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Relevance of Biotic Pathways to the Long-Term Regulation of Nuclear Waste Disposal

Estimation of Radiation Dose to Man
Resulting from Biotic Transport:
The BIOPORT/MAXI1 Software Package

Prepared by D. H. McKenzie, L. L. Cadwell, K. A. Gano, W. E. Kennedy, Jr.,
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Pacific Northwest Laboratory
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ABSTRACT

BIOPORT/MAXI1 is a collection of computerized models designed to estimate the potential magnitude of the radiation dose to man resulting from biotic transport processes. Dose to man is calculated for ingestion of agricultural crops grown in contaminated soil, inhalation of resuspended radionuclides, and direct exposure to penetrating radiation resulting from the radionuclide concentrations established in the available soil surface by the biotic transport model.

The BIOPORT/MAXI1 software package contains five computer codes. CREATE is the interactive computer program that allows the end-user to simply and efficiently create and evaluate biotic transport scenarios. BIOPORT simulates the redistribution of radionuclides by plant and animal processes following intrusion into buried waste. At specified years during the biotic transport simulation, concentrations of radionuclides in the soil plow-layer are determined. MAXI1 is executed with these radionuclide concentrations and a standard maximally-exposed individual scenario to calculate the maximum annual dose to the exposed individual from the various pathways. The maximum annual dose is the largest of the annual organ doses calculated to occur during a 50-year period of continuing exposure. Two additional programs, MAXI2 and MAXI3 are used to calculate annual dose factors and they are included in the software package and are documented here to allow the experienced user complete access to MAXI capabilities. MAXI2 and MAXI3 generate intermediate dose conversion factors for food and aquatic pathways. These dose conversion factors are stored in data files and accessed by the MAXI1 computer program.

The documentation of the BIOPORT/MAXI1 computer software package has been written for two major audiences. The first audience includes persons concerned with the mathematical models of biological transport of commercial low-level radioactive wastes and the computer algorithms used to implement those models. The second audience includes persons concerned with exercising the computer program and exposure scenarios to obtain results for specific applications. This document is designed to function both as an instructional and a reference document. The report contains sections describing the mathematical models, user operation of the computer programs, and program structure. Input and output for five sample problems are included in the report. In addition, appendices are provided that present listings of the computer programs, data libraries, and dose conversion factors.

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ESTIMATION OF RADIATION DOSE TO MAN RESULTING FROM BIOTIC TRANSPORT: THE BIOPORT/MAXI1 SOFTWARE PACKAGE

1. INTRODUCTION

This collection of computerized models is designed to estimate the potential magnitude of the radiation dose to man resulting from biotic transport processes. In addition to biotic transport, models are included for erosion of soil from the burial site cover and waste package decomposition. Dose to man is calculated for ingestion of agricultural crops grown in contaminated soil, inhalation of resuspended radionuclides, and direct exposure to penetrating radiation resulting from the radionuclide concentrations established in the available soil surface by the biotic transport model.

Biotic transport is defined as the actions of plants and animals that redistribute radionuclides from a commercial low-level radioactive waste burial ground to a location where these radionuclides can enter into human exposure pathways. Three biotic transport mechanisms are possible at a waste disposal site. They are 1) transport enhancement, 2) intrusion and active physical transport, and 3) secondary transport (McKenzie et al. 1982a). In transport enhancement, plants and animals modify the wastes or waste site such that there is an increased potential for radionuclide transport. Burrowing animals and invertebrates, for example, may construct tunnels that enhance the exchange of gases and the infiltration of surface water. Intrusion and active transport may occur when biota penetrate the waste zone and cause a horizontal or vertical redistribution of waste material. In secondary transport, radionuclides are available to biota for a horizontal displacement after they have been mobilized by other processes. Only the mechanism of intrusion and active transport by biota is considered in this biotic transport model. This focus results from initial qualitative assessments which indicated that intrusion and active transport is potentially the most important biotic transport mechanism (McKenzie et al. 1982a; 1982b; 1983; 1984). It also results from the fact that there is little documented information available for quantifying either transport enhancement or secondary transport mechanisms.

The BIOPORT/MAXI1 software package contains five computer codes. CREATE is the interactive computer program that allows the end-user to simply and efficiently create and evaluate biotic transport scenarios. CREATE generates input for the BIOPORT (McKenzie et al. 1982b) and MAXI1 (Napier, Peloquin, and Kennedy 1984) computer programs. BIOPORT simulates the redistribution of radionuclides by the plant and animal processes following intrusion into buried waste. At specified years during the biotic transport simulation, concentrations of radionuclides in the soil plow-layer are determined. Upon completion of the BIOPORT simulation, MAXI1 is executed with these radionuclide concentrations and a standard maximally-exposed individual scenario to calculate the maximum annual dose to the exposed individual from ingestion, inhalation, and direct exposure pathways. The maximum annual dose is the largest of the annual organ doses calculated to

occur during a 50-year period of continuing exposure. Each annual dose is determined by accounting for the organ doses from all exposure pathways during the year of interest plus the organ dose received during the year of interest from radionuclides deposited (by ingestion or inhalation) during previous years of intake. Two additional programs, MAXI2 and MAXI3 (Napier, Peloquin, and Kennedy 1984), are used to calculate annual dose factors and they are included in the software package and are documented here to allow the experienced user complete access to MAXI capabilities. MAXI2 generates intermediate dose conversion factors for food pathways. MAXI3 calculates intermediate dose conversion factors for aquatic pathways. The dose conversion factors produced by MAXI2 and MAXI3 are stored in data files and accessed by the MAXI1 computer program.

A database of dose conversion factors and radiological decay information is included with the computer software. External dose conversion factors, soil and leaf mechanism dose conversion factors and inhalation dose conversion factors are used by the MAXI1 computer program. Although ingestion of contaminated aquatic foods and drinking water is not currently considered in the biotic transport scenarios, dose conversion factors for these pathways are included for completeness. The dose conversion factors for drinking water and aquatic food are calculated using the MAXI3 computer program and the dose conversion factors for leaf and soil mechanism are generated by the MAXI2 computer program. Inhalation dose conversion factors are calculated using the DACRIN (Houston, Streng, and Watson 1974) computer program. External dose conversion factors for various waste disposal geometries are calculated using the ISOSHL (Engel, Greenberg and Hendrickson 1966) shielding program.

This report documents the complete BIOPORT/MAXI1 computer software package. The documentation of the BIOPORT/MAXI1 computer software package has been written for two major audiences. The first audience (Audience A) includes persons concerned with the mathematical models of biological transport of commercial low-level radioactive wastes and the computer algorithms used to implement those models. The second audience (Audience B) includes persons concerned with exercising the computer program and exposure scenarios to obtain results for specific applications. This document is designed to function both as an instructional and a reference document.

Section 2 contains information useful to Audience A concerning the mathematical models and computer algorithms used in the BIOPORT/MAXI1 computer programs. Section 3 contains information useful to Audience B concerning the procedures for executing BIOPORT/MAXI1 computer programs, including a discussion of sample problems. Section 4 contains additional details on the structure and organization of the computer programs and is provided for individuals who may be interested in such details and those who wish to modify the computer programs. In addition, appendices are provided that present listings of the computer programs, data libraries, and dose conversion factors. Page-edge tabs have been provided as reference points for Audiences A and B.

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- Napier, B. A., R. A. Peloquin, and W. E. Kennedy, Jr. 1984. Intruder Dose Pathway Analysis for the Onsite Disposal of Radioactive Wastes: The ONSITE/MAXII Computer Program. NUREG/CR-3620, PNL-4054. U. S. Nuclear Regulatory Commission, Washington, D.C.

2. MATHEMATICAL MODELS AND COMPUTER SOFTWARE FOR ASSESSING BIOLOGICAL TRANSPORT IMPACTS

This section contains descriptions of the methodology used to estimate the radiation doses resulting from biological transport, the setting or "environment" that is used to define the default conditions in establishing the MAXII data base, the biotic transport and radiation-exposure scenario considered, and the mathematical models, the computer programs, and the data bases supporting the BIOPORT/MAXII software package. The information in this section is designed to be useful to Audience A, persons concerned with the mathematical models and computer algorithms that are implemented in the BIOPORT/MAXII computer software package. These models and algorithms are used to quantify biological transport of radionuclides at commercial low-level radioactive waste sites.

2.1. Methodology Applied to Solution of the Problem

In the Draft and Final Environmental Impact Statement (DEIS) in support of 10 CFR Part 61 (U.S. NRC 1981; U.S. NRC 1982), the U. S. Nuclear Regulatory Commission (NRC) modeled the potential exposure pathways to man from buried commercial radioactive wastes. In their analysis, the NRC identified four scenarios to describe patterns of human intrusions after the loss of institutional controls (U.S. NRC 1981, App. H, p. H-15):

- Intruder-Construction Scenario. An individual excavates at an abandoned disposal site to build a house.
- Intruder-Discovery Scenario. This scenario is a subset of the intruder-construction scenario and also involves excavation into a closed site. The time over which the excavation proceeds is reduced compared to the intruder-construction scenario.
- Intruder-Agriculture Scenario. An individual lives in a house built on a closed disposal site surrounded by contaminated soil resulting from the intruder-construction scenario. The individual consumes vegetables grown in the contaminated soil.
- Intruder-Well Scenario. An individual uses contaminated water from an onsite well.

The disposal limits that result are based on an annual 500-mrem total-body dose to the maximally exposed individual who intrudes after 100 years of site control. Of the four human-intrusion scenarios defined, only the intruder-construction and intruder-agriculture scenarios control the determination of disposal limits.

For the estimation of doses associated with biological transport of radioactive material from a commercial low-level waste disposal site, an approach similar to that applied in the DEIS in support of 10 CFR Part 61 is used (McKenzie et al 1982a; 1982b; 1983). That is, a radiation-exposure scenario

is established for the maximally exposed individual and a means of determining the resulting radiation dose is provided.

Subsequent to some specified period of radionuclide redistribution by plants and animals, a maximally exposed individual is assumed to intrude and take up residence at a commercial low-level waste site. For purposes of this simulation, biotic transport activities cease at this time and a scenario defining the individual's life-style is initiated. Radionuclides that were transported to the soil surface and the top-most soil strata by biotic transport processes prior to intruder access are assumed to be available to the maximally exposed individual through the exposure scenario/pathway analysis. It is assumed that radionuclides within the plow-layer are readily available in an agricultural scenario. The user may adjust the volume of this available soil surface by varying the depth of the soil strata in a given scenario. This scenario is modeled after the intruder-agriculture scenario defined by the NRC (U. S. NRC 1981). Doses may be calculated for the total body, bone, lungs, thyroid, and the lower large intestine (GI-LLI) of the maximally exposed individual.

The remainder of this section contains descriptions of the reference "environment" used to establish the dose conversion factor data base for the MAXI1 computer program, the maximally exposed individual scenario used in the computer software, and the mathematical models used in the BIOPORT and MAXI1 computer programs.

2.1.1. Reference "Environment" Description

The definition of an "environment" is used to establish the dose conversion factors for estimating the dose to the maximally exposed individual and to simplify use of the MAXI1 computer program. This "environment" defines the general agricultural and life-style practices of the intruder/resident and the listing of radionuclides for which dose conversion factors are available. Dose conversion factors were generated for this "environment" by the MAXI2 and MAXI3 computer programs and are retained in data files. Radiation exposure scenarios can then be constructed within the context of this "environment" using the MAXI1 computer code. Scenario modification factors can be applied to adjust the exposure conditions of the various pathways. In this software package, the reference "environment" and a radiation exposure-scenario have been defined for the maximally exposed intruder/resident. Thus, the user is able to execute the software without extensive understanding of the methodology of the MAXI computer codes. However, the capabilities of manipulating both the scenario and the "environment" have been retained in this software package.

The reference "environment" is based on a site with an area of 1 ha. The individual may be exposed to radioactive contamination via any of the following pathways: external exposure, inhalation of resuspended radionuclides in the surface soil, and ingestion of farm products grown on a contaminated site. The individual's entire diet for the reference "environment" consists of vegetables, fruits, and animal products grown on the site. Table 2.1-1 contains a listing of the maximally exposed individual's terrestrial food

product diet. This diet is based on information obtained from Regulatory Guide 1.109 (U. S. NRC 1977) and has been prorated by food category using the fraction for that category of the total diet consumed by an average individual in the U.S. The resulting diet is smaller than the default diet previously used in the development of this methodology (McKenzie et al. 1982b; 1983). The new diet is felt to more accurately estimate the potential exposure conditions that may occur. Dose conversion factors for the exposure pathways listed above have been calculated for the master list of radionuclides shown in Table 2.1-2. This list contains 100 radionuclides that may be important in low-level waste disposal operations.

2.1.2. Radiation Exposure Scenario Descriptions

A radiation exposure scenario for biotic transport simulation has been defined to consider a subset of the available exposure pathways. The scenario also refines the exposure conditions for selected pathways and is used to simplify the operation of the MAXI computer program. The maximally exposed intruder/resident is exposed by inhalation of resuspended radionuclides, by ingestion of garden and farm crops grown in the soil, and by

Table 2.1-1. Parameters Used for Calculation of Radiation Dose Factors from Consumption of Foods

<u>Food</u>	<u>Growing Period (days)</u>	<u>Yield (kg/m²)</u>	<u>Holdup (days)^(a)</u>	<u>Consumption (kg/year)^(b)</u>
Leafy vegetables	90	1.5	1	9.5
Other above-ground vegetables	60	0.70	1	9.5
Root vegetables	90	9.0	1	76
Fruit	90	1.7	10	42
Wheat and grain	90	0.72	10	51
Eggs	90	0.84 ^(c)	2	19
Milk	30	1.3 ^(c)	2	110 ^(d)
Beef	90	0.84 ^(c)	15	39
Pork	90	0.84 ^(c)	15	29
Poultry	90	0.84 ^(c)	2	8.5

(a) Time between harvest and consumption.

(b) These rates are obtained from Regulatory Guide 1.109 (U.S. NRC 1977) and prorated by food category using the fraction of total consumed by an average individual as calculated from Napier (1981, Table 8).

(c) Yield of animal feeds (i.e., grain or pasture grass).

(d) Units of liters/year.

Table 2.1-2. Master Radionuclide List for BIOPORT/MAXII

<u>Radionuclide</u>	<u>Radionuclide</u>	<u>Radionuclide</u>
^3H	$^{144}\text{Ce}+\text{D}$	$^{137\text{m}}\text{Ba}$
^{14}C	^{152}Eu	^{141}Ce
^{22}Na	^{154}Eu	^{151}Sm
^{32}P	^{160}Tb	^{235}U
^{33}P	^{185}Os	^{231}Th
^{35}S	^{191}Os	^{231}Pa
^{36}Cl	^{192}Ir	^{227}Ac
^{40}K	^{203}Hg	^{227}Th
^{45}Ca	$^{210}\text{Pb}+\text{D}$	^{223}Fr
^{46}Sc	$^{226}\text{Ra}+\text{D}$	^{223}Ra
^{51}Cr	$^{228}\text{Th}+\text{D}$	^{237}Np
^{54}Mn	$^{230}\text{Th}+\text{D}$	^{233}Pa
^{55}Fe	$^{232}\text{Th}+\text{D}$	^{233}U
^{59}Fe	$^{233}\text{U}+\text{D}$	^{229}Th
^{57}Co	^{234}U	^{225}Ra
^{60}Co	$^{235}\text{U}+\text{D}$	^{225}Ac
^{59}Ni	$^{238}\text{U}+\text{D}$	^{238}U
^{63}Ni	$^{237}\text{Np}+\text{D}$	^{234}Th
^{65}Zn	$^{241}\text{Pu}+\text{D}$	$^{234\text{m}}\text{Pa}$
^{75}Se	^{89}Sr	^{234}Pa
^{85}Sr	$^{89\text{m}}\text{Y}$	^{242}Pu
$^{90}\text{Sr}+\text{D}^{(a)}$	^{90}Sr	^{238}Np
^{93}Mo	^{90}Y	^{238}Pu
^{94}Nb	^{99}Mo	^{244}Cm
$^{106}\text{Ru}+\text{D}$	$^{99\text{m}}\text{Tc}$	^{244}Pu
^{109}Cd	^{99}Tc	^{240}U
$^{110\text{m}}\text{Ag}+\text{D}$	^{103}Ru	^{240}Pu
^{111}In	$^{103\text{m}}\text{Rh}$	^{243}Cm
^{124}Sb	^{103}Pd	^{243}Pu
$^{125}\text{Sb}+\text{D}$	^{129}I	^{243}Am
$^{125}\text{I}+\text{D}$	^{134}Cs	^{239}Np
$^{131}\text{I}+\text{D}$	^{135}Cs	^{239}Pu
$^{137}\text{Cs}+\text{D}$	^{137}Cs	^{241}Pu
		^{241}Am

Where +D means plus short-lived daughters in equilibrium.

direct exposure to penetrating radiation. The entire intruder/resident's diet, including eggs and meat products, is assumed to be grown on contaminated soil. The intruder/resident is assumed to inhale contaminated air having a loading of particulates for eight hours per day, five days per week or 2000 hours per year. The dust is derived from resuspended surface soil and contains radiocontaminants having the same concentration as occur in the soil. The intruder/resident is assumed to be exposed for 2000 hours per year to penetrating radiation from the contaminated soil.

2.1.3. Mathematical Models - BIOPORT

The mathematical models that simulate biological transport by plants and animals, soil erosion and waste package decomposition are presented in this section. A time-step of one year is used throughout the simulation. Any length of simulation can be considered though the implementing software defines a maximum of 9999 years. Radionuclides are tracked individually throughout the system. A conceptualization of these models, collectively referred to as BIOPORT, is shown in Figure 2.1-1. The soil column (s) is indexed from zero (surface) to four (available inventory) layers ordered by increasing depth from the surface. The surface layer is modeled as a two-dimensional plane. The first, second, and third soil compartments identify three overburden strata above the waste. The fourth compartment represents the waste zone and contains the radionuclides that are available for relocation by biota due to the decomposition of the waste forms waste packages. The thickness of soil compartments s_1 , s_2 , and s_3 may be defined by the user. The waste zone, s_4 , is assumed to have a volume equal to the volume of the contained waste. The plant model assumes one compartment of above-ground biomass and up to four compartments of root biomass corresponding to s_0 , through s_4 , in the soil column. Radioactivity removed by soil erosion is assumed lost to the system as is radioactivity decayed from all compartments. Radioactive materials transferred to each compartment are assumed to be instantaneously and uniformly mixed.

Several routes of radionuclide transfer are considered in BIOPORT. Listed in the chronological order of calculation during the yearly time-step, they are: 1) waste form/package decomposition, 2) redistribution of radioactivity in soil by animal burrowing activity, 3) uptake and translocation of contaminants by natural invading (or established) vegetation, 4) recycling of contaminants in plant biomass to the soil column, 5) radionuclide transport due to collapse of burrows, and 6) system loss of radioactive material by soil erosion. Each of these transfer routes will be discussed in detail.

2.1.3.1. Waste Form/Package Decomposition

To account for the integrity of different waste containers and waste forms in the waste zone, a waste availability relationship is assumed. In this relationship, the quantity of waste available for movement, Q_i , is defined by the following expression (McKenzie et al. 1982b; 1983):

$$Q_i = Q_{0i} (1 - e^{-\lambda_A t}) \quad (2.1)$$

where:

- Q_i = the quantity of radionuclide i available for movement from decomposed containers or waste forms, Ci/ha yr
- Q_{oi} = the quantity of radionuclide i in the contained waste inventory, Ci/ha yr
- λ_A = the container decomposition constant defined for the waste spectra, yr^{-1}
- t = time period considered, yr.

Figure 2.1-1. Conceptual Transport Model that Describes the Movement of Radionuclides by Biological Organisms from Low-level Waste Burial Grounds

Container decomposition is assumed to be a logarithmic function of time where:

$$\lambda_A = \ln 2 / t_{A\ 1/2} \quad (2.2)$$

where λ_A is defined for Equation 2.1 and where:

$t_{A\ 1/2}$ = the half-time for container decomposition, yr.

Q_i is subtracted from the contained waste inventory and added to the available waste zone, s_4 . At the beginning of a scenario, a calculation is made with t equal to the age of the waste form or waste package at site closure to calculate the quantity of radionuclides available to biota due to package decomposition prior to site closure.

2.1.3.2. Redistribution of Radioactivity in Soil by Animal Burrowing Activity

The burrowing activity of animals results in excavation of soil, all of which is assumed to be deposited on the surface of the low-level waste disposal site. Each below-ground soil strata, s_n , where s_n ranges from 1 to 4, is adjusted according to the following expression:

$$Q_{a\ i\ s_n}' = Q_{a\ i\ s_n} - \sum_{j=1}^a C_{i\ s_n} M_{j\ s_n} I_j \quad (2.3)$$

where:

$Q_{a\ i\ s_n}'$ = the adjusted quantity of radionuclide i in soil strata s_n , Ci/ha yr

$Q_{a\ i\ s_n}$ = the previous quantity of radionuclide i in soil strata s_n , Ci/ha yr

a = the total number of animal species

$C_{i\ s_n}$ = concentration of radionuclide i in stratum s_n of the soil column, Ci/m³

$M_{j\ s_n}$ = mass of soil moved from soil stratum s_n to the surface by animal j , m³/ha yr

I_j = activity index of animal j or fraction of the first year's burrowing activity in successive years, unitless.

Radioactivity deposited on the soil surface, s_0 , as a result of animal burrowing activity is a total of the amount of radioactivity moved from each below-ground strata of the soil column, s , or:

$$Qa_{is_0} = \sum_{n=1}^4 \sum_{j=1}^a C_{is_n} M_{js_n} I_j \quad (2.4)$$

where:

Qa_{is_0} = the quantity of radionuclide i deposited on the soil surface as a result of animal burrowing activity, Ci/ha yr, the remaining terms are defined in Equation 2.3.

2.1.3.3. Uptake and Translocation of Contaminants by Natural Vegetation

Plants are assumed to take up radionuclides through the root system and then redistribute the radionuclides uniformly by translocation. Uptake of radionuclides by plants is from the soil strata with the highest radionuclide concentration encountered by the roots, referred to here as s_x . The highest concentration of radionuclides will usually be found in the available inventory waste zone, s_4 . Figure 2.1-1 shows all plant uptake of radionuclide as transfer from s_4 . However, if a greater concentration occurs in the soil column, transfer will be from the soil stratum with the highest concentration. Uptake of radionuclides by plants may be based on either any contact of the roots with the contaminant (Model 1) or proportioned by the fraction of the total root biomass in contact with s_x (Model 2).

Radioactivity taken up by plants is defined by the following expression:

$$Qp_i = \sum_{l=1}^p C_{is_x} R_i f_{ls_x} B_{lk}' K \quad (2.5)$$

where:

p = the total number of plant associations

Qp_i = quantity of radionuclide i taken up by plants, Ci/ha yr

C_{is_x} = concentration of radionuclide i in s_x , where s_x is the soil strata with the highest concentration of radionuclide i , Ci/m³

R_i = concentration ratio of radionuclide i in units of pCi per gram plant (wet)/pCi per g soil (dry)

f_{ls_x} = fraction of roots of plant l in s_x , unitless, (for plant uptake Model 1, $f_l = 1.0$)

B_{lk}' = total biomass production of plant l for a successional phase k , g/ha yr

K = constant, density of soil⁻¹ = 1 m³/1.7 × 10⁶ g.

In BIOPORT, flora is modeled as a series of successional phases. Changes in biomass within a successional phase may be modeled as either a step function or a linear function. If a linear function is selected, plant biomass is adjusted according to the following equation.

$$B_{lk}' = B_{lk} + d_{lk} Y \quad (2.6)$$

where:

B_{lk}' = production of plant biomass l in successional phase k , g/ha yr

B_{lk} = production of plant biomass l at the start of successional phase k , g/ha yr

d_{lk} = regression coefficient for plant l and successional phase k , gm/yr

Y = year of simulation, yr.

2.1.3.4. Recycling of Contaminants in Plant Biomass to the Soil Column

Radioactive materials taken up by the plants are assumed to be redistributed uniformly throughout the entire plant biomass. At the end of each yearly time-step, a portion, or all of the annual biomass production is assumed to be recycled. When plant material is recycled, the contaminant burden is assumed to be returned to the soil. Radionuclides returned to the soil column through recycling are redistributed in proportion to the plant biomass in each stratum of the soil column. All above-ground contributions from plant recycling are added to the soil surface. Radionuclides are transferred by recycling from the plant to the soil at each strata s_n , where n ranges from 0 to 4, according to the following expression:

$$Qr_{is_n} = \sum_{l=1}^p C_{il} b_{ls_n k} r_{lk}' \quad (2.7)$$

where:

Qr_{is_n} = quantity of radionuclide i returned to soil strata s_n as a result of the recycling of plant biomass, Ci/ha yr

p = total number of plant associations

C_{il} = concentration of radionuclide i in plant l , Ci/g

$b_{ls_n k}$ = biomass of plant l in soil strata s_n for a successional phase k , g/ha yr, ($n=0$ is above ground biomass, $n>0$ is root biomass)

r_{lk}' = fraction of biomass recycled yearly for plant l successional phase k , unitless.

Within each successional phase, the recycled fraction of the plant may be adjusted according to the following expression.

$$r_{lk}' = r_{lk} + g_{lk} Y \quad (2.8)$$

where:

r_{lk}' = recycle fraction for plant l in successional phase k, unitless

r_{lk} = recycle fraction for plant l at the start of successional phase k, unitless

g_{lk} = regression coefficient relating recycle fraction to time for plant l and successional phase k, yr^{-1}

Y = year of simulation, yr.

2.1.3.5. Radionuclide Transport Due to Collapse of Burrows

Voids in the soil strata created by animal burrowing activity are removed at the end of each year to simulate cave-in of burrows. Radioactivity in each soil stratum is adjusted as the voids are removed according to the following expression:

$$Q_{is_n} = C_{is_{n-1}} V_{s_{n-1}} \quad (2.9)$$

where:

Q_{is_n} = quantity of radionuclide i moved from soil stratum s_{n-1} to soil stratum s_n , Ci/ha yr

$C_{is_{n-1}}$ = concentration of radionuclide i in soil strata s_{n-1} , Ci/m³

$V_{s_{n-1}}$ = volume of soil moved from soil strata s_{n-1} to soil strata s_n to fill voids, m³/ha yr.

The above expression effectively mixes all radioactivity that has accumulated on the soil surface during the course of the yearly time-step into the uppermost soil stratum. This is assumed to be a reasonable approximation of biotic processes.

2.1.3.6. System Loss of Radioactive Material by Soil Erosion

A model is included in BIOPORT to simulate erosion of soil with its consequent loss of transported radioactive materials from the surface soil. Radioactivity removed from the system each year due to erosion is calculated by:

$$Q_{e_i} = E w C_{is_1} \quad (2.10)$$

where:

Q_{e_i} = quantity of radionuclide i removed from the system due to erosion of the top soil layer, Ci/ha yr

E = erosion rate, cm/yr

w = conversion factor from cm/yr and m^3 /ha yr, = 100

C_{is_1} = concentration of radionuclide i in soil strata 1, Ci/ m^3 .

The radioactivity remaining in the uppermost soil stratum is expressed by:

$$Q_{is_1}' = Q_{is_1} - Q_{e_i} \quad (2.11)$$

where Q_{e_i} is defined for Equation 2.10 and where:

Q_{is_1}' = quantity of radionuclide i in the top soil layer after erosion, Ci/ha yr

Q_{is_1} = quantity of radionuclide i in the top soil layer prior to erosion, Ci/ha yr.

The above equations represent the transfer of radionuclides between the various compartments of BIOPORT as depicted in Figure 2.1-1. In addition to the transfer routes shown in the figure, radioactive decay is applied to the soil and waste compartments during each time-step.

2.1.4. Mathematical Models - MAXII

The following mathematical equations are arranged to aid understanding of the MAXII model as a whole. Consequently equations contain both environment-defined and scenario-defined parameters as distinguished in Section 2.1.1. The origin of the parameters will be discussed, when applicable, for each equation.

The fundamental relationship for calculating radiation doses to people from any radionuclide exposure pathway is given in Equation 2.12 (Soldat, Robinson, and Baker 1974) as follows:

$$R_{ipr} = C_{ip} U_p D_{ipr} \quad (2.12)$$

where:

R_{ipr} = the radiation dose equivalent or committed radiation dose equivalent from radionuclide i via exposure pathway p to organ r (rem)

C_{ip} = concentration of radionuclide i in the media of exposure pathway p ; for calculations involving airborne radionuclides, C_{ip} is replaced with the term x_i , which represents the average airborne concentration of radionuclide i (pCi/m³, pCi/L, or pCi/kg)

U_p = usage parameter (exposure rate or intake rate) associated with exposure pathway p (h/yr, L/yr, or kg/yr)

D_{ipr} = radiation dose equivalent factor or the committed dose equivalent factor for radionuclide i exposure pathway p and organ r to convert the concentration and usage parameters to the radiation dose equivalent or to the committed radiation dose equivalent (mrem/pCi).

An analysis of radiation doses from separate exposure pathways requires a determination of the radionuclide concentrations and exposure rate or intake rate associated with each exposure pathway. For external exposure, the surface concentration of radionuclides and the duration of exposure must be quantified. For ingestion of farm products grown on a contaminated site, the radionuclide concentration in separate food products must be determined by accounting for root transfer from soil, dry deposition from air on leaves, or animal consumption of contaminated forage or feed. The annual diet for the maximally exposed individual, and the holdup time between harvest and consumption must also be determined.

For inhalation, the airborne concentration of resuspended radionuclides can be determined directly from the ground concentration using a mass-loading factor, resuspension factor, or resuspension rate analysis (Anspaugh et al. 1975). Site-specific parameters can be used to determine the exposure pathways and the radionuclide mixture, pathway concentrations, and exposure or intake rates.

Parts of this relationship are calculated in three MAXI codes as follows:

C_{ip} - Concentrations are calculated in MAXI. Some terms in the equations were calculated in MAXI2 (for food pathways) and MAXI3 (aquatic pathways) and the results are located in the data base. These terms will be identified as each equation is discussed.

U_p - Default (assumed maximum) usage terms are applied in MAXI2 (food pathways) and MAXI3 (aquatic pathways) and the resulting factors are stored in the data files. A modification factor can be applied to this term in MAXI1 to reduce the exposure conditions.

D_{ipr} - This term is applied in MAXI2 for food pathways and MAXI3 for aquatic pathways in the generation of the data files accessed by MAXI1.

Calculation of the annual dose to an organ of reference by the MAXI1 computer program requires the dose equivalent from exposure during the year of interest plus the annual dose resulting from previous years of intake. The general expression for annual dose calculations is deduced by inspecting the annual dose equations for the first three years of continuous exposure. The annual dose for the first year to an organ of reference is simply the summation of the radiation dose equivalents from all internal and external exposure pathways. For the second year, the annual dose is calculated by the following expression (Kennedy et al. 1979):

$$A_2 = R_2^* + (R_{1,2} - R_{1,1}) \quad (2.13)$$

where:

- A_2 = the annual dose during the second year from all exposure pathways to the organ of reference, mrem
- R_2^* = the radiation dose equivalent in the second year to the organ of reference from all internal and external exposure pathways from intake and exposure in the second year, mrem
- $R_{1,2}$ = the committed dose equivalent to the organ of reference for the first two years from radionuclides internally deposited during intake from exposure pathways in the first year, mrem
- $R_{1,1}$ = the radiation dose equivalent to the organ of reference for the first year from radionuclides internally deposited during intake from exposure pathways in the first year (no external component to the dose equivalent), mrem.

The second-year annual dose to an organ of reference (A_2 in Equation 2.13) is the summation of the radiation dose equivalents from all exposure pathways during the second year and the dose equivalent delivered during the second year from the radionuclides internally deposited in that organ during the first year. The term in parentheses in Equation 2.13 is the expression for the dose equivalent to the organ of reference from radionuclides deposited in that organ during the first year. It is found by subtracting the first-year dose equivalent, resulting from internally deposited radionuclides, from the two-year committed dose equivalent. The mathematical expression for the annual dose to an organ of reference in the third year of continuous exposure is (Kennedy et al. 1979):

$$A_3 = R_3^* + (R_{1,3} - R_{1,2}) + (R_{2,2} - R_{2,1}) \quad (2.14)$$

where:

A_3 = the annual dose during the third year from all exposure pathways to the organ of reference, mrem

R_3^* = the radiation dose equivalent in the third year to the organ of reference from all internal and external exposure pathways from intake and exposure in the third year, mrem.

In Equation 2.14, the terms $R_{1,3}$, $R_{1,2}$ and $R_{2,1}$ are similar in form, each containing two subscripts. The first subscript defines the year of intake or exposure after the start of continuous exposure, and the second defines the number of years used in calculating the committed dose equivalent. The quantity in the first parentheses is the dose equivalent to the organ of reference in the third year from radionuclides deposited during the first year of continuous exposure (i.e., the difference between the three-year committed dose equivalent and the two-year committed dose equivalent). The quantity in the second parentheses is the dose equivalent in the third year to the organ of reference from radionuclides deposited during the second year of continuous exposure (i.e., the difference between the two-year committed dose equivalent and the first-year committed dose equivalent).

The general expression for calculating the annual dose to an organ of reference during any year after the start of continuous exposure is expressed as (Kennedy et al. 1979):

$$A_t = R_t^* + \sum_{i=1}^{t-1} R_{i,(t-i+1)} - R_{i,(t-i)} \quad (2.15)$$

where:

A_t = the annual dose during the year t from all exposure pathways to the organ of reference, mrem

R_t^* = the radiation dose equivalent in year t to the organ of reference from all internal and external exposure pathways from intake and exposure in the year t , mrem.

The summation term in Equation 2.15 represents the dose equivalent delivered to the organ of reference in year t from radionuclides deposited in the organ from intake in all previous years since the start of continuous exposure. This term is valid only for positive integer values of t . For t equal to 1, the summation term is zero.

The annual dose, A_t , to the organ of reference is calculated for each value of t from 1 to 50, and the maximum annual dose is determined by inspection. Experience with this method to date indicates 50 years to be a suitable maximum value of t ; however, higher maximum values are not precluded. The

radiation dose equivalent terms required by Equation 2.15 are determined from Equation 2.12 using existing radiation dose computer programs for pertinent radiation-exposure pathways. Details about the methods of calculating the radionuclide concentrations in various media, C_i , from Equation 2.12, are given in Sections 2.1.4.1 through 2.1.4.5.

No special algorithms or numerical techniques are employed by the BIOPORT/MAXI1 computer programs apart from those required to solve Equation 2.15. However, special formulations for some of the parameters in Equation 2.12 are available in the exposure scenario analysis. Other formulations are directly included in the calculation of the dose conversion factors used by MAXI1. The following sections contain discussions of optional and default equations that are incorporated into the BIOPORT/MAXI1 software package.

2.1.4.1. Dose From Ingestion of Food Products

The dose conversion factors for the ingestion of food products accessed by the MAXI1 computer program are obtained from data files that were generated by the MAXI2 computer program for the reference "environment." The dose from any food pathway is given by Equation 2.12. Radionuclides can be deposited on the leaves of plants directly from the air or from irrigation water, and can be taken up by the plant roots.

For direct deposition from the air, the following is used to describe the deposition of airborne particulate radionuclides directly onto food products and onto the ground:

$$d_i^a = 86,400 \bar{x}_i V_{di} \quad (2.16)$$

where:

d_i^a = deposition rate or flux of radionuclide i , pCi/(m²-day)

86,400 = dimensional conversion factor, seconds/day

$\bar{x}_i$ = average air concentration of radionuclide i is estimated using either the mass-loading or resuspension factor as pCi/m³

V_{di} = deposition velocity of radionuclide i , m/second, is assumed in MAXI1 to be 1×10^{-3} m/sec for all particles.

The MAXI1 computer program permits selection of two methods for calculating the average air concentration. These methods are mass-loading and resuspension analysis. The mass-loading method uses the product of the surface soil radionuclide concentration and the average mass-loading of dust or particulate material in the atmosphere. In the absence of data for a particular site, a value of 1×10^{-4} g/m³ has been suggested for predictive

purposes (EPA 1977; Anspaugh et al. 1975). This value is used in this report for the annual average mass-loading factor. Annual arithmetic averages around the United States vary from 9×10^{-6} to 7.9×10^{-5} g/m³ (Anspaugh et al. 1977).

For resuspension, the average airborne concentration is the product of a resuspension factor and the surface contamination level as shown in:

$$\bar{x} = S_f S_A \quad (2.17)$$

where:

$\bar{x}$ = average airborne concentration, pCi/m³

S_f = resuspension factor, m⁻¹

S_A = surface radioactivity, pCi/m².

The MAXII computer program permits the use of a time-dependent resuspension factor (S_f) as given by Anspaugh et al. (1975):

$$S_f = 10^{-4} e^{-\lambda \sqrt{t}} + 10^{-9} \quad (2.18)$$

where:

S_f = resuspension factor, m⁻¹

10^{-4} = resuspension factor at time $t = 0$, m⁻¹

λ = effective decay constant controlling the availability of material for resuspension, 0.15 day^{-1/2}

t = time after deposition, days

10^{-9} = resuspension factor after 17 years, m⁻¹.

The second term in Equation 2.18 (10^{-9}) is added based on the assumption that there is no further measurable decrease in the resuspension factor process after about 17 years, the longest period for which data are available.

For deposition on soil from irrigation, the deposition rate in pCi/m²-day; d_i , for radionuclide i , from irrigation water onto the ground, is defined as follows:

$$d_i^I = C_{iw} I \quad (2.19)$$

where:

d_i^I = deposition rate or flux of radionuclide i applied with irrigation water, (pCi/m²-day)

C_{iw} = concentration of radionuclide i in the water used for irrigation, pCi/L

I = irrigation rate; the amount of water sprinkled on a unit area of field in one day, L/(m²-day).

The concentration of radioactive material in vegetation resulting from direct deposition onto plant foliage and uptake of radionuclides previously deposited in the soil is determined by:

$$C_{iv} = \left[\frac{(d_i^a + d_i^I) r T_v (1 - \exp[-\lambda_{Ei} t_e])}{y_v \lambda_{Ei}} + \frac{(d_i^a + d_i^I) f_{tvi} B_{vi} (1 - \exp[-\lambda_i t_b])}{p \lambda_i} \right. \\ \left. + \frac{0.15 f_{tsi} C_{si} B_{vi}}{p} + \frac{f_{wi} C_{wi} B_{vi}}{p} \right] \exp[-\lambda_i t_h] \quad (2.20)$$

where:

C_{iv} = concentration of radionuclide i in the edible portion of the vegetation, pCi/kg

d_i^a = previously defined (see Equation 2.16), pCi/(m²-day)

r = factor of deposition retained on the vegetation (dimensionless), taken to be 0.25

T_v = factor for translocation of externally deposited radionuclides to the edible parts of the vegetation (dimensionless). For simplicity, this parameter is assumed to be independent of the radionuclide and is assigned values of 1 for leafy vegetables and fresh forage and 0.1 for all other produce, including grain

λ_i = radiological decay constant for radionuclide i , days⁻¹

λ_{Ei} = the effective removal constant for radionuclide i , days⁻¹;
 $\lambda_{Ei} = \lambda_i + \lambda_w$

λ_w = weathering removal constant for vegetation, days⁻¹; taken to be (0.693/14) days⁻¹

Y_v = vegetation yield, kg (wet weight)/m²

B_{vi} = concentration factor for uptake of radionuclide i from the soil in vegetation v , pCi/kg (wet weight) per pCi/kg soil (dry)

t_b = time for buildup of radionuclides in the soil, days; assumed to be 50 years for irrigation

t_e = time of exposure of above-ground vegetation to contamination during growing season, days

f_t = fraction of the roots in the plow layer of soil (dimensionless)

t_h = holdup time between harvest and food consumption; days

p = soil "surface density," kg (dry soil)/m²; a value of 224 kg/m² is used assuming the contaminated ground is plowed to a depth of 15 cm (Napier et al. 1980)

C_{si} = concentration of radionuclide i available for plant uptake from the waste contained in the plow layer (top 15 cm of soil), pCi/m³

0.15 = plow layer, m

f_w = fraction of the roots that penetrate the waste trenches (dimensionless)

C_{ti} = concentration of radionuclide i available for plant uptake from the subsurface waste zone, pCi/m³

ρ = bulk soil density of subsurface material, kg/m³.

The first term inside the brackets of Equation 2.20 relates to the concentration resulting from direct deposition of resuspended material and irrigation on foliage during the growing season. The second term relates to the plant uptake from the soil and reflects the deposition from irrigation. The third and fourth terms account for uptake of waste material contained in the top 0.15 m of soil and below this layer, respectively. Specific values used for the parameters in Equation 2.20 located in data libraries are found in Napier et al. (1980).

The following terms of Equation 2.20 are located in the MAXII computer code:

$$d_i^a + d_i^I \quad f_t \quad 0.15f_t \quad f_w C_{ti}$$

The leaf mechanism dose rate factors generated by the MAXI2 computer code are included in the data library and are accessed by MAXI1. The following terms of Equation 2.20 are included in those factors:

$$\frac{r T_v (1 - \exp [-\lambda_{Ei} t_e])}{y_v \lambda_{Ei}} \quad \frac{B_{vi} (1 - \exp [-\lambda_i t_b])}{p \lambda_i}$$

The soil mechanism dose rate factors generated by the MAXI2 computer code are included in the data library and are accessed by MAXI1. The following terms of Equation 2.18 are included in those factors:

$$\frac{C_{si} B_{vi}}{p} \quad \left(\frac{B_{vi}}{p} \right) \exp (-\lambda_i t_h)$$

The radionuclide concentration in animal products such as meat, milk, and eggs is dependent on the amount of contaminated forage or feed eaten by the animal. This concentration is described by:

$$C_{ia} = S_{ia} [C_{if} Q_f + C_{iaw} Q_{aw}] \quad (2.21)$$

where:

C_{ia} = concentration of radionuclide i in the animal product, pCi/kg or pCi/L

S_{ia} = transfer coefficient of radionuclide i from daily intake of the animal to the edible portion of the animal product, pCi/L (milk) per pCi/day or pCi/kg (animal product) per pCi/day

C_{if} = concentration of radionuclide i in feed or forage, pCi/kg; calculated from Equation 2.21

Q_f = animal consumption rate of contaminated feed or forage, kg/day

C_{iaw} = concentration of radionuclide i in the water consumed by animals, pCi/L; assumed to be the same as the irrigation water, C_{iw} (see Equation 2.19)

Q_{aw} = consumption rate of the contaminated water by the animal,
L/day.

Specific values of the parameters used in Equation 2.21 are given in Napier et al. (1980).

The dose to an organ of the exposed individual resulting from the ingestion of food products raised in the soil at a waste disposal site (R_{Ir} in mrem) is found using a modified version of Equation 2.12. This general relationship is shown as:

$$R_{Ir} = U_p f_D \sum_{i=1}^n C_{ip} - A_C^I - D_{ipr} \quad (2.22)$$

where:

f_D = the fraction of the total diet grown on the site

A_C^I = the area correction factor for internal exposure pathways,
and where U_p , C_{ip} , and D_{ipr} are for ingestion and are generally defined in Equation 2.12.

The data libraries for the BIOPORT/MAXII computer program are based on a minimum site area of one ha. To account for the limited exposure potential from smaller disposal areas, site area correction factors are required. For example, the amount of agricultural products raised on a site depends upon the intensity of the farming and the types of crops raised. A small site may produce a large fraction of the seasonal fruit and vegetable diet with intensive farming, but may be unable to provide enough forage and grain to support a milk cow or other animals. Thus, while a large fraction of the seasonal fruit and vegetable diet may be raised on a small site, the total quantity raised may only equal a small fraction of the total annual diet.

In determining area correction factors for the MAXII computer program, consideration is first given to the default pathway conditions and then to variable exposure conditions as a function of site area. For the default conditions, the individual's entire diet, as defined in Regulatory Guide 1.109 (U.S. NRC 1977), is assumed to be raised on the one ha site. This diet consists of fruits, vegetables and meat and animal products. The air concentrations used for the inhalation calculations are for resuspension resulting from large areas of distributed surface contamination.

Because of the large variability that may exist in the exposure conditions at any given site, we have defined default site area correction factors that modify the default exposure pathway assumptions provided in the scenario analysis.

For the ingestion and inhalation pathway, the correction factors are in the form of a step function as shown in Figure 2.1-2. This function assumes five steps of potential exposure versus site area ranging from small to large sites. The steps of total exposure are: 1) 10% for sites with areas less than 50 m²; 2) 25% for sites with areas between 50 and 200 m²; 3) 50% for sites with areas between 200 and 1,000 m²; 4) 75% for sites with areas between 1,000 and 10,000 m²; and 5) 100% for sites larger than 10,000 m² (or one ha).

A step function is used rather than a continuous curve because of the inherent uncertainty in predicting the future actions of individuals. The step function allows consideration of small areas without forcing extreme conservatism on larger areas. That is, it implies that the small areas may be intensely farmed for vegetables, whereas the larger areas may be less efficiently used (i.e., in raising cattle).

Figure 2.1-2. Area Correction Factors for the Ingestion and Inhalation Pathways

2.1.4.2. Dose From Ingestion of Drinking Water

Dose conversion factors for ingestion of drinking water used in MAXI1 are calculated using the MAXI3 computer program and the results are stored in the data files. The dose R_{wr} in mrem, from ingestion of water containing radionuclides, is calculated from:

$$R_{wr} = U_w \sum_{i=1}^n C_{idw} \exp(-\lambda_i t_h) D_{ir} f_{dw} \quad (2.23)$$

where:

U_w = annual consumption of contaminated drinking water, L

C_{idw} = the concentration of radionuclide i in the drinking water (input by user), pCi/L

λ_i = radiological decay constant for radionuclide i , days⁻¹

t_h = transit time required for radionuclide to reach the point of exposure, days

D_{ir} = radiation dose equivalent factor for ingestion, mrem/pCi

f_{dw} = drinking water cleanup factor (for municipal water supplies).

The drinking water dose rate factors calculated by the MAXI3 computer code are included in a data library and are addressed by MAXI1. The following terms in Equation 2.23 are included in those factors:

$$U_w \exp(-\lambda_i t_h) D_{ir} f_{dw}$$

2.1.4.3. Dose From Inhalation

Dose conversion factors for inhalation used in MAXI1 are calculated using the DACRIN (Houston, Streng, and Watson 1974) computer program and stored in the data files. The inhalation dose, R_{hr} in mrem, is calculated as:

$$R_{hr} = VTt_m \sum_{i=1}^n \left(\bar{x}_i \cdot A_C^I \right) \cdot D_{ir} \quad (2.24)$$

where:

V = ventilation rate of exposed individual, m^3/sec

T = duration of exposure to the airborne radionuclide concentration, seconds

t_m = modification factor applied to T to adjust time of exposure or breathing rate of 230 cc/sec (ICRP 1975)

D_{ir} = radiation dose equivalent factor for inhalation from the DACRIN (Houston, Streng, and Watson 1974) computer code, mrem/pCi

$\bar{x}_i$ = the annual average airborne concentration of radionuclide i , pCi/ m^3

A_C^I = the area correction factor for internal exposure pathways as discussed in Section 2.1.4.1 and shown in Figure 2.1-2.

The following terms of Equation 2.24 are found in the MAXI1 computer code:

$$\bar{x}_i \quad t_m \quad A_C^I$$

The inhalation dose rate factors calculated by the DACRIN (Houston, Streng, and Watson 1974) computer code are included in a data library and are addressed by MAXI1. The following terms in Equation 2.24 are included in those factors:

$$D_{ir} \quad VT$$

2.1.4.4. Dose From External Radiation

Annual doses resulting from exposure to surface and subsurface soil contamination or exposure in a reference room (or vault) are calculated using a modified version of Equation 2.12 in Section 2.1.4. The modified dose equation for external exposure, R_{er} in mrem, is shown as:

$$R_{er} = U_p \sum_{i=1}^n D_{ir} \cdot A_C^E \cdot C_{ip} \quad (2.25)$$

where:

A_C^E = the area correction factor for external exposure, and where U_p , D_{ir} , and C_p are for external exposure and are generally defined in Equation 2.12.

For external exposure, a sensitivity study was conducted for various beta-gamma emitters to determine the exposure rate versus source area. The results of the calculations are shown in Figure 2.1-3. Since the curves in Figure 2.1-3 are parallel, there appears to be a uniform correction for reduced site area over a large range of source energies. Thus, we have

Figure 2.1-3. Exposure Rate Versus Source Area

determined the ratio of the exposure rates (for small to large area sources) and plotted the results versus the fractional hectare of source area as shown in Figure 2.1-4. This figure defines the area correction factors for the external exposure pathway. We have approximated this curve in the MAXII computer program as the sum of four line segments, as shown in Figure 2.1-5.

The dose conversion factors for external exposure model several types of exposure conditions. These include surface soil contamination (using either plane- or slab-source models), subsurface soil contamination (using slab sources at depths of 0.5 and 1.0 m from the soil surface), and contaminated floor, walk, and ceilings in a waste-storage room or vault. These dose conversion factors are in tissue at a point 1 m above the ground surface. The direct exposure rates encountered by the intruder for various

Figure 2.1-4. Exposure Rate Ratio Versus Fractional Hectare of Source Area

contamination levels in a waste-storage room or vault are calculated using the model developed for decommissioning a reference room at a BWR (Oak et al. 1980). All of the external dose equivalent factors are calculated for the radionuclides of concern using the ISOSHLD (Engel et al. 1966; Simmons et al. 1967) computer program.

2.1.4.5. Dose From Ingestion of Aquatic Foods

As an option to the MAXI1 computer program, doses resulting from the ingestion of aquatic food products taken from a river contaminated by radionuclides may be considered. These dose factors are calculated using the MAXI3 computer program and stored in the data files. A description of calculation is included although the default radiation-exposure scenario defined for biotic transport simulations does not consider this pathway.

Figure 2.1-5. Area Correction Factors for External Exposure

Concentrations of radionuclides in aquatic foods are directly related to the concentrations of the radionuclides in water. Equilibrium ratios between the two concentrations, called bioaccumulation factors, are taken from Soldat, Robinson, and Baker (1974). The dose (R_{afr}) in mrem from consumption of aquatic food containing radionuclides is calculated from:

$$R_{afr} = U_{af} \sum_{i=1}^n C_{iw} \exp(-\lambda_i t_h) D_{ir} [B_{xi} + B_{yi} + B_{zi}] \quad (2.26)$$

where:

- U_{af} = annual consumption of contaminated aquatic foods, kg
- C_{iw} = the concentration of radionuclide i in the water, pCi/L
- B_{xi}, B_{yi}, B_{zi} = the bioaccumulation factor for radionuclide i , for:
 x = fish, y = invertebrates, and z = algae, pCi/kg per pCi/L
- D_{ir} = radiation dose equivalent factor for ingestion, mrem/pCi
- λ_i = radiological decay constant for radionuclide i , days⁻¹
- t_h = holdup time between harvest and food consumption, days.

The following term in Equation 2.26 is located in the MAXI1 computer code:

$$C_{iw}$$

Aquatic foods' dose rate factors calculated by the MAXI3 computer code are included in a data library for access by MAXI1. Included in those factors are the following terms of Equation 2.26:

$$U_{af} \exp(-\lambda_i t_h) D_{ir} [B_{xi} + B_{yi} + B_{zi}]$$

2.2. Computer Implementation

Estimates of the maximum annual radiation doses resulting from biotic transport of radionuclides can be made using "environment"-specific information described in Section 2.1.1, the radiation-exposure scenario presented in Section 2.1.2, and computer codes that implement the models discussed in Section 2.1.3 and 2.1.4. These computer codes, scenario and

"environment"-specific information comprise the BIOPORT/MAXI1 software package. The package is comprised of five computer codes and an extensive data base.

The package contains three primary computer programs, CREATE, BIOPORT and MAXI1. Two additional programs, MAXI2 and MAXI3 (Napier, Peloquin, and Kennedy 1984) are included to allow modification of the data base. Figure 2.2-1 depicts the general process flow of the BIOPORT/MAXI1 software. The user interacts with the CREATE program to establish input scenarios for the BIOPORT and MAXI1 programs. Execution of BIOPORT establishes a source term of radionuclide concentrations that is then used by MAXI1 to calculate radiation dose to the intruder/resident. In addition to the BIOPORT-generated source-term and the CREATE-generated intruder/resident scenario, MAXI1 utilizes several files from the data base included with the software package. RMDLIB is the master library containing radionuclide decay and decay-chain information. The files, devoted in Figure 2.2-1 as FILEn, contain dose rate factors for various exposure pathways applicable to the "environment" described in Section 2.1.1.

This data base will be discussed in detail in Section 2.3. This section contains descriptions of the BIOPORT/MAXI1 computer programs, an overview of software operation, and a discussion of capabilities, restrictions, and future enhancements of the software.

2.2.1. Computer Programs Descriptions

The BIOPORT/MAXI1 software package contains five computer codes, as shown in Figure 2.1-1. All computer codes are written in ANSI FORTRAN-77. CREATE is an interactive user interface that allows the user to simply and efficiently create and use both the biological transport and maximally exposed individual scenarios. BIOPORT is executed to simulate a given number of years of biological transport of radionuclides from a low-level waste burial site to the available soil surface. BIOPORT generates concentrations of each radionuclide in the available surface (plow-layer) at the end of biotic transport scenario. This source term is stored in a computer file which MAXI1 accesses. MAXI1 execution is controlled by an input file produced by CREATE that describes the maximally exposed intruder/resident scenario. MAXI1 calculates the maximum annual dose to an exposed individual from selected pathways. MAXI2 generates intermediate dose conversion factors for food pathways that are stored in the data files. MAXI3 calculates the data files containing intermediate dose conversion factors for aquatic pathways. The following sub-sections contain descriptions of each of the computer codes.

2.2.1.1 CREATE Computer Program Description

CREATE is an interactive computer program that allows the user to access or create scenarios of biotic transport of radionuclides and to couple the scenarios to estimations of the resulting dose to man. The software solicits scenario information from the user, controls parameter modifica-

tion, assigns the appropriate data libraries for executing BIOPORT and MAXII, and constructs the input files for BIOPORT and MAXII. CREATE was designed to make the creation and execution of a specific scenario as easy for the user as possible. If the default maximally exposed intruder/resident scenario and reference "environment" is used, CREATE is the only tion automatically produces results from BIOPORT and MAXII.

Figure 2.2-1. BIOPORT/MAXII Software Process Flow Chart

Two data sets have been defined in CREATE to simplify use of the BIOPORT computer program. One data set describes an arid site, typical of the western United States. The other describes a humid site, typical of the eastern United States. Each data set contains two default radionuclide inventories. These inventories describe past/current/as well as future waste storage practices.

The default data sets are based on work of McKenzie (et al. 1982b and 1983). The CREATE program gives the user the option of changing any parameters used in the biological transport scenarios. Each parameter is described in terms that should be meaningful to the end-user. The dimensional units and the upper and lower bounds of each parameter are displayed for most parameters. Each value entered by the end-user are tested against upper and lower limits when applicable. Default (or assumed maximum) values and conditions are activated by a null entry (e.g., pressing the <return> key on the terminal). The selected or user-input radionuclide inventory is displayed in table format and the user given an opportunity to modify entries and add radionuclides to the list. After the user modifies a group of parameters (e.g., plant, animal), the user may review that parameter group to verify input and/or make additional changes.

2.2.1.2. BIOPORT Computer Program Description

The computer program BIOPORT calculates package degradation and biological transport of radionuclides from a commercial low-level waste disposal site. Biological components are plant roots and animals. Plant roots absorb radionuclides and translocate them to other plant organs (i.e., roots, stems, and leaves) and subsequently recycle them back to the soil. Animals move soil and accompanying radionuclides from various soil strata to the surface. The computer program calculates concentrations of radionuclides available to the soil column based on waste form/package decomposition. Biological transport of radionuclides is calculated for each year of the specified time period and for each radionuclide in the waste inventory.

2.2.1.3. MAXI1 Computer Program Description

The computer program MAXI1 (Napier, Peloquin, and Kennedy 1984) is used to calculate the maximum annual dose to an exposed individual from a large number of exposure pathways. This program uses dose conversion factors from the DACRIN (Houston, Streng, and Watson 1974) computer program for estimating doses from inhalation of airborne radionuclides. The dose conversion factors from DACRIN are based on the International Commission on Radiological Protection's (ICRP) Task Group Lung Model (TGLM) (Health Phys. 1966). For ingestion pathways, for either food products or drinking water, dose conversion factors from the MAXI2 and MAXI3 computer programs are used by MAXI1. These dose conversion factors all rely on the dosimetry model of ICRP Committee II as reported in ICRP Publication 2 (1959). For external exposure, dose conversion factors from the ISOSHLD (Engel et al. 1966; Simmons et al. 1967) are used by MAXI1. These factors relate the radionuclide source strength to the dose rate in tissue 1 m above an infinite

plane or slab of contamination. External dose conversion factors are supplied for surface-soil contamination, and for slabs of buried contaminants at depths of either 0.5 or 1.0 m. External dose conversion factors from an optional room exposure condition are also available. These factors are intended to model doses to an intruder who may enter a room (or vault) used for storage of radioactive wastes. The room model was originally developed for a study concerning decommissioning of a reference Boiling Water Reactor (BWR) (Oak et al. 1980). A sensitivity analysis for the dose rate response of ^{60}Co surface contamination in a room of various sizes indicated a dose rate increase of a factor of two or less from small to large rooms (Oak et al. 1980, p. F-16). Thus, dose factors for a room of 100 m³ volume are assumed to be represented by a plane source that appears to provide a reasonable estimate of the dose resulting in most sizes of rooms that may be encountered.

Exposure pathways that can be modeled include 1) direct external exposure to contaminated soil or building surfaces, 2) inhalation of resuspended material, and 3) ingestion of contaminated foods and aquatic products. The time of the maximum dose rate to individual organs of reference is calculated and the annual dose for that organ is reported.

2.2.1.4. MAXI2 Computer Program Description

MAXI2 (Napier, Peloquin, and Kennedy 1984) was used to generate the food pathways dose conversion factors for the maximally exposed intruder/resident reference "environment" described in Section 2.1.2. MAXI2 need be used only when a different "environment" is defined. MAXI2 generates dose conversion factors to account for deposition on farm or garden soil and crops. Leaf mechanism dose rate factors are written to a computer file herein denoted as FILE20. The computer file called FILE21, contains dose conversion factors to account for deposition onto soil in which food crops are grown. MAXI2 also generates external dose rate factors for exposure to soil surface contamination. These factors are written to the computer file denoted as FILE22. The computer code ISOSHLT (Engel et al. 1966; Simmons et al. 1967) is used to calculate surface external dose rate factors. A listing of the MAXI2 code is found in Appendix 2.B. The input files to MAXI2 that generated the dose conversion factors for the reference "environment" are included in Appendix 2.B as an example of code usage. MAXI2 is a specialized version of the FOOD (Napier, et al. 1980) computer program. The user is referred to that document for theoretical and operational information. Differences between the MAXI2 and FOOD computer codes are discussed in Section 3.1.3.

2.2.1.5. MAXI3 Computer Program Description

MAXI3 (Napier, Peloquin, and Kennedy 1984) was used to define drinking-water and aquatic food pathway factors for the reference "environment" described in Section 2.1.1. This "environment" is applicable to the scenario presented in Section 2.1.2. MAXI3 need be executed only when a different "environment" is considered. MAXI3 generates dose conversion factors for

contaminated drinking water and aquatic food harvested from contaminated water. Drinking-water dose conversion factors are written to a computer file assigned to logical unit 24, called FILE24. The computer file assigned to logical unit 25, called FILE25, contains dose conversion factors to account for ingestion of contaminated aquatic food products. A listing of the MAXI3 code is found in Appendix 2.C. The input files to MAXI3 that generated the dose conversion factors for the intruder/resident reference "environment" are shown in Appendix 2.C as an example of code usage. MAXI3 is a specialized version of the ARRRG (Napier, et al. 1980) computer program. The user may reference that document for theoretical and operational information on MAXI3. Differences between the MAXI3 and ARRRG computer programs are discussed in Section 3.1.3.

2.2.2. Operation of the BIOPORT/MAXI1 Software Package

Section 3 contains a detailed discussion of the operation of the BIOPORT/MAXI1 software package. A theoretical overview of software operation is presented here. Because of the complicity of the interrelationships of the components of the software package, levels of operation will be defined. The software process flow at each operation will be presented.

The principal intended scope of the BIOPORT/MAXI1 software package is to calculate radiation dose to man using the CREATE computer program to establish scenarios of biotic transport of radionuclides. However, the user may access additional capabilities of the MAXI1 program, as well as utilize MAXI2 and MAXI3 for application to a wider range of situations. Three levels of operation have been defined to clarify this extended use of the software.

- LEVEL ONE Most users of this software package will fall into this classification. Level One requires the minimum level of user familiarity with the computer codes in this software package and with the computer operating system procedures. The Level One user interacts with the CREATE program to establish biotic transport scenarios. The user is provided assistance by the incorporation of default data sets of input parameters into the software, by restricted ranges of values for each parameter, and by free-formatted parameter input. Interaction with the computer operating system is minimized by utility software included in the package. The resident/intruder scenario has been defined in the software. The data base defining the reference "environment" has been provided.
- LEVEL TWO After establishing and simulating a biotic transport scenario with the CREATE and BIOPORT codes, the user modifies the intruder/resident scenario by modifying the MAXI1 input parameters. The user then executes the

MAXI1 computer code. The user changes the resident/intruder scenario by changing the level of exposure to various pathway (e.g., the number of hours of exposure to external penetrating radiation, the portion of diet grown on the site). The user must be familiar with the MAXI1 models and the interrelationships of input parameters to produce meaningful scenarios.

- **LEVEL THREE** The user creates a different "environment" as defined in Section 2.1.1. This is accomplished by using the MAXI2 and MAXI3 computer codes to establish new dose rate factor libraries. It is not anticipated that this level of operation will be needed for the evaluation of biotic transport scenarios at low-level waste sites. It is included to allow flexibility and complete access to MAXI capabilities.

2.2.3. Restrictions and Future Enhancements

The following restrictions apply to operation of the BIOPORT/MAXI1 software package.

- There is a strong correspondence between the animal and plant input parameters and the input depths of the strata in the soil column. It is the user's responsibility to ensure, when changing from default soil strata thicknesses, that corresponding changes are made to the animal and plant input parameters. Proportion of soil moved from each soil strata by animals and proportion of plant roots in each soil strata are the affected parameters.
- It is assumed that there is no plant or animal activity below the inventory.
- The site overburden is conceptually divided into three distinct layers or strata. The user may vary the thickness of the layers but may not vary the number of layers.
- It is the user's responsibility to ensure that the erosion rate is not so high that the entire top layer of soil is eroded away during the course of the simulation. If this does occur, the simulation will be stopped and an error message will be printed.
- The user may define a maximum of 10 plant and 10 animal associations (i.e., either species and/or communities).
- Up to a total of 50 radionuclides may be considered. The inventory is restricted to the list of 100 radionuclides appearing in Table 2.1-2. Several of these radionuclides (shown in Table 2.1-2) are listed with a +D (plus daughters) designation. For these radionuclides, the energies of the short-lived daughters in equilibrium with the parent radionuclides are included in the organ dose and external dose calculations. For other radionuclides, chain decay calculations are

performed and daughters are permitted to reach their equilibrium values.

- Doses to the following organs may be considered: total body, bone, lung, thyroid, and the lower large intestine (LLI) of the GI tract.

The following enhancements to the BIOPORT/MAXII software package have been considered and determined to be feasible.

- A variable number of soil strata could be added to define the soil overburden of the waste site.
- Plant and animal input parameters could be defined so as to be independent of soil column input parameters.
- Graphic output of radionuclide concentration and dose to man versus time could be generated to simplify analysis of results.
- A separate data base of animal and plant data could be implemented to facilitate collection, storage, and utilization of parameters.
- Additional parameters defining the maximally exposed resident scenario could be brought out to the interactive CREATE program, thus allowing easier modification to the maximally exposed resident scenario.

2.3. Data Base

An understanding of the detailed information which follows is not necessary for the successful execution of BIOPORT/MAXII. This section is provided for individuals interested in the organization and content of the data base and Level Three users (Section 2.2.2) who are defining a different "environment."

The BIOPORT/MAXII data base is composed of 10 data files. The relationship of the data base to the computer codes is depicted in Figure 2.2-1. RMDLIB is the master radionuclide library containing chain decay and translocation class information. The balance of the files contain dose conversion factors for various pathways.

2.3.1. Radionuclide Master Library for MAXII - RMDLIB

The radionuclide master data library (RMDLIB) contains all radiological decay data used by the MAXII programs. The library is organized into two sections. The first section contains radionuclides that are not members of decay chains, and also radionuclides singled out from chains with the "+D" (plus daughters) designation. Radionuclides in the first section are arranged by increasing atomic number. The second section of the library contains radionuclides organized into decay chains ordered under the radionuclides highest in the chain. RMDLIB contains about 280 entries.

The first record of the library contains 80 characters of descriptive information used as identification in the input data report printed by MAXII. The balance of the data records have the following information:

- Alphabetic element symbol
- Atomic weight, also metastable (m) and/or plus daughters (+D) designation
- Radiological half-life, days
- Index of relative position in decay chain (0 is highest position)
- Index of precursor in decay chain (as identified in column 4 of the precursor)
- Branching ratio for primary precursor
- Index of alternate precursor in decay chain
- Branching ratio for alternate precursor
- Translocation class assignment for soluble state of element
- Translocation class assignment for insoluble state of element

Translocation refers to the rate at which radionuclides are transported by body fluids from the lungs to the blood and GI tract after inhalation. For inhalation calculations, translocation classifications are made for each organ based on the usage of the Task Group Lung Model (ICRP 1966). The translocation indices used in RMDLIB refer to the following classes as defined in ICRP (1966):

Index 1 - Class D Materials. A maximum clearance half-time of less than a day.

Index 2 - Class W Materials. A maximum clearance half-time ranging from a few days to a few months.

Index 3 - Class Y Materials. A maximum clearance half-time of from six months to a few years.

BIOPORT/MAXII assumes that for inhalation all elements are insoluble for the lungs and soluble for the other organs. This assumption tends to maximize the organ dose. The translocation classification for soluble and insoluble will be read by the CREATE computer code and applied to each organ according to the above assumption. The default translocation assignments may be modified by the user during scenario creation.

The RMDLIB FORTRAN format is (A2, A6, E10.2, 2I2, F7.4, I2, F7.4, 22X, 2I1). The parameter in column four is used to signal the end of the data library (≤ 0). A listing of the library is located in Appendix 1.C.

2.3.2. Leaf Mechanism Dose Rate Factors - FILE20

The file assigned to logical unit 20, called FILE20, contains "environment"-specific leaf-mechanism dose rate factors for 1 pCi per cubic meter in air. Each record of the file contains dose rate factors of one radionuclide for selected organs. The file is arranged into sets of records for each year. The sets are delimited by a blank record. The file organization, corresponding MAXI1 variable names, and FORTRAN formats of FILE20 are as follows:

- Line 1 - Descriptive title, TIT20; (20A4).
- Line 2 - Type descriptor, ID;
 number of years of data, NYRL;
 number of isotopes, NISOL;
 number of organs, NORGL; (5X, A4, 3I5).
- Line 3 - Index of organs, KORGLS(i),
 for i ranging from one to NORGL; (5I5).

The following set of records follows for each year of data (k); a total of NYRL sets:

- Line A - Blank line
- Next NISOL lines - One line for each isotope (i) containing:
 element symbol as in the master radio-
 nuclide library, ELTSL(i);
 atomic number as in the master radio-
 nuclide library, AWLS(i);
 dose rate factor for KORGLS(j) where
 j ranges from one to NORGL,
 DINCL(k,i,j);
 (A2, A6, 5E12.2).

FILE20 contains dose rate factors for five organs for 100 radionuclides for fifty years. The organs are total body, bone, lungs, thyroid, and the lower large intestine of the GI tract. Consumption parameters included in the dose conversion factors are listed in Table 2.1-1. The radionuclides considered are listed in Table 2.1-2. The first page of this default file is printed in Appendix 1.C. A complete listing of the default file is given in Appendix 2.A.

When creating a new "environment," the computer code MAXI2 is used to generate this file. MAXI2 is a special version of the FOOD computer code (Napier et al. 1980). The user is referred to that document for detailed information. Instructions for executing MAXI2 are given in Section 3.1.3. MAXI2 outputs leaf-mechanism dose rate factors to the file assigned to logical unit 20. The MAXI2 input file that generated FILE20 for the biotic transport "environment" is listed in Appendix 2.B.

2.3.3. Soil Mechanism Dose Rate Factors - FILE21

The file assigned to logical unit 21, called FILE21, contains "environment"-specific soil-mechanism dose rate factors for 1 pCi per square meter in soil. Each record of the file contains dose rate factors of one radionuclide for selected organs. The file is arranged into sets of records for each year.

The sets are delimited by a blank record. The file organization, corresponding MAXII variable names, and FORTRAN formats of FILE21 is as follows:

- Line 1 - Descriptive title, TIT21; (20A4).
- Line 2 - Type descriptor, ID;
 number of years of data, NYRS;
 number of isotopes, NISOS;
 number of organs, NORGS; (5X, A4, 3I5).
- Line 3 - Index of organs, KORGLS(i),
 for i ranging from one to NORGS; (5I5).

The following set of records follows for each year of data (k); a total of NYRS sets:

- Line A - Blank line
- Next NISOS lines - One line for each isotope (i) containing:
 element symbol as in the master radio-
 nuclide library, ELTSL(i);
 atomic number as in the master radio-
 nuclide library, AWLS(i);
 dose rate factor for KORGLS(j) where
 j ranges from one to NORGS,
 DINCS(k,i,j);
 (A2, A6, 5E12.2).

FILE21 contains dose rate factors for five organs for 100 radionuclides for fifty years. The organs are total body, bone, lungs, thyroid, and the lower large intestine of the GI tract. Consumption parameters included in the dose conversion factors are listed in Table 2.1-1. The radionuclides considered are listed in Table 2.1-2. The first page of this file is printed in Appendix 1.C. A complete listing of the file is in Appendix 2.A.

MAXI2, a special version of the FOOD computer (Napier et al. 1980), generates this file. The user is referred to the FOOD program documentation for detailed information. Instructions for executing MAXI2 are located in Section 3.1.3. The input submitted to MAXI2 to generate the FILE21 is given in Appendix 2.B. MAXI2 prints a report of input parameters and outputs soil-mechanism dose rate factors to the file assigned to logical unit 21 in the format described above.

2.3.4. Surface External Exposure Mechanism Dose Rate Factors

The file assigned to logical unit 22 contains external dose rate factors. The file named PLANSOURC contains dose rate factors that represent an infinite plane of soil contamination.

The organization, corresponding MAXII variable names, and FORTRAN formats of the file is as follows:

- Line 1 - Descriptive title, TIT22; (20A4).
- Line 2 - Type descriptor, ID;
 number of isotopes, NISOX; (5X, A4, I5).
- Next NISOX lines - For each isotope (i):
 element symbol as in master radionuclide
 library, ELTX(i);
 atomic number as in master radionuclide
 library, AWX(i);
 external exposure dose rate factor, DFXT(i);
 CA2, A6, E7.1).

The data file PLANSOURC is printed in Appendices 1.C and 2.A. When establishing a new "environment," the user may use the ISOSHL D (Engel et al. 1966; Simmons et al. 1967), MAXI2, or other compatible computer programs to generate external dose rate factors. A file in the above format will probably have to be hand-generated from the results of the shielding calculations. MAXII anticipates external dose rate factors in units of mrem/yr per pCi/m². PLANSOURC was generated using the ISOSHL D computer program.

2.3.5. Inhalation Dose Rate Factors - FILE23

The file assigned to logical unit 23 called FILE23, contains inhalation dose rate factors for 1 pCi per cubic meter of air. The file is arranged into sets of records for each isotope. Each isotope set contains three solubility class subsets. Each solubility class subset is comprised of a variable number of records, one record per year. Each record contains data on up to five organs. The file organization, corresponding MAXII variable names, and FORTRAN formats of FILE23 are as follows:

- Line 1 - Number of radionuclides in library, NDI;
 descriptive title, TIT23; (I5, 15X, 15A4).
- Line 2 - Index of organs, IDORG(i),
 for i ranging from 1 to 5, i=0 indicates data
 for less than five organs; (5I5).

This set of records follows for each radionuclide(k); a total of NDI sets:

- Line A - Element symbol as in the master radionuclide library, ELTD;
 atomic number as in the master radionuclide library, AWD;
 number of years of data solubility class 1, N1;
 number of years of data solubility class 2, N2;
 number of years of data solubility class 3, N3; (A2, A6, 2X, 3I5).
- Next N1 lines - For translocation class 1, one record contains inhalation dose rate factors for five organs (j), DIN(1,i,j); (10X, 5E10.2).
- Next N2 lines - For translocation class 2, one record contains inhalation dose rate factors for five organs (j), DIN(2,i,j); (10X, 5E10.2).
- Next N3 lines - For translocation class 3, one record contains inhalation dose rate factors for five organs (j), DIN(3,i,j); (10X, 5E10.2).

The file contains dose rate factors of 130 radionuclides for five organs for a varying number of translocation classes and a varying number of years. The organs are total body, bone, lungs, thyroid, and the lower large intestine of the GI tract. Dose rate factors are based on a breathing rate of 230 cc/sec. The first page of this file is printed in Appendix 1.D.5. A complete listing is located in Appendix 2.A. FILE23 is created by a special version of the computer code DACRIN (Houston, Streng, Watson, 1974). This library is not "environment"-specific and consequently should not need to be recreated by the user.

2.3.6. Aquatic Foods Dose Rate Factors - FILE24

Aquatic food pathways are not considered for the biotic transport scenario. Information in this section is included for completeness. The file assigned to logical unit 24, called FILE24, contains aquatic foods dose rate factor for 1 pCi per liter of river water. The factors assume a consumption rate of 6.9 kg/yr of fish obtained from Regulatory Guide 1.109 (NRC 1977). Each record of the file contains dose rate factors of one radionuclide for selected organs. The file is arranged into sets of records for each year. The sets are delimited by a blank record. The file organization, corresponding MAXII variable names, and FORTRAN formats of FILE24 are as follows:

- Line 1 - Descriptive title, TIT24; (20A4).

- Line 2 - Type descriptor, ID;
 number of years of data, NYRA;
 number of isotopes, NISOA;
 number of organs, NORGA; (5X, A4, 3I5).
- Line 3 - Index of organs, KORGA(i),
 for i ranging from one to NORGA; (5I5).

The following set of records follows for each year of data (k); a total of NYRA sets:

- Line A - Blank line
- Next NISOA lines - One line for each isotope (i) containing:
 element symbol as in the master radio-
 nuclide library, ELTA(i);
 atomic number as in the master radio-
 nuclide library, AWA(i);
 dose rate factor for KORGA(j) where
 j ranges from one to NORGA,
 DINCA(k,i,j);
 (A2, A6, 5E12.2).

FILE24 contains dose rate factors for five organs for 100 radionuclides for fifty years. The organs are total body, bone, lungs, thyroid, and the lower large intestine of the GI tract. Radionuclides included are listed in Table 2.1-2. The first page of this file is printed in Appendix 1.C. A complete listing of the file is located in Appendix 2.A.

FILE24 is generated by the MAXI3 computer code. MAXI3 is a special version of the ARRRG computer code (Napier et al. 1980). The user is referred to that document for detailed information. Instructions for executing MAXI3 are given in Section 3.1.3. The input to MAXI3 that generated the aquatic foods dose rate factors in FILE24 is given in Appendix 2.C.

2.3.7 Drinking-Water Dose Rate Factors - FILE25

The file assigned to logical unit 25, called FILE25, contains drinking-water dose rate factors for 1 pCi per liter of drinking water. Each record of the file contains dose rate factors of one radionuclide for selected organs. The file is arranged into sets of records for each year. The sets are delimited by blank records. The file organization, corresponding MAXI1 variable names, and FORTRAN format of FILE25 are as follows:

- Line 1 - Descriptive title, TIT25; (20A4).
- Line 2 - Type descriptor, ID;
 number of years of data, NYRW;
 number of isotopes, NISOW;
 number of organs, NORGW; (5X, A4, 3I5).

Line 3 - Index of organs, KORGW(i),
 for i ranging from 1 to NORGW; (515).

The following set of records follows for each year of data (k); a total of NYRW sets:

Line A	- Blank line
Next NISOW lines	- One line for each isotope (i) containing: element symbol as in the master radio- nuclide library, ELTW(i); atomic number as in the master radio- nuclide library, AWW(i); dose rate factor for KORGW(j) where j ranges from one to NORGW, DINCW(k,i,j); (A2, A6, 5E12.2).

FILE25 contains dose rate factors for five organs for 100 radionuclides for fifty years. The organs are total body, bone, lungs, thyroid, and the lower large intestine of the GI tract. The dose rate factors included with this software package are based on consumption of drinking water at a rate of 1.2 liters per day or 440 liters per year. The radionuclides considered are listed in Table 2.1-2. The first page of this file is printed in Appendix 1.C. A complete listing of the file is in Appendix 2.A.

The computer code MAXI3 generates FILE25. MAXI3 is a special version of the ARRRG computer code (Napier et al. 1980). The user is referred to that document for detailed information. Instructions for executing MAXI3 are given in Section 3.1.3. The MAXI3 input file that generated the dose rate factors in FILE25 is given in Appendix 2.C.

2.3.8. Buried Waste External Dose Rate Factors

External exposure from buried waste is not considered in the intruder/resident scenario. However, three files are included in this software for considering buried waste. The files are based on the location (relative depth from the surface) of the waste. The three optional files are:

- "VOLSOURC" - infinite surface slab source
- "BURIEDHF" - infinite slab source buried in soil with an overburden depth of 0.5 meters
- "BURIED1" - infinite slab source buried in soil with an overburden depth of 1.0 meters

The factors in these files relate the radionuclide source strength to the dose rate in tissue 1 m away. These factors are for 1 pCi per cubic meter for the waste. Each record of the file contains dose rate factors for one radionuclide. The file organization, corresponding MAXII variable names, and FORTRAN formats of the optional files are as follows:

- Line 1 - Descriptive title, TIT27; (20A4).
- Line 2 - Type descriptor, ID;
 number of isotopes, NISODX; (5X, A4, I5).
- Next NISODX lines - For each isotope (i)
 element symbol as in master radionuclide
 library, ELTDX(i);
 atomic number as in master radionuclide
 library, AWDX(i);
 dose rate factor in air, DFDXT(i);
 (A2, A6, E7.1)

The files VOLSOURC, BURIEDHF, AND BURIED1 are listed in Appendix 2.A. These files are created by the ISOSHL (Engel et al. 1966; Simmons et al. 1967) computer program.

2.3.9. Radionuclide Master Library for BIOPORT and CREATE - RMDBIO

RMDBIO is a special version of RMDLIB. This library contains radiological decay data and plant/soil concentration ratios for the radionuclides listed in Table 2.1-2. Each record of RMDBIO contains the following information:

- Alphabetic element symbol
- Atomic weight, also metastable (m) and/or plus daughters (+D) designation
- Radiological half-life, days
- Index of relative position in decay chain (0 is highest position)
- Index of precursor in decay chain (as identified in column 4 of the precursor)
- Branching ratio for primary precursor
- Index of alternate precursor in decay chain
- Branching ratio for alternate precursor
- Concentration ratio for plants in units of pCi per gram plant (wet) / pCi per g soil (dry)
- Translocation class assignment for soluble state of element
- Translocation class assignment for insoluble state of element

The RMDBIO FORTRAN format is A2, A6, E10.2, 2I2, F7.4, I2, F7.7, 10X, F7.4, 3X, 2I1. A listing of the library is located in Appendix 1.C.

2.4. References

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3. PROCEDURES

User instructions and technical details on use of the BIOPORT/MAXII software package are presented in this section. To simplify the presentation of user interaction with the computer codes, three levels of software operation were presented in Section 2.2.2. Briefly, the levels of operation are:

- LEVEL ONE The user creates and executes a biotic transport scenario. The user interacts with the CREATE computer program and system level procedures which control execution of the BIOPORT and MAXII computer codes. The biotic transport scenario is simulated and dose to organs is calculated.
- LEVEL TWO After establishing and simulating a biotic transport scenario with the CREATE and BIOPORT codes, the user modifies the intruder/resident scenario by modifying the MAXII input parameters. The user then executes the MAXII computer code.
- LEVEL THREE The user creates a different "environment" as defined in Section 2.1.1. This is accomplished by using the MAXI2 and MAXI3 computer codes to establish different dose rate factor libraries.

It is assumed that the majority of users will operate the BIOPORT/MAXII software at Level One. Levels Two and Three are included to allow flexibility and increased application of the BIOPORT models. Instructions are given for each level of software operation. Detailed information on the BIOPORT/MAXII software input and output is included. This information is primarily of interest to the Level One user. Included are a discussion of two data sets incorporated into the CREATE software, descriptions of all BIOPORT input parameters and the presentation of five sample problems. Program-generated error messages and corresponding corrective actions for the CREATE, BIOPORT, and MAXII computer codes are also listed. The following conventions will be used in this manual to distinguish exact user input from instructions and from computer program displays.

- <cr>** - These symbols indicate that the keyboard key labeled **RETURN** should be pressed when encountered in the manual. This is analogous to the carriage return on typewriters.
- boldface** - Boldface print designates information entered at the terminal by the user.

- CAPITAL LETTERS** - When capital letters in boldface type are encountered, the user should type in the boldface letters exactly as shown.
- lower-case letters** - When lower-case letters are encountered in boldface type, the user should substitute scenario-specific information or a unique file name.

3.1. User Instructions

The BIOPORT/MAXI1 software package is installed on the Brookhaven CDC 6600 MFA and 7600 MFZ computers. It is necessary to obtain a security access identification number, an account name, password, and problem number to use this computer facility. The user is responsible for obtaining the above privileges to access the BIOPORT/MAXI1 software.

User instructions for the three levels of software operation discussed above are provided in this section. The following three subsections correspond to these levels, respectively.

3.1.1. Executing CREATE/BIOPORT/MAXI1 (Level One User)

On the MFA computer, to establish and execute a scenario, the user need only type:

```
ATTACH,PROCFIL,ID=BIO,MR=1 <cr>
BEGIN,BIO <cr>
```

to access the CREATE interactive program. Detailed examples of user interaction with the CREATE program are presented with the sample problems. A general description of user interaction with CREATE follows.

The first messages introduce CREATE and display general instructions on program use. The user is queried for a descriptive title that will identify the output reports. CREATE prompts the user to enter simulation duration and information relative to the output. The user selects from two data sets to establish default reference parameter values. The user then indicates whether or not a default inventory will be used. The user selects a storage package half-life and age. At this point the user is given an opportunity to review and/or modify any of the above parameter values before continuing with construction of the scenario.

When the user is satisfied with parameter values selected, the inventory can be reviewed or entered. If a default inventory was selected by the user, a report of the inventory is displayed on the terminal screen. The user is allowed to modify and/or add radionuclides to the default inventory. If the user opted to enter the inventory, radionuclide names and quantities will be requested. Radionuclides should be selected from Table 2.1-2. CREATE, BIOPORT, and MAXI1 accept radionuclide names only as

they appear in RMDBIO, listed in Appendix 1.C.9. A report of the inventory is displayed when the user has completed inventory input.

Next the user may review and/or modify site-specific parameters. Site-specific parameters are divided into three groups for review/modification purposes: soil strata parameters, plant parameters, and animal parameters. For each group, CREATE first asks if any changes are to be made to this group. If changes are to be made, CREATE will set parameter values based on the user's response to questions.

CREATE provides assistance to the user during scenario creation. This manual should not be necessary during normal executions because the following features are incorporated into the CREATE software:

- Parameter descriptions and default values for each of two data sets are stored in the code.
- Four default inventories may be accessed by the software.
- Questions are "English-phrased." A strong effort has been made to refrain from computer jargon. The code attempts to ask questions meaningful to the end user and logically establishes required parameter values.
- Values entered at the terminal by the user are tested against minimum and maximum allowable limits. If a value is determined to be outside the allowable limits, the user is asked to supply another value.
- When proportion parameters are input, CREATE tests to ensure that the total is not greater than 1.0.
- Default values are installed with a null entry (i.e., pressing the <cr> key).
- When a "YES/NO" question is asked of the user, the default condition is always displayed first (e.g., (N/Y) indicates that a null entry is equivalent to a "no" response).
- Review of related sets of parameters (e.g., plant and/or animal parameters) may be bypassed during scenario modification.
- Radiological inventory input is tested against a shortened version of master radionuclide library, RMDBIO. This establishes that information is available in the data base for the source term in question and that the user entered the radionuclide name in a recognizable form.
- Radiological inventory input is tested against the previously entered input to ensure that an entry is not duplicated.

- Upon the completion of input, the radiological inventory is displayed. The user is given the opportunity to first modify and then add to the inventory.
- Default organ translocation classes are assigned.
- Input is free-formatted as specified in ANSI-FORTRAN-77.
- The user may review and/or modify groups of parameters until satisfied with the selection.

At the end of the CREATE interactive session, the user must supply the account-name and account-number for access to the MFZ computer. The queries are made in the following manner:

ENTER ACCOUNT NAME: **accountname** <cr>

ENTER ACCOUNT NUMBER: **accountnumber** <cr>

The CREATE program generates an execution file for BIOPORT and MAXII from the information supplied by the user. This file is stored in the user's work area under the name TAPE7.

To initiate the BIOPORT simulation and the MAXII dose calculation enter the following command:

BEGIN,MAX <cr>

The user will then be asked to supply a filename and read access password for the execution file generated by CREATE. The requests are made in the following format:

ENTER F FILENAME FOR SCENARIO: **filename** <cr>

ENTER R READ PASSWORD FOR FILE: **readpassword** <cr>

The execution file, TAPE7, will be copied to a file with a local file name of T7 and then catalogued as a permanent file under the user-supplied password to protect the user's account. The file will have a user identification of BIO and will be retained on the system for ten days. Cataloging of the file will allow the user to resubmit a CREATE-generated scenario if the execution is not successful. A system command will be automatically generated to submit the execution file to the MFZ computer. BIOPORT and MAXII will be executed sequentially and the respective reports inserted into the execution log file. Because of time and extended core memory requirements, execution of the job may be delayed.

To check on the status of the BIOPORT and MAXII executions, enter the following command:

FILES <cr>

When the execution is complete, the log file name consisting of the first five characters of the user's account name followed by two system-generated sequence characters will appear under **OUTPUT FILES**.

The user may use the following procedure to print the log file at the RJE terminal in SS-056. To start the procedure, enter:

BEGIN,SEND <cr>

The procedure will respond with the following request:

F NAME OF FILE TO BE PRINTED: filename <cr>

The user should enter the log file name. The SEND procedure then requests a name that will be printed on the banner page of the output. The user may use any five-character sequence to identify the run. The format of the request is as follows:

N FIVE CHARACTER NAME TO IDENTIFY RUN: name <cr>

The above procedures will assist the user in scenario creation, control execution of the biotic transport simulation, control dose calculations, and provide printed reports of the program output. Table 3.1-1 summarizes the procedure for executing this software package.

Table 3.1-1. System Procedures Sequence Summary

ATTACH, PROCFIL, ID = BIO,MR = 1 <cr>

BEGIN,BIO <cr> (scenario is constructed)
ENTER ACCOUNT NAME: accountname <cr> (biotic transport simulated &
ENTER ACCOUNT NUMBER: accountnumber <cr> dose calculations performed)

BEGIN,MAX <cr> (biotic transport simulated &
ENTER F FILENAME FOR SCENARIO: filename dose calculations performed)
ENTER R READ PASSWORD FOR FILE: readpassword

FILES (to check status of execution)

BEGIN,SEND <cr>
F NAME OF OUTPUT FILE TO BE PRINTED: jobname <cr> (to print reports in
N FIVE CHARACTER NAME OT IDENTIFY RUN: name <cr> SS-056)

3.1.2. Modifying the Intruder/Resident Scenario (Level Two User)

The user may modify the intruder/resident MAXI1 scenario by modifying the MAXI1 input file prior to execution of the MAXI1 program. For example, the user may wish to assume that only a portion of the intruder/resident diet was obtained from the site. The user could adjust the MAXI1 input parameter RPF2 to reflect this assumption. Descriptions of all MAXI1 input parameters will be discussed in Section 4.

3.1.3. Creating an "Environment" - MAXI2/MAXI3 (Level Three User)

The experienced user may wish to establish a different "environment" by executing the MAXI2 and MAXI3 computer codes. MAXI2 is a specialized version of the FOOD (Napier et al. 1980) computer program. MAXI3 is a specialized version of the ARRRG (Napier et al. 1980) computer code. The user is referred to the ARRRG and FOOD document for user instructions, with the following exceptions:

- Only the following NAMELIST parameters are used by MAXI2:

NEXT	HLDUP	KORG
KFDTYP	CON	T2
GRWP	TRNS	POP
YELD	EXTIM	IPOP

- Only the following NAMELIST parameters are used by MAXI3:

NEXT	KORG	USAG
KPTHWY	PLIFE	ISALT
T2	HLDUP	

- Release parameter records need only list the radionuclide name, ELTI(1) and AWI(1) in FORTRAN A2, A6 format.
- Special versions of the data libraries used by MAXI2 and MAXI3 are included in the BIOPORT/MAXI software package. These libraries contain information on the radionuclides listed in Table 2.1-2. The library FTRANSLIB contains elemental deposition velocities to account for deposition of resuspended radioactive materials. Transfer coefficients in FTRANSLIB for ^3H and ^{14}C are taken from Regulatory Guide 1.109 (U.S. NRC 1977). The remaining transfer coefficients in FTRANSLIB are from the ARRRG and FOOD document. The libraries included in this package are:

RMDLIB	BIOAC
ORGLIB	FTRANSLIB
GROFLIB	

RMDLIB is also used by MAXI1.

- Files must be assigned to the logical unit devices listed in Table 3.1-2 to obtain dose rate factor output.

MAXI2 and MAXI3 will print reports of input parameters. Output file organization is presented in Section 2.3. Output reports (as provided by FOOD and ARRRG) are not printed. Sample input files to MAXI2 and MAXI3 are listed in Appendices 2.B and 2.C, respectively.

The BIOPORT/MAXI1 data base contains the "environment" described in Section 2.1.1. File names generated by MAXI2 and MAXI3 must not conflict with those currently in the data base.

3.2. Input Parameters

To simplify use of the BIOPORT computer program, two data sets are incorporated into the CREATE program. The data sets characterize general conditions and radionuclide inventories that the user may use as an aid in the construction of a more specific scenario. The first data set defines conditions typical of the plains and intermountain valleys of the western United States. These arid site conditions and radionuclide inventories are from McKenzie et al. (1982b; 1984). The first data set is referred to as the reference arid site. The second data set describes conditions typical of much of the eastern United States. These humid site conditions and radionuclide inventories are also based on the work of McKenzie et al. (1983; 1984). The second data set is referred to as the reference humid site. Two reference waste spectra have been defined for each of the reference sites (McKenzie et al. 1982; 1983). Waste Spectrum 1 is intended to be representative of past and current waste management practices. Waste Spectrum 2 is intended to represent the use of improved solidification and volume reduction methods. The waste spectra concentrations have been decayed for an average of 20 years. The waste spectra have been summarized from information presented in the DEIS for 10 CFR Part 61 (U.S. NRC 1981).

The inclusion of these data sets simplifies construction of a scenario by providing default values for all BIOPORT input parameters. Alternately, the user may construct a scenario entirely of site-specific data. However, when site-specific data is incomplete, the user can use one of the data sets as a

Table 3.1-2. MAXI2/MAXI3 Logical Unit Device Assignments

<u>Logical Unit No.</u>	<u>File Description</u>	<u>Corresponding BIOPORT/MAXI1 File</u>
20	MAXI2 leaf mechanisms	FILE20
21	MAXI2 soil mechanisms	FILE21
22	MAXI2 surface external mechanisms	PLANSOURC
24	MAXI3 aquatic food-product mechanisms	FILE24
25	MAXI3 drinking-water mechanisms	FILE25

base case and incorporate available site-specific data to establish a particular scenario. For example, site-specific data on radionuclide inventories are not readily available; however, if they should become available, these data can be readily incorporated into the default scenarios by the user.

Complete parameter descriptions are included in the CREATE program. The user will become familiar with the required input parameters through execution of the CREATE program. Several tables of input parameter values are presented as aids to the user. Table 3.2-1 is a worksheet that may assist the user in the collection of site-specific data. Default values included in the software for the reference arid and humid sites are given in Tables 3.2-2 and 3.2-3, respectively. The default waste inventories are given in Table 3.2-4. Input variables for BIOPORT/MAXII are described in Table 3.2-5. The name of each parameter is followed by the number of elements (and specification if it is an array), the data type classification, and a description. Each parameter description includes dimensional units, as well as minimum and maximum allowable values if applicable. The parameters are listed in alphabetical order.

3.3. Output Descriptions

Output generated by CREATE, BIOPORT, and MAXII will be discussed in this section. Files are identified by the FORTRAN logical unit number (lun) associated with them for each of the computer programs.

CREATE generates two output files; BIOPORT input (lun 7) and MAXII system control/parameter input (lun 8). These files are usually not printed or retained on the system. However, the user may wish to catalog these files for permanent disk storage. The BIOPORT input file is in the user's work area under the name TAPE7. The MAXII input file is in the user's work area under the name TAPE8.

BIOPORT generates two output files; a report of input parameters and results (lun 2), and a file of radionuclide concentrations in MAXII input format (lun 30). The BIOPORT report includes values and descriptions for all input parameters. For each year selected for output, a table of radioactivity in each soil strata by radionuclide is generated. The table includes the radioactivity eroded in the given year and resulting concentration of each radionuclide in the available soil surface adjusted to the MAXII input units of pCi/m^3 . The inventory file generated by BIOPORT contains an identifying title and a set of records for each year selected for output. Each set includes a title record containing the year of simulation during which the following concentrations were calculated. One record is included for each radionuclide. Input radionuclides as well as all other members of applicable decay chains are included. This is true even if the concentration of some of the radionuclides in the chain is zero. This arrangement is necessary because MAXII expects radionuclides to be arranged in the same order for all cases of the execution. Each record contains the radionuclide name (element following by atomic number), translocation index for each organ and concentration in units of pCi/m^3 .

Table 3.2-1. Site-Specific Data Collection Worksheet

GENERAL PARAMETERS

Title: _____
 Length of the simulation (years): _____
 Output for years: _____
 Doses to be calculated for: Total Body Bone Lungs Thyroid LLI
 Base case selection: Arid reference site Humid reference site
 Base inventory: Waste Spectrum 1 Waste Spectrum 2 User-defined
 Decomposition half-life of the waste package (years): _____
 Mean age of the waste package at site closure (years): _____

SOIL STRATA PARAMETERS

Baseline erosion (cm/yr): _____
 Maximum erosion (cm/yr): _____
 Starting year for maximum erosion: _____
 Duration of maximum erosion (years): _____
 Frequency of maximum erosion (years): _____
 Thickness (m):
 Strata 1 _____ Strata 2 _____ Strata 3 _____
 Volume of the waste inventory (m³): _____

PLANT PARAMETERS

Plant Model: 1) Uptake based on the total mass of the plant
 2) Uptake based on the fraction of roots in contact with wastes

Number of plant associations: 1 2 3 4 5 6 7 8 9 10

	PLANT 1			PLANT 2			PLANT 3			PLANT 4		
Name:	_____			_____			_____			_____		
Dry/wet weight ratio:	_____			_____			_____			_____		
No. of phases:	_____			_____			_____			_____		
	Successional Phase 1	Successional Phase 2	Successional Phase 3	Successional Phase 1	Successional Phase 2	Successional Phase 3	Successional Phase 1	Successional Phase 2	Successional Phase 3	Successional Phase 1	Successional Phase 2	Successional Phase 3
Year of endpoint:	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Root-to-shoot ratio:	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Net prod. (g/m ²):	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Yearly recycle rate:	constant	constant	constant	constant	constant	constant	constant	constant	constant	constant	constant	constant
Production rate:	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-
Recyclerate:	constant	constant	constant	constant	constant	constant	constant	constant	constant	constant	constant	constant
Max rooting depth (m):	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-	lin +/-
Proportion of roots in:												
Soil strata 1	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Soil strata 2	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Soil strata 3	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Waste inventory	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

ANIMAL PARAMETERS

Number of animal species: 1 2 3 4 5 6 7 8 9 10

	ANIMAL 1	ANIMAL 2	ANIMAL 3	ANIMAL 4	ANIMAL 5	ANIMAL 6	ANIMAL 7	ANIMAL 8	ANIMAL 9	ANIMAL 10
Name:	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Total excavation (m ³):	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Activity index:	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Depth of activity (m):	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Proportion moved from:										
Soil strata 1	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Soil strata 2	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Soil strata 3	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Waste inventory	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Table 3.2-2. Reference Arid Site Default Parameter Values

GENERAL PARAMETERS

Length of the simulation (years): **500**

Output for years: **1, 100, 200, 300, 500**

Doses to be calculated for:

Total Body Bone Lungs Thyroid LLI

Decomposition half-life of the waste package (years):

Waste Spectrum 1 - **35.0**

Waste Spectrum 2 - **70.0**

Mean age of the waste package at site closure (years): **10.0**

SOIL STRATA PARAMETERS

Baseline erosion (cm/yr): **0.0**

Maximum erosion (cm/yr): **2.3**

Starting year for maximum erosion: **1**

Duration of maximum erosion (years): **4**

Frequency of maximum erosion (years): **600***

Thickness (m):

Strata 1 **.5** Strata 2 **.5** Strata 3 **.5**

Volume of the waste inventory (m³): **6.5 x 10⁴**

PLANT PARAMETERS

Plant Model: **2) Uptake based on the fraction of roots in contact with wastes**

Number of plant associations: **3**

	PLANT 1			PLANT 2			PLANT 3		
	Cheatgrass Comm			Rabbitbrush Comm			Sagebrush Comm		
Name:									
Dry/wet weight ratio:	0.15			0.15			0.15		
No. of phases:	3			3			3		
	Successional Phase 1	Successional Phase 2	Successional Phase 3	Successional Phase 1	Successional Phase 2	Successional Phase 3	Successional Phase 1	Successional Phase 2	Successional Phase 3
Year of endpoint:	10			30			500		
Root-to-shoot ratio:	0.75			3.0			5.0		
Net prod. (g/m ²):	272.0			104.0			117.0		
Yearly recycle rate:	1.0			1.0			1.0		
Production rate:	constant			constant			constant		
Recycle rate:	constant			constant			constant		
Max rooting depth (m):	2.0			2.0			2.0		
Proportion of roots in:									
Soil strata 1	0.72			0.565			0.61		
Soil strata 2	0.17			0.245			0.23		
Soil strata 3	0.07			0.135			0.11		
Waste inventory	0.04			0.055			0.05		

ANIMAL PARAMETERS

Number of animal species: **3**

	ANIMAL 1	ANIMAL 2	ANIMAL 3
	Pocket Mice	Badgers	Harvester Ants
Name:			
Total excavation (m ³):	0.1	0.211	0.1
Activity index:	1.0	1.0	1.0
Depth of activity (m):	2.0	2.0	2.0
Proportion moved from:			
Soil strata 1	0.7	0.7	0.7
Soil strata 2	0.2	0.15	0.1
Soil strata 3	0.05	0.05	0.1
Waste inventory	0.05	0.1	0.1

* This number represents a number larger than the number of years for which the simulation was run. It was used so that there would only be one period of erosion.

Table 3.2-3. Reference Humid Site Default Parameter Values

GENERAL PARAMETERS

Length of the simulation (years): **500**

Output for years: **1, 100, 200, 300, 500**

Doses to be calculated for: .

Total Body Bone Lungs Thyroid LLI

Decomposition half-life of the waste package (years):

Waste Spectrum 1 - **15.0**

Waste Spectrum 2 - **35.0**

Mean age of the waste package at site closure (years): **10.0**

SOIL STRATA PARAMETERS

Baseline erosion (cm/yr): **0.0**

Maximum erosion (cm/yr): **0.0**

Starting year for maximum erosion: **0**

Duration of maximum erosion (years): **0**

Frequency of maximum erosion (years): **0**

Thickness (m):

Strata 1 **.5** Strata 2 **.5** Strata 3 **.5**

Volume of the waste inventory (m³): **6.5 x 10⁴**

PLANT PARAMETERS

Plant Model: **2) Uptake based on the fraction of roots in contact with wastes**
Number of plant associations: **3**

	PLANT 1			PLANT 2			PLANT 3		
Name:	Forbs			Grass-shrub			Pine-Oak		
Dry/wet weight ratio:	0.15			0.15			0.15		
No. of phases:	3			3			3		
	Successional Phase 1	Successional Phase 2	Successional Phase 3	Successional Phase 1	Successional Phase 2	Successional Phase 3	Successional Phase 1	Successional Phase 2	Successional Phase 3
Year of endpoint:	6			28			500		
Root-to-shoot ratio:	0.25			0.35			0.35		
Net prod. (g/m ²):	468.0			635.0			1300.0		
Yearly recycle rate:	0.6			0.6			0.8		
Production rate:	constant			1in +/-			1in +/-		
Recycle rate:	constant			1in +/-			1in +/-		
Max rooting depth (m):	2.0			2.0			2.0		
Proportion of roots in:									
Soil strata 1	0.60			0.60			0.60		
Soil strata 2	0.30			0.30			0.30		
Soil strata 3	0.07			0.07			0.07		
Waste inventory	0.03			0.03			0.03		

ANIMAL PARAMETERS

Number of animal species: **4**

	ANIMAL 1	ANIMAL 2	ANIMAL 3	ANIMAL 4
Name:	Old Field Mice	Short Tail Shrew	Harvester Ants	Ant (Dorymyrmex)
Total excavation (m ³):	0.35	48.5	0.05	2.55
Activity index:	0.9	1.0	0.9	1.0
Depth of activity (m):	1.0	0.5	2.0	1.5
Proportion moved from:				
Soil strata 1	0.95	1.0	0.7	0.8
Soil strata 2	0.05	0.0	0.1	0.15
Soil strata 3	0.0	0.0	0.1	0.05
Waste inventory	0.0	0.0	0.1	0.0

Table 3.2-4. Decayed Radionuclide Concentrations for
Reference Arid and Humid Waste Spectra

Radio- nuclide	Reference Arid Site		Reference Humid Site	
	Total for Waste Spectrum 1 (Ci/m ³)	Total for Waste Spectrum 2 (Ci/m ³)	Total for Waste Spectrum 1 (Ci/m ³)	Total for Waste Spectrum 2 (Ci/m ³)
H-3	4.0E-02 ^(b)	6.2E-02	2.8E-02	3.6E-02
C-14	4.0E-03	5.3E-03	2.2E-03	3.0E-03
Fe-55	5.0E-01	6.2E-01	6.3E-01	7.8E-01
Ni-59	1.7E-03	2.1E-03	2.2E-03	2.6E-03
Co-60	1.4E+00	1.7E+00	1.7E+00	2.1E+00
Ni-63	1.4E-01	1.7E-01	1.8E-01	2.1E-01
Nb-94	5.4E-05	6.7E-05	6.8E-05	8.4E-05
Sr-90	4.1E-03	5.2E-03	4.1E-03	4.7E-03
Tc-99	6.4E-05	7.8E-05	7.8E-05	9.8E-05
I-129	1.7E-04	2.1E-04	2.2E-04	4.2E-06
Cs-135	6.4E-05	7.8E-05	8.0E-05	9.8E-05
Cs-137	1.4E+00	1.8E+00	1.8E+00	2.2E+00
U-235	2.9E-05	8.7E-05	2.2E-05	6.3E-05
U-238	2.9E-05	5.4E-04	1.3E-04	3.9E-04
Np-237	9.6E-11	1.2E-10	1.2E-10	1.4E-10
Pu-238	5.2E-04	5.8E-04	6.3E-04	8.3E-04
Pu-239/240	4.4E-04	5.9E-04	5.5E-04	7.0E-04
Pu-241	1.4E-02	1.9E-02	1.8E-02	2.3E-02
Pu-242	9.7E-07	1.3E-06	1.2E-06	1.5E-06
Am-241	3.8E-04	5.3E-04	4.8E-04	6.1E-04
Am-243	2.3E-05	3.2E-05	2.8E-05	3.7E-05
Cm-243	4.2E-07	6.1E-07	5.1E-07	6.9E-07
Cm-244	2.7E-04	3.8E-04	3.2E-04	4.3E-04
Totals	3.5E+00	4.2E+00	4.5E+00	5.3E+00

(a) Based on information in Appendix D of (U.S. Nuclear Regulatory Commission 1981).

(b) Where 4.0E-02 = 4.0×10^{-2} .

The end of a set of records is signaled by '**' in the element field. Exhaustive output with intermediate parameter values (lun 3) is available for debugging purposes and hand calculation verification. Logical unit number 1 is reserved for future plotting files. On the CDC computer the BIOPORT report file will be stored in the file named OUTPUT, the radionuclide concentrations in the file named TAPE30, and the optional exhaustive report in the file named TAPE3.

Table 3.2-5. BIOPORT/MAXII Input Parameter Descriptions

<u>Parameter Name</u>	<u>No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
AMT	(10)	Real	The total amount of soil brought to the surface during the first year of activity by each animal species in cubic meters per hectare.
AWI	(100)	Alpha	Two character element symbol of radionuclide in waste package inventory.
BIOMAS	(10,5)	Real	BIOMAS(i,j) is the total net annual production during successional phase j (of each plant i) in grams(dry) /square meter per year.
CNAME	(2,10)	Alpha	Sixteen character descriptive name of each animal species.
DEPTH	(5)	Real	The depth of each soil strata in meters. CREATE calculates this parameter from the user-input values of THICK.
ELTI	(100)	Alpha	Atomic number of a radionuclide. Input can be up to six characters in length and include metastable (M) and daughter (+D) designation, (e.g., TE127M+D).
ERL		Real	Baseline erosion constant in units of cm/yr.
ERU		Real	Maximum erosion constant in units of cm/yr.
IBIO	(5)	Integer	Plant productivity flag: 0 - constant productivity 1 - productivity changes linearly during each successional phase.
IER		Integer	Starting year for maximum erosion.

Table 3.2-5. BIOPORT/MAXII Input Parameter Descriptions - Continued

<u>Parameter Name</u>	<u>No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
IMAX	(20)	Integer	Selected years for MAXII output. Values must be arranged in ascending order. $1 \leq \text{IMAX}(i) \leq \text{NYRS}$. Default values are calculated by CREATE based on the value of NMAX.
IRCY	(5)	Integer	Recycling rate flag: 0 - rate is constant during each successional phase, 1 - rate linearly changes, reaching a maximum at the end of a successional phase.
ISUCC	(10)	Integer	The number of successional phases for each plant. Maximum allowed: 5.
JER		Integer	Frequency of maximum erosion in years.
KORG	(5)	Integer	Index of selected organs: 1 - Total Body 2 - Bone 3 - Lungs 4 - Thyroid 5 - Lower large intestine-GI tract. CREATE determines and prints the corresponding MAXII organ index. $1 \leq \text{KORG}(i) \leq 5$. Default values: 1,2,3,4,5.
NBUG		Integer	Exhaustive output selection index: 0 - no exhaustive output >0 - print out intermediate calculations for all radionuclides for NBUG years. $0 \leq \text{NBUG} \leq \text{NYRS}$. Default values 0.
NCHK		Integer	Frequency for BIOPORT output. Not currently implemented. NMAX and IMAX control output.
NCRIT		Integer	The number of animal species to be considered. Maximum allowed: 10.

Table 3.2-5. BIOPORT/MAXI1 Input Parameter Descriptions - Continued

<u>Parameter Name</u>	<u>No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
NER		Integer	Duration of maximum erosion periods, years.
NIN		Integer	The number of radionuclides in the waste package inventory.
NLYRS		Integer	Number of strata above the waste site, soil surface excluded. $1 \leq \text{NLYRS} \leq 3$. Default value: 3.
NMAX		Integer	Number of years for which MAXI1 output is to be generated. $1 \leq \text{NMAX} \leq \text{NYRS}$. Default value: 5.
NORG		Integer	Number of organs that doses will be calculated for. $1 \leq \text{NORG} \leq 5$. Default value: 5.
NPLTS		Integer	The number of plant associations to be considered. Maximum allowed: 10.
NYSUC	(10,6)	Integer	The endpoint year for each successional phase for each plant.
NYRS		Integer	Number of years to simulate biological transport activities. The minimum value is 1. The maximum value is 9999 (controlled by format statements only). (Default value is 500.)
PACTVE	(10,2)	Real	Activity index for the remainder of each animal's lifecycle in relation to activity in the first year. $0 \leq \text{PACTVE}(i,j) \leq 1$.
PL		Real	The half-life of the package at closure of the site in years.
PLI		Real	The average age of the package at site closure in years.
PMODEL		Integer	Plant model selection index: 1 - plant uptake of radionuclides

Table 3.2-5. BIOPORT/MAXI1 Input Parameter Descriptions - Continued

<u>Parameter Name</u>	<u>No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
PMODEL (continued)			relies on any contact with roots. 2 - plant uptake of radionuclides proportioned by fraction of root in contact with the waste. Default value: 2.
PMOIST	(10)	Real	Input to CREATE as the dry/wet weight ratio of each plant. Converted to the proportion of each plant association composed of H2O by CREATE for input to BIOPORT. $0 \leq \text{PMOIST}(n) \leq 1$.
PMOVE	(10,5)	Real	PMOVE(i,j) is the proportion of the total amount of soil moved, AMT(i), by each animal species i from each strata j. $0 \leq \text{PMOVE}(i,j) \leq 1$.
PNAME	(2,10)	Alpha	The sixteen character descriptive name of each plant association.
PROOT	(10,5)	Real	PROOT(i,j) is the root to shoot ratio during successional phase j (for each plant i). $0 \leq \text{PROOT}(i,j) \leq 1$.
QI	(100)	Real	The quantity in curies of each radionuclide in the waste package inventory.
RANGP	(5)	Real	RANGP(j) is the maximum rooting depth during each successional phase j (for each plant i). Index IRANGP(i,j) is set by this input variable.
RANGC	(10)	Real	The maximum depth of activity for each animal species in meters.
RECYCL	(10,5)	Real	RECYCL(i,j) is the proportion of plant biomass recycled during successional phase k. $0 \leq \text{RECYCL}(i,j) \leq 1$.

Table 3.2-5. BIOPORT/MAXII Input Parameter Descriptions - Continued

<u>Parameter Name</u>	<u>No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
SROOT	(5,5,10)	Real	SROOT(j,k,i) is the proportion of roots during each successional phase j (for each plant i) of each soil strata k. $0 \leq \text{SROOT}(j,k,i) \leq 1$.
TITL	(10)	Alpha	Forty Character title for BIOPORT execution.
VOL	(5)	Double	The volume of each soil strata in cubic meters. VOL(1) is the soil surface volume. VOL(5) is the available inventory volume.

MAXII generates a report of input parameter descriptions and values and a set of tables for each selected year (1 to 6). For each selected year the following tables are generated:

- source term with organ solubility
- soil, air, and water concentrations of each radionuclide for the first year of the resident/intruder scenario (year 1)
- soil, air and water concentrations of each radionuclide for the last year of the resident/intruder scenario (year 50)
- maximum annual dose summary for each organ considered by exposure pathway of each radionuclide.

These reports should provide the user with adequate results. However, additional MAXII reports are available. Logical unit number 40 is reserved for a summary report intended for future plotting report capabilities.

3.4. Sample Problems

Five sample problems are included in this user's manual. The selection of the sample problems and their arrangement is designed to progressively acquaint the user with the interactive software. The sample problems demonstrate various capabilities of the software and also provide reference for verification purposes. To conserve space, only selected output from each sample problem is included in this section. However, complete output for all sample problems is included in Appendix 2 (on microfiche).

3.4.1. Sample Problem One

In the first problem, default values were used for all parameters to demonstrate the simplest level of user operation. The reference arid site scenario with Waste Spectrum 1 was the default selection of the CREATE computer program. Sample Problem One demonstrates how easy it is for the user to duplicate results published in McKenzie (et al. 1984) for the reference sites and defined Waste Spectra. Figure 3.4-1 is a facsimile of the interactive execution of the CREATE program that prepared input for Sample Problem One. Each box represents a terminal screen display. User input is printed in bold-face type. The symbol '<cr>' indicates the 'return' or 'enter' key of the keyboard. The input file for the BIOPORT program created by the Sample Problem One interactive session is shown in Figure 3.4-2. The MAXII execution file, shown in Figure 3.4-3, was also created by the Sample Problem One interactive session. Output from the BIOPORT computer program is shown in the following two figures. Figure 3.4-4 shows the beginning of the inventory concentration file generated by BIOPORT as input for the MAXII computer program. The complete BIOPORT report is shown in Figure 3.4-5. Selected portions of the MAXII output are shown in Figure 3.4-6. Doses resulting from radionuclide concentrations at year 100 of the biotic transport simulation are included for total bone and bone. The user may compare these results to those given for the Reference Arid Site with Waste Spectra 1 in McKenzie (et al. 1984). Complete output from Sample Problem One is included in Appendix 2 (on microfiche).

3.4.2. Sample Problem Two

Sample Problem Two illustrates how the user may modify radionuclide concentrations in the selected waste spectrum. The reference arid site scenario with Waste Spectrum 2 was selected for this sample problem. To demonstrate the inventory modification capability, the concentrations from Liquid Scintillation Wastes as itemized in McKenzie et al. (1982) were increased by a factor of 10. Thus the total concentration of the following radionuclides for Waste Spectrum 2 were changed as follows:

$$\begin{array}{l} {}^3\text{H} - 1.1 \times 10^{-1} \\ {}^{14}\text{C} - 9.5 \times 10^{-3} \\ {}^{90}\text{Sr} - 8.7 \times 10^{-3} \end{array}$$

The increase of Liquid Scintillation Wastes for ${}^{60}\text{Co}$, ${}^{99}\text{Tc}$, and ${}^{137}\text{Cs}$ did not affect the total Waste Spectrum 2 concentrations, which were dominated by Solid Reactor Wastes. Sample Problem Two also illustrates how the user may reduce program output by selecting only organs of interest. For this sample problem only doses to total body were calculated. Figure 3.4-7 is a facsimile of the interactive computer session that prepares input for the BIOPORT and MAXII computer codes. Figures 3.4-8 and 3.4-9 show selected portions of the BIOPORT report and MAXII output, respectively. Complete output from Sample Problem Two is included in Appendix 2.

```

#####
#
#               =====
#             CREATE-BIOPORT-MAXI
#             =====
#
#   This interactive program will assist you in the creation
#   of scenarios to be simulated by BIOPORT-MAXI.
#
#   The following notes may be of interest:
#   When you have finished reading, press <return> <cr>
#
#####

#####
#
#   1) If the default condition is selected, you need only
#       press <return>. YES-or-NO questions are designated by
#       (Y/N) and should be answered with a Y or N. The default
#       condition is always listed first.
#
#   2) The values you enter will be tested against reasonable
#       limits and if they are not accepted you will be asked to
#       supply another value.
#
#   3) [Strata] and [layer] are used interchangeably to define
#       the soil compartments.
#
#####

#####
#
#   4) One hectare = 2.471 acres = 10000 square meters.
#
#   5) A successional phase of a plant or animal can be des-
#       cribed as the replacement of one community with another
#
#       When you have finished reading, press <return> <cr>
#
#       =====
#
#   Enter an identifying title for this run (up to 40 letters long):
#   Sample Problem One <cr>
#
#####

```

Figure 3.4-1. Sample Problem One Interactive Session

```

#####
#
#
#
# The length of the simulation is 500 years.
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####

#####
#
# During the simulation, printed reports and MAXII input will
# be generated from radionuclide concentrations in the
# following years:
#
#         1
#        100
#        200
#        300
#        500
#
# =====
# Do you wish to review or change above parameters (N/Y)? <cr>
#
#####

#####
#
#
# Exhaustive yearly output is available:
#
#     0 - Option not selected
#     1 - Option selected
#
# Default value: 0
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#####

```

Figure 3.4-1. Sample Problem One Interactive Session (Continued)

```

#####
#
# In MAXII doses to various organs will be calculated.
# The available organs are:
#
#     1-Total body
#     2-Bone
#     3-Lungs
#     4-Thyroid
#     5-Lower large intestine
#
# The number of organs considered is 5.
# -----
# Do you wish to change this value (N/Y)? <cr>
#####

#####
#
# Two "base cases" are available to provide default values:
#
#     1 - Arid reference site
#     2 - Humid reference site
#
# Please enter number of selected site: (Default=1)
# -----
# Do you wish to change this value (N/Y)? <cr>
#####

#####
#
# Waste Spectrum 1 is representative of past and current
# waste storage practices. Waste Spectrum 2 represents
# improved practices of the future.
#
# The "base case" inventory for the arid site will be:
#     1 - Waste Spectrum 1
#     2 - Waste Spectrum 2
#     3 - User-defined
#
# Enter index of selected option: (Default=1)
# -----
# Do you wish to change this value (N/Y)? <cr>
#####

```

Figure 3.4-1. Sample Problem One Interactive Session (Continued)

```

#####
#
#
#
# The decomposition half-life of the package at closure
# is 35.00 years.
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####

#####
#
#
#
# The average age of the waste packages at time of site closure
# is 10.00 years.
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####

#####
#
#
#
# =====
# Do you wish to review or change any of the above parameters (N/Y)? <cr>
#
#
#
#
#
#
#
#####

```

Figure 3.4-1. Sample Problem One Interactive Session (Continued)


```

#####
#
#           Radiological inventory (Ci/cubic meter):
#
#           H 3      4.00E-02      C 14      4.00E-03
#           FE55     0.50          NI59     1.70E-03
#           CO60      1.4          NI63     0.14
#           NB94     5.40E-05      SR90     4.10E-03
#           TC99     6.40E-05      I 129    1.70E-04
#           CS135    6.40E-05      CS137     1.4
#           U 235    2.90E-05      U 238    2.90E-05
#           NP237    9.60E-11      PU238    5.20E-04
#           PU239    2.20E-04      PU240    2.20E-04
#           PU241    1.40E-02      PU242    9.70E-07
#           AM241    3.80E-04      AM243    2.30E-05
#           CM243    4.20E-07      CM244    2.70E-04
#
#           =====
#
#           Do you wish to review or change the above      parameters (N/Y)? <cr>
#
#           Do you wish to add radionuclides to the above inventory (N/Y)? <cr>
#
#####

#####
#
#
#
#           =====
#           Do you wish to review or change strata & erosion parameters (N/Y)? <cr>
#
#
#
#           =====
#           Do you wish to review or change plants          parameters (N/Y)? <cr>
#
#
#
#           =====
#           Do you wish to review or change animals        parameters (N/Y)? <cr>
#
#
#
#####

```

Figure 3.4-1. Sample Problem One Interactive Session (Continued)

```

SAMPLE PROBLEM ONE
500      0      3      3      3
2
5
1      100     200     300     500
0
2.300      0.0000E+00      1      4      600
0.5000      1.000      1.500
5000.      5000.      5000.      0.6500E+05
0.35E+02
0.10E+02
24
H 3      00000      4.00E-02
C 14      00000      4.00E-03
FE55      00000      0.50
NI59      00000      1.70E-03
CO60      00000      1.4
NI63      00000      0.14
NB94      00000      5.40E-05
SR90      00000      4.10E-03
TC99      00000      6.40E-05
I 129      00000      1.70E-04
CS135      00000      6.40E-05
CS137      00000      1.4
U 235      00000      2.90E-05
U 238      00000      2.90E-05
NP237      00000      9.60E-11
PU238      00000      5.20E-04
PU239      00000      2.20E-04
PU240      00000      2.20E-04
PU241      00000      1.40E-02
PU242      00000      9.70E-07
AM241      00000      3.80E-04
AM243      00000      2.30E-05
CM243      00000      4.20E-07
CM244      00000      2.70E-04
Cheatgrass Comm
3      0.8500
0.7500      0.7500      0.7500
0.20E+01      0.20E+01      0.20E+01
0.7200      0.1700      0.0700      0.0400      0.0000
0.7200      0.1700      0.0700      0.0400      0.0000
0.7200      0.1700      0.0700      0.0400      0.0000
0      10      30      500
272.0000      0.0000      0.0000
1.0000      1.0000      1.0000
0 0 0
0 0 0
Rabbitbrush Comm
3      0.8500
3.0000      3.0000      3.0000
0.20E+01      0.20E+01      0.20E+01
0.5650      0.2450      0.1350      0.0550      0.0000
0.5650      0.2450      0.1350      0.0550      0.0000
0.5650      0.2450      0.1350      0.0550      0.0000
0      10      30      500
0.0000      104.0000      0.0000
1.0000      1.0000      1.0000
0 0 0
0 0 0

```

Figure 3.4-2. Sample Problem One BIOPORT Input File

```

Sagebrush Comm
  3 0.8500
    5.0000 5.0000 5.0000
    0.20E+01 0.20E+01 0.20E+01
      0.6100 0.2300 0.1100 0.0500 0.0000
      0.6100 0.2300 0.1100 0.0500 0.0000
      0.6100 0.2300 0.1100 0.0500 0.0000
    0 10 30 500
      0.0000 0.0000 117.0000
      1.0000 1.0000 1.0000
0 0 0
0 0 0
Pocket Mice
  0.1000 2.0000
  1.0000 0.8750
  0.7000 0.2000 0.0500 0.0500 0.0000
Badgers
  0.2110 2.0000
  1.0000 1.0000
  0.7000 0.1500 0.0500 0.1000 0.0000
Harvester Ants
  0.1000 2.0000
  1.0000 1.0000
  0.7000 0.1000 0.1000 0.1000 0.0000

```

Figure 3.4-2. Sample Problem One BIOPORT Input File (Continued)

```

ASSIGN [BIO.NEW]RMDLIB.DAT FOR010
ASSIGN [BIO.NEW]FILE20.DAT FOR020
ASSIGN [BIO.NEW]FILE21.DAT FOR021
ASSIGN [BIO.NEW]PLANSOURC.SUR FOR022
ASSIGN [BIO.NEW]FILE23.DAT FOR023
ASSIGN [BIO.NEW]FILE24.DAT FOR024
ASSIGN [BIO.NEW]FILE25.DAT FOR025
ASSIGN [BIO.NEW]BURIEDONE.DAT FOR027
ASSIGN [BIO.START]SAM1.INV FOR030
ASSIGN [BIO.START]SAM1.MOT FOR006
ASSIGN [BIO.SIART]SAM1.SUM FOR040
RUN DISK1:[HDW]MAXI1
SAMPLE PROBLEM ONE : BIOPORT Simulation year 1
$INPUT NEXT=1, IFOD=1, IMO=0, RF1=1.0, RF2=0.,
IARG=0, IWAT=0, IEXT=0, IAIR=0, XFACT=1.33E-11,
AGE=20.0, XDPT=0.067, RINH=0.3, M3M2=0, INTRUD=0,
IT1=0, IT2=49, NORG=5, KORG(1)= 1, 6, 8,16,23,
IOUT=0, IBIO=1, $END
0 0
SAMPLE PROBLEM ONE : BIOPORT Simulation year 100
$INPUT NEXT=5 $END
SAMPLE PROBLEM ONE : BIOPORT Simulation year 200
$INPUT NEXT=5 $END
SAMPLE PROBLEM ONE : BIOPORT Simulation year 300
$INPUT NEXT=5 $END
SAMPLE PROBLEM ONE : BIOPORT Simulation year 500
$INPUT NEXT=5 $END
END OF RUN
$INPUT NEXT=4 $END

```

Figure 3.4-3. Sample Problem One MAXI1 Input File

```

SAMPLE PROBLEM ONE
1 Concentrations in this year of BIOPORT simulation:
H 3 11111 0.25E+05
C 14 11211 0.27E+04
FE55 11311 0.26E+06
CO60 11311 0.97E+06
NI59 11311 0.15E+04
NI63 11311 0.13E+06
NB94 11311 0.43E+02
SR90 11311 0.13E+05
Y 90 11311 0.28E+04
MO99 11311 0.00E+00
TC99M 11311 0.00E+00
TC99 11311 0.24E+03
I 129 11211 0.16E+03
CS135 11111 0.45E+02
CS137 11111 0.96E+06
BA137M 11311 0.95E+06
U 235 22322 0.20E+02
TH231 22322 0.21E+02
PA231 22322 0.43E-03
AC227 22322 0.68E-05
TH227 22322 0.59E-05
FR223 22322 0.90E-07
RA223 22322 0.52E-05
NP237 22322 0.68E-04
PA233 22322 0.68E-04
U 233 22322 0.26E-09
TH229 22322 0.12E-13
RA225 22322 0.97E-14
AC225 22322 0.89E-14
U 238 22322 0.20E+02
TH234 22322 0.21E+02
PA234M 22322 0.20E+02
PA234 22322 0.27E-01
PU242 22322 0.66E+00
NP238 22322 0.00E+00
PU238 22322 0.35E+03
CM244 22322 0.18E+03
PU244 22322 0.00E+00
U 240 22322 0.00E+00
PU240 22322 0.15E+03
CM243 22322 0.29E+00
PU243 22322 0.00E+00
AM243 22322 0.16E+02
NP239 22322 0.16E+02
PU239 22322 0.15E+03
PU241 22322 0.90E+04
AM241 22322 0.27E+03
**
100 Concentrations in this year of BIOPORT simulation:
H 3 11111 0.34E+05
C 14 11211 0.90E+06
FE55 11311 0.39E+02
CO60 11311 0.82E+03
NI59 11311 0.57E+06
NI63 11311 0.23E+08
NB94 11311 0.16E+05
SR90 11311 0.49E+06

```

Figure 3.4-4. Sample Problem One Inventory File, Page 1

SAMPLE PROBLEM ONE

Program :BIOPORT Run :29-JUN-84 10:17:15
Version :6/20/84

PLANT MODEL : Only Biomass in Contact with Waste

Simulation Period (years) : 100
Strata Identification : DEPTH VOLUME CODE
surface 0.00E+00 (0)
0.5m 0.50E+04 (1)
1.0m 0.50E+04 (2)
1.5m 0.50E+04 (3)
inventory 0.65E+05 (4)

Number of plant associations : 3 Number of animal species : 3

Erosion constant cm/yr (high) : 2.30000 (low) : 0.00000
High erosion - starting year : 1 duration : 4
frequency : 600

Conversion for m3 to gm : 0.170000E+07
Conversion for Ci/ha to pCi/m2: 1.00E+08

Radionuclide input inventory	ELT.	WT.	(CI/M**3)
	H	3	0.400E-01
	C	14	0.400E-02
	FE	55	0.500E+00
	NI	59	0.170E-02
	CO	60	0.140E+01
	NI	63	0.140E+00
	NB	94	0.540E-04
	SR	90	0.410E-02
	TC	99	0.640E-04
	I	129	0.170E-03
	CS	135	0.640E-04
	CS	137	0.140E+01
	U	235	0.290E-04
	U	238	0.290E-04
	NP	237	0.960E-10
	PU	238	0.520E-03
	PU	239	0.220E-03
	PU	240	0.220E-03
	PU	241	0.140E-01
	PU	242	0.970E-06
	AM	241	0.380E-03
	AM	243	0.230E-04
	CM	243	0.420E-06
	CM	244	0.270E-03

Figure 3.4-5. Sample Problem One BIOPORT Report

Title of radionuclide master library:
 ONSITE/BIOPORT RADIONUCLIDE MASTER DATA LIBRARY 1-JUN-84 RAP

Radionuclide parent and daughter parameters:

	:	ELT.	WT.	DECAY	CNST	CONC	RATIO	CURIES
H	3			0.561E-01		0.000E+00		0.260E+04
C	14			0.121E-03		0.000E+00		0.260E+03
FE	55			0.257E+00		0.400E-03		0.325E+05
CO	60			0.132E+00		0.940E-02		0.910E+05
NI	59			0.923E-05		0.190E-01		0.111E+03
NI	63			0.721E-02		0.190E-01		0.910E+04
NB	94			0.347E-04		0.940E-02		0.351E+01
SR	90			0.243E-01		0.200E+00		0.267E+03
Y	90			0.948E+02		0.250E-02		0.000E+00
MO	99			0.920E+02		0.130E+00		0.000E+00
TC	99M			0.101E+04		0.250E+00		0.000E+00
TC	99			0.325E-05		0.250E+00		0.416E+01
I	129			0.443E-07		0.200E-01		0.111E+02
CS	135			0.301E-06		0.200E-02		0.416E+01
CS	137			0.230E-01		0.200E-02		0.910E+05
BA	137M			0.143E+06		0.500E-02		0.000E+00
U	235			0.977E-09		0.250E-02		0.188E+01
TH	231			0.239E+03		0.420E-02		0.000E+00
PA	231			0.213E-04		0.250E-02		0.000E+00
AC	227			0.318E-01		0.250E-02		0.000E+00
TH	227			0.135E+02		0.420E-02		0.000E+00
FR	223			0.168E+05		0.000E+00		0.000E+00
RA	223			0.222E+02		0.140E-02		0.000E+00
NP	237			0.324E-06		0.250E-02		0.624E-05
PA	233			0.937E+01		0.250E-02		0.000E+00
U	233			0.437E-05		0.250E-02		0.000E+00
TH	229			0.944E-04		0.420E-02		0.000E+00
RA	225			0.171E+02		0.140E-02		0.000E+00
AC	225			0.253E+02		0.140E-02		0.000E+00
U	238			0.153E-09		0.250E-02		0.188E+01
TH	234			0.105E+02		0.420E-02		0.000E+00
PA	234M			0.311E+06		0.250E-02		0.000E+00
PA	234			0.900E+03		0.250E-02		0.000E+00
PU	242			0.179E-05		0.250E-03		0.631E-01
NP	238			0.116E+03		0.250E-02		0.000E+00
PU	238			0.788E-02		0.250E-03		0.338E+02
CM	244			0.383E-01		0.250E-02		0.175E+02
PU	244			0.838E-08		0.250E-03		0.000E+00
U	240			0.430E+03		0.250E-02		0.000E+00
PU	240			0.106E-03		0.250E-03		0.143E+02
CM	243			0.243E-01		0.250E-02		0.273E-01
PU	243			0.123E+04		0.250E-03		0.000E+00
AM	243			0.937E-04		0.250E-03		0.150E+01
NP	239			0.107E+03		0.250E-02		0.000E+00
PU	239			0.284E-04		0.250E-03		0.143E+02
PU	241			0.481E-01		0.250E-03		0.910E+03
AM	241			0.160E-02		0.250E-03		0.247E+02

Figure 3.4-5. Sample Problem One BIOPORT Report (Continued)

PLANT ASSOCIATION - Cheatgrass Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	0.750000	0.750000	0.750000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	272.000	0.000000E+00	0.000000E+00
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1		0.7200	0.7200	0.7200
Strata : 2		0.1700	0.1700	0.1700
Strata : 3		0.0700	0.0700	0.0700
Strata : 4		0.0400	0.0400	0.0400

PLANT ASSOCIATION - Rabbitbrush Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	3.00000	3.00000	3.00000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	104.000	0.000000E+00
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1		0.5650	0.5650	0.5650
Strata : 2		0.2450	0.2450	0.2450
Strata : 3		0.1350	0.1350	0.1350
Strata : 4		0.0550	0.0550	0.0550

PLANT ASSOCIATION - Sagebrush Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	5.00000	5.00000	5.00000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	0.000000E+00	117.000
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1		0.6100	0.6100	0.6100
Strata : 2		0.2300	0.2300	0.2300
Strata : 3		0.1100	0.1100	0.1100
Strata : 4		0.0500	0.0500	0.0500

Figure 3.4-5. Sample Problem One BIOPORT Report (Continued)

ANIMAL SPECIES - Pocket Mice
 Amount of material moved (m³/ha) 0.100000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 0.8750

Proportion of material moved to surface by strata

1	2	3	4
0.7000	0.2000	0.0500	0.0500

ANIMAL SPECIES - Badgers
 Amount of material moved (m³/ha) 0.211000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 1.0000

Proportion of material moved to surface by strata

1	2	3	4
0.7000	0.1500	0.0500	0.1000

ANIMAL SPECIES - Harvester Ants
 Amount of material moved (m³/ha) 0.100000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 1.0000

Proportion of material moved to surface by strata

1	2	3	4
0.7000	0.1000	0.1000	0.1000

Input prepared by R. A. Delgarn Date 5-SEP-84
 Input checked by R. A. Delgarn Date 5-SEP-84

Figure 4.5-5. Sample Problem One BIOPORT Report (Continued)

Simulation for YEAR 100

Total Curies / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
H 3	0.00E+00	0.00E+00	0.34E-03	0.73E-06	0.18E-06	0.84E+01	0.11E+01	0.34E+05
C 14	0.00E+00	0.00E+00	0.90E-02	0.12E-04	0.71E-06	0.23E+03	0.29E+02	0.90E+06
FE 55	0.00E+00	0.00E+00	0.39E-06	0.81E-07	0.43E-07	0.23E-06	0.26E-07	0.39E+02
CO 60	0.00E+00	0.00E+00	0.82E-05	0.55E-06	0.27E-06	0.15E+00	0.20E-01	0.82E+03
NI 59	0.00E+00	0.00E+00	0.57E-02	0.51E-03	0.24E-03	0.98E+02	0.12E+02	0.57E+06
NI 63	0.00E+00	0.00E+00	0.23E+00	0.20E-01	0.98E-02	0.39E+04	0.50E+03	0.23E+08
NB 94	0.00E+00	0.00E+00	0.16E-03	0.94E-05	0.45E-05	0.31E+01	0.40E+00	0.16E+05
SR 90	0.00E+00	0.00E+00	0.49E-02	0.11E-02	0.55E-03	0.21E+02	0.26E+01	0.49E+06
Y 90	0.00E+00	0.00E+00	0.48E-02	0.11E-02	0.54E-03	0.21E+02	0.26E+01	0.48E+06
MO 99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99	0.00E+00	0.00E+00	0.11E-02	0.25E-03	0.12E-03	0.37E+01	0.47E+00	0.11E+06
I 129	0.00E+00	0.00E+00	0.59E-03	0.55E-04	0.26E-04	0.98E+01	0.13E+01	0.59E+05
CS 135	0.00E+00	0.00E+00	0.16E-03	0.35E-05	0.17E-05	0.37E+01	0.47E+00	0.16E+05
CS 137	0.00E+00	0.00E+00	0.34E+00	0.48E-02	0.21E-02	0.81E+04	0.10E+04	0.34E+08
BA 137M	0.00E+00	0.00E+00	0.32E+00	0.46E-02	0.21E-02	0.77E+04	0.98E+03	0.32E+08
U 235	0.00E+00	0.00E+00	0.77E-04	0.26E-05	0.13E-05	0.17E+01	0.21E+00	0.77E+04
TH 231	0.00E+00	0.00E+00	0.77E-04	0.26E-05	0.13E-05	0.17E+01	0.21E+00	0.77E+04
PA 231	0.00E+00	0.00E+00	0.69E-05	0.13E-05	0.71E-06	0.36E-02	0.45E-03	0.69E+03
AC 227	0.00E+00	0.00E+00	0.69E-05	0.13E-05	0.71E-06	0.25E-02	0.32E-03	0.69E+03
TH 227	0.00E+00	0.00E+00	0.68E-05	0.13E-05	0.70E-06	0.24E-02	0.31E-03	0.68E+03
FR 223	0.00E+00	0.00E+00	0.18E-06	0.37E-07	0.19E-07	0.34E-04	0.44E-05	0.18E+02
RA 223	0.00E+00	0.00E+00	0.69E-05	0.13E-05	0.71E-06	0.25E-02	0.32E-03	0.69E+03
NP 237	0.00E+00	0.00E+00	0.68E-05	0.13E-05	0.71E-06	0.58E-05	0.71E-06	0.68E+03
PA 233	0.00E+00	0.00E+00	0.68E-05	0.13E-05	0.71E-06	0.58E-05	0.71E-06	0.68E+03
U 233	0.00E+00	0.00E+00	0.68E-05	0.13E-05	0.71E-06	0.31E-06	0.31E-09	0.68E+03
TH 229	0.00E+00	0.00E+00	0.67E-05	0.13E-05	0.71E-06	0.30E-06	0.19E-11	0.67E+03
RA 225	0.00E+00	0.00E+00	0.67E-05	0.13E-05	0.71E-06	0.30E-06	0.19E-11	0.67E+03
AC 225	0.00E+00	0.00E+00	0.67E-05	0.13E-05	0.71E-06	0.30E-06	0.19E-11	0.67E+03
U 238	0.00E+00	0.00E+00	0.77E-04	0.26E-05	0.13E-05	0.17E+01	0.21E+00	0.77E+04
TH 234	0.00E+00	0.00E+00	0.77E-04	0.26E-05	0.13E-05	0.17E+01	0.21E+00	0.77E+04
PA 234M	0.00E+00	0.00E+00	0.77E-04	0.26E-05	0.13E-05	0.17E+01	0.21E+00	0.77E+04
PA 234	0.00E+00	0.00E+00	0.19E-06	0.22E-07	0.11E-07	0.22E-02	0.28E-03	0.19E+02
PU 242	0.00E+00	0.00E+00	0.90E-05	0.14E-05	0.71E-06	0.56E-01	0.71E-02	0.90E+03
NP 238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 238	0.00E+00	0.00E+00	0.55E-03	0.26E-05	0.99E-06	0.14E+02	0.17E+01	0.55E+05
CM 244	0.00E+00	0.00E+00	0.16E-04	0.71E-06	0.36E-06	0.34E+00	0.43E-01	0.16E+04
PU 244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U 240	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 240	0.00E+00	0.00E+00	0.51E-03	0.28E-05	0.11E-05	0.13E+02	0.16E+01	0.51E+05
CM 243	0.00E+00	0.00E+00	0.32E-05	0.64E-06	0.34E-06	0.21E-02	0.27E-03	0.32E+03
PU 243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 243	0.00E+00	0.00E+00	0.59E-04	0.15E-05	0.75E-06	0.13E+01	0.17E+00	0.59E+04
NP 239	0.00E+00	0.00E+00	0.59E-04	0.15E-05	0.75E-06	0.13E+01	0.17E+00	0.59E+04
PU 239	0.00E+00	0.00E+00	0.51E-03	0.28E-05	0.11E-05	0.13E+02	0.16E+01	0.51E+05
PU 241	0.00E+00	0.00E+00	0.26E-03	0.11E-05	0.42E-06	0.66E+01	0.84E+00	0.26E+05
AM 241	0.00E+00	0.00E+00	0.17E-02	0.62E-05	0.21E-05	0.42E+02	0.54E+01	0.17E+06
Total	0.00E+00	0.00E+00	0.92E+00	0.33E-01	0.15E-01	0.20E+05	0.26E+04	

Figure 3.4-5. Sample Problem One BIOPORT Report (Continued)

Simulation for YEAR 72

Maximum Year

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
H 3	0.00E+00	0.00E+00	0.10E-02	0.12E-05	0.16E-06	0.37E+02	0.90E+01	0.10E+06
C 14	0.00E+00	0.00E+00	0.57E-02	0.57E-05	0.43E-06	0.21E+03	0.51E+02	0.57E+06
FE 55	0.00E+00	0.00E+00	0.40E-06	0.81E-07	0.43E-07	0.25E-03	0.61E-04	0.40E+02
CO 60	0.00E+00	0.00E+00	0.19E-03	0.96E-05	0.46E-05	0.55E+01	0.14E+01	0.19E+05
NI 59	0.00E+00	0.00E+00	0.36E-02	0.30E-03	0.15E-03	0.89E+02	0.22E+02	0.36E+06
NI 63	0.00E+00	0.00E+00	0.17E+00	0.15E-01	0.72E-02	0.43E+04	0.11E+04	0.17E+08
NB 94	0.00E+00	0.00E+00	0.99E-04	0.56E-05	0.27E-05	0.28E+01	0.69E+00	0.99E+04
SR 90	0.00E+00	0.00E+00	0.59E-02	0.13E-02	0.65E-03	0.37E+02	0.91E+01	0.59E+06
Y 90	0.00E+00	0.00E+00	0.58E-02	0.13E-02	0.64E-03	0.37E+02	0.91E+01	0.58E+06
MO 99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99	0.00E+00	0.00E+00	0.64E-03	0.15E-03	0.73E-04	0.33E+01	0.82E+00	0.64E+05
I 129	0.00E+00	0.00E+00	0.37E-03	0.33E-04	0.16E-04	0.89E+01	0.22E+01	0.37E+05
CS 135	0.00E+00	0.00E+00	0.10E-03	0.21E-05	0.10E-05	0.33E+01	0.82E+00	0.10E+05
CS 137	0.00E+00	0.00E+00	0.40E+00	0.53E-02	0.24E-02	0.14E+05	0.34E+04	0.40E+08
BA 137M	0.00E+00	0.00E+00	0.38E+00	0.52E-02	0.24E-02	0.13E+05	0.32E+04	0.38E+08
U 235	0.00E+00	0.00E+00	0.49E-04	0.15E-05	0.76E-06	0.15E+01	0.37E+00	0.49E+04
TH 231	0.00E+00	0.00E+00	0.49E-04	0.15E-05	0.77E-06	0.15E+01	0.37E+00	0.49E+04
PA 231	0.00E+00	0.00E+00	0.44E-05	0.83E-06	0.43E-06	0.23E-02	0.57E-03	0.44E+03
AC 227	0.00E+00	0.00E+00	0.43E-05	0.83E-06	0.43E-06	0.14E-02	0.35E-03	0.43E+03
TH 227	0.00E+00	0.00E+00	0.43E-05	0.81E-06	0.43E-06	0.14E-02	0.34E-03	0.43E+03
FR 223	0.00E+00	0.00E+00	0.15E-06	0.30E-07	0.16E-07	0.19E-04	0.48E-05	0.15E+02
RA 223	0.00E+00	0.00E+00	0.43E-05	0.83E-06	0.43E-06	0.14E-02	0.35E-03	0.43E+03
NP 237	0.00E+00	0.00E+00	0.43E-05	0.83E-06	0.43E-06	0.52E-05	0.12E-05	0.43E+03
PA 233	0.00E+00	0.00E+00	0.43E-05	0.83E-06	0.43E-06	0.52E-05	0.12E-05	0.43E+03
U 233	0.00E+00	0.00E+00	0.43E-05	0.83E-06	0.43E-06	0.19E-06	0.39E-09	0.43E+03
TH 229	0.00E+00	0.00E+00	0.43E-05	0.83E-06	0.43E-06	0.19E-06	0.18E-11	0.43E+03
RA 225	0.00E+00	0.00E+00	0.43E-05	0.83E-06	0.43E-06	0.19E-06	0.19E-11	0.43E+03
AC 225	0.00E+00	0.00E+00	0.43E-05	0.83E-06	0.43E-06	0.19E-06	0.19E-11	0.43E+03
U 238	0.00E+00	0.00E+00	0.49E-04	0.15E-05	0.76E-06	0.15E+01	0.37E+00	0.49E+04
TH 234	0.00E+00	0.00E+00	0.49E-04	0.15E-05	0.77E-06	0.15E+01	0.37E+00	0.49E+04
PA 234M	0.00E+00	0.00E+00	0.49E-04	0.15E-05	0.76E-06	0.15E+01	0.37E+00	0.49E+04
PA 234	0.00E+00	0.00E+00	0.15E-06	0.20E-07	0.11E-07	0.20E-02	0.48E-03	0.15E+02
PU 242	0.00E+00	0.00E+00	0.57E-05	0.83E-06	0.43E-06	0.51E-01	0.12E-01	0.57E+03
NP 238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 238	0.00E+00	0.00E+00	0.43E-03	0.17E-05	0.70E-06	0.15E+02	0.38E+01	0.43E+05
CM 244	0.00E+00	0.00E+00	0.28E-04	0.82E-06	0.41E-06	0.90E+00	0.22E+00	0.28E+04
PU 244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U 240	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 240	0.00E+00	0.00E+00	0.32E-03	0.16E-05	0.68E-06	0.11E+02	0.28E+01	0.32E+05
CM 243	0.00E+00	0.00E+00	0.26E-05	0.51E-06	0.27E-06	0.38E-02	0.93E-03	0.26E+03
PU 243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 243	0.00E+00	0.00E+00	0.37E-04	0.90E-06	0.46E-06	0.12E+01	0.29E+00	0.37E+04
NP 239	0.00E+00	0.00E+00	0.38E-04	0.92E-06	0.46E-06	0.12E+01	0.29E+00	0.38E+04
PU 239	0.00E+00	0.00E+00	0.32E-03	0.16E-05	0.68E-06	0.11E+02	0.28E+01	0.32E+05
PU 241	0.00E+00	0.00E+00	0.64E-03	0.19E-05	0.68E-06	0.23E+02	0.56E+01	0.64E+05
AM 241	0.00E+00	0.00E+00	0.11E-02	0.35E-05	0.13E-05	0.39E+02	0.96E+01	0.11E+06
Total	0.00E+00	0.00E+00	0.99E+00	0.29E-01	0.14E-01	0.32E+05	0.79E+04	

Figure 3.4-5. Sample Problem One BIOPORT Report (Continued)

MAXI - Maximum Annual Dose Calculation Version VAX2.2 25-APR-84
Executed on 3-MAY-84 at 07:38:10
Case title: SAMPLE PROBLEM ONE

RADIONUCLIDE CHAIN LIBRARY USED: RADIONUCLIDE MASTER DATA LIBRARY /w TRANSLOCATION CLASSES; 6-APR-84 RAP
DOSE FACTOR FILES USED FOR THIS CASE:

*27 ISOSHL D EXTERNAL: ONSITE/BIOPORT EXTERNAL DRFS (BURIED AT 0.5 M) 9-APR

DOSES CALCULATED FROM 10 TO 59 YEARS FOLLOWING TIME ZERO

PATHWAYS INITIALIZED FOR DOSE CALCULATIONS:

FARM PRODUCT INGESTION: OFF
INHALATION OF RESUSPENDED MATERIAL: OFF
AQUATIC FOODS INGESTION: OFF
DRINKING WATER INGESTION: OFF
CONTINUING ATMOSPHERIC DEPOSITION: OFF
EXTERNAL FROM BURIED WASTES: ON
EXTERNAL FROM SURFACE DEPOSITS: OFF

SPECIAL PARAMETERS INITIALIZED:

INVENTORY DILUTION FACTOR: 2.00E-01
DECAY OF RIVER RELEASE SOURCE TERM NOT PERFORMED
DECAY OF AIR RELEASE SOURCE TERM NOT PERFORMED
SITE X/Q: 0.00E+00
SPECIAL INHALATION MODEL NOT USED
SIZE OF THE SITE: 1.00000 FRACTIONAL HECTARES
INTERNAL PATHWAY AREA CORRECTION FACTOR: 1.00E+00
EXTERNAL PATHWAY AREA CORRECTION FACTOR: 1.00E+00

FARM PRODUCT PARAMETERS USED:

FRACTION OF ROOTS IN UPPER SOIL: 0.10E+01
FRACTION OF ROOTS IN BURIED WASTE 0.00E+00
FRACTION OF TOTAL DIET GROWN ON SITE: 1.00E+00

IRRIGATION RATE: 0.00E+00L/M**2/MO
MONTHS PER YEAR IRRIGATED: 6
RIVER DILUTION FACTOR: 1.00E+00YR/L
YEARS OF IRRIGATION WITH CONTAMINATED WATER PRIOR TO
THE DOSE CALCULATIONS: 0

EXTERNAL EXPOSURE PARAMETERS USED:

RATIO OF EXTERNAL CONTAMINATION IN SURFACE SOIL TO SUBSURFACE SOIL 0.00E+00
NUMBER OF HOURS OF EXPOSURE TO EXTERNAL CONTAMINATION 2.00E+03
SURFACE DEPOSITS DRFS FROM ISOSHL D; MODIFICATION FACTOR: 5.844E-11

ORGANS FOR WHICH DOSES ARE CALCULATED (SAME ORDER AS SOLUBILITIES GIVEN BELOW):

TOTAL BODY

INPUT PREPARED BY

R.A. Seligman

DATE

5 SEP 84

INPUT CHECKED BY

R.A. Seligman

DATE

5 SEP 84

Figure 3.4-6. Sample Problem One MAXI1 Output

INVENTORY FOR YEAR RELEASE TERMS		100 OF BIOPORT SIMULATION.					SOIL SOURCE	IRRIGATION/AQUATIC	DRINKING WATER	ATM. RELEASE
NUCLIDE		ORGAN SOLUBILITY CLASSES					(PCI/M**2)	(PCI/L)	(PCI/L)	(CI/YR)
H 3		1	1	1	1	1	3.40E+04	0.00E+00	0.00E+00	0.00E+00
C 14		1	1	2	1	1	9.00E+05	0.00E+00	0.00E+00	0.00E+00
FE 55		1	1	3	1	1	3.90E+01	0.00E+00	0.00E+00	0.00E+00
CO 60		1	1	3	1	1	8.20E+02	0.00E+00	0.00E+00	0.00E+00
NI 59		1	1	3	1	1	5.70E+05	0.00E+00	0.00E+00	0.00E+00
NI 63		1	1	3	1	1	2.30E+07	0.00E+00	0.00E+00	0.00E+00
NB 94		1	1	3	1	1	1.60E+04	0.00E+00	0.00E+00	0.00E+00
SR 90		1	1	3	1	1	4.90E+05	0.00E+00	0.00E+00	0.00E+00
Y 90		1	1	3	1	1	4.80E+05	0.00E+00	0.00E+00	0.00E+00
MO 99		1	1	3	1	1	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99M		1	1	3	1	1	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99		1	1	3	1	1	1.10E+05	0.00E+00	0.00E+00	0.00E+00
I 129		1	1	2	1	1	5.90E+04	0.00E+00	0.00E+00	0.00E+00
CS 135		1	1	1	1	1	1.60E+04	0.00E+00	0.00E+00	0.00E+00
CS 137		1	1	1	1	1	3.40E+07	0.00E+00	0.00E+00	0.00E+00
BA 137M		1	1	3	1	1	3.20E+07	0.00E+00	0.00E+00	0.00E+00
U 235		2	2	3	2	2	7.70E+03	0.00E+00	0.00E+00	0.00E+00
TH 231		2	2	3	2	2	7.70E+03	0.00E+00	0.00E+00	0.00E+00
PA 231		2	2	3	2	2	6.90E+02	0.00E+00	0.00E+00	0.00E+00
AC 227		2	2	3	2	2	6.90E+02	0.00E+00	0.00E+00	0.00E+00
TH 227		2	2	3	2	2	6.80E+02	0.00E+00	0.00E+00	0.00E+00
FR 223		2	2	3	2	2	1.80E+01	0.00E+00	0.00E+00	0.00E+00
RA 223		2	2	3	2	2	6.90E+02	0.00E+00	0.00E+00	0.00E+00
NP 237		2	2	3	2	2	6.80E+02	0.00E+00	0.00E+00	0.00E+00
PA 233		2	2	3	2	2	6.80E+02	0.00E+00	0.00E+00	0.00E+00
U 233		2	2	3	2	2	6.80E+02	0.00E+00	0.00E+00	0.00E+00
TH 229		2	2	3	2	2	6.70E+02	0.00E+00	0.00E+00	0.00E+00
RA 225		2	2	3	2	2	6.70E+02	0.00E+00	0.00E+00	0.00E+00
AC 225		2	2	3	2	2	6.70E+02	0.00E+00	0.00E+00	0.00E+00
U 238		2	2	3	2	2	7.70E+03	0.00E+00	0.00E+00	0.00E+00
TH 234		2	2	3	2	2	7.70E+03	0.00E+00	0.00E+00	0.00E+00
PA 234M		2	2	3	2	2	7.70E+03	0.00E+00	0.00E+00	0.00E+00
PA 234		2	2	3	2	2	1.90E+01	0.00E+00	0.00E+00	0.00E+00
PU 242		2	2	3	2	2	9.00E+02	0.00E+00	0.00E+00	0.00E+00
NP 238		2	2	3	2	2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 238		2	2	3	2	2	5.50E+04	0.00E+00	0.00E+00	0.00E+00
CM 244		2	2	3	2	2	1.60E+03	0.00E+00	0.00E+00	0.00E+00
PU 244		2	2	3	2	2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U 240		2	2	3	2	2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 240		2	2	3	2	2	5.10E+04	0.00E+00	0.00E+00	0.00E+00
CM 243		2	2	3	2	2	3.20E+02	0.00E+00	0.00E+00	0.00E+00
PU 243		2	2	3	2	2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 243		2	2	3	2	2	5.90E+03	0.00E+00	0.00E+00	0.00E+00
NP 239		2	2	3	2	2	5.90E+03	0.00E+00	0.00E+00	0.00E+00
PU 239		2	2	3	2	2	5.10E+04	0.00E+00	0.00E+00	0.00E+00
PU 241		2	2	3	2	2	2.60E+04	0.00E+00	0.00E+00	0.00E+00
AM 241		2	2	3	2	2	1.70E+05	0.00E+00	0.00E+00	0.00E+00

Figure 3.4-6. Sample Problem One MAXI1 Output (Continued)

SAMPLE PROBLEM ONE : BIOPORT Simulation year 100
 MAXI, Version VAX2.2 19-JUN-84 executed on 25-AUG-84 at 15:56:39 .

DOSE RESULTING FROM CONCENTRATIONS AT YEAR 100 OF BIOPORT SIMULATION.
 MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 19 FORTOTAL BODY

RADIONUCLIDE	INGESTION		EXPOSURE PATHWAY INHALATION		EXTERNAL		AQUATIC FOOD		DRINKING WATER	
	REM	%	REM	%	REM	%	REM	%	REM	%
H 3	4.32E-06	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
C 14	4.36E-03	4	4.50E-11	0	7.40E-09	0	0.00E+00	0	0.00E+00	0
FE55	1.04E-13	0	1.22E-16	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
CO60	2.58E-09	0	7.32E-14	0	7.66E-07	0	0.00E+00	0	0.00E+00	0
NI59	1.67E-05	0	2.24E-10	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
NI63	1.60E-03	1	2.16E-08	1	6.67E-18	0	0.00E+00	0	0.00E+00	0
NB94	1.07E-08	0	8.61E-10	0	1.13E-04	0	0.00E+00	0	0.00E+00	0
SR90	8.12E-02	88	1.11E-07	6	1.23E-07	0	0.00E+00	0	0.00E+00	0
Y 90	5.62E-11	0	4.64E-11	0	7.80E-06	0	0.00E+00	0	0.00E+00	0
MO99	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
TC99M	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
TC99	1.62E-06	0	8.49E-13	0	5.85E-09	0	0.00E+00	0	0.00E+00	0
I 129	1.53E-05	0	6.71E-11	0	3.37E-07	0	0.00E+00	0	0.00E+00	0
CS135	3.82E-07	0	6.83E-12	0	2.77E-10	0	0.00E+00	0	0.00E+00	0
CS137	4.74E-03	5	8.38E-08	4	1.20E-05	0	0.00E+00	0	0.00E+00	0
BA137M	0.00E+00	0	8.23E-14	0	6.08E-02	99	0.00E+00	0	0.00E+00	0
U 235	8.58E-07	0	6.58E-10	0	2.05E-06	0	0.00E+00	0	0.00E+00	0
TH231	1.07E-13	0	1.57E-14	0	1.33E-07	0	0.00E+00	0	0.00E+00	0
PA231	1.07E-07	0	8.30E-09	0	7.92E-08	0	0.00E+00	0	0.00E+00	0
AC227	1.11E-07	0	8.47E-09	0	1.19E-10	0	0.00E+00	0	0.00E+00	0
TH227	7.94E-10	0	3.05E-11	0	2.26E-07	0	0.00E+00	0	0.00E+00	0
FR223	0.00E+00	0	0.00E+00	0	9.63E-10	0	0.00E+00	0	0.00E+00	0
RA223	5.66E-07	0	6.74E-11	0	2.39E-07	0	0.00E+00	0	0.00E+00	0
NP237	3.68E-08	0	2.85E-09	0	1.72E-08	0	0.00E+00	0	0.00E+00	0
PA233	1.17E-12	0	7.57E-14	0	5.43E-17	0	0.00E+00	0	0.00E+00	0
U 233	8.24E-08	0	6.30E-11	0	3.80E-11	0	0.00E+00	0	0.00E+00	0
TH229	4.18E-07	0	1.93E-08	1	1.60E-08	0	0.00E+00	0	0.00E+00	0
RA225	7.83E-07	0	8.42E-11	0	6.06E-09	0	0.00E+00	0	0.00E+00	0
AC225	2.86E-10	0	2.17E-11	0	1.51E-08	0	0.00E+00	0	0.00E+00	0
U 238	8.03E-07	0	6.12E-10	0	1.00E-09	0	0.00E+00	0	0.00E+00	0
TH234	5.54E-11	0	2.11E-12	0	7.68E-08	0	0.00E+00	0	0.00E+00	0
PA234M	0.00E+00	0	1.25E-18	0	2.97E-07	0	0.00E+00	0	0.00E+00	0
PA234	2.67E-17	0	3.89E-17	0	8.39E-08	0	0.00E+00	0	0.00E+00	0
PU242	1.56E-09	0	4.02E-09	0	9.70E-12	0	0.00E+00	0	0.00E+00	0
NP238	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
PU238	9.19E-08	0	2.37E-07	13	1.83E-09	0	0.00E+00	0	0.00E+00	0
CM244	4.76E-08	0	3.83E-09	0	1.85E-11	0	0.00E+00	0	0.00E+00	0
PU244	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
U 240	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
PU240	9.19E-08	0	2.36E-07	13	1.83E-09	0	0.00E+00	0	0.00E+00	0
CM243	1.29E-08	0	9.94E-10	0	6.70E-08	0	0.00E+00	0	0.00E+00	0
PU243	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
AM243	3.32E-08	0	2.56E-08	1	2.82E-07	0	0.00E+00	0	0.00E+00	0
NP239	2.50E-13	0	3.90E-14	0	2.27E-06	0	0.00E+00	0	0.00E+00	0
PU239	9.20E-08	0	2.37E-07	13	1.97E-09	0	0.00E+00	0	0.00E+00	0
PU241	8.02E-10	0	2.01E-09	0	4.02E-19	0	0.00E+00	0	0.00E+00	0
AM241	9.84E-07	0	7.59E-07	43	2.42E-06	0	0.00E+00	0	0.00E+00	0
TOTALS	INGESTION 9.19E-02	% 60	INHALATION 1.76E-06	% 0	EXTERNAL 6.09E-02	% 39	AQUATIC FOOD 0.00E+00	% 0	DRINKING WATER 0.00E+00	% 0
										TOTAL 1.53E-01

Figure 3.4-6. Sample Problem One MAXI1 Output (Continued)

```

#####
#
#               =====
#             CREATE-BIOPORT-MAXI
#             =====
#
#   This interactive program will assist you in the creation
#   of scenarios to be simulated by BIOPORT-MAXI.
#
#   The following notes may be of interest:
#
#   When you have finished reading, press <return> <cr>
#
#####

#####
#
#   1) If the default condition is selected, you need only
#       press <return>. YES-or-NO questions are designated by
#       (Y/N) and should be answered with a Y or N. The default
#       condition is always listed first.
#
#   2) The values you enter will be tested against reasonable
#       limits and if they are not accepted you will be asked to
#       supply another value.
#
#   3) [Strata] and [layer] are used interchangeably to define
#       the soil compartments.
#
#####

#####
#
#   4) One hectare = 2.471 acres = 10000 square meters.
#
#   5) A successional phase of a plant or animal can be des-
#       cribed as the replacement of one community with another.
#
#       =====
#       When you have finished reading, press <return> <cr>
#
#
#   Enter an identifying title for this run (up to 40 letters long):
#   SAMPLE PROBLEM TWO <cr>
#
#####

```

Figure 3.4-7. Sample Problem Two Interactive Session

```

#####
#
#
#
#
# The length of the simulation is 500 years.
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####

#####
#
# During the simulation, printed reports and MAXI1 input will
# be generated from radionuclide concentrations in the
# following years:
#
#         1
#        100
#        200
#        300
#        500
#
# =====
# Do you wish to review or change above parameters (N/Y)? <cr>
#
#####

#####
#
#
# Exhaustive yearly output is available:
#
#     0 - Option not selected
#     1 - Option selected
#
# Default value: 0
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#####

```

Figure 3.4-7. Sample Problem Two Interactive Session (Continued)

```

#####
# In MAX11 doses to various organs will be calculated. #
# # #
# The available organs are: #
# 1-Total body #
# 2-Bone #
# 3-Lungs #
# 4-Thyroid #
# 5-Lower large intestine #
# # #
# The number of organs considered is 5. #
# ----- #
# Do you wish to change this value (N/Y)? Y <cr> #
# Enter new value: 1 <cr> #
# # #
#####

#####
# # #
# The available organs are: #
# # #
# 1-Total body #
# 2-Bone #
# 3-Lungs #
# 4-Thyroid #
# 5-Lower large intestine #
# # #
# The current selection for organ 1 is 1. #
# ----- #
# Do you wish to change this value (N/Y)? <cr> #
# # #
#####

#####
# # #
# Two "base cases" are available to provide default values: #
# # #
# 1 - Arid reference site #
# 2 - Humid reference site #
# # #
# Please enter number of selected site: (Default=1) #
# ----- #
# # #
# Do you wish to change this value (N/Y)? <cr> #
# # #
#####

```

Figure 3.4-7. Sample Problem Two Interactive Session (Continued)

```

#####
# Waste Spectrum 1 is representative of past and current      #
# waste storage practices. Waste Spectrum 2 represents        #
# improved practices of the future.                            #
#                                                              #
# The "base case" inventory for the arid site will be:       #
#                                                              #
#         1 - Waste Spectrum 1                                #
#         2 - Waste Spectrum 2                                #
#         3 - User-defined                                     #
#                                                              #
# Enter index of selected option: (Default=1)                 #
# -----                                                    #
# Do you wish to change this value (N/Y)? Y <cr>             #
# Enter new value: 2 <cr>                                     #
#####

#####
#                                                              #
#                                                              #
# The decomposition half-life of the package at closure      #
# is 70.00 years.                                             #
# -----                                                    #
# Do you wish to change this value (N/Y)? <cr>               #
#                                                              #
#                                                              #
# The average age of the waste packages at time of site closure #
# is 10.00 years.                                             #
# -----                                                    #
# Do you wish to change this value (N/Y)? <cr>               #
#                                                              #
#                                                              #
#####

#####
#                                                              #
#                                                              #
#                                                              #
# -----                                                    #
# Do you wish to review or change any of the above parameters(N/Y)? <cr> #
#                                                              #
#                                                              #
#                                                              #
#####

```

Figure 3.4-7. Sample Problem Two Interactive Session (Continued)

```

#####
#
#           Radiological inventory (Ci/cubic meter):
#
#           H 3      6.20E-02      C 14      5.30E-03
#           FE55     0.62          NI59     2.10E-03
#           CO60      1.7          NI63     0.17
#           NB94     6.70E-05      SR90     5.20E-03
#           TC99     7.80E-05      I 129    2.10E-04
#           CS135    7.80E-05      CS137     1.8
#           U 235    8.70E-05      U 238    5.40E-04
#           NP237    1.20E-10      PU238    5.80E-04
#           PU239    3.00E-04      PU240    3.00E-04
#           PU241    1.90E-02      PU242    1.30E-06
#           AM241    5.30E-04      AM243    3.20E-05
#           CM243    6.10E-07      CM244    3.80E-04
#
# Do you wish to review or change the above parameters (N/Y)? Y <cr>
#
#####

#####
#
# You may now modify the quantity of selected
# radionuclides. To delete a radionuclide,
# enter zero quantity.
#
#
# Radionuclide H 3      :      6.20E-02 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: 1.1E-1 <cr>
#
#####

#####
#
# Radionuclide C 14      :      5.30E-03 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: 9.5E-3 <cr>
#
# Radionuclide FE55      :      0.62      Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#####

```

Figure 3.4-7. Sample Problem Two Interactive Session (Continued)


```

#####
#
# Radionuclide NI59      :      2.10E-03 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
#
# Radionuclide CO60      :      1.7      Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)?  <cr>
# Enter new value:
#
#
#####

#####
#
# Radionuclide NI63      :      0.17      Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
#
# Radionuclide NB94      :      6.70E-05 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
#####

#####
#
# Radionuclide SR90      :      5.20E-03 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: 8.7E-3 <cr>
#
#
# Radionuclide TC99      :      7.80E-05 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)?  <cr>
#
#
#####

```

Figure 3.4-7. Sample Problem Two Interactive Session (Continued)

```

#####
#
# (...this sequence continues through remaining radionuclides...)
#
# Do you wish to add radionuclides to the above inventory? (N/Y) <cr>
#
#####

#####
#
# Radiological inventory (Ci/cubic meter):
#
# H 3      1.10E-01      C 14      9.50E-03
# FE55     0.62          NI59     2.10E-03
# CO60     1.7           NI63     0.17
# NB94     6.70E-05      SR90     8.70E-03
# TC99     7.80E-04      I 129    2.10E-04
# CS135    7.80E-05      CS137    1.8
# U 235    8.70E-05      U 238    5.40E-04
# NP237    1.20E-10      PU238    5.80E-04
# PU239    3.00E-04      PU240    3.00E-04
# PU241    1.90E-02      PU242    1.30E-06
# AM241    5.30E-04      AM243    3.20E-05
# CM243    6.10E-07      CM244    3.80E-04
#
# =====
# Do you wish to review or change the above parameters (N/Y)? <cr>
# Do you wish to add radionuclides to the above inventory (N/Y)? <cr>
#####

#####
#
#
# =====
# Do you wish to review or change strata & erosion parameters (N/Y)? <cr>
#
#
# =====
# Do you wish to review or change plants parameters (N/Y)? <cr>
#
#
# =====
# Do you wish to review or change animals parameters (N/Y)? <cr>
#
#
#####

```

Figure 3.4-7. Sample Problem Two Interactive Session (Continued)

SAMPLE PROBLEM TWO

Program :BIOPORT Run :27-JUN-84 13:11:50
Version :6/20/84

PLANT MODEL : Only Biomass in Contact with Waste

Simulation Period (years) : 500
Strata Identification : DEPTH VOLUME CODE
surface 0.00E+00 (0)
0.5m 0.50E+04 (1)
1.0m 0.50E+04 (2)
1.5m 0.50E+04 (3)
inventory 0.65E+05 (4)

Number of plant associations : 3 Number of animal species : 3

Erosion constant cm/yr (high) : 2.30000 (low) : 0.00000
High erosion - starting year : 1 duration : 4
frequency : 600

Conversion for m3 to gm : 0.170000E+07
Conversion for Ci/ha to pCi/m2: 1.00E+08

Radionuclide input inventory	ELT.	WT.	(CI/M**3)
	H	3	0.110E+00
	C	14	0.950E-02
	FE	55	0.620E+00
	NI	59	0.210E-02
	CO	60	0.170E+01
	NI	63	0.170E+00
	NB	94	0.670E-04
	SR	90	0.870E-02
	TC	99	0.780E-04
	I	129	0.210E-03
	CS	135	0.780E-04
	CS	137	0.180E+01
	U	235	0.870E-04
	U	238	0.540E-03
	NP	237	0.120E-09
	PU	238	0.580E-03
	PU	239	0.300E-03
	PU	240	0.300E-03
	PU	241	0.190E-01
	PU	242	0.130E-05
	AM	241	0.530E-03
	AM	243	0.320E-04
	CM	243	0.610E-06
	CM	244	0.380E-03

Figure 3.4-8. Sample Problem Two BIOPORT Report

Title of radionuclide master library:

ONSITE/BIOPORT RADIONUCLIDE MASTER DATA LIBRARY 1-JUN-84 RAP

Radionuclide parent and daughter parameters:

	:	ELT.	WT.	DECAY	CNST	CONC	RATIO	CURIES
H	3			0.561E-01		0.000E+00		0.715E+04
C	14			0.121E-03		0.000E+00		0.618E+03
FE	55			0.257E+00		0.400E-03		0.403E+05
CO	60			0.132E+00		0.940E-02		0.111E+06
NI	59			0.923E-05		0.190E-01		0.137E+03
NI	63			0.721E-02		0.190E-01		0.111E+05
NB	94			0.347E-04		0.940E-02		0.436E+01
SR	90			0.243E-01		0.200E+00		0.566E+03
Y	90			0.948E+02		0.250E-02		0.000E+00
MO	99			0.920E+02		0.130E+00		0.000E+00
TC	99M			0.101E+04		0.250E+00		0.000E+00
TC	99			0.325E-05		0.250E+00		0.507E+01
I	129			0.443E-07		0.200E-01		0.136E+02
CS	135			0.301E-06		0.200E-02		0.507E+01
CS	137			0.230E-01		0.200E-02		0.117E+06
BA	137M			0.143E+06		0.500E-02		0.000E+00
U	235			0.977E-09		0.250E-02		0.566E+01
TH	231			0.239E+03		0.420E-02		0.000E+00
PA	231			0.213E-04		0.250E-02		0.000E+00
AC	227			0.318E-01		0.250E-02		0.000E+00
TH	227			0.135E+02		0.420E-02		0.000E+00
FR	223			0.168E+05		0.000E+00		0.000E+00
RA	223			0.222E+02		0.140E-02		0.000E+00
NP	237			0.324E-06		0.250E-02		0.780E-05
PA	233			0.937E+01		0.250E-02		0.000E+00
U	233			0.437E-05		0.250E-02		0.000E+00
TH	229			0.944E-04		0.420E-02		0.000E+00
RA	225			0.171E+02		0.140E-02		0.000E+00
AC	225			0.253E+02		0.140E-02		0.000E+00
U	238			0.153E-09		0.250E-02		0.351E+02
TH	234			0.105E+02		0.420E-02		0.000E+00
PA	234M			0.311E+06		0.250E-02		0.000E+00
PA	234			0.900E+03		0.250E-02		0.000E+00
PU	242			0.179E-05		0.250E-03		0.845E-01
NP	238			0.116E+03		0.250E-02		0.000E+00
PU	238			0.788E-02		0.250E-03		0.377E+02
CM	244			0.383E-01		0.250E-02		0.247E+02
PU	244			0.838E-08		0.250E-03		0.000E+00
U	240			0.430E+03		0.250E-02		0.000E+00
PU	240			0.106E-03		0.250E-03		0.195E+02
CM	243			0.243E-01		0.250E-02		0.396E-01
PU	243			0.123E+04		0.250E-03		0.000E+00
AM	243			0.937E-04		0.250E-03		0.208E+01
NP	239			0.107E+03		0.250E-02		0.000E+00
PU	239			0.284E-04		0.250E-03		0.195E+02
PU	241			0.481E-01		0.250E-03		0.124E+04
AM	241			0.160E-02		0.250E-03		0.345E+02

Decomposition half time of package (years): 70.0

No. of years of package storage prior to beginning of scenario: 10.0

Figure 3.4-8. Sample Problem Two Bioport Report (Continued)

PLANT ASSOCIATION - Cheatgrass Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	0.750000	0.750000	0.750000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	272.000	0.000000E+00	0.000000E+00
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1		0.7200	0.7200	0.7200
Strata : 2		0.1700	0.1700	0.1700
Strata : 3		0.0700	0.0700	0.0700
Strata : 4		0.0400	0.0400	0.0400

PLANT ASSOCIATION - Rabbitbrush Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	3.00000	3.00000	3.00000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	104.000	0.000000E+00
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1		0.5650	0.5650	0.5650
Strata : 2		0.2450	0.2450	0.2450
Strata : 3		0.1350	0.1350	0.1350
Strata : 4		0.0550	0.0550	0.0550

PLANT ASSOCIATION - Sagebrush Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	5.00000	5.00000	5.00000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	0.000000E+00	117.000
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1		0.6100	0.6100	0.6100
Strata : 2		0.2300	0.2300	0.2300
Strata : 3		0.1100	0.1100	0.1100
Strata : 4		0.0500	0.0500	0.0500

Figure 3.4-8. Sample Problem Two Bioport Report (Continued)

ANIMAL SPECIES - Pocket Mice
 Amount of material moved (m³/ha) 0.100000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 0.8750
 4
 Proportion of material moved to surface by strata
 1 2 3 4
 0.7000 0.2000 0.0500 0.0500

ANIMAL SPECIES - Badgers
 Amount of material moved (m³/ha) 0.211000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 1.0000
 Proportion of material moved to surface by strata
 1 2 3 4
 0.7000 0.1500 0.0500 0.1000

ANIMAL SPECIES - Harvester Ants
 Amount of material moved (m³/ha) 0.100000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 1.0000
 Proportion of material moved to surface by strata
 1 2 3 4
 0.7000 0.1000 0.1000 0.1000

Input prepared by P.A. Pilgum Date 5-SEP-84
 Input checked by P.A. Pilgum Date 5-SEP-84

Figure 3.4-8. Sample Problem Two BIOPORT Report (Continued)

Simulation for YEAR 100

Total Curies / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
H 3	0.00E+00	0.00E+00	0.61E-03	0.96E-06	0.14E-06	0.17E+02	0.88E+01	0.61E+05
C 14	0.00E+00	0.00E+00	0.14E-01	0.17E-04	0.58E-06	0.40E+03	0.21E+03	0.14E+07
FE 55	0.00E+00	0.00E+00	0.31E-06	0.66E-07	0.35E-07	0.21E-06	0.97E-07	0.31E+02
CO 60	0.00E+00	0.00E+00	0.66E-05	0.45E-06	0.22E-06	0.14E+00	0.70E-01	0.66E+03
NI 59	0.00E+00	0.00E+00	0.47E-02	0.42E-03	0.20E-03	0.90E+02	0.46E+02	0.47E+06
NI 63	0.00E+00	0.00E+00	0.18E+00	0.17E-01	0.80E-02	0.36E+04	0.18E+04	0.18E+08
NB 94	0.00E+00	0.00E+00	0.13E-03	0.78E-05	0.38E-05	0.29E+01	0.15E+01	0.13E+05
SR 90	0.00E+00	0.00E+00	0.69E-02	0.16E-02	0.77E-03	0.33E+02	0.17E+02	0.69E+06
Y 90	0.00E+00	0.00E+00	0.68E-02	0.16E-02	0.76E-03	0.33E+02	0.17E+02	0.68E+06
MO 99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99	0.00E+00	0.00E+00	0.86E-03	0.21E-03	0.99E-04	0.34E+01	0.17E+01	0.86E+05
I 129	0.00E+00	0.00E+00	0.48E-03	0.46E-04	0.22E-04	0.91E+01	0.46E+01	0.48E+05
CS 135	0.00E+00	0.00E+00	0.13E-03	0.29E-05	0.14E-05	0.34E+01	0.17E+01	0.13E+05
CS 137	0.00E+00	0.00E+00	0.29E+00	0.41E-02	0.18E-02	0.78E+04	0.39E+04	0.29E+08
BA 137M	0.00E+00	0.00E+00	0.27E+00	0.40E-02	0.18E-02	0.74E+04	0.37E+04	0.27E+08
U 235	0.00E+00	0.00E+00	0.15E-03	0.35E-05	0.17E-05	0.38E+01	0.19E+01	0.15E+05
TH 231	0.00E+00	0.00E+00	0.15E-03	0.36E-05	0.17E-05	0.38E+01	0.19E+01	0.15E+05
PA 231	0.00E+00	0.00E+00	0.57E-05	0.11E-05	0.58E-06	0.80E-02	0.40E-02	0.57E+03
AC 227	0.00E+00	0.00E+00	0.56E-05	0.11E-05	0.58E-06	0.56E-02	0.28E-02	0.56E+03
TH 227	0.00E+00	0.00E+00	0.55E-05	0.11E-05	0.57E-06	0.55E-02	0.28E-02	0.55E+03
FR 223	0.00E+00	0.00E+00	0.15E-06	0.30E-07	0.16E-07	0.77E-04	0.39E-04	0.15E+02
RA 223	0.00E+00	0.00E+00	0.56E-05	0.11E-05	0.58E-06	0.56E-02	0.28E-02	0.56E+03
NP 237	0.00E+00	0.00E+00	0.54E-05	0.11E-05	0.58E-06	0.54E-05	0.26E-05	0.54E+03
PA 233	0.00E+00	0.00E+00	0.54E-05	0.11E-05	0.58E-06	0.54E-05	0.26E-05	0.54E+03
U 233	0.00E+00	0.00E+00	0.54E-05	0.11E-05	0.58E-06	0.25E-06	0.11E-08	0.54E+03
TH 229	0.00E+00	0.00E+00	0.54E-05	0.11E-05	0.58E-06	0.25E-06	0.70E-11	0.54E+03
RA 225	0.00E+00	0.00E+00	0.54E-05	0.11E-05	0.58E-06	0.25E-06	0.70E-11	0.54E+03
AC 225	0.00E+00	0.00E+00	0.54E-05	0.11E-05	0.58E-06	0.25E-06	0.70E-11	0.54E+03
U 238	0.00E+00	0.00E+00	0.87E-03	0.16E-04	0.74E-05	0.23E+02	0.12E+02	0.87E+05
TH 234	0.00E+00	0.00E+00	0.87E-03	0.16E-04	0.75E-05	0.23E+02	0.12E+02	0.87E+05
PA 234M	0.00E+00	0.00E+00	0.87E-03	0.16E-04	0.74E-05	0.23E+02	0.12E+02	0.87E+05
PA 234	0.00E+00	0.00E+00	0.12E-05	0.36E-07	0.18E-07	0.30E-01	0.15E-01	0.12E+03
PU 242	0.00E+00	0.00E+00	0.74E-05	0.11E-05	0.58E-06	0.56E-01	0.28E-01	0.74E+03
NP 238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 238	0.00E+00	0.00E+00	0.41E-03	0.20E-05	0.78E-06	0.11E+02	0.58E+01	0.41E+05
CM 244	0.00E+00	0.00E+00	0.15E-04	0.61E-06	0.30E-06	0.36E+00	0.18E+00	0.15E+04
PU 244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U 240	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 240	0.00E+00	0.00E+00	0.46E-03	0.24E-05	0.95E-06	0.13E+02	0.65E+01	0.46E+05
CM 243	0.00E+00	0.00E+00	0.26E-05	0.52E-06	0.28E-06	0.23E-02	0.12E-02	0.26E+03
PU 243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 243	0.00E+00	0.00E+00	0.54E-04	0.12E-05	0.61E-06	0.14E+01	0.69E+00	0.54E+04
NP 239	0.00E+00	0.00E+00	0.54E-04	0.12E-05	0.62E-06	0.14E+01	0.69E+00	0.54E+04
PU 239	0.00E+00	0.00E+00	0.46E-03	0.24E-05	0.96E-06	0.13E+02	0.65E+01	0.46E+05
PU 241	0.00E+00	0.00E+00	0.24E-03	0.98E-06	0.36E-06	0.67E+01	0.34E+01	0.24E+05
AM 241	0.00E+00	0.00E+00	0.15E-02	0.54E-05	0.18E-05	0.43E+02	0.22E+02	0.15E+06
Total	0.00E+00	0.00E+00	0.78E+00	0.29E-01	0.13E-01	0.19E+05	0.99E+04	

Figure 3.4-8. Sample Problem Two BIOPORT Report (Continued)

MAXI - Maximum Annual Dose Calculation Version VAX2.2 25-APR-84
 Executed on 28-JUN-84 at 00:01:06
 Case title: SAMPLE PROBLEM TWO : BIOPORT Simulation year 1

RADIONUCLIDE CHAIN LIBRARY USED: RADIONUCLIDE MASTER DATA LIBRARY /w TRANSLOCATION CLASSES, 6-APR-84 RAP

*20 FOOD-LEAF: Leaf Incremental Dose Factors for the ONSITE/BIOPORT
 *21 FOOD-SOIL: Soil Incremental Dose Factors for the ONSITE/BIOPORT
 *22 SHALLOW EXTERNAL: ONSITE/BIOPORT EXTERNAL DRFS FOR SURFACE (PLANE SOUR
 *23 DACRIN-INHALATION: DOS) DOSE INCREMENT FILE ONSITE/BIOPORT ENV. 16-APR-84 RAP

BIOPORT INVENTORY FROM:
 SAMPLE PROBLEM TWO

DOSES CALCULATED FROM 0 TO 49 YEARS FOLLOWING TIME ZERO

PATHWAYS INITIALIZED FOR DOSE CALCULATIONS:

FARM PRODUCT INGESTION: ON
 INHALATION OF RESUSPENDED MATERIAL: ON
 AQUATIC FOODS INGESTION: OFF
 DRINKING WATER INGESTION: OFF
 CONTINUING ATMOSPHERIC DEPOSITION: OFF
 EXTERNAL FROM BURIED WASTES: OFF
 EXTERNAL FROM SURFACE DEPOSITS: ON

SPECIAL PARAMETERS INITIALIZED:

INVENTORY DILUTION FACTOR: 1.00E+00
 DECAY OF RIVER RELEASE SOURCE TERM NOT PERFORMED
 DECAY OF AIR RELEASE SOURCE TERM NOT PERFORMED
 SITE X/Q: 0.00E+00
 SPECIAL INHALATION MODEL NOT USED

FARM PRODUCT PARAMETERS USED:

FRACTION OF ROOTS IN UPPER SOIL: 0.10E+01
 FRACTION OF ROOTS IN BURIED WASTE: 0.00E+00
 FRACTION OF TOTAL DIET GROWN ON SITE: 1.00E+00

IRRIGATION RATE: 0.00E+00L/M**2/MO
 MONTHS PER YEAR IRRIGATED: 0
 RIVER DILUTION FACTOR: 1.00E+00YR/L
 YEARS OF IRRIGATION WITH CONTAMINATED WATER PRIOR TO
 THE DOSE CALCULATIONS: 0

EXTERNAL EXPOSURE PARAMETERS USED:

RATIO OF EXTERNAL CONTAMINATION IN SURFACE SOIL TO SUBSURFACE SOIL: 1.00E+00
 XFACT MODIFICATION: 1.33E-11

INHALATION PARAMETERS USED:

MODIFICATION FACTOR, RINH: 3.00E-01
 (EQUIVALENT TO BREATHING RATE OF 23D CC/SEC FOR 2630. HR/YR)
 RESUSPENSION MODEL USED FOR CALCULATING AIR CONCENTRATION: ANSPAUGH
 AVERAGE AGE OF MATERIAL ON GROUND AT TIME ZERO: 2.00E+01 YEARS
 TOP 1.0 CM OF THE CONTAMINATED SURFACE LAYER IS AVAILABLE FOR RESUSPENSION.

ORGANS FOR WHICH DOSES ARE CALCULATED (SAME ORDER AS SOLUBILITIES GIVEN BELOW):

TOTAL BODY

INPUT PREPARED BY *Y. A. Subramanian* DATE *5-SEP-84*

INPUT CHECKED BY *Y. A. Subramanian* DATE *5-SEP-84*

Figure 3.4-9. Sample Problem Two MAXI1 Output

INVENTORY FOR YEAR		100 OF BIOPORT SIMULATION.					SOIL SOURCE	IRRIGATION/AQUATIC	DRINKING WATER	ATM. RELEASE
RELEASE TERMS							(PCI/M**2)	(PCI/L)	(PCI/L)	(CI/YR)
NUCLIDE		ORGAN SOLUBILITY CLASSES								
H	3	1	0	0	0	0	6.10E+04	0.00E+00	0.00E+00	0.00E+00
C	14	1	0	0	0	0	1.40E+06	0.00E+00	0.00E+00	0.00E+00
FE	55	1	0	0	0	0	3.10E+01	0.00E+00	0.00E+00	0.00E+00
CO	60	1	0	0	0	0	6.60E+02	0.00E+00	0.00E+00	0.00E+00
NI	59	1	0	0	0	0	4.70E+05	0.00E+00	0.00E+00	0.00E+00
NI	63	1	0	0	0	0	1.80E+07	0.00E+00	0.00E+00	0.00E+00
NB	94	1	0	0	0	0	1.30E+04	0.00E+00	0.00E+00	0.00E+00
SR	90	1	0	0	0	0	6.90E+05	0.00E+00	0.00E+00	0.00E+00
Y	90	1	0	0	0	0	6.80E+05	0.00E+00	0.00E+00	0.00E+00
MO	99	1	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC	99M	1	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC	99	1	0	0	0	0	8.60E+04	0.00E+00	0.00E+00	0.00E+00
I	129	1	0	0	0	0	4.80E+04	0.00E+00	0.00E+00	0.00E+00
CS	135	1	0	0	0	0	1.30E+04	0.00E+00	0.00E+00	0.00E+00
CS	137	1	0	0	0	0	2.90E+07	0.00E+00	0.00E+00	0.00E+00
BA	137M	1	0	0	0	0	2.70E+07	0.00E+00	0.00E+00	0.00E+00
U	235	2	0	0	0	0	1.50E+04	0.00E+00	0.00E+00	0.00E+00
TH	231	2	0	0	0	0	1.50E+04	0.00E+00	0.00E+00	0.00E+00
PA	231	2	0	0	0	0	5.70E+02	0.00E+00	0.00E+00	0.00E+00
AC	227	2	0	0	0	0	5.60E+02	0.00E+00	0.00E+00	0.00E+00
TH	227	2	0	0	0	0	5.50E+02	0.00E+00	0.00E+00	0.00E+00
FR	223	2	0	0	0	0	1.50E+01	0.00E+00	0.00E+00	0.00E+00
RA	223	2	0	0	0	0	5.60E+02	0.00E+00	0.00E+00	0.00E+00
NP	237	2	0	0	0	0	5.40E+02	0.00E+00	0.00E+00	0.00E+00
PA	233	2	0	0	0	0	5.40E+02	0.00E+00	0.00E+00	0.00E+00
U	233	2	0	0	0	0	5.40E+02	0.00E+00	0.00E+00	0.00E+00
TH	229	2	0	0	0	0	5.40E+02	0.00E+00	0.00E+00	0.00E+00
RA	225	2	0	0	0	0	5.40E+02	0.00E+00	0.00E+00	0.00E+00
AC	225	2	0	0	0	0	5.40E+02	0.00E+00	0.00E+00	0.00E+00
U	238	2	0	0	0	0	8.70E+04	0.00E+00	0.00E+00	0.00E+00
TH	234	2	0	0	0	0	8.70E+04	0.00E+00	0.00E+00	0.00E+00
PA	234M	2	0	0	0	0	8.70E+04	0.00E+00	0.00E+00	0.00E+00
PA	234	2	0	0	0	0	1.20E+02	0.00E+00	0.00E+00	0.00E+00
PU	242	2	0	0	0	0	7.40E+02	0.00E+00	0.00E+00	0.00E+00
NP	238	2	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU	238	2	0	0	0	0	4.10E+04	0.00E+00	0.00E+00	0.00E+00
CM	244	2	0	0	0	0	1.50E+03	0.00E+00	0.00E+00	0.00E+00
PU	244	2	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U	240	2	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU	240	2	0	0	0	0	4.60E+04	0.00E+00	0.00E+00	0.00E+00
CM	243	2	0	0	0	0	2.60E+02	0.00E+00	0.00E+00	0.00E+00
PU	243	2	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM	243	2	0	0	0	0	5.40E+03	0.00E+00	0.00E+00	0.00E+00
NP	239	2	0	0	0	0	5.40E+03	0.00E+00	0.00E+00	0.00E+00
PU	239	2	0	0	0	0	4.60E+04	0.00E+00	0.00E+00	0.00E+00
PU	241	2	0	0	0	0	2.40E+04	0.00E+00	0.00E+00	0.00E+00
AM	241	2	0	0	0	0	1.50E+05	0.00E+00	0.00E+00	0.00E+00

Figure 3.4-9. Sample Problem Two MAXII Output (Continued)

SAMPLE PROBLEM TWO

: BIOPORT Simulation year 100

MAXI, Version VAX2.2 25-APR-84 executed on 28-JUN-84 at 00:01:06 .
DOSE RESULTING FROM CONCENTRATIONS AT YEAR 100 OF BIOPORT SIMULATION.

MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 23 FORTOTAL BODY

RADIONUCLIDE	INGESTION		EXPOSURE PATHWAY INHALATION		EXTERNAL		AQUATIC FOOD		DRINKING WATER	
	REM	%	REM	%	REM	%	REM	%	REM	%
H 3	6.20E-06	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
C 14	6.77E-03	5	6.99E-11	0	1.15E-08	0	0.00E+00	0	0.00E+00	0
FE55	2.98E-14	0	3.48E-17	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
CO60	1.23E-09	0	3.48E-14	0	3.64E-07	0	0.00E+00	0	0.00E+00	0
NI59	1.37E-05	0	1.85E-10	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
NI63	1.21E-03	0	1.64E-08	0	5.07E-18	0	0.00E+00	0	0.00E+00	0
NB94	8.72E-09	0	7.00E-10	0	9.16E-05	0	0.00E+00	0	0.00E+00	0
SR90	1.21E-01	91	1.64E-07	9	1.57E-07	0	0.00E+00	0	0.00E+00	0
Y 90	7.18E-11	0	5.93E-11	0	9.96E-06	0	0.00E+00	0	0.00E+00	0
MO99	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
TC99M	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
TC99	1.27E-06	0	6.64E-13	0	4.57E-09	0	0.00E+00	0	0.00E+00	0
I 129	1.25E-05	0	5.46E-11	0	2.75E-07	0	0.00E+00	0	0.00E+00	0
CS135	3.10E-07	0	5.55E-12	0	2.25E-10	0	0.00E+00	0	0.00E+00	0
CS137	3.69E-03	2	6.52E-08	3	9.32E-06	0	0.00E+00	0	0.00E+00	0
BA137M	0.00E+00	0	6.40E-14	0	4.73E-02	99	0.00E+00	0	0.00E+00	0
U 235	1.67E-06	0	1.28E-09	0	3.99E-06	0	0.00E+00	0	0.00E+00	0
TH231	2.08E-13	0	3.06E-14	0	2.59E-07	0	0.00E+00	0	0.00E+00	0
PA231	1.06E-07	0	8.15E-09	0	6.60E-08	0	0.00E+00	0	0.00E+00	0
AC227	1.01E-07	0	7.71E-09	0	9.81E-11	0	0.00E+00	0	0.00E+00	0
TH227	6.52E-10	0	2.51E-11	0	1.86E-07	0	0.00E+00	0	0.00E+00	0
FR223	0.00E+00	0	0.00E+00	0	7.91E-10	0	0.00E+00	0	0.00E+00	0
RA223	4.65E-07	0	5.53E-11	0	1.96E-07	0	0.00E+00	0	0.00E+00	0
NP237	3.48E-08	0	2.68E-09	0	1.36E-08	0	0.00E+00	0	0.00E+00	0
PA233	9.31E-13	0	6.02E-14	0	4.31E-07	0	0.00E+00	0	0.00E+00	0
U 233	6.55E-08	0	5.00E-11	0	3.02E-11	0	0.00E+00	0	0.00E+00	0
TH229	4.03E-07	0	1.84E-08	1	1.29E-08	0	0.00E+00	0	0.00E+00	0
RA225	6.31E-07	0	6.79E-11	0	4.88E-09	0	0.00E+00	0	0.00E+00	0
AC225	2.31E-10	0	1.75E-11	0	1.22E-08	0	0.00E+00	0	0.00E+00	0
U 238	9.07E-06	0	6.92E-09	0	1.13E-08	0	0.00E+00	0	0.00E+00	0
TH234	6.26E-10	0	2.39E-11	0	8.68E-07	0	0.00E+00	0	0.00E+00	0
PA234M	0.00E+00	0	1.41E-17	0	3.36E-06	0	0.00E+00	0	0.00E+00	0
PA234	3.01E-16	0	4.39E-16	0	9.48E-07	0	0.00E+00	0	0.00E+00	0
PU242	1.54E-09	0	3.93E-09	0	7.97E-12	0	0.00E+00	0	0.00E+00	0
NP238	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
PU238	7.94E-08	0	2.04E-07	11	1.32E-09	0	0.00E+00	0	0.00E+00	0
CM244	4.53E-08	0	3.62E-09	0	1.49E-11	0	0.00E+00	0	0.00E+00	0
PU244	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
U 240	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
PU240	9.91E-08	0	2.53E-07	13	1.65E-09	0	0.00E+00	0	0.00E+00	0
CM243	1.12E-08	0	8.60E-10	0	4.94E-08	0	0.00E+00	0	0.00E+00	0
PU243	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
AM243	3.58E-08	0	2.74E-08	1	2.58E-07	0	0.00E+00	0	0.00E+00	0
NP239	2.28E-13	0	3.56E-14	0	2.08E-06	0	0.00E+00	0	0.00E+00	0
PU239	9.93E-08	0	2.54E-07	13	1.77E-09	0	0.00E+00	0	0.00E+00	0
PU241	7.30E-10	0	1.80E-09	0	3.06E-19	0	0.00E+00	0	0.00E+00	0
AM241	1.02E-06	0	7.78E-07	42	2.12E-06	0	0.00E+00	0	0.00E+00	0
TOTALS	INGESTION	%	INHALATION	%	EXTERNAL	%	AQUATIC FOOD	%	DRINKING WATER	%
	1.32E-01	73	1.82E-06	0	4.74E-02	26	0.00E+00	0	0.00E+00	0
										1.80E-01

Figure 3.4-9. Sample Problem Two MAXI1 Output (Continued)

3.4.3. Sample Problem Three

Sample Problem Three demonstrates how the user may string together several sequential computer runs to best determine the time-dependence of the results produced. The length of the simulation was also varied in this sample problem. The reference humid site scenario with Waste Spectrum 1 was used as the base case for Sample Problem Three. Two hundred years of biotic transport were simulated and dose to bone was calculated. CREATE defaults to five sets of output for each simulation. CREATE will also determine at what times during the simulation the output will be generated. However, the user is encouraged to tailor output selection to each given scenario. Output may only be desired for a given year or cluster of years. On the other hand, it is possible to generate output for each year of the simulation though such a selection would generate an extensive quantity of MAXII output. To demonstrate this feature output was generated for years 1, 80, 100, 130, and 200 of the simulation. Sample Problem Three may be emulated by following the interactive computer session presented in Figure 3.4-10. The complete BIOPORT report from this sample problem is shown in Figure 3.4-11. Portions of the MAXII output are displayed in Figure 3.4-12. Complete output for Sample Problem Three is included in Appendix 2. Because only program control parameters were modified in this sample problem, results from year 100 of the simulation may be compared with the Reference Humid Site Scenario with Waste Spectrum 1 in McKenzie (et al. 1984).

3.4.4. Sample Problem Four

This sample problem demonstrates how the user may modify waste package parameters and provide another example of inventory modification. The reference humid site scenario with Waste Spectrum 2 was the base case for this sample problem. For Sample Problem Four, package decomposition half-life of 100 years was used. The average age of the waste packages at the time of site closure is assumed to be 20 years. The concentration of ^{137}Cs in Waste Spectrum 2 was assumed to be increased by an order of magnitude from 2.2 Ci/m³ to 22.0 Ci/m³. Dose to total body was calculated. Figure 3.4-13 is a facsimile of the interactive computer session that prepared input for the BIOPORT and MAXII computer codes. Portions of the BIOPORT report and the MAXII output are shown in Figures 3.4-14 and 3.4-15, respectively. Complete output from this sample problem is included in Appendix 2.

```

#####
#
#
#          =====
#          CREATE-BIOPORT-MAXI
#          =====
#
#      This interactive program will assist you in the creation
#      of scenarios to be simulated by BIOPORT-MAXI.
#
#      The following notes may be of interest:
#      When you have finished reading, press <return> <cr>
#
#####

#####
#
#      1) If the default condition is selected, you need only
#      press <return>. YES-or-NO questions are designated by
#      (Y/N) and should be answered with a Y or N. The default
#      condition is always listed first.
#
#      2) The values you enter will be tested against reasonable
#      limits and if they are not accepted you will be asked to
#      supply another value.
#
#      3) [Strata] and [layer] are used interchangeably to define
#      the soil compartments.
#
#####

#####
#
#      4) One hectare = 2.471 acres = 10000 square meters.
#
#      5) A successional phase of a plant or animal can be des-
#      cribed as the replacement of one community with another
#
#      When you have finished reading, press <return> <cr>
#
#      =====
#
#      Enter an identifying title for this run (up to 40 letters long):
#      SAMPLE PROBLEM THREE <cr>
#
#####

```

Figure 3.4-10. Sample Problem Three Interactive Session

```

#####
#
#
# The length of the simulation is 500 years.
#
# -----
#
# Do you wish to change this value (N/Y)? Y <cr>
#
# Enter new value: 200
#
#
#
#
#####

#####
#
# During the simulation, printed reports and MAXII input will
# be generated from radionuclide concentrations in the
# following years:
#
#         1
#        40
#        80
#       120
#       200
#
# =====
# Do you wish to review or change above parameters (N/Y)? Y <cr>
#
#####

#####
#
# The number of years for which printed reports and MAXII
# input will be generated is 5 (Range = 0 to 200).
#
# -----
# Do you wish to change this value (N/Y)? <cr>
#
# Enter year for report 1: 1 <cr>
# Enter year for report 2: 80 <cr>
# Enter year for report 3: 100 <cr>
# Enter year for report 4: 130 <cr>
# Enter year for report 5: 200 <cr>
#
#####

```

Figure 3.4-10. Sample Problem Three Interactive Session (Continued)


```

#####
#
#
#   Exhaustive yearly output is available:
#
#       0 - Option not selected
#       1 - Option selected
#
#   Default value: 0
#
#   -----
#
#   Do you wish to change this value (N/Y)? <cr>
#
#####

#####
#
#   In MAX11 doses to various organs will be calculated.
#   The available organs are:
#       1-Total body
#       2-Bone
#       3-Lungs
#       4-Thyroid
#       5-Lower large intestine
#
#   The number of organs considered is 5.
#   -----
#   Do you wish to change this value (N/Y)? Y <cr>
#   Enter new value: 1 <cr>
#
#####

#####
#
#   The available organs are:
#       1-Total body
#       2-Bone
#       3-Lungs
#       4-Thyroid
#       5-Lower large intestine
#
#   The current selection for organ 1 is 1.
#   -----
#   Do you wish to change this value (N/Y)? Y <cr>
#   Enter new value: 2 <cr>
#
#####

```

Figure 3.4-10. Sample Problem Three Interactive Session (Continued)

```

#####
#
#
# Two "base cases" are available to provide default values:
#
#       1 - Arid reference site
#       2 - Humid reference site
#
# Please enter number of selected site: (Default=1)
#
# -----
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: 2 <cr>
#
#####

#####
#
# Waste Spectrum 1 is representative of past and current
# waste storage practices. Waste Spectrum 2 represents
# improved practices of the future.
#
# The "base case" inventory for the humid site will be:
#       1 - Waste Spectrum 1
#       2 - Waste Spectrum 2
#       3 - User-defined
#
# Enter index of selected option: (Default=1)
#
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#####

#####
#
# The decomposition half-life of the package at closure
# is 15.00 years.
#
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
# The average age of the waste packages at time of site closure
# is 10.00 years.
#
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
#####

```

Figure 3.4-10. Sample Problem Three Interactive Session (Continued)

```

#####
#
# =====
#
# Do you wish to review or change any of the above parameters(N/Y)? <cr>
#
#####

#####
#
# Radiological inventory (Ci/cubic meter):
#
# H 3      2.80E-02      C 14      2.20E-03
# FE55     0.63         NI59     2.20E-03
# C060     1.7          NI63     0.18
# NB94     6.80E-05     SR90     4.10E-03
# TC99     7.80E-05     I 129    2.20E-04
# CS135    8.00E-05     CS137    1.8
# U 235    2.20E-05     U 238    1.30E-04
# NP237    1.20E-10     PU238    6.30E-04
# PU239    2.80E-04     PU240    2.80E-04
# PU241    1.80E-02     PU242    1.20E-06
# AM241    4.80E-04     AM243    2.80E-05
# CM243    5.10E-07     CM244    3.20E-04
#
# =====
#
# Do you wish to review or change the above parameters(N/Y)? <cr>
# Do you wish to add radionuclides to the above inventory (N/Y)? <cr>
#
#####

#####
#
# =====
#
# Do you wish to review or change strata & erosion parameters(N/Y)? <cr>
#
# =====
#
# Do you wish to review or change plants parameters(N/Y)? <cr>
#
# =====
#
# Do you wish to review or change animals parameters(N/Y)? <cr>
#
#####

```

Figure 3.4-10. Sample Problem Three Interactive Session (Continued)

SAMPLE PROBLEM THREE

Program :BIOPORT Run :26-JUN-84 09:15:35
Version :6/20/84

PLANT MODEL : Only Biomass in Contact with Waste

Simulation Period (years) : 200
Strata Identification : DEPTH VOLUME CODE
surface 0.00E+00 (0)
0.5m 0.50E+04 (1)
1.0m 0.50E+04 (2)
1.5m 0.50E+04 (3)
Inventory 0.65E+05 (4)

Number of plant associations : 3 Number of animal species : 4
Erosion constant cm/yr (high) : 0.00000 (low) : 0.00000
High erosion - starting year : 0 duration : 0
frequency : 0
Conversion for m3 to gm : 0.170000E+07
Conversion for Ci/ha to pCi/m2: 1.00E+08

Radionuclide input inventory	ELT. WT.	(CI/M**3)
H	3	0.280E-01
C	14	0.220E-02
FE	55	0.630E+00
NI	59	0.220E-02
CO	60	0.170E+01
NI	63	0.180E+00
NB	94	0.680E-04
SR	90	0.410E-02
TC	99	0.780E-04
I	129	0.220E-03
CS	135	0.800E-04
CS	137	0.180E+01
U	235	0.220E-04
U	238	0.130E-03
NP	237	0.120E-09
PU	238	0.630E-03
PU	239	0.280E-03
PU	240	0.280E-03
PU	241	0.180E-01
PU	242	0.120E-05
AM	241	0.480E-03
AM	243	0.280E-04
CM	243	0.510E-06
CM	244	0.320E-03

Figure 3.4-11. Sample Problem Three BIOPORT Report

Title of radionuclide master library:

ONSITE/BIOPORT RADIONUCLIDE MASTER DATA LIBRARY 1-JUN-84 RAP

Radionuclide parent and daughter parameters:

	ELT.	WT.	DECAY CNST	CONC RATIO	CURIES
H	3		0.561E-01	0.000E+00	0.182E+04
C	14		0.121E-03	0.000E+00	0.143E+03
FE	55		0.257E+00	0.400E-03	0.410E+05
CO	60		0.132E+00	0.940E-02	0.111E+06
NI	59		0.923E-05	0.190E-01	0.143E+03
NI	63		0.721E-02	0.190E-01	0.117E+05
NB	94		0.347E-04	0.940E-02	0.442E+01
SR	90		0.243E-01	0.200E+00	0.267E+03
Y	90		0.948E+02	0.250E-02	0.000E+00
MO	99		0.920E+02	0.130E+00	0.000E+00
TC	99M		0.101E+04	0.250E+00	0.000E+00
TC	99		0.325E-05	0.250E+00	0.507E+01
I	129		0.443E-07	0.200E-01	0.143E+02
CS	135		0.301E-06	0.200E-02	0.520E+01
CS	137		0.230E-01	0.200E-02	0.117E+06
BA	137M		0.143E+06	0.500E-02	0.000E+00
U	235		0.977E-09	0.250E-02	0.143E+01
TH	231		0.239E+03	0.420E-02	0.000E+00
PA	231		0.213E-04	0.250E-02	0.000E+00
AC	227		0.318E-01	0.250E-02	0.000E+00
TH	227		0.135E+02	0.420E-02	0.000E+00
FR	223		0.168E+05	0.000E+00	0.000E+00
RA	223		0.222E+02	0.140E-02	0.000E+00
NP	237		0.324E-06	0.250E-02	0.780E-05
PA	233		0.937E+01	0.250E-02	0.000E+00
U	233		0.437E-05	0.250E-02	0.000E+00
TH	229		0.944E-04	0.420E-02	0.000E+00
RA	225		0.171E+02	0.140E-02	0.000E+00
AC	225		0.253E+02	0.140E-02	0.000E+00
U	238		0.153E-09	0.250E-02	0.845E+01
TH	234		0.105E+02	0.420E-02	0.000E+00
PA	234M		0.311E+06	0.250E-02	0.000E+00
PA	234		0.900E+03	0.250E-02	0.000E+00
PU	242		0.179E-05	0.250E-03	0.780E-01
NP	238		0.116E+03	0.250E-02	0.000E+00
PU	238		0.788E-02	0.250E-03	0.410E+02
CM	244		0.383E-01	0.250E-02	0.208E+02
PU	244		0.838E-08	0.250E-03	0.000E+00
U	240		0.430E+03	0.250E-02	0.000E+00
PU	240		0.106E-03	0.250E-03	0.182E+02
CM	243		0.243E-01	0.250E-02	0.331E-01
PU	243		0.123E+04	0.250E-03	0.000E+00
AM	243		0.937E-04	0.250E-03	0.182E+01
NP	239		0.107E+03	0.250E-02	0.000E+00
PU	239		0.284E-04	0.250E-03	0.182E+02
PU	241		0.481E-01	0.250E-03	0.117E+04
AM	241		0.160E-02	0.250E-03	0.312E+02

Decomposition half time of package (years): 15.0

No. of years of package storage prior to beginning of scenario: 10.0

Figure 3.4-11. Sample Problem Three BIOPORT Report (Continued)

PLANT ASSOCIATION - Forbs			
Number of Successional Phases	3	Dry/wet weight ratio =	0.1500
Intervals for succession (yrs)	:	6	28
Root/shoot ratio	:	0.250000	0.250000
Range of roots (m)	:	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	468.000	0.000000E+00
Recycle rate for each phase	:	0.60	0.00
Linear change(biomass)(0=no,1=yes)	:	0	1
Linear change(recycle)(0=no,1=yes)	:	0	1
% Root distribution by strata	:		
Strata : 1		0.6000	0.6000
Strata : 2		0.3000	0.3000
Strata : 3		0.0700	0.0700
Strata : 4		0.0300	0.0300

PLANT ASSOCIATION - Grass-Shrub			
Number of Successional Phases	3	Dry/wet weight ratio =	0.1500
Intervals for succession (yrs)	:	6	28
Root/shoot ratio	:	0.350000	0.350000
Range of roots (m)	:	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	635.000
Recycle rate for each phase	:	0.00	0.60
Linear change(biomass)(0=no,1=yes)	:	0	1
Linear change(recycle)(0=no,1=yes)	:	0	1
% Root distribution by strata	:		
Strata : 1		0.6000	0.6000
Strata : 2		0.3000	0.3000
Strata : 3		0.0700	0.0700
Strata : 4		0.0300	0.0300

PLANT ASSOCIATION - Pine-Oak			
Number of Successional Phases	3	Dry/wet weight ratio =	0.1500
Intervals for succession (yrs)	:	6	28
Root/shoot ratio	:	0.350000	0.350000
Range of roots (m)	:	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	0.000000E+00
Recycle rate for each phase	:	0.00	0.00
Linear change(biomass)(0=no,1=yes)	:	0	1
Linear change(recycle)(0=no,1=yes)	:	0	1
% Root distribution by strata	:		
Strata : 1		0.6000	0.6000
Strata : 2		0.3000	0.3000
Strata : 3		0.0700	0.0700
Strata : 4		0.0300	0.0300

Figure 3.4-11. Sample Problem Three BIOPORT Report (Continued)

ANIMAL SPECIES - Old Field Mouse
 Amount of material moved (m³/ha) = 0.350000 Activity range (m) = 1.0
 Degree of activity by phase = 1.0000 0.9000
 Proportion of material moved to surface by strata
 1 2 3 4
 0.9500 0.0500

ANIMAL SPECIES - Short Tail Shrew
 Amount of material moved (m³/ha) = 48.5000 Activity range (m) = 0.5
 Degree of activity by phase = 1.0000 1.0000
 Proportion of material moved to surface by strata
 1 2 3 4
 1.0000

ANIMAL SPECIES - Harvester Ant
 Amount of material moved (m³/ha) = 0.500000E-01 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 0.9000
 Proportion of material moved to surface by strata
 1 2 3 4
 0.7000 0.1000 0.1000 0.1000

ANIMAL SPECIES - Ant (Dorymyrmex)
 Amount of material moved (m³/ha) = 2.55000 Activity range (m) = 1.5
 Degree of activity by phase = 1.0000 1.0000
 Proportion of material moved to surface by strata
 1 2 3 4
 0.8000 0.1500 0.0500

Input prepared by P. A. Siqueira Date 5-SEP-84
 Input checked by P. A. Siqueira Date 5-SEP-84

Figure 3.4-11. Sample Problem Three BIOPORT Report (Continued)

Simulation for YEAR 100 Total Curies / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
H 3	0.00E+00	0.00E+00	0.40E-04	0.00E+00	0.00E+00	0.66E+01	0.41E-01	0.40E+04
C 14	0.00E+00	0.00E+00	0.85E-03	0.00E+00	0.00E+00	0.14E+03	0.88E+00	0.85E+05
FE 55	0.00E+00	0.00E+00	0.18E-11	0.15E-13	0.14E-14	0.29E-06	0.18E-08	0.18E-03
CO 60	0.00E+00	0.00E+00	0.24E-05	0.11E-06	0.23E-07	0.21E+00	0.13E-02	0.24E+03
NI 59	0.00E+00	0.00E+00	0.25E-02	0.15E-03	0.32E-04	0.14E+03	0.89E+00	0.25E+06
NI 63	0.00E+00	0.00E+00	0.98E-01	0.59E-02	0.13E-02	0.57E+04	0.35E+02	0.98E+07
NB 94	0.00E+00	0.00E+00	0.51E-04	0.23E-05	0.49E-06	0.44E+01	0.27E-01	0.51E+04
SR 90	0.00E+00	0.00E+00	0.29E-02	0.25E-03	0.55E-04	0.23E+02	0.15E+00	0.29E+06
Y 90	0.00E+00	0.00E+00	0.29E-02	0.25E-03	0.55E-04	0.23E+02	0.15E+00	0.29E+06
MO 99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99	0.00E+00	0.00E+00	0.78E-03	0.67E-04	0.15E-04	0.50E+01	0.31E-01	0.78E+05
I 129	0.00E+00	0.00E+00	0.25E-03	0.16E-04	0.34E-05	0.14E+02	0.89E-01	0.25E+05
CS 135	0.00E+00	0.00E+00	0.37E-04	0.70E-06	0.12E-06	0.52E+01	0.32E-01	0.37E+04
CS 137	0.00E+00	0.00E+00	0.84E-01	0.16E-02	0.28E-03	0.12E+05	0.73E+02	0.84E+07
BA 137M	0.00E+00	0.00E+00	0.80E-01	0.15E-02	0.27E-03	0.11E+05	0.69E+02	0.80E+07
U 235	0.00E+00	0.00E+00	0.11E-04	0.23E-06	0.42E-07	0.14E+01	0.89E-02	0.11E+04
TH 231	0.00E+00	0.00E+00	0.11E-04	0.23E-06	0.43E-07	0.14E+01	0.89E-02	0.11E+04
PA 231	0.00E+00	0.00E+00	0.23E-07	0.49E-09	0.90E-10	0.30E-02	0.19E-04	0.23E+01
AC 227	0.00E+00	0.00E+00	0.16E-07	0.34E-09	0.63E-10	0.21E-02	0.13E-04	0.16E+01
TH 227	0.00E+00	0.00E+00	0.16E-07	0.34E-09	0.62E-10	0.21E-02	0.13E-04	0.16E+01
FR 223	0.00E+00	0.00E+00	0.22E-09	0.47E-11	0.85E-12	0.29E-04	0.18E-06	0.22E-01
RA 223	0.00E+00	0.00E+00	0.16E-07	0.34E-09	0.62E-10	0.21E-02	0.13E-04	0.16E+01
NP 237	0.00E+00	0.00E+00	0.58E-10	0.13E-11	0.23E-12	0.78E-05	0.48E-07	0.58E-02
PA 233	0.00E+00	0.00E+00	0.58E-10	0.13E-11	0.23E-12	0.78E-05	0.48E-07	0.58E-02
U 233	0.00E+00	0.00E+00	0.25E-13	0.55E-15	0.10E-15	0.34E-08	0.21E-10	0.25E-05
TH 229	0.00E+00	0.00E+00	0.13E-15	0.31E-17	0.60E-18	0.16E-10	0.99E-13	0.13E-07
RA 225	0.00E+00	0.00E+00	0.13E-15	0.31E-17	0.59E-18	0.16E-10	0.99E-13	0.13E-07
AC 225	0.00E+00	0.00E+00	0.12E-15	0.31E-17	0.59E-18	0.16E-10	0.99E-13	0.12E-07
U 238	0.00E+00	0.00E+00	0.63E-04	0.14E-05	0.25E-06	0.84E+01	0.52E-01	0.63E+04
TH 234	0.00E+00	0.00E+00	0.63E-04	0.14E-05	0.25E-06	0.84E+01	0.52E-01	0.63E+04
PA 234M	0.00E+00	0.00E+00	0.63E-04	0.14E-05	0.25E-06	0.84E+01	0.52E-01	0.63E+04
PA 234	0.00E+00	0.00E+00	0.82E-07	0.18E-08	0.32E-09	0.11E-01	0.68E-04	0.82E+01
PU 242	0.00E+00	0.00E+00	0.48E-06	0.33E-08	0.23E-09	0.78E-01	0.48E-03	0.48E+02
NP 238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 238	0.00E+00	0.00E+00	0.11E-03	0.79E-06	0.55E-07	0.19E+02	0.12E+00	0.11E+05
CM 244	0.00E+00	0.00E+00	0.34E-05	0.73E-07	0.13E-07	0.45E+00	0.28E-02	0.34E+03
PU 244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U 240	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 240	0.00E+00	0.00E+00	0.11E-03	0.76E-06	0.54E-07	0.18E+02	0.11E+00	0.11E+05
CM 243	0.00E+00	0.00E+00	0.22E-07	0.47E-09	0.86E-10	0.29E-02	0.18E-04	0.22E+01
PU 243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 243	0.00E+00	0.00E+00	0.11E-04	0.76E-07	0.54E-08	0.18E+01	0.11E-01	0.11E+04
NP 239	0.00E+00	0.00E+00	0.11E-04	0.78E-07	0.59E-08	0.18E+01	0.11E-01	0.11E+04
PU 239	0.00E+00	0.00E+00	0.11E-03	0.77E-06	0.54E-07	0.18E+02	0.11E+00	0.11E+05
PU 241	0.00E+00	0.00E+00	0.58E-04	0.40E-06	0.28E-07	0.95E+01	0.59E-01	0.58E+04
AM 241	0.00E+00	0.00E+00	0.37E-03	0.26E-05	0.18E-06	0.60E+02	0.38E+00	0.37E+05
Total	0.00E+00	0.00E+00	0.27E+00	0.97E-02	0.20E-02	0.29E+05	0.18E+03	

Figure 3.4-11. Sample Problem Three BIOPORT Report (Continued)

MAXI - Maximum Annual Dose Calculation Version VAX2.2 25-APR-84
 Executed on 3-MAY-84 at 08:07:59 .
 Case title: SAMPLE PROBLEM THREE

RADIONUCLIDE CHAIN LIBRARY USED: RADIONUCLIDE MASTER DATA LIBRARY /w TRANSLOCATION CLASSES, 6-APR-84 RAP
 DOSE FACTOR FILES USED FOR THIS CASE:
 *20 FOOD-LEAF: Leaf Incremental Dose Factors for the ONSITE/BIOPORT
 *21 FOOD-SOIL: Soil Incremental Dose Factors for the ONSITE/BIOPORT
 *22 SHALLOW EXTERNAL: ONSITE/BIOPORT EXTERNAL DRFS FOR SURFACE (PLANE SOUR
 *23 DACRIN-INHALATION: DOS) DOSE INCREMENT FILE ONSITE/BIOPORT ENV. 16-APR-84 RAP

DOSES CALCULATED FROM 10 TO 59 YEARS FOLLOWING TIME ZERO

PATHWAYS INITIALIZED FOR DOSE CALCULATIONS:

FARM PRODUCT INGESTION: ON
 INHALATION OF RESUSPENDED MATERIAL: ON
 AQUATIC FOODS INGESTION: OFF
 DRINKING WATER INGESTION: OFF
 CONTINUING ATMOSPHERIC DEPOSITION: OFF
 EXTERNAL FROM BURIED WASTES: OFF
 EXTERNAL FROM SURFACE DEPOSITS: ON

SPECIAL PARAMETERS INITIALIZED:

INVENTORY DILUTION FACTOR: 2.00E-01
 DECAY OF RIVER RELEASE SOURCE TERM NOT PERFORMED
 DECAY OF AIR RELEASE SOURCE TERM NOT PERFORMED
 SITE X/O: 0.00E+00
 SPECIAL INHALATION MODEL NOT USED
 SIZE OF THE SITE: 0.05000 FRACTIONAL HECTARES
 INTERNAL PATHWAY AREA CORRECTION FACTOR: 5.00E-01
 EXTERNAL PATHWAY AREA CORRECTION FACTOR: 8.05E-01

FARM PRODUCT PARAMETERS USED:

FRACTION OF ROOTS IN UPPER SOIL: 0.10E+01
 FRACTION OF ROOTS IN BURIED WASTE: 0.00E+00
 FRACTION OF TOTAL DIET GROWN ON SITE: 1.00E+00

IRRIGATION RATE: 1.50E+02 L/M**2/MO
 MONTHS PER YEAR IRRIGATED: 6
 RIVER DILUTION FACTOR: 1.00E+00 YR/L
 YEARS OF IRRIGATION WITH CONTAMINATED WATER PRIOR TO
 THE DOSE CALCULATIONS: 0

EXTERNAL EXPOSURE PARAMETERS USED:

RATIO OF EXTERNAL CONTAMINATION IN SURFACE SOIL TO SUBSURFACE SOIL: 1.00E+00
 NUMBER OF HOURS OF EXPOSURE TO EXTERNAL CONTAMINATION: 2.00E+03
 SURFACE DEPOSITS DRFS FROM ISOSHL: MODIFICATION FACTOR: 5.844E-11

INHALATION PARAMETERS USED:

MODIFICATION FACTOR, RINH: 2.30E-01
 (EQUIVALENT TO BREATHING RATE OF 230 CC/SEC FOR 2016. HR/YR)
 RESUSPENSION MODEL USED FOR CALCULATING AIR CONCENTRATION: ANSPAUGH
 AVERAGE AGE OF MATERIAL ON GROUND AT TIME ZERO: 0.00E+00 YEARS
 TOP 1.0 CM OF THE CONTAMINATED SURFACE LAYER IS AVAILABLE FOR RESUSPENSION.

ORGANS FOR WHICH DOSES ARE CALCULATED (SAME ORDER AS SOLUBILITIES GIVEN BELOW):

TOTAL BODY BONE LUNGS THYROID GI-LLI

INPUT PREPARED BY *J. A. Liberman* DATE *5-SEP-84*

INPUT CHECKED BY *J. A. Liberman* DATE *5-SEP-84*

Figure 3.4-12. Sample Problem Three MAXI1 Report

SAMPLE PROBLEM THREE

: BIOPORT Simulation year 100
 MAXI, Version VAX2.2 19-JUN-84 executed on 25-AUG-84 at 17:03:12 .

DOSE RESULTING FROM CONCENTRATIONS AT YEAR 100 OF BIOPORT SIMULATION.
 MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 30 FOR BONE

RADIONUCLIDE	INGESTION		EXPOSURE PATHWAY INHALATION		EXTERNAL		AQUATIC FOOD		DRINKING WATER		
	REM	%	REM	%	REM	%	REM	%	REM	%	
H 3	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
C 14	2.05E-03	0	2.12E-11	0	6.98E-10	0	0.00E+00	0	0.00E+00	0	
FE55	2.64E-19	0	7.68E-23	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
CO60	0.00E+00	0	0.00E+00	0	5.26E-08	0	0.00E+00	0	0.00E+00	0	
NI59	4.39E-05	0	5.90E-10	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
NI63	1.89E-02	8	2.54E-07	2	2.62E-18	0	0.00E+00	0	0.00E+00	0	
NB94	0.00E+00	0	8.49E-10	0	3.59E-05	0	0.00E+00	0	0.00E+00	0	
SR90	2.10E-01	90	2.85E-07	2	5.58E-08	0	0.00E+00	0	0.00E+00	0	
Y 90	9.48E-10	0	7.79E-10	0	3.53E-06	0	0.00E+00	0	0.00E+00	0	
MO99	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
TC99M	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
TC99	2.87E-06	0	1.50E-12	0	4.15E-09	0	0.00E+00	0	0.00E+00	0	
I 129	2.31E-06	0	6.81E-13	0	1.43E-07	0	0.00E+00	0	0.00E+00	0	
CS135	2.16E-07	0	6.33E-12	0	6.40E-11	0	0.00E+00	0	0.00E+00	0	
CS137	1.02E-03	0	3.06E-08	0	2.30E-06	0	0.00E+00	0	0.00E+00	0	
BA137M	0.00E+00	0	1.20E-13	0	1.17E-02	99	0.00E+00	0	0.00E+00	0	
U 235	2.02E-06	0	1.55E-09	0	2.93E-07	0	0.00E+00	0	0.00E+00	0	
TH231	3.31E-13	0	4.89E-14	0	1.90E-08	0	0.00E+00	0	0.00E+00	0	
PA231	1.49E-08	0	1.13E-09	0	3.43E-10	0	0.00E+00	0	0.00E+00	0	
AC227	6.47E-09	0	4.88E-10	0	3.94E-13	0	0.00E+00	0	0.00E+00	0	
TH227	9.05E-11	0	3.48E-12	0	7.47E-10	0	0.00E+00	0	0.00E+00	0	
FR223	0.00E+00	0	0.00E+00	0	3.18E-12	0	0.00E+00	0	0.00E+00	0	
RA223	9.35E-09	0	1.11E-12	0	7.88E-10	0	0.00E+00	0	0.00E+00	0	
NP237	1.08E-11	0	8.26E-13	0	1.47E-13	0	0.00E+00	0	0.00E+00	0	
PA233	5.76E-17	0	3.73E-18	0	4.63E-12	0	0.00E+00	0	0.00E+00	0	
U 233	6.46E-15	0	4.94E-18	0	1.82E-19	0	0.00E+00	0	0.00E+00	0	
TH229	3.36E-16	0	1.52E-17	0	5.30E-19	0	0.00E+00	0	0.00E+00	0	
RA225	1.30E-16	0	1.40E-20	0	2.01E-19	0	0.00E+00	0	0.00E+00	0	
AC225	1.42E-19	0	1.07E-20	0	5.04E-19	0	0.00E+00	0	0.00E+00	0	
U 238	1.11E-05	0	8.47E-09	0	8.21E-10	0	0.00E+00	0	0.00E+00	0	
TH234	1.57E-09	0	5.99E-11	0	6.28E-08	0	0.00E+00	0	0.00E+00	0	
PA234M	0.00E+00	0	2.24E-17	0	2.43E-07	0	0.00E+00	0	0.00E+00	0	
PA234	8.53E-17	0	1.25E-16	0	6.86E-08	0	0.00E+00	0	0.00E+00	0	
PU242	2.69E-09	0	6.84E-09	0	5.17E-13	0	0.00E+00	0	0.00E+00	0	
NP238	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
PU238	5.46E-07	0	1.39E-06	12	3.35E-10	0	0.00E+00	0	0.00E+00	0	
CM244	1.55E-07	0	2.79E-08	0	2.58E-12	0	0.00E+00	0	0.00E+00	0	
PU244	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
U 240	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
PU240	6.65E-07	0	1.69E-06	15	3.94E-10	0	0.00E+00	0	0.00E+00	0	
CM243	1.58E-09	0	1.20E-10	0	3.52E-10	0	0.00E+00	0	0.00E+00	0	
PU243	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	
AM243	2.22E-07	0	1.69E-07	1	5.25E-08	0	0.00E+00	0	0.00E+00	0	
NP239	8.60E-13	0	1.34E-13	0	4.23E-07	0	0.00E+00	0	0.00E+00	0	
PU239	6.66E-07	0	1.69E-06	15	4.24E-10	0	0.00E+00	0	0.00E+00	0	
PU241	4.30E-09	0	9.46E-09	0	5.28E-20	0	0.00E+00	0	0.00E+00	0	
AM241	7.41E-06	0	5.65E-06	50	5.18E-07	0	0.00E+00	0	0.00E+00	0	
TOTALS	2.32E-01	95	1.12E-05	0	1.17E-02	4	0.00E+00	0	0.00E+00	0	TOT 2.43E-01

Figure 3.4-12. Sample Problem Three MAXI1 Output (Continued)

```

#####
#
#
#          =====
#          CREATE-BIOPORT-MAXI
#          =====
#
#   This interactive program will assist you in the creation
#   of scenarios to be simulated by BIOPORT-MAXI.
#
#   The following notes may be of interest:
#   When you have finished reading, press <return> <cr>
#
#####

#####
#
#   1) If the default condition is selected, you need only
#       press <return>. YES-or-NO questions are designated by
#       (Y/N) and should be answered with a Y or N. The default
#       condition is always listed first.
#
#   2) The values you enter will be tested against reasonable
#       limits and if they are not accepted you will be asked to
#       supply another value.
#
#   3) [Strata] and [layer] are used interchangeably to define
#       the soil compartments.
#
#####

#####
#
#   4) One hectare = 2.471 acres = 10000 square meters.
#
#   5) A successional phase of a plant or animal can be des-
#       cribed as the replacement of one community with another
#
#       When you have finished reading, press <return> <cr>
#
#       =====
#
#   Enter an identifying title for this run (up to 40 letters long):
#   SAMPLE PROBLEM FOUR <cr>
#
#####

```

Figure 3.4-13. Sample Problem Four Interactive Session

```

#####
#
#
#
# The length of the simulation is 500 years
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####

#####
#
# During the simulation, printed reports and MAXII input will
# be generated from radionuclide concentrations in the
# following years:
#
#      1
#     100
#     200
#     300
#     500
#
# =====
# Do you wish to review or change above parameters (N/Y)? <cr>
#
#####

#####
#
# Exhaustive yearly output is available:
#
#      0 - Option not selected
#      1 - Option selected
#
# Default value: 0
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#####

```

Figure 3.4-13. Sample Problem Four Interactive Session (Continued)

```

#####
# In MAX11 doses to various organs will be calculated. #
# The available organs are: #
# #
# 1-Total body #
# 2-Bone #
# 3-Lungs #
# 4-Thyroid #
# 5-Lower large intestine #
# #
# The number of organs considered is 5. #
# ----- #
# Do you wish to change this value (N/Y)? Y <cr> #
# Enter new value: 1 <cr> #
#####

#####
# #
# The available organs are: #
# #
# 1-Total body #
# 2-Bone #
# 3-Lungs #
# 4-Thyroid #
# 5-Lower large intestine #
# #
# The current selection for organ 1 is 1. #
# ----- #
# Do you wish to change this value (N/Y)? <cr> #
# #
#####

#####
# #
# Two "base cases" are available to provide default values: #
# #
# 1 - Arid reference site #
# 2 - Humid reference site #
# #
# Please enter number of selected site: (Default=1) #
# ----- #
# #
# Do you wish to change this value (N/Y)? Y <cr> #
# Enter new value: 2 <cr> #
# #
#####

```

Figure 3.4-13. Sample Problem Four Interactive Session (Continued)

```

#####
# Waste Spectrum 1 is representative of past and current      #
# waste storage practices. Waste Spectrum 2 represents        #
# improved practices of the future.                            #
#                                                              #
# The "base case" inventory for the humid site will be:      #
#     1 - Waste Spectrum 1                                    #
#     2 - Waste Spectrum 2                                    #
#     3 - User-defined                                         #
#                                                              #
# Enter index of selected option: (Default=1)                 #
# -----                                                    #
# Do you wish to change this value (N/Y)? Y <cr>              #
# Enter new value: 2 <cr>                                     #
#####

#####
#                                                              #
# The decomposition half-life of the package at closure       #
# is 35.00 years.                                              #
# -----                                                    #
# Do you wish to change this value (N/Y)? Y <cr>              #
# Enter new value: 100 <cr>                                    #
#                                                              #
# The average age of the waste packages at time of site closure #
# is 10.00 years.                                              #
# -----                                                    #
# Do you wish to change this value (N/Y)? Y <cr>              #
# Enter new value: 20 <cr>                                     #
#                                                              #
#####

#####
#                                                              #
#                                                              #
# -----                                                    #
# Do you wish to review or change any of the above parameters(N/Y)? <cr> #
#                                                              #
#                                                              #
#                                                              #
#                                                              #
#                                                              #
#                                                              #
#####

```

Figure 3.4-13. Sample Problem Four Interactive Session (Continued)


```

#####
#
#           Radiological inventory (Ci/cubic meter):
#
#           H 3      3.60E-02      C 14      3.00E-03
#           FE55     0.78          NI59     2.60E-03
#           CO60      2.0          NI63      0.21
#           NB94     8.40E-05      SR90     4.70E-03
#           TC99     9.80E-05      I 129    4.20E-06
#           CS135    9.80E-05      CS137     2.2
#           U 235    6.30E-05      U 238    3.90E-04
#           NP237    1.40E-10      PU238    8.30E-04
#           PU239    3.50E-04      PU240    3.50E-04
#           PU241    2.30E-02      PU242    1.50E-06
#           AM241    6.10E-04      AM243    3.70E-05
#           CM243    6.90E-07      CM244    4.30E-04
#
#           =====
#
#           Do you wish to review or change the above      parameters(N/Y)? Y <cr>
#
#####

#####
#
#           You may now modify the quantity of selected
#           radionuclides. To delete a radionuclide,
#           enter zero quantity.
#
#           Radionuclide H 3      :      3.60E-02 Ci/cubic meter
#           -----
#           Do you wish to change this value (N/Y)? <cr>
#
#           Radionuclide C 14      :      3.00E-03 Ci/cubic meter
#           -----
#           Do you wish to change this value (N/Y)? <cr>
#
#           Radionuclide FE55      :      0.78      Ci/cubic meter
#           -----
#           Do you wish to change this value (N/Y)? <cr>
#
#           Radionuclide NI59      :      2.60E-03 Ci/cubic meter
#           -----
#           Do you wish to change this value (N/Y)? <cr>
#
#####

```

Figure 3.4-13. Sample Problem Four Interactive Session (Continued)

```

#####
#
# Radionuclide C060      :      2.0      Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
# Radionuclide NI63      :      0.21      Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
# Radionuclide NB94      :      8.40E-05 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#####

#####
#
# Radionuclide SR90      :      4.70E-03 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
# Radionuclide TC99      :      9.80E-05 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
# Radionuclide I 129     :      4.20E-06 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#####

#####
#
# Radionuclide CS135     :      9.80E-05 Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? <cr>
#
# Radionuclide CS137     :      2.2      Ci/cubic meter
# -----
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: 22 <cr>
#
# ( ... this sequence continues through remaining radionuclides ...)
#
#####

```

Figure 3.4-13. Sample Problem Four Interactive Session (Continued)

```

#####
#
#
#
#   Do you wish to add radionuclides to the above inventory? (N/Y) <cr>
#
#
#####

#####
#
#   Radiological inventory (Ci/cubic meter):
#
#       H 3      3.60E-02      C 14      3.00E-03
#       FE55     0.78         NI59     2.60E-03
#       CO60      2.0         NI63     0.21
#       NB94     8.40E-05     SR90     4.70E-03
#       TC99     9.80E-05     I 129    4.20E-06
#       CS135    9.80E-05     CS137    22.
#       U 235    6.30E-05     U 238    3.90E-04
#       NP237    1.40E-10     PU238    8.30E-04
#       PU239    3.50E-04     PU240    3.50E-04
#       PU241    2.30E-02     PU242    1.50E-06
#       AM241    6.10E-04     AM243    3.70E-05
#       CM243    6.90E-07     CM244    4.30E-04
#
#   =====
#
#   Do you wish to review or change the above parameters (N/Y)? <cr>
#   Do you wish to add radionuclides to the above inventory (N/Y)? <cr>
#
#####

#####
#
#
#   =====
#   Do you wish to review or change strata & erosion parameters(N/Y)? <cr>
#
#   =====
#   Do you wish to review or change plants parameters(N/Y)? <cr>
#
#   =====
#   Do you wish to review or change animals parameters(N/Y)? <cr>
#
#
#####

```

Figure 3.4-13. Sample Problem Four Interactive Session (Continued)

SAMPLE PROBLEM FOUR

Program :BIOPORT Run :26-JUN-84 09:30:10
Version :6/20/84

PLANT MODEL : Only Biomass in Contact with Waste

Simulation Period (years) : 500
Strata Identification : DEPTH VOLUME CODE
surface 0.00E+00 (0)
0.5m 0.50E+04 (1)
1.0m 0.50E+04 (2)
1.5m 0.50E+04 (3)
inventory 0.65E+05 (4)

Number of plant associations : 3 Number of animal species : 4

Erosion constant cm/yr (high) : 0.00000 (low) : 0.00000
High erosion - starting year : 0 duration : 0
frequency : 0

Conversion for m3 to gm : 0.170000E+07
Conversion for Ci/ha to pCi/m2: 1.00E+08

Radionuclide input inventory	ELT. WT.	(CI/M**3)
H	3	0.360E-01
C	14	0.300E-02
FE	55	0.780E+00
NI	59	0.260E-02
CO	60	0.200E+01
NI	63	0.210E+00
NB	94	0.840E-04
SR	90	0.470E-02
TC	99	0.980E-04
I	129	0.420E-05
CS	135	0.980E-04
CS	137	0.220E+02
U	235	0.630E-04
U	238	0.390E-03
NP	237	0.140E-09
PU	238	0.830E-03
PU	239	0.350E-03
PU	240	0.350E-03
PU	241	0.230E-01
PU	242	0.150E-05
AM	241	0.610E-03
AM	243	0.370E-04
CM	243	0.690E-06
CM	244	0.430E-03

Figure 3.4-14. Sample Problem Four BIOPORT Report

Title of radionuclide master library:

ONSITE/BIOPORT RADIONUCLIDE MASTER DATA LIBRARY 1-JUN-84 RAP

Radionuclide parent and daughter parameters:

		ELT.	WT.	DECAY	CNST	CONC	RATIO	CURIES
H	3			0.561E-01		0.000E+00		0.234E+04
C	14			0.121E-03		0.000E+00		0.195E+03
FE	55			0.257E+00		0.400E-03		0.507E+05
CO	60			0.132E+00		0.940E-02		0.130E+06
NI	59			0.923E-05		0.190E-01		0.169E+03
NI	63			0.721E-02		0.190E-01		0.137E+05
NB	94			0.347E-04		0.940E-02		0.546E+01
SR	90			0.243E-01		0.200E+00		0.306E+03
Y	90			0.948E+02		0.250E-02		0.000E+00
MO	99			0.920E+02		0.130E+00		0.000E+00
TC	99M			0.101E+04		0.250E+00		0.000E+00
TC	99			0.325E-05		0.250E+00		0.637E+01
I	129			0.443E-07		0.200E-01		0.273E+00
CS	135			0.301E-06		0.200E-02		0.637E+01
CS	137			0.230E-01		0.200E-02		0.143E+07
BA	137M			0.143E+06		0.500E-02		0.000E+00
U	235			0.977E-09		0.250E-02		0.409E+01
TH	231			0.239E+03		0.420E-02		0.000E+00
PA	231			0.213E-04		0.250E-02		0.000E+00
AC	227			0.318E-01		0.250E-02		0.000E+00
TH	227			0.135E+02		0.420E-02		0.000E+00
FR	223			0.168E+05		0.000E+00		0.000E+00
RA	223			0.222E+02		0.140E-02		0.000E+00
NP	237			0.324E-06		0.250E-02		0.910E-05
PA	233			0.937E+01		0.250E-02		0.000E+00
U	233			0.437E-05		0.250E-02		0.000E+00
TH	229			0.944E-04		0.420E-02		0.000E+00
RA	225			0.171E+02		0.140E-02		0.000E+00
AC	225			0.253E+02		0.140E-02		0.000E+00
U	238			0.153E-09		0.250E-02		0.254E+02
TH	234			0.105E+02		0.420E-02		0.000E+00
PA	234M			0.311E+06		0.250E-02		0.000E+00
PA	234			0.900E+03		0.250E-02		0.000E+00
PU	242			0.179E-05		0.250E-03		0.975E-01
NP	238			0.116E+03		0.250E-02		0.000E+00
PU	238			0.788E-02		0.250E-03		0.539E+02
CM	244			0.383E-01		0.250E-02		0.279E+02
PU	244			0.838E-08		0.250E-03		0.000E+00
U	240			0.430E+03		0.250E-02		0.000E+00
PU	240			0.106E-03		0.250E-03		0.228E+02
CM	243			0.243E-01		0.250E-02		0.448E-01
PU	243			0.123E+04		0.250E-03		0.000E+00
AM	243			0.937E-04		0.250E-03		0.241E+01
NP	239			0.107E+03		0.250E-02		0.000E+00
PU	239			0.284E-04		0.250E-03		0.228E+02
PU	241			0.481E-01		0.250E-03		0.150E+04
AM	241			0.160E-02		0.250E-03		0.396E+02

Decomposition half time of package (years): 100.0

No. of years of package storage prior to beginning of scenario: 20.0

Figure 3.4-14. Sample Problem Four BIOPORT Report (Continued)

PLANT ASSOCIATION - Forbs				
Number of Successional Phases	3	Dry/wet weight ratio =		0.1500
Intervals for succession (yrs)	:	6	28	500
Root/shoot ratio	:	0.250000	0.250000	0.250000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	468.000	0.000000E+00	0.000000E+00
Recycle rate for each phase	:	0.60	0.00	0.00
Linear change(biomass)(0=no,1=yes)	:	0	1	1
Linear change(recycle)(0=no,1=yes)	:	0	1	1
% Root distribution by strata	:			
Strata : 1		0.6000	0.6000	0.6000
Strata : 2		0.3000	0.3000	0.3000
Strata : 3		0.0700	0.0700	0.0700
Strata : 4		0.0300	0.0300	0.0300

PLANT ASSOCIATION - Grass-Shrub				
Number of Successional Phases	3	Dry/wet weight ratio =		0.1500
Intervals for succession (yrs)	:	6	28	500
Root/shoot ratio	:	0.350000	0.350000	0.350000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	635.000	0.000000E+00
Recycle rate for each phase	:	0.00	0.60	0.00
Linear change(biomass)(0=no,1=yes)	:	0	1	1
Linear change(recycle)(0=no,1=yes)	:	0	1	1
% Root distribution by strata	:			
Strata : 1		0.6000	0.6000	0.6000
Strata : 2		0.3000	0.3000	0.3000
Strata : 3		0.0700	0.0700	0.0700
Strata : 4		0.0300	0.0300	0.0300

PLANT ASSOCIATION - Pine-Oak				
Number of Successional Phases	3	Dry/wet weight ratio =		0.1500
Intervals for succession (yrs)	:	6	28	500
Root/shoot ratio	:	0.350000	0.350000	0.350000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	0.000000E+00	1300.00
Recycle rate for each phase	:	0.00	0.00	0.80
Linear change(biomass)(0=no,1=yes)	:	0	1	1
Linear change(recycle)(0=no,1=yes)	:	0	1	1
% Root distribution by strata	:			
Strata : 1		0.6000	0.6000	0.6000
Strata : 2		0.3000	0.3000	0.3000
Strata : 3		0.0700	0.0700	0.0700
Strata : 4		0.0300	0.0300	0.0300

Figure 3.4-14. Sample Problem Four BIOPORT Report (Continued)

ANIMAL SPECIES - Old Field Mouse
 Amount of material moved (m³/ha) = 0.350000 Activity range (m) = 1.0
 Degree of activity by phase = 1.0000 0.9000

Proportion of material moved to surface by strata

1	2	3	4
0.9500	0.0500		

ANIMAL SPECIES - Short Tail Shrew
 Amount of material moved (m³/ha) = 48.5000 Activity range (m) = 0.5
 Degree of activity by phase = 1.0000 1.0000

Proportion of material moved to surface by strata

1	2	3	4
1.0000			

ANIMAL SPECIES - Harvester Ant
 Amount of material moved (m³/ha) = 0.500000E-01 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 0.9000

Proportion of material moved to surface by strata

1	2	3	4
0.7000	0.1000	0.1000	0.1000

ANIMAL SPECIES - Ant (Dorymyrmex)
 Amount of material moved (m³/ha) = 2.55000 Activity range (m) = 1.5
 Degree of activity by phase = 1.0000 1.0000

Proportion of material moved to surface by strata

1	2	3	4
0.8000	0.1500	0.0500	

Input prepared by RA Elguin Date 5-SEP-01
 Input checked by RA Elguin Date 5-SEP-01

Figure 3.4-14. Sample Problem Four BIOPORT Report (Continued)

Simulation for YEAR 100

Total Curves / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
H 3	0.00E+00	0.00E+00	0.22E-04	0.00E+00	0.00E+00	0.48E+01	0.37E+01	0.22E+04
C 14	0.00E+00	0.00E+00	0.50E-03	0.00E+00	0.00E+00	0.11E+03	0.84E+02	0.50E+05
FE 55	0.00E+00	0.00E+00	0.98E-12	0.74E-14	0.75E-15	0.21E-06	0.16E-06	0.98E-04
CO 60	0.00E+00	0.00E+00	0.12E-05	0.56E-07	0.12E-07	0.14E+00	0.11E+00	0.12E+03
NI 59	0.00E+00	0.00E+00	0.13E-02	0.76E-04	0.17E-04	0.95E+02	0.73E+02	0.13E+06
NI 63	0.00E+00	0.00E+00	0.49E+01	0.30E-02	0.65E-03	0.37E+04	0.29E+04	0.49E+07
NB 94	0.00E+00	0.00E+00	0.27E-04	0.12E-05	0.26E-06	0.31E+01	0.24E+01	0.27E+04
SR 90	0.00E+00	0.00E+00	0.14E-02	0.12E-03	0.28E-04	0.15E+02	0.12E+02	0.14E+06
Y 90	0.00E+00	0.00E+00	0.14E-02	0.12E-03	0.27E-04	0.15E+02	0.12E+02	0.14E+06
MO 99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99	0.00E+00	0.00E+00	0.42E-03	0.37E-04	0.82E-05	0.36E+01	0.28E+01	0.42E+05
I 129	0.00E+00	0.00E+00	0.21E-05	0.13E-06	0.28E-07	0.15E+00	0.12E+00	0.21E+03
CS 135	0.00E+00	0.00E+00	0.20E-04	0.36E-06	0.66E-07	0.36E+01	0.28E+01	0.20E+04
CS 137	0.00E+00	0.00E+00	0.44E+00	0.82E-02	0.15E-02	0.61E+05	0.62E+05	0.44E+08
BA 137M	0.00E+00	0.00E+00	0.42E+00	0.79E-02	0.14E-02	0.77E+05	0.59E+05	0.42E+08
U 235	0.00E+00	0.00E+00	0.13E-04	0.28E-06	0.53E-07	0.23E+01	0.18E+01	0.13E+04
TH 231	0.00E+00	0.00E+00	0.13E-04	0.28E-06	0.53E-07	0.23E+01	0.18E+01	0.13E+04
PA 231	0.00E+00	0.00E+00	0.28E-07	0.60E-09	0.11E-09	0.49E-02	0.38E-02	0.28E+01
AC 227	0.00E+00	0.00E+00	0.20E-07	0.42E-09	0.78E-10	0.34E-02	0.26E-02	0.20E+01
TH 227	0.00E+00	0.00E+00	0.19E-07	0.41E-09	0.78E-10	0.34E-02	0.26E-02	0.19E+01
FR 223	0.00E+00	0.00E+00	0.27E-09	0.57E-11	0.11E-11	0.47E-04	0.37E-04	0.27E-01
RA 223	0.00E+00	0.00E+00	0.20E-07	0.41E-09	0.78E-10	0.34E-02	0.26E-02	0.20E+01
NP 237	0.00E+00	0.00E+00	0.29E-10	0.62E-12	0.12E-12	0.51E-05	0.40E-05	0.29E-02
PA 233	0.00E+00	0.00E+00	0.29E-10	0.62E-12	0.12E-12	0.51E-05	0.40E-05	0.29E-02
U 233	0.00E+00	0.00E+00	0.13E-13	0.27E-15	0.51E-16	0.22E-08	0.17E-08	0.13E-05
TH 229	0.00E+00	0.00E+00	0.64E-16	0.16E-17	0.31E-18	0.11E-10	0.81E-11	0.64E-08
RA 225	0.00E+00	0.00E+00	0.63E-16	0.16E-17	0.31E-18	0.11E-10	0.81E-11	0.63E-08
AC 225	0.00E+00	0.00E+00	0.63E-16	0.16E-17	0.31E-18	0.11E-10	0.81E-11	0.63E-08
U 238	0.00E+00	0.00E+00	0.82E-04	0.17E-05	0.33E-06	0.14E+02	0.11E+02	0.82E+04
TH 234	0.00E+00	0.00E+00	0.82E-04	0.18E-05	0.33E-06	0.14E+02	0.11E+02	0.82E+04
PA 234M	0.00E+00	0.00E+00	0.82E-04	0.17E-05	0.33E-06	0.14E+02	0.11E+02	0.82E+04
PA 234	0.00E+00	0.00E+00	0.11E-06	0.23E-08	0.42E-09	0.19E-01	0.14E-01	0.11E+02
PU 242	0.00E+00	0.00E+00	0.26E-06	0.16E-08	0.13E-09	0.55E-01	0.42E-01	0.26E+02
NP 238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 238	0.00E+00	0.00E+00	0.65E-04	0.41E-06	0.32E-07	0.14E+02	0.11E+02	0.65E+04
CM 244	0.00E+00	0.00E+00	0.20E-05	0.42E-07	0.78E-08	0.34E+00	0.26E+00	0.20E+03
PU 244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U 240	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 240	0.00E+00	0.00E+00	0.60E-04	0.38E-06	0.29E-07	0.13E+02	0.98E+01	0.60E+04
CM 243	0.00E+00	0.00E+00	0.13E-07	0.27E-09	0.51E-10	0.22E-02	0.17E-02	0.13E+01
PU 243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 243	0.00E+00	0.00E+00	0.63E-05	0.40E-07	0.31E-08	0.13E+01	0.10E+01	0.63E+03
NP 239	0.00E+00	0.00E+00	0.63E-05	0.42E-07	0.35E-08	0.13E+01	0.10E+01	0.63E+03
PU 239	0.00E+00	0.00E+00	0.60E-04	0.38E-06	0.29E-07	0.13E+02	0.99E+01	0.60E+04
PU 241	0.00E+00	0.00E+00	0.32E-04	0.21E-06	0.16E-07	0.69E+01	0.53E+01	0.32E+04
AM 241	0.00E+00	0.00E+00	0.20E-03	0.13E-05	0.10E-06	0.44E+02	0.34E+02	0.20E+05
Total	0.00E+00	0.00E+00	0.92E+00	0.19E-01	0.36E-02	0.16E+06	0.12E+06	

Figure 3.4-14. Sample Problem Four BIOPORT Report (Continued)

MAXI - Maximum Annual Dose Calculation Version VAX2.2 25-APR-84
 Executed on 25-AUG-84 at 16:29:43
 Case title: SAMPLE PROBLEM FOUR : BIOPORT Simulation year 1

 RADIONUCLIDE CHAIN LIBRARY USED: RADIONUCLIDE MASTER DATA LIBRARY /w TRANSLOCATION CLASSES, 6-APR-84 RAP
 DOSE FACTOR FILES USED FOR THIS CASE:
 *20 FOOD-LEAF: Leaf Incremental Dose Factors for the ONSITE/BIOPORT
 *21 FOOD-SOIL: Soil Incremental Dose Factors for the ONSITE/BIOPORT
 *22 SHALLOW EXTERNAL: ONSITE/BIOPORT EXTERNAL DRFS FOR SURFACE (PLANE SOUR
 *23 DACRIN-INHALATION: DOS) DOSE INCREMENT FILE ONSITE/BIOPORT ENV. 16-APR-84 RAP

BIOPORT INVENTORY FROM:
 SAMPLE PROBLEM FOUR

DOSES CALCULATED FROM 0 TO 49 YEARS FOLLOWING TIME ZERO

PATHWAYS INITIALIZED FOR DOSE CALCULATIONS:	SPECIAL PARAMETERS INITIALIZED:
FARM PRODUCT INGESTION: ON	
INHALATION OF RESUSPENDED MATERIAL: ON	
AQUATIC FOODS INGESTION: OFF	INVENTORY DILUTION FACTOR: 1.00E+00
DRINKING WATER INGESTION: OFF	DECAY OF RIVER RELEASE SOURCE TERM NOT PERFORMED
CONTINUING ATMOSPHERIC DEPOSITION: OFF	DECAY OF AIR RELEASE SOURCE TERM NOT PERFORMED
EXTERNAL FROM BURIED WASTES: OFF	SITE X/O: 0.00E+00
EXTERNAL FROM SURFACE DEPOSITS: ON	SPECIAL INHALATION MODEL NOT USED

FARM PRODUCT PARAMETERS USED:	
FRACTION OF ROOTS IN UPPER SOIL: 0.10E+01	IRRIGATION RATE: 0.00E+00L/M**2/MO
FRACTION OF ROOTS IN BURIED WASTE 0.00E+00	MONTHS PER YEAR IRRIGATED: 0
FRACTION OF TOTAL DIET GROWN ON SITE: 1.00E+00	RIVER DILUTION FACTOR: 1.00E+00YR/L
	YEARS OF IRRIGATION WITH CONTAMINATED WATER PRIOR TO THE DOSE CALCULATIONS: 0

EXTERNAL EXPDSURE PARAMETERS USED:
 RATIO OF EXTERNAL CONTAMINATION IN SURFACE SOIL TO SUBSURFACE SOIL 1.00E+00
 XFACT MODIFICATION: 1.33E-11

INHALATION PARAMETERS USED:
 MODIFICATION FACTOR, RINH: 3.00E-01
 (EQUIVALENT TO BREATHING RATE OF 230 CC/SEC FOR 2630. HR/YR)
 RESUSPENSION MODEL USED FOR CALCULATING AIR CONCENTRATION: ANSPAUGH
 AVERAGE AGE OF MATERIAL ON GROUND AT TIME ZERO: 2.00E+01 YEARS
 TOP 1.0 CM OF THE CONTAMINATED SURFACE LAYER IS AVAILABLE FOR RESUSPENSION.

ORGANS FOR WHICH DOSES ARE CALCULATED (SAME ORDER AS SOLUBILITIES GIVEN BELOW):
 TOTAL BODY

INPUT PREPARED BY *L.A. Delquin* DATE *5-SEP-84*
 INPUT CHECKED BY *L.A. Delquin* DATE *5-SEP-84*

Figure 3.4-15. Sample Problem Four MAXI1 Output

INVENTORY FOR YEAR RELEASE TERMS NUCLIDE		100 OF BIOPORT SIMULATION. ORGAN SOLUBILITY CLASSES				SOIL SOURCE (PCI/M**2)	IRRIGATION/AQUATIC (PCI/L)	DRINKING WATER (PCI/L)	ATM. RELEASE (CI/YR)
H 3		1	0	0	0	2.20E+03	0.00E+00	0.00E+00	0.00E+00
C 14		1	0	0	0	5.00E+04	0.00E+00	0.00E+00	0.00E+00
FE 55		1	0	0	0	9.80E-05	0.00E+00	0.00E+00	0.00E+00
CO 60		1	0	0	0	1.20E+02	0.00E+00	0.00E+00	0.00E+00
NI 59		1	0	0	0	1.30E+05	0.00E+00	0.00E+00	0.00E+00
NI 63		1	0	0	0	4.90E+06	0.00E+00	0.00E+00	0.00E+00
NB 94		1	0	0	0	2.70E+03	0.00E+00	0.00E+00	0.00E+00
SR 90		1	0	0	0	1.40E+05	0.00E+00	0.00E+00	0.00E+00
Y 90		1	0	0	0	1.40E+05	0.00E+00	0.00E+00	0.00E+00
MO 99		1	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99M		1	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC 99		1	0	0	0	4.20E+04	0.00E+00	0.00E+00	0.00E+00
I 129		1	0	0	0	2.10E+02	0.00E+00	0.00E+00	0.00E+00
CS 135		1	0	0	0	2.00E+03	0.00E+00	0.00E+00	0.00E+00
CS 137		1	0	0	0	4.40E+07	0.00E+00	0.00E+00	0.00E+00
BA 137M		1	0	0	0	4.20E+07	0.00E+00	0.00E+00	0.00E+00
U 235		2	0	0	0	1.30E+03	0.00E+00	0.00E+00	0.00E+00
TH 231		2	0	0	0	1.30E+03	0.00E+00	0.00E+00	0.00E+00
PA 231		2	0	0	0	2.80E+00	0.00E+00	0.00E+00	0.00E+00
AC 227		2	0	0	0	2.00E+00	0.00E+00	0.00E+00	0.00E+00
TH 227		2	0	0	0	1.90E+00	0.00E+00	0.00E+00	0.00E+00
FR 223		2	0	0	0	2.70E-02	0.00E+00	0.00E+00	0.00E+00
RA 223		2	0	0	0	2.00E+00	0.00E+00	0.00E+00	0.00E+00
NP 237		2	0	0	0	2.90E-03	0.00E+00	0.00E+00	0.00E+00
PA 233		2	0	0	0	2.90E-03	0.00E+00	0.00E+00	0.00E+00
U 233		2	0	0	0	1.30E-06	0.00E+00	0.00E+00	0.00E+00
TH 229		2	0	0	0	6.40E-09	0.00E+00	0.00E+00	0.00E+00
RA 225		2	0	0	0	6.30E-09	0.00E+00	0.00E+00	0.00E+00
AC 225		2	0	0	0	6.30E-09	0.00E+00	0.00E+00	0.00E+00
U 238		2	0	0	0	8.20E+03	0.00E+00	0.00E+00	0.00E+00
TH 234		2	0	0	0	8.20E+03	0.00E+00	0.00E+00	0.00E+00
PA 234M		2	0	0	0	8.20E+03	0.00E+00	0.00E+00	0.00E+00
PA 234		2	0	0	0	1.10E+01	0.00E+00	0.00E+00	0.00E+00
PU 242		2	0	0	0	2.60E+01	0.00E+00	0.00E+00	0.00E+00
NP 238		2	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 238		2	0	0	0	6.50E+03	0.00E+00	0.00E+00	0.00E+00
CM 244		2	0	0	0	2.00E+02	0.00E+00	0.00E+00	0.00E+00
PU 244		2	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U 240		2	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU 240		2	0	0	0	6.00E+03	0.00E+00	0.00E+00	0.00E+00
CM 243		2	0	0	0	1.30E+00	0.00E+00	0.00E+00	0.00E+00
PU 243		2	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 243		2	0	0	0	6.30E+02	0.00E+00	0.00E+00	0.00E+00
NP 239		2	0	0	0	6.30E+02	0.00E+00	0.00E+00	0.00E+00
PU 239		2	0	0	0	6.00E+03	0.00E+00	0.00E+00	0.00E+00
PU 241		2	0	0	0	3.20E+03	0.00E+00	0.00E+00	0.00E+00
AM 241		2	0	0	0	2.00E+04	0.00E+00	0.00E+00	0.00E+00

Figure 3.4-15. Sample Problem Four MAXI1 Output (Continued)

SAMPLE PROBLEM FOUR

: BIOPORT Simulation year 100

MAXI, Version VAX2.2 19-JUN-84 executed on 25-AUG-84 at 16:29:43 .

DOSE RESULTING FROM CONCENTRATIONS AT YEAR 100 OF BIOPORT SIMULATION.
MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 1 FORTOTAL BODY

RADIONUCLIDE	INGESTION		EXPOSURE PATHWAY INHALATION		EXTERNAL		AQUATIC FOOD		DRINKING WATER	
	REM	%	REM	%	REM	%	REM	%	REM	%
H 3	7.68E-07	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
C 14	2.43E-04	1	3.00E-12	0	4.12E-10	0	0.00E+00	0	0.00E+00	0
FE55	9.79E-18	0	1.33E-20	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
CO60	4.05E-09	0	1.38E-13	0	1.20E-06	0	0.00E+00	0	0.00E+00	0
NI59	1.64E-06	0	2.73E-11	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
NI63	1.67E-04	1	2.79E-09	1	1.62E-18	0	0.00E+00	0	0.00E+00	0
NB94	7.07E-10	0	7.03E-11	0	1.90E-05	0	0.00E+00	0	0.00E+00	0
SR90	3.26E-03	25	5.35E-09	2	5.45E-08	0	0.00E+00	0	0.00E+00	0
Y 90	2.49E-11	0	2.45E-11	0	3.45E-06	0	0.00E+00	0	0.00E+00	0
MO99	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
TC99M	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
TC99	6.20E-07	0	3.87E-13	0	2.23E-09	0	0.00E+00	0	0.00E+00	0
I 129	5.29E-08	0	2.71E-13	0	1.20E-09	0	0.00E+00	0	0.00E+00	0
CS135	4.56E-08	0	1.03E-12	0	3.46E-11	0	0.00E+00	0	0.00E+00	0
CS137	8.87E-03	70	1.98E-07	88	2.34E-05	0	0.00E+00	0	0.00E+00	0
BA137M	0.00E+00	0	1.92E-13	0	1.19E-01	99	0.00E+00	0	0.00E+00	0
U 235	1.41E-07	0	1.30E-10	0	3.46E-07	0	0.00E+00	0	0.00E+00	0
TH231	1.80E-14	0	3.17E-15	0	2.25E-08	0	0.00E+00	0	0.00E+00	0
PA231	3.54E-11	0	3.08E-12	0	3.23E-10	0	0.00E+00	0	0.00E+00	0
AC227	3.52E-11	0	3.05E-12	0	3.50E-13	0	0.00E+00	0	0.00E+00	0
TH227	2.32E-12	0	1.07E-13	0	6.64E-10	0	0.00E+00	0	0.00E+00	0
FR223	0.00E+00	0	0.00E+00	0	2.83E-12	0	0.00E+00	0	0.00E+00	0
RA223	1.66E-09	0	2.36E-13	0	6.99E-10	0	0.00E+00	0	0.00E+00	0
NP237	1.28E-14	0	1.11E-15	0	7.33E-14	0	0.00E+00	0	0.00E+00	0
PA233	5.00E-18	0	3.89E-19	0	2.31E-12	0	0.00E+00	0	0.00E+00	0
U 233	1.54E-16	0	1.42E-19	0	7.33E-20	0	0.00E+00	0	0.00E+00	0
TH229	3.23E-19	0	1.66E-20	0	1.57E-19	0	0.00E+00	0	0.00E+00	0
RA225	7.68E-18	0	9.90E-22	0	5.96E-20	0	0.00E+00	0	0.00E+00	0
AC225	2.82E-21	0	2.56E-22	0	1.50E-19	0	0.00E+00	0	0.00E+00	0
U 238	8.30E-07	0	7.63E-10	0	1.07E-09	0	0.00E+00	0	0.00E+00	0
TH234	5.90E-11	0	2.70E-12	0	8.18E-08	0	0.00E+00	0	0.00E+00	0
PA234M	0.00E+00	0	1.59E-18	0	3.16E-07	0	0.00E+00	0	0.00E+00	0
PA234	2.84E-17	0	4.94E-17	0	8.93E-08	0	0.00E+00	0	0.00E+00	0
PU242	3.59E-12	0	1.04E-11	0	2.80E-13	0	0.00E+00	0	0.00E+00	0
NP238	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
PU238	9.97E-10	0	2.87E-09	1	2.49E-10	0	0.00E+00	0	0.00E+00	0
CM244	9.97E-10	0	8.95E-11	0	4.61E-12	0	0.00E+00	0	0.00E+00	0
PU244	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
U 240	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
PU240	8.65E-10	0	2.49E-09	1	2.15E-10	0	0.00E+00	0	0.00E+00	0
CM243	6.81E-12	0	5.92E-13	0	4.22E-10	0	0.00E+00	0	0.00E+00	0
PU243	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
AM243	3.05E-10	0	2.65E-10	0	3.02E-08	0	0.00E+00	0	0.00E+00	0
NP239	2.67E-14	0	4.98E-15	0	2.43E-07	0	0.00E+00	0	0.00E+00	0
PU239	8.64E-10	0	2.49E-09	1	2.31E-10	0	0.00E+00	0	0.00E+00	0
PU241	1.86E-11	0	5.44E-11	0	1.18E-19	0	0.00E+00	0	0.00E+00	0
AM241	1.02E-08	0	8.85E-09	3	2.92E-07	0	0.00E+00	0	0.00E+00	0
TOTALS	INGESTION 1.25E-02	% 9	INHALATION 2.24E-07	% 0	EXTERNAL 1.19E-01	% 90	AQUATIC FOOD 0.00E+00	% 0	DRINKING WATER 0.00E+00	% 0
										TOTAL 1.32E-01

Figure 3.4-15. Sample Problem Four MAXI1 Output (Continued)

3.4.5. Sample Problem Five

This sample problem illustrates how the user may replace generic plant and animal parameters with site-specific data and how the user may define a radionuclide inventory. The reference arid site scenario was the base case for this sample problem. As an example of site-specific data modification, this problem shows how the user may use specific data on the root distribution of sagebrush and on the burrowing habits of badgers. The proportion of roots in each soil strata during the Third Successional Phase of the sagebrush community were changed to the following:

<u>Depth</u>	<u>Proportion of Roots</u>
0 - 0.5m	.50
0.5 - 1.0m	.20
1.0 - 1.5m	.10
>1.5m	.20

For this sample problem, badgers were assumed to burrow to a depth of 1.5 m. The proportion of soil and waste material moved to the surface by badgers from each of the strata were:

<u>Depth</u>	<u>Proportion of Material Moved</u>
0.0 - 0.5m	.70
0.5 - 1.0m	.20
1.0 - 1.5m	.10
>1.5m	.0

Parameters selected for modification in this sample problem were those that have the greatest influence on the model output, as determined during the sensitivity analysis of the model.

Only three radionuclides were considered in this sample problem. The radionuclides and their concentrations were as follows:

<u>Radionuclide</u>	<u>Ci/cubic meter</u>
⁹⁰ Sr	1.0
¹³⁷ Cs	1.0
²⁴¹ Am	1.0

Dose to total body was calculated. Default values were used for all other parameters.

Figure 3.4-17 is a facsimile of the interaction computer session that prepares input for the BIOPORT and MAXI1 computer codes. Figures 3.4-18 and 3.4-19 show the complete BIOPORT report and MAXI1 output, respectively. Appendix 2 shows complete Sample Problem Five output.

```

#####
#
#
#          =====
#          CREATE-BIOPORT-MAXI
#          =====
#
#
#      This interactive program will assist you in the creation
#      of scenarios to be simulated by BIOPORT-MAXI.
#
#      The following notes may be of interest:
#      When you have finished reading, press <return> <cr>
#
#####

#####
#
#      1) If the default condition is selected, you need only
#      press <return>. YES-or-NO questions are designated by
#      (Y/N) and should be answered with a Y or N. The default
#      condition is always listed first.
#
#      2) The values you enter will be tested against reasonable
#      limits and if they are not accepted you will be asked to
#      supply another value.
#
#      3) [Strata] and [layer] are used interchangeably to define
#      the soil compartments.
#
#####

#####
#
#      4) One hectare = 2.471 acres = 10000 square meters.
#
#      5) A successional phase of a plant or animal can be des-
#      cribed as the replacement of one community with another.
#
#      When you have finished reading, press <return> <cr>
#
#      =====
#
#      Enter an identifying title for this run (up to 40 letters long):
#      SAMPLE PROBLEM FIVE <cr>
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session

```

#####
#
#
#
# The length of the simulation is 500 years
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####

#####
#
# During the simulation, printed reports and MAXIL input will
# be generated from radionuclide concentrations in the
# following years:
#
#      1
#     100
#     200
#     300
#     500
#
# =====
# Do you wish to review or change above parameters (N/Y)? <cr>
#
#####

#####
#
# Exhaustive yearly output is available:
#
#      0 - Option not selected
#      1 - Option selected
#
# Default value: 0
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
# In MAXI1 doses to various organs will be calculated. #
# The available organs are: #
# #
# 1-Total body #
# 2-Bone #
# 3-Lungs #
# 4-Thyroid #
# 5-Lower large intestine #
# #
# The number of organs considered is 5. #
# ----- #
# Do you wish to change this value (N/Y)? Y <cr> #
# Enter new value: 1 <cr> #
#####

#####
# #
# The available organs are: #
# #
# 1-Total body #
# 2-Bone #
# 3-Lungs #
# 4-Thyroid #
# 5-Lower large intestine #
# #
# The current selection for organ 1 is 1. #
# ----- #
# Do you wish to change this value (N/Y)? <cr> #
# #
#####

#####
# #
# Two "base cases" are available to provide default values: #
# #
# 1 - Arid reference site #
# 2 - Humid reference site #
# #
# Please enter number of selected site: (Default=1) #
# ----- #
# #
# Do you wish to change this value (N/Y)? <cr> #
# #
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)


```

#####
# Waste Spectrum 1 is representative of past and current      #
# waste storage practices. Waste Spectrum 2 represents        #
# improved practices of the future.                            #
#                                                              #
# The "base case" inventory for the arid site will be:        #
#     1 - Waste Spectrum 1                                     #
#     2 - Waste Spectrum 2                                     #
#     3 - User-defined                                         #
#                                                              #
# Enter index of selected option: (Default=1)                  #
# -----                                                      #
# Do you wish to change this value (N/Y)? Y <cr>              #
# Enter new value: 3 <cr>                                       #
#####

#####
#                                                              #
# The decomposition half-life of the package at closure       #
# is 70.00 years.                                              #
# -----                                                      #
# Do you wish to change this value (N/Y)? <cr>                 #
#                                                              #
# The average age of the waste packages at time of site closure #
# is 10.00 years.                                              #
# -----                                                      #
# Do you wish to change this value (N/Y)? <cr>                 #
#                                                              #
#####

#####
#                                                              #
#                                                              #
# =====                                                      #
# Do you wish to review or change any of the above parameters(N/Y)? <cr> #
#                                                              #
#                                                              #
#                                                              #
#                                                              #
#                                                              #
#                                                              #
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
#
#
#       The following questions pertain to the radionuclide
#       inventory.  After inputting the inventory, enter
#       "99" for element name to signal to the program that
#       you are finished.
#
#       =====
#       Press <return> when you have finished reading: <cr>
#
#
#####

#####
#
#   Enter new 2-character element  (99=no more radionuclides): SR <cr>
#
#
#   Atomic number input can be up to 6 characters long.
#   Include metastable (M) and daughter (+D) designation, (i.e., TE127M+D)
#
#   Enter atomic number: 90 <cr>
#
#
#   Enter the quantity of SR90      in the inventory at start of
#   calculation (units: Ci/cu meter) : 1 <cr>
#
#####

#####
#
#   Enter new 2-character element  (99=no more radionuclides): CS <cr>
#
#
#   Atomic number input can be up to 6 characters long.
#   Include metastable (M) and daughter (+D) designation, (i.e., TE127M+D)
#
#   Enter atomic number: 137 <cr>
#
#
#   Enter the quantity of CS137     in the inventory at start of
#   calculation (units: Ci/cu meter) : 1 <cr>
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
# Enter new 2-character element (99=no more radionuclides): AM <cr>
#
# Atomic number input can be up to 6 characters long.
# Include metastable (M) and daughter (+D) designation, (i.e., TE127M+D)
#
# Enter atomic number: 241 <cr>
#
# Enter the quantity of AM241 in the inventory at start of
# calculation (units: Ci/cu meter) : 1 <cr>
#
# =====
# Enter new 2-character element (99=no more radionuclides): 99 <cr>
#####

#####
#
#
# Radiological inventory (Ci/cubic meter):
#
# SR90      1.0      CS137      1.0
# AM241      1.0
#
# =====
#
# Do you wish to review or change the above parameters (N/Y)? <cr>
# Do you wish to add radionuclides to the above inventory (N/Y)? <cr>
#
#####

#####
#
#
# =====
# Do you wish to review or change strata & erosion parameters(N/Y)? <cr>
#
#
# =====
# Do you wish to review or change plants parameters (N/Y)? Y <cr>
#
#
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
# Two plant uptake of radioactivity models are available
# to the user:
#
# 1 - Uptake based on the total mass of the plant
#
# 2 - Uptake based on the fraction of the roots in
# contact with the radioactive waste
#
# The index of the current selection is 2.
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#####

#####
#
#
#
# The number of plant associations to be considered is 3
# (maximum = 10).
#
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####

#####
#
# Plant No. 1: Cheatgrass Comm.
# Do you wish to change any parameters for this plant (N/Y)? <cr>
#
#
# Plant No. 2: Rabbitbrush Comm.
# Do you wish to change any parameters for this plant (N/Y)? <cr>
#
#
# Plant No. 3: Sagebrush Comm.
# Do you wish to change any parameters for this plant (N/Y)? Y <cr>
#
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
#
#
#
# The name of plant association number 3 is Sagebrush Comm.
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####

#####
#
#
#
#
# Plant No. 3: Sagebrush Comm.
# The dry/wet weight ratio is 0.1500 (range: 0.0 to 1.0).
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####

#####
#
#
#
#
# Plant No. 3: Sagebrush Comm.
#
# The number of phases of succession are 3
# (maximum = 5).
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
# NOTE : Ending year for final successional phase MUST be equal to
# or greater than the number of years simulated ( 500 ).
#
#
# Plant No. 3: Sagebrush Comm.
#
# The year of endpoint of successional phase 1 is 10
# (range: 1 to 500).
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#####

#####
#
#
# Plant No. 3: Sagebrush Comm.
#
# The year of endpoint of successional phase 2 is 30
# (range: 10 to 500).
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####

#####
#
#
#
# Plant No. 3: Sagebrush Comm.
#
# The year of endpoint of successional phase 3 is 500
# (range: 30 to 500).
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
#
# Plant No.   3: Sagebrush Comm.      Successional Phase : 1
#
# The root to shoot ratio is 5.0000 (range: 0.0 to 10.0).
# -----
# Do you wish to change this value (N/Y)? <cr>.
#
#
#
#####

```

```

#####
#
#
#
#
# (...The sequence of questions for Successional Phases 1 and 2 has
# been omitted for the sake of brevity...)
#
#
#
#
#
#
#####

```

```

#####
#
#
# Plant No.   3: Sagebrush Comm.      Successional Phase : 3
#
# The root to shoot ratio is 5.0000 (range: 0.0 to 10.0).
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
#
#
#
# Plant No. 3: Sagebrush Comm. Successional Phase : 3
#
# The total net annual production is 117.00 grams(dry)/sq meter/year
# (range: 0.0 to 1.E6).
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#####

#####
#
#
#
#
# Plant No. 3: Sagebrush Comm. Successional Phase : 3
#
# The proportion of the production recycled each year is 1.00
# (range: 0.0 to 1.0).
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#####

#####
#
#
#
#
# Plant No. 3: Sagebrush Comm . Successional Phase : 3
#
# Production during a successional phase may be :
# 0 = constant
# 1 = linearly increase or decrease
#
# The default for this phase is 0.
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)


```
#####
#
# Plant No. 3: Sagebrush Comm . Successional Phase : 3
#
# The proportion of the biomass recycled during a successional phase may
# be:
#       0 = constant
#       1 = linearly increase or decrease
#
# The default for this phase is 0.
#
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#####
```

```
#####
#
#
#
# Plant No. 3: Sagebrush Comm . Successional Phase : 3
#
# The maximum rooting depth is 2.0000 meters
# (range: 0.0 to 1.E6).
#
# -----
# Do you wish to change this value (N/Y)? <cr>
#
#####
```

```
#####
#
#
# Plant No. 3: Sagebrush Comm . Successional Phase : 3
#
# The proportion of roots in strata 1 is 0.6100
# (range: 0.0 to 1.0).
#
# -----
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: .5 <cr>
#
#####
```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
#
# Plant No.   3: Sagebrush Comm .      Successional Phase : 3
#
# The proportion of roots in strata 2 is 0.2300
# (range: 0.0 to 1.0).
#
# -----
#
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: .2 <cr>
#
#####

#####
#
#
# Plant No.   3: Sagebrush Comm .      Successional Phase : 3
#
# The proportion of roots in strata 3 is 0.1100
# (range: 0.0 to 1.0).
#
# -----
#
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: .1 <cr>
#
#####

#####
#
#
# Plant No.   3: Sagebrush Comm .      Successional Phase : 3
#
# The proportion of roots in strata 4 is 0.0500
# (range: 0.0 to 1.0).
#
# -----
#
# Do you wish to change this value (N/Y)? Y <cr>
# Enter new value: .2 <cr>
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```
#####
#
#
#
# =====
# Do you wish to review or change plants      parameters (N/Y)? <cr>
#
#
# =====
# Do you wish to review or change animals    parameters (N/Y)? Y <cr>
#
#
#####
```

```
#####
#
#
#
#
# The number of animal species to be considered is      3
#   (maximum = 10).
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#####
```

```
#####
#
#
# Animal No. 1: Pocket Mice      .
# Do you wish to change any parameters for this animal (N/Y)? <cr>
#
#
# Animal No. 2: Badgers          .
# Do you wish to change any parameters for this animal (N/Y)? Y <cr>
#
#
#####
```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
#
#
# The name of animal number 2 is Badgers
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####

#####
#
#
#
# The total amount of material brought to surface during
# the first year of activity by Badgers
# is      0.21 cubic meters/hectare      (range: 0.0 to 1.E6).
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####

#####
#
#
#
# The activity index of Badgers      after the first year
# is 1.000. This index relates the activity in
# subsequent years to the activity in the first year.
# The first year has an index of 1.0.
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```
#####
#
#
#
# The depth of activity for Badgers is 2.0000 meters
# (range: 0.0 to 1.E6).
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#
#####
```

```
#####
#
#
#
# The proportion of material (i.e, soil and wastes)
# moved by Badgers from strata 1
# to the surface is 0.7000 (range: 0.0 to 1.0).
#
# -----
#
# Do you wish to change this value (N/Y)? <cr>
#
#
#
#####
```

```
#####
#
#
# The proportion of material (i.e, soil and wastes)
# moved by Badgers from strata 2
# to the surface is 0.1500 (range: 0.0 to 1.0).
#
# -----
#
# Do you wish to change this value (N/Y)? Y <cr>
#
# Enter new value: .2 <cr>
#
#####
```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

```

#####
#
#
#
#   The proportion of material (i.e, soil and wastes)
#   moved by Badgers          from strata 3
#   to the surface is 0.0500  (range: 0.0 to 1.0).
#
#   -----
#
#   Do you wish to change this value (N/Y)? Y <cr>
#
#   Enter new value: .1 <cr>
#
#####

#####
#
#
#   The proportion of material (i.e, soil and wastes)
#   moved by Badgers          from strata 4
#   to the surface is 0.1000  (range: 0.0 to 1.0).
#
#   -----
#
#   Do you wish to change this value (N/Y)? Y <cr>
#
#   Enter new value: 0 <cr>
#
#####

#####
#
#
#
#   Animal No. 3: Harvester Ants
#   Do you wish to change any parameters for this animal (N/Y)? <cr>
#
#
#
#   =====
#   Do you wish to review or change animals      parameters (N/Y)? <cr>
#
#
#
#####

```

Figure 3.4-16. Sample Problem Five Interactive Session (Continued)

SAMPLE PROBLEM FIVE

Program :BIOPORT Run :26-JUN-84 09:51:37
 Version :6/20/84

PLANT MODEL : Only Biomass in Contact with Waste

Simulation Period (years) : 500
 Strata Identification : DEPTH VOLUME CODE
 surface 0.00E+00 (0)
 0.5m 0.50E+04 (1)
 1.0m 0.50E+04 (2)
 1.5m 0.50E+04 (3)
 inventory 0.65E+05 (4)

Number of plant associations : 3 Number of animal species : 3

Erosion constant cm/yr (high) : 2.30000 (low) : 0.00000
 High erosion - starting year : 1 duration : 4
 frequency : 600

Conversion for m3 to gm : 0.170000E+07
 Conversion for Ci/ha to pCi/m2: 1.00E+08

Radionuclide input inventory ELT. WT. (CI/M**3)
 SR 90 0.100E+01
 CS 137 0.100E+01
 AM 241 0.100E+01

Title of radionuclide master library:
 ONSITE/BIOPORT RADIONUCLIDE MASTER DATA LIBRARY 1-JUN-84 RAP

Radionuclide parent and daughter parameters:

		ELT. WT.	DECAY CNST	CONC RATIO	CURIES
SR	90	0.243E-01	0.200E+00	0.650E+05	
Y	90	0.948E+02	0.250E-02	0.000E+00	
CS	137	0.230E-01	0.200E-02	0.650E+05	
BA	137M	0.143E+06	0.500E-02	0.000E+00	
PU	241	0.481E-01	0.250E-03	0.000E+00	
AM	241	0.160E-02	0.250E-03	0.650E+05	

Decomposition half time of package (years): 70.0
 No. of years of package storage prior to beginning of scenario: 10.0

Figure 3.4-17. Sample Problem Five BIOPORT Report

PLANT ASSOCIATION - Cheatgrass Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	0.750000	0.750000	0.750000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	272.000	0.000000E+00	0.000000E+00
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1	:	0.7200	0.7200	0.7200
Strata : 2	:	0.1700	0.1700	0.1700
Strata : 3	:	0.0700	0.0700	0.0700
Strata : 4	:	0.0400	0.0400	0.0400

PLANT ASSOCIATION - Rabbitbrush Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	3.00000	3.00000	3.00000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	104.000	0.000000E+00
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1	:	0.5650	0.5650	0.5650
Strata : 2	:	0.2450	0.2450	0.2450
Strata : 3	:	0.1350	0.1350	0.1350
Strata : 4	:	0.0550	0.0550	0.0550

PLANT ASSOCIATION - Sagebrush Comm
Number of Successional Phases 3

Dry/wet weight ratio = 0.1500

Intervals for succession (yrs)	:	10	30	500
Root/shoot ratio	:	5.00000	5.00000	5.00000
Range of roots (m)	:	2.0	2.0	2.0
Net annual production [gm(dry)/m2/yr]	:	0.000000E+00	0.000000E+00	117.000
Recycle rate for each phase	:	1.00	1.00	1.00
Linear change(biomass)(0=no,1=yes)	:	0	0	0
Linear change(recycle)(0=no,1=yes)	:	0	0	0
% Root distribution by strata	:			
Strata : 1	:	0.6100	0.6100	0.5000
Strata : 2	:	0.2300	0.2300	0.2000
Strata : 3	:	0.1100	0.1100	0.1000
Strata : 4	:	0.0500	0.0500	0.2000

Figure 3.4-17. Sample Problem Five BIOPORT Report (Continued)

ANIMAL SPECIES - Pocket Mice
 Amount of material moved (m3/ha) 0.100000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 0.8750

Proportion of material moved to surface by strata

1	2	3	4
0.7000	0.2000	0.0500	0.0500

ANIMAL SPECIES - Badgers
 Amount of material moved (m3/ha) 0.211000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 1.0000

Proportion of material moved to surface by strata

1	2	3	4
0.7000	0.2000	0.1000	0.0000

ANIMAL SPECIES - Harvester Ants
 Amount of material moved (m3/ha) 0.100000 Activity range (m) = 2.0
 Degree of activity by phase = 1.0000 1.0000

Proportion of material moved to surface by strata

1	2	3	4
0.7000	0.1000	0.1000	0.1000

Input prepared by J. A. Libquini Date 5-SEP-84

Input checked by J. A. Libquini Date 5-SEP-84

Simulation for YEAR 1 Total Curies / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
SR 90	0.68E-03	0.00E+00	0.14E-01	0.11E-02	0.45E-03	0.65E+04	0.57E+05	0.14E+07
Y 90	0.77E-04	0.00E+00	0.16E-02	0.14E-04	0.56E-05	0.65E+04	0.57E+05	0.16E+06
CS 137	0.76E-04	0.00E+00	0.16E-02	0.11E-04	0.45E-05	0.66E+04	0.57E+05	0.16E+06
BA 137M	0.80E-04	0.00E+00	0.17E-02	0.26E-04	0.11E-04	0.62E+04	0.54E+05	0.17E+06
PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241	0.72E-04	0.00E+00	0.15E-02	0.14E-05	0.58E-06	0.67E+04	0.58E+05	0.15E+06
Total	0.98E-03	0.00E+00	0.20E-01	0.11E-02	0.47E-03	0.33E+05	0.28E+06	

Simulation for YEAR 100 Total Curies / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
SR 90	0.00E+00	0.00E+00	0.22E+01	0.60E+00	0.30E+00	0.38E+04	0.19E+04	0.22E+09
Y 90	0.00E+00	0.00E+00	0.21E+01	0.59E+00	0.30E+00	0.38E+04	0.19E+04	0.21E+09
CS 137	0.00E+00	0.00E+00	0.88E-01	0.75E-02	0.37E-02	0.43E+04	0.22E+04	0.88E+07
BA 137M	0.00E+00	0.00E+00	0.84E-01	0.73E-02	0.36E-02	0.41E+04	0.21E+04	0.84E+07
PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241	0.00E+00	0.00E+00	0.55E+00	0.89E-02	0.42E-02	0.37E+05	0.19E+05	0.55E+08
Total	0.00E+00	0.00E+00	0.50E+01	0.12E+01	0.61E+00	0.53E+05	0.27E+05	

Simulation for YEAR 200 Total Curies / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
SR 90	0.00E+00	0.00E+00	0.59E+00	0.17E+00	0.82E-01	0.44E+03	0.63E+02	0.59E+08
Y 90	0.00E+00	0.00E+00	0.59E+00	0.16E+00	0.82E-01	0.44E+03	0.63E+02	0.59E+08
CS 137	0.00E+00	0.00E+00	0.28E-01	0.29E-02	0.14E-02	0.57E+03	0.82E+02	0.28E+07
BA 137M	0.00E+00	0.00E+00	0.27E-01	0.27E-02	0.14E-02	0.54E+03	0.77E+02	0.27E+07
PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241	0.00E+00	0.00E+00	0.13E+01	0.25E-01	0.11E-01	0.41E+05	0.59E+04	0.13E+09
Total	0.00E+00	0.00E+00	0.26E+01	0.36E+00	0.18E+00	0.43E+05	0.62E+04	

Figure 3.4-17. Sample Problem Five BIOPORT Report (Continued)

Simulation for YEAR 300 Total Curries / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
SR 90	0.00E+00	0.00E+00	0.95E-01	0.27E-01	0.13E-01	0.42E+02	0.20E+01	0.95E+07
Y 90	0.00E+00	0.00E+00	0.95E-01	0.27E-01	0.13E-01	0.42E+02	0.20E+01	0.95E+07
CS 137	0.00E+00	0.00E+00	0.78E-02	0.11E-02	0.55E-03	0.62E+02	0.30E+01	0.78E+06
BA 137M	0.00E+00	0.00E+00	0.74E-02	0.10E-02	0.52E-03	0.59E+02	0.29E+01	0.74E+06
PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241	0.00E+00	0.00E+00	0.20E+01	0.40E-01	0.17E-01	0.38E+05	0.19E+04	0.20E+09
Total	0.00E+00	0.00E+00	0.22E+01	0.95E-01	0.44E-01	0.39E+05	0.19E+04	

Simulation for YEAR 500 Total Curries / Ha

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
SR 90	0.00E+00	0.00E+00	0.45E-02	0.10E-02	0.53E-03	0.34E+00	0.22E-02	0.45E+06
Y 90	0.00E+00	0.00E+00	0.45E-02	0.10E-02	0.53E-03	0.34E+00	0.22E-02	0.45E+06
CS 137	0.00E+00	0.00E+00	0.34E-02	0.68E-03	0.36E-03	0.65E+00	0.42E-02	0.34E+06
BA 137M	0.00E+00	0.00E+00	0.32E-02	0.65E-03	0.34E-03	0.62E+00	0.40E-02	0.32E+06
PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241	0.00E+00	0.00E+00	0.28E+01	0.64E-01	0.24E-01	0.29E+05	0.19E+03	0.28E+09
Total	0.00E+00	0.00E+00	0.28E+01	0.67E-01	0.25E-01	0.29E+05	0.19E+03	

Simulation for YEAR 83 Maximum Year

Element	Eroded	Surface	Strata (m)			Available Inventory	Contained Inventory	MAXI Input
			0 - 0.50	0.50 - 1.00	1.00 - 1.50			
SR 90	0.00E+00	0.00E+00	0.23E+01	0.65E+00	0.32E+00	0.52E+04	0.34E+04	0.23E+09
Y 90	0.00E+00	0.00E+00	0.23E+01	0.63E+00	0.32E+00	0.52E+04	0.34E+04	0.23E+09
CS 137	0.00E+00	0.00E+00	0.96E-01	0.77E-02	0.39E-02	0.58E+04	0.38E+04	0.96E+07
BA 137M	0.00E+00	0.00E+00	0.91E-01	0.76E-02	0.38E-02	0.55E+04	0.36E+04	0.91E+07
PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241	0.00E+00	0.00E+00	0.42E+00	0.65E-02	0.31E-02	0.34E+05	0.23E+05	0.42E+08
Total	0.00E+00	0.00E+00	0.52E+01	0.13E+01	0.65E+00	0.56E+05	0.37E+05	

Figure 3.4-17. Sample Problem Five BIOPORT Report (Continued)

MAXI - Maximum Annual Dose Calculation Version VAX2.2 25-APR-84
 Executed on 25-AUG-84 at 17:55:39
 Case title: SAMPLE PROBLEM FIVE : BIOPORT Simulation year 1

 RADIONUCLIDE CHAIN LIBRARY USED: RADIONUCLIDE MASTER DATA LIBRARY /w TRANSLOCATION CLASSES, 6-APR-84 RAP
 DOSE FACTOR FILES USED FOR THIS CASE:
 *20 FOOD-LEAF: Leaf Incremental Dose Factors for the ONSITE/BIOPORT
 *21 FOOD-SOIL: Soil Incremental Dose Factors for the ONSITE/BIOPORT
 *22 SHALLOW EXTERNAL: ONSITE/BIOPORT EXTERNAL DRFS FOR SURFACE (PLANE SOUR
 *23 DACRIN-INHALATION: DOS) DOSE INCREMENT FILE ONSITE/BIOPORT ENV. 16-APR-84 RAP

BIOPORT INVENTORY FROM:
 SAMPLE PROBLEM FIVE

DOSES CALCULATED FROM 0 TO 49 YEARS FOLLOWING TIME ZERO

PATHWAYS INITIALIZED FOR DOSE CALCULATIONS:

FARM PRODUCT INGESTION: ON
 INHALATION OF RESUSPENDED MATERIAL: ON
 AQUATIC FOODS INGESTION: OFF
 DRINKING WATER INGESTION: OFF
 CONTINUING ATMOSPHERIC DEPOSITION: OFF
 EXTERNAL FROM BURIED WASTES: OFF
 EXTERNAL FROM SURFACE DEPOSITS: ON

SPECIAL PARAMETERS INITIALIZED:

INVENTORY DILUTION FACTOR: 1.00E+00
 DECAY OF RIVER RELEASE SOURCE TERM NOT PERFORMED
 DECAY OF AIR RELEASE SOURCE TERM NOT PERFORMED
 SITE X/Q: 0.00E+00
 SPECIAL INHALATION MODEL NOT USED

FARM PRODUCT PARAMETERS USED:

FRACTION OF ROOTS IN UPPER SOIL: 0.10E+01
 FRACTION OF ROOTS IN BURIED WASTE 0.00E+00
 FRACTION OF TOTAL DIET GROWN ON SITE: 1.00E+00

IRRIGATION RATE: 0.00E+00L/M**2/MO
 MONTHS PER YEAR IRRIGATED: 0
 RIVER DILUTION FACTOR: 1.00E+00YR/L
 YEARS OF IRRIGATION WITH CONTAMINATED WATER PRIOR TO
 THE DOSE CALCULATIONS: 0

EXTERNAL EXPOSURE PARAMETERS USED:

RATIO OF EXTERNAL CONTAMINATION IN SURFACE SOIL TO SUBSURFACE SOIL 1.00E+00
 XFACT MODIFICATION: 1.33E-11

INHALATION PARAMETERS USED:

MODIFICATION FACTOR, RINH: 3.00E-01
 (EQUIVALENT TO BREATHING RATE OF 230 CC/SEC FOR 2630. HR/YR)
 RESUSPENSION MODEL USED FOR CALCULATING AIR CONCENTRATION: ANSPAUGH
 AVERAGE AGE OF MATERIAL ON GROUND AT TIME ZERO: 2.00E+01 YEARS
 TOP 1.0 CM OF THE CONTAMINATED SURFACE LAYER IS AVAILABLE FOR RESUSPENSION.

ORGANS FOR WHICH DOSES ARE CALCULATED (SAME ORDER AS SOLUBILITIES GIVEN BELOW):

TOTAL BODY

INPUT PREPARED BY *P.A. Lebquin* DATE *5-SEP-84*

INPUT CHECKED BY *P.A. Lebquin* DATE *5-SEP-84*

Figure 3.4-18. Sample Problem Five MAXI1 Output

INVENTORY FOR YEAR		100 OF BIOPORT SIMULATION.					SOIL SOURCE (PCI/M**2)	IRRIGATION/AQUATIC (PCI/L)	DRINKING WATER (PCI/L)	ATM. RELEASE (CI/YR)
RELEASE TERMS	NUCLIDE	ORGAN SOLUBILITY CLASSES								
SR 90		1	0	0	0	0	2.20E+08	0.00E+00	0.00E+00	0.00E+00
Y 90		1	0	0	0	0	2.10E+08	0.00E+00	0.00E+00	0.00E+00
CS 137		1	0	0	0	0	8.80E+06	0.00E+00	0.00E+00	0.00E+00
BA 137M		1	0	0	0	0	8.40E+06	0.00E+00	0.00E+00	0.00E+00
PU 241		2	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241		2	0	0	0	0	5.50E+07	0.00E+00	0.00E+00	0.00E+00

SOIL,AIR, AND WATER CONCENTRATION SUMMARY FOR THE YEAR 0

RADIONUCLIDE	SURFACE SOIL PCI/M2	DEEP SOIL PCI/M3	AIR PCI/M3	IRRIGATION PCI/L	DRINKING WATER PCI/L
SR 90	2.20E+08	0.00E+00	1.87E-02	0.00E+00	0.00E+00
Y 90	2.10E+08	0.00E+00	1.78E-02	0.00E+00	0.00E+00
CS 137	8.80E+06	0.00E+00	7.47E-04	0.00E+00	0.00E+00
BA 137M	8.40E+06	0.00E+00	7.13E-04	0.00E+00	0.00E+00
PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241	5.50E+07	0.00E+00	4.67E-03	0.00E+00	0.00E+00

SOIL,AIR, AND WATER CONCENTRATION SUMMARY FOR THE YEAR 49

RADIONUCLIDE	SURFACE SOIL PCI/M2	DEEP SOIL PCI/M3	AIR PCI/M3	IRRIGATION PCI/L	DRINKING WATER PCI/L
SR 90	6.68E+07	0.00E+00	4.47E-03	0.00E+00	0.00E+00
Y 90	6.68E+07	0.00E+00	4.47E-03	0.00E+00	0.00E+00
CS 137	2.85E+06	0.00E+00	1.91E-04	0.00E+00	0.00E+00
BA 137M	2.70E+06	0.00E+00	1.81E-04	0.00E+00	0.00E+00
PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM 241	5.08E+07	0.00E+00	3.41E-03	0.00E+00	0.00E+00

Figure 3.4-18. Sample Problem Five MAXI1 Output (Continued)

SAMPLE PROBLEM FIVE : BIOPORT Simulation year 100

MAXI, Version VAX2.2 19-JUN-84 executed on 25-AUG-84 at 17:55:39 .

DOSE RESULTING FROM CONCENTRATIONS AT YEAR 100 OF BIOPORT SIMULATION.

MAXIMUM ANNUAL DOSE SUMMARY FOR THE YEAR 30 FORTOTAL BODY

RADIONUCLIDE	EXPOSURE PATHWAY		INHALATION		EXTERNAL		AQUATIC FOOD		DRINKING WATER	
	INGESTION REM	%	REM	%	REM	%	REM	%	REM	%
SR90	3.95E+01	99	5.34E-05	13	4.23E-05	0	0.00E+00	0	0.00E+00	0
Y 90	1.93E-08	0	1.59E-08	0	2.68E-03	17	0.00E+00	0	0.00E+00	0
CS137	9.53E-04	0	1.68E-08	0	2.41E-06	0	0.00E+00	0	0.00E+00	0
BA137M	0.00E+00	0	1.65E-14	0	1.22E-02	77	0.00E+00	0	0.00E+00	0
PU241	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0	0.00E+00	0
AM241	4.57E-04	0	3.48E-04	86	7.67E-04	4	0.00E+00	0	0.00E+00	0
TOTALS	INGESTION	%	INHALATION	%	EXTERNAL	%	AQUATIC FOOD	%	DRINKING WATER	%
	3.95E+01	99	4.01E-04	0	1.57E-02	0	0.00E+00	0	0.00E+00	0
										TOTAL
										3.96E+01

Figure 3.4-18. Sample Problem Five MAXI1 Output (Continued)

3.5. Error and Recovery

To further ease the user interaction with the BIOPORT MAXII computer programs, error-checking and recovery capabilities have been added. The following paragraphs describe the error and recovery procedures that have been built into each of the computer programs.

3.5.1. Error and Recovery - CREATE

CREATE has extensive error-checking and interactive-recovery capabilities. Most input values are tested against minimum and maximum allowable limits. If a value does not fall within the allowable limits, the user is asked immediately to re-enter that value.

CREATE will display the following error messages. Details of the error condition are discussed and appropriate corrective actions are suggested.

"??? Total of proportions of material moved from all strata cannot be greater than 1.0 ??? Total = n --REENTER." This message is self-explanatory. The computer program logic will immediately ask the user to reenter these proportions.

"???? Total of proportions of material moved from all soil strata is less than 1.0 ??? Total = n. Do you wish to reenter (N/Y)?"

"The ending year for the last successional phase MUST be equal to or greater than the number of years simulated --n, reenter ending years." The code will ask the user to reenter the endpoint of each successional phase.

"??? Total of proportions of roots in all soil strata cannot be greater than 1.0 ??? Total = n. --REENTER." The code will ask the user to reenter the proportion of roots in each soil strata.

"???? Total of proportions of roots in all soil strata is less than 1.0 ??? Total = n. Do you wish to reenter (N/Y)?" This possible error condition is flagged for the user. The user may wish a total less than 1.0 to simulate plant root penetration below the available waste inventory. If this is true, the user would respond with "N" and code logic would proceed to the next question. Otherwise the user should respond with "Y" to reenter the proportions.

"???? No more than five radionuclides can be considered with exhaustive option set ???" The user has selected the exhaustive output option that is intended for hand calculation and debugging purposes. A limit of five radionuclides in the source term has been set when this option is selected to control the volume of output.

"???? Radionuclide not found in library, try again ????? The radionuclide name was not found in RMDBIO as entered by the user. Possible causes are: 1) the name was not in a recognizable format, and 2) the radionuclide is not contained in RMDLIB and consequently not considered part of the "environment " defined in Section 2.1.1. The user should verify the input form of the radionuclide name by referring to Appendix 1.C.9.

"???? Radionuclide already included, try again ????? The user is alerted that an entry has already been entered for the radionuclide name entered. The entry is disregarded, and the user asked to proceed.

"Error opening radionuclide library." The program could not access the radionuclide library, RMDBIO. Refer this problem to the person maintaining the BIOPORT/MAXII computer package.

"Premature end-of-file discovered in library." The program expected additional data in the master radionuclide library, RMDBIO. Refer this problem to the person maintaining the BIOPORT/MAXII computer package.

3.5.2. Error and Recovery - BIOPORT

BIOPORT generates three error messages, numbered 1 to 3, that correspond to Diagnostics 5, 6, and 7 of MAXII, respectively. Refer to the appropriate text in Section 3.5.3. In addition, the following messages indicate error conditions.

"Strata 1 has been completely eroded after n years. Simulation cannot continue." The user should examine soil erosion input parameters and verify their appropriateness to the selected scenario. The thickness of the top soil strata may be increased. Note: corresponding changes must then be made to animal and plant parameters relative to depth. If the scenario cannot be modified in either of these ways, the scenario is beyond the limits of the BIOPORT computer code.

"ERROR! Subscript ID out of range: n." This is a programming error. Refer this error to the individual maintaining the BIOPORT/MAXII software package.

"ERROR! TOTMAS .LE.0:n." This is a programming error. Refer this error to the individual maintaining the BIOPORT/MAXII software package.

3.5.3. Error and Recovery - MAXI1

MAXI1 generates the following error messages listed with the source-code module in parentheses. Extended explanations and corrective actions are included, if applicable.

DIAGNOSTIC 1: END OF FILE ON INPUT, STOP (MAIN). The program expected additional input. Suggestion: check use of variable NEXT.

DIAGNOSTIC 2: ERROR ON NAMELIST INPUT (MAIN). The program encountered an error while reading the NAMELIST. Suggestions: check spelling of variable names, check for proper punctuation, verify that column one is blank in each record, and check for "\$END" terminating statement.

DIAGNOSTIC 3: ERROR IN NUMBER OF NUCLIDES. INPUT, NONUC= n1, MAXIMUM ALLOWED IS n2 (MAIN). The program attempts to read NONUC radionuclide data records. Suggestions: verify that NONUC equals the number of radionuclide inventory records, check that NONUC is not greater than the maximum allowed, and verify format of NONUC record (I5?).

DIAGNOSTIC 4: END OF INPUT FOR THIS RUN, NORMAL TERMINATION (MAIN). This message is not an error condition; this message is printed to indicate a successful completion of the execution.

DIAGNOSTIC 5: DECAY CHAIN n1 HAS IMPROPER ORDER. CURRENT MEMBER INDEX IS n2. (RLIBIN). This message indicates a problem with a decay chain organization while reading the master radionuclide library. Its occurrence indicates that (1) an unsuccessful update was made to the library, or (2) that the file has been corrupted. In either case, refer the problem to the person maintaining the data base.

DIAGNOSTIC 6: IMPROPER NUMBER OF NUCLIDES IN MASTER LIBRARY, NUC = n (RLIBIN). The program expected to find n records in the radionuclide master library. This message indicates that (1) an unsuccessful update was made to the library, or (2) that the file has been corrupted. In either case, refer the problem to the person maintaining the data base.

DIAGNOSTIC 7: END OF FILE ON MASTER LIBRARY UNIT 10. STOP (RLIBIN). The program expected additional records in the master radionuclide library. This message indicates that (1) an unsuccessful update was made to the library, or (2) that the file has been corrupted. In either case, refer the problem to the person maintaining the data base.

DIAGNOSTIC 8: NUMBER OF ISOTOPES FOR DFREAD OUT OF BOUNDS (DFREAD), followed by five values which are:

First value - (NISOL) number read in File 20 for leaf DRFs.
Second value - (NISOS) number read in File 21 for soil DRFs.
Third value - (NISOX) number read in File 22 for external-exposure DRFs.
Fourth value - (NISOA) number read in File 24 for aquatic-food DRFs.
Fifth value - (NISOW) number read in File 25 for drinking-water DRFs.

There is an error in one of the dose rate factor files. The number of isotopes listed in the file does not agree with the specified number also read from the file.

DIAGNOSTIC 9: NUMBER OF YEARS FOR DFREAD OUT OF BOUNDS (DFREAD) followed by four values which are:

First value - (NYRL) number read in File 20 for leaf DRFs.
Second value - (NYRS) number read in File 21 for soil DRFs.
Third value - (NYRA) number read in File 24 for aquatic-food DRFs.
Fourth value - (NYRW) number read in File 25 for drinking-water DRFs.

One of the dose rate factor files is in error. The number of years listed does not correspond to the number of years specified in the beginning of the file.

DIAGNOSTIC 10: NUMBER OF ORGANS OUT OF BOUNDS FOR DFREAD followed by four values which are:

First value - (NORGL) number read in File 20 for leaf DRFs.
Second value - (NORGS) number read in File 21 for soil DRFs.
Third value - (NORGA) number read in File 24 for aquatic-food DRFs.
Fourth value - (NORGW) number read in File 25 for drinking-water DRFs.

One of the dose rate factor files is in error. The number of organs listed does not correspond to the number of organs specified at the beginning of the file.

DIAGNOSTIC 11: UNIDENTIFIED NUCLIDE name (IDNUC). The program did not find a radionuclide with this name when it checked the master radionuclide library. Suggestions: check spelling of name and verify that "name" is included in the master radionuclide library (checking both sections of the library).

DIAGNOSTIC 12: THERE ARE UNIDENTIFIED NUCLIDES, ISTOP = n (IDNUC). This message will appear after Diagnostic 11, giving the total number (n) of radionuclide names that were not identified in the master radionuclide library. The program will not execute until all name discrepancies have been resolved. Be sure to change the number of radionuclides (NONUC) if any radionuclides are eliminated at this time.

DIAGNOSTIC 13: TOO MANY NUCLIDES ATTEMPTED IN SUBROUTINE SETDAT. INUC= n (SETDAT). More than the maximum allowable number of radionuclides were encountered. This may have been caused by the automatic building in of daughters into the decay chain by the program.

DIAGNOSTIC 14: TEST INUC.NE.NONUC=END - PNT0 (PNT0). This error condition occurs when number of radionuclides encountered does not equal the maximum index set.

3.6. References

Napier, B. A., R. L. Roswell, W. E. Kennedy, Jr. and D. L. Streng. 1980. ARRRG and FOOD - Computer Programs for Calculating Radiation Dose to Man from Radionuclides in the Environment. PNL-3180, Pacific Northwest Laboratory, Richland, Washington.

McKenzie, D. H., L. L. Cadwell, L. E. Eberhardt, W. E. Kennedy, Jr., R. A. Peloquin, and M. A. Simmons. 1982. Relevance of Biotic Pathways to the Long-Term Regulation of Nuclear Waste Disposal, Topical Report on Reference Western Arid-Low-Level Sites. NUREG/CR-2675:PNL-4241, Vol. 2. U.S. Nuclear Regulatory Commission, Washington, D.C.

McKenzie, D. H., L. L. Cadwell, K. A. Gano, W. E. Kennedy, Jr., R. A. Peloquin, L. A. Prohammer and M. A. Simmons. 1984. Relevance of Biotic Pathways to the Long-Term Regulation of Nuclear Waste Disposal: Phase II Final Report. NUREG/CR-2675, PNL-4241, Vol. 5, U.S. Nuclear Regulatory Commission, Washington, D.C.

4. PROGRAMMING DETAIL

The information in this section is not necessary for a theoretical or operational understanding of the BIOPORT/MAXII computer software package. It is included for those who wish to gain a better understanding of the structure and organization of the computer codes and for the programmer who must maintain or modify the software package.

The organization of the code modules and descriptions of all modules are presented in this section. Flow charts of the program control and simulation control are included. The use of data arrays, common blocks, and data constants are tabulated for each of the programs. The organization of the input files is presented and the parameters of MAXII, that are not reviewed by CREATE, are identified and described.

4.1. Program Hierarchy and Structure

BIOPORT/MAXII is a package of three separate computer codes and a data base. All the computer codes have been designed in modular fashion and are written to meet ANSI FORTRAN-77 standards. The hierarchical organization of code modules is presented graphically followed by tables describing each module.

The computer code BIOPORT consists of the controlling module, named BIOPORT and eleven subroutines. The hierarchy of BIOPORT design is depicted in Figure 4.1-1. Summaries of each of the modules are given in Table 4.1-1.

Figure 4.1-1. BIOPORT Design Hierarchy

Table 4.1-1. BIOPORT Module Summaries

<u>Module Name</u>	<u>Major Function and Description of Module</u>
BIOPORT	Reads input file, writes output files, performs simulation. (Controlling module).
ACHAIN	Calculates radiological decay for one decay chain. (Subroutine called by ADJUST).
ADJUST	Controls radiological and package decay calculations. (Subroutine called by BIOPORT).
ASUM	Sums terms of array. (Function called by ACHAIN).
CRITTER	Calculates animal movement of soil and radioactivity between strata. (Subroutine called by BIOPORT).
ERSION	Calculates the volume of soil and corresponding radionuclide quantity eroded yearly and readjusts soil strata volumes to remove voids. (Subroutine called by BIOPORT).
IDNUC	Identifies radionuclides in the input inventory (Subroutine called by INVEN).
INVEN	Reads radiological inventory and package half-life; controls verification of the input inventory; calculates the package decay constant, initial package decay, and initial available inventory. (Subroutine called by BIOPORT).
PLANT	Calculates the movement of radionuclides by plant communities; determines the highest concentration encountered in strata; recycles biomass. (Subroutine called by BIOPORT).
RADQA	Prints report of radiological inventory and package parameters. (Subroutine called by INVEN).
RLIBIN	Controls reading of the master radionuclide library with chain decay data. (Subroutine called by INVEN).
ZEROI	Initializes an integer array to zero. (Subroutine called by IDNUC).
ZEROR	Initializes a real array to zero. (Subroutine called by RLIBIN and IDNUC).

MAXI1 is controlled by the module named MAIN and includes twenty-one subroutines. The code module hierarchy of MAXI1 is presented in Figure 4.1-2. Descriptions of the modules are given in Table 4.1-2.

Figure 4.1-2. MAXI1 Design Hierarchy

Table 4.1-2. MAXII Module Summary

<u>Module Name</u>	<u>Major Function and Description of Module</u>
ACHAIN	Calculates radiological decay for one radionuclide chain. (Subroutine called by SOLCON and WATER.)
AFACT	Calculates a resuspension factor using the Anspaugh model. (Subroutine called by PADOS.)
AIRDIS	Decays the atmospheric release source term if necessary. (Subroutine called by PADOS.)
ANDOS	Calculates annual doses. (Subroutine called by MAIN.)
DFREAD	Reads dose rate factor libraries, except inhalation. (Subroutine called by MAIN)
DUMMY	Reads past unused entries in inhalation dose rate factor library. (Subroutine called by INSET.)
IDNUC	Identifies input radionuclides in the inventory. (Subroutine called by MAIN.)
INSET	Reads the inhalation dose rate factor library. (Subroutine called by MAIN.)
MAIN	Controls library and parameter input, data organization, dose calculations, report printing and successive case handling. (Controlling module.)
MAXDOS	Calculates maximum annual dose. (Subroutine called by MAIN.)
MLOAD	Calculates a mass-loading factor. (Subroutine called by PADOS.)
OUTPUT	Prints report of results. (Subroutine called by MAIN.)
PADOS	Calculates pathway doses. (Subroutine called by MAIN.)
PNT0	Prints the resulting time dependent soil, air, irrigation-water and drinking-water concentrations. (Subroutine called by PADOS.)
QAPAGE	Prints a report of input variables. (Subroutine called by MAIN.)

Table 4.1-2. MAXI1 Module Summary (Continued)

<u>Module Name</u>	<u>Major Function and Description of Module</u>
RDSUB	Initializes inventory arrays and sets input inventory data into arrays. This subroutine is used only when special option is set. (Subroutine called by MAIN, not shown in Figure 4.1-2.)
RLIBIN	Reads master radionuclide library with chain decay. (Subroutine called by MAIN.)
SETDAT	Stores data for radionuclides into arrays. (Subroutine called by MAIN.)
SOLCON	Calculates the soil concentration accounting for both the radioactive decay and deposition of radionuclides in irrigation. (Subroutine called by PADOS.)
WATER	Decays the water release source term, if necessary. (Subroutine called by PADOS.)
ZEROI	Initializes an integer array to zero. (Subroutine called by IDNUC and SETDAT.)
ZEROR	Initializes a real array to zero. (Subroutine called by SETDAT, INSET, PADOS, ANDOS, and MAXDOS.)

The interactive program CREATE is organized into seventeen modules; CREATE, the control program, and sixteen subroutines. Figure 4.1-3 depicts the module hierarchy of CREATE. Table 4.1-3 presents a summary of the modules.

4.2. Computer Program Flow

The logic of the computer programs in the BIOPORT/MAX1 software package is depicted using flow-charting techniques described by Chapin (1974). The reader is presented concise overviews of the program control logic and the simulation control logic. Detailed flow charts are not provided for the following reasons: 1) the codes are modularly designed; 2) the logic within each module is readily apparent; and 3) each module is enhanced with comments. Figures 4.2-1 and 4.2-2 show BIOPORT program control logic and simulation control logic, respectively. Figure 4.2-3 depicts MAX11 program control logic and Figure 4.2-4 summarizes MAX11 dose calculation logic. The program logic of CREATE is charted in Figure 4.2-5. Figure 4.2-6 shows the logic that controls parameter modification in CREATE.

Figure 4.1-3. CREATE Design Hierarchy

Table 4.1-3. CREATE Module Summary

<u>Module Name</u>	<u>Major Function and Description of Module</u>
ARID	Establish default values for reference arid site. (Subroutine called by CREATE.)
CHANGE	Query if user requests parameter value change; and if so, input new value, test if within allowable limits, and repeat if not accepted. (Subroutine called by CREATE, RADIN, EDANIM, EDBUG, DISINV, EDDOSE, EDPLAN, and EDSTRA.)

Table 4.1-3. CREATE Module Summary (Continued)

<u>Module Name</u>	<u>Major Function and Description of Module</u>
CHAREL	Query for parameter value change of a character-type array. Controls user input of parameter. (Subroutine called by EDPLAN and EDANIM.)
CREATE	Control program functions and review general parameters. (Controlling module.)
DEFINV	Defines Waste Spectrum 1 and 2 for the selected reference site. (Subroutine called by CREATE.)
DISINV	Display radionuclide inventory and control modification/additions. (Subroutine called by CREATE.)
EDANIM	Allows user to review and/or modify animal parameters. (Subroutine called by CREATE.)
EDBUG	Allows user to review and /or modify detailed output parameters. (Subroutine called by CREATE.)
EDDOSE	Review/modify years selected for dose calculations. (Subroutine called by CREATE.)
EDPLAN	Allows user to review and/or modify plant parameters. (Subroutine called by CREATE.)
EDSTRA	Review and/or modify soil strata and erosion parameters. (Subroutine called by CREATE.)
GROUP	Query if user wishes to review/modify any of a given collection of parameters. (Subroutine called by CREATE and DISINV.)
HUMID	Establishes default values for reference humid site. (Subroutine called by CREATE.)
INTRO	Display introductory messages and instructions on screen. (Subroutine called by CREATE.)
QUANTI	Input source terms for each radionuclide. (Subroutine called by RADIN.)
RADIN	Input and test radiological source term. (Subroutine called by CREATE and DISINV.)
RITFIL	Write BIOPORT and MAX11 execution and input files. (Subroutine called by CREATE.)

Figure 4.2-1. BIOPORT Program Control Flow Chart

Figure 4.2-2. BIOPORT Simulation Flow Chart

Figure 4.2-3. MAX11 Program Control Flow Chart

Figure 4.2-4. MAXI1 Dose Calculation Flow Chart

Figure 4.2-5. CREATE Program Flow Chart

Figure 4.3-6. CREATE Parameter Modification Flow Chart

4.3. Program Data and Data Structures

This section contains tables of the data arrays, common block definition and usage, and data constants for BIOPORT, MAX11, and CREATE. The arrays are identified and their locations given in Tables 4.3-1 through 4.3-3, respectively. Common block usage in each of the codes is described in Tables 4.3-4 through 4.3-6. Data constants are identified, and the assigned values are listed and described in Tables 4.3-7 through 4.3-9. Table 4.3-9 identifies data constants for CREATE. In addition to the data constants in this table, CREATE includes constant default values for the reference arid and humid sites as was shown in Tables 3.2-2 and 3.2-3, respectively.

Table 4.3-1. BIOPORT Data Arrays

<u>Array Name</u>	<u>Number of Elements</u>	<u>Common Block</u>	<u>Module Location</u>
A	(45)		ACHAIN
A	(1)		ZEROR, ASUM
AB	(10,5)	SHRUB	
ACTPLT	(10,5)	SHRUB	
APLT	(5)		BIOPORT
AL	(100)	DECAY	
AL	(9)		ACHAIN
AM	(9)		ACHAIN
AMT	(10)		BIOPORT
AO	(9)		ACHAIN
AR	(10,5)		BIOPORT
AW	(100)	NAMES	
AWI	(100)	SOURCE	
BB	(10,5)	SHRUB	
BIOMAS	(10,5)	SHRUB	
BR	(10,5)		BIOPORT
CNAME	(2,20)		BIOPORT
CR	(100)	ACTVTY	
DAT	(10)		BIOPORT
DEPTH	(5)		BIOPORT
DIRT	(10,5)	ANIMAL	
DIRTM	(5)	ANIMAL	
DK	(2,9)		ACHAIN
DKF	(2,100)	DECAY	
DMOVE	(5)		CRITTER
DQD	(100,5)		ERSION
ELT	(100)	NAMES	
ELTI	(100)	SOURCE	
EXPO	(9)		ACHAIN
FR	(2)		RLIBIN
HRS	(10)		BIOPORT
IBIO	(5)		BIOPORT
IFR	(2,100)	DECAY	
IFRM	(2,9)		ACHAIN
IMAX	(20)	FILES	
INFLG	(100)	FLAGS	
IRANGC	(10)	ANIMAL	
IRANGP	(10,5)	SHRUB	
IRCY	(5)		BIOPORT
ISUCC	(10)	SHRUB	
IT	(2)		RLIBIN
K			ZERDI
NCHST	(100)	DECAY	
NCHN	(100)	DECAY	

Table 4.3-1 BIOPORT Data Arrays (Continued)

<u>Array Name</u>	<u>Number of Elements</u>	<u>Common Block</u>	<u>Module Location</u>
NFLAGC	(100)	FLAGS	
NFLAG	(100)	FLAGS	
NOFNUC	(100)	DECAY	
NS	(5,100)	ACTVTY	
NSO	(2,100)	DECAY	
NSI	(5,100)	SOURCE	
NYSUC	(10,5)	SHRUB	
OLDV	(5)		BIOPORT
PACTVE	(10,2)	ANIMAL	
PMOVE	(10,5)		BIOPORT
PMOIST	(10)		BIOPORT
PNAME	(2,10)		BIOPORT
PROOT	(10,5)	SHRUB	
Q	(100)	ACTVTY	
QC	(100,5)	ACTVTY	
QD	(100,5)	ACTVTY	
QDE	(100)	EARTH	
QI	(100)	SOURCE	
QM	(100,7)		BIOPORT
QSUM	(7)		BIOPORT
RANGP	(5)		BIOPORT
RECYCL	(10,5)		BIOPORT
RMAS	(6)		BIOPORT
ROOT	(5)		PLANT
RRCY	(6)		BIOPORT
SROOT	(5,5,10)	SHRUB	
SVOL	(5)	EARTH	
TITL	(10)	FILES	
TITLR	(20)		INVEN, RADQA, RLIBIN
VOL	(5)	ACTVTY	

Table 4.3-2. MAXII Data Arrays

<u>Array Name</u>	<u>Number of Elements</u>	<u>Common Block</u>	<u>Module Location</u>
A	(1)		ASUM, SUMPRD, ZEROR
A	(45)		ACHAIN
AARDOS	(50,5)	DOSE1	
ADADOS	(50,5)	DOSE1	
ADWDOS	(50,5)	DOSE1	
AEXDOS	(50)	DOSE1	
AFDOS	(50,5)	DOSE1	
AIDOS	(50,50,5)	DATA2	
AIRCON	(50)		PADOS, PNT0
AIRFA	(50)		AFACT, MLOAD, PADOS
AL	(50)	DATA1	
AL	(9)		ACHAIN
AM	(50)	DATA1	
AM	(9)		ACHAIN
AMI	(50)	DATA1	PNT0
AMJ	(50)	DATA1	PNT0
AMK	(50)		PADOS, WATER, SOLCON
AML	(50)	THIRDS	
AMM	(50)		PADOS, SOLCON, AIRDIS
AMT	(50)		PADOS, PNT0, SOLCON
AO	(9)		ACHAIN, PADOS, SOLCON
ARDOS	(50,50,5)	DOSE1	
ARDW	(50,50,5)	DATA2	
ARGF	(50,50,5)	DATA2	
AW	(300)	RLIB	IDNUC
AWAW	(100)	FREAD	
AWDX	(100)	FREAD	
AWI	(50)		MAIN, IDNUC, SETDAT
AWLS	(100)	FREAD	
AWO	(50)	DATA1	PNT0
AWW	(100)	FREAD	
AWX	(100)	FREAD	
B	(1)	SUMPRD	
DADOS	(50,50,5)	DOSE1	
DEDXT	(50,50,5)	DATA2	
DEXT	(50)	DATA2	
DFDOS	(50,50,5)	DATA2	
DFDXT	(100)	FREAD	
DFXT	(100)	FREAD	
DIN	(3,50,5)		INSET
DK	(2,50)	DATA1	
DK	(2,9)		ACHAIN
DKF	(2,300)	RLIB	
DWDOS	(50,50,5)	DOSE1	
ELT	(300)	RLIB	IDNUC

Table 4.3-2. MAXII Data Arrays (Continued)

<u>Array Name</u>	<u>Number of Elements</u>	<u>Common Block</u>	<u>Module Location</u>
ELTA	(100)	FREAD	
ELTDX	(100)	FREAD	
ELTI	(50)		MAIN, IDNUC, SETDAT
ELTLS	(100)	FREAD	
ELTO	(50)	DATA1	PNT0
ELTX	(100)	FREAD	
EXDOS	(50,50)	DOSE1	
EXMO	(9)		ACHAIN
FADOS	(50,50,5)		MAIN
FDOS	(50,50,5)	DOSE1	
FR	(2)		RLIBIN
IDORG	(5)		INSET
IFR	(2,300)	RLIB	
IFRM	(2,50)	DATA1	
IFRM	(2,9)		ACHAIN
IMEM	(300)	RLIB	
INDOS	(50,50,5)	DATA2	
IOFNUC	(50)	DATA1	
IT	(2)		RLIBIN
K	(1)		ZEROI
KORG	(5)		MAIN, INSET, OUTPUT, QAPAGE, SETDAT
KORGA	(5)		MAIN, DFREAD, SETDAT
KORGLS	(5)		MAIN, DFREAD, SETDAT
KORGW	(5)		MAIN, DFREAD, SETDAT
MAXD	(5)	MXTIM	MAIN
MAXTIM	(5)	MXTIM	
NCHN	(300)	RLIB	IDNUC
NFLAG	(300)		MAIN, IDNUC, SETDAT
NFLAGC	(200)		MAIN, IDNUC, SETDAT
NOFNUC	(200)	RLIB	
NSOLD	(5,50)		MAIN, SETDAT
NTR	(5,50)		MAIN, INSET, QAPAGE, SETDAT
ONA	(5)		OUTPUT
ONAME	(23)		OUTPUT, QAPAGE
Q	(50)		MAIN, SETDAT
QAPR	(50)		MAIN, QAPAGE, SETDAT
QI	(50)		MAIN, SETDAT
QJ	(50)		MAIN, SETDAT
QK	(50)	THIRDS	
SOILCN	(50)	DATA1	PNT0
TIT20	(13)	TITLR	

Table 4.3-2. MAXII Data Arrays (Continued)

<u>Array Name</u>	<u>Number of Elements</u>	<u>Common Block</u>	<u>Module Location</u>
TIT21	(13)	TITLR	
TIT22	(13)	TITLR	
TIT24	(13)	TITLR	
TIT25	(13)	TITLR	
TIT27	(13)	TITLR	
TITLDI	(15)		MAIN, QAPAGE
TITLE1	(20)	JUNK	
TITLR	(20)		MAIN, QAPAGE, RLIBIN
TR	(300)	RLIB	
X	(100000)		MAIN

Table 4.3-3. CREATE Data Arrays

<u>Array Name</u>	<u>Number of Elements</u>	<u>Common Block</u>	<u>Module Location</u>
A	(300)		RADIN
AACTPL	(5)		ARID
AAMT	(10)		ARID
ABIOMA	(10,5)		ARID
ACTPLT	(5)	SHRUB	
ACNAME	(2,10)		ARID
ADIRT	(5,10)		ARID
ADIRTM	(5)		ARID
AIBIO	(10,5)		ARID
AIRCY	(10,5)		ARID
AISUCC	(10)		ARID
AMT	(10)	ANIMAL	
ANYSUC	(10,5)		ARID
APACTV	(10,2)		ARID
APMOIS	(10)		ARID
APMOVE	(10,5)		ARID
APNAME	(2,10)		ARID
APROOT	(10,5)		ARID
ARANGC	(10)		ARID
ARANGP	(10,5)		ARID
ARECYC	(10,5)		ARID
ASROOT	(5,5,10)		ARID
AWI	(100)	INV	
BIOMAS	(10,5)	SHRUB	
CL	(3)		RADIN
CNAME	(2,10)	ANIMAL	
DEPTH	(5)	EARTH	

Table 4.3-3. CREATE Data Arrays (Continued)

<u>Array Name</u>	<u>Number of Elements</u>	<u>Common Block</u>	<u>Module Location</u>
DIRT	(5,10)	ANIMAL	
DIRTM	(5)	ANIMAL	
E	(300)		RADIN
ELTI	(100)	INV	
GNAME	(2)	GRP	
HACTPL	(5)		HUMID
HAMT	(10)		HUMID
HBIOMA	(10,5)		HUMID
HCNAME	(2,10)		HUMID
HDIRT	(5,10)		HUMID
HDIRTM	(5)		HUMID
HIBIO	(10,5)		HUMID
HIRCY	(10,5)		HUMID
HISUCC	(10)		HUMID
HNYSUC	(10,5)		HUMID
HPACTV	(10,2)		HUMID
HPMOIS	(10)		HUMID
HPMOVE	(10,2)		HUMID
HPNAME	(2,10)		HUMID
HPROOT	(10,5)		HUMID
HRANGC	(10)		HUMID
HRANGP	(10,5)		HUMID
HRECYC	(10,5)		HUMID
HSROOT	(5,5,10)		HUMID
IBIO	(10,5)	SHRUB	
IDORG	(5)		RADIN
IMAX	(20)	TIME	
IRANGC	(10)	ANIMAL	
IRANGP	(10,5)	SHRUB	
IRCY	(10,5)	SHRUB	
IS	(2)		RADIN
ISUCC	(10)	SHRUB	
KDORG	(5)		CREATE
KORG	(5)	ORGANS	
KSORG	(5)		RADIN
NS	(2,300)		RADIN
NSOLD	(5,10)	INV	
NYSUC	(10,5)	SHRUB	
ORG	(23)		RADIN
PACTVE	(10,2)	ANIMAL	
PMOIST	(10)	SHRUB	
PMOVE	(	ANIMAL	
PNAME	(2,10)	SHRUB	
PROOT	(10,5)	SHRUB	
QI	(100)	INV	

Table 4.3-3. CREATE Data Arrays (Continued)

<u>Array Name</u>	<u>Number of Elements</u>	<u>Common Block</u>	<u>Module Location</u>
R8X10	(10)		PLANT, CRITTER, CHAREL
RANGC	(	ANIMAL	
RANGP	(10,5)	SHRUB	
RECYCL	(10,5)	SHRUB	
SITIT	(2)	TIME	
SROOT	(5,5,10)	SHRUB	
THICK	(5)	EARTH	
TITL	(10)	TIME	
WS	(4,100)		DEFINV
WSTIT	(2,3)	INV	

Table 4.3-4. BIOPORT Common Block Definition and Usage

<u>Common Block Name</u>	<u>Variables</u>		<u>Used by Module</u>
unnamed	J		BIOPORT
	NLYR5		CRITTER
	NB		PLANT
			ERSION
ACTVTY	QD(100,5)		BIOPORT
	QC(100,5)		ADJUST
	CR(100)		INVEN
	Q(100)		PLANT
	PDC		IDNUC
	VOL(5)		RADQA
	NS(5,100)		RLIBIN
			ERSION
			CRITTER
ANIMAL	IRANGC(10)	NCRIT	BIOPORT
	PACTIVE(10,2)	DIRT(10,5)	CRITTER
	DIRTM(5)		
DECAY	NOFNUC(100)	NUC	BIOPORT
	NCHST(100)	NCH	ADJUST
	IFR(2,100)	AL(100)	IDNUC
	DKF(2,100)	NSD(2,100)	RADQA
	NCHN(100)		RLIBIN

Table 4.3-4. BIOPORT Common Block Definition and Usage (Continued)

<u>Common Block Name</u>	<u>Variables</u>	<u>Used by Module</u>
.....		
EARTH	ERL ERU IER NER	JADJ ODE(100) JER SVOL(5)
		BIOPORT ERSION
.....		
FILES	NBUG NMAX IMAX(20) TITL(10)	
		BIOPORT ADJUST
.....		
FLAGS	NFLAGC(100) NFLAG(100) INFLG(100) NONUC	
		BIOPORT ADJUST IDNUC RADQA
.....		
NAMES	ELT(100) AW(100) NUCS	
		BIOPORT ADJUST IDNUC RADQA RLIBIN INVEN ERSION
.....		
SHRUB	NPLTS ISUCC(10) BIOMAS(10,5) SROOT(5,5,10) ACTPLT(10,5) PMODEL BB(10,5)	IRANGP(10,5) NYSUC(10,5) PROOT(10,5) IC CONV AB(10,5)
		BIOPORT PLANT
.....		
SOURCE	ELTI(100) AWI(100) QI(100) PLI	NIN PL NSI(5,100)
		BIOPORT INVEN IDNUC RADQA
.....		

Table 4.3-5. MAX11 Common Block Definition and Usage

<u>Common Block Name</u>	<u>Variables</u>	<u>Used by Module</u>
DATA1	ELTO(50) IFOD AWO(50) IARG IOFNUC(50) IWAT NONUC DK(2,50) IFRM(2,50) RIRR AL(50) RPF AM(50) XMLF SOILCN(50) DILF ICHN IMO AMI(50) DEN AMJ(50) IEXT	MAIN AIRDIS ANDOS DFREAD INSET OUTPUT PADOS QAPAGE SETDAT SOLCON WATER
DATA2	DFDOS(50,50,5) AIDOS(50,50,5) INDOS(50,50,5) DEXT(50) ARGF(50,50,5) ARDW(50,50,5) DEDXT(50)	MAIN INSET PADOS SETDAT
DOSE1	EXDOS(50,50) AEXDOS(50) FDOS(50,50,5) FADOS(50,50,5) DADOS(50,50,5) ARDOS(50,50,5) DWDOS(50,50,5) AFDOS(50,5) ADADOS(50,5) ADOS(50,5) AARDOS(50,5) ADWDOS(50,5)	MAIN ANDOS MAXDOS OUTPUT PADOS

Table 4.3-5. MAXII Common Block Definition and Usage (Continued)

<u>Common Block Name</u>	<u>Variables</u>		<u>Used by Module</u>	
FREAD	ELTLS(100)	NYRL	MAIN	
	AWLS(100)	NYRS	DFREAD	
	ELTX(100)	NORGL	SETDAT	
	AWX(100)	NORGS		
	DFXT(100)	NISOL		
	ELTA(100)	NISOS		
	AWAW(100)	NYRW		
	ELTW(100)	NYRA		
	AWW(100)	NORGW		
	ELTDX(100)	NORGA		
	AWDX(100)	NISOW		
	DFDXT(100)	NISOA		
	NISODX			
				
JUNK	DD		MAIN	PADOS
	IT1		ANDOS	QAPAGE
	IT2		MAXDOS	
	TITLE1(20)		OUTPUT	
MXTIM				
	MAXTIM(5)		MAIN	
	MAXD(5)		MAXDOS	
RLIB				
	ELT(300)	NCHST(200)	MAIN	
	AW(300)	IFR(2,300)	RLIBIN	
	TR(300)	DKF(2,300)	SETDAT	
	NUC	IMEM(300)		
	NCHN(300)	NCH		
	NOFNUC(200)			
THIRDS				
	QK(50)	IAIR	MAIN	QAPAGE
	AML(50)	IDKAIR	AIRDIS	SETDAT
	XOSITE	IBLOW	PADOS	
TITLS				
	TIT20(13)	TIT24(13)	DFREAD	
	TIT21(13)	TIT25(13)	QAPAGE	
	TIT22(13)	TIT27(13)		
				

Table 4.3-6. CREATE Common Block Definition and Usage

Common Block Name	Variables		Used by Module
TIME	NYRS SITIT(2) NMAX TITL(20)	IRS NBUG IMAX(20)	All modules
EARTH	NLYRS ERLL NER DEPTH(5) THICK(5)	ERU IER JER VOLIN	All modules
SHRUB	NPLTS ISUCC(10) BIOMAS(10,5) SROOT(5,5,10) ACTPLT(5) IRANGP(10,5) RECYCL(10,5) IRCY(10,5)	PNAME(2,10) NYSUC(10,5) PROOT(10,5) CONV RANGP(10,5) PMOIST(10) IBIO(10,5) PMODEL	All modules
ANIMAL	NCRIT AMT(10) DIRT(5,10) DIRTM(5) RANGC(10)	CNAME(2,10) IRANGC(10) PACTIVE(10,2) PMOVE(	All modules
INV	NIN AWI(100) NSOLD(5,10) IWS	ELTI(100) QI(100) WSTIT(2,3)	All modules
PACK	PL PL1 PLI1	PLI PL2 PLI2	All modules
IONUM	SCRN KEY MAX	KEY BIO	All modules
GRP	GNAME(2)	IGFLAG	All modules
ORGANS	NORG	KORG(5)	All modules

Table 4.3-7. BIOPORT Data Constants

<u>Constant Name</u>	<u>Constant Value</u>	<u>Module Location</u>	<u>Description</u>
CMT	1.0×10^8	BIOPORT	Ci/ha to pCi/m ² conversion.
CONV	1.7×10^6	BIOPORT	Ci/m ³ to Ci/g conversion.
HA	10000.	BIOPORT	Conversion factor: square meters/hectare.
ONAME(n)	"organ name"	OUTPUT	Organ titles for report: "organ name" as it appears in Table 4.5-2.
unnamed	2.	INVEN RLIBIN	Reciprocal of 1/2.
unnamed	1	BIOPORT	Logical unit number of an optional plot file.
unnamed	2	BIOPORT	Logical unit number of the output report file. (Standard output.)
unnamed	3	BIOPORT PLANT ANIMAL ERSION ADJUST	Logical unit number of the exhaustive output file.
unnamed	4	RLIBIN	Logical unit number of the BIOPORT master radionuclide library.
unnamed	11	BIOPORT	Logical unit number of the input file.
unnamed	30	BIOPORT	Logical unit number of the inventory file to be used by MAX11.
unnamed	365.	RLIBIN	Conversion factor from years to days.

Table 4.3-8. MAXII Data Constants

<u>Constant Name</u>	<u>Constant Value</u>	<u>Module Location</u>	<u>Description</u>
ONAME(n)	"organ name"	OUTPUT QAPAGE	Organ titles for report: "organ name" as it appears in Table 4.5-3.
Unnamed	1.0×10^9	AFACT	Resuspension factor after 17 years, m^{-1} , used with Anspaugh model. (See Equation 2.7).
Unnamed	0.15	MLOAD	Correction factor for units in PADOS with SOILCN in pCi/m^2 .
Unnamed	3.15×10^4	SOILCN	Air concentration time and deposition velocity conversion factor: $3.15 \times 10^7 \text{ sec/yr} \times 1.0 \times 10^{-3} \text{ m/sec}$.
Unnamed	3.175×10^4	MAIN	Air concentration conversion factor from Ci/yr to pCi/m^3 .
Unnamed	1.0×10^{-4}	AFACT	Resuspension factor - Anspaugh model. (See Equation 2.7.)
Unnamed	-2.87	AFACT	Effective decay constant used in the Anspaugh equation. (See Equation 2.7.)
Unnamed	5.844×10^{-11}	PADOS	Unit conversion factor; $\text{rem/mrem} \cdot \text{hr/yr} \cdot \text{Ci/pCi} \cdot \text{m}^2/0.15 \text{ m}^3$.
Unnamed	1.0×10^{-3}	PADOS	Air deposition velocity for all resuspended particles, m/sec .
Unnamed	2.635×10^6	PADOS	Number of seconds in a month.
Unnamed	365.25	SETDAT	Number of days in a year.
Unnamed	0.693	SETDAT	The $\ln 2.0$.
Unnamed	5	MAIN	Logical unit number of input file.
Unnamed	6	OUTPUT PNT0	Logical unit number of the output report file.
Unnamed	10	RLIBIN	Logical unit number of the radio-nuclide master library.

Table 4.3-8. MAXII Data Constants (Continued)

<u>Constant Name</u>	<u>Constant Value</u>	<u>Module Location</u>	<u>Description</u>
Unnamed	20	DFREAD	Logical unit number of the leaf mechanism dose rate factors file.
Unnamed	21	DFREAD	Logical unit number of the soil mechanism dose rate factors file.
Unnamed	22	DFREAD	Logical unit number of the surface external exposure mechanism dose rate factors file.
Unnamed	23	INSET	Logical unit number of the inhalation dose rate factors file.
Unnamed	24	DFREAD	Logical unit number of the aquatic food dose rate factors file.
Unnamed	25	DFREAD	Logical unit number of the drinking water dose rate factors file.
Unnamed	27	DFREAD	Logical unit number of the buried waste external dose rate factors file.

Table 4.3-9. CREATE Data Constants

<u>Constant Name</u>	<u>Constant Value</u>	<u>Module Location</u>	<u>Description</u>
BIO	7	CREATE	Logical unit number of the output file from CREATE that contains the BIOPORT input file.
KDORG	1, 6, 8, 16, 23	CREATE	Indices of default organs as they appear in Table 4.5-3.
KEY	5	CREATE	Logical unit number of the computer terminal keyboard.
MAX	8	CREATE	Logical unit number of the output file from CREATE that contains the MAXII input file.

Table 4.3-9. CREATE Data Constants (Continued)

<u>Constant Name</u>	<u>Constant Value</u>	<u>Module Location</u>	<u>Description</u>
ORG(23)	"organ name"	RADIN	Organ titles for translocation class review: "organ name" arranged as indexed in Table 4.5-3.
SCRN	6	CREATE	Logical unit number of the computer terminal screen.
SITIT	"arid" "humid"	CREATE	Titles of reference site user options.
UNNAMED	1.0×10^4	CREATE	Square meters per ha.
WSTIT	"Waste Spectrum 1" "Waste Spectrum 2" "User-defined"	CREATE	Titles of default inventory user options.

4.4. Input File Organization

The CREATE computer program relieves the user of the need to be concerned with details of input file organization. The following descriptions will assist the Level Two and Level Three users, defined in Sections 2.2.2 and 3.0, in setting up proper input for the MAXI1, MAXI2, and MAXI3 computer codes. The information in Sections 3.12, 3.13, and 4.5 will assist the Level Two and Level Three user in appropriate parameter selection and organization.

The BIOPORT input file may be created interactively using the CREATE program. Descriptions of BIOPORT input parameters are given in Table 3.2-5. The organization of the file is presented in Table 4.4-1. The parameters must be arranged in the order specified. All input to BIOPORT is free formatted with the exceptions of the title, plant names, animal names, radionuclide names, and radionuclide input concentrations. Consequently, the user need not follow the line designations given in Table 4.4-1 as long as the parameters are arranged in the specified order. Each of the BIOPORT free-formatted input parameters must be followed by a comma, a blank space, or an end-of-line. The line numbers listed in Table 4.4-1 correspond to the lines in the CREATE-generated file. If the parameter is read by a FORTRAN formatted-read statement, the FORTRAN format specification is included in the table.

Table 4.4-1. BIOPORT Execution File Organization

<u>File Position</u>	<u>Variable/Description/Format</u>
Line 1	- Title of this scenario (10A4)
Line 2	- NYRS, NCHK, NLYRS, NPLTS, NCRIT
Line 3	- PMODEL
Line 4	- NMAX
Line 5	- IMAX(n), where n ranges from 1 to NMAX
Line 6	- NBUG
Line 7	- ERU, ERL, IER, NER, JER
Line 8	- DEPTH(n), where n ranges from 1 to NLYRS
Line 9	- VOL(n), where n ranges from 2 to NLYRS+2. VOL(1) - surface volume, initially set to zero and readjusted to zero yearly. VOL(n) - corresponds to soil strata NLYRS+1. VOL(NLYRS+2) - volume of the inventory.
Line 10	- PL
Line 11	- PLI
Line 12	- NIN
Next NIN lines	- A,E,QI for each radionuclide from 1 to NIN; one line per radionuclide for NIN lines;
Next NPLTS lines	- For (n) plant associations, insert this block of lines for each associate where n ranges from 1 to NPLTS: PNAME(n) (2A8) ISUCC(n), PMOIST(n) PROOT(n,i) - where i ranges from 1 to ISUCC(n) RANGP(i) - where i ranges from 1 to ISUCC(n) SROOT(i,j,n) - for (i) successional phases, insert one line containing proportion of roots in each strata j.

Table 4.4-1. BIOPORT Execution File Organization (Continued)

<u>File Position</u>	<u>Variable/Description/Format</u>
	NYSUC(n,i) - where i ranges from 0 to ISUCC(n)
	BIOMASS(n,i) - where i ranges from 1 to ISUCC(n)
	RECYCL(n,i) - where i ranges from 1 to ISUCC(n)
	IBIO(i) - where i ranges from 1 to ISUCC(n)
	IRCY(i) - where i ranges from 1 to ISUCC(n)
Next n lines	- For (n) animals, insert this block of lines for each animal where n ranges from 0 to NCRIT:
	CNAME(n) (2A8)
	AMT(n), RANGC
	PACTIVE(n,i) - where i ranges from 1 to 2
	PMOVE(n,i) - where i ranges from 1 to IRANGC(n). IRANGC(n) is the strata index of the deepest soil strata penetrated by this animal.

A special version of MAXII program control was established to allow several successive runs of MAXII from a single BIOPORT execution. The following discussion pertains to the BIOPORT version of MAXII execution. The MAXII execution file contains system commands to assign appropriate files from the data base and to run the MAXII code. The MAXII execution file contains system control records, and an identifying title and NAMELIST input for each MAXII input case. The BIOPORT version of MAXII program control reads the radionuclide inventory from a BIOPORT-generated file. The organization of the MAXII execution file is detailed in Figure 4.4-2. Figure 4.4-3 contains the organization of the radionuclide inventory file.

It is recommended that only BIOPORT-generated inventory files be used with this version of MAXII. It is necessary that the radionuclides entries in this file be arranged in exactly the same order as the previous cases. Also, there may be no additions or deletions to the inventory in subsequent cases. This is why there are sometimes radionuclide entries in this file with concentrations of zero. MAXII assumes that this inventory file was generated by a computer program and consequently does not check for entry errors during input of subsequent cases. The NAMELIST parameter IBIO must be set to one to activate the BIOPORT version of MAXII program control.

MAXII uses the FORTRAN NAMELIST set INPUT for entering parameter values. For this set the first NAMELIST record must be blank in column one, "\$INPUT" must be located in columns 2-8, and may optionally be followed by

data items. The data items are separated by commas and the last item must be followed by " \$END". The data items must have one of the three forms:

- (1) Parameter name = constant. Where the parameter name may be either subscripted or not.
- (2) Array name = set of constants (separated by commas). The number of constants may be less than, but not greater than, the number of elements in the array, and must be in the same order as the array is stored; i.e., the first subscript changes most rapidly.
- (3) Subscripted parameter = set of constants (separated by commas). The set of constants will be placed in consecutive array elements, starting with the element designated by the subscripted parameter.

Data items that are set via the NAMELIST statement are identified in Table 3.2-5 and Table 4.5-1 by the name of the set (e.g., INPUT) in the second column.

Table 4.4-2. MAXI1 Execution File Organization

<u>File Position</u>	<u>Variable/Description/Format</u>
First n1 lines	- Logical unit/file assignment statements to assign the master radionuclide file and selected dose rate factor files for logical units 20-25 and logical unit 27.
Following line	- System command to execute MAXI1
Next line	- Identifying title of the first case (A80)
Following n2 lines	- NAMELIST set INPUT for the first case as described above using as many lines as needed. The NAMELIST parameters IBIO and NEXT must both be set to one.
Next line	- IRR (number of years of irrigation prior to calculation) (I5)
	- IBLOW (number of years contaminant blow onto site prior to calculation) (I5)
Following n3 sets of lines	- For each successive case of MAXI1 execution the following lines are included:

Table 4.4-2. MAXII Execution File Organization (Continued)

<u>File Position</u>	<u>Variable/Description/Format</u>
	Line a - Identifying title of this case (A80)
	Line b - " \$INPUT NEXT=5 \$END"
Last line in file -1	- Blank line or dummy title record such as "End of calculation" (A80)
Last line in file	- " INPUT NEXT=4 \$END"

Table 4.4-3. MAXII BIOPORT-Generated Inventory File Organization

<u>File Position</u>	<u>Variable/Description/Format</u>
The following set of lines is included for each MAXII case:	
First line	- One record contains the following information: IBYR - year of BIOPORT simulation in which the following concentrations resulted, (I5) Inventory identifying title, (A40)
Next n lines	- For each radionuclide n one line contains the following information: AWI(n) - atomic element symbol (A2) ELTI(n) - atomic number (A6) NSOLD(1,n) - first organ (I1) NSOLD(2,n) - second organ (I1) NSOLD(3,n) - third organ (I1) NSOLD(4,n) - fourth organ (I1) NSOLD(5,n) - fifth organ (I1) Q(n) - concentration of radionuclide n in the available soil surface (E10.2) Note: NSOLD is the translocation classification index for selected organs where 1=Class D, 2=Class W, and 3=Class Y.
Last line in set	- '***' in first two columns of record

4.5. MAXII Parameter Descriptions

The Level Two user may modify the intruder/resident scenario by changing MAXII parameters in the input file. The only MAXII input parameters that the user may modify using the interactive CREATE program concern organ selection. MAXII input parameters not manipulated by CREATE are listed and described in Table 4.5-1. Table 4.5-2 lists the organs used by the MAXII code and the organ reference index associated with each organ. The default organs for this application are total body, bone, lungs, thyroid, and the lower large intestine of the GI tract (LLI). To consider other organs, the Level Three user may execute the MAXI2 and MAXI3 computer programs as discussed in 3.1.3.

Table 4.5-1. MAXII Parameter Descriptions

<u>Parameter Name</u>	<u>NAMelist Set/No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
AGE	INPUT	Real	Anspaugh model. Average age of surface contamination at the beginning of the calculation in years.
AREAEX	INPUT	Real	Area correction factor for external pathways to account for the limited exposure potential from smaller disposal sites. This parameter is based on the size of the site, FRSIZ not used in this application (default value: 1.0).
AREAIN	INPUT	Real	Area correction factor for internal pathways to account for the limited exposure potential from smaller disposal sites. This parameter is based on the size of the site, FRSIZ not used in this application (default value: 1.0).
AWI	(100)	Alpha	Two-character element symbol of each radionuclide in the source term.
DEN	INPUT	Real	Mass-loading model. Soil density in grams per cubic meter. (default value: 1.0E+6).
DILF	INPUT	Real	River dilution factor in units of $(1/\text{yr})^{-1}$ to convert input river

Table 4.5-1. MAXI1 Parameter Descriptions (Continued)

<u>Parameter Name</u>	<u>NAMELIST Set/No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
			source term of pCi per year to pCi per liter. (Default value: 1.0 - no modification)
ELT1	(100)	Alpha	Atomic number for each radionuclide. Input may be up to six characters in length and include metastable (m) and daughter (+D) designation (e.g., TE127m+D).
FRSIZ	INPUT	Real	Disposal site size in terms of fractional hectares not used in this application (default value: 1.0).
I22	INPUT	Integer	Index of source computer program of the external dose rate factors in the file assigned to logical unit 22: 0 - ISOSHL 1 - MAXI2 If I22=0, MAXI1 will set XFACT = 5.844E-11. If I22=1, MAXI1 will set XFACT = 1.0 (default value: 0).
IAIR	INPUT	Integer	Will there be continuing atmospheric deposition? 0 - no 1 - yes (default value: 0).
IARG	INPUT	Integer	Consumption of aquatic food products from a contaminated river pathway: 0 - pathway not selected 1 - pathway selected (default value: 0).
IBIO	INPUT	Integer	(default value: 0).
IBLOW		Integer	Number of years contaminants blow onto the site prior to the beginning of the dose calculation (default value: 0).

Table 4.5-1. MAXII Parameter Descriptions (Continued)

<u>Parameter Name</u>	<u>NAMELIST Set/No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
IBYR		Integer	Year of BIOPORT simulation for this MAXII case (default value: 0).
IDKAIR	INPUT	Integer	Decay the air release term for IT2-IT1 years, starting at the beginning of the scenario? 0 - no 1 - yes (default value: 0).
IDKWAT	INPUT	Integer	Decay the irrigation and aquatic food release term for IT2-IT1 years, starting at the beginning of the scenario? 0 - no 1 - yes (default value: 0).
IEXT	INPUT	Integer	External exposure and crop root penetration for deeply buried waste: 0 - pathway not selected 1 - pathway selected.
IFOD	INPUT	Integer	Farm products ingestion pathway: 0 - pathway not selected 1 - pathway selected.
IMO	INPUT	Integer	The number of months per year that crops are irrigated. (default value: 6).
INHAL		Integer	Inhalation from resuspension pathway: 0 - pathway not selected 1 - pathway selected. This parameter used only by the ONSITE (Napier et al. 1984) program
INTRUD	INPUT	Integer	Special inhalation model selection: 0 - model not selected 1 - model selected; allows a one year exposure with annual doses (default value: 0).

Table 4.5-1. MAXII Parameter Descriptions (Continued)

<u>Parameter Name</u>	<u>NAMelist Set/No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
ION	INPUT	Integer	Print control parameter. Not used in this application (default value: 0).
IOUT	INPUT	Integer	Output class index: 0 - print tables of maximum annual doses per organ with radio-nuclide and pathway contribution 1 - prints above table and a running summary of the annual doses listed by organ and total only 2 - prints above summaries and gives all annual tables by organ, pathway, and radio-nuclide.
IRR		Integer	Number of years irrigation accumulates radionuclides on the site prior to beginning the dose calculation.
IRS		Integer	Index of the selected default scenario: 1 - external exposure 2 - external exposure plus inhalation from resuspension 3 - external exposure from agricultural activities 4 - use of contaminated water for irrigation and/or drinking 5 - user-created.
ISUR	INPUT	Integer	External exposure to surface contamination: 0 - not selected 1 - selected If this parameter is set to 0, XFACT will be set to 1.0 in MAXII (default value: 1).

Table 4.5-1. MAXI1 Parameter Descriptions (Continued)

<u>Parameter Name</u>	<u>NAMelist Set/No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
IT1	INPUT	Integer	The year after waste disposal when intrusion occurs and the annual dose calculation begins. This parameter allows for correct chain decay of source term (default value: 1).
IT2	INPUT	Integer	Number of years of annual dose calculations. The maximum allowed is 49 + IT1 (default value: 50).
IWAT	INPUT	Integer	Drinking water ingestion from well water pathway: 0 - pathway not selected 1 - pathway selected (default value: 0).
M3M2	INPUT	Integer	Surface source term input: 0 - permits input of pCi/square meter 1 - permits input of pCi/cubic meter 2 - permits input of pCi/kilogram of soil (default value: 1).
NEXT	INPUT	Integer	Case control index: 1 - this is the first case: read libraries, NAMelist INPUT, and inventory; perform calculations and prepare for following cases 2 - not used by MAXI1 3 - this is a subsequent case; read title and NAMelist INPUT, perform calculations, and prepare for following case 4 - finished; end execution, previous title record was a dummy record 5 - special case handling for CREATE/BIOPORT-generated input; a value of five signals that this is not the first case of a CREATE/BIOPORT-generated

Table 4.5-1. MAXII Parameter Descriptions (Continued)

<u>Parameter Name</u>	<u>NAMELIST Set/No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
NEXT (continued)			execution; the parameters IRR and IBLOW will not be read and the radionuclide inventory will be read from the file assigned to logical unit 30.
NIN		Integer	Number of radionuclides in the source term. MAXII calculates this parameter under the BIOPORT version of MAXII program control.
Q	(100)	Real	Concentration of radionuclides in the available soil surface. Units as specified by M3M2.
QI	(100)	Real	Irrigation/river release source term in units of pCi/L. Not used in this application.
QJ	(100)	Real	Drinking water source term in units of pCi/L. Not used in this application.
OK	(100)	Real	Atmospheric release source term in pCi/yr. Not used in this application.
RF1	INPUT	Real	The fraction of total roots in top 15 cm of the soil (default value: 1).
RF2	INPUT	Real	The fraction of total roots entering the buried waste below the top 15 cm plow layer of soil (default value: 0). Note: RF1+RF2 $\leq$ 1.0.
RINH	INPUT	Real	RINH modifies the hours of inhalation per year from 8660 hours per year to case-specific values and modifies breathing rate. CREATE establishes a value of 0.3 for RINH which is the equivalent of 2000 hours per year.

Table 4.5-1. MAXII Parameter Descriptions (Continued)

<u>Parameter Name</u>	<u>NAMelist Set/No. Array Elements</u>	<u>Data Type</u>	<u>Description</u>
RIRR	INPUT	Real	Irrigation rate in liters per square meter per month (default value: 0.0 - no irrigation).
RPF	INPUT	Real	This parameter value is calculated by MAXII ($RPF = RPF1 * RPF2$) unless RPF is zero or unspecified; in that case $RPF = RPF1$.
RPF1	INPUT	Real	This is a ratio of waste concentration in surface to subsurface soils (default value: 1.0).
RPF2	INPUT	Real	Fraction of the total diet grown on the site (default value: 1.0).
SRDIL	INPUT	Real	Inventory dilution factor (default value: 1.0).
XDPT	INPUT	Real	Anspaugh resuspension model. Fraction of the soil plow-layer thickness available for resuspension (default value: 0.067).
XF2	Input	Real	Number of hours of external exposure to surface contamination. This parameter will modify XFACT by $XF2/8766$ in MAXII (default value: 2000).
XMLF	INPUT	Real	Mass-loading resuspension model. Mass-loading factor in grams per cubic meter (default value: $1E-4$).
XQSITE	INPUT	Real	Chi/q value at the site (default value: 0.0).
XFACT	INPUT	Real	This parameter has three functions: it can be used to turn off the surface external pathway ($XFACT=0.$); it can modify the units of the surface external DRF file assigned to logical unit 22 allowing use of ISOHLD-generated

Table 4.5-1. MAXI1 Parameter Descriptions (Continued)

Parameter Name	NAMELIST		Data Type	Description
	Set/No.	Array Elements		
XFACT (continued)				files (XFACT=1.0 for MAXI2-generated file 22, XFACT=5.844E-11 for ISOSHL generated file 22); and it can modify the number of hours of exposure per year (based on a full year of exposure or 8766 hours per year=1.0). MAXI1 will calculate XFACT only if values have been entered in NAMELIST INPUT for ISUR, I22, and XF2. This logic allows the user to enter a value for XFACT through the NAMELIST statement.

Table 4.5-2. Organ Selection

1 - Total body	9 - Adrenals	17 - Pancreas
2 - Body water	10 - Testes	18 - Heart
3 - Kidneys	11 - Ovaries	19 - GI tract
4 - Liver	12 - Skin	20 - Stomach
5 - Spleen	13 - Brain	21 - Small intestine
6 - Bone	14 - Muscle	22 - Upper large intestine
7 - Fat	15 - Prostrate	23 - Lower large intestine
8 - Lungs	16 - Thyroid	

4.6. CDC Computer Code Installation

The installation of the BIOPORT/MAXI1 software package on the Control Data Corporation (CDC) computers at Brookhaven National Laboratories is discussed in this section. Computer operation-system interfacing on the CDC computers is largely transparent to the user due to procedures included with this software package. These command level procedures are discussed in Section 4.6.1. Software security procedures established on the CDC are discussed in Section 4.6.2. Conversion of the computer codes for execution on the CDC is discussed in Section 4.6.3.

The BIOPORT/MAXI1 software package is installed on the Brookhaven National Laboratory CDC 6600 (MFA) and CDC 7600 (MFZ) computers. The package has been modified to execute under INTERCOM Version 4 software control. MFA uses the NOS/BE 1 operating system and MFZ uses the SCOPE Version 2.1 operating system. The source code is compiled with the FTN5 FORTRAN

compiler. The contents of the BIOPORT/MAXI software packages are listed in Table 4.6-1.

BIOPORT was developed on a PDP-11/34 minicomputer. MAXI1, MAXI2, and MAXI3 were developed on a UNIVAC 1100/70 computer. The CREATE computer code was developed on a Zenith-89 microcomputer. The software package was assembled, debugged, and tested on a VAX-11/780 computer.

4.6.1. Command Level Procedures and Utility Programs

Four interactive Cyber Control Language (CCL) procedures have been written to handle most of the operating-system interface for the BIOPORT/MAXI1 executions. Instructions for using these procedures are given in Section 3.1.1. The first CCL procedure, named CREATE, performs the necessary system-level commands to attach files, connect the files INPUT and OUTPUT to the terminal screen, and execute the CREATE computer program. The second CCL procedure, named BIO, controls execution of the BIOPORT simulation. The third procedure, MAX, controls construction and submission of the MAXI1 execution file, removes interim files from the user's work area, and disconnects the files INPUT and OUTPUT from the terminal screen. A fourth procedure, named SEND, routes an output file from the batch process output queue to the RJE printer at the SS-056 Computer Operations Facility, Willste Building, Silver Springs, MD. A listing of the file containing these procedures is located in Appendix 1.D.1.

4.6.2. Software Security

All files in the BIOPORT/MAXI1 software package have been protected against modification, extension, deletion, and performance of control functions by passwords. These passwords are not necessary for execution of any of the codes in the BIOPORT/MAXI1 software package. Requests for access to the passwords should be directed to the NRC Project Manager. Execution files created by CREATE contain user identification and accounting information. These files are protected from read-access by a user-supplied password as discussed in Section 3.1.1.

4.6.3. Computer Code Conversion

Most changes to the codes in the BIOPORT/MAXI1 software package were the result of minor syntax variations in the hardware and FORTRAN compilers. The only major change in the CDC version of the software package is the coding of the module RITFIL of the CREATE computer code. A listing of the CDC version of RITFIL is located in Appendix 1.D.2

4.7. References

Chapin, N. 1974. "New Format for Flowcharts," In Vol. 4 of Software - Practice and Experience, pp. 341-357. John Wiley and Sons Ltd., London.

Napier, B. A., R. A. Peloquin, and W. E. Kennedy, Jr. 1984. Intruder Dose Pathway Analysis for the Onsite Disposal of Radioactive Wastes: The ONSITE/MAXII Computer Program. NUREG/CR-3620:PNL-4054. U.S. Nuclear Regulatory Commission, Washington, D.C.

Table 4.6-1. Contents of the BIOPORT/MAXII Software Package

<u>Filename</u>	<u>Computer</u>	<u>Identification</u>	<u>File Type</u>
BIO20	MFZ	ZZRNRC	Sequential data
BIO21	MFZ	ZZRNRC	Sequential data
BIO23	MFZ	ZZRNRC	Sequential data
BIO24	MFZ	ZZRNRC	Sequential data
BIO25	MFZ	ZZRNRC	Sequential data
BIOAC	MFA	BIODB	Sequential data
BIOBURIED1	MFZ	ZZRNRC	Sequential data
BIOMAXIIABS	MFZ	ZZRNRC	Machine executable code
BIOPLANSOURC	MFZ	ZZRNRC	Sequential data
BIOPORT	MFA	BIODB	Batch process file for MFZ containing compilation directives and FORTRAN source code
BIOPORTABS	MFZ	ZZRNRC	Machine executable code
BIORMDLIB	MFZ	ZZRNRC	Sequential data
CREATE	MFA	BIODB	FORTTRAN source code
CREATEABS	MFA	BIODB	Machine executable code
CRFOR	MFA	BIODB	Batch compilation
FTRANSLIB	MFA	BIODB	Sequential data
GRDFLIB	MFA	BIODB	Sequential data
MAXII	MFA	BIODB	Batch process file for MFZ containing compilation directives and FORTRAN source code
MAXI2	MFA	BIODB	FORTTRAN source code
MAXI3	MFA	BIODB	FORTTRAN source code
MAXI2ABS	MFA	BIODB	Machine executable code
MAXI3ABS	MFA	BIODB	Machine executable code
M2FOR	MFA	BIODB	Batch compilation
M3FOR	MFA	BIODB	Batch compilation
ORGLIB	MFA	BIODB	Sequential data
PROCFIL	MFA	BIO	Command level procedure
RMDBIO	MFA	BIODB	Sequential data

APPENDIX 1.A

COMPUTER CODE LISTING - BIOPORT

APPENDIX 1.A Computer Code Listing - BIOPORT

C-----
C
C Program Title: BIOPORT
C
C Developed for: U.S. Nuclear Regulatory Commission
C Office of Nuclear Regulatory Research
C Division of Health, Siting, and Waste Management
C
C Date: May 31, 1984
C
C NRC Contact: Dr. John Randall (NRR)
C Phone: 301-427-4633
C
C Code Developer: Dr. D.H. McKenzie, L.L. Cadwell, L.E. Eberhardt,
C W.E. Kennedy, Jr., R.A. Peloquin, M.A. Simmons
C Pacific Northwest Laboratory
C Richland, WA 509-376-6573 (DHM)
C
C
C This program was prepared for an agency of the United States
C Government. Neither the United States government nor any agency
C thereof, or any of their employees, make any warranty, expressed
C or implied, or assumes any legal liability or responsibility for
C any third party's use, or the results of such use, of any portion
C of this program or represents that its use by such third party
C would not infringe privately owned rights.
C
C
C-----
C
C
C

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

PROGRAM BIOPORT

```
C
C-----
C
C  BIOPORT - Models BIOlogical transPORT of radionuclides from a
C             waste disposal site. Biological components are plant
C             roots which take up the material and distribute it
C             within the plant system (i.e., roots and leaves) and
C             subsequently back into the soil; and an animal component
C             which moves soil and the accompanying radiation from
C             various strata to the surface.
C             The number of years simulated is variable. There are a
C             maximum of 3 strata (of variable thickness) plus a surface
C             and a repository layer.
C             Community composition is determined on input. It is
C             assumed that plant succession will occur and that animal
C             activity will vary over time. Presently animal activity
C             is assumed to decrease after the first year. Succession
C             in the plant community affects : production (gm dry wt/m2/yr),
C             root/shoot ratio, range of roots, the percent of roots in
C             each strata and the rate the biomass is recycled.
C             Plant production and the proportion recycled can
C             increase linearly over time within any successional phase
C             (AB,BB,AR,BR).
C
C
C  INPUT - By line (# refers to a line) :
C           1) title;
C           2) number of years for simulation, frequency for plot points,
C              number of strata in overburden, number of plant species
C              (or communities), number of animal species;
C           3) plant model index;
C           4) number of years for dose calculations;
C           5) years of dose calculations;
C           6) debug option/index
C           7) upper and lower erosion constants, starting year,
C              duration and frequency for increased erosion;
C           8) depths for each strata;
C           9) volumes for each strata (m3).
```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

C Package life and radionuclide inventory data includes :
C 1) package life in years (E10.2 format);
C 2) number of years of waste storage prior to the beginning
C of the scenario (E10.2 format);
C 3) number of radionuclides in the inventory (I3 format).
C It is assumed that the input quantity of activity in
C curies has been decayed for the number of years of prior
C storage.
C 4) Each radionuclide in the inventory is then entered on a
C separate line which contains the following information :
C atomic symbol, atomic weight, quantity in curies per cubic
C meter of waste. The format is: A2, A6, 5E10.2.
C The atomic symbol and atomic weight must be presented
C in the same notation as the radionuclide master library.
C
C
C Plant and Animal Data is entered as follows :
C
C 1) plant name (8 character limit);
C 2) number of phases in succession, conversion for dry to
C wet weight;
C 3) root to shoot ratio;
C 4) range of roots in meter intervals;
C 5) % distribution of roots by strata;
C 6) years of years in each successional phase (start with
C 0, e.g., 0,10,30);
C 7) production (gm/m2) for each successional phase;
C 8) proportion recycled for each successional phase;
C 9) index for linear change in biomass during each phase
C (0=no;1=yes);
C 10) index for linear change in amount recycled during
C each phase (0=no;1=yes).
C
C 1) animal name (8 character limit);
C 2) total amount of dirt moved per year (m3), range of
C movement in meter intervals;
C 3) % activity for first year and subsequent years;
C 4) % material moved between strata.
C
C Data for additional plants and animals is repeated in
C order (i.e., all plants together and then all animals).

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
C
C
C
C      OUTPUT - Output file contains all input parameter values, the
C                radionuclide input inventory and concentrations by
C                strata at specified frequency. Inputs for MAXI are
C                also included. A separate file is opened for the total
C                curies by strata at each check year; this file is
C                used (via BPLT) to generate plots.
C                A debug option is available, but should be used ONLY
C                with abridged data sets. Concentrations of radionuclides
C                at selected years are printed to the file assigned to
C                logical unit no. 30 in MAXI1 input format.
C
C      LATEST REVISION - Aug 10,1982 (M.A.Simmons/R.A.Peloquin)
C                        Oct 14,1982 (revisions for eastern site *)
C                        Jul 27,1983 (recalculates soil volumes)
C                        Dec 16,1983 (combines western & eastern models)
C                        Jan 6,1984 (variable erosion option added)
C                        Feb 14, 1984 (VAX installation and MAXI input)
C                        Mar 1,1984 (fixed erosion)
C                        Mar 7,1984 (made depth of strata variable)
C                        Apr 17, 1984 (linked to CREATE and MAXI1)
C                        May 8, 1984 (plant model modification)
C                        Jun 20, 1984 (soil concentration bug fixed)
C
C-----
C
C      DIMENSION AMT(10),PMOVE(10,5),PMOIST(10),DEPTH(5)
C      DIMENSION RANGP(5),QSUM(7),QM(100,7),RECYCL(10,5),IRCY(5)
C      DIMENSION IBIO(5),AR(10,5),BR(10,5),PMAS(6)
C      DIMENSION RRCY(6),APLT(5)
C      REAL*8 OLDV(5)
C
C      Names : PNAME(plant);CNAME(critter);
C      REAL*8  ANAME,PNAME(2,10),CNAME(2,20),VERS
C      BYTE    DAT(10),HRS(10)
C

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

COMMON //JY,NLYRS,NB
INCLUDE 'FILES.FOR'
INCLUDE 'SHRUB.FOR'
INCLUDE 'ANIMAL.FOR'
INCLUDE 'EARTH.FOR'
INCLUDE 'ACTVTY.FOR'
INCLUDE 'DECAY.FOR'
INCLUDE 'FLAGS.FOR'
INCLUDE 'NAMES.FOR'
INCLUDE 'SOURCE.FOR'

C
C      m2 to hectare conversion--
C      HA = 10000.

C
C      Ci/m3 to Ci/gm conversion--
C      CONV = 1.7E6

C
C      Ci/ha to pCi/m2 conversion--
C      CMT = 1.0E+8

C
CALL DATE(DAT)
CALL TIME(HRS)
ANAME = 'BIOPORT'
VERS = '6/20/84'

C
C      Read parameter file :
C      number years, check pts, number layers,
C      number plants, number animals, upper and
C      lower erosion constants (m/yr), start,
C      duration and frequency for increased erosion,
C      depths for each strata, volumes for each strata,
C

READ(11,131) (TITL(I),I=1,10)
READ(11,*) NYRS,NCHK,NLYRS,NPLTS,NCRIT
READ(11,*) PMODEL
READ(11,*) NMAX
READ(11,*) (IMAX(I),I=1,NMAX)
READ(11,*) NBUG
READ(11,*) ERU,ERL,IER,NER,JER
READ(11,*) (DEPTH(K),K=1,NLYRS)
READ(11,*) (VOL(K),K=2,NLYRS+2)

```

```

C
C
C                                     !Write to output file
C
C      WRITE(2,132) TITL
C      WRITE(2,200) ANAME,DAT,HRS,VERS
C      WRITE(30,413) TITL
C
C      IF (PMODEL .EQ. 1) WRITE(2,201)
C      IF (PMODEL .EQ. 2) WRITE(2,202)
C      WRITE(2,205) NYRS,VOL(1)
C      DO 1 K = 1,NLYRS
C          WRITE(2,210) DEPTH(K),VOL(K+1),K
1  CONTINUE
C      WRITE(2,215) VOL(NLYRS+2),NLYRS+1,NPLTS,NCRIT
C      WRITE(2,216) ERU,ERL,IER,NER,JER,CONV,CMT
C
C      IF(NBUG .GT. 0) WRITE(3,160) ANAME,DAT,HRS,PMODEL,NYRS,NLYRS
C      IF(NBUG .GT. 0) WRITE(3,161) NPLTS,NCRIT,ERU,ERL,IER,NER,JER
C
C                                     Convert from cm/yr to m3/yr
C      ERU = ERU * 1.0E2
C      ERL = ERL * 1.0E2
C
C                                     Read radiological input
C      CALL INVEN
C
C
C
C      IF(NPLTS .EQ. 0) GO TO 8
C                                     Page eject
C      WRITE(2,500)
C
C
C                                     Read in plant data :
C                                     plant name, number of phases in succession,
C                                     moisture content, proportion of
C                                     biomass in roots, range of roots, distribution
C                                     of roots by strata, number of years,
C                                     production in each successional phase,
C                                     proportion recycled in each phase,
C                                     index for linear change in each phase.
C
C      DO 6 I = 1,NPLTS
C

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

READ(11,I30) (PNAME(J,I),J=1,2)
READ(11,*) ISUCC(I),PMOIST(I)
READ(11,*) (PROOT(I,I2),I2=1,ISUCC(I))
READ(11,*) (RANGP(I2),I2=1,ISUCC(I))
C          Convert m's to strata index
DO 2 I2 = 1,ISUCC(I)
    IRANGP(I,I2) = 1
    DO 25 K = 1,NLYRS-1
        IF (RANGP(I2) .GT. DEPTH(K) .AND.
            RANGP(I2) .LE. DEPTH(K+1))
            IRANGP(I,I2) = K + 1
25    CONTINUE
        IF (RANGP(I2) .GT. DEPTH(NLYRS)) IRANGP(I,I2)
            = NLYRS + 1
2    CONTINUE
C
DO 3 I2 = 1,ISUCC(I)
    READ(11,*) (SROOT(I2,K2,I),K2=1,IRANGP(I,I2))
3    CONTINUE
    READ(11,*) (NYSUC(I,I2),I2=1,ISUCC(I) + 1)
    READ(11,*) (BIOMAS(I,I2),I2=1,ISUCC(I))
    READ(11,*) (RECYCL(I,I2),I2=1,ISUCC(I))
    READ(11,*) (IBIO(I2),I2=1,ISUCC(I))
    READ(11,*) (IRCY(I2),I2=1,ISUCC(I))
C
DO 44 I2 = 1, ISUCC(I)
    IF (IRANGE .LT. IRANGP(I,I2)) IRANGE=IRANGP(I,I2)
44    CONTINUE
C
C
WRITE(2,220) (PNAME(J,I),J=1,2)
WRITE(2,225) ISUCC(I),( 1.0 - PMOIST(I))
WRITE(2,230) (NYSUC(I,I2),I2=2,ISUCC(I)+1)
WRITE(2,235) (PROOT(I,I2),I2=1,ISUCC(I))
WRITE(2,240) (RANGP(I2),I2=1,ISUCC(I))
WRITE(2,245) (BIOMAS(I,I2),I2=1,ISUCC(I))
WRITE(2,248) (RECYCL(I,I2),I2=1,ISUCC(I))
WRITE(2,249) (IBIO(I2),I2=1,ISUCC(I))
WRITE(2,246) (IRCY(I2),I2=1,ISUCC(I))
WRITE(2,250) !Heading
DO 5 K2 = 1,IRANGE

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

WRITE(2,255) K2,(SROOT(I2,K2,I),I2=1,ISUCC(I))
5      CONTINUE
C
      IRANGE = 0
      RMAS(1) = 0.
      RRCY(1) = 0.
C
      DO 4 I2 = 1,ISUCC(I)
C
C          Convert dry weight to wet.
C          And gm/m2 to gm/ha.
      BIOMAS(I,I2) = (BIOMAS(I,I2) / (1. - PMOIST(I))) * HA
      RMAS(I2+1) = BIOMAS(I,I2)
      RRCY(I2+1) = RECYCL(I,I2)
4      CONTINUE
C
C          Calculate reg. coef. for production
C          and amount recycled.
      DO 11 I2 = 1,ISUCC(I)
C
      BR(I,I2) = 0.
      AR(I,I2) = RECYCL(I,I2)
C
      IF (IRCY(I2) .EQ. 0) GO TO 12
C
      BR(I,I2) = (RRCY(I2+1) - RRCY(I2)) /
1          (NYSUC(I,I2+1) - NYSUC(I,I2))
      AR(I,I2) = RRCY(I2+1) - BR(I,I2) * NYSUC(I,I2+1)
C
12     CONTINUE
      BB(I,I2) = 0.
      AB(I,I2) = BIOMAS(I,I2)
      IF (IBIO(I2) .EQ. 0) GO TO 9
      BB(I,I2) = (RMAS(I2+1) - RMAS(I2)) / (NYSUC(I,I2+1)
1          - NYSUC(I,I2))
      AB(I,I2) = AB(I,I2) - BB(I,I2) * NYSUC(I,I2+1)
C
9      CONTINUE
      IF(NBUG .GT. 0) WRITE(3,162) AR(I,I2),BR(I,I2),
1          AB(I,I2),BB(I,I2)
C
11     CONTINUE

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
6  CONTINUE
C
C          Read in animal data :
C          critter name, total amount of dirt moved,
C          range of movement, % activity/yr,
C          % dirt moved between strata.
C
8  CONTINUE
   IF(NCRIT .EQ. 0) GO TO 18
   WRITE(2,500)
C
   DO 10 I = 1,NCRIT
C
       READ(11,130) (CNAME(J,I),J=1,2)
       READ(11,*)   AMT(I),RANGC
C
       IRANGC(I) = 1
       DO 7 K = 1,NLYRS - 1
           IF (RANGC .GT. DEPTH(K) .AND. RANGC .LE.
               DEPTH(K+1)) IRANGC(I) = K+1
C
7      CONTINUE
       IF (RANGC .GT. DEPTH(NLYRS)) IRANGC(I) = NLYRS + 1
C
       READ(11,*)   (PACTIVE(I,L),L=1,2)
       READ(11,*)   (PMOVE(I,K2),K2=1,IRANGC(I))
C
       WRITE(2,260)  (CNAME(J,I),J=1,2)
       WRITE(2,265)  AMT(I),RANGC
       WRITE(2,270)  (PACTIVE(I,L),L=1,2)
       WRITE(2,275)
       WRITE(2,280)  (PMOVE(I,K2),K2=1,IRANGC(I))
C
10  CONTINUE
C
C          Print QA signature lines
C          WRITE (2,420)
C
C          Maximum amount of dirt moved/critter/layer/year
C
   IF(NBUG .GT. 0) WRITE(3,165)

```


APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
DO 15 I = 1,NCRIT
    DO 14 K2 = 1,IRANGC(I)
        DIRT(I,K2) = AMT(I) * PMOVE(I,K2)
        IF(NBUG.GT.0) WRITE(3,166)I,K2,DIRT(I,K2)
14      CONTINUE
15    CONTINUE
C
18  CONTINUE
C
C          Write heading on debug file
C      IF(NBUG .GT. 0) WRITE(3,167)
C
C          Include surface and inventory in NLYRS
C      NLYRS = NLYRS + 2
C
C      DO 20 K = 1,NLYRS
C
C          Zero soil movement totals.
C          DIRTM(K) = 0.
C          SVOL(K) = VOL(K)
C          IF(NBUG .GT. 0) WRITE(3,168) K,SVOL(K)
20    CONTINUE
C
C          Minimum for max. concentration check.
C      QMAX = 1.0E-25
C
C
C***** Start of Simulation *****
C
C      DO 99 JY = 1,NYRS
C
C          Set index for printout
C          IWRT = 0
C          DO 13 IRAP = 1, NMAX
C              IF (IMAX(IRAP) .EQ. JY) IWRT = 1
13      CONTINUE
C          IF (JY .EQ. 1) IWRT = 1
C          IF (JY .EQ. NMAX) IWRT = 1
C
C
C

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

      NB = 0
      IF(NBUG.GT.0 .AND. JY .LE. NBUG) NB = 1
      IF(NB .EQ. 1) WRITE(3,185) JY
C
      DO 22 K = 1,7
          QSUM(K) = 0.
22      CONTINUE
C
C                                     Index for ADJUST
      T = JY
C
C                                     Decay inventory and package,
C                                     release available activity
      CALL ADJUST(T)
C
      IF(NCRIT .EQ. 0) GO TO 30
C
      DO 36 K = 1, NLYRS
          OLDV(K) = VOL(K)
36      CONTINUE
C
      CALL CRITTER
C
30      CONTINUE
C
C----- Loop for chains -----
C
      DO 75 IC = 1,NUCS
C
C                                     Skip if no activity for this
C                                     radionuclide
          IACT = 0
          DO 62 K = 1, NLYRS
              IF (QD(IC,K) .GT. 0.) IACT = 1
62      CONTINUE
          IF (IACT .EQ. 0) GO TO 75
C
C                                     Convert curies to curies/m3
C                                     (QD)          (QC)

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C          K1= 1
C          IF (NCRIT .EQ. 0) K1 = 2
C          DO 35 K = 2,NLYRS
C              QC(IC,K) = QD(IC,K) / OLDV(K)
35          CONTINUE
C
C              Zero surface activity due to critters
C
C          SURFCE = 0.
C
C          IF(NCRIT .EQ. 0) GO TO 50
C          IF(NB .EQ. 1) WRITE(3,190) IC
C
C              Sum for determining surface conc.
C              and adjustment of concentration for soil
C              movement.
C
C          DO 40 K = 2,NLYRS
C              QT = DIRTM(K-1) * QC(IC,K)
C              QD(IC,K) = QD(IC,K) - QT
C              SURFCE = SURFCE + QT
C              IF(NB .EQ. 1) WRITE(3,191) K-1,DIRTM(K-1),
1                  QC(IC,K),QT
C          CONTINUE
40          QD(IC,1) = QD(IC,1) + SURFCE
C
C          CONTINUE
50          plants
C
C          IF (NPLTS .EQ. 0) GO TO 60
C
C          QC(IC,1) = 0.
C          DO 61 K = 2, NLYRS
C              QC(IC,K) = QD(IC,K) / VOL(K)
61          CONTINUE
C
C          CALL PLANT
C
C              Calculate amt recycled, use linear
C              extrapolation when appropriate.

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

DO 48 K = 1,5
    APLT(K) = 0.
48 CONTINUE
C
DO 58 I = 1,NPLTS
    CYCLE = AR(I,1)
    DO 45 I2 = 1,ISUCC(I)
C
        IF (JY .GT. NYSUC(I,I2) .AND. JY
            1 .LE. NYSUC(I,I2+1)) CYCLE =
            2 AR(I,I2) + BR(I,I2) * JY
C
45 CONTINUE
C
DO 55 K = 2,NLYRS
    activity resulting from plant decay
    QD(IC,K) = QD(IC,K) + ACTPLT(I,K) *
        CYCLE
    1 APLT(K) = APLT(K) + ACTPLT(I,K)
55 CONTINUE
C
C
    Surface concentration
    QD(IC,1) = QD(IC,1) + ACTPLT(I,1) * CYCLE
    APLT(1) = APLT(1) + ACTPLT(I,1)
C
58 CONTINUE
C
60 CONTINUE
C
    IF(NB .EQ. 0) GO TO 75
    WRITE(3,170)
    WRITE(3,175) VOL(1),SURFCE,APLT(1),QD(IC,1)
    DO 65 K = 2,NLYRS
        WRITE(3,180) K-1,VOL(K),APLT(K),QD(IC,K)
65 CONTINUE
C
C
75 CONTINUE
C----- End of chain loop -----
C
    IF(NB .EQ. 1) WRITE(3,195) (VOL(K),K=1,NLYRS)

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C                                     Erosion and layer adjustment
C                                     CALL ERSION
C
C      DO 77 IC = 1,NUCS
C          DO 70 K = 1,NLYRS
C              Sums for total curies/strata
C              QSUM(K) = QSUM(K) + QD(IC,K)
70          CONTINUE
C              QSUM(NLYRS+1) = QSUM(NLYRS+1) + Q(IC)
C              QSUM(NLYRS+2) = QSUM(NLYRS+2) + QDE(IC)
C                                     (QDE = eroded curies)
C      77 CONTINUE
C
C                                     Check for maximum total curies
C
C      DO 80 K = 1,NLYRS - 1
C          IF (QSUM(K) .LE. QMAX) GO TO 80
C          QMAX = QSUM(K)
C          MAXY = JY
80      CONTINUE
C
C      IF (MAXY .NE. JY) GO TO 84
C
C      DO 82 IC = 1,NUCS
C          DO 81 K = 1,NLYRS
C              QM(IC,K) = QD(IC,K)
81          CONTINUE
C              QM(IC,NLYRS+1) = Q(IC)
C              QM(IC,NLYRS+2) = QDE(IC)
82      CONTINUE
C
C      84 CONTINUE
C
C                                     Check for year to print.
C
C      IPRT = 0
C      DO 87 JW = 1,NMAX
C          IF(JY .EQ. IMAX(JW)) IPRT = 1
87      CONTINUE
C      IF(IPRT .EQ. 1) GO TO 88
C      IF(IWRT .EQ. 1) GO TO 89
C      GO TO 99

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
88      CONTINUE
        WRITE(2,285)JY
        WRITE(2,295) (DEPTH(K),K=1,NLYRS-3),(DEPTH(K),K=1,NLYRS-2)
C
        WRITE(30,410) JY
C
89      CONTINUE
        INUC = 0
C
        DO 90 IC = 1,NCH
C
            IF(NFLAGC(IC) .LE. 0) GO TO 92
            JCH = NOFNUC(IC)
            IST = INUC + 1
            KCH = IST + JCH - 1
C
C
86      CONTINUE
            DO 91 IN = IST,KCH
                QMT = (QD(IN,1) + QD(IN,2)) * CMT
                IF (IPRT .EQ. 1) WRITE(2,300) ELT(IN),AW(IN),
1                    QDE(IN),(QD(IN,K),K=1,NLYRS),
2                    Q(IN),QMT
C
                IF (IPRT .EQ. 1) WRITE(30,411) ELT(IN),
                    AW(IN), (NS(J,IN), J=1,5),
                    QMT
C
91      CONTINUE
C
92      CONTINUE
            INUC = INUC + NOFNUC(IC)
C
90      CONTINUE
            IF (IPRT .EQ. 1) WRITE(2,320) QSUM(NLYRS+2),(QSUM(K),K=1,
1                    NLYRS+1)
C
            IF (IPRT .EQ. 1) WRITE(30,412)

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
      IF(IWRT .NE. 1) GO TO 99
      IF (VOL(2) .GT. 0.D0) GO TO 99
      WRITE(2,350) JY
      GOTO 100

C
C
99    CONTINUE                                !End of year simulation
C
C*****
C
      DO 97 K=1,NLYRS+2
          QSUM(K) = 0.
97    CONTINUE
C
C                                     Write QD's for maximum year.
C
      WRITE(2,290) MAXY
      WRITE(2,295) (DEPTH(K),K=1,NLYRS-3),(DEPTH(K),K=1,NLYRS-2)
C
      INUC = 0
C
      DO 95 IC = 1,NCH
C
          IF(NFLAGC(IC) .LE. 0) GO TO 94
          JCH = NOFNUC(IC)
          IST = INUC + 1
          KCH = IST + JCH - 1
C
C
          DO 93 IN = IST,KCH
              QMI = QM(IN,NLYRS) * CMI
              QMT = (QM(IN,1) + QM(IN,2)) * CMT
              DO 96 K = 1,NLYRS+2
                  QSUM(K) = QSUM(K) + QM(IN,K)
96          CONTINUE
              WRITE(2,300) ELT(IN),AW(IN),QM(IN,NLYRS+2),
1              (QM(IN,K),K=1,NLYRS+1),QMT
93          CONTINUE
C
94          CONTINUE
          INUC = INUC + NOFNUC(IC)

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
95  CONTINUE
    WRITE(2,320) QSUM(NLYRS+2),(QSUM(K),K=1,NLYRS+1)
C
    WRITE(2,305)
    DO 98 K = 1,NLYRS
        WRITE(2,310) K-1,VOL(K)
98  CONTINUE
C
C
100 CONTINUE
    STOP
C
C-----
C
C                                     Formats
C
130  FORMAT(2A8)
131  FORMAT (10A4)
132  FORMAT (T10,10A4)
133  FORMAT (I5)
150  FORMAT(//,1X,'End of program ',A8)
C
160  FORMAT(T2,'Program :',A8,T20,'Run :',10A1,2X,10A1,/,/,
2      T2,'PLANT MODEL CODE (1=total;2=partial)',T39,':',I2,/,/,
3      T2,'Simulation Period (years)',T39,':',T42,I4,T57,
4      'Number of strata',T83,':',T85,I4)
161  FORMAT(T2,'Number of plant associations',T39,':',T42,I4,T57,
1      'Number of animal species',T83,':',T85,I4,/,T2,
2      'Erosion constants [cm/yr(high/low)]',T39,':',T42,F7.5,/,F7.5,
3      T57,'Starting year for high',T83,':',T85,I4,/,T2,
4      'Duration at high (yrs)',T39,':',T42,I4,T57,
5      'Frequency for high (yrs)',T83,':',T85,I4,/)
162  FORMAT(/,T2,'Regression coefficients for :',T45,'a',T58,'b',/,
1      T13,'Biomass recycling',T42,F6.4,T55,F6.4,/,T23,'Biomass',
2      T40,E10.2,T52,E10.2,/)
165  FORMAT(//,T2,'Maximum amount of dirt moved per year',/,T5,
1      'Animal',T13,'Strata',T22,'Amount',/,T7,'Code',T24,'m3')
166  FORMAT(T8,I2,T15,I2,T19,G13.6)
167  FORMAT(//,T2,'---Starting Volumes---',/,T2,'Strata',T12,'Volume',
1      /,T15,'m3')

```


APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

168  FORMAT(T4,I2,T9,G13.6)
170  FORMAT(//,T2,'Strata',T10,'Volume',T23,'Animals',T37,
      1      'Plant',T54,'QD',/,T12,'m3',T25,'ci',T39,'ci',T54,
      2      'ci',/)
175  FORMAT(T5,'0',T8,G13.6,T19,G13.6,T33,G13.6,T47,G13.6)
180  FORMAT(T4,I2,T8,G13.6,T33,G13.6,T47,G13.6)
185  FORMAT(//,T2,'**** SIMULATION ---- ',I2,' ****',/)
190  FORMAT(/,T11,'FOR NUCLIDE -- ',I2,/,T2,
      1      'Soil Movement due to Animals, starting QC and curies',/,
      2      T4,'Strata',
      3      T13,'Soil',T29,'QC',T45,'QT',/,T14,'m3',T27,'ci/m3',T45,
      4      'ci',/)
191  FORMAT(T6,I2,T10,G13.6,T25,G13.6,T41,G13.6)
192  FORMAT(T7,'0',T25,G13.6,T41,G13.6)
195  FORMAT(//,T2,'New Volumes (m3) :',T21,G13.6,4(/,T21,G13.6))
C
200  FORMAT(//,T10,'Program :',A8,T35,'Run :',10A1,3X,10A1,/,T10,
      .      'Version :',A8,/)
201  FORMAT(T10,'PLANT MODEL : Total Plant Fraction',/)
202  FORMAT(T10,'PLANT MODEL : Only Biomass in Contact with Waste',/)
205  FORMAT(T10,'Simulation Period (years)',T40,':',T43,I4,/,T10,
      1      'Strata Identification',T40,':',T44,'DEPTH',T55,'VOLUME',
      2      T67,'CODE',/,T43,'surface',T53,E10.2,T68,'(0)')
210  FORMAT(T45,F3.1,'m',T53,E10.2,T68,'( ',I1,') ')
215  FORMAT(T43,'inventory',T53,E10.2,T68,'( ',I1,') ',/,T10,
      1      'Number of plant associations',T40,':',T45,I2,T50,
      2      'Number of animal species ',T80,':',T85,I2)
216  FORMAT(/T10,'Erosion constant cm/yr (high)',T40,':',T43,F7.5,T67,
      .      '(low)',T80,':',T83,F7.5/
      .      T10,'High erosion - starting year',
      .      T40,':',T44,I5,T67,'duration',T80,':',T82,I4/
      .      T25,'frequency',T40,':',T44,I5//
      .      T10,'Conversion for m3 to gm ',T40,':',T43,G13.6/
      .      T10,'Conversion for Ci/ha to pCi/m2',T40,':',T43,
      .      1PE10.2,/)
220  FORMAT(//,T10,'PLANT ASSOCIATION - ',2A8)
225  FORMAT(T10,'Number of Successional Phases =',T40,I6,T60,
      1      'Dry/wet weight ratio =',T95,F6.4,/)
230  FORMAT(T10,'Intervals for succession (yrs)',T54,':',T55,5(I6,12X))
235  FORMAT(T10,'Root/shoot ratio ',T54,':',T58,5(G13.6,5X))
240  FORMAT(T10,'Range of roots (m) ',T54,':',T58,5(F6.1,12X))

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

245  FORMAT(T10,'Net annual production [gm(dry)/m2/yr]'),'T54,':',T58,
      1      5(G13.6,5X))
246  FORMAT(T10,'Linear change(recycle)(0=no,1=yes)'),'T54,':',T57,
      1      5(I5,13X))
248  FORMAT(T10,'Recycle rate for each phase',T54,':',T57,5(F5.2,13X))
249  FORMAT(T10,'Linear change(biomass)(0=no,1=yes)'),'T54,':',T57,
      1      5(I5,13X))
250  FORMAT(T10,'% Root distribution by strata',T54,':')
255  FORMAT(T16,'Strata :',T27,I2,T57,5(F6.4,12X))
260  FORMAT(//,T10,'ANIMAL SPECIES - ',2A8)
265  FORMAT(T10,'Amount of material moved (m3/ha)      =',T45,G13.6,T60,
      1      'Activity range (m) =',T80,F6.1)
270  FORMAT(T10,'Degree of activity by phase      =',T47,2(F6.4,4X))
275  FORMAT(/,T10,'Proportion of material moved to surface by strata',/,
      1      T12,' 1 ',T19,' 2 ',T26,' 3 ',T33,' 4 ')
280  FORMAT(T10,F6.4,T17,F6.4,T24,F6.4,T31,F6.4)
285  FORMAT(1H1,T10,'Simulation for YEAR ',I5,T40,'Total Curies / Ha',
      1      //)
290  FORMAT(1H1,T10,'Simulation for YEAR ',I5,T40,'Maximum Year',//)
295  FORMAT(T58,'Strata (m)'/T49,' 0 -',T58,F5.2,' -',T68,F5.2,' -',
      .      T77,'Available',T87,'Contained',T105,'MAXI',/,
      1      T12,'Element',T27,'Eroded',T37,'Surface',T49,F5.2,T58,
      2      F5.2,T68,F5.2,T77,'Inventory',T87,'Inventory',
      3      T100,'Input'/)
300  FORMAT(T14,A2,1X,A6,T25,E10.2,T35,E10.2,T45,E10.2,T55,E10.2,
      1      T65,E10.2,T75,E10.2,T85,E10.2,T97,E10.2)
305  FORMAT(1H1,/,T10,'Strata',T18,'Final Volume',/,T22,'m3'/)
310  FORMAT(T13,I2,T17,G13.6)
320  FORMAT(/,T14,'Total',T25,E10.2,T35,E10.2,T45,E10.2,T55,E10.2,
      1      T65,E10.2,T75,E10.2,T85,E10.2)
350  FORMAT(//,' STRATA 1 HAS BEEN COMPLETELY ERODED AFTER ',I6,
      1      ' YEARS',/, ' SIMULATION CAN NOT CONTINUE ',//)
400  FORMAT(2(1X,I3),I4,E12.4)

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```
410  FORMAT (' ',I5,' Concentrations in this year of BIOPORT ',  
      .      'simulation: ')  
411  FORMAT (' ',A2,A6,5I1,E10.2)  
412  FORMAT (' **')  
413  FORMAT(10A4)  
420  FORMAT(//,20X,'Input prepared by',25X,'Date',/,37X,25('='),4X,  
      . 10('='),//,20X,'Input checked by',26X,'Date',/37X,25('='),4X,  
      . 10('='))  
500  FORMAT(1H1)  
C  
C  
C-----  
      END  
C-----
```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
C      SUBROUTINE ACHAIN(NUC,T,DK,IFRM,AL,AM,AO)
C
C      THIS SUBROUTINE IS THE HEART OF THE CHAIN DECAY PROCEDURE.
C
C      Module of BIOPORT
C      Version of 25-JUN-84
C
C-----
C
C
C
C      REAL*8 A(45), SUMPR, ASUM, AMD
C      DIMENSION DK(2,9),IFRM(2,9),AL(9),AM(9),AO(9),EXPO(9)
C
C      INITIALIZE COEFFICIENT ARRAY TO ZERO
C
C      N2N=NUC*(NUC-1)/2+NUC
C      CALL ZEROR(N2N,A)
C      DO 100 IJK = 1, N2N
C          A(IJK) = 0.000
C 100 CONTINUE
C
C      DO LOOP ON CHAIN MEMBERS, MAX = NUC
C      DO 5 J=1,NUC
C          PRINT 8883, NUC
C 8883 FORMAT(/' ENTERING ACHAIN, NUCLIDE: ',I4)
C
C      CALCULATE EXPONENTIAL FOR CURRENT NUCLIDE
C      EXPO(J)=EXP(-AL(J)*T)
C      JJ=J*(J-1)/2
C      J1=J-1
C      IF(J1.LE.0) GO TO 4
C      IMAX=MIN0(J1,2)
C      DO 3 M=1,J1
C      DO 2 L=M,J1
C      DO 1 I=1,IMAX
C      IF(IFRM(I,J).EQ.L) THEN
C          A(M+JJ)=A(M+JJ)+DK(I,J)*AL(L)*A(M+L*(L-1)/2)
C      IRL = M+L*(L-1)/2
C      PRINT 8888, M,L,I,JJ,IRL,A(M+JJ)

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C 8888  FORMAT (' M,L,I,JJ,IRA,A: ',5I5,E10.3)
      ENDIF
      1 CONTINUE
      2 CONTINUE
        A(M+JJ)=A(M+JJ)/(AL(J)-AL(M))
C      ADIF = AL(J) - AL(M)
C      PRINT 8887, J,M,JJ,AL(J),AL(M),ADIF,A(M+JJ)
C 8887  FORMAT (' J,M,JJ,AL(J),AL(M),ADIF,A: ',3I5,2X,4E10.3)
      3 CONTINUE
C
      4 CONTINUE
        ASUM = 0.0D0
        IF (J1 .EQ. 0) GO TO 11
        DO 12 IRAP = 1, J1
          JK = JJ + IRAP
          ASUM = ASUM + A(JK)
12      CONTINUE
11      CONTINUE
C
C      4 A(J+JJ)=AM(J)-ASUM(J1,A(JJ+1))
C
      AMD = AM(J)
      A(J+JJ) = AMD - ASUM
C
C      PRINT 8885, NUC, J1, A(J+JJ), AM(J), ASUM
C 8885  FDMAT (' NUC,J1,A,AM,ASUM: ',2I5,2X,3E10.3)
C
C      AO(J)=SUMPRD(J,EXPO,A(JJ+1))
C      THE VAX HAS A PROBLEM WITH THIS CODE- USR THE FOLLOWING:
C
      SUMPR = 0.0D0
      DO 8884 IN = 1,J
        JK = JJ + IN
        SUMPR = SUMPR + EXPO(IN) * A(JK)
C      PRINT 8880, JK,A(JK),EXPO(IN),SUMPR
C 8880  FORMAT (' JK,A(JK),EXPO(J),SUMPR: ',I5,2X,8E10.2)
      8884 CONTINUE
        AO(J) = SUMPR
C      PRINT 8882, J,AO(J)
C 8882  FORMAT (' J,AO: ',I5,2X,2E11.3)
C

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```
C
C   ELIMINATE ALL SMALL QUANTITIES--
C   IF (AO(J) .LT. 1.0E-12) AO(J)=0.
C
C   5 CONTINUE
C
C   RETURN
C
C-----
C
C   END
```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C-----
C
      SUBROUTINE ADJUST (T)
C
C   ADJUST controls radiological and package decay calculations
C
C   Module of BIOPORT
C   Version of 10-MAY-84  RAP
C-----
C
      INCLUDE 'ACTVTY.FOR'
      INCLUDE 'FILES.FOR'
      INCLUDE 'NAMES.FOR'
      INCLUDE 'DECAY.FOR'
      INCLUDE 'FLAGS.FOR'
C
      INUC = 0
C
C   CALCULATE FRACTION OF PACKAGE AVAILABLE--
      AF = 1. - EXP ( -PDC )
C
      IF (NBUG .GT. 0) THEN
        WRITE (3,8008)
8008    FORMAT(// ' BEFORE RADIONULIDE DECAY: '/
          .      ' Name           OD(1)      OD(2)      OD(3)
          .      'OD(4)      OD(5)      Contained')
        DO 400 I = 1,NUCS
          WRITE (3,8006) ELT(I), AW(I), (OD(I,J),J=1,5),Q(I)
400    CONTINUE
        ENDIF
C
C   FOR EACH CHAIN--
      DO 100 IC = 1, NCH
C
C   IF DATA SUPPLIED FOR ANY RADIONUCLIDES IN THIS CHAIN--
      IF (NFLAGC (IC) .LE. 0) GO TO 300
C
      J = NOFNUC(IC)
      IST = INUC + 1
      K = IST + J - 1

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
C
C      CONVERT CHANGE MEMBERS TO PROPER UNITS FOR ACHAIN (CURIES/TIME)--
C
C      DO 101 IN = IST, K
C
C          Q(IN) = Q(IN) / AL(IN)
C          QD(IN,5) = QD(IN,5) / AL(IN)
C          QD(IN,4) = QD(IN,4) / AL(IN)
C          QD(IN,3) = QD(IN,3) / AL(IN)
C          QD(IN,2) = QD(IN,2) / AL(IN)
C          QD(IN,1) = QD(IN,1) / AL(IN)
C
C      101      CONTINUE
C
C      DECAY INVENTORY REMAINING IN PACKAGE--
C      CALL ACHAIN (J, 1., DKF(1,IST), IFR(1,IST), AL(IST), Q(IST),
C      +          Q(IST), 0)
C
C
C      DECAY PREVIOUSLY AVAILABLE INVENTORY--
C      CALL ACHAIN (J, 1., DKF(1,IST), IFR(1,IST), AL(IST), QD(IST,5),
C      +          QD(IST,5), 0)
C
C      DECAY LAYER 4--
C      CALL ACHAIN (J, 1., DKF(1,IST), IFR(1,IST), AL(IST), QD(IST,4),
C      +          QD(IST,4), 0)
C
C
C      DECAY LAYER 2--
C      CALL ACHAIN (J, 1., DKF(1,IST), IFR(1,IST), AL(IST), QD(IST,3),
C      +          QD(IST,3), 0)
C
C
C      DECAY LAYER 1--
C      CALL ACHAIN (J, 1., DKF(1,IST), IFR(1,IST), AL(IST), QD(IST,2),
C      +          QD(IST,2), 0)
C
C
C      DECAY SURFACE--
C      CALL ACHAIN (J, 1., DKF(1,IST), IFR(1,IST), AL(IST), QD(IST,1),
C      +          QD(IST,1), 0)
C
C
C

```


APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
C      CONVERT CURIES/YEAR BACK TO CURIES--
C
C      DO 200 IN = IST, K
C
C          Q(IN) = Q(IN) * AL(IN)
C          QD(IN,5) = QD(IN,5) * AL(IN)
C          QD(IN,4) = QD(IN,4) * AL(IN)
C          QD(IN,3) = QD(IN,3) * AL(IN)
C          QD(IN,2) = QD(IN,2) * AL(IN)
C          QD(IN,1) = QD(IN,1) * AL(IN)
C
C
C
C      200      CONTINUE
C
C      300 CONTINUE
C
C          INUC = INUC + NOFNUC(IC)
C
C      100 CONTINUE
C
C      IF (NBUG .GT. 0) THEN
C          WRITE (3,8007)
C      8007  FORMAT(// ' AFTER RADIONULIDE DECAY: ' /
C          .      ' Name           QD(1)       QD(2)       QD(3)
C          .      ' QD(4)       QD(5)       Contained')
C          DO 401 I = 1,NUCS
C              WRITE (3,8006) ELT(I), AW(I),(QD(I,J),J=1,5),Q(I)
C      8006  FORMAT(' ',A2,A6,2X,6(1PE12.4))
C      401  CONTINUE
C          ENDIF
C
C      MOVE AVAILABLE INVENTORY FROM PACKAGE TO INVENTORY LAYER--
C
C      IF (NBUG .GT. 0) WRITE (3,8009)
C      8009  FORMAT (' After package decay:')
C
C      DO 500 I = 1, NUCS

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```
C
      IF (Q(I) .EQ. 0.0) GOTO 500
      QM = AF * Q(I)
      Q(I) = Q(I) - QM
      QD(I,5) = QD(I,5) + QM
C
      IF (NBUG .GT. 0) WRITE (3,8001) ELT(I),AW(I),Q(I),QD(I,5),QM
8001  FORMAT (' ', A2,A6,37X, 3(1PE12.4))
C
      500 CONTINUE
C
      RETURN
C
C-----
C
      END
```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```
C-----  
C  
C      FUNCTION ASUM(J,A)  
C  
C      THIS FUNCTION SUMS J ELEMENTS OF THE ARRAY A.  
C  
C      Module of BIOPORT  
C      Version of 14-MAY-84  RAP  
C-----  
C  
C      DIMENSION A(1)  
C  
C      ASUM=0.  
C      IF(J.LE.0) GO TO 2  
C  
C      DO 1 I=1,J  
C          ASUM=ASUM+A(I)  
C      1 CONTINUE  
C  
C      2 RETURN  
C-----  
C  
C      END
```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C-----
C
C      SUBROUTINE CRITTER
C
C      Animals move dirt and radioactivity from various layers
C      to the surface. The amount of dirt moved is dependent on
C      the activity cycle of the animal, which generally decreases
C      after the first year.
C
C      Module of BIOPORT
C      Version of 20-JUN-84  RAP
C-----
C
C      COMMON //JY,NLYRS,NB
C
C      INCLUDE 'ANIMAL.FOR'
C      INCLUDE 'ACTVTY.FOR'
C
C      DOUBLE PRECISION      DMOVE(5),ACTIVE,SDIRT
C
C
C      DO 1 K2 = 1,NLYRS
C          DMOVE(K2) = 0.DO
C 1    CONTINUE
C
C      L1 = 1
C      IF(JY .GT. 1) L1 = 2
C
C      DO 10 I = 1,NCRIT
C
C          ACTIVE = PACTIVE(I,L1)
C
C          DO 5 K2 = 1,NLYRS
C              SDIRT = DIRT(I,K2)
C              IF(K2 .GT. IRANGC(I)) GO TO 5
C              DMOVE(K2) = DMOVE(K2) + SDIRT * ACTIVE
C 5          CONTINUE
C
C 10    CONTINUE

```

```

C      DO 25 K2 = 1,NLYRS-1
          VOL(1) = VOL(1) + DMOVE(K2)
          VOL(K2+1) = VOL(K2+1) - DMOVE(K2)
          IF (VOL(K2+1) .LE. 0.) THEN
              PRINT *,K2,DMOVE(K2),VOL(1),VOL(K2+1)
              STOP
          ENDIF
25      CONTINUE
C
      DO 30 K2 = 1,NLYRS
          DIRTM(K2) = DMOVE(K2)
30      CONTINUE
C
C
      RETURN
C
C-----
C
      END

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C-----
C
C      SUBROUTINE ERSION
C
C      ERSION calculates erosion for BIOPORT and adjusts soil volumes
C      so surface volume = 0.
C
C      Module of BIOPORT
C      Version of 16-MAY-84  MAS
C-----
C
C
C      COMMON //JY,NLYRS,NB
C
C      DOUBLE PRECISION  EROD,QE,QT,DQD(100,5),VOLD
C
C      INCLUDE 'EARTH.FOR'
C      INCLUDE 'ACTVTY.FOR'
C      INCLUDE 'NAMES.FOR'
C
C
C      EROD = ERL
C      IF (IER .EQ. 0 .AND. JER .EQ. 0) GO TO 5
C                               Checks for years of high erosion
C      ISTART = IER
C      IF (JER .LE. IER) ISTART = 0
C
C      IF (JER .EQ. 0) GO TO 5
C      IF (JY/IER .EQ. 0) GO TO 5
C
C      JYE = JY - JER * (JY/JER)
C      IF (JYE .GE. ISTART .AND. JYE .LT. ISTART+NER) EROD = ERU
C
C      5  CONTINUE
C                               Change to double precision
C      DO 10 IC = 1,NUCS
C          DO 7 K = 1,NLYRS
C              DQD(IC,K) = QD(IC,K)
C          7  CONTINUE
C      10  CONTINUE

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
C                               Recalculate soil volumes
C                               so surface = 0
C
IF (NB .EQ. 1) WRITE(3,197)
C
DO 20 K = NLYRS,3,-1
C
      VOLD = SVOL(K) - VOL(K)
      IF (VOLD .LE. 0.D0) VOLD = 0.D0
      IF (NB .EQ. 1) WRITE(3,198) K,SVOL(K),VOL(K),VOLD
C
      DO 15 IC = 1,NUCS
C
C                               Skip if no activity for this
C                               radionuclide
C                               IF (QD(IC,K) .LE. 0.) GO TO 15
C
C                               QT = VOLD * DQD(IC,K-1) / VOL(K-1)
C                               DQD(IC,K) = DQD(IC,K) + QT
C                               DQD(IC,K-1) = DQD(IC,K-1) - QT
C                               IF (NB .EQ. 1) WRITE(3,199) IC,DQD(IC,K),DQD(IC,K-1)
C
15      CONTINUE
C
      VOL(K) = VOL(K) + VOLD
      VOL(K-1) = VOL(K-1) - VOLD
C
20      CONTINUE
C                               Surface calculations
      DO 18 IC = 1,NUCS
        DQD(IC,2) = DQD(IC,2) + DQD(IC,1)
        DQD(IC,1) = 0.D0
18      CONTINUE
      VOL(2) = VOL(2) + VOL(1)
      VOL(1) = 0.D0
C
      IF (NB .NE. 1) GO TO 23
      WRITE(3,202)
      DO 19 IC = 1,NUCS
        IF (QD(IC,2) .GT. 0.) WRITE (3,200) IC,DQD(IC,2)
19      CONTINUE

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
WRITE(3,8883) (VOL(K),K=1,NLYRS)
WRITE(3,203)

C
C
C Adjusts for erosion
23 CONTINUE
DO 24 IC = 1,NUCS
    ODE(IC) = 0.
    IF (VOL(2)*EROD .LE. 0.D0) GO TO 24
    QE = DOD(IC,2) / VOL(2) * EROD
    DOD(IC,2) = DOD(IC,2) - QE
C        ERODED CURIES (QE)
    ODE(IC) = QE
    IF (NB .NE. 1) GOTO 24
    IF (ODE(IC) .NE. 0.) WRITE(3,201) IC,ODE(IC)
24 CONTINUE
C
VOL(2) = VOL(2) - EROD
IF (NB .EQ. 1) WRITE(3,196) VOL(2)
C
DO 25 K = 1,5
    DO 25 IC = 1,NUCS
        OD(IC,K) = DOD(IC,K)
25 CONTINUE
C
RETURN
C
C
196 FORMAT(//,T2,'Volume of layer 1 after erosion (m3) :', G13.6,/)
197 FORMAT(T2,'Volumes and curies after adjustment',/,T2,'Layer',T12,
1      'Svol',T26,'Pvol',T51,'Diff',T63,'Chain',T73,'Ci(layer)',T87,
2      'Ci(layer-1)',/)
198 FORMAT(T3,I2,T8,D14.8,T23,D14.8,T48,D14.8)
199 FORMAT(T64,I4,T73,G13.6,T88,G13.6)
200 FORMAT(T4,I5,T12,D14.8)
201 FORMAT(T4,I5,T12,D14.8)
202 FORMAT(//,T2,'Curies in layer 1 (first strata)',/,T2,'Nuclide #',
1      T15,'Curies')
203 FORMAT(//,T2,'Curies eroded from layer 1',/,T2,'Nuclide #',T15,
1      'Curies')
8883 FORMAT(' Final vols :',5(D14.8,X))

```



```

C      APPENDIX 1.A  Computer Code Listing - BIOPORT  (Continued)
C-----
C
C      END
C-----
C
C      SUBROUTINE IDNUC
C
C      IDNUC identifies radionuclides in the input inventory
C
C      Module of BIOPORT
C      Version of 10-MAY-84
C-----
C
C      INCLUDE 'ACTVTY.FOR'
C      INCLUDE 'DECAY.FOR'
C      INCLUDE 'FLAGS.FOR'
C      INCLUDE 'NAMES.FOR'
C      INCLUDE 'SOURCE.FOR'
C
C
C      INITIALIZE COUNT INDEX ON UNIDENTIFIED NUCLIDES
C
C      ISTOP=0
C      NONUC=0
C
C      CALL ZEROI(50,NFLAGC)
C      CALL ZEROI(100,NFLAG)
C      CALL ZEROR(100,Q)
C      CALL ZEROI(500,NS)
C
C
C      LOOP ON NUCLIDES INPUT.  TEST AGAINST MASTER LIST.
C
C      DO 3 IN=1,NIN
C      DO 1 IL=1,NUCS
C      ILN=IL
C      IF(ELT(IL).NE.ELTI(IN)) GO TO 1
C      IF(AW(IL).EQ.AWI(IN)) GO TO 2
C      1 CONTINUE
C
C      NO MATCH IN LIBRARY FOR INPUT NUCLIDE.  PRINT NAME OF UNKNOWN NUCLIDE

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C      ISTOP=ISTOP+1
      GO TO 3
2  CONTINUE
      NFLAG(ILN)=IN
      NFLAGC(NCHN(ILN))=1
C
C      CONVERT INPUT CONCENTRATION TO CURIES---
      Q(ILN) = QI(IN) * VOL(5)
C
C      TRANSFER SOLUBILITY INDICES
      DO 10 INS = 1, 5
        NS(INS,ILN)=NSI(INS,IN)
10  CONTINUE
C
C
C      IF SOLUBILITIES ARE NOT SUPPLIED ON INPUT, USE DEFAULTS
      DO 20 IL = 1, NUCS
        DO 21 INS = 1, 5
          IF (NS(INS,IL) .EQ. 0) THEN
            IF (INS .EQ. 3) THEN
              NS(INS,IL) = NSD(2,IL)
            ELSE
              NS(INS,IL) = NSD(1,IL)
            ENDIF
          ENDIF
        ENDIF
21  CONTINUE
20  CONTINUE
C
C
      3  CONTINUE
C
C      CALCULATE NUMBER OF NUCLIDES WITH DAUGHTERS
      DO 30 IL = 1, NUC
        IF (NFLAG(IL) .GT. 0) NONUC = NONUC + 1
30  CONTINUE
C
      IF(ISTOP.LT.1) RETURN
C
C      PRINT TOTAL NUMBER OF UNKNOWN NUCLIDES AND STOP.
C
      TYPE 200, ISTOP
100 FORMAT(1H0,'UNIDENTIFIED NUCLIDE ',A2,A6)
200 FORMAT(1H0,'THERE WERE UNIDENTIFIED NUCLIDES, ISTOP =',I4)

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C      STOP
C-----
C
C      END
C-----
C
C      SUBROUTINE INVEN
C
C      INVEN READS RADIOLOGICAL INVENTORY AND PACKAGE LAMBDA; CONTROLS
C      CHECKING OF INVENTORY AND FLAG SETTING; CALCULATES PACKAGE
C      DECAY CONSTANT, INITIAL PACKAGE DECAY AND INITIAL AVAILABLE
C      INVENTORY; AND CONTROLS QA REPORT PRINTING.
C
C      Module of BIOPORT
C      Version of 16-APR-84  RAP
C-----
C
C      INCLUDE 'ACTVTY.FOR'
C      INCLUDE 'SOURCE.FOR'
C      INCLUDE 'NAMES.FOR'
C
C      DIMENSION TITLR(20)
C
C      READ IN MASTER RADIONUCLIDE LIBRARY--
C      CALL RLIBIN (TITLR)
C
C      READ IN PACKAGE LIFE--
C      READ (11,*) PL
C
C      READ IN NO. OF YEARS OF PRIOR STORAGE OF WASTE--
C      READ (11,*) PLI
C
C      READ NUMBER OF RADIONUCLIDES IN INVENTORY--
C      READ (11,200) NIN
C
C      READ INVENTORY--
C      DO 1 IN = 1, NIN
C          READ (11,300) ELTI(IN), AWI(IN), (NSI(J,IN),J=1,5), QI(IN)
1 CONTINUE

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
C
C   CHECK INVENTORY AND SET FLAGS--
C   CALL IDNUC
C
C   CALCULATE PACKAGE DECAY CONSTANT--
C   PDC = (ALOG (2.)) / (PL )
C
C
C   PRINT QA REPORT--
C   CALL RADQA (TITLR)
C
C   CALCULATE INITIAL AVAILABLE FRACTION OF PACKAGE--
C   AFI = 1. - EXP ( - (PDC * (PLI)))
C
C   CALCULATE INITIAL RELEASE OF EACH RADIONUCLIDE--
C
C   DO 700 IN = 1, NUCS
C
C       QD(IN,5) = Q(IN) * AFI
C       Q(IN) = Q(IN) - QD(IN,5)
C
C   700 CONTINUE
C
C   RETURN
C
C
C   FORMAT STATEMENTS--
C
C   100 FORMAT (E10.2)
C   200 FORMAT (I3)
C   300 FORMAT (A2, A6, 5I1, E10.2)
C
C-----
C
C   END
C-----
C
C   SUBROUTINE PLANT
C
C   Movement of radionuclides by the plant communities is
C   determined by the highest concentration encountered and
C   by the concentration ratio (CR) for each element.
C   Plant biomass is assumed to recycle each year.

```


APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

IF(NB .EQ. 1) WRITE(3,60) I

C                               Biomass of roots by strata
DO 10 K2 = 1,IRANGP(I,IP)
    ROOT(K2) = ROOTM * SROOT(IP,K2,I)
10 CONTINUE

C                               Initial plant concentration = 0
PCONC = 0.
IS = 0

C
C                               Determine highest concentration
C                               encountered by plant roots.
DO 15 K2 = 2,NLYRS

C                               IF(K2 .GT. IRANGP(I,IP)+1) GO TO 15
C                               IF(QC(IC,K2) .GT. PCONC) IS = K2
C                               IF(QC(IC,K2) .GT. PCONC) PCONC = QC(IC,K2)

C
15 CONTINUE

C
C                               IF(NB .EQ. 1) WRITE(3,65)TOTMAS,BIOMAS(I,IP),ROOTM,PCONC,IS
C
C                               IF (IS .EQ. 0) GO TO 50
C
C                               Curies per ha. for plant.
C                               Determine root fraction
C
C                               IF (PMODEL .EQ. 2) THEN
C                                   CFCT = ROOT(IS-1)/ROOTM
C                               ELSE
C                                   CFCT = 1.0
C                               ENDIF

C
C                               PCONC = (PCONC / CONV) * CR(IC) * TOTMAS * CFCT
C                               PCONC now is activity, not
C                               concentration!
C
C                               Subtract curies from strata
16 IF (NBUG .GT. 0) WRITE (3,16) CFCT,SROOT(IP,IS-1,I),PCONC
    FORMAT (' CFCT, SROOT,PCONC; ',3(1PE12.4))

C
C                               QD(IC,IS) = QD(IC,IS) - PCONC

C
C                               Calculate activity

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C                                     for leaf and root parts.
      IF (TOTMAS .LE. 0.) THEN
        WRITE (6,8889) TOTMAS
        STOP
      ENDIF

C
      DO 20 K2 = 1,IRANGP(I,IP)
        ACTPLT(I,K2+1) = PCONC * (ROOT(K2) / TOTMAS)
20    CONTINUE
      ACTPLT(I,1) = PCONC * (BIOMAS(I,IP) / TOTMAS)

C
      IF(NB .NE. 1) GO TO 40

C
      WRITE(3,80)
      WRITE(3,85) BIOMAS(I,IP),ACTPLT(I,1)
      WRITE(3,90)
      DO 30 K2 = 1,IRANGP(I,IP)
        WRITE(3,85) ROOT(K2),ACTPLT(I,K2+1)
30    CONTINUE
      WRITE(3,75) PCONC,CR(IC)

C
40    CONTINUE

C
50    CONTINUE

C
C
      RETURN

C
C                                     Formats
C
60    FORMAT(//,T2,'Contribution from PLANT ',T40,':',T42,I2,/)
65    FORMAT(T2,'Plant biomass (gm/ha)',T40,':',T42,G13.6,/,
1      T2,' (Leaf) (gm/ha)',T40,':',T42,G13.6,/,
1      T2,' (Root) (gm/ha)',T40,':',T42,G13.6,/,
1      T2,'Highest soil activity (ci/m3)',T40,':',T42,G13.6,/,
1      T2,' (removed from layer)',T40,':',T42,I2)
75    FORMAT(/T2,'Total plant activity (ci/ha)',T40,':',T42,G13.6,/,
1      T2,'Plant concentration by parts -- CR',T40,':',T42,G13.6,/)
80    FORMAT(T6,'Leaf',T20,'Activity',/,T5,'gm/ha',T21,'ci/ha',/)
65    FORMAT(T2,G13.6,T17,G13.6)
90    FORMAT(/,T6,'Root',T20,'Activity',/,T5,'gm/ha',T21,'ci/ha',/)
8888  FORMAT('OERROR! Subscript IP out of range: ',I5)
8889  FORMAT('OERROR! TOTMAS .LE. 0.: ',E10.2)
C

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C
C-----
C
      END
C-----
C
      SUBROUTINE RADQA (TITLR)
C
C
C      RADQA PRINTS RADIOLOGICAL INVENTORY INPUT DATA REPORT
C
C      Module of BIOPORT
C      Version of 14-MAY-84  RAP
C-----
C
      INCLUDE 'SOURCE.FOR'
      INCLUDE 'ACTVTY.FOR'
      INCLUDE 'DECAY.FOR'
      INCLUDE 'NAMES.FOR'
      INCLUDE 'FLAGS.FOR'
C
C
C      DIMENSION TITLR(20)
C
C      PRINT RADIONUCLIDE INVENTORY--
      WRITE (2,200)
      WRITE (2,300) (ELTI(I), AWI(I), QI(I), I= 1,NIN)
C
C
C
C      PRINT RADIONUCLIDE MASTER LIBRARY TITLE--
      WRITE(2, 150) TITLR
C
C      PRINT RADIONUCLIDE REPORT--
      WRITE (2,151)
C
      INUC = 0
      DO 500 IC = 1, NCH
C      PRINT 8880,NCH,IC,NFLAGC(IC)
C8880  FORMAT (' NCH, IC, FLAGC(IC): ',3I5)
C
      IF (NFLAGC(IC) .LE. 0) GO TO 600
C

```


APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

      J = NOFNUC(IC)
      IST = INUC + 1
      K = IST + J - 1
C      PRINT 8881,INUC,J,IST,K
C8881  FORMAT (' INUC, J, IST, K: ',4I5)
C
      DO 550 IN = IST, K
C
          WRITE (2,152) ELT(IN),AW(IN),AL(IN),CR(IN),Q(IN)
C
      550  CONTINUE
      600  CONTINUE
C
      INUC = INUC + NOFNUC(IC)
C
      500 CONTINUE
C
C
C      PRINT PACKAGE HALF LIFE--
      WRITE (2,100) PL
C
C      PRINT MEAN RESIDENCE TIME--
      WRITE (2,153) PLI
C
C
      RETURN
C
C
C      FORMAT STATEMENTS--
C
C
      100 FORMAT (//,' ',T10,'Decomposition half time of package ',
.           '(years): ', F10.1)
C
      150 FORMAT (1H1,' ',T10,'Title of radionuclide master library:',
+           /,' ',T42,20A4)
      151 FORMAT (//,' ',T10,'Radionuclide parent and daughter ',
+           'parameters:',//,
+           ' ',T42,': ELT. WT.',T53,'DECAY CNST CONC RATIO ',
+           'CURIES')
C
      152 FORMAT (' ',T42,A2,2X,A6,3(E10.3,2X))
C
      200 FORMAT (//,' ',T10,'Radionuclide input inventory',T40,

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

+      'ELT. WT.',T53,'(CI/M**3)')
153 FORMAT (' ',T10,'No. of years of package storage prior '
+      ',to beginning of scenario: ',F10.1)
C
C
300 FORMAT (' ',T42,A2,2X,A6,E10.3)
C
C-----
C
      END
C-----
C
      SUBROUTINE RLIBIN (TITLR)
C
C      THIS SUBROUTINE READS A MASTER NUCLIDE DATA LIBRARY WITH CHAIN
C      DECAY DATA.
C
C      Module of BIOPORT
C      Version of 14-MAY-84  RAP
C
C-----
C
      INCLUDE 'DECAY.FOR'
      INCLUDE 'NAMES.FOR'
      INCLUDE 'ACTVTY.FOR'
C
      DIMENSION TITLR(20),IT(2),FR(2)
C
      REAL*8 A
C
      OPEN (UNIT=4,NAME='RMDLIB.BIO',TYPE='OLD')
C
      INITIALIZE INDICES
      CALL ZEROR (100, AL)
C
      AL2 = ALOG (2.)
      IMO=0
      NCH=0
      NUC=1
C
C      READ TITLE CARD
C
      READ(4,200,END=99) TITLR
C

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C  READ AND COUNT NUCLIDE ID AND DECAY DATA.
C
  1 READ(4,100,END=99) E,A,T,IM,IT(1),FR(1),IT(2),FR(2),CRI,
    .
      NSDS, NSDI
C
C  TEST FOR END OF LIBRARY
C
  IF(IM.GT.0) GO TO 2
  NUC=NUC-1
  IF(NUC.GT.300) GO TO 98
  IF(NUC.LT.1) GO TO 98
  NUCS = NUC
C
  CLOSE (UNIT=4)
C
  RETURN
C
C  TEST FOR NEW CHAIN, IM = 1
C
  2 IF(IM.GT.1) GO TO 3
C
C  FIRST MEMBER, NEW CHAIN
C
  NCH=NCH+1
C  PRINT 8888, NCH
C8888 FORMAT (' NCH: ',I4)
  NOFNUC(NCH)=1
  IMO=1
  NCHST(NCH)=NUC
  GO TO 4
C
C  DAUGHTER NUCLIDES
C  TEST ORDER
C
  3 IF(IM-IMO.NE.1) GO TO 97
  IMO=IM
  NOFNUC(NCH)=NOFNUC(NCH)+1
  IFR(1,NUC)=IT(1)
  IFR(2,NUC)=IT(2)
  DKF(1,NUC)=FR(1)
  DKF(2,NUC)=FR(2)
C
C  SET DATA FOR CURRENT NUCLIDE.
C

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

4  ELT(NUC)=E
   AW(NUC)=A
   CR(NUC)=CRI
   NSD(1,NUC) = NSDS
   NSD(2,NUC) = NSDI
C
   AL(NUC) = AL2 / T* 365.
C
C   IMEM(NUC)=IM
   NCHN(NUC)=NCH
   NUC=NUC+1
   GO TO 1
C
C PRINT ERROR MESSAGES AND STOP
C
   97 TYPE 500,  NCH,IM
500 FORMAT(1H1,' DIAGNOSTIC 1: DECAY CHAIN',I4,' HAS IMPROPER ORDER. C
   .URRENT MEMBER INDEX IS',I4)
   STOP
   98 TYPE 300,  NUC
300 FORMAT(1H1,' DIAGNOSTIC 2: IMPROPER NUMBER OF NUCLIDES IN MASTER L
   .IBRARY, NUC=',I8)
   STOP
   99 TYPE 400
400 FORMAT(1H1,' DIAGNOSTIC 3: END OF FILE ON MASTER LIBRARY UNIT 10')
   STOP
C
C INPUT DATA FORMATS
C
100 FORMAT(A2,A6,E10.2,I2,2(I2,F7.4), E10.2, 13X, 2I1)
200 FORMAT(20A4)
C
C-----
C
   END
C-----
C
   SUBROUTINE ZEROI(N,K)
C
C   THIS MODULE SETS N VALUES OF ARRAY K TO INTEGER ZERO.
C
C   Module of BIOPORT
C   Version of 14-MAY-84  RAP
C

```

APPENDIX 1.A Computer Code Listing - BIOPORT (Continued)

```

C-----
C
      DIMENSION K(1)
C
      DO 1 J=1,N
        K(J)=0
      1 CONTINUE
C
      RETURN
C
C-----
C
      END
C-----
C
      SUBROUTINE ZEROR(N,A)
C
C
C      THIS MODULE SETS N VALUES OF ARRAY A TO REAL ZERO.
C
C      Module of BIOPORT
C      Version of 14-MAY-84  RAP
C
C-----
C
      DIMENSION A(1)
C
      DO 1 J=1,N
        A(J)=0.
      1 CONTINUE
C
      RETURN
C
C-----
C
      END

```

APPENDIX 1.B

COMPUTER CODE LISTING - CREATE

APPENDIX 1.B Computer Code Listing - CREATE

C
C
C Program Title: CREATE
C
C Developed for: U.S. Nuclear Regulatory Commission
C Office of Nuclear Regulatory Research
C Division of Health, Siting, and Waste Management
C
C Date: May 31, 1984
C
C NRC Contact: Dr. John Randall (NRR)
C Phone: 301-427-4633
C
C Code Developer: Dr. D.H. McKenzie, L.L. Cadwell, L.E. Eberhardt,
C W.E. Kennedy, Jr., R.A. Peloquin, M.A. Simmons
C Pacific Northwest Laboratory
C Richland, WA 509-376-6573 (DHM)
C
C
C This program was prepared for an agency of the United States
C Government. Neither the United States government nor any agency
C thereof, or any of their employees, make any warranty, expressed
C or implied, or assumes any legal liability or responsibility for
C any third party's use, or the results of such use, of any portion
C of this program or represents that its use by such third party
C would not infringe privately owned rights.
C
C
C-----

C
C
C
C
C CREATE is the interactive user interface for the BIOPORT/MAXII
C computer program. CREATE requests information from the user,
C tests the user's response for validity and creates execution
C runstreams for the BIOPORT and MAXII computer codes.
C
C
C
C The program CREATE calls the following subroutines:
C
C ARID - to establish arid site parameters
C of parameters
C CHANGE - to query if parameter is to be changed, and if so,
C to input the new value
C CHAREL - to query for change of character input of an array
C DEFINV - to define Waste Spectrum 1 and 2 for each site
C DISINV - to display user inventory and control modification
C and additions to inventory
C EDANIM - review/modify animal parameters
C EDBUG - review/modify debug parameters
C EDDOSE - review/modify years selected for dose calculation
C EDPLAN - review/modify plant parameters
C EDSTRA - review/modify strata and erosion parameters

APPENDIX 1.B Computer Code Listing - CREATE

```

C      GROUP - to determine if changes are required for a group
C      HUMID - to establish humid site parameters
C      INTRD - to display introductory message
C      QUANTI - to input the concentration of a radionuclide in the
C               inventory
C      RADIN - to input and test radiological inventory
C      RITFIL - to write BIOPORT and MAXIL input files
C
C
C
C      Program variable descriptions --
C      IRS - Index of reference site used for default values
C      IWS - Index of selected waste spectrum:
C             1 - Waste Spectrum 1
C             2 - Waste Spectrum 2
C             3 - User-defined Inventory
C      ICFLAG - CHANGE subroutine passing flag: (returned)
C             0 - no change requested
C             1 - change requested
C      IGFLAG - GROUP subroutine flag: (returned)
C             0 - no change requested in this group
C             1 - change requested in this group
C      ITFLAG - CHANGE subroutine passing flag: (sent)
C             1 - integer value
C             2 - real value
C             3 - double precision value
C      IX - CHANGE subrouotine passing parameter - integer value
C      IH - CHANGE passing parameter - maximum allowable integer input
C      IL - CHANGE passing parameter - minimum allowable integer input
C      GNAME - Real*8 name of subgroup passed to GROUP
C      RX - CHANGE subroutine passing parameter - real value
C      RH - CHANGE passing parameter - maximum allowable real input
C      RL - CHANGE passing parameter - minimum allowable real input
C      RBX _ CHANGE subroutine passing parameter - real*8 value
C      WSTIT(2,3) - Title of each waste spectrum option
C
C      Version of 25-JUN-84  RAP
C
C-----
C
C                                     include common blocks
C
C      INCLUDE 'CREATE.CMN'
C
C      REAL*8 RBX
C      DIMENSION KDORG(5)
C
C      Program input constants
C      DATA SCRN, KEY, BIO, MAX  /6,5,7,8/
C      DATA NYRS /500/
C      DATA IRS, IWS /1, 1/
C      DATA NBUG /0/
C      DATA NMAX /5/
C      DATA PMODEL /2/
C      DATA IFIRST, IFRST /0,0/

```


APPENDIX 1.B Computer Code Listing - CREATE

```

DATA KDORG /1,6,8,16,23/
DATA KORG /1,2,3,4,5/
C
DATA WSTIT /'Waste Sp','ectrum 1',
.          'Waste Sp','ectrum 2',
.          'User-def','ined'  '/'
C
DATA SITIT /'arid    ',
.          'humid    '/'
C
C                                INTRO displays user messages
CALL INTRO
C
WRITE (SCRN,1060)
1060 FORMAT (' ',10('/),' ',
. 'Enter an identifying title for this run ',
. '(up to 40 letters long):')
READ (SCRN,1061) TITL
1061 FORMAT (10A4)
C
C
100 CONTINUE
C
WRITE (SCRN,1010) NYRS
1010 FORMAT (' ',24('/),' ',
. 'The length of the simulation is ',I5,' years')
CALL CHANGE ((1), ICFLAG, IX, (1), (9999), RX, RL, RH, R8X)
IF (ICFLAG.EQ.1) NYRS = IX
C
IF (IFIRST .LT. 1) THEN
  NMAX = 5
  IF (NYRS .LT. NMAX) NMAX = NYRS
  INC = NYRS / NMAX
  IMAX(1) = 1
  IMAX(NMAX) = NYRS
  IF (NMAX .GT. 2) THEN
    ITOT = 0
    DO 111 II = 2, NMAX-1
      ITOT = ITOT + INC
      IMAX(II) = ITOT
111 CONTINUE
    ENDIF
    IFIRST = 1
  ENDIF
C
WRITE (SCRN,1020)
1020 FORMAT (' ',10('/),' ',
. 'During the simulation, printed reports and MAXI1 input will'/
. ' be generated from radionuclide concentrations in the '/
. ' following years: '//)
DO 110 I = 1, NMAX
  WRITE (SCRN, 1021) IMAX(I)
1021 FORMAT (15X,I5)
110 CONTINUE

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C      GNAME(1) = 'above  '
      GNAME(2) = '        '
      CALL GROUP
      IF (IGFLAG .GT. 0) CALL EDDOSE
C
      IBUG = NBUG
      IF (IBUG .GT. 1) IBUG = 1
      WRITE (SCRN,1030) IBUG
1030  FORMAT(' ',10('/),' ',
      . ' Exhaustive yearly output is available://'
      . '      0 - Option not selected'//
      . '      1 - Option selected'//
      . ' Default value: ',I1)
      CALL CHANGE ((1),ICFLAG,IX,(0),(1),RX,RL,RH,R8X)
      IF (ICFLAG.EQ.1) IBUG = IX
      IF (NBUG .GT. 0 .AND. IBUG .EQ. 0) NBUG = 0
C
      IF (IBUG .GT. 0) CALL EDBUG
C
C
C
      WRITE (SCRN,1801)
1801  FORMAT (////' In MAX11 doses to various organs will be ',
      . 'calculated.')
      WRITE (SCRN,1810)
      WRITE (SCRN,1800) NORG
1800  FORMAT (' ',
      . 'The number of organs considered is ',I2,'.')
      CALL CHANGE ((1), ICFLAG, IX, (1), (5), RX, RL, RH, R8X)
      IF (ICFLAG.EQ.1) NORG = IX
C
      IF (NORG .EQ. 5) GOTO 811
      DO 810 I = 1, NORG
      WRITE (SCRN,1810)
1810  FORMAT (' ',////,' ',
      . 'The available organs are://'
      . '      1-Total body'//
      . '      2-Bone'//
      . '      3-Lungs'//
      . '      4-Thyroid'//
      . '      5-Lower large intestine'//)
      WRITE (SCRN,1811) I, KORG(I)
1811  FORMAT (' The current selection for organ ',I2,' is ',I2,'.')
      CALL CHANGE ((1), ICFLAG, IX, (1), (5), RX, RL, RH, R8X)
      IF (ICFLAG.EQ.1) THEN
          KORG(I) = IX
      ELSE
          KORG(I) = I
      ENDIF
      810  CONTINUE
      811  CONTINUE
C

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C      WRITE (SCRN,1000) IRS
1000  FORMAT (' ',24('/),
      . ' Two "base cases" are available to provide default values:'''
      . '           1 - Arid reference site'/'
      . '           2 - Humid reference site'/'
      . ' Please enter number of selected site: (Default=' ,I1,')')
      CALL CHANGE((1),ICFLAG,IX,(1),(2),RX,RL,RH,RX8)
      IF (ICFLAG.EQ.1) IRS = IX
C
C
      IF (IRS .EQ. 1) CALL ARID
      IF (IRS .EQ. 2) CALL HUMID
      WRITE (SCRN,8881) IRS
8881  FORMAT (' IRS: ',I4)
C
C
      WRITE (SCRN,1100) SITIT(IRS)
1100  FORMAT (///' ',
      . 'Waste Spectrum 1 is representative of past and current'/'
      . ' waste storage practices. Waste Spectrum 2 represents'/'
      . ' improved practices of the future.'///
      . ' The "base case" inventory for the ',A5,' site will be:'''
      DO 140 I = 1,3
        WRITE (SCRN,1101) I, (WSTIT(J,I),J=1,2)
140   CONTINUE
1101  FORMAT (10X,I1,' - ',2A8)
      WRITE (SCRN,1102) IWS
1102  FORMAT (//,' ',
      . 'Enter index of selected option: (Default=' ,I1,')')
      CALL CHANGE ((1), ICFLAG, IX, (1), (3), RX, RL, RH, R8X)
      IF (ICFLAG.EQ.1) IWS = IX
C
C
      IF (IFRST .EQ. 0) THEN
        IF (IWS .EQ. 1) THEN
          PL = PL1
          PLI = PLI1
        ELSE
          PL = PL2
          PLI = PLI2
        ENDIF
        IFRST = 1
      ENDIF
C
C
      WRITE (SCRN,1070) PL
1070  FORMAT (' ',24('/,' ',
      . 'The decomposition half-life of the package at closure'/'
      . ' is ', F5.2, ' years.')
      CALL CHANGE ((2), ICFLAG, IX, IL, IH, RX, (.0001), (1.E6), R8X)
      IF (ICFLAG.EQ.1) PL = RX
C

```

APPENDIX 1.B Computer Code Listing - CREATE

```

WRITE (SCRN,1080) PLI
1080 FORMAT (///' ',
.'The average age of the waste packages at time of site closure'/
.' is ',F5.2,' years.')
```

C

```

CALL CHANGE ((2), ICFLAG,IX,IL,IH,RX,(0.),(99999.),R8X)
IF (ICFLAG.EQ.1) PLI = RX
```

C

```

C
GNAME(1) = 'any of t'
GNAME(2) = 'he above'
CALL GROUP
IF (IGFLAG .EQ. 1) GO TO 100
```

C

```

C---- repeat above loop until user is satisfied with parameters -----
C
IF (IWS .LT. 3 .AND. NBUG .EQ. 0) THEN
  CALL DEFINV
ELSE
  CALL RADIN
ENDIF
```

C

```

CALL DISINV
```

C

```

150 CONTINUE
GNAME(1) = 'strata &'
GNAME(2) = ' erosion'
CALL GROUP
IF (IGFLAG .GT. 0) THEN
  CALL EDSTRA
  GO TO 150
ENDIF
```

C

```

TOT = 0.
DO 155 I = 1,NLYRS
  VOL(I) = THICK(I) * 1.0E+4
  TOT = TOT + THICK(I)
  DEPTH(I) = TOT
155 CONTINUE
```

C

```

160 CONTINUE
GNAME(1) = 'plants '
GNAME(2) = ' '
CALL GROUP
IF (IGFLAG .GT. 0) THEN
  CALL EDPLAN
  GO TO 160
ENDIF
```

C

```

170 CONTINUE
GNAME(1) = 'animals '
GNAME(2) = ' '
CALL GROUP
IF (IGFLAG .GT. 0) THEN
```

APPENDIX 1.B Computer Code Listing - CREATE

```

      CALL EDANIM
      GO TO 170
    ENDIF
C
C
C   Pick up organ indices for MAXI1--
      DO 180 I = 1, NORG
        KORG(I) = KDORG(KORG(I))
180  CONTINUE
C
      CALL RITFIL
C
      WRITE (SCRN, 2000)
2000  FORMAT (' ', 20('/),
      . ' You have successfully established a BIOPORT scenario. To'/
      . ' execute the scenario interactively, (report printed on this'/
      . ' screen), type: '//
      . '                                @BIOPORT'//
      . ' To obtain a printed report of the scenario, type: '//
      . '                                SUBMIT BIOPORT'//
      . ' To store report on a disk file type: '//
      . '                                ASSIGN filename FOR003'/
      . '                                SUBMIT BIOPORT'//
      . ' where "filename" is a valid filename of your choice.'//)
C
C-----
      END

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE ARID
C
C      This subroutine establishes default parameter values for the
C      reference arid site.
C
C      Module of CREATE
C      Version of 1-JUN-84  RAP
C-----
C
C                                          common blocks
C      INCLUDE 'CREATE.CMN'
C
C      INTEGER APMODE
C      INTEGER AIER, ANER, AJER
C
C      REAL ABIOMA(10,5), APROOT(10,5), ASROOT(5,5,10),
C      .      AACTPL(5), ARANGP(10,5), APMOIS(10), ARECYC(10,5)
C
C      REAL*8 APNAME(2,10)
C
C      INTEGER ANPLTS, AISUCC(10), ANYSUC(10,5), AIBIO(10,5),
C      .      AIRCY(10,5)
C
C      REAL AAMT(10), ADIRT(5,10), APACTV(10,2), ADIRTM(5),
C      .      APMOVE(10,5), ARANGC(10)
C
C      REAL*8 ACNAME(2,10)
C
C      INTEGER ANCRIT
C-----
C
C      DATA NLYRS /3/
C      DATA THICK /.5, .5, .5, 0., 0./
C      DATA VOLIN /6.5E+4/
C      DATA APMODE /2/
C
C
C      DATA AERU, AERLL, AIER, ANER, AJER /2.3,0.,1,4,600/
C
C
C      DATA APL1, APL2 /35.,70./
C      DATA APLI1, APLI2 /10., 10./
C
C
C      DATA ANPLTS /3/
C      DATA APNAME /8HHeatgra,8Hss Comm ,8HRabbitbr,8Hush Comm,
C      .           8HSagebrus,8Hh Comm ,8H           ,8H           ,
C      .           8H           ,8H           ,8H           ,8H           ,
C      .           8H           ,8H           ,8H           ,8H           ,
C      .           8H           ,8H           ,8H           ,8H           /

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C
DATA AISUCC /3,3,3,0,0,0,0,0,0,0/
DATA APMOIS / .15, .15, .15, 0., 0., 0., 0., 0., 0., 0./
C
Note: PMOIST is actually wet/dry weight ratio during CREATE
C
DATA APROOT /0.75,3.,5.,7*0.,0.75,3.,5.,7*0.,0.75,3.,5.,27*0.0/
C
DATA ARANGP /2.,2.,2.,7*0.,2.,2.,2.,7*0.,2.,2.,2.,27*0./
C
DATA ASROOT /3*.72,2*0.0, 3*.17,2*0.0, 3*.07,2*0.0,
.      3*.04,2*0.0, 5*0.0, 3*.565,2*0.0, 3*.245,
.      2*0.0, 3*.135,2*0.0, 3*.055,2*0.0, 5*0.0,
.      3*.61,2*0.0, 3*.23,2*0.0, 3*.11,2*0.0, 3*.05,
.      2*0.0, 5*0.0, 175*0.0/
C
DATA ANYSUC /10*0,10,10,10,7*0,30,30,30,7*0,500,500,500,17*0/
C
DATA ABIOMA /272.,9*0.,0.,104.,8*0.,0.,0.,117.,27*0./
C
DATA ARECYC / 1.,1.,1.,7*0.,1.,1.,1.,7*0.,1.,1.,1.,27*0./
C
DATA AIBIO / 50*0/
C
DATA AIRCY / 50*0/
C
DATA ANCRIT /3/
C
DATA ACNAME /8HPocket M,8Hice      ,8HBadgers ,8H      ,
.      8HHarveste,8Hr Ants ,8H      ,8H      ,
.      8H      ,8H      ,8H      ,8H      ,
.      8H      ,8H      ,8H      ,8H      ,
.      8H      ,8H      ,8H      ,8H      /
C
DATA AAMT / .1, .211, .1, 0., 0., 0., 0., 0., 0., 0./
C
DATA ARANGC /2.,2.,2.,0.,0.,0.,0.,0.,0.,0./
C
DATA APACTV /10*1.0, .875, 1., 1., 7*0./
C
DATA APMOVE / .70, .70, .70, 7*0.,
.      .20, .15, .10, 7*0.,
.      .05, .05, .10, 7*0.,
.      .05, .10, .10, 7*0.,
.      10*0.0/
C
-----
C
ERU = AERU
ERLL = AERLL
IER = AIER
NER = ANER
JER = AJER

```

APPENDIX 1.B Computer Code Listing - CREATE

```

PL1 = APL1
PL2 = APL2
PLI1 = APLI1
PLI2 = APLI2
PMODEL = APMODE
NPLTS = ANPLTS
C
DO 100 I = 1, 10
C
    ISUCC(I) = AISUCC(I)
    PMOIST(I) = APMOIS(I)
C
    DO 101 J = 1,2
        PNAME(J,I) = APNAME(J,I)
101    CONTINUE
C
    DO 110 J = 1,5
        PROOT(I,J) = APROOT(I,J)
        RANGP(I,J) = ARANGP(I,J)
        NYSUC(I,J) = ANYSUC(I,J)
        BIOMAS(I,J) = ABIOMA(I,J)
        RECYCL(I,J) = ARECYC(I,J)
        IBIO(I,J) = AIBIO(I,J)
        IRCY(I,J) = AIRCY(I,J)
        DO 112 K = 1,5
            SROOT(K,J,I) = ASROOT(K,J,I)
112    CONTINUE
110    CONTINUE
C
100 CONTINUE
C
    NCRIT = ANCRIT
C
DO 200 I = 1, 10
C
    DO 201 J = 1,2
        CNAME(J,I) = ACNAME(J,I)
        PACTVE(I,J) = APACTV(I,J)
201    CONTINUE
C
    AMT(I) = AAMT(I)
    RANGC(I) = ARANGC(I)
C
    DO 202 J = 1,5
        PMOVE(I,J) = APMOVE(I,J)
202    CONTINUE
C
200 CONTINUE
C
    RETURN
C
C-----
END

```


APPENDIX 1.B Computer Code Listing - CREATE

```
C-----C
SUBROUTINE CHANGE (ITFLAG, ICFLAG, IX, IL, IH, RX, RL, RH, R8X)

C      CHANGE is called to query if parameter is to be changed,
C      and if so, to input the new value and test if within the limits.
C
C      This subroutine will handle integer, real and alphanumeric
C      input and will test the limits on integer and real input.
C      Alphanumeric input is read into the real*8 variable.
C
C      ICFLAG - CHANGE subroutine passing flag: (returned)
C              0 - no change requested
C              1 - change requested
C      ITFLAG - CHANGE subroutine passing flag: (received)
C              1 - integer value
C              2 - real value
C              3 - alphanumeric input - real*8
C      IX - new integer value (returned)
C      IH - maximum allowable integer input (received)
C      IL - minimum allowable integer input (received)
C      RX - new real value (returned)
C      RH - maximum allowable real input (received)
C      RL - minimum allowable real input (received)
C      R8X - real*8 alphanumeric string input (returned)
C
Module of CREATE
Version of 11-APR-84  RAP
C-----C
C
INCLUDE 'CREATE.CMN'
REAL*8 R8X
C
ICFLAG = 0
WRITE (SCRN,1000)
1000 FORMAT (' ',70('-',),'//
.' Do you wish to change this value (N/Y)?')
READ (KEY,8001) IY
8001 FORMAT (A1)
C
IF (IY .NE. 'Y' .AND. IY .NE. 'y') GO TO 700
C
ICFLAG = 1
100 CONTINUE
C
WRITE (SCRN, 1010)
1010 FORMAT (' //' Enter new value: ')
C
integer input
IF (ITFLAG .NE. 1) GO TO 200
READ (KEY,*) IX
IF (IX .LT. IL .OR. IX .GT. IH) GO TO 100
```

APPENDIX 1.B Computer Code Listing - CREATE

```

      GO TO 700
200   CONTINUE
C
C                                     real input
      IF (ITFLAG .NE. 2) GO TO 300
      READ (KEY,*) RX
      IF (RX .LT. RL .OR. RX .GT. RH) GO TO 100
      GO TO 700
300   CONTINUE
C
C                                     real*8 alpha input
      IF (ITFLAG .NE. 3) GO TO 400
      READ (KEY,8003) R8X
400   CONTINUE
C
700  CONTINUE
C
      WRITE (SCRN,1001)
1001  FORMAT (' ',4(/))
C
      RETURN
C
C ---- format statements ----
C
8003  FORMAT (A8)
C
C-----
C
      END

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE CHAREL (ITFLAG, ICFLAG, R8X10)
C
C          CHAREL is a special version of CHANGE to handle REAL*8 arrays
C
C          This subroutine will handle integer, real and alphanumeric
C          input and will test the limits on integer and real input.
C          Alphanumeric input is read into the real*8 variable.
C
C          ICFLAG - CHANGE subroutine passing flag: (returned)
C                   0 - no change requested
C                   1 - change requested
C          ITFLAG - CHANGE subroutine passing flag: (received)
C                   1 - integer value
C                   2 - real value
C                   3 - alphanumeric input - real*8
C          R8X10 - real*8 alphanumeric string input (returned)
C
C      Module of CREATE
C      Version of 24-APR-84  RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C      REAL*8 R8X10(10)
C
C      ICFLAG = 0
C      WRITE (SCRN,1000)
1000  FORMAT (/ ' ',70('-'),//
C      . ' Do you wish to change this value (N/Y)? ' )
C      READ (KEY,8001) IY
8001  FORMAT (A1)
C
C      IF (IY .NE. 'Y' .AND. IY .NE. 'y') GO TO 700
C
C      ICFLAG = 1
100  CONTINUE
C
C      WRITE (SCRN, 1010)
1010  FORMAT ( ' ' // ' Enter new value: ' )
C
C
C
C
C      IF (ITFLAG .NE. 3) GO TO 400
C      READ (KEY,8003) R8X10
C      400  CONTINUE
C
C      700 CONTINUE
C
C      WRITE (SCRN,1001)
1001  FORMAT ( ' ',4(/))
C
C      RETURN

```

real*8 alpha input

```
C
C ---- format statements ----
C
C 8003 FORMAT (10A8)
C-----
C
C      END
```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE DEFINV
C
C      This subroutine establishes default inventory parameter values for
C      the selected reference site. The user has selected either Waste
C      Spectrum 1 or 2 prior to this subroutine call.
C
C      Module of CREATE
C      Version of 11-APR-84  RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      DIMENSION WS(4,100)
C
C      Read over default inventory file header--
C      READ(13,1001,ERR=800) IDUM
C      READ(13,1001,ERR=800) IDUM
C
C      I=1
C      Beginning of read loop--
100 CONTINUE
C
C      READ (13,1000,END=200,ERR=800) ELTI(I), AWI(I), (WS(J,I),J=1,4)
C      I = I + 1
C      GO TO 100
C      End of read loop--
C
C
200 CONTINUE
C      NIN = I - 1
C
C      IF (IRS .EQ. 1) THEN
C        IF(IWS .EQ. 1) THEN
C          IW = 1
C        ELSE
C          IW = 2
C        ENDIF
C      ELSE
C        IF (IWS .EQ. 1) THEN
C          IW = 3
C        ELSE
C          IW = 4
C        ENDIF
C      ENDIF
C
C      DO 400 I = 1, NIN
C        QI(I) = WS(IW,I)
400 CONTINUE
C
C      RETURN

```

APPENDIX 1.B Computer Code Listing - CREATE

```
C
C      Error routine--
C
      800 WRITE (SCRN,2000)
          STOP
C
C      Format statements--
C
      1000 FORMAT (A2,A6,3X,4E10.2)
      1001 FORMAT (A1)
      2000 FORMAT ('0 Error reading Default Inventory File')
C
C-----
C
      END
```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE DISINV
C
C      This subroutine displays the radionuclide inventory, allows the user
C      to first modify quantities in the inventory, and then to add radio-
C      nuclides to the list.  If changes or additions are requested, the
C      inventory will be redisplayed; the user does not return from this
C      subroutine until satisfied with the inventory.
C
C      Module of CREATE
C      Version of  3-MAY-84 RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      300 CONTINUE
C
C      WRITE (SCRN,1000)
1000  FORMAT(///,10X,'Radiological inventory (Ci/cubic meter):')
C
C      N = NIN/2
C      N = N*2
C
C      DO 100 I = 1, N, 2
C        WRITE (SCRN,1001) ELTI(I), AWI(I), QI(I),
C                          ELTI(I+1), AWI(I+1), QI(I+1)
100  CONTINUE
C      IF (N .LT. NIN) THEN
C        WRITE (SCRN,1001) ELTI(NIN), AWI(NIN), QI(NIN)
C      ENDIF
1001  FORMAT(2(8X,A2,A6,1PG10.2,4X))
C
C      GNAME(1) = 'the above'
C      GNAME(2) = 'e'
C      CALL GROUP
C      IF (IGFLAG .NE. 0) THEN
C
C        IMOD = 1
C        WRITE (SCRN,1011)
1011  FORMAT (///' You may now modify the quantity of selected'
C          .   ' radionuclides.  To delete an radionuclide,'
C          .   ' enter zero quantity.'////)
C
C        DO 200 I = 1, NIN
C          WRITE (SCRN,1010) ELTI(I), AWI(I), QI(I)
1010  FORMAT (///' Radionuclide ',A2,A6,' : ',1PG10.2,
C          .   ' Ci/cubic meter')
C          CALL CHANGE((2),ICFLAG,IX,IL,IH,RX,(0.),(1.E38),RX8)
C          IF (ICFLAG.EQ.1) QI(I) = RX
200  CONTINUE
C

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C
C     ELSE
C
C         IMOD = 0
C
C     ENDIF
C
C
C     WRITE (SCRN,1020)
1020  FORMAT (////' Do you wish to add radionuclides to the above'
C         .           ' inventory? (N/Y)')
C     READ (KEY,8001) IY
8001  FORMAT (A1)
C
C     IF (IY .EQ. 'Y' .OR. IY .EQ. 'y') THEN
C         IMOD = 1
C         CALL RADIN
C     ENDIF
C
C
C     IF (IMOD .EQ. 1) GO TO 300
C
C     RETURN
C
C-----
C
C     END

```


APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE EDANIM
C
C      This subroutine allows the user to review and/or modify animal
C      parameters.
C
C      Module of CREATE
C      Version of 14-MAY-84 RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      REAL*8 R8X
C      REAL*8 R8X10(10)
C
C      WRITE (SCRN,1040) NCRIT
1040  FORMAT (///' ',
.      'The number of animal species to be considered is ', I5,
.      /' (maximum = 10)')
      CALL CHANGE ((1), ICFLAG, IX, (0), (10), RX, RL, RH, R8X)
      IF (ICFLAG.EQ.1) NCRIT = IX
C
C      For each animal--
      DO 278 I = 1, NCRIT
C
C      WRITE (SCRN,2200) I, (CNAME(II,I),II=1,2)
2200  FORMAT (///' ',
.      'Animal No.', I2, ': ', 2A8, '.'/ ' ',
.      'Do you wish to change any parameters for this animal? (N/Y)')
      READ (KEY,8003) IY
      IF (IY.NE. 'Y' .AND. IY.NE. 'y') GO TO 276
C
C      WRITE (SCRN,1201) I, (CNAME(II,I),II=1,2)
1201  FORMAT (///' ',
.      'The name of animal number', I2, ' is ', 2A8)
      CALL CHAREL((3), ICFLAG, R8X10)
      IF (ICFLAG.EQ.1) THEN
         CNAME(1,I) = R8X10(1)
         CNAME(2,I) = R8X10(2)
      ENDIF
C
C      WRITE (SCRN,2202) (CNAME(II,I),II=1,2), AMT(I)
2202  FORMAT (///' ',
.      'The total amount of material brought to surface during'/
.      ' the first year of activity by ', 2A8, /
.      ' is ', F10.2, ' cubic meters/hectare. ',
.      ' (range: 0.0 to 1.E6)')
      CALL CHANGE ((2), ICFLAG, IX, IL, IH, RX, (0.0), (1.E6), R8X)
      IF (ICFLAG.EQ.1) AMT(I) = RX
C
C

```

APPENDIX 1.B Computer Code Listing - CREATE

```

WRITE (SCRN,2204) (CNAME(II,I),II=1,2), PACTIVE(I,2)
2204  FORMAT (////,' ',
      .  'The activity index of ',2A8,' after the first year '/
      .  ' is ',F6.3,'. This index relates the activity in '/
      .  ' subsequent years to the activity in the first year.'/
      .  ' The first year has an index of 1.0.')
      CALL CHANGE ((2),ICFLAG,IX,IL,IH,RX,(0.),(1.E4),R8X)
      IF (ICFLAG.EQ.1) PACTIVE(I,2) = RX
C
WRITE (SCRN,2203) (CNAME(II,I),II=1,2), RANGC(I)
2203  FORMAT (///,' ',
      .  'The depth of activity for ',2A8,' is ', F10.4,
      .  ' meters.'/
      .  ' (range: 0.0 to 1.E6)')
      CALL CHANGE ((2), ICFLAG, IX, IL, IH, RX, (0.),(1.E6), R8X)
      IF (ICFLAG .EQ. 1) RANGC(I) = RX
C
      IRANGC(I) = 1
      DO 255 K = 1,NLYRS - 1
        IF (RANGC(I) .GT. DEPTH(K) .AND. RANGC(I) .LE. DEPTH(K+1))
255  1  IRANGC(I) = K + 1
      CONTINUE
      IF (RANGC(I) .GT. DEPTH(NLYRS)) IRANGC(I) = NLYRS + 1
C
256  CONTINUE
      PTOT = 0.
C
      DO 270 J = 1, IRANGC(I)
        WRITE (SCRN,2206) (CNAME(II,I),II=1,2), J, PMOVE(I,J)
2206  FORMAT (' ',////,' ',
      .  'The proportion of material (i.e, soil and wastes)'/
      .  ' moved by ',2A8,' from strata ',I2,/
      .  ' to the surface is ', F6.4,
      .  ' (range: 0.0 to 1.0)')
        CALL CHANGE ((2),ICFLAG,IX,IL,IH,RX,(0.),(1.),R8X)
        IF (ICFLAG.EQ.1) PMOVE(I,J) = RX
        PTOT = PTOT + PMOVE(I,J)
270  CONTINUE
C
C
      IF (PTOT .NE. 1.0) THEN
        WRITE (SCRN,2225)
        WRITE (SCRN,2224) (J, PROOT(I,J),J=1,IRANGC(I))
2225  FORMAT (///' Proportion of material moved from: '/')
2224  FORMAT (10X,'Strata ',I1,': ',1PG10.4)
      ENDIF
C
      IF (PTOT .GT. 1.0) THEN
        WRITE (SCRN,2220) PTOT
2220  FORMAT (/ ' ??? Total of proportions of material moved'/
      .  ' from all strata cannot be greater than 1.0 ???'//
      .  ' Total = ',1PG10.3,' -- REEENTER ')
      GO TO 256

```

APPENDIX 1.B Computer Code Listing - CREATE

```

ELSE
  IF (PTOT .LT. 1.0) THEN
    WRITE (SCRN,2221) PTOT
2221    FORMAT (/ ' ??? Total of proportions of material',
      .      ' moved'/
      .      ' from all soil strata is less than 1.0 ????'//
      .      ' Total = ',1PG10.3//
      .      ' Do you wish to reenter (N/Y)?')
    READ (KEY,2222) ANS
2222    FORMAT (A1)
    IF (ANS .EQ. 'Y' .OR. ANS .EQ. 'y') GO TO 256
  ENDIF
ENDIF
C
C
276  CONTINUE
278  CONTINUE
C
  RETURN
C
C  FORMAT STATEMENTS--
8003  FORMAT (A8)
C
C-----
C
  END

```

APPENDIX 1.B Computer Code Listing - CREATE

```
C-----
C
C      SUBROUTINE EDEBUG
C
C      This subroutine allows the user to review and/or modify the output
C      selection parameters for yearly output of intermediate parameters.
C
C      Module of CREATE
C      Version of 3-MAY-84  RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      REAL*8 RBX
C
C      WRITE (SCRN,1001) NBUG
1001 FORMAT (' ',10('/),' ',
. 'The number of years the will be monitored with exhaustive '/
. ' output is ', I3, '. ')
      CALL CHANGE ((1),ICFLAG,IX,(1),(10),RX,RL,RH,RBX)
      IF (ICFLAG .EQ. 1) NBUG = IX
C
C      RETURN
C-----
C
C      END
```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE EDDOSE
C
C      This subroutine allows the user to review and/or modify the years
C      where dose calculations will be made from the radionuclide concen-
C      trations.
C
C      Module of CREATE
C      Version of 24-APR-84  RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      REAL*8 R8X
C
C      WRITE (SCRN,1001) NMAX, NYRS
1001  FORMAT(' ',10('/),' ',
C      . 'The number of years for which printed reports and MAXI1' /
C      . ' input will be generated is'
C      . I5, ' ' / ' (Range = 0 to ', I5, ') ' )
C      CALL CHANGE ((1),ICFLAG,IX,(0),NYRS,RX,RL,RH,R8X)
C
C      IF (ICFLAG .EQ. 1) NMAX = IX
C
C      WRITE (SCRN,1003)
1003  FORMAT (////)
C      DO 100 I = 1, NMAX
101    CONTINUE
C      WRITE (SCRN,1002) I
1002  FORMAT(' Enter year for report ', I5, ': ')
C      READ (KEY,*) IMAX(I)
C      IL = 0
C      IF (I .GT. 1) IL = IMAX(I-1)
C      IF (IMAX(I) .LE. IL) GO TO 101
100  CONTINUE
C
C      RETURN
C-----
C
C      END

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE EDPLAN
C
C      This subroutine allows the user to review and/or modify plant
C      parameters.
C
C      Module of CREATE
C      Version of 8-MAY-84 RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      REAL*8 R8X10(10)
C      REAL*8 R8X
C
C
C      WRITE (SCRN,1020) PMODEL
1020  FORMAT (////' ',
.      'Two plant uptake of radioactivity models are available'//
.      ' to the user:'//
.      '      1 - Uptake based on the total mass of the plant'//
.      '      2 - Uptake based on the fraction of the roots in'//
.      '            contact with the radioactive waste'//
.      ' The index of the current selection is ',I1,'.')
      CALL CHANGE ((1), ICFLAG, IX,(1),(2), RX,RL,RH,R8X)
      IF (ICFLAG.EQ.1) PMODEL = IX
C
C      WRITE (SCRN,1030) NPLTS
1030  FORMAT (///' ',
.      'The number of plant associations to be considered is ', I5,
.      '/' (maximum = 10)')
      CALL CHANGE ((1), ICFLAG, IX, (0), (10), RX, RL, RH, R8X)
      IF (ICFLAG.EQ.1) NPLTS = IX
C
C
C      For each plant
      DO 168 I = 1, NPLTS
C
C      WRITE (SCRN,1200) I, (PNAME(II,I),II=1,2)
1200  FORMAT (' ',24('/),' ',
.      'Plant No. ',I3,': ',2A8,'.'/
.      ' Do you wish to change any parameters for this plant? (N/Y)')
      READ (KEY,8003) IY
8003  FORMAT (A8)
      IF (IY.NE.'Y' .AND. IY.NE.'y') GO TO 168
C
C      WRITE (SCRN,1201) I, (PNAME(II,I),II=1,2)
1201  FORMAT (////' ',
.      'The name of plant association number',I2,' is ',2A8)
      CALL CHAREL((3), ICFLAG, R8X10)
      IF (ICFLAG.EQ.1) THEN

```

APPENDIX 1.B Computer Code Listing - CREATE

```

        PNAME(1,I) = R8X10(1)
        PNAME(2,I) = R8X10(2)
    ENDIF
C
    WRITE (SCRN,1203) I,(PNAME(II,I),II=1,2), PMOIST(I)
1203    FORMAT (////' ',
    .      'Plant No. ',I3,': ',2A8,'.'/
    .      ' The dry/wet weight ratio is ',F10.4,
    .      ' (range: 0.0 to 1.0)')
    CALL CHANGE ((2), ICFLAG, IX, IL, IH, RX, (0.), (1.), R8X)
    IF (ICFLAG.EQ.1) PMOIST(I) = RX
C
C
    WRITE (SCRN,1202) I,(PNAME(II,I),II=1,2), ISUCC(I)
1202    FORMAT (////' ',
    .      'Plant No. ',I3,': ',2A8,'.'//
    .      ' The number of phases of succession are',I2,/
    .      ' (maximum = 5)')
    CALL CHANGE ((1), ICFLAG, IX, (1), (5), RX, RL, RH, R8X)
    IF (ICFLAG.EQ.1) ISUCC(I) = IX
C
C
    WRITE(SCRN,1214) NYRS
1214    FORMAT(///,' ',
    .      'NOTE : Ending year for final successional phase',
    .      ' MUST be equal to',/,', ' or greater than the number of',
    .      ' years simulated (' ,I5,' )'.)
C
140    CONTINUE
    DO 145 J = 1,ISUCC(I)
        IL = 1
        IF ( J .GT. 1) IL = NYSUC(I,J)
        WRITE(SCRN,1208) I,(PNAME(II,I),II=1,2),J,NYSUC(I,J+1),
    .      IL, NYRS
1208    FORMAT (///' ',
    .      'Plant No. ',I3,': ',2A8,'.'//
    .      ' The year of endpoint of successional phase ',I2,
    .      ' is ',I5/
    .      ' (range: ',I5,' to ',I5,')')
        CALL CHANGE ((1), ICFLAG, IX, IL, NYRS, RX, RL, RH, R8X)
        IF (ICFLAG.EQ.1) NYSUC(I,J+1) = IX
145    CONTINUE
C
C
    IF (NYSUC(I,ISUCC(I)+1) .GE. NYRS) GOTO 148
    WRITE (SCRN,1215) NYRS
1215    FORMAT(//,' The ending year for the last successional ',
    .      'phase MUST be equal to ',/,', ' or greater than ',
    .      'the number of years simulated (' ,I5,' ) -- ',
    .      'reenter ending years ',//)
    GOTO 140
148    CONTINUE
C

```

APPENDIX 1.B Computer Code Listing - CREATE

```

DO 160 J = 1, ISUCC(I)
C
    WRITE (SCRN,1204) I,(PNAME(II,I),II=1,2), J, PROOT(I,J)
1204    FORMAT (' ',24('/),' ',
    .      'Plant No. ',I3,': ',2A8,'.',5X,
    .      'Successional Phase : ',I3,//
    .      'The root to shoot ratio is ',F6.4,
    .      ' (range: 0.0 to 10.0)')
    CALL CHANGE ((2),ICFLAG,IX,IL,IH,RX,(0.),(10.),R8X)
    IF (ICFLAG.EQ.1) PROOT(I,J) = RX
C
    WRITE (SCRN,1210) I,(PNAME(II,I),II=1,2), J, BIOMAS(I,J)
1210    FORMAT (///' ',
    .      'Plant No. ',I3,': ',2A8,'.',5X,
    .      'Successional Phase : ',I3,//
    .      'The total net annual production is ',F9.2,' grams(dry)',
    .      '/sq meter/year'//
    .      ' (range: 0.0 to 1.E6)')
    CALL CHANGE ((2), ICFLAG,IX,IL,IH,RX, (0.), (1.E6), R8X)
    IF (ICFLAG.EQ.1) BIOMAS(I,J) = RX
C
    WRITE (SCRN,1211) I,(PNAME(II,I),II=1,2), J, RECYCL(I,J)
1211    FORMAT (///' ',
    .      'Plant No. ',I3,': ',2A8,'.',5X,
    .      'Successional Phase : ',I3,//
    .      'The proportion of the production recycled each year',
    .      ' is ',F4.2/
    .      ' (range: 0.0 to 1.0)')
    CALL CHANGE ((2), ICFLAG,IX,IL,IH,RX, (0.), (1.), R8X)
    IF (ICFLAG.EQ.1) RECYCL(I,J) = RX
C
    WRITE (SCRN,1212) I,(PNAME(II,I),II=1,2), J, IBIO(I,J)
1212    FORMAT (///' ',
    .      'Plant No. ',I3,': ',2A8,'.',5X,
    .      'Successional Phase : ',I3,//
    .      'Production during a successional phase may be :',/,
    .      '      0 = constant'//
    .      '      1 = linearly increase or decrease'//
    .      'The default for this phase is ',I2,'.')
    CALL CHANGE ((1), ICFLAG,IX,(0),(1),RX, RL, RH, R8X)
    IF (ICFLAG.EQ.1) IBIO(I,J) = IX
C
    WRITE (SCRN,1213) I,(PNAME(II,I),II=1,2), J, IRCY(I,J)
1213    FORMAT (///' ',
    .      'Plant No. ',I3,': ',2A8,'.',5X,
    .      'Successional Phase : ',I3,//
    .      'The proportion of the biomass recycled during a ',
    .      'successional phase may be ',/,
    .      '      0 = constant'//
    .      '      1 = linearly increase or decrease '///
    .      'The default for this phase is ',I2,'.')
    CALL CHANGE ((1), ICFLAG,IX,(0),(1),RX, RL, RH, R8X)
    IF (ICFLAG.EQ.1) IRCY(I,J) = IX

```


APPENDIX 1.B Computer Code Listing - CREATE

```

C      WRITE (SCRN,1206) I,(PNAME(II,I),II=1,2), J, RANGP(I,J)
1206    FORMAT (///' ',
.      'Plant No. ',I3,': ',2A8,'.',5X,
.      'Successional Phase : ',I3,//
.      ' The maximum rooting depth is ',F6.4,' meters.'/
.      ' (range: 0.0 to 1E6)')
      CALL CHANGE ((2),ICFLAG,IX,IL,IH,RX,(0.),(1.E6),R8X)
      IF (ICFLAG.EQ. 1) RANGP(I,J) = RX

C
C      check against strata depths and adjust
      IRANGP(1,J) = 1
      DO 152 K = 1,NLYRS - 1
        IF (RANGP(I,J) .GT. DEPTH(K) .AND. RANGP(I,J)
.          .LE. DEPTH(K+1)) IRANGP(I,J) = K + 1
152    CONTINUE
      IF (RANGP(I,J) .GT. DEPTH(NLYRS)) IRANGP(I,J) = NLYRS + 1

C
C
165    CONTINUE
      TROOT = 0.

C
      DO 158 K = 1, IRANGP(I,J)

C
      WRITE (SCRN,1207) I,(PNAME(II,I),II=1,2), J, K,
.      SROOT(J,K,I)
1207    FORMAT (///' ',
.      'Plant No. ',I3,': ',2A8,'.',5X,
.      'Successional Phase : ',I3,//
.      ' The proportion of roots in strata ',I2,' is ',F6.4/
.      ' (range: 0.0 to 1.0)')
      CALL CHANGE ((2),ICFLAG,IX,IL,IH,RX,(0.),(1.),R8X)
      IF (ICFLAG.EQ.1) SROOT(J,K,I) = RX

C
      TROOT = TROOT + SROOT(J,K,I)

C
158    CONTINUE

C
C
      IF (TROOT .NE. 1.0) THEN
        WRITE (SCRN,2225)
        WRITE (SCRN,2224) (K, SROOT(J,K,I),K=1,IRANGP(I,J))
2225    FORMAT (///' Proportion of roots: '/')
2224    FORMAT (10X,'Strata ',I1,': ',1PG10.4)
      ENDIF

C
      IF (TROOT .GT. 1.0) THEN
        WRITE (SCRN,2220) TROOT
2220    FORMAT (/ ' ??? Total of proportions of roots in all' /
.      ' soil strata cannot be greater than 0.0 ???' //
.      ' Total = ',1PG10.3,' -- REEENTER ')
      GO TO 165

C

```

APPENDIX 1.B Computer Code Listing - CREATE

```

ELSE
  IF (TROOT .LT. 1.0) THEN
    WRITE (SCRN,2221) TROOT
2221    FORMAT (/ ' ??? Total of proportions of roots in all' /
      ' soil strata is less than 1.0 ???' //
      ' Total = ',1PG10.3//
      ' Do you wish to reenter (N/Y)?')
    READ (KEY,2222) ANS
2222    FORMAT (A1)
    IF (ANS .EQ. 'Y' .OR. ANS .EQ. 'y') GO TO 165
    ENDIF
  ENDIF
C
C
276    CONTINUE
278    CONTINUE
C
C
160    CONTINUE
168    CONTINUE
C
    RETURN
C
C-----
C
    END

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE EDSTRA
C
C      This subroutine allows the user to review and/or modify soil strata
C      and erosion parameters.
C
C      Module of CREATE
C      Version of 24-APR-84  RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      REAL*8 R8X
C
C      WRITE (SCRN, 1020) ERLL,ERU,IER,NER,JER
1020  FORMAT (// ' ',
.      'There are two erosion constants:/'
.      '      a baseline      (default = ',1PG10.3,')',/,
.      '      and a maximum    (default = ',1PG10.3,')'/'
.      ' Both in units of centimeters per year.',//
.      ' Additional input concerns maximum erosion:/'
.      '      the starting year (default = ',I4,')',/
.      '      the duration      (default = ',I4,')'/'
.      '      and the frequency  (default = ',I4,')'///// )
C
C      WRITE (SCRN,1021) ERLL
1021  FORMAT(/ ' ',
.      'The baseline erosion is ',1PG10.3,' centimeters/year')
      CALL CHANGE ((2), ICFLAG, IX, IL, IH, RX, (0.), (1.E6), R8X)
      IF (ICFLAG.EQ.1) ERLL = RX
C
C      WRITE (SCRN,1022) ERU
1022  FORMAT(/ ' ',
.      'The maximum erosion is ',1PG10.3,' centimeters/year')
      CALL CHANGE ((2), ICFLAG, IX, IL, IH, RX, (0.), (1.E6), R8X)
      IF (ICFLAG.EQ.1) ERU = RX
C
C      WRITE (SCRN,1023) IER
1023  FORMAT(/ ' ',
.      'The starting year for maximum erosion is ',I4)
      CALL CHANGE ((1), ICFLAG, IX, (1), (9999), RX, RL, RH, R8X)
      IF (ICFLAG.EQ.1) IER = IX
C
C
C      WRITE (SCRN,1024) NER
1024  FORMAT(/ ' ',
.      'The duration of maximum erosion is ',I4,' years')
      CALL CHANGE ((1), ICFLAG, IX, (1), (9999), RX, RL, RH, R8X)
      IF (ICFLAG.EQ.1) NER = IX
C
C

```

APPENDIX 1.B Computer Code Listing - CREATE

```

WRITE (SCRN,1025) JER
1025  FORMAT(/' ',
      . 'The frequency of maximum erosion is every ',I4,' years')
      CALL CHANGE ((1), ICFLAG, IX, (1), (9999), RX, RL, RH, R8X)
      IF (ICFLAG.EQ.1) JER = IX
C
C   For each strata
      DO 128 I = 1, NLYRS
C
      WRITE (SCRN,1050) I, THICK(I)
1050  FORMAT (' ',24('/),' ',
      . 'The thickness of layer',I2,' is ',F10.2,' meters.')
      CALL CHANGE ((2), ICFLAG, IX, IL, IH, RX,(.0001),(100.), R8X)
      IF (ICFLAG.EQ.1) THICK(I) = RX
C
128  CONTINUE
C
      WRITE (SCRN,1061) VOLIN
1061  FORMAT (///' ',
      . 'The volume of the inventory is',1PG10.2,' cubic meters.')
      CALL CHANGE ((2), ICFLAG, IX, IL, IH, RX,(1.), (1.E6), R8X)
      IF (ICFLAG.EQ.1) VOLIN = RX
C
C
      RETURN
C
C-----
C
      END

```

APPENDIX 1.B Computer Code Listing - CREATE

```
C-----
C
C      SUBROUTINE GROUP
C
C      This subroutine introduces a new category of parameters and allows
C      the user of skipping edits to that entire group of parameters.
C
C      Parameters passed through named common GRP:
C
C          IGFLAG - flag returned to calling program to indicate user
C                  preference concerning this group:
C                  0 - do not change any parameters
C                  1 - display/query this parameter group
C
C          GNAME - description of parameter group passed from calling
C                  program (Real*8)
C
C      Module of CREATE
C      Version of 14-MAY-84  RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      IGFLAG = 0
C
C      WRITE (SCRN,1000) (GNAME(I),I=1,2)
1000  FORMAT (' ',2(/),' ',70('#')////
. ' Do you wish to review or change ', 2A8,
. ' parameters (N/Y)')
C
C      READ (KEY,8003) IDUM
8003  FORMAT (A1)
      IF (IDUM .EQ. 'Y' .OR. IDUM .EQ. 'y') IGFLAG = 1
C
C      RETURN
C-----
C
C      END
```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE HUMID
C
C      This subroutine establishes default parameter values for the
C      reference humid site.
C
C      Module of CREATE
C      Version of 22-JUN-84  RAP
C-----
C
C                                          common blocks
C      INCLUDE 'CREATE.CMN'
C
C      INTEGER HPMODE
C      INTEGER HIER, HNER, HJER
C
C      REAL HBIOMA(10,5), HPROOT(10,5), HROOT(5,5,10),
C      .      HACTPL(5), HRANGP(10,5), HPMOIS(10), HRECYC(10,5)
C
C      REAL*8 HPNAME(2,10)
C
C      INTEGER HNPLTS, HISUCC(10), HNYSUC(10,5), HIBIO(10,5),
C      .      HIRCY(10,5)
C
C      REAL HAMT(10), HDIRT(5,10), HPACTV(10,2), HDIRTM(5),
C      .      HPMOVE(10,5), HRANGC(10)
C
C      REAL*8 HCNAME(2,10)
C
C      INTEGER HNCRIT
C-----
C
C      DATA HERU, HERLL, HIER, HNER, HJER /0.0, 0.0, 0, 0, 0/
C
C      DATA NLYRS /3/
C      DATA THICK /.5, .5, .5, 0., 0./
C      DATA VOLIN /6.5E+4/
C      DATA VOL /0.0, 0.0, 0.0, 0.0, 0.0/
C
C
C      DATA HPL1, HPL2 /15., 35./
C      DATA HPLI1, HPLI2 /10., 10./
C
C      DATA HPMODE /2/
C
C      DATA HNPLTS /3/
C      DATA HPNAME /8HForbs      ,8H      ,8HGrass-Sh,8Hrub      ,
C      .      8HPine-Oak,8H      ,8H      ,8H      ,
C      .      8H      ,8H      ,8H      ,8H      ,
C      .      8H      ,8H      ,8H      ,8H      ,
C      .      8H      ,8H      ,8H      ,8H      /

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C      DATA HISUCC /3,3,3,0,0,0,0,0,0,0/
C
C      DATA HPMOIS /.15,.15,.15,0.,0.,0.,0.,0.,0./
C      Note: PMOIST is actually wet/dry weight ratio during CREATE
C
C      DATA HPROOT /.25,.35,.35,7*0.,.25,.35,.35,7*0.,.25,.35,.35,
.          27*0./
C      .          0.,0.,0.,0.,0., 0.,0.,0.,0.,0., 0.,0.,0.,0.,0.,
C      .          0.,0.,0.,0.,0., 0.,0.,0.,0.,0., 0.,0.,0.,0.,0./
C
C      DATA HRANGP /2.,2.,2.,7*0., 2.,2.,2.,7*0., 2.,2.,2.,27*0./
C
C      DATA HROOT/3*.60,2*0.0, 3*.30,2*0.0, 3*.07,2*0.0,
.          3*.03,2*0.0, 5*0.0, 3*.60,2*0.0, 3*.30,
.          2*0.0, 3*.07,2*0.0, 3*.03,2*0.0, 5*0.0,
.          3*.60,2*0.0, 3*.30,2*0.0, 3*.07,2*0.0,
.          3*.03,2*0.0, 5*0.0, 175*0.0/
C
C      DATA HNYSUC /10*0, 6,6,6,7*0, 28,28,28,7*0, 500,500,500,17*0/
C
C      DATA HBIOMA /468.,0.,0.,7*0., 0.,635.,0.,7*0.,0.,0.,1300.,27*0./
C
C      DATA HRECYC /0.6,9*0., 0.,.6,8*0., 2*0.,.8,7*0.,20*0.0/
C      DATA HIRCY /10*0, 3*1,7*0, 3*1,27*0/
C      DATA HIBIO /10*0, 3*1,7*0, 3*1,27*0/
C
C      DATA HNCRIT /4/
C      DATA HCNAME /8H01d Fiel,8Hd Mouse ,8HShort Ta,8H1l Shrew,
.          8HHarveste,8Hr Ant ,8HAnt (Dor,8Hymymex),
.          8H      ,8H,      ,8H      ,8H      ,
.          8H      ,8H      ,8H      ,8H      ,
.          8H      ,8H      ,8H      ,8H      /
C
C      DATA HAMT /.35,48.5,.05,2.55,0.,0.,0.,0.,0.,0./
C      DATA HRANGC /1.,.5,2.,1.5,0.,0.,0.,0.,0.,0./
C      DATA HPACTV /10*1.0, .9,1.,.9,1.,6*0./
C
C      DATA HPMOVE /.95, 1.0, .70, .80, 6*0.,
.          .05, 0.0, .10, .15, 6*0.,
.          0.0, 0.0, .10, .05, 6*0.,
.          0.0, 0.0, .10, 0.0, 6*0.,
.          10*0.0/
C
C
C-----
C
C      ERU = HERU
C      ERL = HERLL
C      IER = HIER
C      NER = HNER
C      JER = HJER
C

```

APPENDIX 1.B Computer Code Listing - CREATE

```

PL1 = HPL1
PL2 = HPL2
PLI1 = HPLI1
PLI2 = HPLI2
C
PMODEL = HPMODE
C
NPLTS = HNPLTS
C
DO 100 I = 1, 10
C
    ISUCC(I) = HISUCC(I)
    PMOIST(I) = HPMOIS(I)
C
    DO 101 J = 1,2
        PNAME(J,I) = HPNAME(J,I)
101    CONTINUE
C
    DO 110 J = 1,5
        PROOT(I,J) = HPROOT(I,J)
        RANGP(I,J) = HRANGP(I,J)
        NYSUC(I,J) = HNYSUC(I,J)
        BIOMAS(I,J) = HBIOMA(I,J)
        RECYCL(I,J) = HRECYC(I,J)
        IBIO(I,J) = HIBIO(I,J)
        IRCY(I,J) = HIRCY(I,J)
        DO 112 K = 1,5
            SROOT(K,J,I) = HROOT(K,J,I)
112    CONTINUE
110    CONTINUE
C
100 CONTINUE
C
NCRIT = HNCRIT
C
DO 200 I = 1, 10
    DO 201 J = 1,2
        CNAME(J,I) = HCNAME(J,I)
        PACTIVE(I,J) = HPACTV(I,J)
201    CONTINUE
C
    AMT(I) = HAMT(I)
    RANGC(I) = HRANGC(I)
C
    DO 202 J = 1,5
        PMOVE(I,J) = HPMOVE(I,J)
202    CONTINUE
200 CONTINUE
C
RETURN
C
C-----
END

```


APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE INTRO
C
C      This subroutine displays introductory messages on the terminal.
C
C      Module of CREATE
C      Version of 11-APR-84  RAP
C-----
C      INCLUDE 'CREATE.CMN'
C      WRITE (SCRN,2000)
C      2000 FORMAT (' ',24(/),30X, 19('=')/30X,'CREATE-BIOPORT-MAXI'/30X,
C      . 19('=')////////)
C
C      WRITE (SCRN,2011)
C      2011 FORMAT (14X,'This interactive program will assist you ',
C      . 'in the creation'/
C      .14X,'of scenarios to be simulated by BIOPORT-MAXI.'/
C      .14X,'The following notes may be of interest:')
C
C      WRITE (SCRN,2010)
C      READ (KEY,8003) IDUM
C
C      WRITE (SCRN,2001)
C      2001 FORMAT (' ', 24(/), 11X,
C      . '1) If the default condition is selected, you need only'/
C      .14X,'press <return>. YES-or-NO questions are designated by'/
C      .14X,'(Y/N) and should be answered with a Y or N. The default'/
C      .14X,'condition is always listed first.')
C
C      WRITE (SCRN,2002)
C      2002 FORMAT ('0',
C      .10X,'2) The values you enter will be tested against reasonable'/
C      .14X,'limits and if they are not accepted you will be asked to'/
C      .14X,'supply another value.')
C
C      WRITE (SCRN,2003)
C      2003 FORMAT ('0',
C      .10X,'3) [Strata] and [layer] are used interchangeably to define'/
C      .14X,'the soil compartments.'//
C      .11X,'4) One hectare = 2.471 acres = 10000 square meters.'//
C      .11X,'5) A successional phase of a plant or animal can be des-'/
C      .14X,'cribed as the replacement of one community with another')
C
C      WRITE (SCRN,2010)
C      2010 FORMAT(/14X,'When you have finished reading, press <return>')
C      READ (KEY,8003) IDUM
C      8003 FORMAT (A8)
C
C      RETURN
C-----
C      END

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE QUANTI (I)
C
C      QUANTI requests the concentration of the current radionuclide from
C      the user.
C
C      Module of CREATE
C      Version of 1-MAY-84  RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      REAL*8 R8X
C
C      202 CONTINUE
C
C          WRITE (SCRN,1050) ELTI(I), AWI(I)
1050      FORMAT (//' ',
C          .   'Enter the quantity of ',A2,A6,' in the inventory at',
C          .   ' start of/'/' calculation (units: Ci/cu meter) :')
C          READ (KEY,*) RX
C          IF (RX .LT. 0.) GO TO 202
C          QI(I) = RX
C      206 CONTINUE
C
C      RETURN
C-----
C      END

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE RADIN
C
C      This subroutine inputs and tests radionuclide names for inclusion
C      in the inventory. Input of concentration is also controlled. The
C      list of allowable radionuclides for this environment is read if this
C      is the first time the subroutine is called during an execution.
C      If this is the first call of a user-defined inventory, initialization
C      is performed.
C
C      Module of CREATE
C      Version of 23-APR-84 RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C      REAL*8 R8X,  ORG(23), CL(3)
C      DIMENSION E(300), A(300), NS(2,300), IS(2), IDORG(5), KSORG(5)
C      REAL*8 A
C      INTEGER E
C
C      DATA ORG / 'tot body','body H2O','kidneys ','liver ','spleen ',
C      .          'bone ','fat ','lungs ','adrenals','testes ',
C      .          'ovaries ','skin ','brain ','muscle ','prostrat',
C      .          'thyroid ','pancreas','heart ','GI ','stomach ',
C      .          'sm. int.','ULI ','LLI '/'
C
C      DATA IDORG / 1,6,8,16,23/
C      DATA IS / ' ','in'/
C      DATA CL / 'Class D ','Class W ','Class Y '/'
C      DATA NORG /5/
C      DATA KSORG /1,6,8,16,23/
C      DATA FIRTIM /0/
C
C
C----- read in radionuclide library -----
C
C      IF (FIRTIM .EQ. 0) THEN
C          NUC = 1
C          READ(10,8003) IDUM
C8003  FORMAT (A8)
C
C      100  CONTINUE
C          READ(10,1001,END=992) E(NUC), A(NUC), IM, (NS(J,NUC),J=1,2)
C1001  FORMAT(A2,A8,8X,I2,41X,2I1)
C          IF (IM .EQ. 0) GO TO 200
C          NUC = NUC + 1
C          GO TO 100
C
C      200  CONTINUE
C      ENDIF

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C
C---- set flag if translocation review/check desired -----
C
      IF (FIRTIM .EQ. 0) THEN
        ITC = 0
C
      IF (INHAL .EQ. 0 ) GO TO 410
        WRITE (SCRN,4101)
4101  FORMAT (' ',20('/),' ',
      . 'Do you wish to review and/or change solubility classification'
      . '/' for each organ for each radionuclide. The default assump-'
      . '/' tion is elements are insoluble for lung and soluble for all'
      . '/' other organs. (N/Y)')
        READ (KEY,8001) IDUM
        IF (IDUM .EQ. 'Y' .OR. IDUM .EQ. 'y') ITC = 1
410  CONTINUE
      ENDIF
C
C---- test if this is original or addition inventory and set flags
C
      IF (IWS .LT. 3) FIRTIM=1
C
      IF (FIRTIM .EQ. 0) THEN
        NIN = 0
        I = 0
      ELSE
        I = NIN
      ENDIF
C
C---- initialize quantity arrays -----
C
      IF (FIRTIM .EQ. 0) THEN
        DO 610 IQ = 1, 100
          QI(IQ) = 0.
610  CONTINUE
      ENDIF
C
C---- signal beginning of inventory input -----
C
208  CONTINUE
      WRITE (SCRN,1100)
1100  FORMAT (' ',20('/),' ',
      . 14X, 'The following questions pertain to the radionuclide '/'
      . 14X, ' inventory. After inputting the inventory, enter '/'
      . 14X, ' "99" for element name to signal to the program that '/'
      . 14X, ' you are finished.'///, ' ',80('#')//
      . 14X, ' Press <return> when you have finished reading:')
      READ (KEY,8001) IDUM
8001  FORMAT (A1)
C
C---- input name and source terms for each radionuclide -----
C
149  CONTINUE

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C
      IF (NBUG .GT. 0 .AND. NIN .GT. 5) WRITE (SCRN,2200)
2200      FORMAT (' ??? No more than five radionuclides can be' /
      .          ' considered with exhaustive option set?????')
C
C
      WRITE (SCRN,2400)
2400      FORMAT (' ',5('/),' ',70(' '),///)
300      CONTINUE
      ICFLAG = 1
      WRITE (SCRN, 1010)
1010      FORMAT (///' Enter new 2-character element ',
      .          ' (99=no more radionuclides): ')
      READ (KEY,8005) IZ
8005      FORMAT (A2)
      IF (IZ .EQ. '99') GO TO 148
C
      WRITE (SCRN, 1011)
1011      FORMAT ('0Atomic number input can be up to ',
      .          '6 characters long.' /
      .          ' Include metastable (M) and daughter (+D) designation,',
      .          ' (i.e., TE127M+D)' /
      .          ' Enter atomic number: ')
      READ (KEY,8003) R8X
C
      DO 140 IX = 1, NUC
      IF (IZ .EQ. E(IX) .AND. R8X .EQ. A(IX)) GO TO 142
140      CONTINUE

      WRITE (SCRN,2401)
2401      FORMAT (///' ??? Radionuclide not found in library, ',
      .          'try again ???'///)
      GOTO 300
142      CONTINUE
C
      DO 144 IN = 1, NIN
      IF (ELTI(IN) .EQ. IZ .AND. AWI(IN) .EQ. R8X) THEN
      WRITE (SCRN,2402)
2402      FORMAT (///' ??? Radionuclide already included, try ',
      .          'again ???'///)
      GOTO 300
      ENDIF
144      CONTINUE
C
      IXS = IX
      NIN = NIN + 1
      I = I + 1
      ELTI(I)=IZ
      AWI(I)=R8X
      DO 143 J = 1, 5
      NSOLD(J,I) = NS(1,IXS)
      IF (KSORG(J) .EQ. 8) NSOLD(J,I) = NS(2,IXS)
143      CONTINUE

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C      IF (ITC .EQ. 0) GO TO 210
        DO 212 J = 1,5
          WRITE (SCRN,2020) ELTI(I)
2020      FORMAT (' ',4('/),' ',
        .      'Element ',A2,' Translocation Classification: '/')
          DO 213 K = 1,2
            WRITE (SCRN,2021) K, CL(NS(K,IXS)), IS(K)
213      CONTINUE
2021      FORMAT (5X, I2,' - ',A8,' for ',A2,'soluble')
          WRITE (SCRN,2022) ELTI(I), AWI(I), CL(NSOLD(J,I)),
        .      ORG(KSORG(J))
2022      FORMAT (// ' The translocation index for ',A2,A6,' is ',
        .      A8,' for ',A8/
        .      ' To change enter index.')
          CALL CHANGE ((1), ICFLAG, IX, (1), (3), RX,RL,RH,R8X)
          IF (ICFLAG .EQ. 1) NSOLD(J,I) = NS(IX,IXS)
212      CONTINUE
210      CONTINUE
C
        CALL QUANTI (I)
        GO TO 149
C
148 CONTINUE
      FIRTIM = 1
C
C      RETURN
C
C----- error messages -----
C
990 WRITE (SCRN,9000)
9000 FORMAT (' Error opening radionuclide library.')
      STOP
C
992 WRITE (SCRN,9002)
9002 FORMAT (' Premature end-of-file discovered in library')
C
C
C-----
C
      END

```

APPENDIX 1.B Computer Code Listing - CREATE

```

C-----
C
C      SUBROUTINE RITFIL
C
C      This subroutine writes files with input parameters and
C      system commands for BIOPORT and MAXII. RITFIL is called
C      by the program CREATE.
C
C      Module of CREATE
C      Version of 1-MAY-84 RAP
C-----
C
C      INCLUDE 'CREATE.CMN'
C
C          1) BIOPORT file - lun: 7 (BIO)
C          2) MAXII file - lun: 8 (MAX)
C-----
C-----write BIOPORT input file -----
C
C      WRITE (BIO,1008) TITL
1008 FORMAT (10A4)
C
C      WRITE (BIO,1010) NYRS, NCHK, NLYRS, NPLTS, NCRIT
1010 FORMAT (5I5)
C
C      WRITE (BIO,1010) PMODEL
C
C      WRITE (BIO,1012) NMAX
C      WRITE (BIO,1012) (IMAX(I), I=1,NMAX)
1012 FORMAT (20I5)
C
C      WRITE (BIO,1014) NBUG
1014 FORMAT (I5)
C
C      WRITE (BIO,1015) ERU, ERL, IER, NER, JER
1015 FORMAT(2G12.4,3I5)
C
C      WRITE (BIO,1020) (DEPTH(I), I=1, NLYRS)
1020 FORMAT (5G12.4)
C
C      WRITE (BIO,1030) (VOL(I), I=1, NLYRS), VOLIN
1030 FORMAT (6G12.4)
C
C      WRITE (BIO,1050) PL
C      WRITE (BIO,1050) PLI
1050 FORMAT (E10.2)
C
C      WRITE (BIO,1060) NIN
1060 FORMAT (I3)
C
C

```

```

      DO 600 I = 1, NIN
        WRITE (BIO,3212) ELTI(I), AWI(I), (NSOLD(J,I),J=1,5), QI(I)
3212  FORMAT (A2,A6,5I1,1PG10.2)
      600 CONTINUE
C
C
      DO 200 I = 1, NPLTS
C
      PMOIST(I) = 1. - PMOIST(I)
C
      WRITE (BIO,1080) (PNAME(II,I),II=1,2)
1080  FORMAT (2A8)
      WRITE (BIO,1090) ISUCC(I), PMOIST(I)
1090  FORMAT (I5, F10.4)
      WRITE (BIO,1100) (PROOT(I,J), J=1,ISUCC(I))
1100  FORMAT (5F10.4)
      WRITE (BIO,1110) (RANGP(I,J), J=1,ISUCC(I))
1110  FORMAT (5E10.2)
C
      DO 300 J = 1, ISUCC(I)
        WRITE (BIO,1120) (SROOT(J,K,I), K=1,NLYRS+2)
1120  FORMAT (5F12.4)
      300 CONTINUE
C
      WRITE (BIO,1130) (NYSUC(I,J), J=1,ISUCC(I)+1)
1130  FORMAT (6I5)
C
      WRITE (BIO,1140) (BIOMAS(I,J), J=1,ISUCC(I))
1140  FORMAT (5F12.4)
C
      WRITE (BIO,1150) (RECYCL(I,J), J=1,ISUCC(I))
1150  FORMAT (5F12.4)
C
      WRITE (BIO,1170) (IBIO(I,J), J=1,ISUCC(I))
1170  FORMAT (5I2)
C
      WRITE (BIO,1180) (IRCY(I,J), J=1,ISUCC(I))
1180  FORMAT (5I2)
C
      200 CONTINUE
C
C
      DO 500 I = 1, NCRIT
C
      WRITE (BIO,2000) (CNAME(II,I),II=1,2)
2000  FORMAT (2A8)
C
      WRITE (BIO,2010) AMT(I), RANGC(I)
2010  FORMAT (2F12.4)
C
      WRITE (BIO,2020) (PACTIVE(I,J), J=1,2)
2020  FORMAT (2F12.4)
C
      WRITE (BIO,2030) (PMOVE(I,J), J=1,5)
2030  FORMAT (5F12.4)

```


APPENDIX 1.B Computer Code Listing - CREATE

```

C
  500 CONTINUE
C
C
C----- write MAX11 input file -----
C
C
      WRITE (MAX, 3010)
3010 FORMAT ('ASSIGN [BIO.NEW]RMDLIB.DAT FOR010'/
.          'ASSIGN [BIO.NEW]FILE20.DAT FOR020'/
.          'ASSIGN [BIO.NEW]FILE21.DAT FOR021'/
.          'ASSIGN [BIO.NEW]PLANSOURC.SUR FOR022'/
.          'ASSIGN [BIO.NEW]FILE23.DAT FOR023'/
.          'ASSIGN [BIO.NEW]FILE24.DAT FOR024'/
.          'ASSIGN [BIO.NEW]FILE25.DAT FOR025'/
.          'ASSIGN [BIO.NEW]BURIEDONE.DAT FOR027'/
.          'ASSIGN [BIO]FOR030.DAT FOR030'/
.          'RUN [BIO.NEW]MAX11')
C
      WRITE (MAX, 3100) (TITL(I), I=1,10), IMAX(1)
3100 FORMAT (10A4, ' : BIOPORT Simulation year ',I5)
C
      WRITE (MAX, 3200) NORG, (KORG(I), I=1,5)
3200 FORMAT (' $INPUT NEXT=1, IFOD=1, IMO=0, RF1=1.0, RF2=0.,'/
.          ' IARG=0, IWAT=0, IEXT=0, IAIR=0, XFACT=1.33E-11,'/
.          ' AGE=20.0, XDPT=0.067, RINH=0.3, M3M2=0, INTRUD=0,'/
.          ' IT1=0, IT2=49, NORG=',I1,', KORG(1)=',5(I2,',')'/
.          ' IOUT=0, IBIO=1, $END'/
.          ' 0 0')
C
      IF (NMAX .GT. 1) THEN
        DO 100 I = 2, NMAX
          WRITE (MAX,3100) TITL, IMAX(I)
          WRITE (MAX,3202)
3202   FORMAT (' $INPUT NEXT=5 $END')
        100 CONTINUE
      ENDIF
C
      WRITE (MAX, 3220)
3220 FORMAT ('END OF RUN'/
.          ' $INPUT NEXT=4 $END')
C
      RETURN
C
C-----
C
      END

```


APPENDIX 1.C

RADIONUCLIDE MASTER LIBRARY FOR MAXI - RMDLIB

APPENDIX 1.C
Radionuclide Master Library for MAXI - RMDLIB

RADIONUCLIDE MASTER DATA LIBRARY /w TRANSLOCATION CLASSES, 6-APR-84					RAP
H 3	4.51E+3	1 0	0		11
BE10	5.84E+8	1 0	0		12
C 14	2.091E+6	1 0	0		12
N 13	6.92E-3	1 0	0		12
F 18	7.62E-2	1 0	0		11
NA22	9.50E+2	1 0	0		11
NA24	6.25E-1	1 0	0		11
P 32	1.43E+1	1 0	0		12
P 33	2.44E+1	1 0	0		12
S 35	8.72E+1	1 0	0		12
CL36	1.1E+8	1 0	0		11
K 40	4.67E11	1 0	0		11
AR39	9.83E+4	1 0	0		11
AR41	7.61E-2	1 0	0		11
CA41	5.11E+7	1 0	0		12
CA45	2.77E+1	1 0	0		12
SC46	8.38E+1	1 0	0		13
CR51	2.77E+1	1 0	0		13
MN54	3.12E+2	1 0	0		13
MN56	1.07E-1	1 0	0		13
FE55	9.86E+2	1 0	0		13
FE59	4.46E+1	1 0	0		13
CO57	2.71E+2	1 0	0		13
CO58	7.08E+1	1 0	0		13
CO60	1.92E+3	1 0	0		13
NI59	2.74E+7	1 0	0		13
NI63	3.51E+4	1 0	0		13
NI65	1.05E-1	1 0	0		13
CU64	5.29E-1	1 0	0		13
ZN65	2.44E+2	1 0	0		13
SE75	1.2E+2	1 0	0		12
AS76	1.10E+0	1 0	0		12
SE79	2.37E+7	1 0	0		12
BR82	1.47E+0	1 0	0		11
BR83+D	9.96E-2	1 0	0		11
BR84	2.21E-2	1 0	0		11
SR85	6.5E+1	1 0	0		13
KR90	3.74E-4	1 0	0		11
KR91	1.13E-4	1 0	0		11
RB86	1.87E+1	1 0	0		11
RB89+D	1.06E-2	1 0	0		11
SR89+D	5.06E+1	1 0	0		13
SR90+D	1.04E+4	1 0	0		13
SR91+D	3.96E-1	1 0	0		13
SR92+D	1.13E-1	1 0	0		13
Y 91M+D	3.45E-2	1 0	0		13
ZR93+D	5.59E+8	1 0	0		13
ZR95+D	6.40E+1	1 0	0		13
ZR97+D	7.04E-1	1 0	0		13

Radionuclide Master Library for MAXI - RMDLIB, continued

MO93	3.65E+4	1	0	0	13
NB94	7.30E+6	1	0	0	13
MO99+D	2.75E+0	1	0	0	13
TC101	9.86E-3	1	0	0	13
RU103+D	3.94E+1	1	0	0	13
RU105+D	1.85E-1	1	0	0	13
RU106+D	3.68E+2	1	0	0	13
PD107	2.37E+9	1	0	0	13
CD109	4.4E+2	1	0	0	13
AG110M+D	2.52E+2	1	0	0	13
AG111	7.45E+0	1	0	0	13
IN111	2.8E+0	1	0	0	13
CD113M	4.97E+3	1	0	0	13
SN117M	1.40E+1	1	0	0	13
SN119M	2.50E+2	1	0	0	13
SN121M	2.78E+4	1	0	0	13
SN123	1.29E+2	1	0	0	13
SN125+D	9.64E+0	1	0	0	13
SN126+D	3.65E+7	1	0	0	13
SB124	6.02E+1	1	0	0	13
SB125+D	1.01E+3	1	0	0	13
TE123M	1.17E+2	1	0	0	13
TE127M+D	1.09E+2	1	0	0	13
TE129M+D	3.36E+1	1	0	0	13
TE131M+D	1.25E+0	1	0	0	13
TE131+D	1.74E-2	1	0	0	13
TE132+D	3.26E+0	1	0	0	13
TE133M+D	3.85E-2	1	0	0	13
I 125+D	5.97E+1	1	0	0	12
I 130	5.15E-1	1	0	0	12
I 131+D	8.04E+0	1	0	0	12
I 135+D	2.75E-1	1	0	0	12
CS136	1.31E+1	1	0	0	11
CS137+D	1.10E+4	1	0	0	11
CS139+D	6.53E-3	1	0	0	11
BA140+D	1.28E+1	1	0	0	13
CE143+D	1.38E+0	1	0	0	23
CE144+D	2.84E+2	1	0	0	23
PM148M+D	4.13E+1	1	0	0	23
PM149	2.21E+0	1	0	0	23
SM153	1.95E+0	1	0	0	23
EU152	4.97E+3	1	0	0	23
EU153	1.94E+0	1	0	0	23
EU154	3.14E+3	1	0	0	23
EU155	1.81E+3	1	0	0	23
EU156	1.52E+1	1	0	0	23
GD153	2.42E+2	1	0	0	23
TB160	7.23E+1	1	0	0	23
HO166M	4.38E+5	1	0	0	23
W 181	1.40E+2	1	0	0	23

Radionuclide Master Library for MAXI - RMDLIB, continued

W 185	7.51E+1	1	0	0	23
OS185	9.40E+1	1	0	0	23
OS191	1.5E+1	1	0	0	23
IR192	7.3E+1	1	0	0	23
HG203	4.66E+1	1	0	0	23
PB210+D	8.14E+3	1	0	0	23
BI210+D	5.01E+0	1	0	0	23
RN222+D	3.82E+0	1	0	0	11
RA223+D	1.14E+1	1	0	0	23
RA224+D	3.66E+0	1	0	0	23
RA225+D	1.48E+1	1	0	0	23
RA226+D	5.84E+5	1	0	0	23
RA228+D	2.10E+3	1	0	0	23
AC227+D	7.95E+3	1	0	0	23
TH227+D	1.87E+1	1	0	0	23
TH228+D	6.99E+2	1	0	0	23
TH230+D	2.81E+7	1	0	0	23
TH232+D	5.13E12	1	0	0	23
PA231+D	1.19E+7	1	0	0	23
U 232+D	2.62E+4	1	0	0	23
U 233+D	5.79E+7	1	0	0	23
U 234	8.91E+7	1	0	0	23
U 235+D	2.59E11	1	0	0	23
U 236	8.55E+9	1	0	0	23
U 238+D	1.65E12	1	0	0	23
NP237+D	7.82E+8	1	0	0	23
PU236	1.04E+3	1	0	0	23
PU237	4.56E+1	1	0	0	23
PU241+D	5.26E+3	1	0	0	23
CM246	1.73E+6	1	0	0	23
CM247+D	5.70E+9	1	0	0	23
CM248	1.24E+8	1	0	0	23
CF252	9.64E+2	1	0	0	23
ZN69M	5.73E-1	1	0	0	13
ZN69	3.96E-2	2	1	1.0	13
BR83	9.96E-2	1	0	0	11
KR83M	7.62E-2	2	1	1.0	11
BR85	1.99E-3	1	0	0	11
KR85M	1.87E-1	2	1	1.0	11
KR85	3.92E+3	3	2	0.211	11
KR87	5.30E-2	1	0	0	11
RB87	1.72E13	2	1	1.0	11
KR88	1.18E-1	1	0	0	11
RB88	1.24E-2	2	1	1.0	11
KR89	2.20E-3	1	0	0	11
RB89	1.06E-2	2	1	1.0	11
SR89	5.06E+1	3	2	1.0	13
Y 89M	1.86E-4	4	3	0.0002	13
SR90	1.04E+4	1	0	0	13
Y 90	2.67E+0	2	1	1.0	13

Radionuclide Master Library for MAXI - RMDLIB, continued

SR91	3.96E-1	1	0	0	13	
Y 91M	3.45E-2	2	1	0.58	0	13
Y 91	5.85E+1	3	2	1.0	1 0.42	13
SR92	1.13E-1	1	0	0	13	
Y 92	1.48E-1	2	1	1.0	0	13
Y 93	4.21E-1	1	0	0	13	
ZR93	5.59E+8	2	1	1.0	0	13
NB93M	4.97E+3	3	2	0.25	0	13
ZR95	6.40E+1	1	0	0	13	
NB95M	3.61E+0	2	1	0.007	0	13
NB95	3.52E+1	3	2	1.0	1 0.993	13
ZR97	7.04E-1	1	0	0	13	
NB97M	6.94E-4	2	1	0.946	13	
NB97	5.01E-2	3	2	1.0	1 0.054	13
MO99	2.75E+0	1	0	0	13	
TC99M	2.51E-1	2	1	0.868	0	13
TC99	7.78E+7	3	2	1.0	1 0.132	13
RU103	3.94E+1	1	0	0	13	
PD103	1.70E+1	2	0	0	13	
RH103M	3.90E-2	3	1	.9974	1 .9997	13
RU105	1.85E-1	1	0	0	13	
RH105M	5.21E-4	2	1	0.28	0	13
RH105	1.47E+0	3	2	1.0	1 0.72	13
RU106	3.68E+2	1	0	0	13	
RH106	3.46E-4	2	1	1.0	0	13
PD109M	5.43E-5	1	0	0	13	
PD109	5.61E-1	2	1	1.0	0	13
AG109M	4.58E-4	3	2	1.0	0	13
AG110M	2.52E+2	1	0	0	13	
AG110	2.85E-4	2	1	0.0113	0	13
IN114M	5.00E+1	1	0	0	13	
IN114	8.33E-4	2	1	1.0	0	13
CD115M	4.46E+0	1	0	0	13	
CD115	2.23E+0	2	0	0	13	
IN115M	1.88E-1	3	2	1.0	0	13
IN115	2.19E17	4	3	0.963	1 1.0	13
SN125	9.64E+0	1	0	0	13	
SB125	1.01E+3	2	1	1.0	0	13
TE125M	5.80E+1	3	2	0.23	0	13
SN126	3.65E+7	1	0	0	13	
SB126M	1.32E-2	2	1	1.0	0	13
SB126	3.75E-1	3	2	0.14	0	13
SB127	3.85E+0	1	0	0	13	
TE127M	1.09E+2	2	1	0.139	0	13
TE127	3.90E-1	3	2	0.976	1 0.861	13
TE129M	3.36E+1	1	0	0	13	
TE129	4.83E-2	2	1	1.0	0	13
I 129	5.73E+9	3	2	1.0	0	12
TE131M	1.25E+0	1	0	0	13	
TE131	1.74E-2	2	1	0.222	0	13

Radionuclide Master Library for MAXI - RMDLIB, continued

I 131	8.04E+0	3	2	1.0	1	0.778	12
XE131M	1.19E+1	4	3	0.0109	0		11
TE132	3.26E+0	1	0		0		13
I 132	9.58E-2	2	1	1.0	0		12
TE133M	3.85E-2	1	0		0		13
TE133	8.64E-3	2	1	0.13	0		13
I 133	8.67E-1	3	2	1.0	1	0.87	12
XE133M	2.19E+0	4	3	0.029	0		11
XE133	5.24E+0	5	4	1.0	3	0.971	11
TE134	2.90E-2	1	0		0		13
I 134	3.65E-2	2	1	1.0	0		12
CS134M	1.21E-1	1	0		0		11
CS134	7.53E+2	2	1	1.0	0		11
I 135	2.75E-1	1	0		0		12
XE135M	1.09E-2	2	1	0.166	0		11
XE135	3.78E-1	3	2	1.0	1	0.834	11
CS135	8.40E+8	4	3	1.0	0		11
XE137	2.66E-3	1	0		0		11
CS137	1.10E+4	2	1	1.0	0		11
BA137M	1.77E-3	3	2	0.946	0		13
XE138	9.84E-3	1	0		0		11
CS138	2.24E-2	2	1	1.0	0		11
XE139	4.98E-4	1	0		0		11
CS139	6.53E-3	2	1	1.0	0		11
BA139	5.74E-2	3	2	1.0	0		13
XE140	1.85E-4	1	0		0		11
CS140	7.64E-4	2	1	1.0	0		11
BA140	1.28E+1	3	2	1.0	0		13
LA140	1.68E+0	4	3	1.0	0		23
BA141	1.27E-2	1	0		0		13
LA141	1.64E-1	2	1	1.0	0		23
CE141	3.25E+1	3	2	1.0	0		23
BA142	7.43E-3	1	0		0		13
LA142	6.44E-2	2	1	1.0	0		23
CE143	1.38E+0	1	0		0		23
PR143	1.36E+1	2	1	1.0	0		23
CE144	2.84E+2	1	0		0		23
PR144	1.20E-2	2	1	1.0	0		23
ND144	8.77E17	3	2	1.0	0		23
ND147	1.11E+1	1	0		0		23
PM147	9.58E+2	2	1	1.0	0		23
SM147	3.91E13	3	2	1.0	0		23
PM148M	4.13E+1	1	0		0		23
PM148	5.37E+0	2	1	1.0	0		23
PM151	1.18E+0	1	0		0		23
SM151	3.29E+4	2	1	1.0	0		23
W 187	9.95E-1	1	0		0		23
RE187	1.83E13	2	1	1.0	0		23
TH230	2.81E+7	1	0		0		23
RA226	5.84E+5	2	1	1.0	0		23

Radionuclide Master Library for MAXI - RMDLIB, continued

RN222	3.82E+0	3	2	1.0		11
PB210	8.14E+3	4	3	1.0	0	23
BI210	5.01E+0	5	4	1.0	0	23
PO210	1.38E+2	6	5	1.0	0	23
U 232	2.62E+4	1	0		0	23
TH232	4.16E13	2	0		0	23
RA228	2.10E+3	3	2	1.0	0	23
AC228	2.55E-1	4	3	1.0	0	23
TH228	6.99E+2	5	4	1.0	1 1.0	23
RA224	3.66E+0	6	5	1.0	0	23
PB212	4.43E-1	7	6	1.0	0	23
BI212	4.20E-2	8	7	1.0	0	23
U 235	2.59E11	1	0		0	23
TH231	1.06E+0	2	1	1.0	0	23
PA231	1.19E+7	3	2	1.0	0	23
AC227	7.95E+3	4	3	1.0	0	23
TH227	1.87E+1	5	4	0.9862	0	23
FR223	1.51E-2	6	4	0.0138	0	23
RA223	1.14E+1	7	5	1.0	6 1.0	23
U 237	6.75E+0	1	0		0	23
NP237	7.82E+8	2	1	1.0	0	23
PA233	2.70E+1	3	2	1.0	0	23
U 233	5.79E+7	4	3	1.0	0	23
TH229	2.68E+6	5	4	1.0	0	23
RA225	1.48E+1	6	5	1.0	0	23
AC225	1.00E+1	7	6	1.0	0	23
U 238	1.65E12	1	0	0.0	0	23
TH234	2.41E+1	2	1	1.0	0	23
PA234M	8.13E-4	3	2	1.0	0	23
PA234	2.81E-1	4	3	0.0013	0	23
AM242M	5.55E+4	1	0		0	23
AM242	6.68E-1	2	1	1.0	0	23
CM242	1.63E+2	3	2	0.827	0	23
PU242	1.41E+8	4	2	0.173	0	23
NP238	2.18E+0	5	0		0	23
PU238	3.21E+4	6	5	1.0	3 1.0	23
CM244	6.61E+3	1	0		0	23
PU244	3.02E10	2	0		0	23
U 240	5.88E-1	3	2	0.999	0	23
PU240	2.39E+6	4	3	1.0	1 1.0	23
CM247	5.70E+9	1	0		0	23
CM243	1.04E+4	2	0		0	23
PU243	2.06E-1	3	1	1.0	0	23
AM243	2.70E+6	4	3	1.0	2 0.0024	23
NP239	2.36E+0	5	4	1.0	0	23
PU239	8.91E+6	6	5	1.0	2 0.9976	23
CM245	3.10E+6	1	0		0	23
PU241	5.26E+3	2	1	1.0	0	23
AM241	1.58E+5	3	2	1.0	0	23
		0				

Reference "Environment" FILE20 (Leaf), page 1

Leaf Incremental Dose Factors for ONSITE/BIOPORT Environment - 16-APR-84 RAP

LEAF	50	99	5		
1	6	8	16	23	
H 3	1.44E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C 14	1.67E-05	7.31E-05	0.00E+00	0.00E+00	1.17E-05
NA22	1.27E-03	0.00E+00	0.00E+00	0.00E+00	8.24E-04
P 32	1.23E-04	3.18E-03	0.00E+00	0.00E+00	4.20E-04
P 33	3.14E-05	8.46E-04	0.00E+00	0.00E+00	6.83E-05
S 35	1.94E-04	4.31E-04	0.00E+00	0.00E+00	0.00E+00
CL36	1.55E+00	0.00E+00	0.00E+00	0.00E+00	4.07E-01
K 40	5.23E+00	0.00E+00	0.00E+00	0.00E+00	5.69E-01
CA45	1.90E-05	8.57E-04	0.00E+00	0.00E+00	6.85E-05
SC46	1.91E-08	3.36E-08	0.00E+00	0.00E+00	3.91E-04
CR51	1.40E-08	0.00E+00	2.88E-08	8.33E-09	4.34E-06
MN54	6.36E-06	0.00E+00	0.00E+00	0.00E+00	1.22E-04
FE55	1.14E-06	5.28E-06	1.71E-06	0.00E+00	1.31E-05
FE59	2.41E-05	2.79E-05	1.75E-05	0.00E+00	2.94E-04
C057	2.17E-06	0.00E+00	0.00E+00	0.00E+00	3.82E-05
C060	3.68E-05	0.00E+00	0.00E+00	0.00E+00	3.63E-04
NI59	3.47E-06	1.77E-05	0.00E+00	0.00E+00	9.76E-06
NI63	9.45E-06	2.41E-04	0.00E+00	0.00E+00	2.66E-05
ZN65	7.04E-05	4.71E-05	0.00E+00	0.00E+00	2.46E-04
SE75	2.85E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR85	4.03E-05	3.34E-05	0.00E+00	0.00E+00	0.00E+00
SR90+D	4.29E-04	1.60E-03	0.00E+00	0.00E+00	7.50E-04
M093	2.98E-06	0.00E+00	0.00E+00	0.00E+00	2.04E-05
NB94	1.12E-07	0.00E+00	0.00E+00	0.00E+00	3.64E-04
RU106+D	2.39E-06	1.83E-05	0.00E+00	0.00E+00	1.40E-03
CD109	2.00E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG110M+D	3.86E-06	6.41E-06	0.00E+00	0.00E+00	3.01E-03
IN111	1.20E-09	2.18E-09	0.00E+00	4.88E-10	9.84E-06
SB124	7.11E-06	1.68E-05	1.38E-05	4.71E-08	6.22E-04
SB125+D	3.18E-06	1.04E-05	9.09E-06	1.56E-08	1.91E-04
I 125+D	7.36E-05	3.43E-04	0.00E+00	6.03E-02	8.66E-06
I 131+D	3.05E-05	3.75E-05	0.00E+00	1.74E-02	1.61E-05
CS137+D	9.00E-04	9.08E-04	1.43E-04	0.00E+00	4.93E-05
CE144+D	8.24E-08	1.31E-06	0.00E+00	0.00E+00	1.29E-03
EU152	6.03E-08	1.59E-07	0.00E+00	0.00E+00	2.25E-04
EU154	8.72E-08	5.58E-07	0.00E+00	0.00E+00	4.80E-04
TB160	2.82E-08	2.24E-07	0.00E+00	0.00E+00	3.10E-04
OS185	9.01E-05	0.00E+00	0.00E+00	0.00E+00	3.18E-03
OS191	7.33E-06	0.00E+00	0.00E+00	0.00E+00	8.51E-04
IR192	8.51E-06	0.00E+00	0.00E+00	0.00E+00	6.98E-04
HG203	2.35E-04	0.00E+00	0.00E+00	0.00E+00	3.72E-04
PB210+D	3.82E-04	5.51E-03	0.00E+00	0.00E+00	4.43E-04
RA226+D	3.34E-02	3.36E-02	0.00E+00	0.00E+00	2.83E-03
TH228+D	2.12E-05	6.26E-04	0.00E+00	0.00E+00	4.87E-03
TH230+D	5.11E-06	1.80E-04	0.00E+00	0.00E+00	5.32E-04
TH232+D	6.62E-06	2.00E-04	0.00E+00	0.00E+00	4.53E-04

Reference "Environment" FILE21 (Soil), page 1

Soil Incremental Dose Factors for ONSITE/BIOPORT Environment - 16-APR-84 RAP

SOIL	50	99	5		
1	6	8	16	23	
H 3	3.54E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C 14	4.66E-09	2.04E-08	0.00E+00	0.00E+00	3.27E-09
NA22	2.12E-09	0.00E+00	0.00E+00	0.00E+00	1.37E-09
P 32	5.14E-07	1.33E-05	0.00E+00	0.00E+00	1.76E-06
P 33	1.16E-07	3.13E-06	0.00E+00	0.00E+00	2.53E-07
S 35	4.61E-09	1.02E-08	0.00E+00	0.00E+00	0.00E+00
CL36	1.33E-04	0.00E+00	0.00E+00	0.00E+00	3.50E-05
K 40	3.24E-05	0.00E+00	0.00E+00	0.00E+00	3.52E-06
CA45	5.17E-11	2.33E-09	0.00E+00	0.00E+00	1.86E-10
SC46	2.69E-15	4.73E-15	0.00E+00	0.00E+00	5.49E-11
CR51	4.47E-16	0.00E+00	9.23E-16	2.67E-16	1.39E-13
MN54	2.20E-11	0.00E+00	0.00E+00	0.00E+00	4.21E-10
FE55	4.61E-14	2.14E-13	6.94E-14	0.00E+00	5.30E-13
FE59	1.20E-12	1.39E-12	8.71E-13	0.00E+00	1.46E-11
CO57	2.25E-12	0.00E+00	0.00E+00	0.00E+00	3.96E-11
CO60	3.69E-11	0.00E+00	0.00E+00	0.00E+00	3.64E-10
NI59	4.91E-12	2.50E-11	0.00E+00	0.00E+00	1.38E-11
NI63	1.33E-11	3.40E-10	0.00E+00	0.00E+00	3.76E-11
ZN65	2.00E-09	1.34E-09	0.00E+00	0.00E+00	6.98E-09
SE75	2.99E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR85	8.44E-10	6.99E-10	0.00E+00	0.00E+00	0.00E+00
SR90+D	7.88E-09	2.94E-08	0.00E+00	0.00E+00	1.38E-08
MO93	2.79E-11	0.00E+00	0.00E+00	0.00E+00	1.91E-10
NB94	1.00E-13	0.00E+00	0.00E+00	0.00E+00	3.28E-10
RU106+D	2.85E-12	2.18E-11	0.00E+00	0.00E+00	1.67E-09
CD109	6.66E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG110M+D	1.95E-11	3.23E-11	0.00E+00	0.00E+00	1.52E-08
IN111	1.16E-13	2.09E-13	0.00E+00	4.68E-14	9.45E-10
SB124	9.24E-12	2.18E-11	1.79E-11	6.12E-14	8.08E-10
SB125+D	3.58E-12	1.17E-11	1.03E-11	1.76E-14	2.16E-10
I 125+D	8.80E-11	4.10E-10	0.00E+00	7.21E-08	1.04E-11
I 131+D	5.63E-11	6.93E-11	0.00E+00	3.21E-08	2.97E-11
CS137+D	1.28E-10	1.29E-10	2.03E-11	0.00E+00	7.00E-12
CE144+D	4.93E-15	7.84E-14	0.00E+00	0.00E+00	7.71E-11
EU152	1.72E-14	4.53E-14	0.00E+00	0.00E+00	6.40E-11
EU154	2.49E-14	1.59E-13	0.00E+00	0.00E+00	1.37E-10
TB160	9.58E-15	7.60E-14	0.00E+00	0.00E+00	1.05E-10
OS185	3.21E-10	0.00E+00	0.00E+00	0.00E+00	1.13E-08
OS191	3.57E-11	0.00E+00	0.00E+00	0.00E+00	4.15E-09
IR192	9.65E-12	0.00E+00	0.00E+00	0.00E+00	7.91E-10
HG203	6.25E-09	0.00E+00	0.00E+00	0.00E+00	9.90E-09
PB210+D	3.01E-09	4.33E-08	0.00E+00	0.00E+00	3.48E-09
RA226+D	5.23E-09	5.26E-09	0.00E+00	0.00E+00	4.42E-10
TH228+D	1.03E-11	3.03E-10	0.00E+00	0.00E+00	2.36E-09
TH230+D	2.43E-12	8.59E-11	0.00E+00	0.00E+00	2.54E-10
TH232+D	3.16E-12	9.56E-11	0.00E+00	0.00E+00	2.16E-10

Reference "Environment" Surface Soil PLANSOURC (External)

ONSITE/BIOPORT EXTERNAL DRFS FOR SURFACE (PLANE SOURCE) 10-APR-84 RAP

PLAN 100

H 3	0.0
C 14	6.2E-04
NA22	4.3E+02
P 32	9.2E-01
P 33	9.4E-01
S 35	0.0
CL36	2.8E-01
K 40	5.7E+01
CA45	2.8E-03
SC46	7.2E+02
CR51	1.1E+01
MN54	2.9E+02
FE55	0.0
FE59	4.0E+02
CO57	2.1E+01
CO60	8.6E+02
NI59	0.0
NI63	2.5E-14
ZN65	2.2E+02
SE75	9.2E+01
SR85	1.8E+02
SR90+D	1.9
MO93	1.4
NB94	5.3E+02
RU106+D	8.9E+02
CD109	7.6
AG110M+D	1.0E+03
IN111	7.6E+01
SB124	7.2E+02
SB125+D	1.7E+02
I 125+D	8.8E-01
I 131+D	1.2E+02
C5137+D	2.1E+02
CE144+D	1.7E+01
EU152	4.0E+02
EU154	4.3E+02
TB160	3.8E+02
OS185	2.5E+02
OS191	7.9
IR192	2.5E+02
HG203	4.7E+01
PB210+D	3.4E-01
RA226+D	1.3
TH228+D	3.3E+01
TH230+D	1.3
TH232+D	3.2E+02
U 233+D	4.2
U 234	6.9E-02
U 235+D	8.9E+01

Reference "Environment" Surface Soil PLANSOURC (External), continued

U 238+D	5.0
NP237+D	6.6E+01
PU241+D	1.1
SR89	5.7E-01
Y 89M	0.0
SR90	3.0E-02
Y 90	1.9
M099	4.8E+01
TC99M	1.9E+01
TC99	4.0E-03
RU103	1.8E+02
RH103M	5.1E-02
PD103	2.8E-01
I 129	4.3E-01
CS134	6.0E+02
CS135	1.3E-03
CS137	4.1E-02
BA137M	2.2E+02
CE141	1.0E+01
SM151	2.4E-04
U 235	2.0E+01
TH231	1.3
PA231	8.6
AC227	1.3E-02
TH227	2.5E+01
FR223	7.6
RA223	2.6E+01
NP237	1.9
PA233	6.0E+01
U 233	4.2E-03
TH229	1.8
RA225	6.8E-01
AC225	1.7
U 238	9.8E-03
TH234	7.5E-01
PA234M	2.9
PA234	6.3E+02
PU242	8.1E-04
NP238	2.0E+02
PU238	2.9E-03
CM244	1.8E-03
PU244	6.8E-07
U 240	3.4E-02
PU240	2.7E-03
CM243	2.5E+01
PU243	2.7
AM243	3.6
NP239	2.9E+01
PU239	2.9E-03
PU241	2.9E-12
AM241	1.1

Reference "Environment" FILE23 (Air), page 1

130		DACRIN (DIFDOS) DOSE INCREMENT FILE ONSITE/BIOPORT ENV. 16-APR-84 RAP				
	1	6	8	16	23	
H 3			0	0	2	
H	3	1	1	1.05E-06	.00	1.05E-06 1.05E-06 .00
H	3	1	2	5.32E-08	.00	5.32E-08 5.32E-08 .00
C 14			4	0	0	
C	14	1	1	2.39E-06	1.05E-05	2.39E-06 2.39E-06 2.06E-06
C	14	1	2	1.01E-07	1.97E-06	1.01E-07 1.01E-07 1.23E-10
C	14	1	3	.00	3.51E-09	.00 .00 .00
C	14	1	4	.00	6.37E-12	.00 .00 .00
NA22			2	4	27	
NA22	1	1		7.25E-05	0.00E+00	5.01E-05 0.00E+00 1.15E-05
NA22	1	2		3.33E-06	0.00E+00	9.90E-08 0.00E+00 6.88E-10
NA22	2	1		6.82E-05	0.00E+00	2.37E-03 0.00E+00 3.62E-05
NA22	2	2		6.65E-06	0.00E+00	5.32E-04 0.00E+00 1.35E-06
NA22	2	3		2.88E-08	0.00E+00	2.57E-06 0.00E+00 6.24E-09
NA22	2	4		1.82E-10	0.00E+00	1.23E-08 0.00E+00 3.27E-11
NA22	3	1		5.80E-05	0.00E+00	6.03E-03 0.00E+00 3.71E-05
NA22	3	2		6.21E-06	0.00E+00	7.40E-03 0.00E+00 1.87E-06
NA22	3	3		1.84E-06	0.00E+00	3.42E-03 0.00E+00 8.29E-07
NA22	3	4		9.47E-07	0.00E+00	1.58E-03 0.00E+00 3.83E-07
NA22	3	5		4.96E-07	0.00E+00	7.28E-04 0.00E+00 1.77E-07
NA22	3	6		2.65E-07	0.00E+00	3.37E-04 0.00E+00 8.17E-08
NA22	3	7		1.43E-07	0.00E+00	1.55E-04 0.00E+00 3.76E-08
NA22	3	8		7.85E-08	0.00E+00	7.18E-05 0.00E+00 1.74E-08
NA22	3	9		4.36E-08	0.00E+00	3.31E-05 0.00E+00 8.03E-09
NA22	3	10		2.45E-08	0.00E+00	1.52E-05 0.00E+00 3.69E-09
NA22	3	11		1.39E-08	0.00E+00	7.05E-06 0.00E+00 1.72E-09
NA22	3	12		7.97E-09	0.00E+00	3.25E-06 0.00E+00 7.86E-10
NA22	3	13		4.61E-09	0.00E+00	1.51E-06 0.00E+00 3.64E-10
NA22	3	14		2.67E-09	0.00E+00	6.91E-07 0.00E+00 1.67E-10
NA22	3	15		1.57E-09	0.00E+00	3.20E-07 0.00E+00 8.00E-11
NA22	3	16		9.09E-10	0.00E+00	1.49E-07 0.00E+00 3.64E-11
NA22	3	17		5.38E-10	0.00E+00	6.71E-08 0.00E+00 1.46E-11
NA22	3	18		3.20E-10	0.00E+00	3.17E-08 0.00E+00 1.09E-11
NA22	3	19		1.82E-10	0.00E+00	1.49E-08 0.00E+00 0.00E+00
NA22	3	20		1.16E-10	0.00E+00	5.59E-09 0.00E+00 3.64E-12
NA22	3	21		6.55E-11	0.00E+00	3.73E-09 0.00E+00 0.00E+00
NA22	3	22		3.64E-11	0.00E+00	1.86E-09 0.00E+00 0.00E+00
NA22	3	23		2.18E-11	0.00E+00	0.00E+00 0.00E+00 0.00E+00
NA22	3	24		1.46E-11	0.00E+00	0.00E+00 0.00E+00 0.00E+00
NA22	3	25		7.28E-12	0.00E+00	1.86E-09 0.00E+00 0.00E+00
NA22	3	26		7.28E-12	0.00E+00	0.00E+00 0.00E+00 0.00E+00
NA22	3	27		7.28E-12	0.00E+00	0.00E+00 0.00E+00 0.00E+00
P 32			2	2	2	
P 32	1	1		3.79E-05	9.79E-04	4.18E-05 0.00E+00 2.58E-05
P 32	1	2		2.18E-06	5.89E-05	7.98E-08 0.00E+00 1.53E-09
P 32	2	1		2.56E-05	6.62E-04	5.85E-04 0.00E+00 6.96E-05
P 32	2	2		1.57E-06	4.24E-05	2.55E-05 0.00E+00 2.90E-07
P 32	3	1		2.30E-05	5.95E-04	7.15E-04 0.00E+00 7.77E-05

Reference "Environment" FILE24 (Aquatic), page 1

Incremental Aquatic Foods Dose Factors - ONSITE/BIOPORT Env. - 16-APR-84 RAP

FISH	50	92	5		
1	6	8	16	23	
H 3	2.61E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C 14	1.76E-05	7.72E-05	0.00E+00	0.00E+00	1.24E-05
NA22	1.80E-05	0.00E+00	0.00E+00	0.00E+00	1.17E-05
P 32	4.64E-03	1.20E-01	0.00E+00	0.00E+00	1.58E-02
P 33	9.20E-04	2.48E-02	0.00E+00	0.00E+00	2.00E-03
CA45	4.76E-07	2.14E-05	0.00E+00	0.00E+00	1.71E-06
SC46	4.08E-10	7.18E-10	0.00E+00	0.00E+00	8.34E-06
CR51	1.23E-09	0.00E+00	2.55E-09	7.37E-10	3.84E-07
MN54	2.42E-06	0.00E+00	0.00E+00	0.00E+00	4.64E-05
FE55	8.21E-08	3.82E-07	1.24E-07	0.00E+00	9.45E-07
FE59	2.37E-06	2.75E-06	1.73E-06	0.00E+00	2.90E-05
C057	1.21E-07	0.00E+00	0.00E+00	0.00E+00	2.13E-06
C060	1.96E-06	0.00E+00	0.00E+00	0.00E+00	1.93E-05
NI59	2.12E-07	1.08E-06	0.00E+00	0.00E+00	5.96E-07
NI63	5.77E-07	1.47E-05	0.00E+00	0.00E+00	1.63E-06
ZN65	4.29E-05	2.87E-05	0.00E+00	0.00E+00	1.50E-04
SE75	2.78E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR85	1.48E-06	1.22E-06	0.00E+00	0.00E+00	0.00E+00
SR90+D	1.30E-05	4.85E-05	0.00E+00	0.00E+00	2.28E-05
M093	9.20E-08	0.00E+00	0.00E+00	0.00E+00	6.28E-07
NB94	2.52E-06	0.00E+00	0.00E+00	0.00E+00	8.23E-03
RU106+0	9.71E-08	7.42E-07	0.00E+00	0.00E+00	5.69E-05
CD109	3.55E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG110M+D	2.77E-08	4.59E-08	0.00E+00	0.00E+00	2.16E-05
SB124	3.56E-07	8.43E-07	6.91E-07	2.36E-09	3.12E-05
SB125+D	1.30E-07	4.25E-07	3.72E-07	6.38E-10	7.83E-06
I 125+D	1.52E-06	7.07E-06	0.00E+00	1.24E-03	1.78E-07
I 131+D	1.38E-06	1.70E-06	0.00E+00	7.86E-04	7.26E-07
CS137+D	6.06E-04	6.12E-04	9.65E-05	0.00E+00	3.32E-05
CE144+D	1.11E-09	1.76E-08	0.00E+00	0.00E+00	1.73E-05
EU152	1.98E-09	5.23E-09	0.00E+00	0.00E+00	7.40E-06
EU154	2.87E-09	1.84E-08	0.00E+00	0.00E+00	1.58E-05
TB160	1.13E-09	8.95E-09	0.00E+00	0.00E+00	1.24E-05
IR192	5.39E-07	0.00E+00	0.00E+00	0.00E+00	4.42E-05
HG203	6.29E-04	0.00E+00	0.00E+00	0.00E+00	9.95E-04
PB210+D	5.63E-05	8.12E-04	0.00E+00	0.00E+00	6.52E-05
RA226+D	2.84E-03	2.85E-03	0.00E+00	0.00E+00	2.40E-04
TH228+D	1.40E-06	4.13E-05	0.00E+00	0.00E+00	3.21E-04
TH230+D	3.29E-07	1.16E-05	0.00E+00	0.00E+00	3.43E-05
TH232+D	4.27E-07	1.29E-05	0.00E+00	0.00E+00	2.92E-05
U 233+D	1.08E-05	1.17E-04	0.00E+00	0.00E+00	2.21E-05
U 234	1.05E-05	8.69E-05	0.00E+00	0.00E+00	2.17E-05
U 235+D	9.89E-06	8.32E-05	0.00E+00	0.00E+00	2.75E-05
U 238+D	9.25E-06	7.96E-05	0.00E+00	0.00E+00	1.94E-05
NP237+D	2.45E-07	5.63E-06	0.00E+00	0.00E+00	3.31E-05
PU241+D	2.94E-09	8.19E-08	0.00E+00	0.00E+00	5.17E-07

Reference "Environment" FILE25 (Drink), page 1

Incremental Drinking Water Dose Factors - ONSITE/BIOPORT Env. 16-APR-84 RAP

	H2O	50	92	5	
	1	6	8	16	23
H 3		2.57E-08		0.00E+00	0.00E+00
C 14		2.40E-07		1.05E-06	0.00E+00
NA22		6.54E-06		0.00E+00	0.00E+00
P 32		1.18E-06		3.05E-05	0.00E+00
P 33		2.34E-07		6.29E-06	0.00E+00
CA45		1.15E-07		5.16E-06	0.00E+00
SC46		3.70E-10		6.50E-10	0.00E+00
CR51		9.15E-10		0.00E+00	1.89E-09
MN54		1.78E-07		0.00E+00	0.00E+00
FE55		9.25E-09		4.30E-08	1.39E-08
FE59		2.68E-07		3.10E-07	1.95E-07
CO57		2.45E-08		0.00E+00	0.00E+00
CO60		3.97E-07		0.00E+00	0.00E+00
NI59		2.39E-08		1.22E-07	0.00E+00
NI63		6.50E-08		1.66E-06	0.00E+00
ZN65		5.38E-07		3.60E-07	0.00E+00
SE75		6.40E-07		0.00E+00	0.00E+00
SR85		4.39E-07		3.63E-07	0.00E+00
SR90+D		3.87E-06		1.44E-05	0.00E+00
MO93		7.83E-08		0.00E+00	0.00E+00
NB94		3.73E-09		0.00E+00	0.00E+00
RU106+D		7.38E-08		5.64E-07	0.00E+00
CD109		5.68E-09		0.00E+00	0.00E+00
AG110M+D		2.63E-08		4.36E-08	0.00E+00
SB124		3.49E-07		8.27E-07	6.78E-07
SB125+D		1.27E-07		4.16E-07	3.65E-07
I 125+D		1.17E-06		5.46E-06	0.00E+00
I 131+D		1.06E-06		1.31E-06	0.00E+00
CS137+D		1.68E-05		1.70E-05	2.68E-06
CE144+D		1.03E-09		1.63E-08	0.00E+00
EU152		6.68E-10		1.76E-09	0.00E+00
EU154		9.67E-10		6.19E-09	0.00E+00
TB160		3.80E-10		3.01E-09	0.00E+00
IR192		1.09E-07		0.00E+00	0.00E+00
HG203		9.97E-07		0.00E+00	0.00E+00
PB210+D		2.05E-05		2.95E-04	0.00E+00
RA226+D		1.34E-03		1.34E-03	0.00E+00
TH228+D		8.35E-07		2.46E-05	0.00E+00
TH230+D		1.97E-07		6.93E-06	0.00E+00
TH232+D		2.55E-07		7.72E-06	0.00E+00
U 233+D		1.03E-05		1.12E-04	0.00E+00
U 234		1.01E-05		8.31E-05	0.00E+00
U 235+D		9.47E-06		7.96E-05	0.00E+00
U 238+D		8.85E-06		7.62E-05	0.00E+00
NP237+D		2.00E-07		4.59E-06	0.00E+00
PU241+D		2.73E-09		7.59E-08	0.00E+00

Reference "Environment" VOLSOURC (External)

ONSITE/BIOPORT VOLUME SOURCE SURFACE EXTERNAL DRFS 10-APR-84 RAP
VOLU 100

H 3	0.0
C 14	6.2E-04
NA22	5.1E+02
P 32	9.8E-01
P 33	1.0
S 35	0.0
CL36	2.8E-01
K 40	7.0E+01
CA45	2.8E-03
SC46	8.4E+02
CR51	1.2E+01
MN54	3.3E+02
FE55	0.0
FE59	4.7E+02
CO57	2.1E+01
CO60	1.0E+03
NI59	0.0
NI63	2.5E-14
ZN65	2.7E+02
SE75	9.6E+01
SR85	2.0E+02
SR90+D	2.1
MO93	1.4
NB94	6.0E+02
RU106+D	1.0E+03
CD109	7.6
AG110M+D1	1.2E+03
IN111	7.8E+01
SB124	8.6E+02
SB125+D	1.9E+02
I 125+D	8.8E-01
I 131+D	1.3E+02
CS137+D	2.3E+02
CE144+D	2.9E+01
EU152	4.7E+02
EU154	4.9E+02
TBI60	4.4E+02
OS185	2.7E+02
OS191	8.0
IR192	2.7E+02
HG203	4.9E+01
PB210+D	3.5E-01
RA226+D	1.3
TH228+D	3.4E+01
TH230+D	1.3
TH232+D	3.8E+02
U 233+D	4.3
U 234	6.9E-02
U 235+D	8.3E+01

Reference "Environment" VOLSOURC (External), continued

U 238+D	5.6
NP237+D	7.1E+01
PU241+D	1.1
SR89	6.1E-01
Y 89M	0.0
SR90	3.0E-02
Y 90	2.1
M099	5.4E+01
TC99M	1.9E+01
TC99	4.0E-03
RU103	2.0E+02
RH103M	5.1E-02
PD103	2.8E-01
I 129	4.3E-01
CS134	6.7E+02
CS135	1.3E-03
CS137	4.2E-02
BA137M	2.4E+02
CE141	1.0E+01
SM151	2.4E-04
U 235	2.0E+01
TH231	1.3
PA231	9.3
AC227	1.3E-02
TH227	2.6E+01
FR223	8.0
RA223	2.7E+01
NP237	2.0
PA233	6.5E+01
U 233	4.2E-03
TH229	1.9
RA225	6.8E-01
AC225	1.7
U 238	9.8E-03
TH234	7.6E-01
PA234M	3.4
PA234	7.2E+02
PU242	8.1E-04
NP238	2.4E+02
PU238	2.9E-03
CM244	1.8E-03
PU244	6.8E-07
U 240	3.4E-02
PU240	2.7E-03
CM243	2.6E+01
PU243	2.7
AM243	3.6
NP239	3.0E+01
PU239	2.9E-03
PU241	2.9E-12
AM241	1.1

Reference "Environment" BURIEDHF (External)

ONSITE/BIOPORT EXTERNAL ORFS (BURIED AT 0.5 M) 9-APR-84 RAP

0.5M	100
H 3	0.0
C 14	1.2E-12
NA22	1.8
P 32	4.3E-04
P 33	1.5E-03
S 35	0.0
CL36	9.3E-06
K 40	3.9E-01
CA45	1.9E-10
SC46	2.3
CR51	2.8E-03
MN54	4.4E-01
FE55	0.0
FE59	1.6
CO57	8.4E-06
CO60	3.7
NI59	0.0
NI63	0.0
ZN65	9.4E-01
SE75	1.5E-02
SR85	1.1E-01
SR90+D	1.7E-03
MO93	3.5E-34
NB94	6.1E-01
RU106+D	2.6
CD109	5.5E-08
AG110M+D	2.6
IN111	1.3E-03
SB124	4.2
SB125+D	1.1E-01
I 125+D	1.2E-34
I 131+D	4.0E-02
CS137+D	1.4E-01
CE144+D	1.2E-01
EU152	1.6
EU154	1.4
TB160	1.1
OS185	2.0E-01
OS191	2.2E-06
IR192	9.0E-02
HG203	1.1E-03
PB210+D	5.0E-05
RA226+D	1.3E-04
TH228+D	1.6E-03
TH230+D	1.3E-04
TH232+D	1.1
U 233+D	1.4E-05
U 234	1.9E-08
U 235+D	8.3E-03

Reference "Environment" BURIEDHF (External), continued

U 238+D	1.2E-02
NP237+D	1.6E-02
PU241+D	2.6E-09
SR89	1.8E-04
Y 89M	0.0
SR90	5.5E-07
Y 90	1.7E-03
MO99	4.4E-02
TC99M	7.6E-06
TC99	7.8E-10
RU103	1.1E-01
RH103M	2.8E-26
PD103	9.3E-06
I 129	6.3E-13
CS134	8.0E-01
CS135	3.4E-11
CS137	4.4E-06
BA137M	1.5E-01
CE141	4.3E-06
SM151	1.8E-19
U 235	8.7E-05
TH231	1.0E-07
PA231	1.9E-03
AC227	4.3E-09
TH227	2.4E-03
FR223	2.2E-03
RA223	3.9E-03
NP237	2.7E-08
PA233	1.6E-02
U 233	6.5E-19
TH229	7.1E-07
RA225	4.3E-09
AC225	1.4E-05
U 238	5.2E-18
TH234	4.6E-08
PA234M	9.1E-03
PA234	1.6
PU242	2.8E-27
NP238	7.5E-01
PU238	8.4E-10
CM244	6.2E-27
PU244	0.
U 240	1.1E-13
PU240	8.4E-10
CM243	3.5E-04
PU243	2.1E-04
AM243	8.5E-10
NP239	7.9E-04
PU239	8.4E-10
PU241	0.0
AM241	2.6E-09

Reference "Environment" BURIED1 (External)

ONSITE/BIOPORT EXTERNAL DRF (BURIED AT 1.0 M) 9-APR-84 RAP
1.0M 100

H 3	0.0
C 14	1.1E-19
NA22	9.2E-03
P 32	9.1E-07
P 33	6.7E-06
S 35	0.0
CL36	3.0E-09
K 40	3.0E-03
CA45	1.2E-16
SC46	1.0E-02
CR51	8.9E-07
MN54	7.9E-04
FE55	0.
FE59	7.3E-03
CO57	5.4E-12
CO60	1.8E-02
NI59	0.0
NI63	0.0
ZN65	4.6E-03
SE75	1.0E-05
SR85	7.7E-05
SR90+D	7.7E-06
MO93	0.
NB94	9.4E-04
RU106+D	2.1E-02
CD109	7.2E-16
AG110M+D1	1.4E-02
IN111	4.3E-08
SB124	4.8E-02
SB125+D	8.7E-05
I 125+D	0.0
I 131+D	2.1E-05
CS137+D	1.2E-04
CE144+D	2.0E-03
EU152	9.5E-03
EU154	6.6E-03
TB160	4.9E-03
OS185	2.2E-04
OS191	1.4E-12
IR192	4.9E-05
HG203	3.5E-08
PB210+D	4.1E-08
RA226+D	9.1E-08
TH228+D	2.9E-06
TH230+D	9.1E-08
TH232+D	5.7E-03
U 233+D	4.6E-10
U 234	1.2E-14
U 235+D	3.0E-06

Reference "Environment" BURIED1 (External), continued

U 238+D	5.2E-05
NP237+D	5.7E-06
PU241+D	1.6E-15
SR89	2.8E-07
Y 89M	0.0
SR90	1.5E-10
Y 90	7.7E-06
M099	6.6E-05
TC99M	4.9E-12
TC99	1.3E-14
RU103	7.9E-05
RH103M	0.0
PD103	3.0E-09
I 129	4.2E-20
CS134	2.1E-03
CS135	1.9E-17
CS137	4.1E-09
BA137M	1.3E-04
CE141	9.3E-11
SM151	7.8E-30
U 235	2.6E-09
TH231	6.0E-14
PA231	6.0E-07
AC227	2.7E-15
TH227	6.5E-07
FR223	3.6E-06
RA223	1.7E-06
NP237	1.6E-16
PA233	5.7E-06
U 233	1.1E-33
TH229	4.6E-13
RA225	1.2E-13
AC225	4.6E-10
U 238	8.5E-33
TH234	1.6E-14
PA234M	3.6E-05
PA234	8.2E-03
PU242	0.0
NP238	3.2E-03
PU238	5.4E-16
CM244	0.0
PU244	0.0
U 240	6.4E-21
PU240	5.4E-16
CM243	1.1E-08
PU243	6.7E-08
AM243	4.3E-19
NP239	1.5E-07
PU239	5.4E-16
PU241	0.
AM241	1.6E-15

Reference "Environment" Selected Radionuclides - RMDB10

ONSITE/BIOPORT RADIONUCLIDE MASTER DATA LIBRARY 23-MAY-84 RAP					
H 3	4.51E+3	1 0	0	4.8	11
C 14	2.091E+6	1 0	0	5.5	12
NA22	9.50E+2	1 0	0	5.0E-2	11
P 32	1.43E+1	1 0	0	5.0E+1	12
P 33	2.44E+1	1 0	0	5.0E+1	12
S 35	8.72E+1	1 0	0	5.9E-1	12
CL36	1.1E+8	1 0	0	5.0	11
K 40	4.67E11	1 0	0	3.6E-1	11
CA45	1.65E+2	1 0	0	4.0E-2	12
SC46	6.5E+1	1 0	0	1.1E-3	13
CR51	2.77E+1	1 0	0	2.5E-4	13
MN54	3.12E+2	1 0	0	3.0E-2	13
FE55	9.86E+2	1 0	0	4.0E-4	13
FE59	4.46E+1	1 0	0	4.0E-4	13
CO57	2.71E+2	1 0	0	9.4E-3	13
CO60	1.92E+3	1 0	0	9.4E-3	13
NI59	2.74E+7	1 0	0	1.9E-2	13
NI63	3.51E+4	1 0	0	1.9E-2	13
ZN65	2.44E+2	1 0	0	4.0E-1	13
SE75	1.20E+2	1 0	0	1.3	12
SR85	6.5E+1	1 0	0	2.0E-1	13
SR90+D	1.04E+4	1 0	0	2.0E-1	13
MO93	3.65E+4	1 0	0	1.3E-1	13
NB94	7.30E+6	1 0	0	9.4E-3	13
RU106+D	3.68E+2	1 0	0	1.0E-2	13
CD109	4.40E+2	1 0	0	3.0E-1	13
AG110M+D	2.52E+2	1 0	0	1.5E-1	13
IN111	2.8E+0	1 0	0	2.5E-1	13
SB124	6.02E+1	1 0	0	1.1E-2	13
SB125+D	1.01E+3	1 0	0	1.1E-2	13
I 125+D	5.97E+1	1 0	0	2.0E-2	12
I 131+D	8.04E+0	1 0	0	2.0E-2	12
CS137+D	1.10E+4	1 0	0	2.0E-3	11
CE144+D	2.84E+2	1 0	0	5.0E-4	23
EU152	4.97E+3	1 0	0	2.5E-3	23
EU154	3.14E+3	1 0	0	2.5E-3	23
TB160	7.2E+1	1 0	0	2.6E-3	23
OS185	9.40E+1	1 0	0	5.0E-2	23
OS191	1.5E+1	1 0	0	5.0E-2	23
IR192	7.30E+1	1 0	0	9.4E-3	23
HG203	4.66E+1	1 0	0	3.8E-1	23
PB210+D	8.14E+3	1 0	0	6.8E-2	23
RA226+D	5.84E+5	1 0	0	1.4E-3	23
TH228+D	6.97E+2	1 0	0	4.2E-3	23
TH230+D	2.81E+7	1 0	0	4.2E-3	23
TH232+D	5.13E12	1 0	0	4.2E-3	23
U 233+D	5.79E+7	1 0	0	2.5E-3	23
U 234	8.91E+7	1 0	0	2.5E-3	23
U 235+D	2.59E11	1 0	0	2.5E-3	23
U 238+D	1.65E12	1 0	0	2.5E-3	23

Reference "Environment" Selected Radionuclides - RMD BIO, continued

NP237+D	7.82E+8	1	0	0	2.5E-3	23		
PU241+D	5.26E+3	1	0	0	2.5E-4	23		
SR89	5.06E+1	1	0	0	2.0E-1	23		
Y 89M	1.86E-4	2	1	0.0002	0	2.5E-3	13	
SR90	1.04E+4	1	0	0	2.0E-1	13		
Y 90	2.67E+0	2	1	1.0	0	2.5E-3	13	
M099	2.75E+0	1	0	0	1.3E-1	13		
TC99M	2.51E-1	2	1	0.868	0	2.5E-1	13	
TC99	7.78E+7	3	2	1.0	1	0.132	2.5E-1	13
RU103	3.94E+1	1	0	0	1.0E-2	13		
RH103M	3.90E-2	2	0	0	1.3E+1	13		
PD103	1.70E+1	3	1	.9974	0	.9997	5.0	13
I 129	5.71E+9	1	0	0	2.0E-2	12		
CS134	7.53E+2	1	0	1.0	0	2.0E-3	11	
CS135	8.40E+8	1	0	0	2.0E-3	11		
CS137	1.10E+4	1	0	0	2.0E-3	11		
BA137M	1.77E-3	2	1	0.946	0	5.0E-3	13	
CE141	3.25E+1	1	0	0	5.0E-4	23		
SM151	3.29E+4	1	0	0	2.5E-3	23		
U 235	2.59E11	1	0	0	2.5E-3	23		
TH231	1.06E+0	2	1	1.0	0	4.2E-3	23	
PA231	1.19E+7	3	2	1.0	0	2.5E-3	23	
AC227	7.95E+3	4	3	1.0	0	2.5E-3	23	
TH227	1.87E+1	5	4	0.9862	0	4.2E-3	23	
FR223	1.51E-2	6	4	0.0138	0	0	23	
RA223	1.14E+1	7	5	1.0	6	1.0	1.4E-3	23
NP237	7.82E+8	1	0	0	2.5E-3	23		
PA233	2.70E+1	2	1	1.0	0	2.5E-3	23	
U 233	5.79E+7	3	2	1.0	0	2.5E-3	23	
TH229	2.68E+6	4	3	1.0	0	4.2E-3	23	
RA225	1.48E+1	5	4	1.0	0	1.4E-3	23	
AC225	1.00E+1	6	5	1.0	0	1.4E-3	23	
U 238	1.65E12	1	0	0.0	0	2.5E-3	23	
TH234	2.41E+1	2	1	1.0	0	4.2E-3	23	
PA234M	8.13E-4	3	2	1.0	0	2.5E-3	23	
PA234	2.81E-1	4	3	0.0013	0	2.5E-3	23	
PU242	1.41E+8	1	0	0	2.5E-4	23		
NP238	2.18E+0	2	0	0	2.5E-3	23		
PU238	3.21E+4	3	2	1.0	0	2.5E-4	23	
CM244	6.61E+3	1	0	0	2.5E-3	23		
PU244	3.02E10	2	0	0	2.5E-4	23		
U 240	5.88E-1	3	2	0.999	0	2.5E-3	23	
PU240	2.39E+6	4	3	1.0	1	1.0	2.5E-4	23
CM243	1.04E+4	1	0	0	2.5E-3	23		
PU243	2.06E-1	2	0	1.0	0	2.5E-4	23	
AM243	2.70E+6	3	2	1.0	1	0.0024	2.5E-4	23
NP239	2.36E+0	4	3	1.0	0	2.5E-3	23	
PU239	8.91E+6	5	4	1.0	1	0.9976	2.5E-4	23
PU241	5.26E+3	1	0	0	2.5E-4	23		
AM241	1.58E+5	2	1	1.0	0	2.5E-4	23	

0

APPENDIX 1.D

CDC COMMAND LEVEL PROCEDURES - PROCFIL

AND

CDC VERSION OF CREATE MODULE RITFIL

APPENDIX 1.D.1 CDC Command Level Procedures - PROCFIL

```
ATTACH,ABS,CREATEABS,ID=BIODB.
COPY,ABS,LGO.
RETURN,ABS.
RETURN,TAPE10.
RETURN,TAPE4.
ATTACH,TAPE10,RMDBIO,ID=BIODB,MR=1.
REWIND,TAPE10.
RETURN,TAPE13.
ATTACH,TAPE13,DEFAULTINV,ID=BIODB,MR=1.
REWIND TAPE13.
CONNECT,OUTPUT.
CONNECT,INPUT.
CONNECT,TAPE5.
CONNECT,TAPE6.
REWIND,LGO.
LGO.
RETURN,T7.
REVERT.
*EOR
  R"READ PASSWORD FOR FILE"=(*A).
REQUEST,T7,*PF.
REWIND,TAPE7.
COPY,TAPE7,T7.
REWIND,TAPE7.
REWIND,T7.
CATALOG,T7,F,ID=BIO,RP=10,RD=R.
BATCH,TAPE7,INPUT,HERE.
RETURN,TAPE10.
RETURN,TAPE13.
DISCONT,OUTPUT.
DISCONT,INPUT.
DISCONT,TAPE5.
DISCONT,TAPE6.
RETURN TAPE5.
RETURN,TAPE6.
RETURN LGO.
FILES.
REVERT.
```

APPENDIX 1.D.1 CDC Command Level Procedures - PROCFIL

```
*EOR
  N"FIVE CHARACTER NAME TO IDENTIFY RUN"=(*A).
BATCH,F,LOCAL.
REQUEST,X,*Q.
REWIND,F.
COPY,F,X.
ROUTE,X,DC=PR,FID=*N,TID=KT.
RETURN X.
FILES.
REVERT.
*EOR
REVERT.
```

APPENDIX 1.D.2 CDC Version of CREATE Module RITFIL

```

SUBROUTINE RITFIL
C
C   THIS SUBROUTINE WRITES FILES WITH INPUT PARAMETERS AND
C   SYSTEM COMMANDS FOR BIOPORT AND MAXII.  RITFIL IS CALLED
C   BY THE PROGRAM CREATE.
C
C   MODULE OF CREATE
C   VERSION OF 4-JUN-84 RAP
C
C-----
C
C   INCLUDE 'CREATE.CMN'
C-----
C
C   COMMON BLOCK INCLUSION FILE FOR THE CREATE USER INTERFACE FOR THE
C   BIOPORT COMPUTER PROGRAM
C
C   VERSION OF 8-MAY-84 RAP
C-----
C
C   COMMON /TIME/ NYRS, IRS, NBUG,
C   .             NMAX, IMAX(20), TITL(10)
C   REAL*8 SITIT
C   CHARACTER*8 SITIT
C
C   COMMON /EARTH/ NLYRS, ERU, ERLI, IER, NER, JER, DEPTH(5), VOL(5),
C   .             VOLIN, THICK(5)
C
C   COMMON /SHRUB/ NPLTS, ISUCC(10), NYSUC(10,5),
C   .             BIOMAS(10,5), PROOT(10,5), SROOT(5,5,10),
C   .             CONV, ACTPLT(5), RANGP(10,5), IRANGP(10,5),
C   .             PMOIST(10), RECYCL(10,5), IBIO(10,5),
C   .             IRCY(10,5), PMODEL
C   REAL*8 PNAME
C   CHARACTER*8 PNAME
C   INTEGER PMODEL
C
C   COMMON /ANIMAL/ NCRIT, AMT(10), IRANGC(10),
C   .             DIRT(5,10), PACTIVE(10,2), DIRTM(5), PMOVE(10,5),
C   .             RANGC(10)
C   REAL*8 CNAME
C   CHARACTER*8 CNAME
C
C   COMMON /INV/ NIN, ELTI(100), AWI(100), QI(100), NSOLD(5,100)
C   .             , IWS
C   REAL*8 AWI, WSTIT
C   CHARACTER*8 WSTIT

```

APPENDIX 1.D.2 CDC Version of CREATE Module RITFILL

```

C      INTEGER ELTI
C
C      COMMON /PACK/ PL, PLI, PL1, PL2, PLI1, PLI2
C
C      COMMON /IONUM/ SCRN, KEY, BIO, MAX
C      INTEGER SCRN, KEY, BIO, MAX
C
C      COMMON /GRP/ IGFLAG
C      REAL*8 GNAME
C      CHARACTER*8 GNAME
C
C      COMMON /ORGANS/ NORG, KORG(5)
C
C      COMMON /CHAR/ SITIT(2),PNAME(2,10),CNAME(2,10),WSTIT(2,3),
C      .                GNAME(2)
C
C
C
C
C      WRITE (SCRN,4000)
4000  FORMAT (' ',10('/),' ',
C      .14X,'ENTER YOUR CDC ACCOUNT NAME: ')
C      READ (KEY,4001) ACNT
4001  FORMAT (A10)
C      WRITE (SCRN,4002)
4002  FORMAT ('0',14X,'ENTER YOUR CDC PROBLEM NO: ')
C      READ (KEY,4001) PRBLM
C
C
C----- WRITE JOB CONTROL RECORDS FOR BATCH PROCESSING ON MFZ -----
C
C      WRITE (BIO,3000) ACNT,ACNT,PRBLM,PRBLM
3000  FORMAT (A5,' ',STMFZ,CM160000,EC400,T377.'/'
C      . 'ACCOUNT',' ',A7,' ',',',A4,' ',',',A4,' '.'/
C      . 'ATTACH,BABS,BIOPORTABS,ID=ZZRNRC.'/'
C      . 'REWIND,BABS.'')
C      WRITE (BIO,3001)
3001  FORMAT ('ATTACH,TAPE4,RMDBIO,ID=ZZRNRC.'/'
C      . 'REWIND,TAPE4.'/'
C      . 'MAP,OFF.'/'
C      . 'LDSET,PRESET=ZERO.'/'
C      . 'BABS.'/'
C      . 'RETURN,BABS.'')
C      WRITE (BIO,3002)
3002  FORMAT ('ATTACH,TAPE10,BIORMDLIB,ID=ZZRNRC.'/'
C      . 'ATTACH,TAPE20,BIO20,ID=ZZRNRC.'/'
C      . 'ATTACH,TAPE21,BIO21,ID=ZZRNRC.'/'
C      . 'ATTACH,TAPE22,BIOPLAN,ID=ZZRNRC.'/'

```

APPENDIX 1.D.2 CDC Version of CREATE Module RITFIL

```

      . 'ATTACH,TAPE23,BIO23,ID=ZZRNRC.'/
      . 'ATTACH,TAPE24,BIO24,ID=ZZRNRC.'/
      . 'ATTACH,TAPE25,BIO25,ID=ZZRNRC.'/
      . 'ATTACH,TAPE27,BIOBURL,ID=ZZRNRC.'/
      . 'ATTACH,MABS,MAXI1BIO,ID=ZZRNRC.'/
      . 'REWIND,TAPE30.'/
      . 'MAP,OFF.'/
      . 'LDSET,PRESET=ZERO.'/
      . 'MABS.')
C
      ENDFILE BIO
      BACKSPACE BIO
C
      WRITE (BIO,1008) TITL
1008  FORMAT (' ',10A4)
C
      NCHK=0
      WRITE (BIO,1010) NYRS, NCHK, NLYRS, NPLTS, NCRIT
1010  FORMAT (5I5)
C
      WRITE (BIO,1010) PMODEL
C
      WRITE (BIO,1012) NMAX
      WRITE (BIO,1012) (IMAX(I), I=1,NMAX)
1012  FORMAT (20I5)
C
      WRITE (BIO,1014) NBUG
1014  FORMAT (I5)
C
      WRITE (BIO,1015) ERU, ERLI, IER, NER, JER
1015  FORMAT(2G12.4,3I5)
C
      WRITE (BIO,1020) (DEPTH(I), I=1, NLYRS)
1020  FORMAT (5G12.4)
C
      WRITE (BIO,1030) (VOL(I), I=1, NLYRS), VOLIN
1030  FORMAT (6G12.4)
C
      WRITE (BIO,1050) PL
      WRITE (BIO,1050) PLI
1050  FORMAT (E10.2)
C
      WRITE (BIO,1060) NIN
1060  FORMAT (I3)
C
      DO 600 I = 1, NIN
          WRITE (BIO,3212) ELTI(I), AWI(I), (NSOLD(J,I),J=1,5), QI(I)
3212  FORMAT (A2,A6,5I1,1PG10.2)

```

APPENDIX 1.D.2 CDC Version of CREATE Module RITFIL

```

600 CONTINUE
C
C
DO 200 I = 1, NPLTS
C
    PMOIST(I) = 1. - PMOIST(I)
C
    WRITE (BIO,1080) (PNAME(II,I),II=1,2)
1080    FORMAT (2A8)
    WRITE (BIO,1090) ISUCC(I), PMOIST(I)
1090    FORMAT (I5, F10.4)
    WRITE (BIO,1100) (PROOT(I,J), J=1,ISUCC(I))
1100    FORMAT (5F10.4)
    WRITE (BIO,1110) (RANGP(I,J), J=1,ISUCC(I))
1110    FORMAT (5E10.2)
C
    DO 300 J = 1, ISUCC(I)
        WRITE (BIO,1120) (SROOT(J,K,I), K=1,NLYRS+2)
1120        FORMAT (5F12.4)
    300 CONTINUE
C
    WRITE (BIO,1130) (NYSUC(I,J), J=1,ISUCC(I)+1)
1130    FORMAT (6I5)
C
    WRITE (BIO,1140) (BIOMAS(I,J), J=1,ISUCC(I))
1140    FORMAT (5F12.4)
C
    WRITE (BIO,1150) (RECYCL(I,J), J=1,ISUCC(I))
1150    FORMAT (5F12.4)
C
    WRITE (BIO,1170) (IBIO(I,J), J=1,ISUCC(I))
1170    FORMAT (5I2)
C
    WRITE (BIO,1180) (IRCY(I,J), J=1,ISUCC(I))
1180    FORMAT (5I2)
C
    200 CONTINUE
C
C
DO 500 I = 1, NCRIT
C
    WRITE (BIO,2000) (CNAME(II,I),II=1,2)
2000    FORMAT (2A8)
C
    WRITE (BIO,2010) AMT(I), RANGC(I)
2010    FORMAT (2F12.4)
C
    WRITE (BIO,2020) (PACTIVE(I,J), J=1,2)

```


APPENDIX 1 n.2 CDC Version of CREATE Module RITFIL

```

2020  FORMAT (2F12.4)
C
      WRITE (BIO,2030) (PMOVE(I,J), J=1,5)
2030  FORMAT (5F12.4)
C
      500 CONTINUE
C
C
C----- WRITE MAXI1 INPUT FILE -----
C
C
C      INSERT END-OF-RECORD INTO FILE
      ENDFILE BIO
      BACKSPACE BIO
C
C      WRITE (MAX, 3010)
C3010  FORMAT ('ASSIGN [BIO.NEW]RMDLIB.DAT FOR010'/
C      .      'ASSIGN [BIO.NEW]FILE20.DAT FOR020'/
C      .      'ASSIGN [BIO.NEW]FILE21.DAT FOR021'/
C      .      'ASSIGN [BIO.NEW]PLANSOURC.SUR FOR022'/
C      .      'ASSIGN [BIO.NEW]FILE23.DAT FOR023'/
C      .      'ASSIGN [BIO.NEW]FILE24.DAT FOR024'/
C      .      'ASSIGN [BIO.NEW]FILE25.DAT FOR025'/
C      .      'ASSIGN [BIO.NEW]BURIEDONE.DAT FOR027'/
C      .      'ASSIGN [BIO]FOR030.DAT FOR030'/
C      .      'RUN [BIO.NEW]MAXI1')
3010  FORMAT (' ATTACH,TAPE20,BIO20,ID=ZZRNRC.'/
      .      ' ATTACH,TAPE21,BIO21,ID=ZZRNRC.'/
      .      ' ATTACH,TAPE22,BIOPLAN,ID=ZZRNRC.'/
      .      ' ATTACH,TAPE23,BIO23,ID=ZZRNRC.'/
      .      ' ATTACH,TAPE24,BIO24,ID=ZZRNRC.'/
      .      ' ATTACH,TAPE25,BIO25,ID=ZZRNRC.'/
      .      ' ATTACH,TAPE27,BIOBUR1,ID=ZZRNRC.'/
      .      ' ATTACH,ABS,MAXI1BIO,ID=ZZRNRC.'/
      .      ' COPY,ABS,LGO.'/
      .      ' RETURN,ABS.'/
      .      ' MAP,OFF.'/
      .      ' LDSET,PRESET=ZERO.'/
      .      ' REWIND,TAPE30.'/
      .      ' LGO.')
C
      WRITE (BIO, 3100) (TITL(I), I=1,10), IMAX(1)
3100  FORMAT (10A4, ' : BIOPORT SIMULATION YEAR ',I5)
C
      WRITE (BIO, 3200) NORG, (KORG(I),I=1,5)
3200  FORMAT (' $INPUT NEXT=1, IFOD=1, IMO=0, RF1=1.0, RF2=0.,'/
      .      ' IARG=0, IWAT=0, IEXT=0, IAIR=0, XFACT=1.33E-11, '/
      .      ' AGE=20.0, XDPT=0.067, RINH=0.3, M3M2=0, INTRUD=0, '/

```

APPENDIX 1.D.2 CDC Version of CREATE Module RITFIL

```
.      ' IT1=0, IT2=49, NORG=' ,I1,' , KORG(1)=' ,5(I2,' ,')/
.      ' IOUT=0, IBIO=1, '/
.      ' $END'/
.      ' 0 0')
C
      IF (NMAX .GT. 1) THEN
        DO 100 I = 2, NMAX
          WRITE (BIO,3100) TITL, IMAX(I)
          WRITE (BIO,3202)
3202    FORMAT (' $INPUT NEXT=5 $END')
100    CONTINUE
      ENDIF
C
      WRITE (BIO, 3220)
3220    FORMAT ('END OF RUN'/
.      ' $INPUT NEXT=4 $END')
C
      ENDFILE BIO
C
C
      RETURN
C
C-----
C
      END
```

NRC FORM 336 (2-84) NRCM 1102, 3201, 3202 BIBLIOGRAPHIC DATA SHEET SEE INSTRUCTIONS ON THE REVERSE		U.S. NUCLEAR REGULATORY COMMISSION 1. REPORT NUMBER (Assigned by TIDC, add Vol. No., if any) NUREG/CR-2675 PNL-4241 Vol. 5	
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13. ABSTRACT (200 words or less) <p>BIOPORT/MAXI1 is a collection of five computer codes designed to estimate the potential magnitude of the radiation dose to man resulting from biotic transport processes. Dose to man is calculated for ingestion of agricultural crops grown in contaminated soil, inhalation of resuspended radionuclides, and direct exposure to penetrating radiation resulting from the radionuclide concentrations established in the available soil surface by the biotic transport model.</p> <p>This document is designed as both an instructional and reference document for the BIOPORT/MAXI1 computer software package and has been written for two major audiences. The first audience includes persons concerned with the mathematical models of biological transport of commercial low-level radioactive wastes and the computer algorithms used to implement those models. The second audience includes persons concerned with exercising the computer program and exposure scenarios to obtain results for specific applications. The report contains sections describing the mathematical models, user operation of the computer programs, and program structure. Input and output for five sample problems are included. In addition, listings of the computer programs, data libraries, and dose conversion factors are provided in appendices.</p>			
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