E-13	8.550E-08	4.328E-07	0.					
3.800E+04	0.	0.	2.432E-07	0.	3.727E-11	9.698E-13	2.824E-10	0.	0.	0.
	0.	0.	3.900E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.306E-08	0.	0.	0.	0.	0.
	1.244E-14	1.259E-13	8.767E-08	4.536E-07	0.					
3.900E+04	0.	0.	2.541E-07	0.	2.495E-10	9.698E-13	3.040E-10	0.	0.	0.
	0.	0.	4.154E-10	0.	0.	0.	7.293E-11	0.	0.	0.
	0.	0.	0.	0.	3.183E-08	0.	0.	0.	0.	0.
	1.314E-14	1.259E-13	9.062E-08	4.535E-07	0.					
4.000E+04	0.	0.	2.657E-07	0.	4.345E-10	9.698E-13	3.255E-10	0.	0.	0.
	0.	0.	4.417E-10	0.	0.	0.	7.293E-11	5.786E-15	0.	0.
	0.	0.	0.	0.	3.028E-08	0.	0.	0.	0.	0.
	1.314E-14	1.259E-13	9.223E-08	4.853E-07	0.					
4.100E+04	0.	0.	2.779E-07	0.	5.576E-10	9.698E-13	3.497E-10	0.	0.	0.
	0.	0.	4.683E-10	0.	0.	0.	7.293E-11	9.642E-15	0.	0.
	0.	0.	0.	0.	2.864E-08	0.	0.	0.	0.	0.
	1.363E-14	1.259E-13	9.518E-08	5.175E-07	0.					
4.200E+04	0.	0.	2.910E-07	0.	8.117E-10	9.698E-13	3.701E-10	0.	0.	0.
	0.	0.	4.954E-10	0.	0.	0.	7.293E-11	1.350E-14	0.	0.
	0.	0.	0.	0.	2.694E-08	0.	0.	0.	7.058E-12	0.
	1.392E-14	1.259E-13	9.736E-08	5.189E-07	0.					
4.300E+04	0.	0.	3.050E-07	0.	1.261E-09	9.698E-13	3.905E-10	0.	0.	0.
	0.	0.	5.230E-10	0.	0.	0.	7.293E-11	1.735E-14	0.	0.
	0.	0.	0.	0.	2.492E-08	0.	0.	0.	1.228E-11	0.
	1.392E-14	1.259E-13	9.794E-08	5.499E-07	0.					
4.400E+04	0.	0.	3.193E-07	0.	2.936E-09	9.698E-13	4.107E-10	0.	0.	0.
	0.	0.	5.513E-10	0.	0.	0.	7.293E-11	3.715E-14	0.	0.
	0.	0.	0.	0.	2.301E-08	0.	0.	0.	1.751E-11	0.
	1.396E-14	1.259E-13	1.028E-07	5.835E-07	0.					

4.500E+04	0.	0.	3.339E-07	0.	3.295E-09	9.698E-13	4.309E-10	0.	0.	0.
	0.	0.	5.802E-10	0.	0.	0.	7.293E-11	6.403E-14	0.	0.
	0.	0.	0.	0.	2.181E-08	0.	0.	0.	2.274E-11	0.
	1.473E-14	1.259E-13	1.034E-07	5.876E-07	0.					
4.600E+04	0.	0.	3.488E-07	0.	3.600E-09	9.698E-13	4.512E-10	0.	0.	0.
	0.	0.	6.095E-10	0.	0.	0.	7.293E-11	9.090E-14	0.	0.
	0.	0.	0.	0.	2.068E-08	0.	0.	0.	2.761E-11	0.
	1.487E-14	1.259E-13	1.056E-07	6.172E-07	0.					
4.700E+04	0.	0.	3.647E-07	0.	3.933E-09	9.698E-13	4.716E-10	0.	0.	0.
	0.	0.	6.396E-10	0.	0.	0.	7.293E-11	1.178E-13	0.	0.
	0.	0.	0.	0.	1.955E-08	0.	0.	0.	3.226E-11	0.
	1.487E-14	1.259E-13	1.089E-07	6.516E-07	0.					
4.800E+04	0.	0.	3.817E-07	0.	4.317E-09	9.698E-13	4.921E-10	0.	0.	0.
	0.	0.	6.701E-10	0.	0.	0.	7.293E-11	1.446E-13	0.	0.
	0.	0.	0.	0.	1.845E-08	0.	0.	0.	3.692E-11	0.
	1.487E-14	1.259E-13	1.111E-07	6.588E-07	0.					
4.900E+04	0.	0.	3.999E-07	0.	4.718E-09	9.698E-13	5.126E-10	0.	0.	0.
	0.	0.	7.012E-10	0.	0.	0.	7.293E-11	1.815E-13	0.	0.
	0.	0.	0.	0.	1.743E-08	0.	0.	0.	4.158E-11	0.
	1.494E-14	1.259E-13	1.115E-07	6.861E-07	0.					
5.000E+04	0.	0.	4.198E-07	0.	5.142E-09	9.698E-13	5.334E-10	0.	0.	0.
	0.	0.	7.329E-10	0.	0.	0.	7.293E-11	2.194E-13	0.	0.
	0.	0.	0.	0.	1.651E-08	0.	0.	0.	4.499E-11	0.
	1.568E-14	1.259E-13	1.171E-07	7.216E-07	0.					
5.100E+04	0.	0.	4.414E-07	0.	5.597E-09	9.698E-13	5.542E-10	0.	0.	0.
	0.	0.	7.650E-10	0.	0.	0.	7.293E-11	2.572E-13	0.	0.
	0.	0.	0.	0.	1.528E-08	0.	0.	0.	4.499E-11	0.
	1.580E-14	1.259E-13	1.172E-07	7.215E-07	0.					
5.200E+04	0.	0.	4.646E-07	0.	6.087E-09	9.698E-13	5.750E-10	0.	0.	0.
	0.	0.	7.978E-10	0.	0.	0.	7.293E-11	2.951E-13	0.	0.
	0.	0.	0.	0.	1.404E-08	0.	0.	0.	4.499E-11	0.
	1.580E-14	1.259E-13	1.192E-07	7.695E-07	0.					
5.300E+04	0.	0.	4.894E-07	0.	6.612E-09	9.698E-13	5.961E-10	0.	0.	0.
	0.	0.	8.311E-10	0.	0.	0.	7.293E-11	3.327E-13	0.	0.
	0.	0.	0.	0.	1.330E-08	0.	0.	0.	4.499E-11	0.
	1.580E-14	1.259E-13	1.235E-07	7.694E-07	0.					

Table 15 (cont'd)

5.400E+04	0.	0.	5.167E-07	0.	7.196E-09	3.056E-10	6.172E-10	0.	0.	0.
	0.	0.	8.648E-10	0.	0.	0.	7.293E-11	3.688E-13	0.	0.
	0.	0.	0.	0.	1.261E-08	0.	0.	0.	4.499E-11	0.
	1.580E-14	1.259E-13	1.236E-07	8.182E-07	0.					
5.500E+04	0.	0.	5.463E-07	0.	7.801E-09	3.298E-10	6.384E-10	0.	0.	0.
	0.	0.	8.992E-10	0.	0.	0.	7.293E-11	4.048E-13	0.	0.
	0.	0.	0.	0.	1.196E-08	0.	0.	0.	4.499E-11	0.
	1.580E-14	1.259E-13	1.268E-07	8.181E-07	0.					
5.600E+04	0.	0.	5.780E-07	0.	8.439E-09	3.553E-10	6.597E-10	0.	0.	0.
	0.	0.	9.340E-10	0.	0.	0.	7.293E-11	4.409E-13	0.	0.
	0.	0.	0.	0.	1.136E-08	0.	0.	0.	4.499E-11	0.
	1.580E-14	1.259E-13	1.268E-07	8.677E-07	0.					
5.700E+04	0.	0.	6.118E-07	0.	9.118E-09	3.811E-10	6.810E-10	0.	0.	0.
	0.	0.	9.693E-10	0.	0.	0.	7.293E-11	4.770E-13	0.	0.
	0.	0.	0.	0.	1.080E-08	0.	0.	0.	4.499E-11	0.
	1.580E-14	1.259E-13	1.298E-07	8.677E-07	0.					
5.800E+04	0.	0.	6.490E-07	0.	9.836E-09	4.079E-10	7.026E-10	0.	0.	0.
	0.	0.	1.005E-09	0.	0.	0.	7.293E-11	5.124E-13	0.	0.
	0.	0.	0.	0.	1.086E-08	0.	0.	0.	4.499E-11	0.
	1.607E-14	1.259E-13	1.299E-07	9.180E-07	0.					
5.900E+04	0.	0.	6.890E-07	0.	1.059E-08	4.355E-10	7.242E-10	0.	0.	0.
	0.	0.	1.042E-09	0.	0.	0.	7.293E-11	5.466E-13	0.	0.
	0.	0.	0.	0.	1.290E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.301E-07	9.180E-07	0.					
6.000E+04	0.	0.	7.316E-07	0.	1.108E-08	4.636E-10	7.458E-10	0.	0.	0.
	0.	0.	1.078E-09	0.	0.	0.	7.293E-11	5.808E-13	0.	0.
	0.	0.	0.	0.	1.949E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.334E-07	9.692E-07	0.					
6.100E+04	0.	0.	7.770E-07	0.	1.195E-08	4.930E-10	7.677E-10	0.	0.	0.
	0.	0.	1.115E-09	0.	0.	0.	7.293E-11	6.151E-13	0.	0.
	0.	0.	0.	0.	3.190E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.334E-07	9.691E-07	0.					
6.200E+04	0.	0.	8.269E-07	0.	1.293E-08	5.228E-10	7.896E-10	0.	0.	0.
	0.	0.	1.153E-09	0.	0.	0.	7.293E-11	6.493E-13	0.	6.791E-12
	0.	0.	0.	0.	4.730E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.334E-07	1.021E-06	0.					

Table 15 (cont'd)

6.300E+04	0.	0.	8.804E-07	0.	1.389E-08	5.538E-10	2.101E-09	0.	0.	0.
	0.	0.	1.191E-09	0.	0.	0.	7.293E-11	6.825E-13	0.	3.223E-10
	0.	0.	0.	0.	6.047E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.334E-07	1.021E-06	0.					
6.400E+04	0.	0.	9.375E-07	0.	1.462E-08	5.855E-10	2.147E-09	0.	0.	0.
	0.	0.	1.206E-09	0.	0.	0.	7.293E-11	7.150E-13	0.	8.409E-10
	0.	0.	0.	0.	6.804E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.369E-07	1.074E-06	0.					
6.500E+04	0.	0.	9.982E-07	0.	1.537E-08	6.178E-10	2.194E-09	0.	0.	0.
	0.	0.	1.206E-09	0.	0.	0.	7.293E-11	7.475E-13	0.	2.136E-09
	0.	0.	0.	0.	7.471E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.369E-07	1.074E-06	0.					
6.600E+04	0.	0.	1.065E-06	0.	1.616E-08	6.512E-10	2.233E-09	0.	0.	0.
	0.	0.	1.283E-09	0.	0.	0.	7.293E-11	7.799E-13	0.	3.030E-09
	0.	0.	0.	0.	7.436E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.369E-07	1.128E-06	0.					
6.700E+04	0.	0.	1.137E-06	0.	1.705E-08	6.849E-10	2.253E-09	0.	0.	0.
	0.	0.	1.327E-09	0.	0.	0.	7.293E-11	8.124E-13	0.	3.313E-09
	0.	0.	0.	0.	7.754E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.370E-07	1.128E-06	0.					
6.800E+04	0.	0.	1.214E-06	0.	1.814E-08	7.198E-10	2.274E-09	0.	0.	0.
	0.	0.	1.327E-09	0.	0.	0.	7.293E-11	8.436E-13	0.	3.431E-09
	0.	0.	0.	0.	7.755E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.370E-07	1.177E-06	0.					
6.900E+04	0.	0.	1.295E-06	0.	1.923E-08	7.552E-10	2.317E-09	0.	0.	0.
	0.	0.	1.392E-09	0.	0.	0.	7.293E-11	8.744E-13	0.	3.431E-09
	0.	0.	0.	0.	8.093E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.408E-07	1.196E-06	0.					
7.000E+04	0.	0.	1.385E-06	0.	2.038E-08	7.914E-10	2.385E-09	0.	0.	0.
	0.	0.	1.451E-09	0.	0.	0.	7.293E-11	9.052E-13	0.	3.331E-09
	0.	0.	0.	0.	8.063E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.408E-07	1.196E-06	0.					
7.100E+04	0.	0.	1.481E-06	0.	2.140E-08	8.290E-10	2.453E-09	0.	0.	0.
	0.	0.	1.451E-09	0.	0.	0.	7.293E-11	9.360E-13	0.	3.203E-09
	0.	0.	0.	0.	8.464E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.439E-07	1.266E-06	0.					

7.200E+04	0.	0.	1.582E-06	0.	2.231E-08	8.666E-10	2.488E-09	0.	0.	0.
	0.	0.	1.504E-09	0.	0.	0.	7.293E-11	9.668E-13	0.	2.541E-09
	0.	0.	0.	0.	8.436E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.440E-07	1.266E-06	0.					
7.300E+04	0.	0.	1.688E-06	0.	2.317E-08	9.056E-10	2.504E-09	0.	0.	0.
	0.	0.	1.576E-09	0.	0.	0.	7.293E-11	9.960E-13	0.	1.857E-09
	0.	0.	0.	0.	8.834E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.440E-07	1.327E-06	0.					
7.400E+04	0.	0.	1.803E-06	0.	2.406E-08	9.451E-10	2.520E-09	0.	0.	0.
	0.	0.	1.576E-09	0.	0.	0.	7.293E-11	1.025E-12	0.	1.160E-09
	0.	0.	0.	0.	8.809E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.478E-07	1.338E-06	0.					
7.500E+04	0.	0.	1.924E-06	0.	2.520E-08	9.856E-10	2.545E-09	0.	0.	0.
	0.	0.	1.617E-09	0.	0.	0.	7.293E-11	1.054E-12	0.	6.589E-10
	0.	0.	0.	0.	8.811E-08	0.	0.	0.	4.499E-11	0.
	1.665E-14	1.259E-13	1.478E-07	1.338E-06	0.					
7.600E+04	0.	0.	2.049E-06	0.	2.645E-08	1.027E-09	2.571E-09	0.	0.	0.
	0.	0.	1.697E-09	0.	0.	0.	7.293E-11	1.084E-12	0.	5.280E-10
	0.	0.	0.	0.	9.215E-08	0.	0.	0.	4.499E-11	0.
	1.755E-14	1.259E-13	1.478E-07	1.411E-06	0.					
7.700E+04	0.	0.	2.179E-06	0.	2.774E-08	1.069E-09	2.598E-09	0.	0.	0.
	0.	0.	1.704E-09	0.	0.	0.	7.293E-11	1.112E-12	0.	4.670E-10
	0.	0.	0.	0.	9.217E-08	0.	1.246E-14	0.	4.499E-11	0.
	1.863E-14	1.259E-13	1.478E-07	1.411E-06	0.					
7.800E+04	0.	0.	2.314E-06	0.	2.906E-08	1.113E-09	2.628E-09	0.	0.	0.
	0.	0.	1.732E-09	0.	0.	0.	7.293E-11	1.140E-12	0.	4.670E-10
	0.	0.	0.	0.	9.675E-08	0.	2.778E-14	0.	4.499E-11	0.
	2.039E-14	1.259E-13	1.478E-07	1.484E-06	0.					
7.900E+04	0.	0.	2.452E-06	0.	2.903E-08	1.157E-09	2.658E-09	0.	0.	0.
	0.	0.	1.814E-09	0.	0.	0.	7.293E-11	1.168E-12	0.	4.670E-10
	0.	0.	0.	0.	9.653E-08	0.	4.311E-14	0.	4.499E-11	0.
	2.335E-14	1.259E-13	1.519E-07	1.485E-06	0.					
8.000E+04	0.	0.	2.592E-06	0.	3.106E-08	1.202E-09	2.684E-09	0.	0.	0.
	0.	0.	1.834E-09	0.	0.	0.	7.334E-11	1.195E-12	0.	4.670E-10
	0.	0.	0.	0.	9.655E-08	0.	5.843E-14	0.	4.499E-11	0.
	2.806E-14	1.259E-13	1.519E-07	1.487E-06	0.					

Table 15 (cont'd)

8.100E+04	0.	0.	2.733E-06	0.	3.158E-08	1.249E-09	2.685E-09	0.	3.	0.
	0.	0.	1.848E-09	0.	0.	0.	7.337E-11	1.223E-12	0.	4.670E-10
	0.	0.	0.	0.	1.011E-07	0.	7.375E-14	0.	4.499E-11	0.
	3.895E-14	1.259E-13	1.519E-07	1.562E-06	0.					
8.200E+04	0.	0.	2.875E-06	0.	3.312E-08	1.296E-09	2.687E-09	0.	0.	0.
	0.	0.	1.931E-09	0.	0.	0.	7.340E-11	1.250E-12	0.	4.655E-10
	0.	0.	0.	0.	1.009E-07	0.	8.908E-14	0.	4.499E-11	0.
	5.501E-14	1.259E-13	1.519E-07	1.562E-06	0.					
8.300E+04	0.	0.	3.016E-06	0.	3.469E-08	1.345E-09	2.699E-09	0.	0.	0.
	0.	0.	1.965E-09	0.	0.	0.	7.343E-11	1.276E-12	0.	4.512E-10
	0.	0.	0.	0.	1.009E-07	0.	9.726E-13	0.	4.499E-11	0.
	7.777E-14	1.259E-13	1.520E-07	1.571E-06	0.					
8.400E+04	0.	0.	3.157E-06	0.	3.526E-08	1.394E-09	2.731E-09	0.	0.	0.
	0.	0.	1.966E-09	0.	0.	0.	7.346E-11	1.302E-12	0.	4.410E-10
	0.	0.	0.	0.	1.058E-07	0.	1.998E-12	0.	4.499E-11	0.
	1.094E-13	1.259E-13	1.534E-07	1.655E-06	0.					
8.500E+04	0.	0.	3.295E-06	0.	3.744E-08	1.446E-09	2.762E-09	0.	0.	0.
	0.	0.	2.051E-09	0.	0.	0.	7.349E-11	1.328E-12	0.	4.410E-10
	0.	0.	0.	0.	1.056E-07	0.	3.023E-12	0.	4.499E-11	0.
	1.522E-13	1.259E-13	1.565E-07	1.655E-06	0.					
8.600E+04	0.	0.	3.431E-06	0.	3.744E-08	1.499E-09	2.776E-09	0.	0.	0.
	0.	0.	2.099E-09	0.	0.	0.	7.352E-11	1.355E-12	0.	4.410E-10
	0.	0.	0.	0.	1.056E-07	0.	4.048E-12	0.	4.499E-11	0.
	2.145E-13	1.259E-13	1.565E-07	1.673E-06	0.					
8.700E+04	0.	0.	3.554E-06	0.	3.970E-08	1.534E-09	2.776E-09	0.	0.	0.
	0.	0.	2.099E-09	0.	0.	0.	7.355E-11	1.380E-12	0.	4.410E-10
	0.	0.	0.	0.	1.107E-07	0.	5.073E-12	0.	4.499E-11	0.
	2.986E-13	1.259E-13	1.597E-07	1.752E-06	0.					
8.800E+04	0.	0.	3.667E-06	0.	4.066E-08	1.610E-09	2.776E-09	0.	0.	0.
	0.	0.	2.172E-09	0.	0.	0.	7.357E-11	1.405E-12	0.	4.410E-10
	0.	0.	0.	0.	1.107E-07	0.	6.098E-12	0.	4.499E-11	0.
	4.076E-13	1.259E-13	1.598E-07	1.752E-06	0.					
8.900E+04	0.	0.	3.667E-06	0.	4.201E-08	1.667E-09	2.823E-09	0.	0.	0.
	0.	0.	2.235E-09	0.	0.	0.	7.360E-11	1.429E-12	0.	4.410E-10
	0.	0.	0.	0.	1.105E-07	0.	1.073E-11	0.	4.499E-11	0.
	5.469E-13	1.259E-13	1.598E-07	1.777E-06	0.					

Table 15 (cont'd)

9.000E+04	0.	0.	3.889E-06	0.	4.414E-08	1.726E-09	2.889E-09	0.	0.	0.
	0.	0.	2.235E-09	0.	0.	0.	7.363E-11	1.454E-12	0.	4.410E-10
	0.	0.	0.	0.	1.105E-07	0.	1.573E-11	0.	4.499E-11	0.
	7.177E-13	1.259E-13	1.643E-07	1.851E-06	0.					
9.100E+04	0.	0.	4.005E-06	0.	4.436E-08	1.787E-09	2.955E-09	0.	0.	0.
	0.	0.	2.294E-09	0.	0.	0.	7.363E-11	1.479E-12	0.	4.403E-10
	0.	0.	0.	0.	1.105E-07	0.	2.073E-11	0.	4.499E-11	0.
	1.264E-12	1.259E-13	1.643E-07	1.851E-06	0.					
9.200E+04	0.	0.	4.051E-06	0.	4.681E-08	1.848E-09	2.962E-09	0.	0.	0.
	0.	0.	2.373E-09	0.	0.	0.	7.366E-11	1.502E-12	0.	4.255E-10
	0.	0.	0.	0.	1.105E-07	0.	2.573E-11	0.	4.499E-11	0.
	1.872E-12	1.259E-13	1.643E-07	1.884E-06	0.					
9.300E+04	0.	0.	4.289E-06	0.	4.709E-08	1.911E-09	2.962E-09	0.	0.	0.
	0.	0.	2.373E-09	0.	0.	0.	7.370E-11	1.526E-12	0.	4.142E-10
	0.	0.	0.	0.	1.105E-07	0.	3.073E-11	0.	4.499E-11	0.
	2.530E-12	1.259E-13	1.643E-07	1.952E-06	0.					
9.400E+04	0.	0.	4.324E-06	0.	4.928E-08	1.975E-09	2.965E-09	0.	0.	0.
	0.	0.	2.419E-09	0.	0.	0.	7.370E-11	1.549E-12	0.	4.142E-10
	0.	0.	0.	0.	1.158E-07	0.	3.573E-11	0.	4.499E-11	0.
	4.962E-12	1.259E-13	1.643E-07	1.952E-06	0.					
9.500E+04	0.	0.	4.441E-06	0.	5.081E-08	2.041E-09	3.000E-09	0.	0.	4.264E-13
	0.	0.	2.507E-09	0.	0.	0.	7.376E-11	1.572E-12	0.	4.142E-10
	0.	0.	0.	0.	1.157E-07	0.	3.996E-11	0.	4.499E-11	0.
	6.167E-12	1.259E-13	1.643E-07	1.995E-06	0.					
9.600E+04	0.	0.	4.629E-06	0.	5.184E-08	2.108E-09	3.034E-09	0.	0.	7.631E-13
	0.	0.	2.513E-09	0.	0.	0.	7.377E-11	1.596E-12	0.	4.142E-10
	0.	0.	0.	0.	1.157E-07	0.	4.415E-11	0.	4.499E-11	0.
	7.526E-12	1.259E-13	1.691E-07	2.056E-06	0.					
9.700E+04	0.	0.	4.629E-06	0.	5.445E-08	2.177E-09	3.061E-09	0.	0.	9.413E-13
	0.	0.	2.545E-09	0.	0.	0.	7.380E-11	1.618E-12	0.	4.142E-10
	0.	0.	0.	0.	1.157E-07	0.	4.835E-11	0.	4.499E-11	0.
	9.039E-12	1.259E-13	1.691E-07	2.056E-06	0.					
9.800E+04	0.	0.	4.811E-06	0.	5.445E-08	2.247E-09	3.061E-09	0.	0.	1.104E-12
	0.	0.	2.635E-09	0.	0.	0.	7.383E-11	1.640E-12	0.	4.142E-10
	0.	0.	0.	0.	1.157E-07	0.	5.254E-11	0.	4.499E-11	0.
	1.069E-11	1.259E-13	1.691E-07	2.108E-06	0.					

9.900E+04	0.	0.	4.924E-06	0.	5.712E-08	2.319E-09	3.061E-09	0.	0.	1.111E-12
	0.	0.	2.656E-09	0.	0.	0.	7.384E-11	1.662E-12	0.	4.142E-10
	0.	0.	0.	0.	1.157E-07	0.	5.673E-11	0.	4.499E-11	0.
	1.248E-11	1.259E-13	1.691E-07	2.164E-06	0.					
1.000E+05	0.	0.	4.955E-06	0.	5.711E-08	2.393E-09	3.075E-09	0.	0.	1.111E-12
	0.	0.	2.672E-09	0.	0.	0.	7.389E-11	1.684E-12	0.	4.142E-10
	0.	0.	0.	0.	1.157E-07	0.	6.092E-11	0.	4.499E-11	0.
	1.441E-11	1.259E-13	1.692E-07	2.164E-06	0.					

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APPENDIX

This Appendix contains samples of the three calculations (Parts 1 to 3) requested in Sample Problem 3. In addition, a computer output from the execution of this problem through the DHECC is included in Table A.1.

SAMPLE CALCULATION FOR PROBLEM 3

PART 1

Zone 1 - ^{240}Pu - EXTERNAL EXPOSURE - SOIL

Soil conc   9.62E-13 Ci/kg (Table 12)

Equation 13 Table 2 (Problem 2)	EXPOSURE

$$\text{Soil Exposure} = 2.04E5\ \text{HRS} * 9.62E\text{-}13\ \text{Ci/kg} * 2.8E3\ \text{kg/m}^3 * .025\text{m}$$

$$= 1.37E\text{-}5\ \frac{\text{Ci} \cdot \text{hr}}{\text{m}^2}$$

Table 5 Problem 2	DOSE

$$1.37E\text{-}5\ \frac{\text{Ci} \cdot \text{hr}}{\text{m}^2} * \frac{1.3E\text{-}3\text{rem} \cdot \text{m}^2}{\text{hr} \cdot \text{Ci}} = 1.78E\text{-}8\text{rem}$$

Table 6 Problem 2	RISK ESTIMATE

Leukemia	2.85E-5	* 1.78E-8	=	5.07E-13
Lung	2.50E-5	* 1.78E-8	=	4.45E-13
.	.	.		.
.	.	.		.
.	.	.		.
.	.	.		.
.	.	.		.
				2.62E-12 Individual Cancer Risk

SAMPLE PROBLEM 3

PART 2

Zone 2 - ^{236}U - INGESTION PATHWAY WITH IRRIGATION

Drinking Water
Fish (Invertebrates = 0)
Plant
Beef
Milk

Table 12

Water Conc 4.11E-12 Ci/ℓ
Soil Conc 9.21E-12 Ci/kg

Table 2 (Problem 2)

(1) Drinking Water (Ci/yr) = (370 ℓ/yr) * (1.0) * (4.11E-12 Ci/ℓ)

= 1.52E-9 Ci/yr

(2) Fish (Ci/yr) = (6.9 kg/yr) * $(2.0 \frac{Ci \cdot \ell}{Kg \cdot Ci})$ * (4.11E-12 Ci/ℓ)

= 5.67E-11 Ci/yr

Total Water Based Intake = 1.57E-9 Ci/yr

Table 2 (Problem 2)	PLANT CONCENTRATION WITH IRRIGATION

(7) Deposition Rate (Ci/kg-yr) = $(.25) \star (4.11E\text{-}12\ \frac{Ci}{\ell}) \star \left(\frac{300\ \ell/m^2\text{-}yr}{5.2 kg/m^2}\right)$

$= 5.93E\text{-}11$ Ci/kg

(8) Weathering Rate(yr^{-1}) = $\frac{.693}{.0384} = 18.05\ yr^{-1}$

(9) Plant Conc (Ci/kg) = $\{(2.5E\text{-}3) \star (9.21E\text{-}12\ Ci/kg)\}$

$+ [(5.93E\text{-}11\ Ci/kg)/18.05] \star \left[1 - e^{-(.693)(.17)/.0384}\right]$

$= (2.3E\text{-}14) + [3.28E\text{-}12 \star .95]$

$= 2.3E\text{-}14 + 3.13E\text{-}12$

$= 3.15E\text{-}12$ Ci/kg

Table 2 (Problem 2) INTAKE

(4) Plant Intake (Ci/yr) = $(190.0\ \frac{kg}{yr})$ (3.15E-12 Ci/kg)

= 5.99E-10 Ci/yr

(5) Milk Intake (Ci/yr) = [(50 kg/day) * (3.15E-12 Ci/kg)

+ (60 ℓ/day) * (4.11E-12 Ci/ℓ)]

x $(5.0E\text{-}4\ \frac{day}{kg})$ * (110 ℓ/yr)

= (1.57E-10 + 2.47E-10) * 5.5E-2

= 2.22E-11 Ci/yr

(6) Meat Intake (Ci/yr) = [(50 kg/day) * (3.15E-12 Ci/kg)

+ $\frac{50\ell}{day}$ * (4.11E-12 Ci/ℓ)

x $(3.4E\text{-}4\ \frac{day}{kg})$ * $(\frac{95\ kg}{yr})$

= (1.57E-10 + 2.1E-10) * 3.2E-2

= 1.17E-11 Ci/yr

Total Land Based = 6.3E-10 Ci/yr

Total Ingestion = 2.2E-9 Ci/yr

Part 2 (Cont.)

| Table 5 (Problem 2) |

DOSE

Total Body $3.5E6 \frac{rem \cdot yr}{Ci} * 2.2E-9\ Ci/yr = 7.6E-3\ rem$

Bone $5.5E7 \frac{rem \cdot yr}{Ci} * 2.2E-9\ Ci/yr = 1.2E-1\ rem$

Lung $0.0 * 2.2E-9\ Ci/yr = 0.0$

GI TRACT $4.0E6 \frac{rem \cdot yr}{Ci} * 2.2E-9\ Ci/yr = 8.9E-3\ rem$

PART 2 (cont.)

Table 6 (Problem 2) RISK ESTIMATES

	Individual Risk per rem	Dose (rem)	Individual Cancer Risk
Lung	2.5E-5	0.0	0.0
Leukemia	2.8E-5	1.2E-1	3.42E-6
Stomach	1.1E-5	8.9E-3	1.02E-7
Pancreas	3.8E-6	8.9E-3	3.42E-8
Rest of GI	3.8E-6	8.9E-3	3.42E-8
Breast	2.9E-5	7.6E-3	2.1E-7
Bone	9.8E-6	1.2E-1	1.17E-6
Other	3.6E-5	7.6E-3	2.74E-7
			5.24E-6

SAMPLE CALCULATION FOR PROBLEM 3

PART 3

Zone 2 - ^{240}Pu - INHALATION DOSE (REM)

Soil Conc   8.24E-13 Ci/Kg (Table 12)

Equation 10 - Table 2 (Problem 2)

$$\text{Air conc } (Ci/m^3) = (8.24E\text{-}13 \frac{Ci}{Kg}) (3.5E\text{-}9 \; Kg/m^3)$$

$$= 2.9E\text{-}21 \; Ci/m^3$$

Equation 11 Table 2 (Problem 2)

EXPOSURE

$$\text{Inhalation } (Ci/yr) = (2.9E\text{-}21 \; Ci/m^3) * (8000 \; m^3/yr)$$

$$= 2.3E\text{-}17 \; Ci/yr$$

Table 5 (Problem 2)

DOSE

Total Body $7.9E9 \; \frac{rem \; yr}{Ci} * 2.3E\text{-}17 \; Ci/yr = 1.8E\text{-}7$ rem

Bone $3.3E11 \; \frac{rem \; yr}{Ci} * 2.3E\text{-}17 \; Ci/yr = 7.5E\text{-}6$ rem

Lung $1.2E10 \; \frac{rem \; yr}{Ci} * 2.3E\text{-}17 \; Ci/yr = 2.8E\text{-}7$ rem

GI TRACT $2.9E6 \; \frac{rem \; yr}{Ci} * 2.3E\text{-}17 \; Ci/yr = 6.8E\text{-}11$ rem

Table A.1

Sample Problem 3 Output

Page 1

```
SAMPLE PROBLEM 3

NUMBER OF ZONES     2
NUMBER OF VECTORS     1
NUMBER OF RADIONUCLIDE CHAINS     1

INPUT IS FROM CARDS
ENVIRONMENTAL CONCENTRATIONS WILL BE INPUT

SELECTED OUTPUT OPTIONS
CONCENTRATIONS
CONCENTRATIONS AND INTAKES
DOSE
RISK

NUMBER OF DIFFERENT SIZE TIME STEPS     1
    1 TIME STEPS OF SIZE 1.000E+02 YRS WILL BE TAKEN TO 1.000E+02 YRS
TOTAL NUMBER OF TIME STEPS     1
```

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

CONCENTRATIONS(CI/KG OR CI/L)

ISOTOPE	ZONE	SOIL CONC	WTR CONC	SED CONC
PU240	1	9.620E-13	1.240E-12	2.410E-13
U236	1	8.430E-12	9.720E-12	1.340E-11
PU240	2	8.240E-13	1.040E-12	2.310E-13
U236	2	9.210E-12	4.110E-12	1.940E-12

Table A.1 (cont'd)

Page 3

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

INTAKES VIA INGESTION(CI/YR)

ISOTOPE	ZONE	WATER BASED DRKWTR	WATER BASED FISH	INVRT	LAND WITH IRRIGATION PLANT	LAND WITH IRRIGATION MILK	LAND WITH IRRIGATION MEAT	LAND W/O IRRIGATION PLANT	LAND W/O IRRIGATION MILK	LAND W/O IRRIGATION MEAT
PU240	1	4.588E-10	2.995E-11	0.	1.795E-10	2.576E-14	1.453E-13	4.570E-14	1.537E-14	8.248E-14
U236	1	3.595E-09	1.341E-10	0.	1.411E-09	5.250E-11	2.769E-11	4.004E-12	3.213E-11	1.573E-11
PU240	2	3.848E-10	2.512E-11	0.	1.506E-10	2.245E-14	1.219E-13	3.914E-14	1.373E-14	6.917E-14
U236	2	1.521E-09	5.672E-11	0.	5.993E-10	2.224E-11	1.173E-11	4.375E-12	1.363E-11	5.575E-12

Table A.1 (cont'd)

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

CONCENTRATIONS(CI/KG OR CI/L) AND INTAKES(CI/YR)

ISOTOPE	ZONE	SOIL CONC	WTR CONC	SED CONC	AIR CONC	INHALE	WTR BASED	ING/IRR	ING/NO IR	TOT ING
PU240	1	9.620E-13	1.240E-12	2.410E-13	3.367E-21	2.694E-17	4.887E-10	1.797E-10	1.445E-13	5.685E-10
U236	1	8.430E-12	9.720E-12	1.340E-11	2.951E-20	2.360E-16	3.731E-09	1.491E-09	5.187E-11	5.222E-09
PU240	2	8.240E-13	1.040E-12	2.310E-13	2.884E-21	2.307E-17	4.099E-10	1.507E-10	1.220E-13	5.606E-10
U236	2	9.210E-12	4.110E-12	1.940E-12	3.224E-20	2.579E-16	1.577E-09	6.333E-10	2.468E-11	2.211E-09

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

EXTERNAL EXPOSURES-TOTAL BODY(REM)

ISOTOPE	ZONE	SOIL EXP	WTR EXP	SED EXP	AIR EXP	TOT EXP
PU240	1	1.791E-08	1.823E-10	2.138E-11	1.342E-16	1.812E-08
U236	1	2.483E-08	3.031E-11	1.884E-10	2.243E-17	2.510E-08
PU240	2	1.534E-08	1.529E-10	2.050E-11	1.149E-16	1.552E-08
U236	2	2.713E-08	1.282E-11	2.728E-11	2.450E-17	2.722E-08

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

TOTAL EXTERNAL EXPOSURES-TOTAL BODY(REM)

ZONE	TOT EXP
1	4.321E-08
2	4.274E-08

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

DOSE(REM)

ISOTOPE	ORGAN	ZONE	DOSE ING	DOSE INH
PU240	TOTAL BODY	1	6.347E-04	2.131E-07
PU240	BONE	1	2.612E-02	8.769E-06
PU240	THYROID	1	0.	0.
PU240	LIVER	1	3.553E-03	1.209E-06
PU240	KIDNEYS	1	2.714E-03	9.115E-07
PU240	LUNGS	1	0.	3.298E-07
PU240	GI-LLI	1	3.173E-03	7.938E-11
U236	TOTAL BODY	1	1.803E-02	2.037E-08
U236	BONE	1	2.878E-01	3.312E-07
U236	THYROID	1	0.	0.
U236	LIVER	1	0.	0.
U236	KIDNEYS	1	6.974E-02	8.025E-08
U236	LUNGS	1	0.	8.547E-07
U236	GI-LLI	1	2.105E-02	5.899E-10
PU240	TOTAL BODY	2	5.323E-04	1.826E-07
PU240	BONE	2	2.190E-02	7.511E-06
PU240	THYROID	2	0.	0.
PU240	LIVER	2	2.980E-03	1.035E-06
PU240	KIDNEYS	2	2.277E-03	7.807E-07
PU240	LUNGS	2	0.	2.825E-07
PU240	GI-LLI	2	2.661E-03	6.799E-11
U236	TOTAL BODY	2	7.633E-03	2.226E-08
U236	BONE	2	1.219E-01	3.618E-07
U236	THYROID	2	0.	0.
U236	LIVER	2	0.	0.
U236	KIDNEYS	2	2.953E-02	8.767E-08
U236	LUNGS	2	0.	9.338E-07
U236	GI-LLI	2	8.914E-03	6.444E-10

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

TOTAL DOSE(REM)

ORGAN	ZONE	TOT ING	TOT INH
TOTAL BODY	1	1.865E-02	2.335E-07
BONE	1	3.139E-01	9.101E-05
THYROID	1	0.	0.
LIVER	1	3.553E-03	1.209E-06
KIDNEYS	1	7.245E-02	9.917E-07
LUNGS	1	0.	1.185E-05
GI-LLI	1	2.423E-02	6.692E-10
TOTAL BODY	2	8.165E-03	2.048E-07
BONE	2	1.438E-01	7.873E-05
THYROID	2	0.	0.
LIVER	2	2.980E-03	1.035E-06
KIDNEYS	2	3.180E-02	8.684E-07
LUNGS	2	0.	1.216E-05
GI-LLI	2	1.157E-02	7.124E-10

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

RISK

CANCER	ZONE	RISK ING	RISK INH	RISK EXT
LUNG	1	0.	2.961E-11	1.080E-12
LEUKEMIA	1	8.948E-06	2.594E-10	1.232E-12
STOMACH	1	2.785E-07	7.696E-15	4.970E-13
PANCREAS	1	9.327E-08	2.577E-15	1.664E-13
REST OF GI	1	9.327E-08	2.577E-15	1.664E-13
BREAST	1	5.375E-07	6.725E-12	1.245E-12
BONE	1	3.061E-06	8.873E-11	4.213E-13
OTHER	1	6.719E-07	8.406E-12	1.556E-12
LUNG	2	0.	3.041E-11	1.068E-12
LEUKEMIA	2	4.097E-06	2.244E-10	1.218E-12
STOMACH	2	1.331E-07	8.193E-15	4.915E-13
PANCREAS	2	4.455E-08	2.743E-15	1.645E-13
REST OF GI	2	4.455E-08	2.743E-15	1.645E-13
BREAST	2	2.352E-07	5.899E-12	1.231E-12
BONE	2	1.402E-06	7.675E-11	4.167E-13
OTHER	2	2.939E-07	7.373E-12	1.539E-12

SAMPLE PROBLEM 3

VECTOR NUMBER 1 TIME 1.000E+02 YRS

TOTAL RISK

ZONE	RISK ING	RISK INH	RISK EXT	TOT RISK
1	1.368E-05	3.929E-10	6.363E-12	1.368E-05
2	6.250E-06	3.448E-10	6.293E-12	6.251E-06

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16. ABSTRACT (200 words or less)
This report contains a series of sample problems and solutions for the Dosimetry and Health Effects (DHEJL81) model developed at Sandia National Laboratories for the Risk Methodology for Geologic Disposal of Radioactive Waste Project. With this document and the DHEJL81 User's Manual (NUREG/CR-2346), the user may familiarize himself with the computer program, its capabilities and limitations. When the user has completed this curriculum, he or she should be able to prepare data input for DHEJL81 and have some insights into interpretation of model output. This report is one of a series of self-teaching curricula prepared under a technology transfer contract for the U. S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards.

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