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TECHNOLOGY

HERMES -- A DIGITAL COMPUTER CODE FOR ESTIMATING REGIONAL RADIOLOGICAL EFFECTS FROM THE NUCLEAR POWER INDUSTRY

DECEMBER 1971

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UNITED STATES ATOMIC ENERGY COMMISSION

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DECEMBER 1971 *

COMPILED
by
J. F. Fletcher
W. L. Dotson

* At press time, WADCO's name had been officially changed to Westinghouse Hanford Company

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FOREWORD

This report represents the results of a team effort to produce a mathematical model for characterizing the effects, on man, of the predicted requirement for nuclear facilities (reactor and fuel reprocessing plants) to satisfy the projected electrical energy usage during the year 2000. The multidisciplinary team assembled for this effort included chemical and nuclear engineers, health physicists, biologists, meteorologists, hydrologists and computer programming specialists. The final product represents the combined efforts of three Hanford contractors: WADCO Corporation,* Battelle-Northwest and Computer Sciences Corporation.

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HERMES -- A DIGITAL COMPUTER CODE FOR ESTIMATING REGIONAL RADIOLOGICAL EFFECTS FROM THE NUCLEAR POWER INDUSTRY

I. INTRODUCTION

With the increasing use of nuclear energy for electrical generation, considerable attention has been focused on the question of the radiation dose to man which might result in the future from large scale use of nuclear facilities in the electric power industry. In an attempt to provide rational estimates of the dose which might be expected, a computer model has been developed to estimate the release of radionuclides to the environment, and the resultant population dose, within a geographical region as a result of the operation of nuclear facilities within that region.

Development of the regional dose model was authorized by the U. S. Atomic Energy Commission on January 1, 1970. Responsibility for model development was initially assigned to the Pacific Northwest Laboratory (PNL). On July 1, 1970, the Hanford Engineering Development Laboratory (HEDL) was formed, managed by the WADCO Corporation, a subsidiary of Westinghouse Electric Corporation. Responsibility for the model was transferred to HEDL at that time, and subsequent development work has been performed by HEDL with PNL cooperation. Development of the model has been undertaken under the direction and guidance of the AEC Division of Reactor Development and Technology (RDT) and the AEC Regulatory Division.

Substantial assistance in the supplying of information necessary to the model was given by the National Oceanographic and Aeronautic Administration, the U. S. Department of Agriculture, the U. S. Army Corps of Engineers, the U. S. Bureau of Census, the U. S. Bureau of Sport Fisheries and Wildlife, and the Upper Mississippi River Conservation Commission.

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The computer model developed has been designated as HERMES (Hanford Engineering Regional Model for Environmental Study). The HERMES model is designed to calculate radionuclide release and radiation dose occurring within a study area in a given year. While cumulative radionuclide release as such is not considered, the accumulated buildup and deposition of key radionuclides is "back-calculated" for a five-to-ten-year period for use in dose calculations.

The model does not consider near-site conditions (at or near-site boundaries) in dose calculations, since near-site dose is not normally a significant factor in the overall radiation dose. However, it is planned to provide the HERMES model with near-site calculation abilities in the near future.

The initial development of the HERMES model was based on a study of the region comprising the Upper Mississippi and Lower Missouri River basins, excluding the Chicago metropolitan area. To estimate the effects on dose in the study area caused by air transport of radionuclides from adjacent regions, an "air envelope" some 200 miles in width was included around the study area. Considerations in the study included the operation of 400,000 MW generating capacity (nuclear and fossil) at 185 separate sites, and reprocessing plants at 9 sites.

In order to provide comprehensive estimates of population dose over regions of the size indicated, the HERMES model as inititally developed is large and complex. It will be further refined to reduce its complexity based on the results of sensitivity studies performed during the study of the Upper Mississippi region. Refinements are expected to include the elimination of radionuclides and dose pathways that are shown to be insignificant in their contribution to dose; elimination of the "air envelope" considerations may also be feasible (a provision for linkage between study areas would be substituted).

The HERMES model was designed and developed in modular form. Its component computer codes describe the events relating electric energy generation to the resultant radiation dose to the populace. These codes are designed to be used sequentially, but may be used individually to study a given aspect of the events leading to dose.

In this report the component codes of the HERMES model are described, and their design and intended use are discussed. The report narrative discusses the general philosophy of operation of each code; the appendices give detailed listings and supporting data to assist in operation of the codes.

Subsequent reports will describe the results obtained in the initial study where HERMES was utilized, and refinements to the model that result from that study.

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II. OVERALL MODEL STRUCTURE

The HERMES model is an engineering analysis tool that provides regional estimates of the effects on the biosphere, in terms of the radiological dose to man, of the use of nuclear power for electrical energy generation.

There are six major interdependent subelements in the HERMES model. These subelements are structured to develop sequentially:

1. Regional electric generation capability to satisfy postulated demands; numbers and types of generating plants utilized, and of supporting fuel reprocessing facilities required.
2. Radioisotope inventories and effluent rates associated with each nuclear facility.
3. A radioisotope source map, including location of nuclear facilities and characterization of effluent streams.
4. A receptor location and population density map, with supporting data pertinent to dose pathway calculation at each location.
5. Source-to-receptor transport mechanisms.
6. Population dose calculation at each receptor location, structured by population type and age groups, human organs considered, nuclide, and dose pathway.

The data flow required for the HERMES model calculations is shown in Figure II-1. The individual subelements are discussed below:

- Projections of Plant Selection, Siting, and Scheduling

  Regional projections of electrical energy requirements through 1990 have been made by the Federal Power Commission. These projections were used as the basis for the projections of steam plant generation requirements needed in regional studies. The annual

increase in generating capacity required to meet the energy demands is calculated and, through use of a chain of computer codes utilizing linear programming techniques, the optimum mixture of plant types within the region is selected. Separately, an inventory of potential plant sites is selected in the study region (by "hand-processing" techniques in the original study) based upon projected load center locations and criteria defining site requirements. Each plant selected through the LP program is then assigned to a site by a computer code (SITE). Another code (MOPOSH) assigns typical monthly average capacity factors to each plant to meet monthly demand characteristics of the area where the plant site is located.

- Radioactive Effluent Release

An applied health physics and nuclear engineering analysis was conducted to provide a radionuclide master list (Appendix A) for inclusion in the HERMES model. This analysis selected those radionuclides that might most likely contribute to radiation dose from nuclear facility effluents.

In using the HERMES model, the computer code DOSIS calculates monthly average effluent rates for each radionuclide as a function of plant type and age, average capacity factor of the plant for the month of interest, and waste treatment process used. Similarly, the code REPARE calculates effluents from reprocessing plants, based on radionuclide inventories in the incoming fuel, fuel throughput rate, and type of waste treatment used. Both the DOSIS and REPARE codes "follow" each radionuclide from generation through each component of the cleanup and holding facilities of the plant under consideration, to the point of emission. Radionuclide inventories in retained wastes are also calculated.

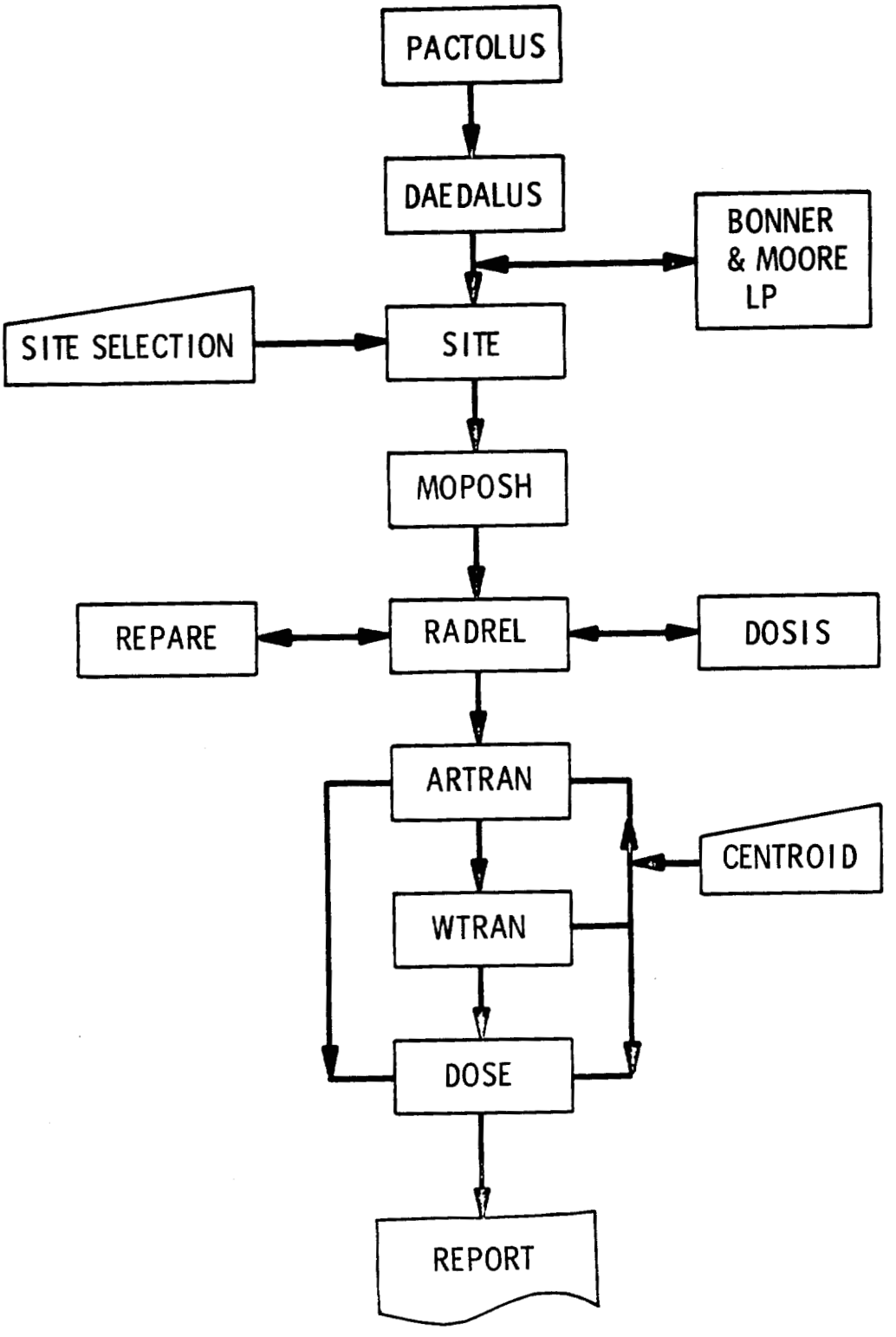

Figure II-1

Data Flow For HERMES

- Radionuclide Emission Source Map

The output of the foregoing codes (SITE, MOPOSH, DOSIS, and REPARE) are combined by the RADREL code to provide a computer data tape in the format required by codes that model air and water transport of the radionuclides after discharge. The RADREL "map," or output tape, lists the location of each plant site, plant types and characteristics (including year of startup and stack height) and a month-by-month, site-by-site listing of monthly average emission rates for each radionuclide considered.

- Receptor Map

Radiation dose evaluation via the HERMES model requires the development of a "receptor map" defining the patterns of demographic characteristics, food production and consumption, work habits, and recreational practices in the region being studied. Population data, and much of the other needed data, are normally assembled at the county level; the county, therefore, was chosen as the basic unit for the receptor map.

Calculational routines may be simplified without destroying the utility of the data by combining certain of the counties into larger units. Because of their potential importance in the evaluation, all urban counties and all counties containing nuclear facilities should be excluded from combination. Combination of the remaining counties should be based on the following criteria:

- All counties in a combined unit must be the same classification (either rural or rural - nonfarm; not mixtures of the two).
- Population types, work and recreation habits, and types of food produced should be similar in all counties in a single combination.

- Boundaries of a multiple-county combination must not cross state boundaries.

Each receptor area - single or multiple county - should then be analyzed to determine the singular point that most effectively represents the population distribution. This point, designated as a "centroid," then serves to uniquely represent the receptor area. Data representing the pertinent statistics of each centroid can then be assembled into a data bank and placed on magnetic tape.

In the original study performed with the HERMES model, 479 counties in the study region were combined into 300 centroids, and data for each centroid were assembled and processed as described above.

- Transportation from Source to Receptor

Radionuclides emitted at a source are transported to a receptor by air transport, water transport, or both. Two computer codes were developed to simulate the mechanisms involved in these transport processes.

The air transport code (ARTRAN) utilizes monthly climatological data applied to standard mathematical models for diffusion, deposition, and transport. This model calculates the radionuclide concentrations at each centroid by summing the contributions from each emission source. Included in these concentrations are the residual amounts of deposited materials contributed by each nuclear facility since its startup.

The water transport model (WTRAN) accepts data from the source map tape describing the location of each water emission source and rates of radionuclide emission. From the receptor map tape, it obtains the location of each centroid where concentration

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calculations are required. ARTRAN supplies calculated data on radionuclide deposition at each centroid. In addition, data are read in defining river flow characteristics, sediment types and concentrations, and hydrologic data on surface and ground waters for the watersheds within the study area. WTRAN then calculates the diffusion of radionuclides from the emission points, and resultant concentrations in solution and on sediments at each location requested; calculates over-bank deposition of radionuclides during flood season; and estimates radionuclide concentrations in surface water and ground water drinking sources resulting from the solution and transport of deposited radionuclides.

- Dose to Man

The final model, DOSE, utilizes the processed data from all preceding codes and was developed to calculate the dose to man resulting from the radionuclide emissions from nuclear facility sites. This code considers the radionuclide contribution to total body dose and to the dose to six specific organs - the GI tract, bones, liver, skin, thyroid, and lungs.

The primary pathways to dose considered in the DOSE code are: (1) direct immersion in air and water containing radionuclides; (2) inhalation of radionuclides in air; (3) direct external exposure to radiation (e.g., from radionuclides deposited on ground surfaces, river banks, etc.); and (4) ingestion of radionuclides in food and water. The ingestion pathway incorporates a large number of specific food-chain pathways, and considers the effects of radionuclide deposition on plant surfaces and on soil, incorporation of radionuclides into plant and animal tissues, and concentration effects that occur in specific food chains.

Dose evaluations are made for three age groups in the population--the child (age 0 to 11 years); the teenager (age 12 to 17 years); and the adult (18 years and older). At each centroid, dose evaluations are made for the average person and maximum individual in each age group.

Dose in this program is calculated from exposure to or ingestion of radionuclides in the Year 2000. No contribution to dose from exposure in previous years is considered. Paralleling each dose calculation, dose commitment for the succeeding 50 years resulting from this exposure is calculated.

The code subelements described above are processed individually and sequentially in the computer; the final output is thus drawn from all preceding calculations. In each code, certain assumptions have been introduced - assumptions to simplify complex "real world" situations to permit modeling, or to cover areas where insufficient data are available (an example of the latter would be the treatment of groundwater flows in the WTRAN code). In each case, assumptions were made in an attempt to approximate the most likely conditions, as opposed to "worst condition" assumptions. In the following discussions of the individual codes and data reduction procedures, the basic assumptions inherent in each code are discussed in some detail. The user of the HERMES model or of the output data would be well advised to have an understanding of these assumptions and their potential effect on the results.

In the development of the HERMES model, it was recognized that, to be a useful regional model, it would need to be easily adaptable to changes. Advancing technology may well introduce radwaste treatment systems not now included in DOSIS. Consideration of an area with a marine environment would require changes in WTRAN; a mountainous region would require that ARTRAN be modified. In several areas, e.g., the groundwater modeling in WTRAN, or some of the food pathways leading to radionuclide ingestion , data are sparse or totally lacking, and modeling was necessarily done on a "best estimate" basis.

To accommodate making changes in the model, HERMES was structured in modular form. The subelement codes are essentially independent, being linked only in the transfer of data. In most cases, these codes may be used independently of the HERMES model, if required, for specific problems not requiring the entire model. Furthermore, individual codes can be modified to meet changing conditions without affecting other parts of the model. In many cases, the "building block" routine is extended to the structure of these individual codes. Introduction of a new radwaste system, for example, could be accommodated by modifying DOSIS subroutines, or at most by adding a few new subroutines.

It is hoped that the modular structure of HERMES will contribute to making it useful as a generalized code for regional dose evaluations, and to its potential improvement as additional data become available.

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III. HERMES CODE ELEMENTS

A. ELECTRICAL POWER ECONOMY MODEL

The first step in using the HERMES model for evaluation of radiation dose in a study area is the projection of the extent to which the operation of nuclear facilities contributes to the generation of electric power in the region. The computer code PACTOLUS[1] calculates costs of power generation for various types of plants available for use in the region, and in addition provides cash flow data, and mass balances for fuels used (or produced) in the generation of electric power. The code DAEDALUS[2] accepts these data; factors in time-dependent data on energy requirements, costs of plant construction and operation, costs of fuels and fuel cycle operations, and resource stockpiles and availabilities for the region; and generates a set of linear equations representing factors in the electric power economy of the region.

These equations are then used in a linear programming routine (LP) to optimize the costs of electric power in the region, subject to four major constraints:

- The projected energy requirement must be satisfied.
- The limits of available resources must not be exceeded.
- Potential advances in technology must be considered.
- Overall costs of electric power generation must be minimized.

It is obvious that all of these requirements are not necessarily expressible in linear relationships. This difficulty is overcome by approximation of the nonlinear functions by a set of linear equations valid for discrete segments of the nonlinear function. After the necessary linear representations of the constraints are generated, an existing generalized LP[3] is used for the final solution.

This report does not discuss the linear program solution technique,

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but the interested reader may refer to one of the many excellent texts on the subject ; for example, References (4) and (5). The LP solution technique continuously seeks to minimize all possible constraints prescribed for a problem. The resultant unique solution incorporates all factors bearing on the problem and arrives at an optimum answer providing minimum power costs.

During an LP run, fossil generating plants and selected types of nuclear generating plants "compete" for entry into the regional power economy; the mixture of plants finally selected is that which provides the required energy at minimum cost over the study period, consistent with constraints applied to the system.

In adapting linear programming techniques to the simulation of regional power economies, several safeguards must be introduced to assure representation simulation. The first of these relates to the selection of optimum mixtures of power plants by the linear programming codes.

For its use in power studies, the Federal Power Commission (FPC) has divided the contiguous United States into 48 separate Power Supply Areas (PSA). Within each PSA the conditions of the power economy are reasonably uniform, so that for most purposes, the PSA may be treated as an entity. The national power forecasts of the FPC are based on individual forecasts for each PSA. The PSA forecasts, in turn, are made in cooperation with local electric utilities and tend to reflect the conditions under which these utilities operate.

A regional projection of the power economy must take the individual PSA forecasts into account and satisfy their conditions. For example, even though analysis indicates that a region will utilize primarily nuclear plants in the future, a PSA with abundant reserves of low-cost fossil fuel would not be expected to "go nuclear" along with the rest of the region. In performing the LP analysis for such a region, appropriate constraints must be applied to assure that as a minimum, enough fossil plants are

selected to accommodate the needs of the "fossil" PSA.

Other constraint considerations relate to "stockpiles" of resources which are national in nature, or to constraints applied to the introduction of new technology. For example, if uranium diffusion cascade capacity were limiting on a national scale, equitable constraints must be applied in a regional problem (otherwise, in the extreme, one region may "use" all the available cascade capacity).

As currently utilized in the HERMES model, the regional LP analysis generates a power plant mix consisting of fossil fuel plants, Light Water Reactor plants (LWR) and Liquid Metal Fast Breeder Reactor plants (LMFBR). Other nuclear plant types can easily be added provided the appropriate cost and performance data for these plants are available, and provided the DOSIS and REPARE codes are modified to model the radionuclide release characteristics of these plants and their associated fuel reprocessing facilities.

The output of this linear programming process is a listing of the numbers of each type of plant selected (started up) in each year during the study period.

B. NUCLEAR FACILITY SITING

SITE SELECTION

Operation of the HERMES model to provide estimates of population dose requires that the nuclear facilities selected by LP programming techniques be assigned to specific sites in the study area. The dependence of dose on the locations of nuclear sites introduces the potential for considerable uncertainty in the final dose estimates, and makes it essential that judgment be used in the selection of nuclear sites.

Suggested criteria for selection of nuclear facility sites for use in the HERMES model are:

- Conformance with AEC siting criteria as expressed in Part 100, Title 10 of the U.S. Code of Federal Regulations (10CFR100).[6] Relaxation of these criteria may be assumed for sites utilized in the more distant future.
- Sufficient water supply availability for plant operation (as a minimum, sufficient supply for makeup to recirculating, evaporative cooling systems).
- Minimizing of transmission costs to load centers.
- Meeting of power demand projections for each PSA, and distribution of demand within each PSA.

Plant sites selected for the year 2000 in the Upper Mississippi River Basin area, in the study upon which development of the HERMES model was based, are shown in Figure III-1, and a list of these sites is given in Appendix G. In accordance with usual utility practice, these sites are preponderantly designated as multi-plant sites, accommodating up to four plants per site.

SITE ASSIGNMENT

The individual plants in the mixture selected by the LP program are assigned to sites by the SITE code (this code, and the major portions

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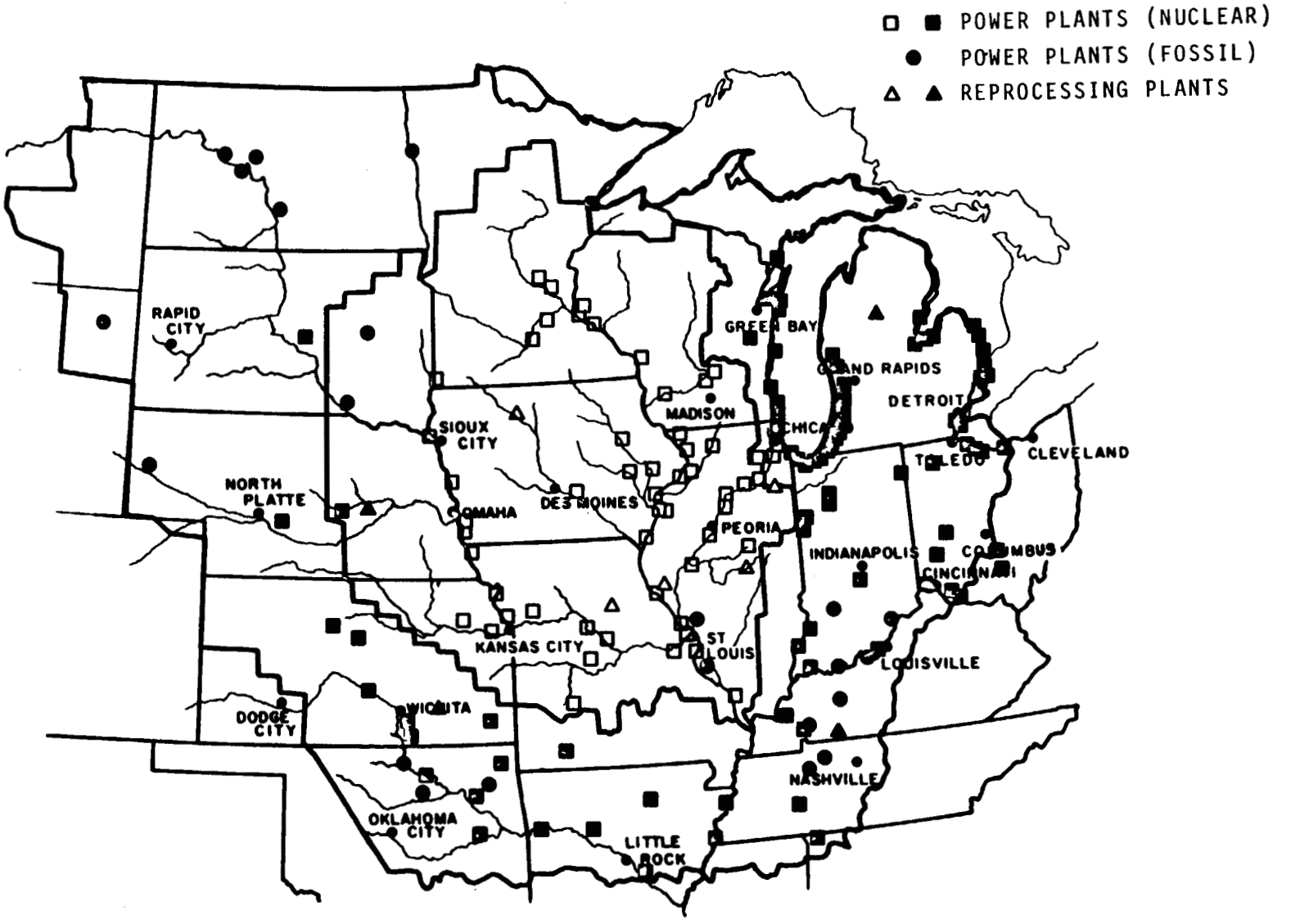

Figure III-1

Possible Electric Power and Fuel Reprocessing Installations (2000 A.D.)

of all subsequent modules of the HERMES model, are written in FORTRAN V Language). Preliminary to the process of assignment, the sites are assigned priority numbers (one number for each plant a site can accommodate). These priorities are assigned in a manner such that the subsequent assignment of plants to sites will match the projected patterns of development of power demand. In addition, sites are "flagged" so that fossil fueled plants will, for the most part, be assigned to sites in areas where fossil power is expected to predominate.

The SITE code then scans the year-by-year plant selection of the linear program output, assigning each plant to turn to the site with the lowest priority number. Additionally, since the LP output does not specify the types of LWR plants selected, the SITE code arbitrarily defines these as pressurized water reactor (PWR) plants or boiling water reactor (BWR) plants according to a preset ratio. In the initial study using the HERMES program, a ratio of 3 PWR: 1 BWR was assumed.

By tallying the numbers of PWR's, BWR's, and LMFBR's selected each year by the LP, and by the processing fuel consumption data, the SITE code also defines a time frame for the introduction of fuel reprocessing plants, and sites these plants using a priority system similar to that used at power plant sites.

The information flow sheet for the SITE code is shown in Figure III-2.

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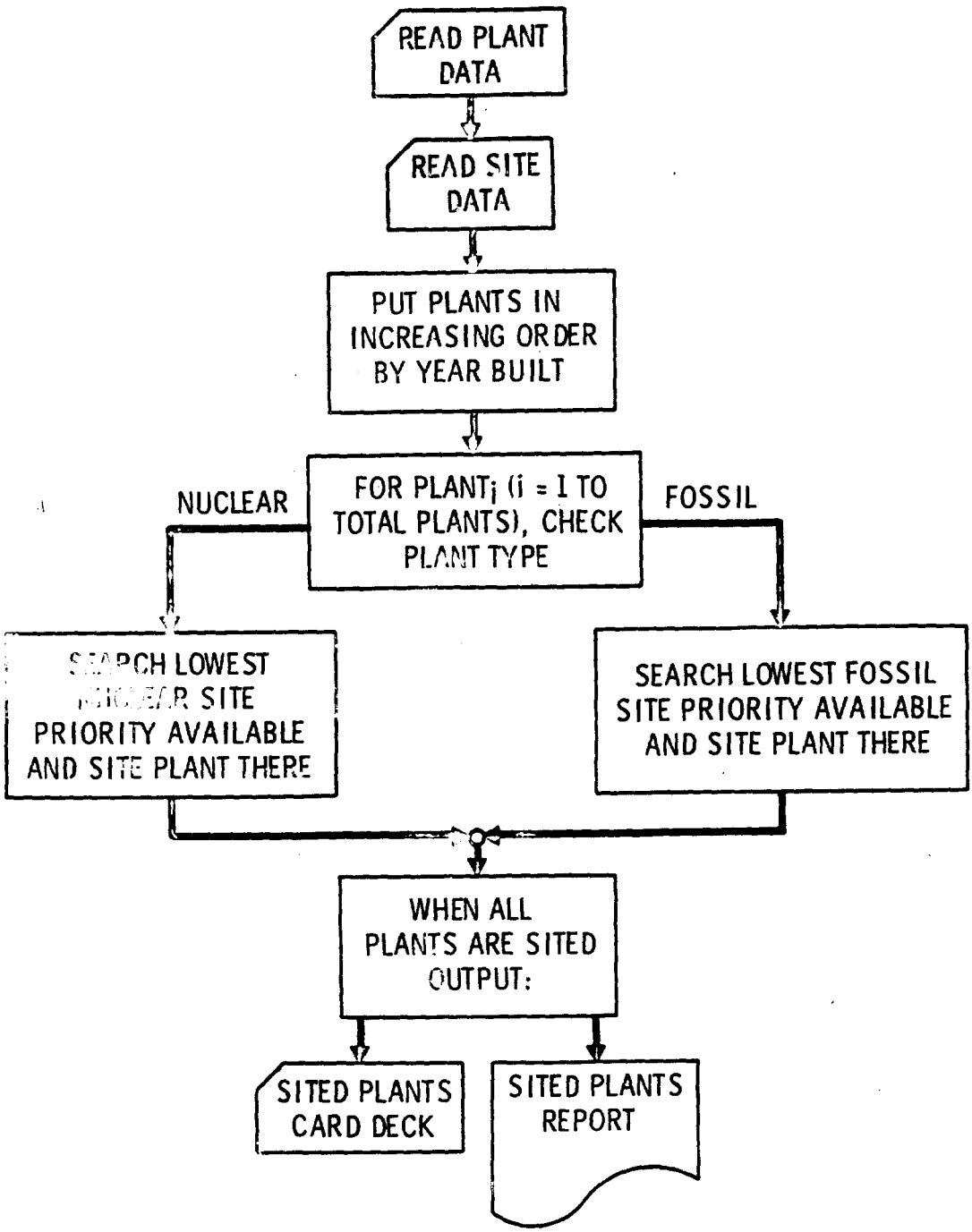

Figure III-2

Data Flow for SITE

PLANT OPERATING CHARACTERISTICS

The output from DAEDALUS and SITE codes must be modified to provide monthly operational characteristics for the power plants for use in RAPPEL. This is accomplished in the HERMES program MOPOSH (MOnthly Plant Operating ScHedule).

The power demand forecasts made by FPC for individual PSA's usually contain data on monthly variations in demand, or at least enough information on annual peaks that monthly demand curves can be synthesized. These data are typified by those used in the initial Upper Mississippi River Basin (UMRB) study[7,8,9,10]. Power plants within a PSA (or a group of similar PSA's) must operate in such a manner that the monthly demand is met. At the time it is selected during the linear program analysis, each power plant is assigned a load history curve which it is constrained to follow throughout life; its annual capacity factor is preset for each year of operation.

MOPOSH (Figure III-3) reconciles these requirements by scheduling the monthly operation of each plant within a PSA (or PSA grouping) by assigning it a monthly capacity factor, each month, to satisfy (1) monthly demand for the PSA, (2) annual demand for the PSA, and (3) the annual capacity factor constraint for the plant. Each nuclear plant is assumed to require a six-week shutdown for refueling and maintenance (the outage time selected was based on data from AEC-directed studies of the national power economy).[11,12] An individual plant may be shut down for additional periods, or run at partial power, to meet the constraints imposed in MOPOSH.

The output from MOPOSH is a monthly average capacity factor for each month of the year for every power plant included in the study.

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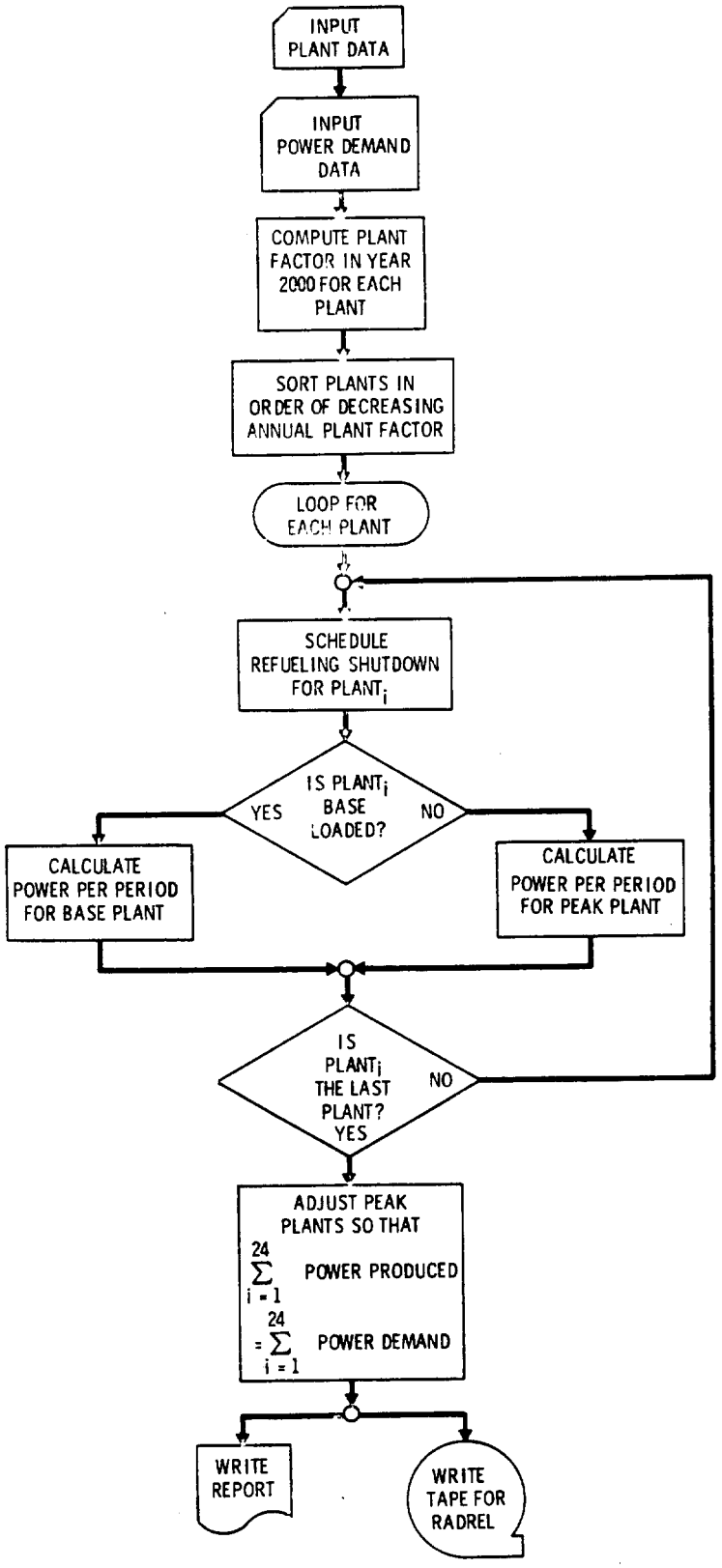

Figure III-3: Data Flow for MOPOSH

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C. RADIOACTIVE EFFLUENT CHARACTERIZATION

The RADREL (RADiation RELease) subelement of the HERMES code performs several functions which ultimately produce output files for subsequent use in the remaining three codes (Figure III-4). Initially, the RADREL code sorts the regional nuclear plant sites to optimize the output format for the downstream codes. The sort routine relists the various geographical locations for the plant sites into a table where the first site has the largest numerical value for latitude and least numerical value for longitude. The table is then completed by listing each plant site within one degree longitudinal strips, working from north to south and then from east to west across the region.

The tables of nuclear facility locations are scanned to match BWR, PWR, and LMFBR facilities against startup dates. All of the BWR and PWR plants scheduled to be on-line during or after 1985 are designated as "advanced" system facilities. This separation enables the corollary code DOSIS to assign the appropriate treatment to be given to the radionuclides generated by operation of the various reactor types.

REACTOR RELEASE MODEL

The DOSIS code is designed to simulate the major nuclear plant characteristics affecting radionuclide release to the environs. The majority of the factors that reflect the anticipated performance of reactors were obtained from Safety Analysis Reports (SAR). Reactor releases were subsequently calibrated to reflect the guidelines of Part 50, Title 10, Code of Federal Regulations (10CFR50).[6]

The subdivision of potential reactor types for the study region and year (BWR, BWRA,* PWR, PWRA,* and LMFBR) was made by the codes preceding DOSIS in recognition of the potential for simultaneous employment of the several types of nuclear plants for electrical energy production in the study region. The DOSIS code is constructed to consider each reactor type

*The 'A' designates advanced.

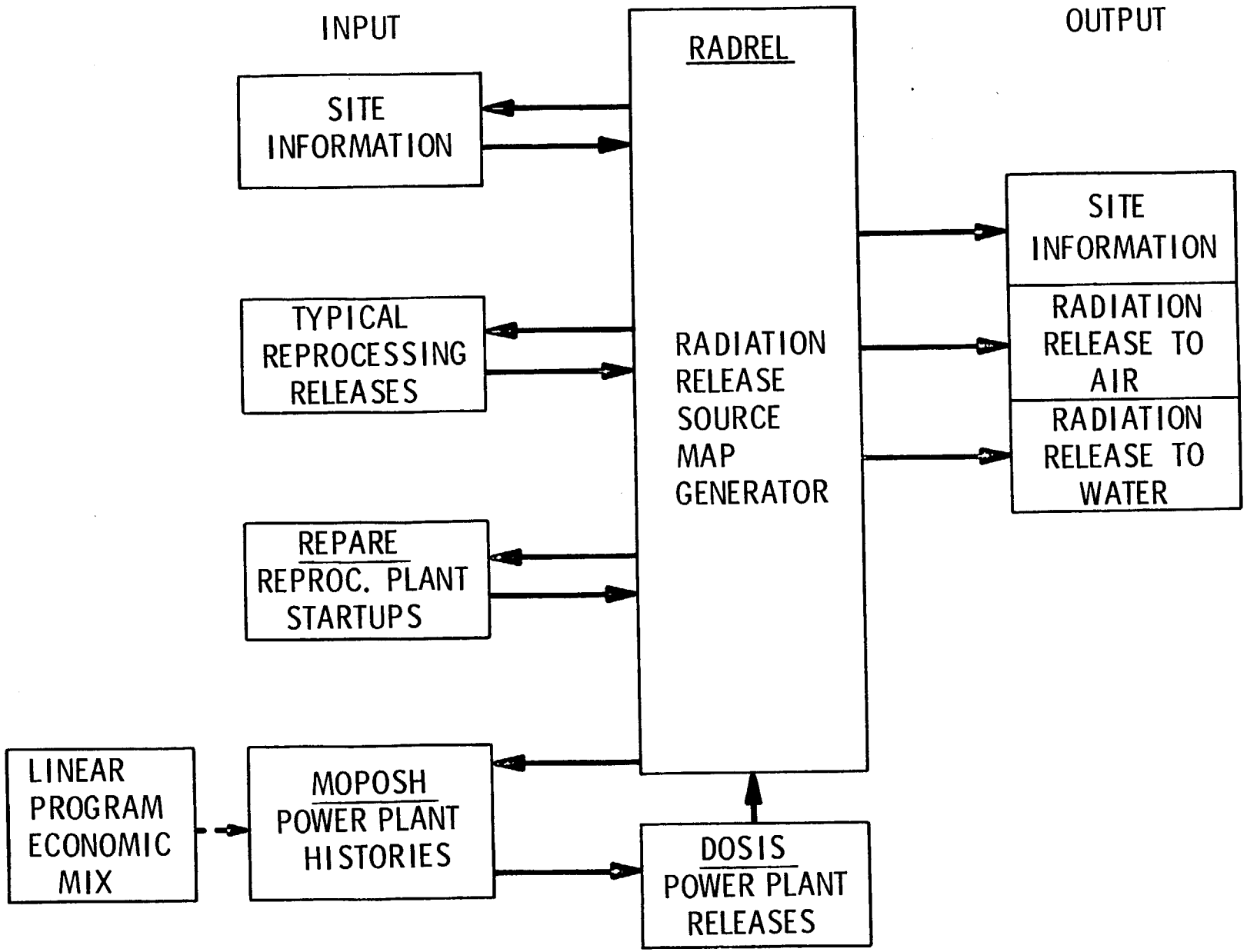

Figure III-4: Data Flow for RADREL

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as a separate entity (Figures III-5 and III-6). Code segments for the advanced light water reactors include the effects of the anticipated increased fuel rating.[12] Improved radwaste treatment systems are assumed for both advanced and present-day plants. The model is so constructed that the various system treatment factors may be modified to accommodate changes resulting from advances in technology, either actual or anticipated.

The DOSIS code follows the radionuclides of interest (see Appendix A) from their points of generation, through the coolant to the radwaste system, then to their eventual point of release, for each reactor type. At each step in this path, various equations, generally with different constants for each radionuclide, are used to calculate the effect of that part of the system on the eventual release rate for the particular radionuclide to the environs. As used in the HERMES code, the constants between the point of generation and the coolant were adjusted to yield coolant concentrations similar to those published in typical SAR's.[13,14] Where these numbers were not available from SAR's, the constants were approximated by relating the radionuclide in question to a chemically similar radionuclide that was available.

Radionuclide Generation and Coolant Concentrations

Determination of reactor-generated radionuclide releases requires that the generation rate in the fuel and the release rate to the reactor coolant of the fission products of interest be calculated. This part of the analysis is carried out in the subroutine called SMALL where the fission product releases are calculated as a function of burnup and linear rod power for each radionuclide. The fuel is considered in fractions, and in the computer program nested DO loops are used to consider burnup, radial peaking and axial peaking. Fuel failure is considered as a function of burnup and maximum axial linear rod power for each radionuclide.

The equation form used in evaluating fuel failure probability is the Weibull function:[15]

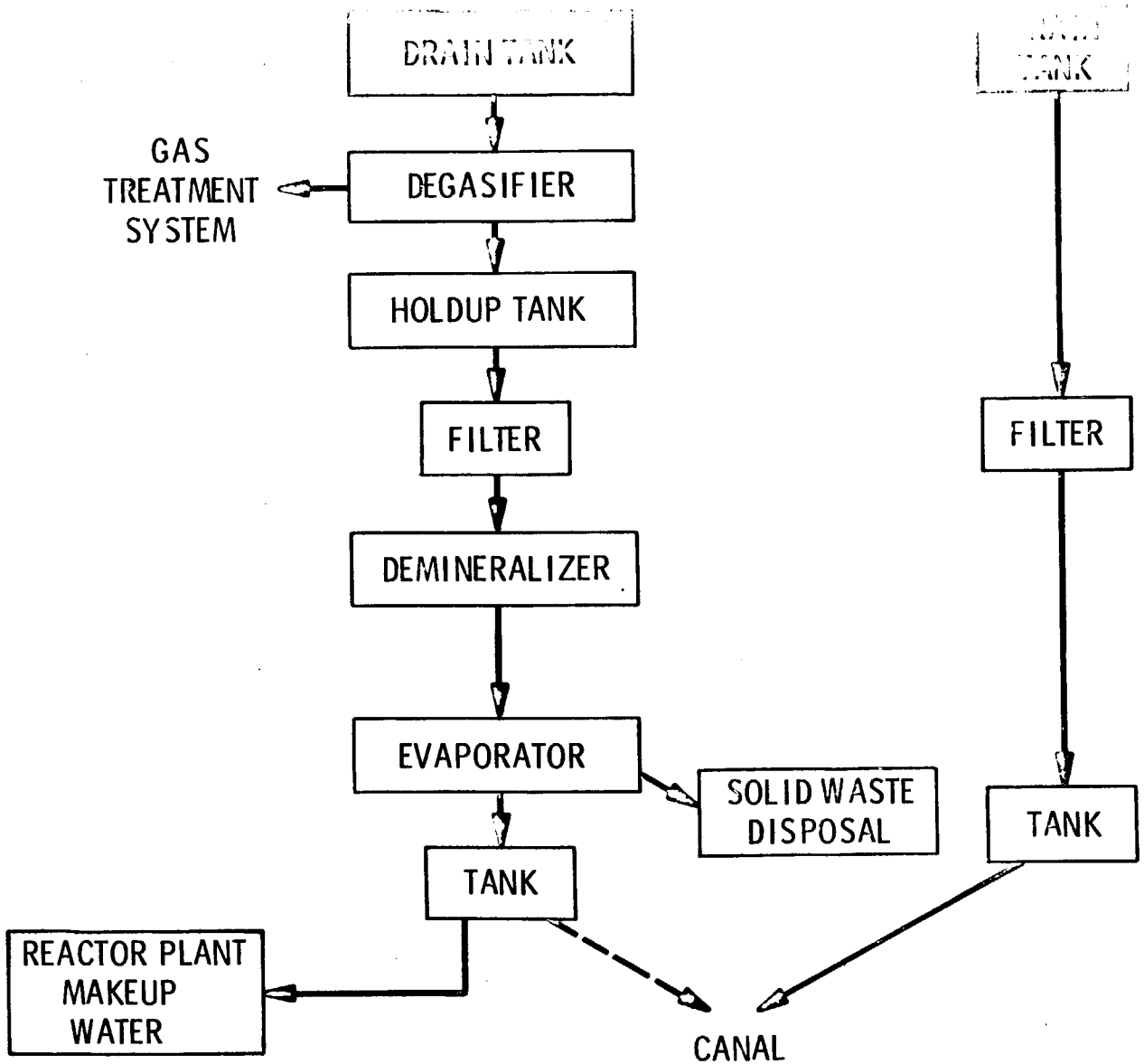

Figure III-5: PWR Liquid Waste Treatment System

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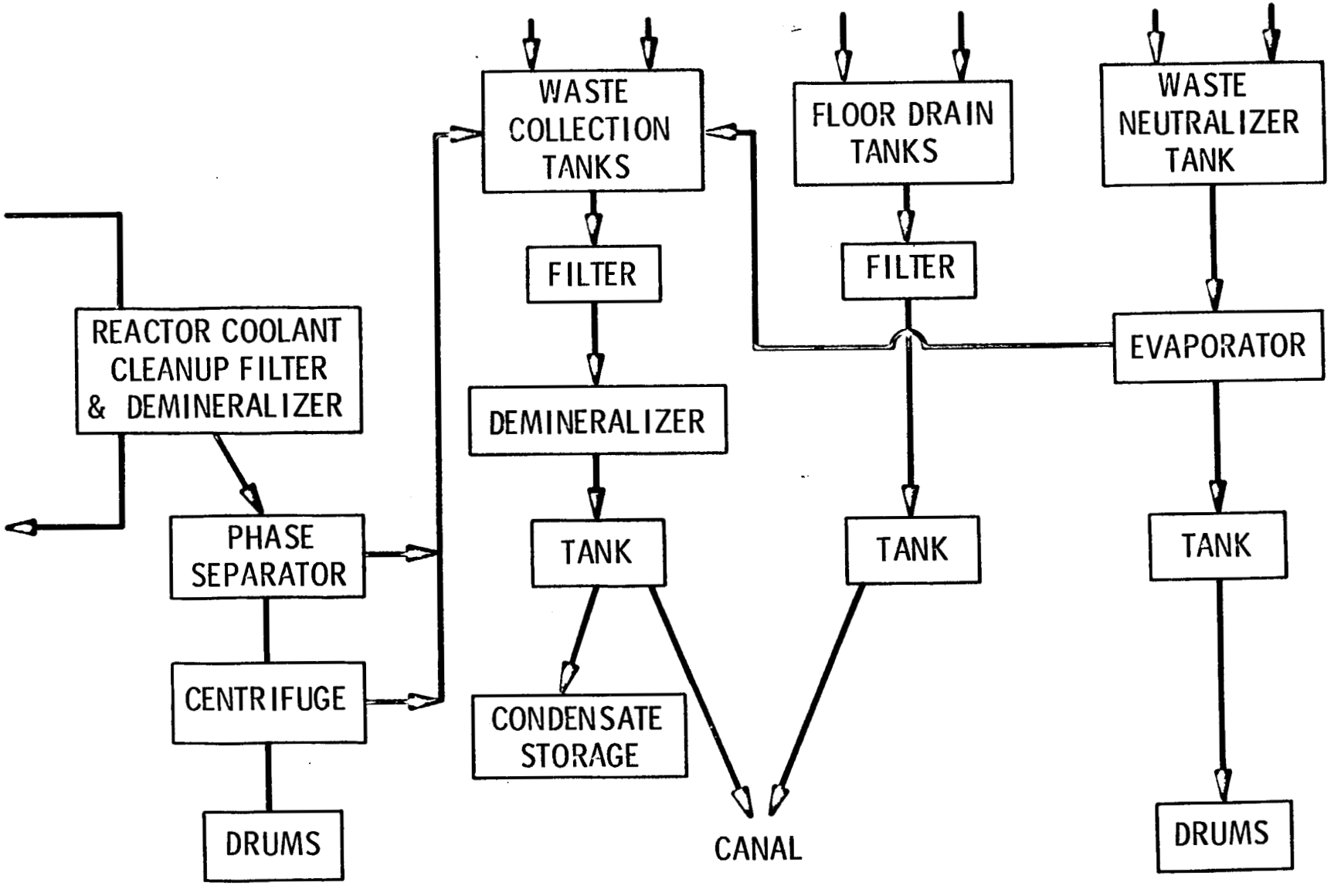

Figure III-6: BWR Liquid Waste Treatment System

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$$P = 1 - \exp\left(-(BU)^{\beta}\,(LHR)^{\eta}\,C\right) \tag{1}$$

The exponential constants were selected empirically to yield a reasonable curve shape. A constant C is calculated from the user-specified value of the code variable FFRS, the fraction of failed fuel in the core.

The outside DO loop calculates burnup. For these calculations, the core is considered to be divided into segments corresponding to fuel reloads, and in each fraction of the core, the fuel is assumed to have the average burnup of that fraction. (Note that this is essentially an assumption of a scattered fuel loading pattern.) The next loop factors in the radial power distribution. A typical distribution is included in the DATA statement called RODF. The burnup and the maximum linear rod power in each group of rods are used in calculating fuel rod failure probability. The axial power, distribution is accounted for in the next loop, and the innermost loop iterates over each radionuclide in turn. The code essentially calculates the release of each radionuclide from each axial power segment, in each fraction of the rods that are at each fraction of the maximum core linear rod power, and in each burnup segment. The radionuclide generation is calculated by using the average core power since the fuel element has probably been at a variety of rod powers before reaching high burnup where the failure probability is higher.

The radionuclide generation rate is then multiplied by a release function, calculated by equations of the form:

$$F = 3\sqrt{\frac{D}{\lambda}} \tag{2}$$

for short half-life radionuclides, and

$$F = 4\sqrt{\frac{Dt}{\pi}} \tag{3}$$

for long half-life radionuclides,[16]

where F is the fraction of generated fission gas in fuel rod void spaces,

D is the empirical fission gas release parameter derived from Equation (4), given below,

λ is the decay constant for the radionuclide being investigated, and

t is the irradiation time.

The diffusivity parameter D used in these equations was obtained from a curve given in Reference (16)*. The equation

$$D = \exp\left(-.066045(LHR)^2 + 2.7432\ (LHR) - 47.703\right) \tag{4}$$

was obtained from this curve, where LHR is the linear heat rate.

This was modified by the fission gas diffusivity burnup factor attributed to Evans and Shilling.[17] An additional constant for each radionuclide was added to calibrate the release model to SAR coolant concentrations. It was initially anticipated that two parallel paths for fission product release would be included in DOSIS; diffusion limited volatile fission product release and washout release of less volatile fission products. The difficulties encountered in attempting to provide this capability could not be resolved in time for inclusion in the present HERMES code. The single diffusion pathway is used in calculations for all fission products.

For each reactor type, the activation products are considered in separate parts of the subroutine ACTIVA. The potential sources of activation products are considered to be the vessel, clad and coolant. The general equation used in each part of the code is of the form:

$$I = P\ C\ (1-e^{-\lambda t})pf \tag{5}$$

where C is the corrosion rate,

---

* Figure 1.5, p. 14 of Reference (16).

pf is the plant factor,

t is the coolant turnover time, the fuel residence time, or the plant age, and

P represents the combined amount of parent and probability of activation. P has been adjusted to yield desired coolant concentrations.

During analytical treatment of this portion of a reactor system, the spatial dependence of flux levels, flux spectra, and corrosion and deposition rates must be considered. A start on a more rigorous consideration of activation product generation has been made (Appendix C). This analysis was used in extending SAR coolant concentrations and, thus, the values for the P constants to activation products not included in the SAR's.

Radionuclide Treatment Systems

A basic assumption in the DOSIS code is that all radionuclides are released to the coolant. There are a number of paths considered for their subsequent removal from the coolant system. Mass balance calculations are performed for each radionuclide in accord with the scheme shown in Figure III-7. The immediate split of radionuclides between the gaseous streams and liquid streams is established by values of the code constants designated as SPPWR, SPBWR and SPLM. (In the treatment systems, vents from tanks are similarly handled). Much of the code in this subroutine is used to account for the radionuclide inventory modification resulting from decay.

The radwaste systems, as a function of reactor type, are simulated by the DOSIS code. The code has a logic capability for more detailed simulation of the radwaste systems than was utilized in the UMRB base case. Full utilization of all of the code capabilities requires validated pertinent data characterizing the various system subelements which, at this time, are not available. However, as they become available, this logic may be actuated and the system simulation will become more meaningful.

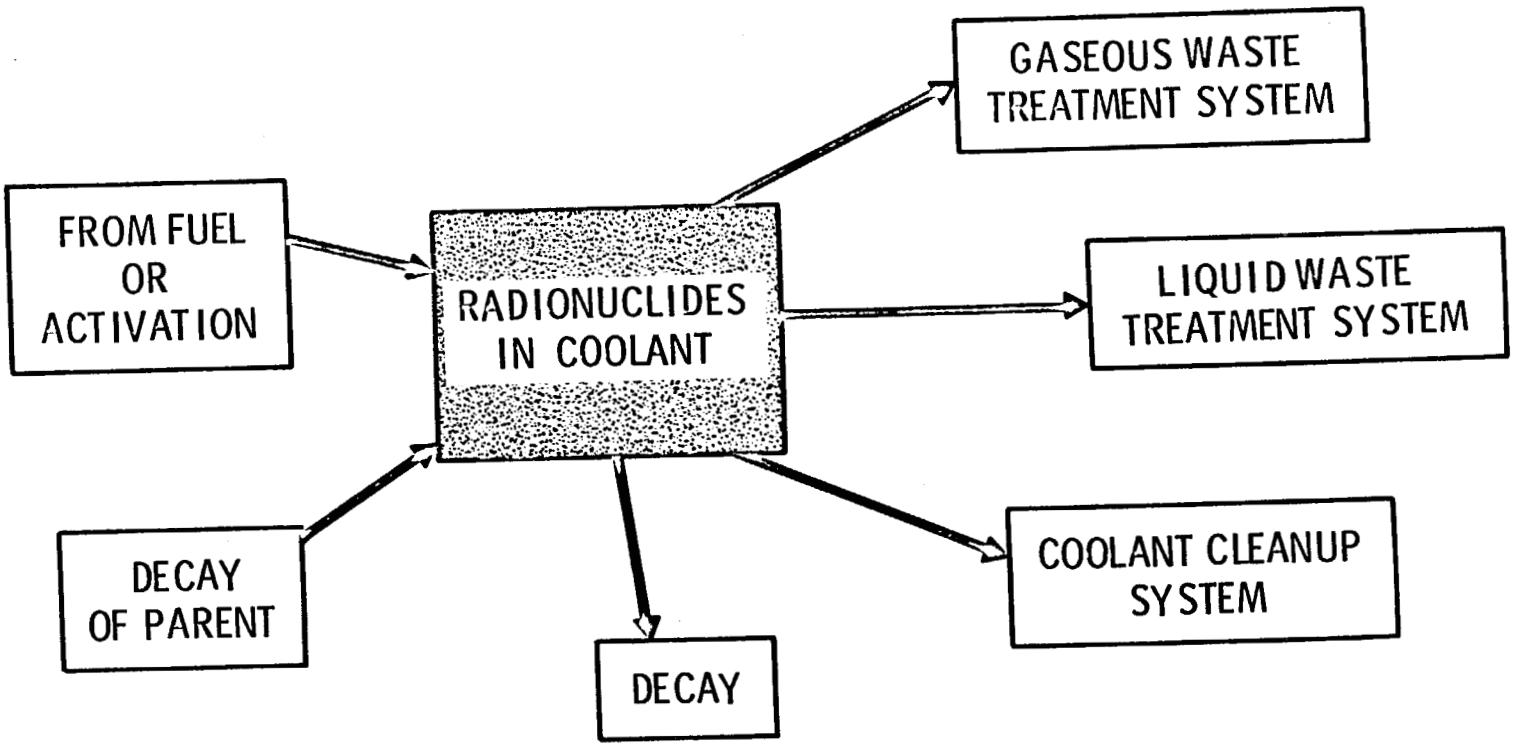

Figure III-7: Mass Balance Diagram for Radionuclide Concentrations in Coolant.

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PWR Systems

The PWR flow chart (Figure III-5) illustrates the two paths available for waste streams to follow. One, starting in the drain tank (DRNTNK), is the path used for streams that could be characterized as chemically clean. They are assumed to have radionuclide concentrations similar to that of the primary coolant. The outer path, starting in the floor drain tank (FLRDRN), is used for wastes that are low in radionuclide concentrations and are "dirty" enough so that discharge, rather than cleanup and return to the liquid system, is desirable.

In the first path, the liquid passes from the drain tank to the degasifier (DEGAS), which simulates the removal from the liquid stream of the gases either not removed directly from the coolant by the SPPWR variable or those that have been generated during the decay process to this point. The liquid stream is processed through the holdup tank (HOLDUP) routine for process decay and then processed through the routine simulating filtration (FILTER). The routine accounts for removal of some of the radionuclides; the remainder go to the routine for the demineralization process (DEMIN). After removing some radionuclides, the demineralizer flow passes through the evaporator simulator (EVAP). The flow is then passed to a final tank simulation (TANK3). In this flow path, a small fraction is assumed to be released while the remainder is assumed to be returned to the coolant system.

In the outer path simulation, the liquid is assumed to pass from the floor drain, through the filter (FILTER) to a tank (TANK4). All of the liquid following this path is assumed to be released.

The gas treatment simulation for the PWR is encountered after the gaseous contributions are added up in DOSIS. This system is a simulation of a delay and a filter for the PWR; it is accomplished with routines for a storage tank (STANK) and a filter (GFILTER).

The PWR simplifications made in the HERMES code for the UMRB case have only one inlet stream for each pathway. The stream using the demineralizer is assumed to have reactor coolant concentrations, and the floor drain pathway has the concentrations reduced to account for dilution effects.

The advanced PWR (PWRA) has essentially the same treatment system as the PWR. The only difference is the increased fuel linear heat rate in the fuel release modeling.

BWR Systems

The boiling water reactor treatment system (Figure III-6) has available a simulation that is slightly more complex than that for the PWR for the available flow paths. The first path is assumed to go to the phase separator (PHASEP); the overheads go directly to the waste collection tank (COLTNK); while the bottoms are to be treated by the centrifuge. The liquids from the centrifuge flow to the collection tank. There is a path simulation available for wastes that would require evaporator treatment and subsequent reuse because of their relatively high activity. Starting at the waste neutralizer tank (NEUTNK), the liquid is assumed to flow to the evaporator (EVAP). The evaporator overhead flow goes to the waste collection tank. The waste collection tank may also receive flows directly. All streams going to the waste collection tank flow to the filter (FILTER), to the demineralizer (DEMIN), and lastly to a tank (TANK1). Part of the flow is then released; the remainder is assumed to be returned to the coolant.

The BWR system used in the UMRB case has only two simulated input streams to the radwaste system. One of these streams is assumed to go directly to the waste collection tank; it has reactor coolant radionuclide concentrations as calculated in the COLANT routine. The other stream is assumed to go directly to the floor drain tank; it has radionuclide concentrations that are reduced by a constant factor. The floor drain

pathway simulation is similar to that of the PWR.

The BWR gas treatment system simulators are routines for delay time (BWRD), for a charcoal filter holdup system (CHAR), and filtration (GFILTR).

LMFBR Systems

The LMFBR waste treatment system simulation is much simpler than the light water reactor treatment systems because most of the radionuclides of interest are assumed to remain in the sodium coolant and therefore are not released to the environment.

The LMFBR gas treatment system mechanism is provided in the routine called FREON. As with the other gas treatment systems, provisions are also made for a delay time (DELA) and the gas filtration (GFILTR). The gas stream is then directed to the FREON subroutine where a removal decontamination factor of 300 is assumed for the noble gases.

A subroutine called CRYO is also included, but not used, for the reactor types as presently visualized. This subroutine may be used to simulate a gaseous delay time or could have a removal efficiency added if the gaseous wastes were bottled after delay, as has been visualized with the FREON system.

The HERMES code has a number of parameters describing each reactor type as a part of the DOSIS code for the UMRB case. For more general applications, these characteristics would probably be included as input description variables for the reactor being considered. These characteristics (Table III-1) are in addition to the flow paths chosen, etc.

TABLE III-1

ASSUMED REACTOR CHARACTERISTICS

	BWR	PWR	BWRA	PWRA	LMFBR
Flow to Collection Tank (liters/sec)	0.79	0.473	0.79	0.0473	
Flow to Floor Drain Tank (liters/sec)	0.40	1.37	0.40	1.37	
No. of Reload Fractions	4	3	4	3	5
Goal Burnup (MWd/MT)	27500	30000	27500	30000	80000
Power Density (MW/MT)	22	35	24	39	150
Max. Linear Heat Rate (kW/ft)	18	18	20	20	20

REPROCESSING PLANT RELEASE MODEL

Concurrently, with the determination of the general radioactive nuclide effluent characteristics for nuclear power electrical energy generation facilities, a similar process is initiated for the fuel reprocessing plants in the study region by RADREL. These plants consisting of two types, PUREX and the General Electric Company patented Aquaflour process (MFR), are assumed to be built as required by the spent fuel production of the reactors in the study area. For the UMRB case,there is an assumed requirement for nine reprocessing plants--eight PUREX types and one MFR. Sites for these facilities were preselected as in the case of the reactor sites. Simulation of the effluent characteristics of these plants is accomplished by the general HERMES subelement with the acronym REPARE (REprocessing Plant Analog for Radioactive Effluents) shown in Figure III-8. The same techniques employed by DOSIS are applied to this problem, e.g., separate subroutines are used to simulate the various plant processes employed in reducing the impact of the radioactive nuclide inventory on the environs.

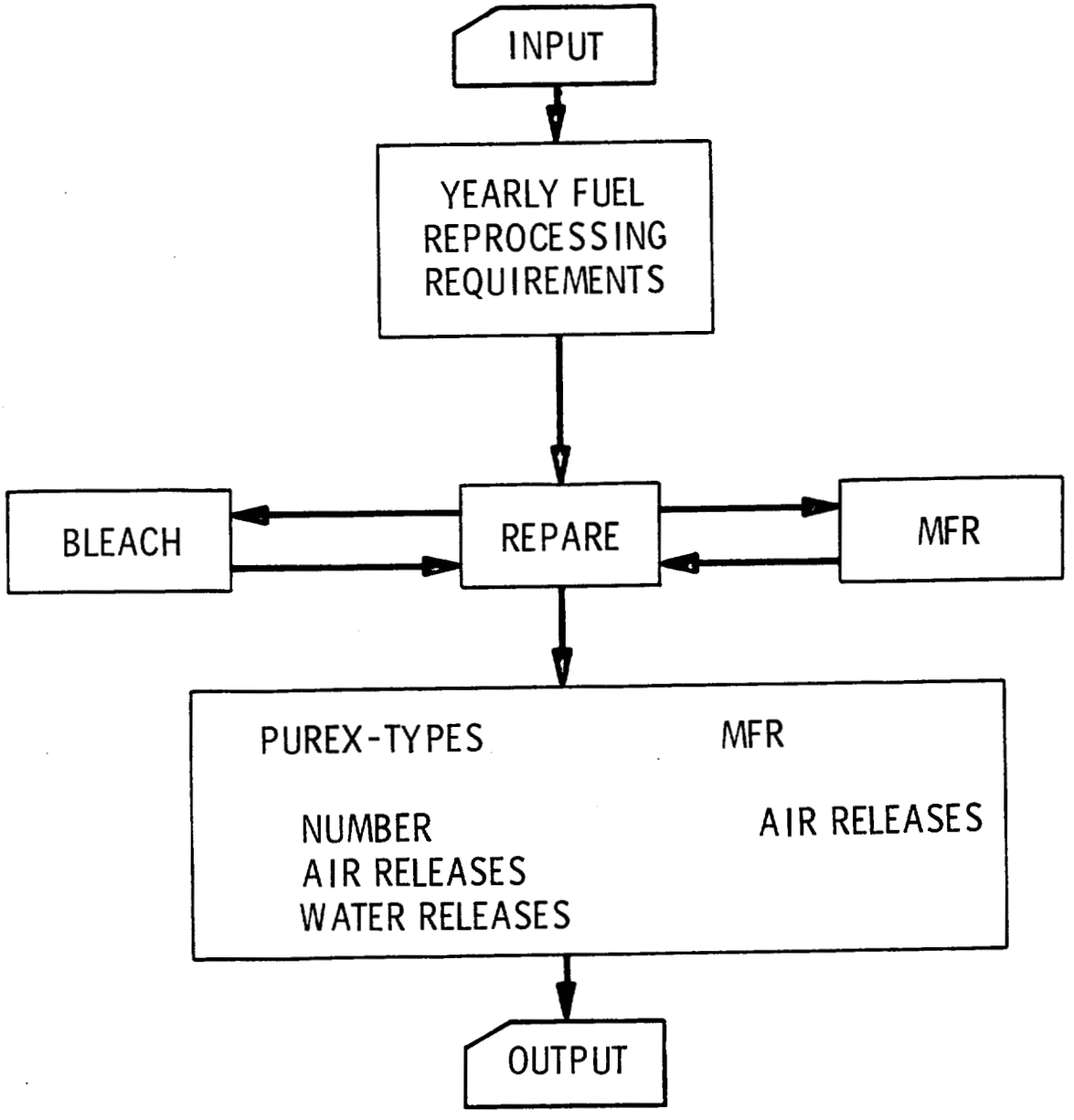

Figure III-8: Data Flow for REPARE

The effluent treatment systems of reprocessing plants have been characterized by parametric equations in a series of modules that model particular components in the system. For instance, the dissolver off-gas treatment system in dual-purpose plants is composed of three modules (Figure III-9). The modules simulate the operations of a condenser, a scrubber, and a silver reactor by parametric equations which can treat each radionuclide separately.

The detail and flexibility provided by modules, with their parametric equations, permit sensitivity studies to be made that will determine the functional relation of the input data and effluent treatment system designs to the calculated radionuclide releases.

To predict the contributions of the reprocessing plant effluent releases to the total radioactive effluent burden within the study area, a model must satisfy the following constraints:

- The number and type of reprocessing plants should correspond to the best projection of the area's requirements.
- The radioactive effluent for each plant should be released from likely sites to provide a reasonable simulation of these contributions.
- All fuel utilized by reactors in the study area must be reprocessed within the study area.

Plant Types Modeled

Two separate algorithms were developed to compute reprocessing plant radioactive effluent rates within the constraints above. One model, called MFR, represents the Midwest Fuel Recovery Plant, MFRP (Figure III-10), which utilizes the patented Aquaflour process[18] for LWR fuel. The other model describes a Purex-type aqueous reprocessing plant (Figure III-11) capable of processing either LWR or LMFBR fuel.

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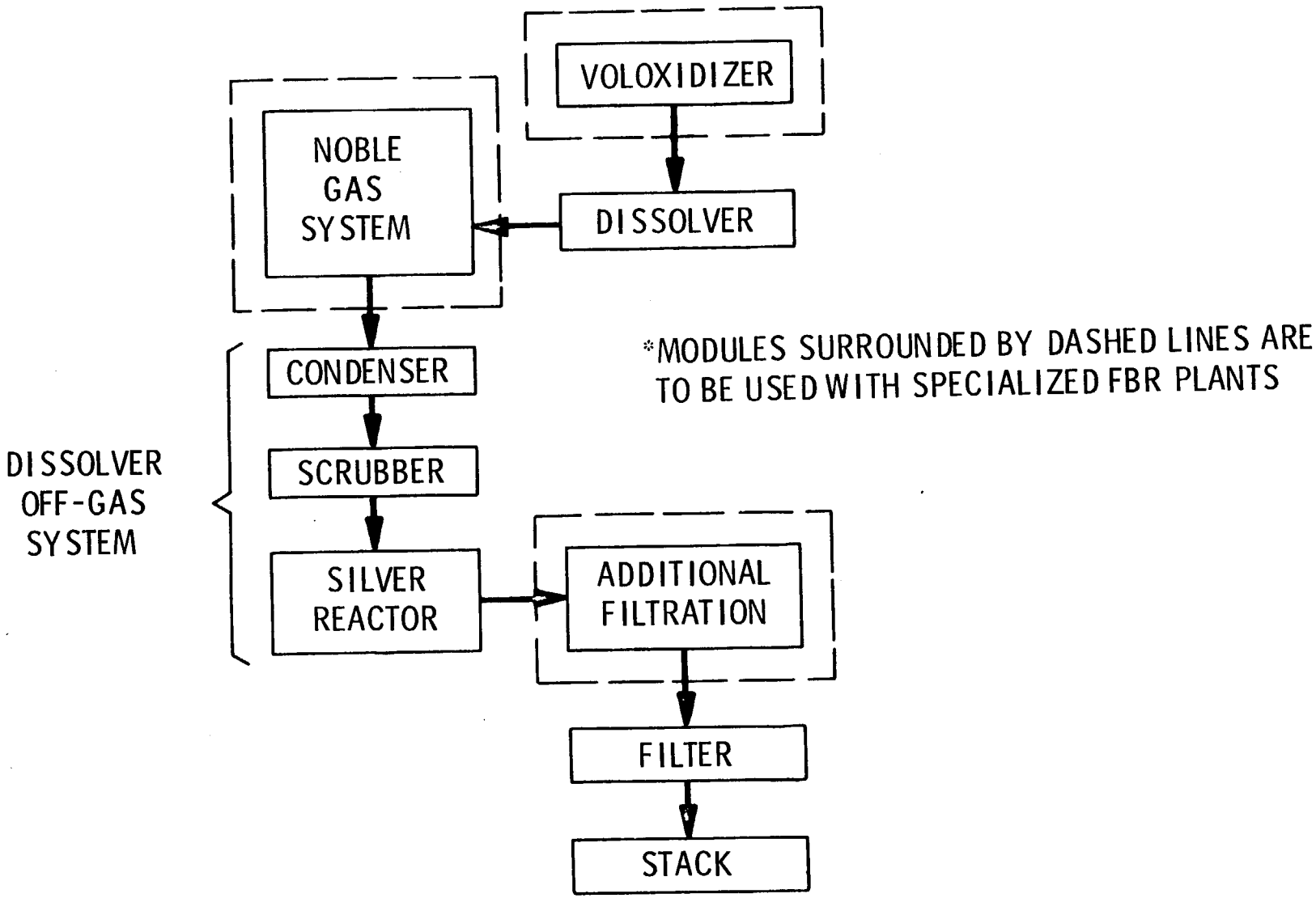

Figure III-9: Dual Purpose Reprocessing Plant Dissolver Off-Gas System

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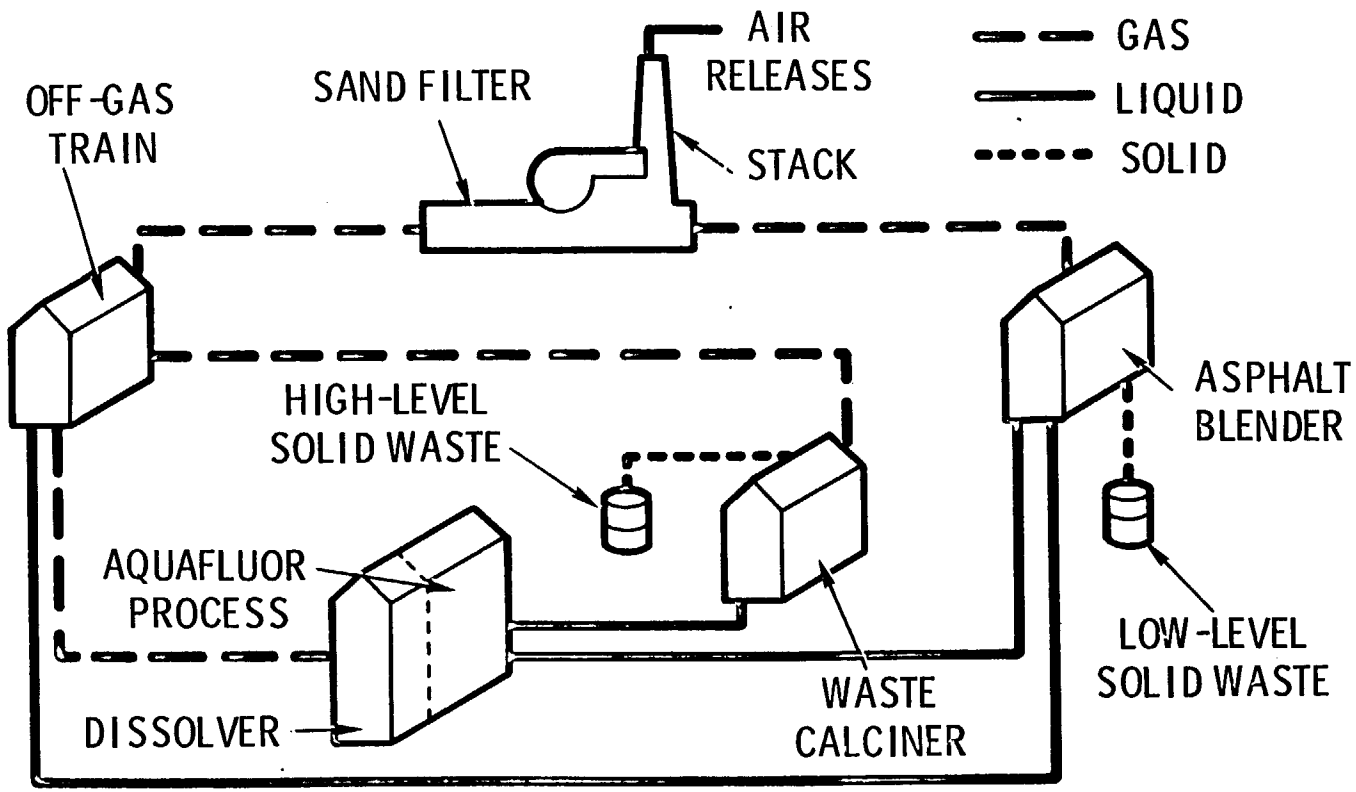

Figure III-10: Midwest Fuel Recovery Plant

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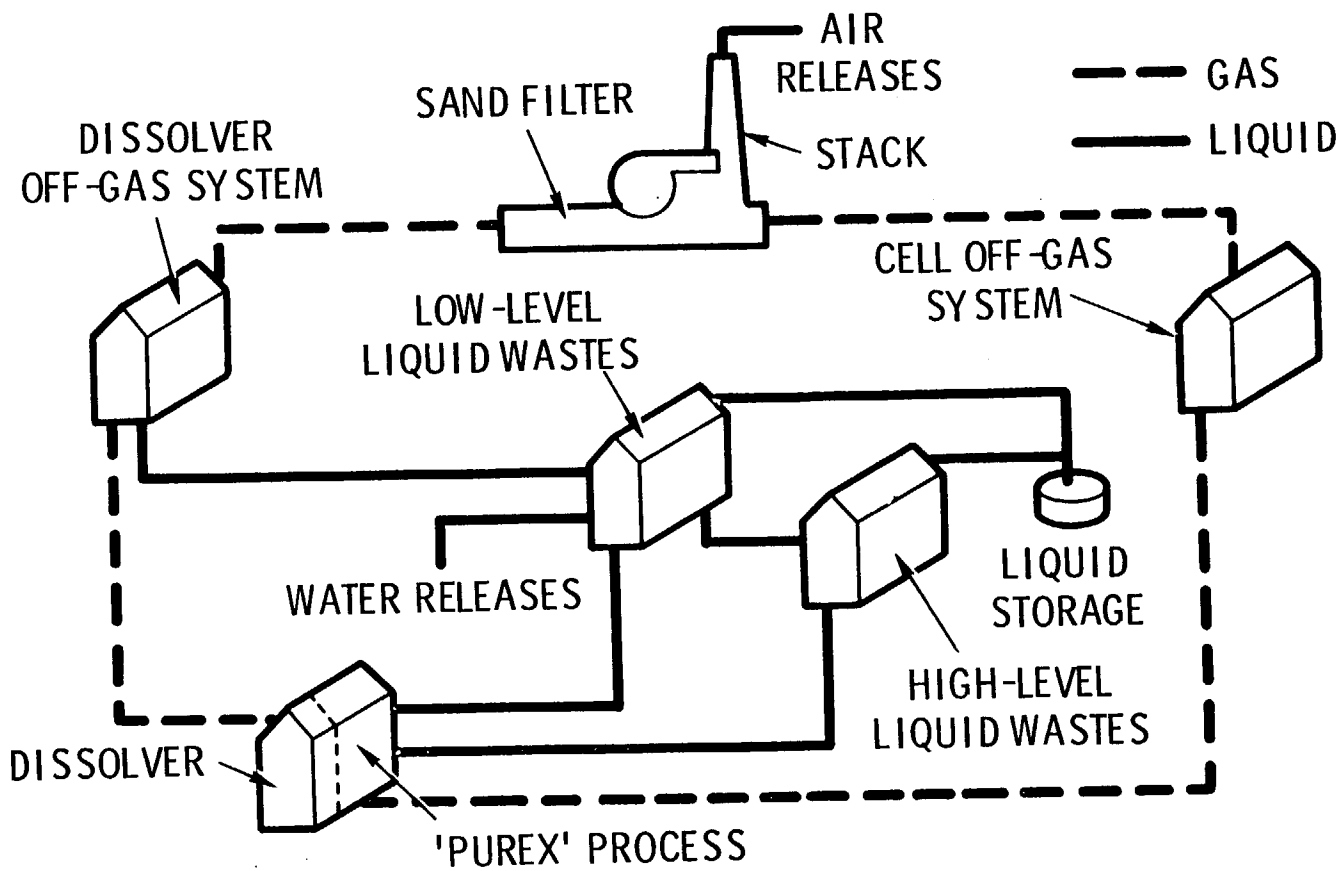

Figure III-11: Dual Purpose Reprocessing Plant

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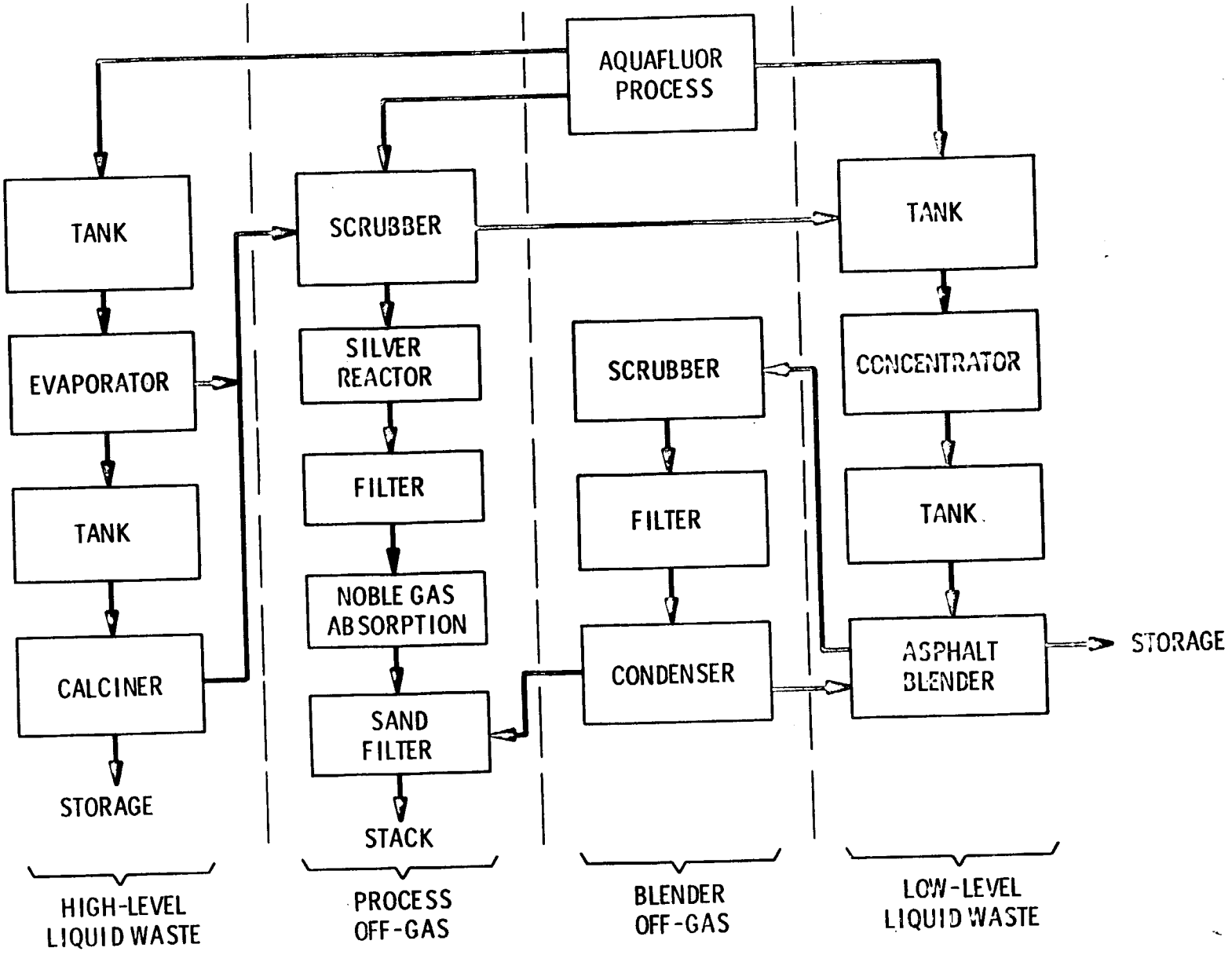

Figure III-12: MFR Reprocessing Plant Waste Treatment

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The dual-purpose Purex-type model, BLEACH, was developed to reflect the designs for the next generation of reprocessing plants. The effluent treatment flowsheet (Figure III-13) closely resembles the systems presently used in the Nuclear Fuel Services (NFS) plant[19] and planned for the proposed Allied Chemical plant,[20] which are designed to reprocess LWR fuels. During the early years of LMFBR operation, the spent fuel inventory will probably be processed in LWR fuel reprocessing plants at one-half the design feed rate after five months cooling.[21] When sufficient quantities of LMFBR fuel become available, specialized reprocessing plants capable of processing short-cooled LMFBR fuel will probably be built. The dual-purpose Purex-type algorithm can be used to compute the effluents from LWR fuel plants, LWR fuel plants reprocessing LMFBR fuels, or specialized LMFBR fuel plants. The algorithm's flexibility stems from its modular construction. Each of the three types of plants noted above can be simulated by using separate combinations of the modules in the BLEACH code according to the values of input parameters.

The MFR algorithm is based on the Preliminary Safety Analysis Report (PSAR) submitted by the General Electric Company.[18] The plant is intended only for use as an LWR fuel reprocessing facility, so the model is restricted to LWR fuel input at a rate equal to or less than the maximum design capacity of 300 tonnes/yr.

The major differences in the MFR and Purex-type plants lie in the process treatment of the liquid waste streams. The MFR design incorporates low-activity wastes into asphalt-solid storage and high-activity wastes into calcined storage (Figure III-12). The Purex-type concept assigns the high level wastes to liquid storage and routes low-level wastes to temporary hold-up and ultimate release (Figure III-13).

No attempt has been made to model fully the separations processes for either type of facility. Only major waste streams and the effluents from them have been simulated. Not having altered the mass balance, these modifications have only simplified the accounting system. All constituents

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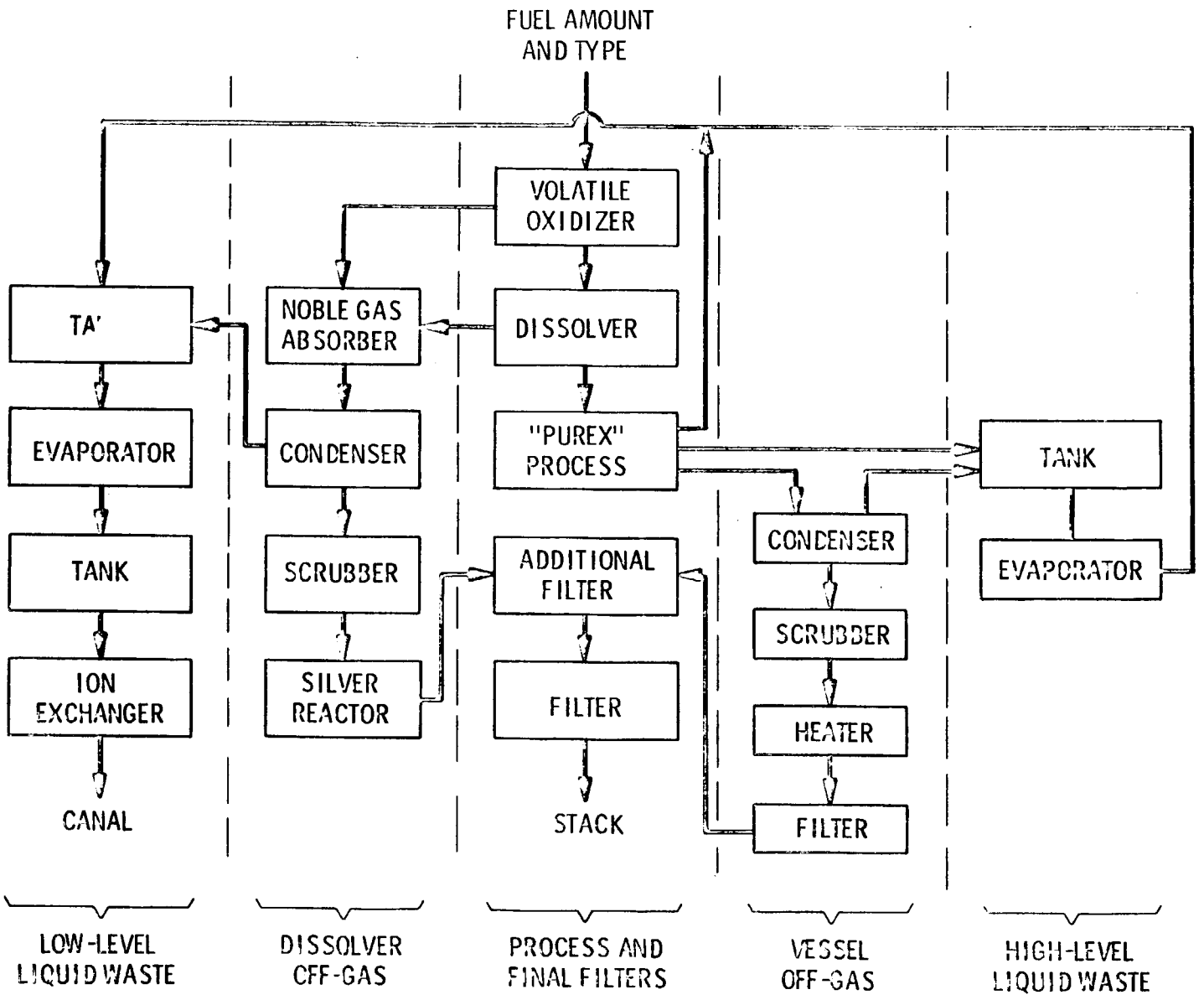

Figure III-13: Purex-Type Reprocessing Plant Waste Treatment

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of the fuel are included in at least one of the following categories:

- Gaseous effluent stream
- Liquid effluent stream
- Permanent storage
- Product stream

The radioactivity contained in small waste streams such as laundry drains and working gallery ventilation air is not discarded but, instead, is included in the considerations of a major waste stream. The level of detail included in the model was dictated primarily by the available data that could be used to write and verify the necessary parametric equations.

The nominal capacity of the MFR facility is 300 tonnes/yr of LWR fuel. The hypothetical dual-purpose plants can process a maximum 750 tonnes/yr of LMFBR fuel or 1500 tonnes/yr of LWR fuel. A dual-purpose plant is brought online for each increment of 1500 tonnes of equivalent LWR fuel/yr, where 1/2 tonne LMFBR fuel and one tonne of LWR fuel are each considered 1 tonne of equivalent LWR fuel.

The radioactive releases computed by the model are summarized for the MFRP and a typical dual-purpose facility. The typical dual-purpose releases are determined by mixing the fuel so that each plant has the same ratio of FBR fuel to LWR fuel. To facilitate rapid assessment of relative contributions to the total effluent, an additional algorithm may be utilized to normalize the results and separate any subset of isotopes from the main total.

Release Calculation Methods

The BLEACH and MFR algorithms are both composed of parametric equations that form process modeling modules. Each major waste stream is represented by a series of modules simulating the significant points of radionuclide addition or removal from the stream (Figures III-12 and III-13). In addition to the process modules, two modules provide

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calculation of fuel composition change due to decay. One decay module is used to determine composition after the preprocessing cooling period; the other is used to determine composition changes that occur by decay during the hold-up time in each process module.

The parametric equations of each module permit a unique description of the effect of the process on each radionuclide. After the inventory of radionuclides enters a process module, the composition leaving the module can be altered in three ways: (1) removal from the stream to permanent storage, (2) radionuclide decay during the hold-up time, and (3) selective distribution into each output stream. The latter mode, of course, does not influence the composition of single output streams.

Removal of radionuclides from a stream occurs in a reprocessing plant at filters, scrubbers, evaporators, silver reactors, waste storage processes, and product packaging processes. The equations describing permanent removal of radionuclides have a general form

$$I_{2(i)} = I_{1(i)} (1 - \eta_i) \tag{6}$$

The term $I_{2(i)}$ is the amount of isotope i leaving the module and is calculated as indicated in Equation (6), as the difference of the quantity of isotope i entering the module and the quantity of i removed within the module. In Equation (6) η_i is the effective removal efficiency for isotope i characterizing the module. The equation

$$\eta_i = C_{1(i)} - C_{2(i)} L_j \tag{7}$$

computes the effective removal efficiency of isotope i a function of the equipment loading parameter L_j, to account for changes in efficiency caused by increased loading such as accumulation on filters, and heavy flow through ion exchangers.

Decay of the radionuclides during the hold-up time in process modules is computed by an algorithm that considers reduction of individual isotopic

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inventories by decay, and inventory buildup through the decay of parent isotopes. The equation used to compute inventory changes through decay mechanisms is

$$I_{2(i)} = I_{1(i)}\, e^{-\lambda_i t_i}$$

$$+ \left(\frac{\lambda_{Ai}}{\lambda_i - \lambda_{Ai}}\right) I_{Ai}\, \alpha_{Ai} \left(e^{-\lambda_{Ai} t_i} - e^{-\lambda_i t_i}\right) \tag{8}$$

$$+ \left(\frac{\lambda_{Bi}}{\lambda_i - \lambda_{Ai}}\right) I_{Bi}\, \alpha_{Bi} \left(e^{-\lambda_{Bi} t_i} - e^{-\lambda_i t_i}\right) .$$

This equation allows for contributions to an isotope's inventory from two parents, where:

I_{1i}, I_{Ai}, I_{Bi} are input inventories of isotope i and parents A and B

λ_i, λ_{Ai}, λ_{Bi} are decay constants of i, A, and B

t_i is the holdup time for i, A, and B

α_A, α_B are fractional yields of i from decay of A and B

A similar algorithm is used to compute the change in inventory during preprocessing cooling; in which case, the cooling time is used as the "hold-up" time. Both algorithms convert curies to atoms prior to entering the decay equations and then convert them back to curies for output.

Some process modules have multiple outlet streams such as evaporators with overhead and bottom streams. The input stream is multiplied by a parameter defined separately for each isotope and for each output stream. For example, the module simulating the wastes from the separations process in the Purex-type plant, PUREX, has three output streams: (1) low-level liquid waste, (2) high-level liquid waste, and (3) vessel off-gas. Each stream is transferred to the next module in its treatment scheme after multiplying the inventory in PUREX by a constant expressing the "split" for each isotope among streams. For example, the vessel off-gas

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stream inventory is computed by the equation

$$I_{OG(i)} = I_{p(i)} K_{VOG(i)} \tag{9}$$

where $I_{p(i)}$ is the PUREX inventory. The values for $K_{VOG(i)}$ are given in a FORTRAN DATA statement, defining its value for each isotope.

The flowsheet describing the information flow between modules for BLEACH and MFR can be subdivided by columns to show the general process loops (Figure III-11 and III-12). The BLEACH flowsheet (Figure III-11) can be divided by columns from left to right into the (1) low-level liquid waste system, (2) dissolver off-gas system, (3) process system, (4) vessel off-gas systems, and (5) high-level liquid waste system. The MFR flowsheet can be similarly divided into (1) high-level liquid waste, (2) process off-gas, (3) scrubber off-gas, and (4) low-level liquid waste.

Fuel inventories for typical LWR and LMFBR fuel input are internally defined in the BLEACH and MFR subroutines as curies per metric ton of heavy metal for each isotope on the master list (Appendix A). The LWR fuel inventory is based on the Diablo Canyon Nuclear Power Reactor. Isotopic compositions were computed on the basis of 30 MW/tonne, 33,000 MWd/tonne, at an average flux of 5.82×10^{13} n/cm^2-sec, and with Zircaloy-4 cladding using Inconel spacers. The inventory values represent the isotopic composition after removal from the reactor for 90 days. The LMFBR fuel inventory is based on the Atomics International Reference Oxide LMFBR.[23] The average power level for the AI-LMFBR is 58.23 MW/tonne, assuming the core operates at 148.5 MW/tonne for 540 days and the axial blanket averages 4.63 MW/tonne. A fuel mixture resulting from proportional mixing of blankets and core has an average burnup of 33,000 MWd/tonne, although the core reaches 80,000 MWd/tonne.[21]

RADIONUCLIDE RELEASE CORRELATION

The RADREL code serves to correlate the calculations of the SITE, MOPOSH, DOSIS, and REPARE codes, and generates a "source map" tape summarizing the radionuclide discharges in the region being studied. First,

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RADREL scans the output of the SITE and MOPOSH codes, noting the site locations, the number and types of plants at each site (a nuclear site may contain plants of different type), and the monthly average plant capacity factor for each plant for each month of the study year. It then proceeds to calculate releases from the plants on a month-by-month basis for the year of study.

Usually, RADREL calculations begin in January of the year of study (although the code can be used to compute releases for any 12 consecutive months). Releases are calculated in turn for each site in the study area. For each site, data are received from the SITE and MOPOSH codes denoting the plant type and age of each plant at the site, and the monthly average plant capacity factor for each plant. RADREL then calls DOSIS to calculate monthly average releases for each plant under the prescribed operating conditions, and combines the calculated radionuclide releases into a single set of equivalent monthly average release rates to air, and a single set to water. RADREL performs these calculations for each site in turn, then repeats all calculations for the second month, and so on.

In the case of reprocessing plants, which are assumed to operate at constant load during a given year, interpretation of release data by RADREL is not necessary. The monthly average release data received from REPARE are transcribed directly to the RADREL output tape.

In order to minimize computer time requirements, capacity factors of power plants are grouped according to the following scheme:

Input Capacity Factor	Capacity Factor Used by RADREL
0 (not operating)	0
0 - 0.19	0.20
0.20 - 0.29	0.30
0.30 - 0.39	0.40
↓ (etc.)	↓(etc.)
0.90 - 1.00	1.00

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In similar fashion, plant ages are grouped into five-year increments. More rigorous account of both plant factor and age could be taken, of course, at the expense of increased computer time requirements.

The combining of effluents for all plants at a site into a single set of air and water effluents effectively specifies each site as a point source of radionuclides, simplifying calculations in subsequent subelements of the HERMES model.

In addition to the data on radionuclide source strengths, the RADREL output tape record contains several other data banks for use of the HERMES subelement codes that follow. The complete output tape contains 6 files, as follows:

File 1	Title and indices, for use of other programs, defining the number of sites, months, isotopes, isotopic release to air and water, and of total nuclear facilities in the region.
File 2	Listing of half-life data for isotopes considered.
File 3	Site data for air transport module, i.e., location (latitude and longitude), stack height, and startup year of the first plant at the site.
File 4	Site data for water transport module, i.e., river name and river mile for each site.
File 5	Radionuclide release rates (picocuries per sec.) to atmosphere, by isotope, for each month of the study year, for each site.
File 6	Radionuclide release rates (picocuries per sec.) to water bodies, following same format as atmosphere release data.

A complete listing of RADREL is found in Appendix B.

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D. LIVING PATTERNS MODEL

The subelements of the HERMES code which follow RADREL require, in addition to radionuclide release data, large amounts of data on the area being studied, its population, food production and consumption, and the many activities which can contribute to radiation dose. This information is contained in a data bank and, collectively, forms the Living Patterns Model.

Webster's Seventh New Collegiate Dictionary defines a pattern as "a reliable sample of traits, acts, or other observable features characterizing an individual." The Living Patterns Model (LPM) attempts to satisfy this definition for the UMRB case study. This simulation technique gives a descriptive estimate of where the people live, what foods they eat, produce, and irrigate, and where the food is grown and procured if local production is not enough to satisfy demand. The model also gives an estimate of the recreational activities of a typical individual, including the types of recreational activities likely to contribute to dose, where these activities are undertaken, average time (hours per day) spent at the activities, and seasonal variations in activities. Estimates of drinking water sources and purification treatments are also provided.

Complete evaluation of each of the above patterns for each and every individual would require careful perusal of enormous amounts of data. This is neither desirable nor necessary. For example, the central study area for the UMRB case comprises some 303,230 square miles of land and approximately 18 million[24] people. One can easily deduce that if geographic units smaller than a county were employed, the data handling would become unmanageable, not only for creation of the LPM but for use by Air (ARTRAN) and Water Transport (WTRAN) Models and the Exposure Pathways (DOSE) Model. A literature search revealed that the lowest level for which data were reliably available was at the county level.

The overall data flow for the simulation of the LPM subelement is shown in Figure III-14. Links are provided for both ARTRAN and WTRAN,

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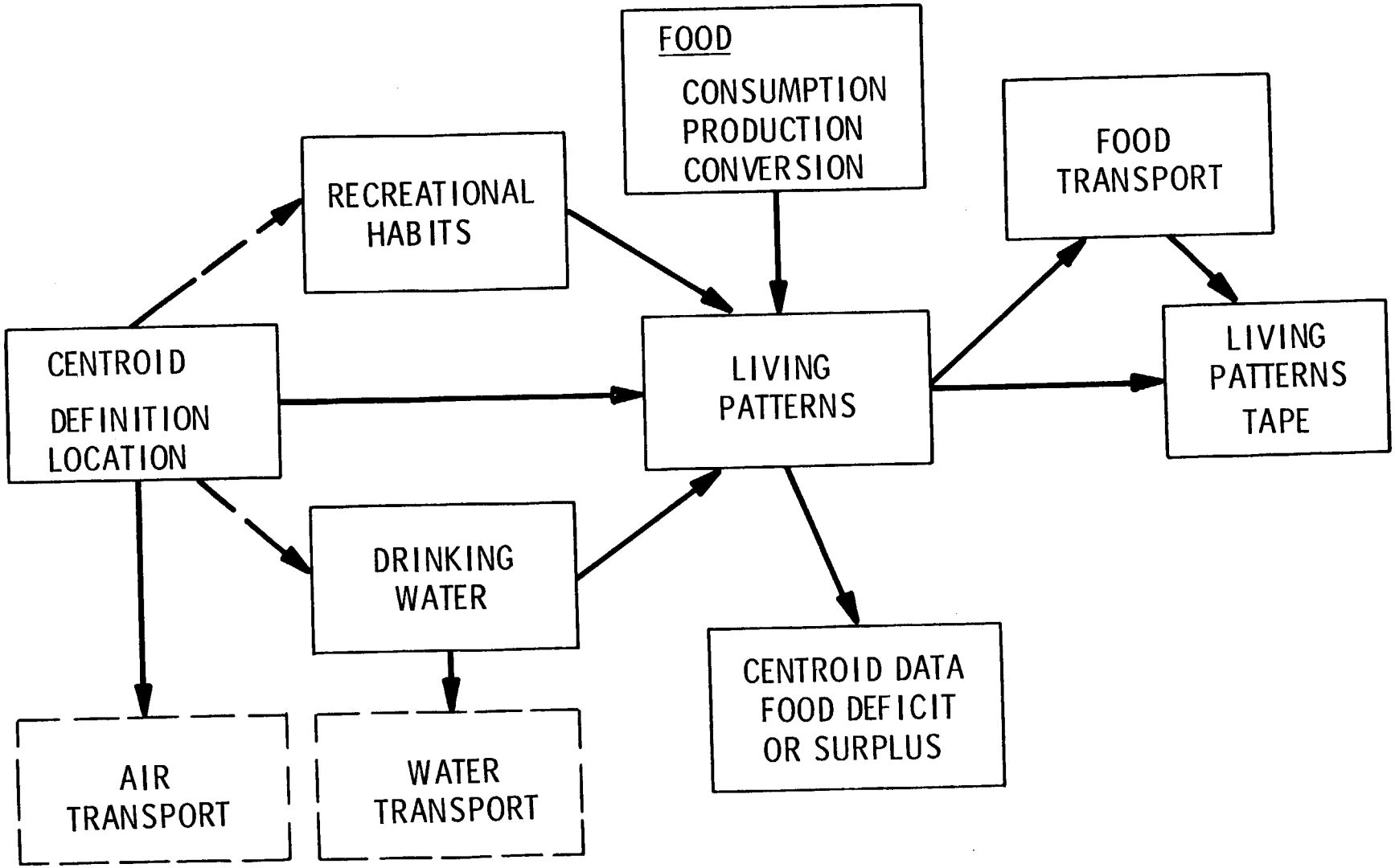

Figure III-14: Living Patterns Data Flow

i.e., basic centroid location data (latitude and longitude) and river mile locations for drinking water access. In addition, LPM provides data to DOSE in the form of recreational habits, food consumption characteristics, food acquisition patterns, and population statistics for the study year.

CENTROID DESIGNATION

The organization of living patterns data is best described by reference to the methods used in the study of the UMRB region.

The UMRB study area was divided into three hundred unique geographical locations (Figure III-15). Data for 479 counties were used either as single-county or multiple-county units to provide the basis for data assembly and evaluation for the entire model. These geographical locations were designated as "centroids."

Urban counties and counties that contained possible power plant sites were defined as single-county centroids. The remaining counties were combined into multiple county centroids with two limitations: they must be of like classification (Rural-nonfarm, or Rural-farm), and the area delineating a centroid must not cross state boundaries.

The centroids were numbered from 1 to 300, utilizing a north to south - east to west scheme based upon latitude and longitude, with location accuracy to the nearest minute. For purposes of this study, the point chosen to locate an Urban centroid was the latitude and longitude of the major city. Rural and Rural-nonfarm centroids were defined as being located at or near the geographical center of the area represented by the centroid. The centroid geographic and demographic data are given in Appendix G.

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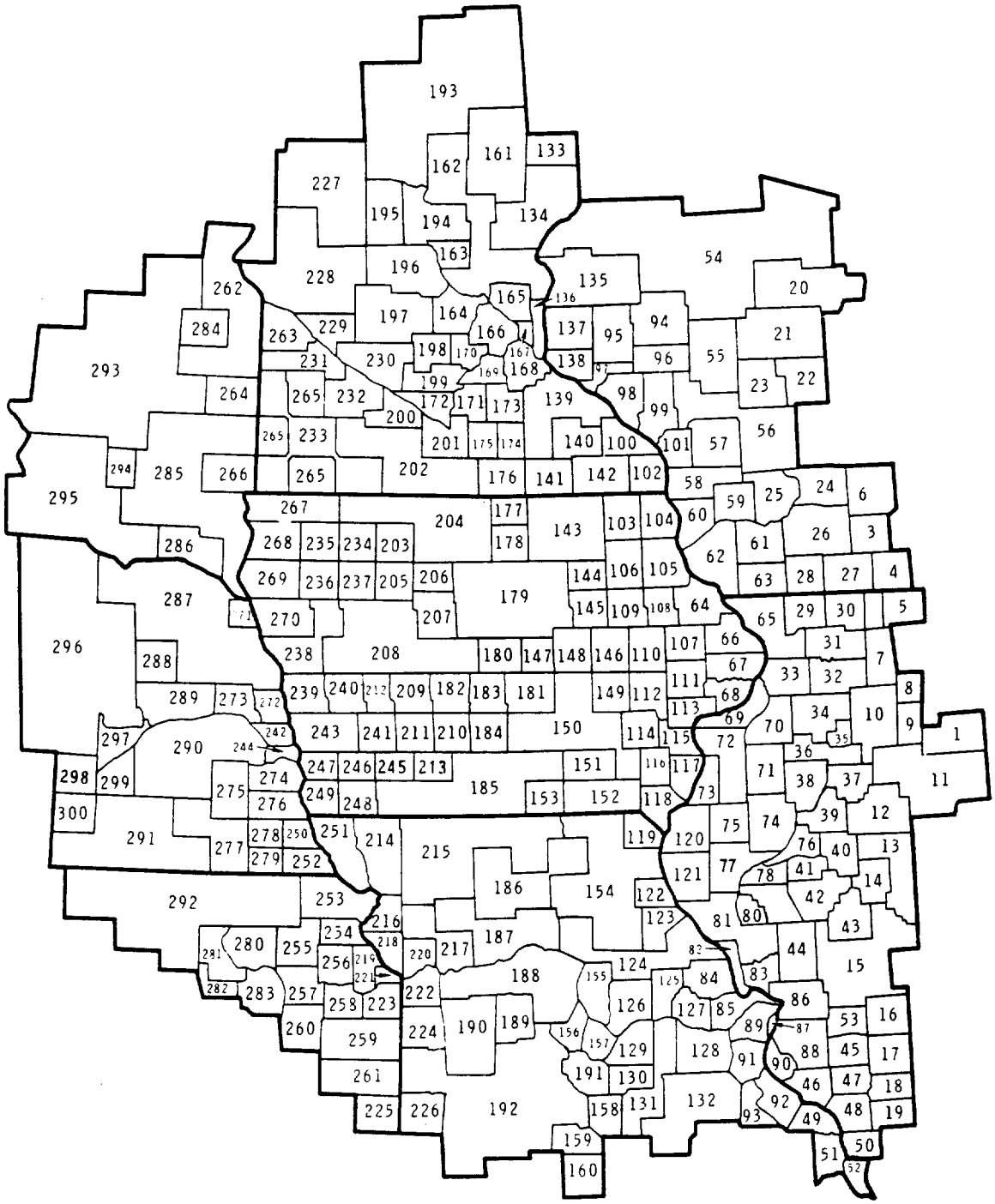

Figure III-15: UMRB Study Area Centroid Map

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POPULATION PATTERNS

The population of each centroid for the year 2000 was determined by extension of the 1940 to 1970 growth rate to the 1970 to 2000 time period. Actual county populations for 1940 and 1970 were tabulated and summed to obtain the centroid populations. Bureau of the Census data were utilized in this tabulation.[25, 26, 27]

The pattern of food consumption varies as a function of the urbanization characteristics of an area. The three classifications commonly used are Urban, Rural-nonfarm and Rural-farm. These classifications as used by the Population Census (1960)[26] and the Agriculture Census (1964)[28] are taken to mean:

- Urban - Households in places with at least 2500 inhabitants and in closely settled fringe areas surrounding cities of 50,000 or more inhabitants.
- Rural-nonfarm - Households outside of urban places without a farm operator.
- Rural-farm - Households outside of urban places with a farm operator.

The above definitions, if followed literally, are much too unwieldy for use in the UMRB study. The report, "Food Consumption of Households in the North Central, Spring 1965"[24] estimated that 70% of the households were Urban, 20% were Rural-nonfarm, and 10% were Rural-farm. This description technique was extended to the county level, e.g., all counties were ranked by population density, and a cumulative percentage of the population of the study area was tabulated. Those counties, in order of decreasing population density, which included 70% of the total population were classified as Urban counties. Those encompassing the next 20% of population were classified Rural-nonfarm, and the remainder were designated as Rural-farm.

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DRINKING WATER

The ingestion of water is a primary pathway for intake of radioactive materials. To allow proper evaluation of the contribution of drinking water supplies to population dose, a survey was made of the sources of drinking water and of the treatment given the water, throughout the study area. For larger metropolitan areas, detailed information on water supplies was available.[29,30] For smaller communities, data from a U. S. Public Health Service survey of water supply facilities in the study area[31] were used.

For use in the LPM, drinking water sources were classified as:

- River water
- Ground water
- Both river and ground water
- Surface water (lakes)

Similarly, drinking water treatment processes were classified into four categories:

- No treatment (except chlorination)
- Filtration
- Chemical treatment
- Both filtration and chemical treatment

Data descriptive of the source of the drinking water for each centroid were also compiled; for purposes of the LPM, all drinking water for a given centroid was assumed to come from a single source representative of the centroid, and a single treatment process was assumed to be provided. For the larger metropolitan areas, factual data on water supplies were used,[29,30] and were assumed to represent supply and treatment for the entire centroid containing each city. For less populous centroids, a single source location and treatment were specified, representing the water supply to the entire centroid.

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WORK AND RECREATIONAL PATTERNS

Activities of an individual create exposure patterns that may contribute to the overall dose he receives. These activities vary in accordance with the several variables that make up the living pattern characteristics of a population group. Standing or sitting on a river bank while fishing may bring an individual in contact with material that has been transported by the river or stream and deposited on the bank. Likewise, an individual submerged in water while swimming may be exposed to different radioactive material. Thus, these recreational habits and others must be considered a part of the living pattern of consequence to this study. The activities assumed to be of importance were swimming, boating and water skiing, fishing, waterfowl hunting, and upland game bird hunting. An estimate was made for the number of hours per month a typical person from each centroid would devote to such recreational activity. (The category boating and water skiing includes canoeing, sailing, barge fishing and boat fishing; whereas, fishing is used to denote bank fishing only.) The seasonal characteristics of each recreational activity were considered in establishing the number of hours each month in which the average individual engaged in each recreational pursuit. These time patterns were established based on 1970 fish and game regulations and on information obtained from References (32) through (37).

FOOD PRODUCTION AND CONSUMPTION

Food consumption patterns of individuals in the study area form an important aspect of the living patterns. Consideration was given to some 73 foods (Table III-2) included in the dietary habits of inhabitants of the area. Production and consumption data for these foods were assimilated for each centroid. The food balance (deficit or surplus) for each centroid was determined by comparing consumption statistics, less home production, with production statistics. The shipment of food from surplus areas to deficit areas was allowed.

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TABLE III-2

FOOD TYPES CONSIDERED IN LIVING PATTERNS MODEL

1. Strawberries
2. Other Berries
3. Grapes
4. Plums
5. Pears
6. Apples
7. Peaches
8. Apricots
9. Cherries
10. Cantaloupe
11. Other Melons
12. Bananas
13. Pineapple
14. Lemons
15. Limes
16. Grapefruit
17. Avacado
18. Oranges
19. Irish Potatoes
20. Sweet Potatoes
21. Carrots
22. Beets
23. Turnips
24. Dry Onions
25. Green Onions
26. Other Root Veg.
27. Cabbage
28. Lettuce
29. Other Leafy Veg.
30. Pumpkin
31. Squash
32. Tomatoes
33. Asparagus
24. Lima Beans
35. Wax Beans
36. Peas
37. Celery
38. Cucumbers
39. Cauliflower
40. Sweet Corn
41. Broccoli
42. Other Veg.
43. Rhubarb
44. Grain Corn
45. Oats
46. Rye
47. Barley
48. Rice
49. Wheat
50. Fresh Milk
51. Frozen Milk
52. Cream
53. Cheese
54. Processed Milk Desserts
55. Butter
56. Eggs
57. Beef
58. Veal
59. Lamb
60. Liver
61. Fresh Pork
62. Cured Pork
63. Canned Pork
64. Pork Lunch Meat
65. Chicken
66. Turkey
67. Water Fowl
68. Fresh Ocean Fish
69. Processed Ocean Fish
70. Shell Fish
71. Sports Fish
72. Upland Game Birds
73. Secondary Water

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Food production estimate data were determined by assessment of county production figures found in the 1964 Census of Agriculture[28] for each state in the study area. The same documents provided estimates of irrigated production from which the percentage of total production attributable to irrigated crops was calculated.

The units of measurement for production and consumption data were not uniformly catalogued. These data were converted to the common base of pounds per household per week, except for eggs which are given in dozens per week. Numerous assumptions were required to make this conversion. For example, beef production data were given as number of cattle sold for slaughter while consumption was in pounds. Therefore, a 1000 pound steer was assumed to incur 43% loss in processing resulting in 570 pounds available for consumption. Other differences were also found, e.g., the 1964 Census of Agriculture did not utilize the same units of measurement from state to state. For example, apples were listed in pounds in three states, but in bushels in the remaining five states. To further compound the problem, produce (i.e., carrots, peas, lettuce, etc.) were almost universally reported in acres of production. Agricultural statistics for 1967, as published by the United States Department of Agriculture,[38] were utilized to obtain these basic production figures to convert to pounds.

The 73 food types were combined into 35 categories. This categorization provided a more efficient model for handling of data, not only in this model but in the subsequent evaluations of exposure pathways and dose (Table III-3). Most fresh-food categories have corollary categories representing processed food types. Categorization in this manner was made to represent differences in exposure and subsequent treatment of the foods, and their effects on dose.

Food Transportation and Distribution

There is an obvious correlation to be made between the proximity of a food production area to an environmental pollution source and the degree

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TABLE III-3

FOOD CONSUMPTION CATEGORIES FOR LIVING PATTERNS MODEL

1. Fresh Berries
2. Processed Berries
3. Fresh Tree Fruit
4. Processed Tree Fruit
5. Fresh Melons
6. Fresh Tropical Fruit
7. Processed Tropical Fruit
8. Fresh Citrus Fruit
9. Processed Citrus Fruit
10. Fresh Potatoes
11. Processed Potatoes
12. Fresh Root Vegetables
13. Processed Root Vegetables
14. Fresh Green Leafy Vegetables
15. Processed Green Leafy Vegetables
16. Fresh Other Above Ground Vegetables
17. Processed Other Above Ground Vegetables
18. Grain and Grain Products
19. Rice and Rice Products
20. Wheat and Wheat Products
21. Fresh Milk
22. Processed Milk Products
23. Butter
24. Eggs
25. Beef and Lamb
26. Fresh Pork
27. Processed Pork
28. Poultry
29. Water Fowl
30. Ocean Fish
31. Processed Ocean Fish
32. Shell Fish
33. Sports Fish
34. Upland Game Birds
35. Secondary Water

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of pollutant loading that may be found in the marketable crop. However, it is not a sufficient premise that the resultant effects of this variation would be applied only to the immediate proximity of the food production area. Food stuffs are transported, sometimes over great distances, to various processing and marketing regions for consumption. To accommodate this factor in the HERMES code, a transportation model was employed to simulate the shipment of food between centroids. This model synthesizes a transportation network for food shipments, simulating exports of food from surplus areas and imports to areas of deficit. In so doing, it acts to minimize food transportation charges by searching for the nearest surplus area that might be used to satisfy a deficit. These patterns of shipment are representative of those for many foods which are perishable or for which transportation charges are an important factor in total food cost. They were assumed to hold true also for other foods, such as wheat and certain processed foods, whose distribution tends to be more widespread.

Food consumption habits of modern man, be he urban or rural, are cosmopolitan. A quick survey of Table III-3 will show that there are several food products that cannot be satisfied from within the UMRB area. It is also a well known fact that the study area is a primary producer and exporter of food to far distant points. To accommodate these factors, (trans-shipment between centroids, import from outside the region, and export out of the region), the following procedures were adhered to:

- All imports to satisfy deficits would be first filled by excess production from the nearest centroid.
- Export out of the region would be allowed after all internal deficits were satisfied.
- Imports from outside the region were assumed to be free of radionuclide contamination.

The transportation of food from surplus to deficit areas is simulated by means of two computer codes, FIGURE and TRANS. Data flow charts for

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these codes are shown in Figures III-16 and III-17; program listings are given in Appendix B.

DATA REDUCTION

All data generated for the Living Patterns Model were compiled, correlated, reduced to a computer-compatible format, and placed on magnetic tape for use in subsequent subelements of the HERMES code. Format for the LPM tape is described in Appendix D.

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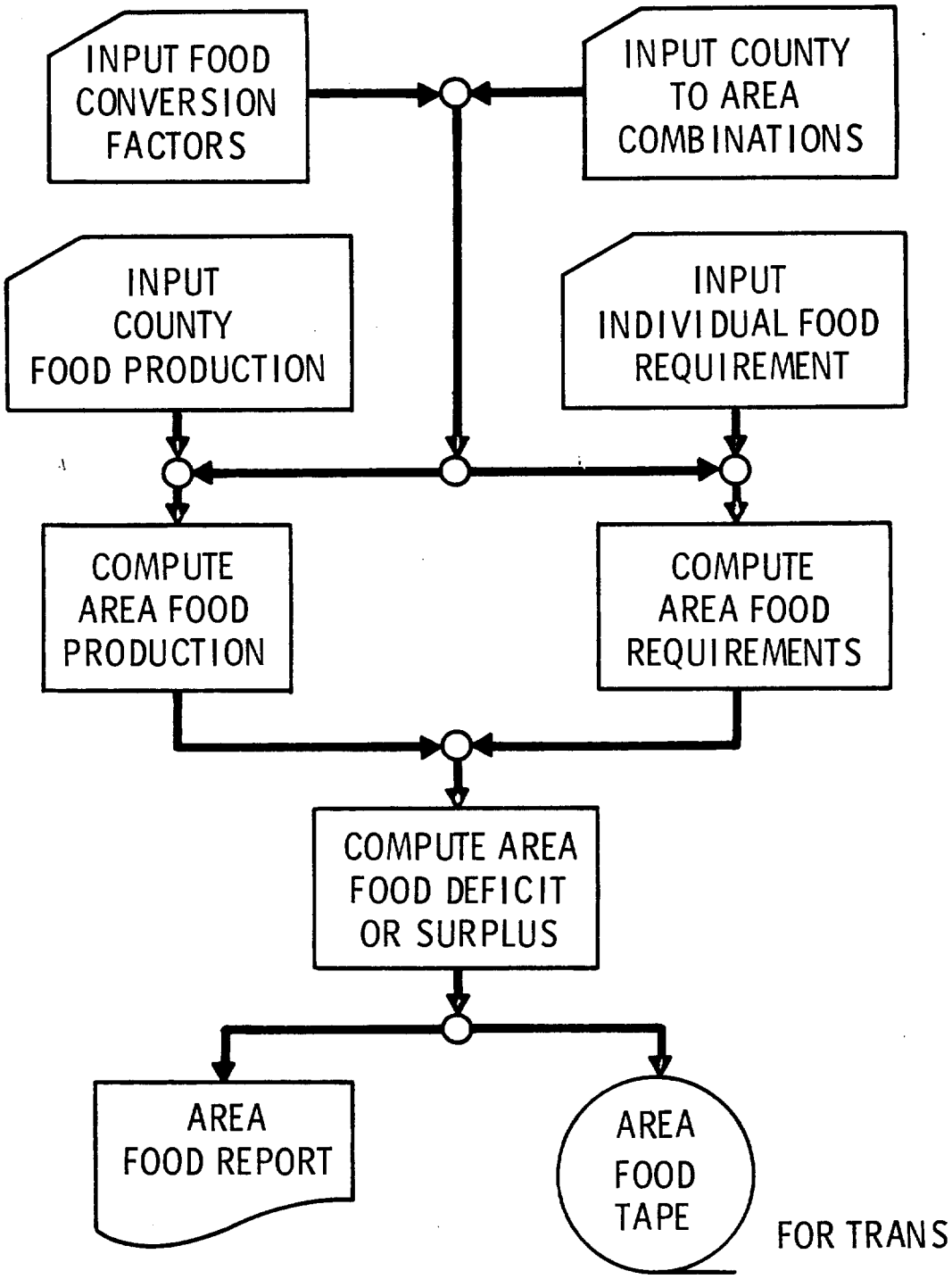

Figure III-16: Data Flow for FIGURE

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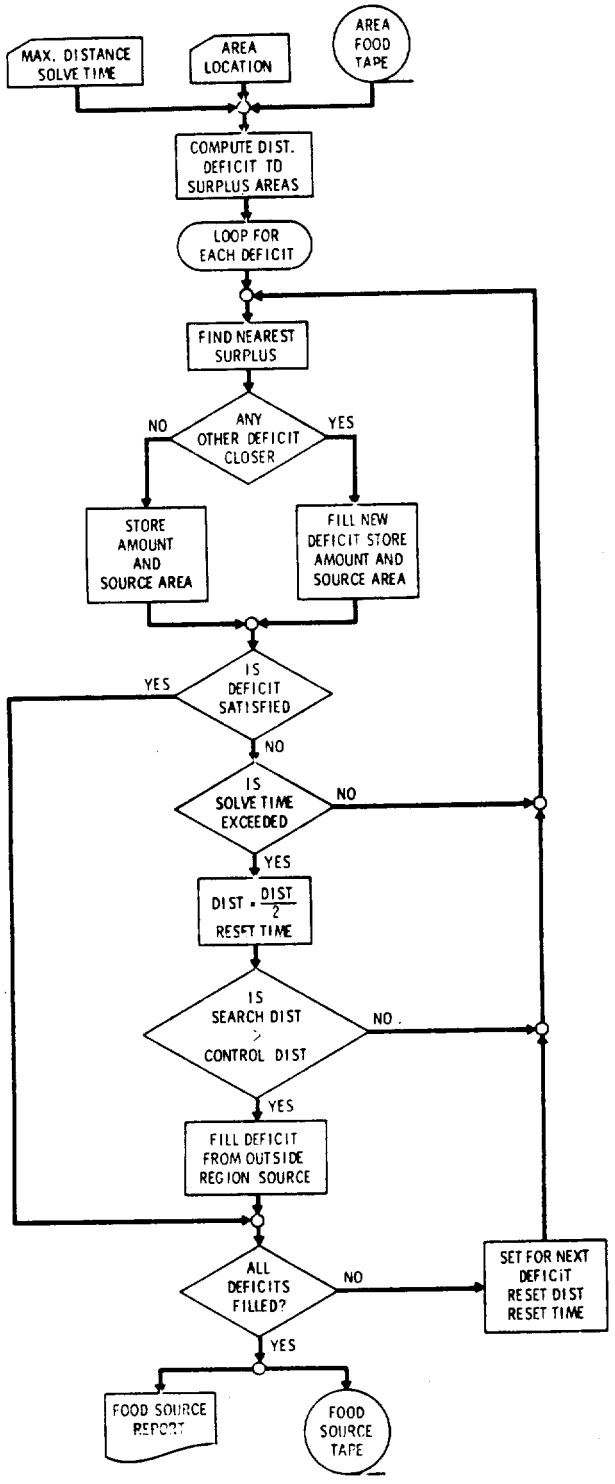

Figure III-17: Data Flow for TRANS

E. ATMOSPHERIC TRANSPORT MODEL

The ARTRAN code is designed to calculate the atmospheric transport, diffusion, and deposition of radioactive effluent downwind of the various nuclear facility sources to the receptor locations - - the "centroids" in the study area. The diffusion equation employed is a modification of the bivariate normal model

$$\bar{\chi} = \frac{\dot{Q}}{2\pi\ \sigma_y \sigma_z\ u} \exp \frac{-1}{2} \left\{ \frac{y^2}{\sigma_y{}^2} + \frac{h^2}{\sigma_z{}^2} \right\} . \tag{10}$$

As an initial simplification Equation (10) is integrated with respect to y from $-\infty$ to ∞ which yields

$$\bar{\chi}_{CWI} = \left(\frac{2}{\pi}\right)^{0.5} \frac{\dot{Q}}{\sigma_z u} \exp \frac{-1}{2} \left\{ \frac{h^2}{\sigma_z{}^2} \right\} . \tag{11}$$

If the time period of averaging for χ is very large in comparison with the period over which the mean wind is computed, as it is in this case, Equation (11) may be further modified through multiplication by the frequency of wind direction in a given sector and division by the width of the sector, to yield:

$$\bar{\chi}_{LTA} = \left(\frac{2}{\pi}\right)^{0.5} \frac{0.01\ f\ \dot{Q}}{\sigma_z \bar{u}\ (2\pi x/n)} \exp \frac{-1}{2} \left\{ \frac{h^2}{\sigma_z{}^2} \right\} \tag{12}$$

Equation (12) is the basic equation used in this code.

In the equations cited above the following nomenclature holds:

$\bar{\chi}$ is the average air concentration usually expressed as picocuries per cubic meter (pCi/m^3). When the subscript 'CWI' is used the average air concentration values are representative of the entire circular area around a point source. The subscript 'LTA' denotes the average air concentrations in a particular sector of the compass. If the compass rose is divided into n sectors, each sector is characterized by the sector angle θ and a frequency value "f". For the

UMRB case, the sector angle is 22.5°, i.e., a 16-point compass rose.

$\dot{Q}$ is the rate of discharge of effluent into the atmosphere, picocuries per second (pCi/sec).

σ_y and σ_z are the statistical diffusion parameters representing the standard deviation of distribution of pollutant material in the airborne effluent plume. These are usually accepted to be a Gaussian distribution for relatively short travel distances, and approaching a uniform distribution for long travel distances. In particular, σ_z for distances greater than that where $\sigma_z = 0.8L$ is considered to be a uniform distribution. For calculations of χ for these distances, Dickson et. al.[39] have shown that σ_z values would be of the form:

$$\sigma_z = 0.465\ L + \frac{(S-X_L)}{X_L}\ (0.335L) \text{ for } X_L \leq S \leq 2X_L \tag{13}$$

and

$$\sigma_z = 0.8L \text{ for } S > 2X_L \tag{14}$$

where

S is the downwind distance (meters)

L is a seasonal mixing depth (meters)

X_L is the downwind distance beyond which vertical mixing would be inhibited. This is also the downwind point where the vertical distribution of the pollutant loading may be considered to commence changing from Gaussian to uniform.

$2X_L$ is the downwind distance where the vertical distribution of pollutant load concentration may be assumed to be uniform.

$\bar{u}$ is the mean wind speed variable. In this code, because surface based data are used, this is the climatological mean wind speed for the month and compass rose sector.

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y is the crosswind distance over which the σ_y value is taken for a specified downwind distance χ. For this study, since we are considering a basic 22.5° sector, y would be the arc distance at some radial distance X.

h^2 is the square of the stack height, or emission point above the surface. Stack height for the UMRP study was set at 100 meters; no direct credit was taken for initial plume rise.

SCOPE OF MODEL

Calculations in this code are made for the radioactive nuclide contamination contribution, from the several nuclear facility sources, at a series of geographical areas represented by centroids. As previously defined, a centroid is a geographical point downwind of the source, which approximates a center of population density. Since it is important, when dealing with radioactive effluent diffusion, to have a knowledge of both air concentrations and surface deposition, it is necessary to calculate the depletions of the plume upwind of the receptor. These depletion factors -- radioactive decay, dry fallout and wet removal -- are derived by assuming that each may be represented by an exponential of the form $\dot{Q}_1 = \dot{Q}_o e^{-bt}$. In these equations, $\dot{Q}_1$ is the effective air concentration at a downwind point resulting from depletion of the initial source $\dot{Q}_o$, as a function of travel time and another factor representative of the depletion process being considered. For radioactive decay, b is equal to $\frac{\ln 2}{T_R}$ where T_R is the nuclide half-life. The dry deposition term is V_d/X, where V_d is the deposition velocity and X is the downwind distance. The entire function bT for dry deposition may then be represented by $V_d t/X \equiv V_d/\bar{u}$. Depletion of the plume upwind of the centroid by precipitation processes is accounted for by assigning to the coefficient (-bT) appropriate values described by λ_w and t. Here λ_w is the wet deposition coefficient variable that describes the below cloud washout characteristics for the nuclide of concern. The three equations are then

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$$\dot{Q}_R = \dot{Q}_o \, e^{-\lambda_R t} \tag{15}$$

$$\dot{Q}_D = \dot{Q}_R \, e^{-\lambda_d t} \tag{16}$$

$$\dot{Q}_w = \dot{Q}_R \, e^{-\lambda_w t} \tag{17}$$

When the appropriate calculations have been made by application of Equations (15), (16) and (17), the resultant is the "effective source" at the downwind distance of the centroid. Equation (12) may then be solved to provide an initial air concentration value for this geographical location without concern for depletion processes. This value, as a function of nuclide, is then depleted by both wet and dry deposition, at the centroid location, over the time available for these processes to be operative. The remainder is the effective air concentration.

The calculations referenced above are repeated for each month, source, centroid, and nuclide (Figure III-18). An obvious point regarding good computer programming practice should be made here. Before any calculational process is initiated, a check should be made to ascertain the validity of proceeding further. As one example, if a nuclide source term were zero, it would be unnecessary to proceed further in the calculational routine. In the code, checks of this nature are made for: source equal to zero, source to centroid travel time excessive and unrealistic, or source to centroid distance unrealistically large. These checks are made at the earliest possible time to eliminate unnecessary computational steps and thus reduce running time.

The data resulting from the computations referenced above are accumulated for the contributions to each centroid and nuclide series for each month from each source. Thus, during any one month of the iteration process, each plant site and each nuclide source term is checked for its contribution at the centroid, then the values are calculated and accumulated. Because of the large number of data points involved, the data arrays are stored onto and retreived from drum as required. To accomplish this, one of the

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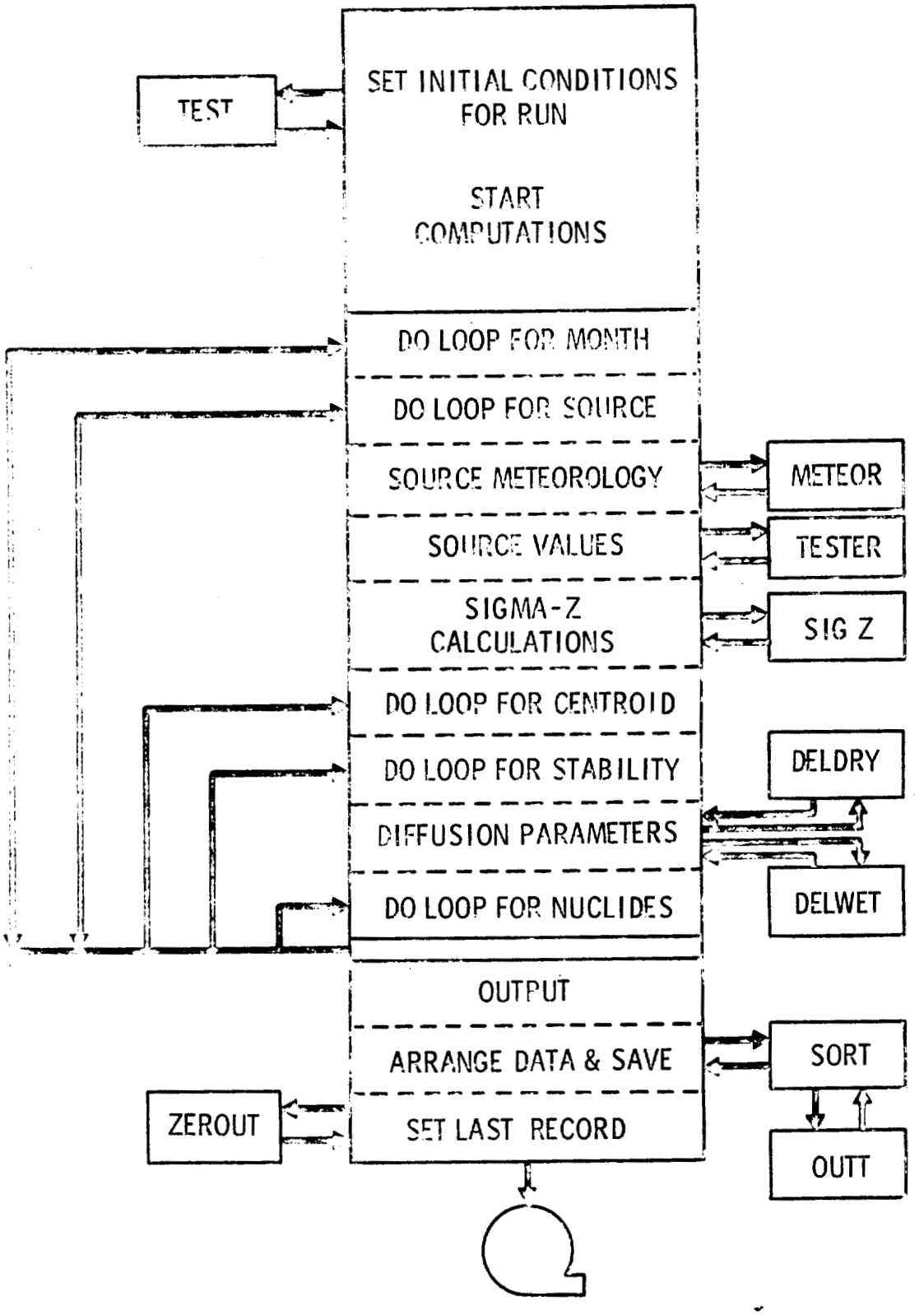

Figure III-18: Data Flow for ARTRAN

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first actions taken in the program is the construction of a 'drum map'. The pertinent addresses and storage location sites are retained in core for use as required.

DIFFUSION CHARACTERISTICS

The several variables used in the basic equations of this code may be assigned values by use of concepts developed by the research efforts of the past few years. Unfortunately, these concepts are not always in agreement, particularly for downwind travel distances in excess of 100 km. A particular instance is the diffusion variable σ_z. There are several reliable concepts, all in general agreement, that may be used to derive suitable values for σ_z for downwind distances of a few thousand meters. However, for downwind travel of distances of tens of kilometers there are very few sources of data. For this study this apparent dilemma has been considered and for downwind distances of less than those where $\sigma_z = 0.465L$, the 'Pasquill' curves[40] are utilized as a basic source for determination. Because the basic meteorological data are derived from surface climatological records, as discussed below, it has not been possible (nor in reality very practical) to develop a complete stability criteria breakdown for determination of σ_z. Instead, it has been assumed that, on the average, the daytime stability classification could be approximated by Type C and the nighttime classification as Type D (code capability is built in to accept the six stability classes defined in Reference (40), as well as the more recently adopted Type G classification). Further, it is assumed that, on the average, vertical diffusion is limited by a stable layer.

A discussion of the equations and concepts that accommodate this assumption has been provided earlier in this chapter. The variables used in the calculation are: WINDAY, WINNIT, SUMDAY, SUMNIT, WDALVL, WNTLVL, SDALVL, and SNTLVL. The syntax scheme used to develop these variable names is: WIN or W denotes winter, SUM or S denotes summer, DAY or DA denotes daytime, NIT or NT denotes nighttime and LVL denotes mixing layer depth. Thus, WINDAY is the variable for control of the downwind distance for winter day time conditions. These variables are preset as follows:

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- WINDAY = 5000 (m)
- WINNIT = 8000 (m)
- SUMDAY = 20000 (m)
- SUMNIT = 40000 (m)
- WDALVL = 800 (m)
- WNTLVL = 300 (m)
- SDALVL = 1000 (m)
- SNTLVL = 500 (m)

Changes may be made, at the user's discretion, by use of the NAMELIST option in OPERAT (see Appendix D).

SURFACE DEPOSITION

Determination of appropriate deposition velocities for surface accumulations of pollutant material is in accord with the Hanford experimental work.[41] This concept describes deposition coefficients ($v_d/\bar{u}$) as functions of atmospheric stability and particle characteristics. Analogous concepts for precipitation process plume depletions are not well documented for a large variety of radionuclides. In this chapter conceptual relationships for gaseous effluent depletions provide a basis for the assumptions of below-cloud washout in the code. Washout of particulate matter is calculated by assuming that all of the particulate matter are in the 1-micron size range and that the primary depletion mechanism is below-cloud washout. Slinn[42] has shown that the washout coefficient may be closely approximated by

$$\Lambda(a) = \frac{J_o}{2\,R_m}\left[\left\{1 - \exp\left(\frac{-K}{k}\right)\right\} + \frac{0.8}{Pe}\left\{1 - 0.8\ [Re]^{1/2}\ Sc^{1/3}\right\}\right] \tag{18}$$

where

$\Lambda(a)$ is the washout coefficient as a function of particle radius a.

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J_o = precipitation rate

R_m = mean raindrop size

K = Stokes number $2/9 \frac{a^2 \rho_p}{R^2 \rho_a} Re$

k = 2 (an empirical constant)

Pe = Peclet number (ReSc)

Re = Reynolds number (VR/ν) where V is terminal velocity of drop with radius R and ν is the kinematic viscosity

Sc = Schmidt number (ν/D) where D is the mass density of the aerosol

The basic input requirements for most of the assumptions discussed above are an estimate of meteorological variables for the source area. In the present code, these have been represented from the basic climatology by assigning the records from the nearest reporting station to a particular plant site.

CODE STRUCTURE AND OPERATION

The main program of this code is the routine called ARTRAN (see Appendix B). The first action of this routine is to make the initial call to the subroutine TEST (Figure III-18). This subroutine, discussed later, reads in operating data, initializes certain data arrays and subroutines, and calculates and stores drum addresses.

Immediately after these first actions, the major iterative calculation loops are started. The sequence of iterative operation is month, source, centroid, and nuclide. These nested loops perform the following functions:

- Acquire data by call to subroutines as required.
- Iterate through data arrays to acquire appropriate data for the particular calculation being performed.

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- Calculate appropriate values. Where calculations would be meaningless, i.e., zero source strength, incredible travel distances, etc., the iterative process is terminated at the earliest possible time.
- Store calculated data in temporary arrays.
- Read data to and from drum.

When the iterative process is complete, the program then activates subroutines designed to acquire data from drum, sort these data, output it to tape for further use, and output to the printer, if desired.

The first subroutine called during operation of the ARTRAN code is TEST. This subroutine is the primary vehicle by which data are read into the computer for processing. TEST is written as a two-part subroutine; its mode of use is governed by means of an ENTRY point. The full subroutine is used only once, in the first call from ARTRAN. Subsequent calls, which use only portions of the TEST subroutine, are made by means of a call to TESTER.

The TEST routine, on initial call, sets up program control variables, initializes certain data arrays, reads the three NAMELIST data lists (if required), initializes a subroutine called SIGZ, reads the input tapes for the initial data input, and sets drum file addresses. If desired, these data are printed out. On subsequent calls to TESTER, during the iteration loops of the main program, data are acquired from the data tapes as required.

Immediately after each source point loop is started, the subroutine METEOR is called. This routine acquires, arranges, and stores meteorological data applicable to the source and month under consideration for subsequent calculational requirements. These data are acquired from input tape.

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The next important action is within the centroid loop. The drum addresses of the data arrays pertinent to the particular loop process are identified, and the necessary actions are taken to bring these into core. Following this, the centroid loop begins to consider each location, sequentially, in relation to the particular source point. The first action is to determine the distance and sector angle for the transport deposition and diffusion calculations. A check is initiated to determine if the calculated distance separating source and centroid is too distant for further consideration.

The preset value for this check is 3×10^5 meters, but can be changed at the operator's discretion by an entry, DISMAX = XXXX., in the NAMELIST OPERAT. If the calculated distance exceeds the DISMAX value, an immediate transfer to the next centroid is made. If the calculated distance is within the operator-specified limits, then the meteorological data array is read to provide proper values for the calculated sector of: mean wind speed, percent frequency of wind direction, precipitation rate, percent frequency of precipitation occurrence, stability values, and percent frequency values for the selected stability category for calculation of the proper value for the source term.

Based upon the meteorological values now available, the subroutines DELDRY, DELWET and SIGZ, if appropriate, are called to provide additional data. If the conditions are not met for use of the Pasquill curves, then a value for σ_z is calculated by the NRTS[39] method. DELDRY calculates the dry deposition coefficient, λ_d, and the deposition velocity as a function of nuclide characteristics and Pasquill stability classification. DELWET calculates the wet deposition coefficient as a function of nuclide characteristics and precipitation rate.

At this point the code starts the iteration loop for nuclides. The first action is to identify the proper nuclide in the data array. The appropriate discharge rate value is then extracted and modified as a function of time. The result of this calculation is checked for a zero

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(or very near zero) condition. If this is detected, an immediate transfer is made to the next nuclide. If the source term for a particular nuclide is worthy of further consideration, then the plume depletion processes upwind of the centroid are applied. The first is for radioactive decay; the second, dry deposition; and finally, wet deposition. The resultant is an effective nuclide pollutant plume which would contribute to the ground deposition and air concentration at the geographical point of the centroid. By using this value, the effective mean air concentration is calculated, and the dry and wet deposition processes for that centroid are applied. The result is air concentration and ground accumulation at a specified centroid for the source, nuclide, and month being considered. The contribution from each potential source is summed for each centroid and nuclide for each month.

After the iterative processes described above are completed, the drum files contain all of the necessary data for output to tape and printer. Successive calls to the SORT subroutine take care of this function, and a call to OUTT in SORT activates the actual write process.

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F. WATER TRANSPORT MODEL

The water transport subelement of the HERMES code, WTRAN, is designed to calculate concentrations in streams of both dissolved radionuclides and radionuclides absorbed on sediments. In addition, concentrations of dissolved radionuclides are calculated for lakes fed by local runoff, for shallow groundwater recharged locally, and artesian groundwater recharged from distant sources.

SOLUTION TRANSPORT

Concentrations of dissolved radionuclides on a given stream are calculated by the algorithm:

$$C_{x,t} = \frac{1}{Q_{x,t}} \left[Q_{x-\Delta x,\ t-\Delta t}\ C_{x-\Delta x,\ t-\Delta t}\ e^{-\lambda \Delta t} + \sum_{1}^{n} Q_i\ C_i \right] \qquad (19)$$

where

$C_{x,t}$ = concentration in reach x, at time t

$Q_{x,t}$ = streamflow in reach x, at time t

λ = ln 2/half life

$Q_i C_i$ = fraction added in reach x (tributary flow, cooling water from power plants, etc.)

In cases where a tributary stream is large enough to be considered as a sub-basin, a concentration is calculated at its mouth for each time period simulated and stored with its associated flow for input to the trunk stream. The calculations above are stepped through a stream system, from upstream to downstream, and are repeated for each nuclide and for each month.

The proportion of radionuclides entering a waterway that are transported in solution is determined by a distribution coefficient, K_D, which is the ratio of the fraction of ions sorbed per unit weight of sediment

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to the fraction of ions remaining in solution per unit volume of solution. K_D is a steady state coefficient representing the total activity that can be absorbed on sediment under the prevailing chemical conditions. Sorptivity of certain ions is affected by pH; consequently, major changes in pH associated with, say, acid mine drainage, could invalidate this basic assumption. Presently, no provision has been included in the model to vary K_D as a function of pH, primarily because basic data are inadequate for the formulation.

SEDIMENT TRANSPORT

Sediment transport is determined by a set of equations that describe the sediment load characteristics of a given reach:

$$S = K_1 Q^{K_2} \tag{20}$$

where

S = sediment concentration or flow rate

Q = streamflow

K_1, K_2 = constants

This equation is used in the model to describe the relationship between monthly average streamflow rates and monthly average sediment flow rates; and thus to determine radionuclide-containing sediments will will be deposited or scoured in a given reach in a given month. Additional information in the form of a stage-discharge function or table, flood stage data, and data on particle size distribution are required to calculate overbank deposition associated with floods.

The sediment transport equation, Equation (20), is dependent on field data on sediment transport for calibration of the constants K_1 and K_2. The values of these constants depend on the characteristics of the stream bed and of the sediments. Since in many regions there is a paucity of

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data on sediment characteristics, the development of a method less dependent on observations may be desirable in the future.

GROUNDWATER AND SURFACE WATER CONCENTRATIONS

Concentrations of radionuclides in groundwater and local surface water are calculated by a different method than are river water concentrations. For groundwater and surface water, input data are required on the average monthly runoff rates and radionuclide deposition rates for each centroid being studied. In addition, for groundwater calculations, the centroid where the water is used must be correlated with centroids supplying the groundwater, and travel times must be defined.

CODE STRUCTURE AND OPERATION

The water transport model consists of two primary subunits: MAIN, which reads the input data; WTRAN, which calculates the concentrations and gives the output used in DOSE, through actions in subroutines called as required. MAIN, however, calculates local surface water and groundwater concentrations. A data flowchart of the model is given in Figure III-19. The code listing is given in Appendix B, and input card deck representations are shown in Appendix D.

The primary function of MAIN is to read and process control cards and set up interfaces with the RADREL, ARTRAN and DOSE subelements of the HERMES code.

The RMAP subroutine reads the River Map data cards, which provide directive information to the code as to the order in which the tributary streams join the main stem. River Map cards specify the appropriate river by use of the name in common usage. An exception to this occurs when two rivers or sections of rivers have the same name and must be listed in modified form, e.g., Platte (West) and Platte (East). The river code is a two-letter designation for each stream in the system. The first letter, which can vary from A(1) through N(14) corresponds to the trunk

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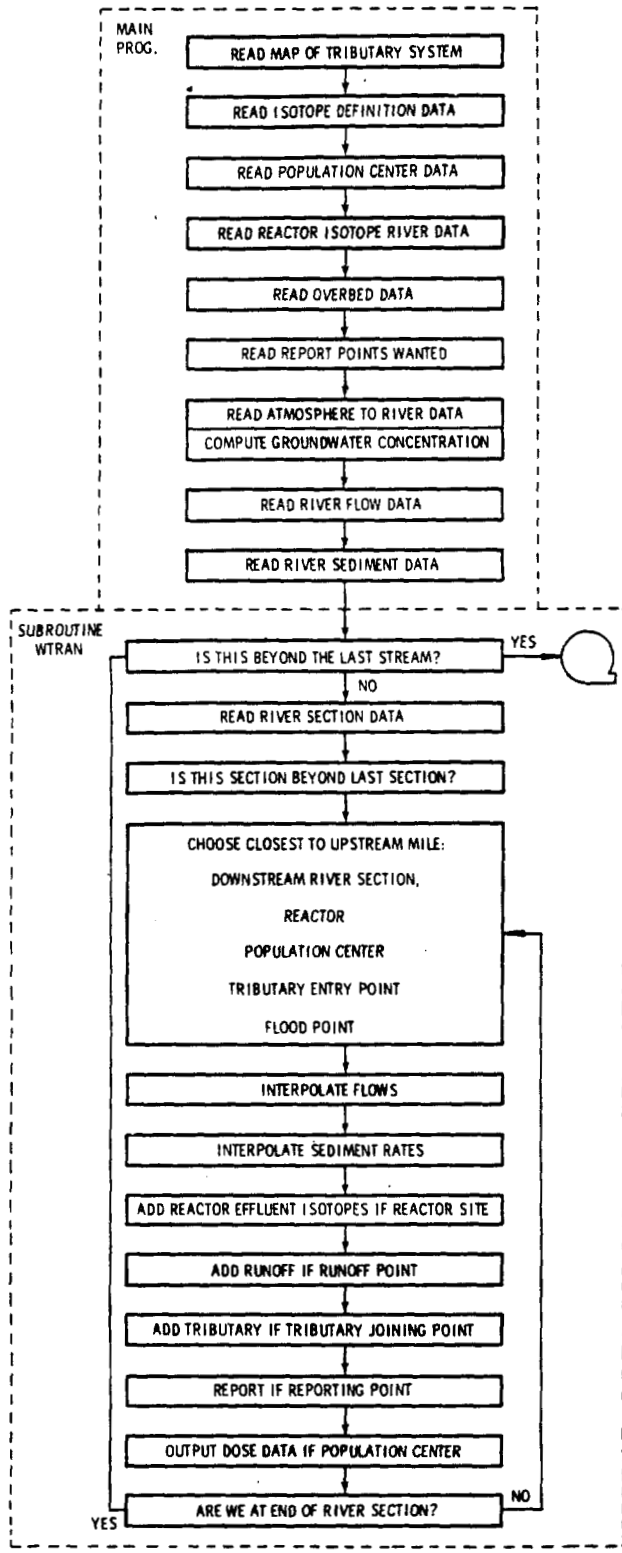

Figure III-19: Data Flow for WTRAN

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stream of each of the 14 major river basins as defined by the U.S. Geological Survey. The second letter is arbitrary but normally corresponds to the order, upstream to downstream, in which a tributary enters the main stream. For example, in the UMRB case, EC corresponds to the third tributary (C) to join the Mississippi River (E), which is U. S. Geological Survey Basin No. 5. Each stream is described in terms of river miles upstream of a reference mile 0, generally the mouth of the stream. For UMRB, mile 0 is at the confluence of the Ohio and Mississippi Rivers.

Subroutine FLREAD reads data cards that depict monthly flow data. These data are not restricted to average conditions; median or low flows may also be of interest. The streamflow records, the basis for input information, are generally obtained from U.S. Geological Survey data. Frequently, the U. S. Army Corps of Engineers has additional flow information in unpublished form; statistical flow-duration curves or tables are often available.

The flow cards include 6 columns for a date or other information, followed by the two-letter river code as described under Subroutine RMAP. River mile identifies the location of flow control on a given stream. An option is available whereby flows can be increased at the control point (e.g., at the confluence of two streams) or changed to a new value at a main stem control point (e.g., a dam). Flows are tabulated in units of 10^3 cubic feet per second.

The RBDPTS module reads river section data cards, and sorts and writes these data on drum for use in subroutine RBED. For computational purposes, the rivers are subdivided into reaches (or reservoirs). Detailed dimensions of a river are modified for computer use by transforming them into equivalent trapezoidal sections where the surface and cross-sectional areas are conserved and the depth is taken as the average depth. A given card depicts the length of a river reach: upstream top width, bottom width, depth and downstream top width, bottom width and depth. The density current indicator is not used in this model; it remains on

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the data cards to make the data compatible with other computer codes. Card columns 74-78 contain data that refer to the river mile at the upstream end of a given reach.

The POPCNT subroutine reads the tape created by the LPM to determine the river mile location of a given population center and the source of drinking water. These data are sorted and stored in core.

The ISODEF routine reads and processes isotope data for the water transport model.

The input to the DOSIS subroutine is from the output of the HERMES code subelement RADREL. The number of months, isotopes, and reactors are read from the first file; river miles and names are read from the fourth file; and a list of map numbers is created for each record in the sixth file. These map numbers are then regrouped by river and sorted by descending river mile.

Subroutine RUNPTS reads input data cards that indicate the point where runoff from each centroid enters a stream. This input accounts for the indirect contribution to the river system from atmospheric deposition at a given centroid.

The GNDM element is the only subroutine in which calculations for nuclide concentrations in groundwater and local surface water are made for direct input to the DOSE. In addition, GNDM reads the output from ARTRAN by centroid, calculates unit runoff by centroid, and determines (ground) water use centroid and groundwater source centroid. It also determines travel time if the use and source centroid are not identical.

The river sediment equations to be used and associated location data are read by RSED and stored in core.

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OVERBED reads and processes flood and sediment data associated with overbank deposition in times of flood flow. It also outputs the data for use in subroutine FLDRPT. Overbank deposition can be initiated by a stage-discharge (streamflow) function and its associated zero flood stage or by the user specifying a flood stage. An empirical equation for determining the density of sediments in reservoirs normally dry is included in OVERBED. Input of the decimal fraction of sand, silt, and clay in the suspended sediment is required for the density calculation.

CONTRL determines the nature of the printed reports. It is available for the user's convenience only in specifying printed output, and is not related to output required for DOSE.

WTRAN logic provides the calculational routines by which the river water transport of radionuclides are performed in a large DO loop for each stream in RMAP. Concentrations associated with suspended sediment, sediment deposition, and dissolved ions are calculated as output to tape for DOSE and/or are reported out in printed form. For each successive river reach downstream where a reactor site is located, nuclides may be added to the stream. If an overland runoff point or a tributary is encountered, nuclides are added. If the sedimentation rate is changing, a change in nuclide load in suspension is calculated; if flooding is encountered, overbank deposition of sediments and absorbed radionuclides is calculated; and if a point of interest is encountered, requested information is passed to DOSE tape or a report is printed, or both.

The modeling of a river basin, and of its characteristics in the transport of radionuclides, requires massive quantities of hydrologic data. Unfortunately, sufficient data to fully characterize a river basin are seldom available, and portions of this information must be estimated or extrapolated from available data. The scope of data needed is typified by References (43 - 58), used in the UMRB study.

WTRAN has been designed to handle these massive quantities of data, while providing to the user the ability to revise or update any data set.

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G. ~~RADIOACTIVE~~ RADIATION DOSE MODEL

The dose evaluation subelement of the HERMES code uses the output of ARTRAN and WTRAN, and the food and demographic studies from the Living Patterns Model (LPM) to estimate annual radiation dose (mrem/yr), dose commitment (mrem/50 yr), and integrated population dose (man-rem/yr), and integrated population dose commitment (man-rem/50 yr). The doses are calculated by considering the accumulation over previous years of long-lived nuclides in the environs. Doses are calculated for both external and internal exposure to the whole body and to certain selected organs (skin, lungs, GI tract, bone, thyroid, liver).

The following groups are considered:

- Average child (age 4)
- Maximum child
- Average teenager (age 14)
- Maximum teenager
- Average adult (age $\geq$ 18)
- Maximum adult

The maximum individuals are members of populations living at each population center of interest whose dietary and living habits tend to maximize the radiation doses they receive. For purposes of calculating integrated man-rems for either a population center or for the entire region, the population is divided into three age categories: 0 to 11, 12 to 17, and $\geq$ 18 years.

The integrated man-rem dose for the first category is taken to be the dose to the average child, multiplied by the number of persons in the range of 0 to 11 years. Similarly, the calculation for the second and third categories employs the dose to the average teenager and the average adult, respectively.

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Doses are calculated for each of several pathways of exposure (Figure III-20). Air and water concentrations are used directly to calculate doses to various body organs from inhalation of air, submersion in air, consumption of water, and immersion in water. Concentrations in river bottom sediment are used to calculate external exposure from fishing, hunting, picnicking, etc., along the rivershore. Deposition on farm land from air and from irrigation practices is used to estimate external exposure received while farming or hunting.

Such deposition is also used as input to the FOOD PATHWAYS MODEL (FPM) subroutine which calculates concentrations of radionuclides in animal feed crops, animal products, and food crops consumed by humans. Once the concentrations in the several foods have been determined by the FPM, then the dose to man from consumption of the various foods can be calculated from factors for annual dose and for fifty-year dose commitment.

The various considerations used in designing the FPM, the DOSE CALCULATION (DC) program, and the method employed in determining the values of the numerous dose factors required as discussed below. A listing of the code is given in Appendix B, and a data flow chart is shown in Figure III-21.

Although the general logic of the program is illustrated in Figure III-21, the following added comments may aid the user. A restart capability is provided to avoid the transformation of all input data except the parameters and the 3rd file of the LPM tape if these data remain constant from one processing to the next, e.g., if the program is restarted, only the parameters, the LPM tape and the restart tape are required.

One feature of this code requires that all of the food concentrations for a given centroid are calculated before any dose is calculated for that centroid. If food concentrations are input directly on cards, this calculation is bypassed and the input values will be used. The constants required for the transformation of input data in a form usable by the program are stored in subroutines POPFIL and DIET, and those used for the food

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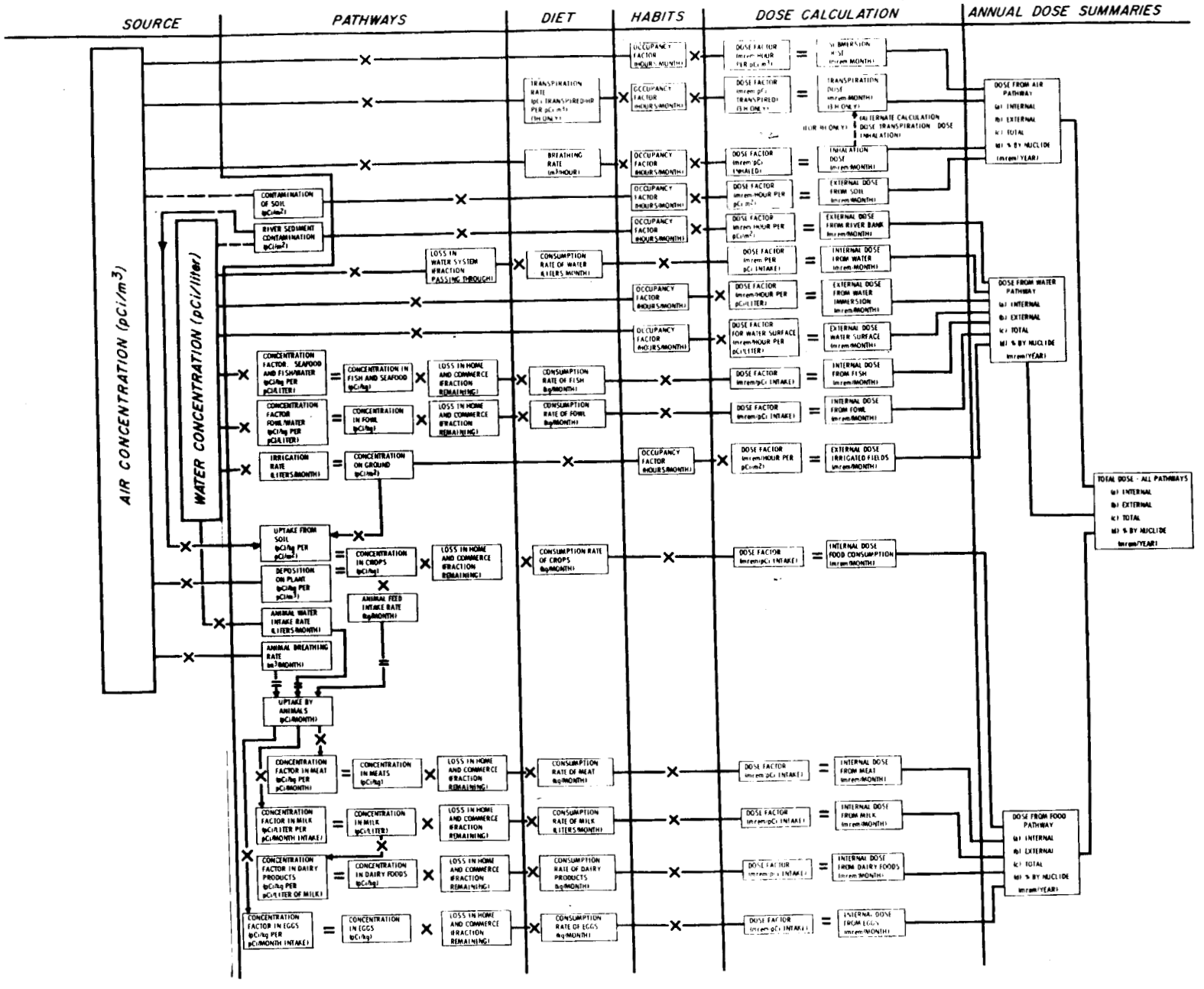

Figure III-20: Dose Calculation Model

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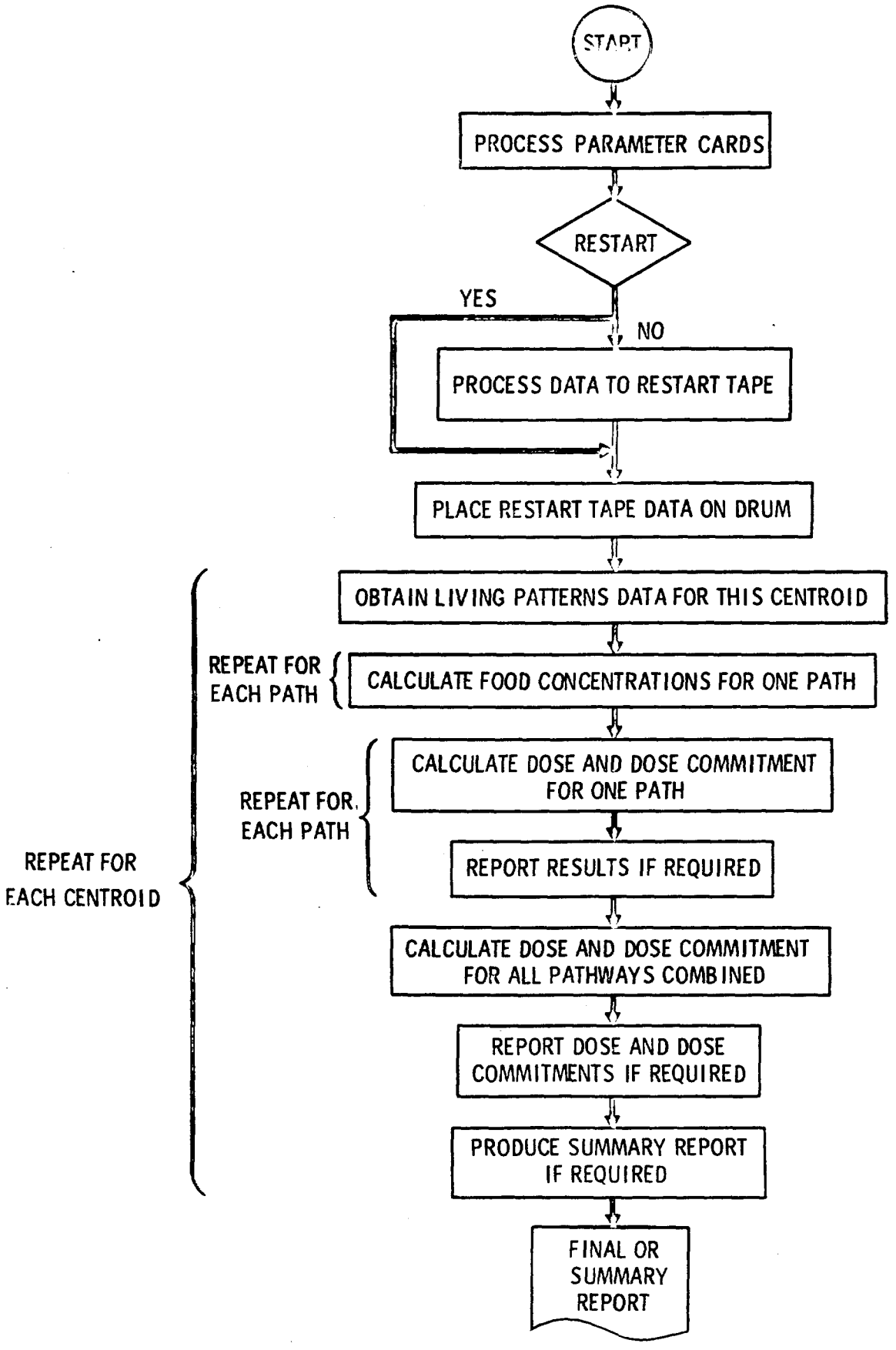

Figure III-21: Data Flow for DOSE

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concentration calculations are stored in subroutines STARTF. These constants may be changed by suitable alterations in these subroutines.

The following limitations are imposed in the present version of the program: 50 different isotopes, 7 different organs, 6 types of people, 998 different centroids, and 12 consecutive months. A centroid designation of 999 is interpreted as being outside the study area. The total amount of concentration data that can be processed at one time is dependent on the type of data involved and the size of the drum area. DRUM utilization is printed at the completion of each run. Computer run time increases significantly as data processing and output demands are extended. Injudicious choice of options that provide unwanted data may prove to be very costly.

Three types of printed reports are produced:

- Detailed report for each pathway at a given population centroid,
- Detailed reports for all pathways combined at a given population centroid,
- Summary report for a group of centroids.

The formats of the first two report types are almost identical. The detailed report for each pathway lists the total dose and dose commitment to each organ for the average and maximum child, teenager and adult. This total is divided into internal and external dose, and the percentage contribution of each nuclide to the total dose is given. The summary report is in two parts: the first part is a listing of the total dose and dose commitment for the average and maximum child, teenager, and adult at each population centroid together with the starting page number of the detailed reports (if any). The second part lists the integrated population dose and dose commitment for the child, teenager and adult at each centroid (one centroid per line) together with the starting page number of detailed reports (if any) for that centroid. Each category is totaled and the total population dose and dose commitment are printed.

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FOOD CONCENTRATIONS

A computational subroutine is provided to convert concentrations of radionuclides in air, water, and soil (including long term accumulation) into corresponding concentrations in human foods at time of production. The FPM was developed to meet the following three objectives for the UMRB study:

- Development of a general pathways model which includes most of the variables influencing radionuclide concentrations in foods, regardless of their relative importance in a study region.
- Estimation of radionuclide concentrations in foods produced in the UMRB region for any future study year, based on current agricultrual practices, concentrations of the radionuclides in air, water and soil, and known (and, where necessary, assumed) behavior of radionuclides in food chains.
- Delineation of areas where additional research would provide data needed to assess more credibly radionuclide concentrations in food in future versions of the model.

The model, as developed, estimates radionuclide concentrations in food at the time of production or harvest. Radionuclide losses during commercial or home processing, or those resulting from radioactive decay during the time lag between production and consumption, are not included. However, they are included as a separate part of the overall dose calculation sub-element and are discussed later in this section.

There are several limitations on the accuracy of the estimates of food concentrations generated by the FPM. Recent agricultural history and current trends indicate that agricultural practices will be significantly modified, as a function of elapsed time, for any year that might be chosen for study because of loss of agricultural land to urban development coupled with more intensive use of the remaining land. The latter

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involves the increased application of sprinkler irrigation, especially for sandy soils and combatting summer drought; use of higher yield varieties of crops; and increased use of stored feed by dairy farms.

The second limitation on the accuracy of the model is the paucity of information about radionuclide behavior in soil, plants, and animals. Most research has concentrated on the behavior of the nuclides ^{89}Sr, ^{90}Sr, ^{131}I, and ^{137}Cs. Frequently, this lack of data has encouraged the utilization of transfer factors obtained for stable elements regardless of any potential effects from differences in chemical or physical form between the stable and radioactive isotopes. It also necessitated the application of one set of median or average transfer factors across the UMRB region in spite of the large variations in soil and climatic conditions and farming practices.

Pathways included in the FPM and discussed in the following paragraphs, are:

1. Milk and milk products
2. Meat
   - Beef and Lamb
   - Pork
   - Poultry
3. Food crops
   - Leafy above-ground vegetables
   - Other above-ground vegetables
   - Potatoes
   - Other below-ground vegetables
   - Berries
   - Orchard fruit
   - Wheat and wheat products
   - Other grains
4. Eggs
5. Fish
6. Waterfowl
7. Upland game birds

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In the discussions that follow, the general equations given are used in the HERMES subelement DOSE. Detailed discussions of data development for the base case study of the UMRB region illustrate the care needed for meaningful results.

Milk

The milk pathway involves the transfer of radionuclides through the (air and water)-soil-plant-cow-milk-man chain. Radionuclide concentrations in milk consumed by man depend on: (1) the total daily radionuclide intake by the cow from forage, grain, stored feed, drinking water and inhalation, (2) the fraction of the daily intake transferred to the milk, and (3) losses of radionuclides between the times of production of the milk and subsequent human consumption.

The above considerations lead to the following apparently simple equation for the concentration in milk at time of production:

$$C_d = S_d I_d \tag{21}$$

where

C_d = the concentration of a particular radionuclide in milk at time of production.

I_d = the total daily intake by the cow of that nuclide.

S_d = the fraction of the daily intake of the nuclide which appears in each liter of milk produced by the cow.

The coefficient of secretion (S_d) is the percentage of daily radionuclide intake secreted to each liter of milk produced by dairy cattle consuming contaminated feeds. Median values of (S_d) have been obtained from the literature for ^{65}Zn, ^{131}I, ^{90}Sr, and ^{137}Cs, which have been studied more frequently than other radionuclides that might appear in milk. The values of (S_d) for other radionuclides were obtained from data[59] published by Livermore Radiation Laboratory, and generally

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represent maximum literature values or upper limit estimates. The values of (S_d) used in the Milk Pathway equation are tabulated in Table III-4.

The daily intake of the cow (I_d) depends heavily on the particular dairy management practice employed and the season of the year; thus, an exact description of the factors affecting this term leads to a more complicated equation for (I_d):

$$I_d = Q_f \left[\frac{R}{Y_f} \left(\frac{1-e^{-\lambda_E t_f}}{\lambda_E} \right) \left(\frac{D_{fm} + \varepsilon_{fm}\omega_{fm}}{30} \right) + \frac{B_f}{p} \left(F_{fA} + F_{fW} \right) \right] \tag{22}$$

$$+ Q_{gd} e^{-\lambda_r t_{\theta g}} \left\{ \frac{RT_g}{Y_g} \left[\sum_{m=a}^{h} \left(D_{gm} + \varepsilon_{gm}\omega_{gm} \right) e^{-\lambda_E t_\beta} \right] + \frac{B_g}{p} \left(F_{gA} + F_{gW} \right) \right\}$$

$$+ Q_{sd} e^{-\lambda_r t_{\theta s}} \left\{ \frac{RT_s}{Y_s} \left[\sum_{m=a}^{h} \left(D_{sm} + \varepsilon_{sm}\omega_{sm} \right) e^{-\lambda_E t_\beta} \right] + \frac{B_s}{p} \left(F_{sA} + F_{sW} \right) \right\}$$

$$+ G_d A_m N_d + L_{dm}\omega_m$$

where

A_m = Radionuclide concentration in air during "m" (pCi/l).

a = First month of crop contamination.

B_f = Forage crop concentration factor (pCi/kg per pCi/kg soil).*

B_g = Grain concentration factor (pCi/kg per pCi/kg soil).*

B_s = Stored feed concentration factor (pCi/kg per pCi/kg soil).*

C_d = Radionuclide concentration in milk (pCi/l).

D_{fm} = Deposition on forage crop during month "m" (pCi/m^2).

D_{gm} = Deposition on grain crop during month "m" (pCi/m^2).

D_{sm} = Deposition on stored feed crop during month "m" (pCi/m^2).

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F_{fA} = Radionuclide concentration in plowlayer of forage crop from air deposition (pCi/m^2).

F_{fW} = Radionuclide concentration in plowlayer of forage crop from water deposition (pCi/m^2).

F_{gA} = Radionuclide concentration in plowlayer of grain crop from air deposition (pCi/m^2).

F_{gw} = Radionuclide concentration in plowlayer of grain crop from water deposition (pCi/m^2).

F_{sA} = Radionuclide concentration in plowlayer of stored feed from air deposition (pCi/m^2).

F_{sw} = Radionuclide concentration in plowlayer of stored feed from water deposition (pCi/m^2).

G_d = Breathing rate of dairy cow (m^3/day).

h = Month of crop harvest.

I_d = Daily ingestion of radionuclide by dairy cow (pCi).

L_d = Daily ingestion of drinking water by dairy cow (l).

m = Month.

N_d = Radionuclide inhalation retention factor.

P = 2.24×10^2 kg soil/m^2 plowlayer.*

Q_f = Daily fresh forage ingestion by dairy cow (kg).

Q_{gd} = Daily grain ingestion by dairy cow (kg).

Q_{sd} = Daily stored feed intake by dairy cow (kg).

R = Deposition retention factor.

S_d = Coefficient of transfer of radionuclide from diet to milk (pCi/l per pCi/day).

T_g = Grain crop translocation factor.

T_s = Stored feed translocation factor.

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t_f = Time between successive removals of forage crop (days).

t_β = Time between deposition and harvest (h-m)(days).

$t_{\theta g}$ = Time between harvest and consumption of grain (days).

$t_{\theta s}$ = Time between harvest and consumption of stored feed (days).

Y_f = Forage crop yield (kg/m^2).*

Y_g = Grain crop yield (kg/m^2).*

Y_s = Stored feed crop yield (kg/m^2).*

ε_{fm} = Irrigation rate for forage crop during month "m" (l/m^2).

ε_{gm} = Irrigation rate for grain crop during month "m" (l/m^2).

ε_{sm} = Irrigation rate for stored feed during month "m" (l/m^2).

ω_{fm} = Radionuclide concentration during month "m" (pCi/l) in irrigation water applied to forage.

ω_{gm} = Radionuclide concentration during month "m" (pCi/l) in irrigation water applied to grain.

ω_{sm} = Radionuclide concentration during month "m" (pCi/l) in irrigation water applied to stored feed crop.

λ_E = Effective decay constant ($days^{-1}$).

λ_r = Radioactive decay constant ($days^{-1}$).

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* Plants are measured in kg of fresh weight while soils are measured in kg of dry weight.

It is important to remember that the air deposition and water and soil concentrations to be used with the above equations (and with those that follow for human food) must be those concentrations estimated for the centroid where the food was produced, not where it was consumed (if the two are different). In the instance of animal feed, however, it was assumed that all three types -- forage, stored feed and grain -- were grown in the same centroid where they were consumed by the animals. As

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TABLE III-4

COEFFICIENTS OF TRANSFER OF RADIONUCLIDES FROM DIET TO MILK[59]

Transfer Coefficient (S_d), pCi/Liter Milk per pCi/Day Intake

Nuclide	S_d	Nuclide	S_d	Nuclide	S_d
H-3	2.0 E-2[a]	Ni-63	6.7 E-3	I-129	1.0 E-2[b]
N-13	2.2 E-2	Cu-64	1.4 E-2	I-131	1.0 E-2[b]
C-14	1.5 E-2	Zn-65	3.0 E-2[b]	I.132	1.0 E-2[b]
Na-22	5.0 E-2	Sr-89	1.0 E-3[b]	I-133	1.0 E-2[b]
Na-24	5.0 E-2	Sr-90	1.0 E-3[b]	I-135	1.0 E-2[b]
Cr-51	2.2 E-3	Zr-95	5.0 E-6	Cs-134	5.0 E-3[b]
Mn-54	2.5 E-4	Nb-95	2.5 E-3	Cs-137	5.0 E-3[b]
Fe-55	1.2 E-3	Mo-99	7.5 E-3	Ba-140	6.0 E-4
Fe-59	1.2 E-3	Ru-103	1.0 E-6	La-140	5.0 E-6
Co-58	1.0 E-3	Ru-106	1.0 E-6	Ce-141	2.0 E-5
Co-60	1.0 E-3	Te-132	1.0 E-3	Ce-144	2.0 E-5

[a] 2.0 E-2 means 0.02.

[b] These values are not those given in Reference (59) but are median of values found in other literature. (References (60-69).

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explained elsewhere in the text, a production-consumption balance was obtained for human foods to determine the centroid of production for each major food category consumed in each centroid.

Detailed interpretation and application of literature data to these equations are discussed below.

There are wide seasonal and geographical variations in the intake of radionuclides by cows, which are imposed by the several different dairy management systems employed. Also, grazing seasons vary across the study region. Three principal grazing seasons can be defined in the region:[70,71]

1. Early summer (may 1 to July 15),
2. Late summer (July 15 to October 15), and
3. Winter (October 15 to May 1).

Five different dairy management systems are used in the UMRB region:[70,71]

1. Uncontrolled continuous grazing. Cows remain on open pasture for an entire grazing season.
2. Controlled rotational grazing. Cows are moved between two or more pastures during the grazing season.
3. Controlled strip grazing. Cows are offered a portion of a pasture once or twice a day.
4. Controlled silage feeding. Forage is cut in the field and brought to the cows which are kept in dry-lots or idling yards.
5. Controlled storage feeding. Cows are kept in dry-lots and fed hay and silage all year.

Systems 2, 3, and 4 are the ones most widely used in the region at present, but the long term trend is towards increased use of System 5.

Relative forage yields, inherent inefficiencies among management systems (losses due to trampling, selective grazing, despoiling edible

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forage by excreta, etc.), and ingestion rates associated with each management system result in area grazing requirements that may vary up to 50 percent. The ingestion rates and forage crop yields used in conjunction with Equation (22) are listed in Table III-5.

TABLE III-5

INGESTION RATES AND CROP YIELDS

USED IN THE MILK PATHWAY MODEL[63,70-73]

	Ingestion, kg/day[a]			Yield kg/m^2 (Fresh Wt.)		
Month	Forage (Q_{fd})	Grain (Q_{gd})	Stored Feed (Q_{sd})	Forage (Y_f)	Stored Feed (Y_s)	Grain (Y_g)
1	0	3.6 E+1	4.3 E+1	0	0	0
2	0	3.6 E+1	4.3 E+1	0	0	0
3	0	3.6 E+1	4.3 E+1	0	0	0
4	0	3.6 E+1	4.3 E+1	0	0[b]	0[b]
5	6.5 E+1	3.6 E+1	0	1.8 E+0	0	0
6	6.5 E+1	3.6 E+1	0	1.8 E+0	0	0
7	5.5 E+1	3.6 E+1	1.3 E+1	1.8 E+0	2.3 E+0[c]	3.5 E-1[c]
8	4.5 E+1	3.6 E+1	3.0 E+1	1.8 E+0	0	0
9	4.5 E+1	3.6 E+1	3.0 E+1	1.8 E+0	0	0
10	0	3.6 E+1	4.3 E+1	0	0	0
11	0	3.6 E+1	4.3 E+1	0	0	0
12	0	3.6 E+1	4.3 E+1	0	0	0

(a) Fresh weight: for purposes of calculating required drinking water intake, fresh forage was assumed to be 80% moisture; and stored feed, 25%.

(b) Month when crop "appears" above ground in sufficient quantity to collect radionuclides via deposition from air and/or sprinkler irrigation.

(c) Month of crop harvest.

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The values in the table are averages for all management systems combined. Green feed intake varies 5 to 10 percent, and grain intake varies 28 to 38 percent of their respective averages among management systems.

Potential radioactive contaminants of milk may originate with both air and water releases, but deposition of airborne radionuclides will be by far the most important source of contamination because of the very small fraction of the pastures irrigated ($\sim 10^{-2}$)[28] in the study region. The probability of contamination by irrigation water is further reduced when sources of irrigation water are considered. In the UMRB study area proper, the majority of the irrigation systems presently employ ground water as the primary source. Approximately 60 percent of all irrigation water comes from wells, 30 percent from streams, and the remainder from surface storage. Similar conditions are assumed to exist in other portions of the central study area because of similarities of climate, soils, and geology. Milk produced from irrigated forage will be diluted by milk from within the same milkshed produced from non-irrigated forage. Because of this, waterborne radionuclides will probably contribute an extremely small percentage of total potential radioactive contamination of milk produced in the central study area. Therefore, the contribution to forage contamination from irrigation water was ignored in the final calculations (i.e., the factor (ε_{fm}) in Equation (22) was set equal to zero).

For grain and stored feed (and human food crops), an attempt was made to include the contribution to contamination of the crops from irrigation water, assuming the same fraction of crops are irrigated in the base case study year as in 1964. Estimates of concentrations of radionuclides in irrigation water were generated by the HERMES subelement WTRAN based on the following assumptions:

(1) All irrigation water comes from wells and is applied with sprinkler systems.

(2) All wells are recharged from ground water originating as

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precipitation and having concentrations of radionuclides as determined by the HERMES subelement ARTRAN.

(3) Radioactive decay during the time of travel from the place of precipitation to the well is included.

(4) Since these travel times are relatively long, only annual average concentrations of radionuclides in precipitation and well water were considered.

(5) There is no retention of radionuclides by the soil during travel of the ground water to the well.

Since the exact location and source of irrigation water cannot be specified for each centroid, a compromise was devised. (It may be possible in the future to modify the model if more realistic data become available.) Irrigation water was assumed to be applied at a constant rate of 110 liters/m^2/mo. throughout the growing period from month of appearance to month of harvest only.

The fraction (R) of each month's deposition from air and from sprinkler irrigation, which is initially retained by vegetation, was taken to be 0.25 for all radionuclides and for all crops, including both animal and human foods.[74]

To determine what amount of radionuclide is actually present on forage when it is ingested by the dairy cow, the original deposition retained by the forage is adjusted by an accumulation factor defined as

$$\frac{1-e^{-\lambda_E T_f}}{\lambda_E} \qquad (23)$$

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where

$$\lambda_E = \frac{0.693}{T_E} = \frac{0.693}{T_R} + \frac{0.693}{T_B}$$

T_E = effective half-life = $\frac{T_R T_B}{T_R + T_B}$ (days).

T_R = radioactive half-life (days)

T_B = biological half-life (days).

T_f = time between successive removals of forage (days).

All radionuclides, whether deposited from air or from irrigation water, were assumed to behave similarly following deposition on vegetation. That is, they are removed with a biological half-life (T_B) of 14 days, the average value found in published data concerning fallout radionuclides. The values of T_f given in the literature or derivable from literature data vary from 14 to 50 days,[70] depending upon crop yield, type of forage, and season. A constant value of 30 days was assumed for T_f in the milk pathway model.

Total monthly radionuclide deposition on forage ($D_{fm} + \varepsilon_{fm}\omega_{fm}$) is assumed to be equally distributed throughout the month so that the average daily rate is obtained by dividing the total by 30 days/mo in Equation (22).

Feed crops other than forage have a growing season of several months duration during which direct deposition from air and irrigation can be accumulated. From the available agricultural data, an average growing season, "month of appearance" and "month of harvest" were determined for grain and for crops used for stored feed. The "month of appearance" is defined as that month when the crop has attained sufficient growth to provide a significant amount of surface area for direct areal deposition. Direct deposition was then calculated only for the months between the time of appearance and time of harvest. Each month's deposition was corrected for effective decay (radioactive and biological removal) for the

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time (t_β) between deposition and harvest.

This summation of decay-corrected monthly deposition leads to the terms

$$\sum_{m=a}^{h} (D_m + \varepsilon_m \omega_m)\, e^{-\lambda_E t_\beta} \tag{24}$$

found in Equation (22) for grain, subscript (g), and for stored feed, subscript (s). The months of appearance and harvest selected for grain and stored feed are indicated in Table III-~~6~~5 as April and July, respectively.

The factors (T_g) and T_s) in the milk pathway equation are necessary to correct for the fraction of the material deposited on the surfaces of grain crops and stored feed crops, which is translocated to the portions of the plant actually consumed by the cows. The fraction is taken to be 1.0 for radionuclides deposited on forage and stored feed. Values for grain are given in Table III-6.

The few translocation factors given in the literature included the contribution from any radionuclides deposited directly onto the grain.

The uptake of a radionuclide by vegetation from soil depends upon the particular nuclide and plant species involved and upon the nuclide concentration in soil. The accumulated soil concentrations (F_A) are computed from the monthly depositions, corrected for decay, by ARTRAN on an annual basis up to the study year and on a monthly basis during the study year.

The crops were assumed to be in constant equilibrium with the radionuclides in soil so that the values of (F) used are the accumulated quantities present in the soil during the month of harvest. Unfortunately, no mechanism is included in the current version of the model for long term soil accumulation via irrigation water.

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TABLE III-6

TRANSLOCATION FACTORS FOR GRAIN AND POTATOES

Fraction of Radionuclide Deposited on Plant Which Reaches Portion Eaten[75-77]

Nuclide	Grain[a] (T_g)	Potatoes[b] (T_c)	Nuclide	Grain[a] (T_g)	Potatoes[b] (T_c)
H-3	1.0 E+0	1.0 E+0	Zr-95	2.0 E-2	1.0 E-2
N-13	0	0	Nb-95	2.0 E-2	1.0 E-2
C-14	1.0 E+0	1.0 E+0	Mo-99	0	0
Na-22	5.0 E-2	5.0 E-2	Ru-103	5.0 E-2	5.0 E-2
Na-24	5.0 E-2	5.0 E-2	Ru-106	5.0 E-2	5.0 E-2
Cr-51	0	0	Te-132	1.0 E-1	1.0 E-1
Mn-54	5.0 E-2	5.0 E-2	I-129	1.0 E-1	1.0 E-1
Fe-55	5.0 E-2	5.0 E-2	I-131	1.0 E-1	1.0 E-1
Fe-59	5.0 E-2	5.0 E-2	I-132	1.0 E-1	1.0 E-1
Co-58	5.0 E-2	5.0 E-2	I-133	1.0 E-1	1.0 E-1
Co-60	5.0 E-2	5.0 E-2	I-135	1.0 E-1	1.0 E-1
Ni-63	5.0 E-2	5.0 E-2	Cs-134	1.0 E-1	1.0 E-1
Cu-64	5.0 E-2	5.0 E-2	Cs-137	1.0 E-1	1.0 E-1
Zn-65	5.0 E-2	5.0 E-2	Ba-140	2.0 E-2	1.0 E-2
Sr-89	2.0 E-2	1.0 E-2	La-140	2.0 E-2	1.0 E-2
Sr-90	2.0 E-2	1.0 E-2	Ce-141	2.0 E-2	2.0 E-2
			Ce-144	2.0 E-2	2.0 E-2

(a) These same factors are also applicable to grain and above-ground vegetables consumed by humans.

(b) These same factors apply to root vegetables.

Even though a fraction (R) of the areal deposition is retained by the plants during the growing season, 100 percent of the deposition was assumed to reach the soil (less that which disappears by radioactive decay) eventually. The biological removal process for radionuclides deposited on plants releases some of the material to soil. In addition, some crop residues are plowed under after harvest, and an additional fraction of the directly deposited material reaches the soil at that time. The small amount of radionuclides removed during foraging by cattle or by harvesting was ignored when calculating long term accumulation in soil.

The values computed by the HERMES subelement ARTRAN are in units of picocuries deposited per square meter of soil surface and must be converted to units of pCi/kg of soil for estimation of vegetation concentrations. The conversion is accomplished by the assumption of a uniform mixing of all radionuclides in a plowlayer of 15 cm depth, representing a value of 224 kg of dry soil per m^2 of surface for the term (P) in Equation (22).

Uptake of radionuclides from soil by plants is given in the literature for a limited number of radionuclides and plant species, usually in terms of a concentration factor (B) with units of pCi/kg of plant (dry weight) per pCi/kg of dry soil. As with most foodstuffs, considerably more study has been made of the crop uptake of ^{90}Sr and ^{137}Cs than of other radionuclides. Unfortunately, the concentration factors reported have been obtained under a wide range of conditions, often without exact specification of the climate, soil type, or agricultural practices involved. An attempt was made to pick median values where a range was found in the literature. Concentration factors selected for isotopes of strontium, cesium, and cerium converted to pCi/kg of plant (wet weight) versus pCi/kg dry soil are listed in Table III-7. Also listed there are the concentration factors (B_c) calculated from data on stable element concentrations in plants and soil published by Livermore Radiation Laboratory[59] and intended for estimation of maximum uptake of radionuclides in human food crops.

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TABLE III-7

CONCENTRATION FACTORS USED IN THE MILK PATHWAY EQUATION

Concentration Factors (B), pCi/kg (Wet Weight) per pCi/kg dry soil[59]

Nuclide	Estimated From Ref (59) (B_c)	Estimated From Other Literature: Forage (B_f)	Stored Feed (alfalfa) (B_s)	Grain (Including Corn) (B_g)
H-3	2.0 E-1[a]			
N-13	--			
C-14	5.5 E+0			
Na-22	5.0 E-2			
Na-24	5.0 E-2			
Cr-51	2.5 E-4			
Mn-54	2.9 E-2			
Fe-55	4.0 E-4[a]			
Fe-59	4.0 E-4[a]			
Co-58	9.4 E-3			
Co-60	9.4 E-3			
Ni-63	1.9 E~~-0~~-2			
Cu-64	1.3 E-1			
Zn-65	4.0 E-1			
Sr-89	2.0 E-1[b]	1.0 E+0	1.0 E+0	6.4 E-2
Sr-90	2.0 E-1[b]	1.0 E+0	1.0 E+0	6.4 E-2
Zr-95	1.7 E-4			
Nb-95	9.4 E-3			
Mo-99	1.3 E-1			
Ru-103	1.0 E-2[a]	4.0 E-2	4.0 E-2	
Ru-106	1.0 E-2[a]	4.0 E-2	4.0 E-2	
Te-132	1.3 E+0			
I-129	2.0 E-2			
I-131	2.0 E-2			
I-132	2.0 E-2			
I-133	2.0 E-2			
I-135	2.0 E-2			
Cs-134	2.0 E-3[a]	4.0 E-2	4.0 E-2	6.4 E-4
Cs-137	2.0 E-3[a]	4.0 E-2	4.0 E-2	6.4 E-4
Ba-140	5.0 E-3			
La-140	2.5 E-3			
Ce-141	5.0 E-4[a]			2.6 E-3
Ce-144	5.0 E-4[a]			2.6 E-3

(a) This value is not that calculated from Reference(59),but is selected from the literature as being more realistic.[78-81]

(b) These values are based on Ca and Sr content in soil in region of interest rather than the concentration of Sr in soil given in Reference (59)

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After the concentrations in the feed crops have been calculated for areal deposition and soil uptake, the two are added together to yield a concentration at time of harvest. This concentration must next be corrected for radioactive decay during the time interval (t_θ) between month of harvest and month of consumption by the cattle. For this calculation, it was assumed that all feed consumed was produced in the immediately preceding growing season, and no feed was held over past the following growing season. No losses other than radioactive decay were assumed to operate during the time interval (t_θ) so that the simple exponential terms ($e^{-\lambda_r t_{\theta g}}$) and $e^{-\lambda_r t_{\theta s}}$) are employed in Equation (22).

The daily radionuclide intake by the dairy cow (and other animals) via drinking water depends on the concentrations present in the water and the quantity of water consumed each day. Water concentrations are generated by WTRAN directly for surface streams and indirectly for surface ponds and lakes via runoff of precipitation. The distribution of irrigation water sources can be assumed to be similar to the distribution of sources for animal drinking water supplies, i.e., 30 percent from surface streams, 60 percent from wells, and 10 percent from surface storage. Therefore, concentrations of radionuclides previously generated for irrigation water (well water) were also used for drinking water concentrations.

Drinking water intake by dairy cattle depends upon the type of feed consumed; it varies from about 30 liters per day during periods when fresh forage is readily available to 75 liters/day during periods when only grain and stored feed are consumed. The monthly average values for water intake were derived from the total water requirements of the dairy cow[82] and the moisture content of the feeds ingested (Table III-8).[73]

Concentrations of radionuclides in air inhaled by dairy cattle are those air concentrations generated by ARTRAN for the centroid of interest. Inhalation rate for dairy cattle (G_d) was listed by Comar as 90

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TABLE III-8

MONTHLY AVERAGE DRINKING WATER CONSUMPTION

BY THE DAIRY COW

Month	L_{dm} (liters/day)[a]
1	7.5 E+1
2	7.5 E+1
3	7.5 E+1
4	3.0 E+1
5	3.0 E+1
6	4.0 E+1
7	5.0 E+1
8	5.0 E+1
9	7.5 E+1
10	7.5 E+1
11	7.5 E+1
12	7.5 E+1

(a) These values do not include moisture content of feed. Fresh forage was assumed to be 80% moisture; stored feed, 25% moisture. Total moisture intake is ∿100 liters/day all sources.[82]

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liters per minute.[71] However, no data were found in the literature applicable to estimating the transfer of inhaled radionuclides to animal products. Therefore, in the current version of the model, contamination of any animal products via inhalation is ignored. (This pathway can easily be included at a later date if the required information is developed).

Dairy Products

Lack of data on the transfer of radionuclides from milk to dairy products necessitated the assumption that a unit weight (or volume) of a dairy product contained the same quantity of radionuclides as a unit weight (or volume) of the original milk (except for radioactive decay). For example, each pound of butter or cheese contained the quantity of radionuclides present in a pound of the whole milk from which it was produced, and a pint of cream contained the same quantity of radionuclides as a pint of the milk from which it was extracted.

Ice cream was assumed to contain all of the radionuclides present in the ingredients from which it was made, with no loss in the production process. One gallon of ice cream was assumed to contain three quarts of milk, one pint of cream, 1 egg, 1-1/2 cups of sugar, and flavoring. The last two items were considered free of contamination since they were imported.

Beef, Lamb, and Pork

The equations for calculation of radionuclide concentrations in beef and pork are nearly identical to those used for milk [Equations (21) and (22)]. The single exception is the omission from the meat equations of the terms relating to fresh forage. These were omitted because the animals harvested for food were assumed to be only feed-lot fattened. Because few lambs are consumed in the region of interest, lamb consumption was combined with beef consumption in the dietary summary. This is analogous to defining the radionuclide concentrations in lamb and beef as identical.

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The equations for the beef pathway are given below:

$$C_{kb} = I_b S_{kb} \tag{25}$$

where

C_{kb} is the concentration of a given radionuclide in beef (pCi/kg).

S_{kb} is the "Coefficient of Transfer" of the nuclide to beef at or near dietary equilibrium (fraction of I_b appearing in each kg of meat).

I_b is the daily intake of the radionuclide by the beef cattle (pCi/day) as defined in Equation (26) below.

As in the milk pathway, literature data[83, 84] on transfer of radionuclides from diet to animal products were limited. In addition, it was not always clear whether the values of (S_k) reported (or derived from reported data) represented equilibrium conditions or were merely based on a limited sampling of diet prior to slaughter of the animal. The values of (S_{kb}) selected for use in the above equation [along with those for pork (S_{ks}), poultry (S_{kc}), and eggs ($S_{k\alpha}$)] are tabulated in Table III-9.

For nuclides other than isotopes of Sr, I, and Cs where little or no data were available for estimating values of (S_{kb}) and (S_{ks}), approximations were made on the basis of chemical and biological similiarity between the nuclide in question and those for which data were available.

Radionuclide intake of beef cattle was estimated with the help of Equation (26).

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$$I_b = Q_{gb} e^{-\lambda_r t_{\theta g}} \left\{ \frac{RT_g}{Y_g} \left[\sum_{m=a}^{h} \left(D_{gm} + \varepsilon_{gm} \omega_{gm} \right) e^{-\lambda_E t_\beta} \right] + \frac{B_g}{p} \left(F_{gA} + F_{gW} \right) \right\}$$

$$+ Q_{sb} e^{-\lambda_r t_{\theta s}} \left\{ \frac{RT_s}{Y_s} \left[\sum_{m=a}^{h} \left(D_{sm} + \varepsilon_{sm} \omega_{sm} \right) e^{-\lambda_E t_\beta} \right] + \frac{B_s}{p} \left(F_{sA} + F_{sW} \right) \right\} \quad (26)$$

$$+ G_b A_m N_b + L_b \omega_m$$

The terms of Equation (26) are the same as the corresponding terms of Equation (22), except that they now refer to beef cattle, subscript (b) instead of dairy cows, subscript (d). The parameters relating to daily ingestion rates of various foods and water by beef cattle were assumed to be constant throughout the year. The average values to be applied each month in the equation are given in Table III-10.

Although inhalation was ignored, the daily breathing rate (G_b) can be taken as 90 liters/min[71] if this mechanism is included at a later date.

Concentrations of radionuclides in pork can also be estimated by Equation (26), with the substitution of the appropriate parameters for daily ingestion of feed and water by swine. These parameters on an annual average basis are also listed in Table III-10. Comar[71] lists the breathing rate of swine as 6 liters/min, which seems low compared to the values he lists for cattle (90 liters/min) and sheep (6 liters/min). The value given by Altman and Dittmer[90] 37 liters/min for a 225 kg hog seems more realistic.

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TABLE III-9

TRANSFER COEFFICIENTS FOR MEAT AND EGGS

Fraction of Daily Intake (S_k) Which Appears in Each kg of Meat and Each Egg

Nuclide	Beef (S_{kb})	Pork (S_{ks})	Poultry (S_{kc})	Eggs ($S_{k\alpha}$)
H-3	1 E+0	1 E+0	1 E+0	1 E+0
N-13	0	0	0	0
C-14	1 E+0	1 E+0	1 E+0	1 E+0
Na-22	5 E-2	1 E-1	1 E-2	1 E-2
Na-24	0	0	0	0
Cr-51	0	0	0	0
Mn-54	5 E-3	1 E-2	1 E-3	5 E-3
Fe-55	1 E-3	5 E-3	1 E-3	5 E-3
Fe-59	1 E-3	5 E-3	1 E-3	5 E-3
Co-58	1 E-3	5 E-3	1 E-3	5 E-3
Co-60	1 E-3	5 E-3	1 E-3	5 E-3
Ni-63	1 E-3	5 E-3	1 E-3	5 E-3
Cu-64	2 E-3	5 E-3	2 E-3	1 E-2
Zn-65	2 E-3	5 E-3	2 E-3	2 E-4
Sr-89	2 E-3	8 E-3	9 E-4	2 E-2(87)
Sr-90	2 E-3(63,85)	8 E-3(85)	9 E-4(87)	2 E-2
Zr-95	5 E-4	1 E-3	1 E-4	6 E-5
Nb-95	5 E-4	1 E-3	1 E-4(87)	6 E-5(87)
Mo-99	1 E-2	2 E-2	2 E-3(87)	2 E-2
Ru-103	1 E-3	5 E-3	3 E-4(87	2 E-4(87)
Ru-106	1 E-3	5 E-3	3 E-4	2 E-4
Te-132	5 E-3	1 E-2	1 E-2(87)	2 E-2(87)
I-129	2 E-2	9 E-2	4 E-3	8 E-2
I-131	2 E-2(67,85)	9 E-2(85)	4 E-3(88)	8 E-2(87,88)
I-132	2 E-2	9 E-2	4 E-3	8 E-2
I-133	2 E-2	9 E-2	4 E-3	8 E-2
I-135	2 E-2	9 E-2	4 E-3	8 E-2
Cs-134	3 E-2	4 E-2	4 E-1(87)	3 E-2(84,87,89)
Cs-137	3 E-2(84-86)	4 E-2(85)	4 E-1	3 E-2
Ba-140	5 E-4	2 E-3	5 E-4(87)	2 E-2(87)
La-140	5 E-3	1 E-2	4 E-3(87)	1 E-4(87)
Ce-141	1 E-3	5 E-3	6 E-4	1 E-4
Ce-144	1 E-3	5 E-3	6 E-4(87)	1 E-4(87)

Numbers in parentheses are reference numbers.

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TABLE III-10

ANNUAL AVERAGE INGESTION RATES OF FEED AND WATER BY BEEF CATTLE, SWINE AND CHICKENS

Annual Rates For Use in Equations (26) and (28) [Ref. 71, 73, 91, 92]

Item	Beef Cattle	Swine	Chickens
kg/day of Stored Feed (Q_s)	5.4 E+1	8.0 E-1	-
kg/day of Grain (Q_g)	1.4 E+1	3.4 E+0	1.2 E-1
liters/day of Water (L)	5.0 E+1	1.0 E+1	3.0 E-1

Poultry and Game Birds

Poultry including chickens, turkey, and domestic ducks, and geese were assumed to eat no forage or stored feed so the equation for intake of radionuclides (I_c) includes only terms for grain, water and air. Chickens were considered representative of the entire class of domestic fowl because they represent the majority of the poultry consumed and because both dietary data and radionuclide uptake have been well documented for chickens. The equations for calculating radionuclide concentrations in chicken flesh at the time of slaughter are given below:

$$C_{kc} = I_c S_{kc} \tag{27}$$

where

C_{kc} is the concentration of a given radionuclide in chicken flesh (pCi/kg)

S_{kc} is the coefficient of transfer to meat for the radionuclide in terms of fraction of daily intake (I_c) appearing in each kg of meat.

I_c is the daily intake of the radionuclide (pCi/day) as defined in Equation (28) below.

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The transfer coefficients (S_{kc}) are given in Table III-9. Published data were available for the fission product radionuclides ^{89}Sr, ^{90}Sr, ^{95}Nb, ^{99}Mo, ^{103}Ru, ^{106}Ru, ^{131}I, ^{134}Cs, ^{137}Cs, ^{140}Ba, ^{140}La, ^{141}Ce, and ^{144}Ce,[84,87,88,89] but not for activation products. The transfer coefficients for the remaining nuclides were estimated on the basis of the chemical and biological similarity to those having published data.

$$I_c = Q_{gc} e^{-\lambda_r t_{\theta g}} \left\{ \frac{RT_g}{Y_g} \left[\sum_{m=a}^{h} \left(D_{gm} + \varepsilon_{gm} \omega_{gm} \right) e^{-\lambda_E t_\beta} \right] + \frac{B_g}{p} \left(F_{gA} + F_{gW} \right) \right\} \quad (28)$$

$$+ G_c A_m N + L_c \omega_m$$

The terms in Equation (28) have the same definitions as given previously for the milk pathway Equation (22), except that they now refer to chickens, subscript (c), in place of dairy cows, subscript (d). The ingestion rate of grain (Q_{gc}) and water (L_c) are given in Table III-10. As for other animals, inhalation was ignored and all drinking water was assumed to come from wells.

Very little data were available for diet and radionuclide uptake of game birds. Young game birds will eat insects but switch to grain as they mature. For purposes of this study, radionuclide concentrations in upland game birds were assumed to be identical to those in chickens raised in the same centroid. Waterfowl will be discussed later in the section on fish.

Eggs

Equation (29) was used to estimate the concentration of radionuclides in chicken eggs.

$$C_\alpha = I_c \quad S_{k\alpha} \quad (29)$$

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where

C_α is the concentration of a given radionuclide in egg (pCi/egg)

$S_{k\alpha}$ is the coefficient of transfer to eggs for the radionuclide (fraction of daily intake appearing in each egg)

I_c is the daily intake of the radionuclide by the chicken (pCi/day) as previously defined in Equation (28).

Specific data on transfer of radionuclides from diet to eggs of chicken were available for the same list of nuclides as given above for transfer to chicken flesh. Transfer coefficients for other nuclides were again estimated on the basis of similarity of chemical and biological behavior of the nuclides. Values of ($S_{k\alpha}$) selected are given in Table III-9.

Food Crops

The equation for calculation of radionuclide concentration in food crops includes terms for direct deposition from air and sprinkler irrigation, and for uptake from soil. It is given below as Equation (30).

$$C_c = \frac{RT_c}{Y_c} \sum_{m=a}^{h} \left[\left(D_{cm} + \varepsilon_{cm} \omega_{cm} \right) e^{-\lambda_E t_\beta} \right] + \frac{B_c}{p} \left(F_{cA} + F_{cW} \right) \qquad (30)$$

The terms in this equation are similar to the terms in the equations for radionuclide intake by animals that relate to concentrations in their feed crops. The definitions of the two sets of symbols are similar with the substitution of the subscript (c) for (g) or (s).

Equation (30) can be applied to a considerable variety of food crops, provided the appropriate parameters can be estimated. There is a wide range in the values for crop yield (Y_c), month of appearance (a), a month of harvest (h), factors for uptake from soil (B_c) and translocation to edible parts of the plant (T_c), and rate of application of irrigation water. These parameters vary not only with radionuclide and crop but also with location within the region. Differences due to location were ignored

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(except for deposition rates from air and water concentrations), and only one set of parameters per crop type was selected for the entire region after careful consideration of the available data.

As with animal feed crops, values of certain parameters could not be found in the literature for many of the radionuclides. This was especially true for concentration factors (B_c) and translocation factors (T_c). Month of appearance (a) of various crops often had to be "gestimated" from growing season and harvest date. Month of harvest (h) and crop yield (Y_c) were readily available for nearly all crops and in all states of the region from routine agriculture reports.

Irrigation water was again assumed to be obtained solely from wells and applied by sprinklers at a constant rate of 110 liters/m^2/mo. throughout the period from month of appearance to month of harvest. The fraction of crop production irrigated was obtained from the literature and recorded in the LPM for each centroid. Concentrations of radionuclides in irrigation water were calculated as explained under the milk pathway. Again, long-term accumulation of radionuclides in soil from irrigation (F_{cW}) was not included in the model at this time.

The fraction (R) of the radionuclides deposited per square meter from irrigation (and air), actually intercepted and initially retained by the plant surfaces, was taken as 0.25.[74]

The concentration factors (B_c), crop yield (Y_c), and months of appearance and harvest are given in Table III-11.

Concentration factors are listed in the table only for those radionuclide plant combinations for which data could be found in the literature. For those combinations not listed, concentration factors derived from Reference (59) (and previously listed in Table III-7) should be used.

TABLE III-11

PARAMETERS FOR USE IN EQUATION (30) FOR ESTIMATING RADIONUCLIDE CONCENTRATIONS IN FOOD

Nuclide	Leafy Vegetables	Other Above Ground Vegetables	Potatoes	Root Vegetables	Straw-Berries	Melons	Orchard Fruit	Wheat	Corn and Other Grain
				CONCENTRATION FACTORS, B_c (38,65,76,77,78,81,93)					
Fe-55	1.5 E-4	2.7 E-4	2.9 E-4	2.7 E-4					
Fe-59	1.5 E-4	2.7 E-4	2.9 E-4	2.7 E-4					
Co-58		1.3 E-3		1.8 E-3					
Co-60		1.3 E-3		1.8 E-3					
Sr-89	3.2 E-1	1.5 E-1	2.7 E-2	1.5 E-1	1.2 E-1				6.4 E-2
Sr-90	3.2 E-1	1.5 E-1	2.7 E-2	1.5 E-1	1.2 E-1				6.4 E-2
Ru-103	3.8 E-3								
Ru-106	3.8 E-3								
Cs-134	1.9 E-2	1.9 E-2	1.1 E-2	6.2 E-3	7.8 E-2				6.4 E-4
Cs-137	1.9 E-2	1.9 E-2	1.1.E-2	6.2 E-3	7.8 E-2				6.4 E-4
Ce-141	7.5 E-4	6.8 E-3							2.6 E-3
Ce-144	7.5 E-4	6.8 E-3							2.6 E-3
				YIELD (Y_c) kg FRESH WEIGHT/m^2 (38)					
	1.5 E+0	7.0 E-1	1.8 E+0	4.0 E+0	2.7 E+0	8.3 E-1	1.7 E+0	3.4 E-1	3.5 E-1
				MONTH OF APPEARANCE (a) AND HARVEST (h) (38)					
(a)	06	06	06	06	03	05	06	04	04
(h)	09	08	09	09	05	08	09	07	07

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Translocation factors (T_c), given previously in Table III-6 for grain and potatoes, also apply to grain consumed by humans and all above ground vegetables. Those factors given in Table III-6 for potatoes also apply to root vegetables such as carrots and turnips. For all other vegetables and food crops, the translocation factor is taken to be 1.0, i.e., the concentration of radionuclides in the edible part of the plant is the same as the average concentration in the overall plant from direct deposition.

Fish and Waterfowl

Concentrations of radionuclides in fish flesh were calculated on the basis of rapid equilibrium between the fish and the water in which it grows; the food web lying between them is ignored. The oversimplification yields the following equation that relates fish flesh concentration directly and solely to water concentration:

$$C_A = B_A \omega_m \tag{31}$$

where

C_A is the concentration of a given radionuclide in fish flesh (pCi/kg wet weight).

B_A is the concentration factor (pCi/kg flesh per pCi/liter water) for the radionuclide.

ω_m is the concentration of the radionuclide in water (pCi/liter) for month of harvest of fish.

Concentration factors (B_A) for fish are listed in Table III-12.

Values of (B_A) for specific radionuclides were used whenever available. Data published for concentrations of stable elements in fresh water and fish[59] were used to derive the concentration ratios appearing in the last column of Table III-12.

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TABLE III-12

CONCENTRATION FACTORS (B_A) FOR UPTAKE OF RADIONUCLIDES BY FRESH WATER FISH AND WATERFOWL

Nuclide	Radionuclides[a] pCi/kg per pCi/liter	Elements[b] ppm fish/ppm water
H-3	1.0 E+0(95,96)	9.3 E-1 (g)
N-13	0	1.5 E+5 (h)
C-14		4.6 E+3 (h)
Na-22	1.0 E+2(60,61,95,96)	3.2 E+1 (g)
Na-24	1.0 E+2(60,61)	3.2 E+1 (g)
Cr-51	1.0 E+0(c)	2.0 E+2 (i)
Mn-54	1.0 E+3(95,96)	2.5 E+1 (g)
Fe-55	5.0 E+3(95,96)	3.0 E+2 (h)
Fe-59	5.0 E+3(95,96)	3.0 E+2 (h)
Co-58	5.0 E+1(95)	5.0 E+2 (h)
Co-60	5.0 E+1(95)	5.0 E+2 (h)
Ni-63		4.0 E+1 (h)
Cu-64	5.0 E+1(97)	2.0 E+1 (g)
Zn-65	1.5 E+2(60,61)	1.0 E+3 (g)
Sr-89	1.0 E+0(d)	4.0 E+1 (i)
Sr-90	1.0 E+0(d)	4.0 E+1 (i)
Zr-95	1.0 E+1(96)	1.0 E+2 (i)
Nb-95		3.0 E+4 (j)
Mo-99		1.0 E+2 (h)
Ru-103	5.0 E+0(96)	1.0 E+2 (j)
Ru-106	5.0 E+0(96)	1.0 E+2 (j)
Te-132	1.0 E+3 (e)	1.0 E+5 (k)
I-129		1.0 E+0 (i)
I-131	1.0 E+0(98)	1.0 E+0 (i)
I-132		1.0 E+0 (i)
I-133		1.0 E+0 (i)
I-135		1.0 E+0 (i)
Cs-134	1.0 E+3(f)	1.0 E+3 (g)
Cs-137	1.0 E+3(f)	1.0 E+3 (g)
Ba-140		1.0 E+1 (j)
La-140		1.0 E+2 (l)
Ce-141	5.0 E+1(95,96)	1.0 E+2 (l)
Ce-144	5.0 E+1(95,96)	1.0 E+2 (l)

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TABLE III-12 (continued)

(a) Midrange of literature values unless otherwise stated.

(b) Calculated from fish and water concentrations given in Reference (59).

(c) Samples of Columbia River water and fish at Hanford yield a value of < 1.0 for B_A for Cr-51.[60,61]

(d) Based on calcium concentration in Upper Mississippi River.[99-101]

(e) Assumed as more reasonable than the element ratio (10^5) given in Reference (59) because of relatively short half-life.

(f) Based on potassium concentration in Upper Mississippi River.[99,102-106]

Notes from Reference (59)

(g) Data available for both fresh fish and fresh water.

(h) Data for fresh water fish not available; concentration data for marine fish used.

(i) Data on ratio available in literature.

(j) Ratio based on data for sea fish and sea water.

(k) Data lacking, assumed ratio of 10^5 as highest found for any element.

(l) Based on composite of rare earth data (including a B_A of 80 for ^{144}Ce).

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Although it may seem logical that radioactive decay would result in smaller concentration ratios for short-lived nuclides than for the elements, experience with ^{24}Na ($t_{1/2}$ = 15 hours) has not borne this out. Data in the literature and from Hanford's environmental survey program both lead to a value of 100 for (B_A) for ^{24}Na compared to a value of 35 derived for stable elements.[69] This higher ratio (of 100) implies rapid equilibrium between sodium in water and sodium in fish. Radionuclide concentrations in fish are not, of course, solely dependent upon the concentration in water. For some nuclides the relative metabolic activity of the fish is important, with higher uptakes noted at higher water temperatures.[94] Concentration factors for ^{89}Sr, ^{90}Sr, and ^{134}Cs, ^{137}Cs were calculated from data in the literature modified for measured values of calcium and potassium content of the UMRB region. For the first version of the FPM, shellfish and marine fish imported from outside of the region of interest were considered to be free of contamination.

Waterfowl generally have radionuclide concentration in their flesh similar to the concentrations found in fish harvested at the same location. For these reasons, waterfowl flesh was considered to have the same contamination levels (at time of harvest) as fish. However, decay times between harvest and consumption for these two types of food are not necessarily identical (as explained in a subsequent section).

The centroid where fish and waterfowl are harvested determines the concentrations of radionuclides in their flesh. This centroid is not always the same as the one where they are eaten. Methods of determining centroid of harvest are explained later.

Concentrations in Food at Time of Consumption

The FPM calculates concentrations in food at time of harvest. Concentrations of radionuclides in food are reduced by losses due to radioactive decay between harvest and consumption, and losses caused by commercial processing. Losses of radionuclides from drinking water occur during water treatment and vary with nuclide, form (suspended or dissolved),

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and treatment type. These losses are discussed in the following subsections.

A fixed regime of production dates and decay times between harvest and consumption was created, based principally on the author's opinion and judgment. Foods were placed into one of three groups: (1) fixed harvest and fixed decay, (2) variable harvest and fixed decay, and (3) fixed harvest and variable decay. Group one included seasonal foods eaten fresh only for a limited period of the year soon after harvest, i.e., melons. Group two included food generally eaten all year round but grown in different locations with different harvest dates. This group included items such as lettuce which is imported from outside the region in the winter months. Group three included items that were either processed (canned or frozen) or that could be stored for long periods without processing, e.g., potatoes. All foods were assumed to have been consumed within 12 months following their harvest date. Table III-13 lists the 35 food categories and defines the decay period assumptions. The decay time listed in the table includes the time required for commercial processing and storage, transportation and marketing, and storage at home prior to consumption. For those foods with variable decay times, the dose calculation program calculates the number of days between the month of harvest and the month of consumption prior to establishing the exponential decay correction factor.

Losses of radionuclides from food products occur during commercial processing and during home preparation. It was assumed that all such losses were physical, and no conversion of radionuclides from soluble to insoluble forms occurred. Processing steps include washing, peeling trimming of undesirable portions, and cooking by boiling, baking, frying, etc. In addition, milling of grain products leads to significant losses of radionuclides.[107-109]

For purposes of the UMRB study, such losses were counted only once for each food. For example, if a food is purchased fresh, the losses occur in the home; if it is purchased canned or frozen, the losses occur during commercial processing. Even though certain foods may be eaten fresh, such

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TABLE III-13

DECAY PERIODS ASSUMED BETWEEN
HARVEST AND CONSUMPTION FOR 35 FOOD CATEGORIES

	Food Category	Time of Harvest	Decay Time (days)
1.	Berries - fresh	Fixed	4
2.	Berries - processed	Fixed	Variable
3.	Tree Fruit - fresh	Fixed	10
4.	Tree Fruit - processed	Fixed	Variable
5.	Melons - fresh	Fixed	7
6.	Tropical Fruit - fresh	Variable	N.D.[a]
7.	Tropical Fruit - processed	Variable	Variable
8.	Citrus Fruit - fresh	Fixed	Variable
9.	Citrus Fruit - processed	Fixed	Variable
10.	Potatoes - fresh	Fixed	Variable
11.	Potatoes - processed	Fixed	Variable
12.	Root Vegetables - fresh	Fixed	10
13.	Root Vegetables - processed	Fixed	Variable
14.	Green Leafy Vegetables - fresh	Fixed	7
15.	Green Leafy Vegetables - processed	Fixed	Variable
16.	Other above ground Veg. - fresh	Fixed	5
17.	Other above ground Veg. - processed	Fixed	Variable
18.	Grain & Grain Products	Fixed	Variable
19.	Rice and Rice Products	Fixed	Variable
20.	Wheat & Wheat Products	Fixed	Variable
21.	Milk - fresh	Variable	3
22.	Milk - processed & Products	Variable	20
23.	Butter	Variable	10
24.	Fresh Whole Eggs	Variable	7
25.	Beef & Lamb	Variable	20
26.	Pork - fresh	Variable	20
27.	Pork - processed	Variable	30
28.	Poultry	Variable	5
29.	Waterfowl	(b)	7
30.	Ocean Fish - processed	Variable	Variable
31.	Shell Fish	Variable	N.D.
32.	Ocean Fish - fresh	Variable	N.D.
33.	River Fish (sports)	Variable	3
34.	Upland Game Birds	(b)	2
35.	Secondary Water	Variable	0

(a) N.D. means not defined for the current region since all of these foods are imported free of contamination.

(b) Dependent upon hunting season.

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as lettuce and carrots, they will experience losses of radionuclides due to washing, peeling of outer leaves or paring. The limited data found in the literature for losses of ^{89}Sr, ^{90}Sr, ^{131}I, ^{134}Cs, and ^{137}Cs during food preparation, and, in addition, losses of ^{54}Mn and ^{144}Ce during milling of wheat, are tabulated in Table III-14.

Since the data in Table III-14 were so limited, an average loss factor was assumed for each type of crop for all radionuclides. These factors selected are listed in Table III-15 in terms of the fraction of the radionuclide content that actually passes through the processing; in other words, the ratio of the radionuclide concentration (pCi/kg) measured after processing to the concentration measured before processing.

One final loss results from the fraction of food taken into the household that is thrown away as scraps or fed to pets. Since this actually affects the quantity consumed rather than the concentration of the radionuclide, it will be discussed in the subsection concerned with determination of the individual diets.

Drinking Water

Water actually consumed by human beings is subject to a wide variety of treatment processing prior to consumption. These processes range from no treatment to chemical treatment followed by filtration. Radionuclides will be removed with varying degrees of efficiency, depending not only upon the specific process used but also whether the radionuclides are dissolved in the water or are associated with suspended material. Concentrations of the radionuclides in both soluble and insoluble forms are calculated by WTRAN. The LPM tape contains a record of the type of water source and type of water treatment for each centroid in the study region.

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TABLE III-14

LOSSES OF RADIONUCLIDES DURING PROCESSING OF FOODS

Food	Processing Steps	^{54}Mn	$^{89,90}Sr$	^{131}I	$^{134,137}Cs$	^{144}Ce	Experimental Conditions
Carrot	peeled, washed, boiled		19 (110)				Contamination throughout growing season
Onion	" " "		37 (110)				
Potato	" " "		24 (110)				
Tomato	washed		28 (110)				
Cabbage	outer leaves removed, washed, boiled		55 (110)	65(112)			
Beans	ends removed, washed, boiled		36 (110)				
Potato	peeled				25-27(113)		
Spinach	washed (external only)		58 (111)	65(112)	72(111)		Contamination 1-2 hrs. before harvest
Broccoli	washed (external only)		93 (111)	65(112)	91(111)		
Spinach	washed (internal)		53 (111)		33(111)		
Broccoli	washed (internal)		68				
Peach	peeled (external)		91 (111)		97(111)		Contamination 1-2 hrs before harvest
Pear	washed (external)		5 (111)				
Pear	washed, peeled (external)		19 (111)		50(111)		
Strawberry	washed (external)		31 (111)	65(112)	36(111)		
Cauliflower	washed			65(112)			
Escarole	washed			65(112)			
Grapes	washed			65(112)			
Peaches	washed			65(112)			
Wheat	milling	96(108)	92 (109)		84(107)	91(107)	
Fish	boiling			58(114)			
Fish	grilling			23(114)			
Fish	frying			20(114)			

Losses given as percentage loss.

Numbers in parentheses are references.

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TABLE III-15

FRACTION OF RADIONUCLIDE CONCENTRATIONS REMAINING IN VARIOUS FOODS AFTER PREPARATION FOR CONSUMPTION

Food	Fraction Remaining After Preparation[a]
Milk	1.0
Leafy Vegetables	0.4
Other Above Ground Vegetables	0.4
Potato	0.75
Other Below Ground Vegetables	0.75
Orchard Fruit, fresh	0.9
Orchard Fruit, processed	0.4
Berries	0.67
Melons	0.9
Wheat	0.15
Other Grain	0.15
Fish	0.8
Beef (& lamb)	0.9
Pork	0.9
Poultry (& game birds & waterfowl)	0.9

[a] Ratio of concentration (pCi/g wet weight) measured after preparation to that measured before concentration.

Four treatment processes and their effect on the radionuclide content of the water were defined:

- No treatment other than chlorination: No reduction in dissolved or suspended radionuclides.
- Filtration (and chlorination): Removes all suspended, but no dissolved radionuclides.
- Chemical processing (e.g., alum floc.): Removes variable amounts of dissolved and nearly all suspended radionuclides.
- Filtration plus chemical processing: Removes all suspended and variable amounts of dissolved radionuclides (see Table III-16).

The effects of the treatment system on water concentrations can be expressed as Equation (32) below:

$$C_{wm} = F'W'_m + F''W''_m \tag{32}$$

where C_{wm} is the total concentration of a given radionuclide in the water leaving the treatment plant.

W'_m is the concentration of the radionuclide dissolved in the water entering the plant during month (m).

F' is the fraction of the dissolved radionuclide that passes through the treatment process.

W''_m is the concentration of the radionuclide suspended in the water entering the plant during month (m).

F'' is the fraction of the suspended radionuclide that passes through the treatment process.

No factors for physical loss in the piping or reservoir, or for radioactive decay between the treatment plant and the consumer, are employed. Some persons will consume water directly from a home well or will live close to the water treatment plant. Therefore C_w also represents the concentrations at the time of water consumption.

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The values of (F') and (F'') for use with each treatment type are tabulated below:

Plant Type	F'	F''
1	1.0	1.0
2	1.0	0.0
3	(Use Table III-16)	0.0
4	(Use Table III-16)	0.0

Extensive experience with the alum-floc processes at Richland and Pasco, Washington, has indicated the efficiency of removal in a Type 4 plant for several radionuclides.[60,61, 115-121] Water samples have been collected before and after processing at these two city treatment plants for a combined total of 12 years of operating data. These samples have been analyzed for several of the radionuclides of interest in the current study. From these analyses and from chemical similarity of those radionuclides not measured, the fractions of the dissolved radionuclides that would pass through a type 3 or 4 treatment plant have been estimated. These values are summarized in Table III-16.

CALCULATION OF AVERAGE DIETS

Food entering households in units of pounds per week per household are recorded on the LPM tape for three distinct types of households -- Urban, Rural farm, and Rural nonfarm. These data were given in a USDA report "Food Consumption of Households in the North Central U.S. Spring 1965,"[24] which tabulated the foods in a manner related to nutritive value. The food categories were rearranged on the basis of similarity of agricultural practices, and mixtures such as baked goods and ice cream were broken down into primary ingredients and added to the totals in the list of the 35 items. Table III-17 lists the adjusted pounds per week of each category of food entering the household.

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TABLE III-16

FRACTION OF DISSOLVED RADIONUCLIDES PASSING THROUGH TYPICAL (CLASS 3 or 4) MUNICIPAL WATER TREATMENT PLANT

Nuclide	Fraction Passing	Remarks
H-3	1.0	
N-13	0.0	(by decay)
C-14	0.2	(as HCO_3)
Na-22	0.9	
Na-24	0.6	† (mostly decay)
Cr-51	0.9	†
Mn-54	0.2	
Fe-55	0.2	
Fe-59	0.2	
Co-58	0.2	
Co-60	0.2	
Ni-63	0.2	
Cu-64	0.3	†
Zn-65	0.4	†
Sr-89	0.2	
Sr-90	0.2	
(Y-90)	(0.2)	† (measured as RE + Y*)
Zr-95	0.3	
Nb-95	0.3	
Mo-99	0.8	(similar to Cr)
Ru-103	0.2	(similar to Fe)
Ru-106	0.2	(similar to Fe)
Te-132	0.7	
I-129	0.8	
I-131	0.8	†
I-132	0.0	(decay plus removal)
I-133	0.8	
I-135	0.2	(decay plus removal)
Cs-134	0.8	
Cs-137	0.8	
Ba-140	0.2	
La-140	0.2	†(measured as RE + Y)
Ce-141	0.2	†(" " " ")
Ce-144	0.2	†(" " " ")
(Pr-144)	(0.2)	†(" " " ")

†Average of 6 yrs. measurements at Pasco, Washington, and 5-1/2 yrs. measurements at Richland, Washington, alum-floc water treatment plants.

*Rare earths plus Yttrium.

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TABLE III-17

QUANTITIES OF VARIOUS FOODS ENTERING HOUSEHOLDS IN THE STUDY REGION AND FRACTIONS AVAILABLE FOR CONSUMPTION

Food Item	Fraction Consumed	lbs/week entering household[a] Urban	Rural	Rural Nonfarm
1. F Berries	0.95	0.42	1.29	1.02
2. P Berries	1.0	0.07	0.12	0.13
3. F Tree Fruit	0.85	1.88	3.26	2.26
4. P Tree Fruit	1.0	3.94	3.83	3.61
5. F Melons	0.5	1.61	1.28	0.94
6. F Tropical Fruit	0.6	1.51	2.07	1.61
7. P. Tropical Fruit	1.0	0.2	0.28	0.29
8. F Citrus Fruit	0.7	3.02	3.14	2.81
9. P Citrus Fruit	1.0	12.25	10.77	12.37
10. F Potatoes	0.8	4.92	9.23	6.41
11. P Potatoes	1.0	0.72	0.63	0.73
12. F Root Vegetables	0.35	1.56	1.96	1.68
13. P Root Vegetables	1.0	0.23	0.19	0.19
14. F Leafy Vegetables	0.7	2.15	2.39	2.22
15. P Leafy Vegetables	1.0	0.16	0.10	0.11
16. F OAG Vegetables	0.65	2.88	4.91	3.64
17. P OAG Vegetables	1.0	3.99	4.03	4.06
18. Misc. Grain	1.0	0.83	1.39	1.02
19. Rice	1.0	0.32	0.25	0.26
20. Wheat	1.0	9.92	14.18	11.40
21. F Milk	1.0	19.18	25.30	21.10
22. Milk Products	1.0	3.81	5.23	4.15
23. Butter	1.0[b]	0.50	1.01	0.50
24. Eggs (doz/week)	1.0	0.53	3.72	2.84
25. Beef & Lamb	0.85	6.29	8.65	6.22
26. F Pork	0.85	3.91	2.00	3.78
27. P Pork	0.9	4.06	4.84	4.15
28. Poultry	0.65	2.74	2.50	2.31
29. Waterfowl	1.0[b]	0.003[c]	0.023[c]	0.017[c]
30. P Ocean Fish	1.0	0.45	0.40	0.45
31. Shell fish	0.7	0.06	0.05	0.09
32. F Ocean fish	0.6	0.05	0.10	0.05
33. Sports fish	1.0	0.12[d]	0.22[d]	0.21[d]
34. Upland Game Birds	1.0[b]	0.007[c]	0.047[c]	0.033[c]
35. Secondary Water	1.0[b]	22.86	31.77	33.43

(a) Derived from Reference (24)
(b) Originally estimated directly in edible weight.
(c) Estimated from (1) total harvest of migratory fowl,[36] (2) assumption from experience in S.E. Washington that total edible wt. of upland game birds harvested is twice total edible wt. of waterfowl harvested, and (3) weighted by data on game birds from Reference (24)
(d) Estimated from total catch in region (33,37,123-125) and weighted by data on "non-bought fish" given in Reference (24).
F = Fresh; P = Processed; OAG = Other above ground vegetables.

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Category 35 encompasses total water including both tap water consumed directly and secondary water consumed as part of soup, frozen juice, powdered and canned milk, beer, pop, etc. Although secondary water consumption could have been estimated from the intake of foods, data on total water consumption were found to be available in the literature.

A combination of several factors and methods was required to convert the LPM tape records for given pounds per week per household into quantities actually consumed per person per week. These methods are discussed below.

Food not eaten is lost in trimming, fed to pets, or discarded as "left-overs". The fraction of each food category entering a household available for consumption was determined from the data recorded in USDA Agricultural handbook 8, "Consumption of Foods, Raw, Processed, Prepared"[122] and was included in Table III-17.

The total quantity of food type (i) actually consumed in a given household of type (n) [(urban, rural-nonfarm, rural farm)] then is the product of the quantity entering the household ($\Delta_{n,i}$) and the fraction not wasted (E_i). The fraction not wasted was assumed to be constant for each of the three types of households.

The total quantity consumed is also equal to the summation of the diets of the individual members of the household as given in Equation (33) below:

$$(\Delta_{n,i})\ E_i = F_{A,n}\ (A_{n,i}) + F_{T,n}\ (T_{n,i}) + F_{C,n}\ (C_{n,i}) \qquad (33)$$

where $\Delta_{n,i}$ is the pounds per week of food type (i) entering the household type (n).

E_i is the fraction of food type (i) actually consumed. Assumed the same for all (n).

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$$\left.\begin{matrix} A_{n,i} \\ T_{n,i} \\ C_{n,i} \end{matrix}\right\}$$ are the diets (lbs/week/person) of the adult (A), teen(T), or child (C) for food (i) in household (n).

$$\left.\begin{matrix} F_{A,n} \\ F_{T,n} \\ F_{C,n} \end{matrix}\right\}$$ are the numbers of persons of type A, T, or C in household (n), as given in Reference (24) and Table III-18.

The individual diets $(A_{n,i})$, $(T_{n,i})$, $(C_{n,i})$ are the items being sought. Data on the actual consumption by these groups in the region of interest were not readily available. However, data were available for different locations. For example, Reference (126) lists the consumption of various foods by age for Northern and Southern U.S. by incomes. From these data, it was possible to derive ratios of consumption of various food items in the North (for all incomes) for child/teen/adult diets. These ratios were then assumed to hold true for the North Central[127,128] region. To check the validity of this assumption, data from local diet surveys were converted to similar ratios and compared with those for the North. Both sets of ratios are tabulated in Table III-19.

Equation (33) can now be modified to include diet ratios in place of individual diets.

Set $K_{C,i} = C_i/A_i$ for all (n)

and $K_{T,i} = T_i/A_i$ for all (n)

then Equation (33) becomes:

$$(\Delta_{n,i})E_i = (F_{A,n})(A_{n,i}) + (F_{T,n})(K_{T,i})(A_{n,i}) + (F_{C,n})(K_{C,n})(A_{n,i}) \quad (34)$$

or $$(\Delta_{n,k})E_i = A_{n,i}[(F_{A,n}) + (F_{T,n})(K_{T,i}) + (F_{C,n})(K_{C,i})] \quad (35)$$

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TABLE III-18

NUMBERS OF PERSONS IN EACH HOUSEHOLD TYPE WHO ARE CHILDREN, TEENS, AND ADULTS[24]

Person Type	Symbol	Urban	Rural Nonfarm	Rural Farm	All
Child (0-11 yrs)	$F_{C,n}$	0.83	0.96	0.94	0.89
Teen (12-19 yrs)	$F_{T,n}$	0.38	0.40	0.54	0.40
Adult ($\geq$ 20 yrs)	$F_{A,n}$	2.0	2.0	2.1	2.0
All Ages		3.2	3.6	3.6	3.3
% of households of each type in the North Central area		70	20	10	100

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TABLE III-19

RATIOS OF AVERAGE FOOD INTAKES FOR CHILDREN, TEENS, AND ADULTS

Food Items	Category Numbers on LPT[a]	Ratios - Child/Teen/Adult	
		Northern U.S.[b]	Local Surveys[c]
Fruit (local)	1-6	1.1/1.3/1	---
Fruit, Citrus	7-9	0.77/1/1	---
Potatoes	10,11	0.45/0.70/1	0.48/1/1
Root Vegetables	12,13	0.67/1/1	
Green Leafy Vegetables	14,15	0.42/0.68/1	0.33/0.87/1
Other above Ground Vegetables	16,17	0.44/0.75/1	
Cereal	18,20	1.3/1.5/1	0.48/1/1
Milk	21	1.6/1.9/1	---
Milk Products	22	0.60/0.97/1	---
Butter	23	0.5/1/1	
Eggs	24	0.39/0.51/1	---
Beef & Lamb	25	0.34/0.56/1	0.39/0.94/1
Pork	26,27	0.41/0.62/1	
Poultry	28,29,34	0.46/0.81/1	0.43/1/1
Fish & Seafood	30,33	0.33/0.75/1	0.24/0.71/1
Total Fruit	--	0.98/1.2/1	---

(a) See Table III-17.

(b) From Reference (126).

(c) From References (127,128).

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The factor necessary to convert lbs/week/household to lbs/week consumed by an average adult is the ratio $(A_{n,i}/\Delta_{n,i})$. This factor is obtained by rearranging Equation (35) to yield Equation (36):

$$\frac{A_{n,i}}{\Delta_{n,i}} = \frac{E_i}{(F_{A,n}) = (F_{T,n})\ (K_{T,i}) + (F_{C,n})\ (K_{C,i})} \ . \qquad (36)$$

The factors for teen and child are then found by multiplying the adult factor by the appropriate ratio (K_i) as follows:

$$\frac{T_{n,i}}{\Delta_{n,i}} = K_{T,i}\ \left(\frac{A_{n,i}}{\Delta_{n,i}}\right) \qquad (37)$$

and

$$\frac{C_{n,i}}{\Delta_{n,i}} = K_{C,i}\ \left(\frac{A_{n,i}}{\Delta_{n,i}}\right) \qquad (38)$$

The results of these calculations are given in Tables III-20, III-21, III-22 for urban, rural-nonfarm, and rural-farm households, respectively.

The factors in the last three tables multiplied by the data on the LPM tape will yield consumption in lbs/week/person. The dose calculation requires the consumption to be stated in units of kilograms per month per person. The necessary conversion factor of 1.97 kg/mo per lbs/week has been entered into the portion of the program that calculates dose from food consumption.

Consumption of sports fish, upland game birds and waterfowl were calculated differently than other food categories, and the methods used are explained in the subsequent sections.

TABLE III-20

CALCULATED DIET FACTORS FOR AVERAGE ADULT, TEEN, AND CHILD IN URBAN HOUSEHOLDS OF NORTH CENTRAL U.S.

Food	Adult ($A_i/\ _i$)	Teen ($T_i/\ _i$)	Child ($C_i/\ _i$)
F Berries	0.279	0.362	0.307
P Berries	0.293	0.381	0.323
F Tree Fruit	0.249	0.324	0.275
P Tree Fruit	0.293	0.381	0.323
F Melons	0.146	0.190	0.162
F Tropical Fruit	0.176	0.229	0.194
P Tropical Fruit	0.329	0.329	0.263
F Citrus Fruit	0.231	0.231	0.179
P Citrus Fruit	0.331	0.331	0.255
F Potatoes	0.303	0.212	0.136
P Potatoes	0.379	0.265	0.170
F Root Vegetables	0.119	0.119	0.080
P Root Vegetables	0.341	0.341	0.228
F Leafy Vegetables	0.268	0.183	0.113
P Leafy Vegetables	0.384	0.261	0.161
F Other Above Ground Veg.	0.245	0.184	0.108
P Other Above Ground Veg.	0.377	0.283	0.166
Miscellaneous Grain	0.274	0.411	0.356
Rice	0.274	0.411	0.356
Wheat	0.274	0.411	0.356
F Milk	0.247	0.469	0.395
Milk Products	0.349	0.388	0.209
Butter	0.358	0.358	0.179
Eggs (doz/wk)	0.397	0.203	0.155
Beef and Lamb	0.340	0.191	0.116
F Pork	0.330	0.205	0.135
P Pork	0.349	0.216	0.143
Poultry	0.242	0.196	0.111
Waterfowl	0.372	0.301	0.171
P Ocean Fish	0.391	0.293	0.129
Shell Fish	0.274	0.205	0.090
F Ocean Fish	0.235	0.176	0.077
Sports Fish	0.391	0.293	0.129
Upland Game Birds	0.379	0.307	0.152
Secondary Water	—	—	—

F = Fresh

P = Processed

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TABLE III-21

CALCULATED DIET FACTORS FOR AVERAGE ADULT, TEEN, AND CHILD IN RURAL NON-FARM HOUSEHOLDS OF NORTH CENTRAL U.S.

FOOD	Adult (A_i/Δ_i)	Teen (T_i/Δ_i)	Child (C_i/Δ_i)
F Berries	0.266	0.345	0.292
P Berries	0.280	0.364	0.308
F Tree Fruit	0.238	0.309	0.261
P Tree Fruit	0.280	0.364	0.308
F Melons	0.140	0.182	0.154
F Tropical Fruit	0.168	0.218	0.185
P Tropical Fruit	0.316	0.316	0.253
F Citrus Fruit	0.223	0.223	0.172
P Citrus Fruit	0.319	0.319	0.245
F Potatoes	0.295	0.206	0.133
P Potatoes	0.369	0.258	0.166
F Root Vegetables	0.115	0.115	0.077
P Root Vegetables	0.329	0.329	0.220
F Leafy Vegetables	0.262	0.178	0.110
P Leafy Vegetables	0.373	0.254	0.157
F Other Above Ground Veg.	0.239	0.179	0.105
P Other Above Ground Veg.	0.367	0.275	0.162
Miscellaneous Grain	0.260	0.390	0.338
Rice	0.260	0.390	0.338
Wheat	0.260	0.390	0.338
F Milk	0.233	0.442	0.372
Milk Products	0.337	0.327	0.202
Butter	0.347	0.347	0.174
Eggs	0.183	0.093	0.071
Beef and Lamb	0.333	0.187	0.113
F Pork	0.322	0.200	0.132
P Pork	0.341	0.211	0.140
Poultry	0.235	0.190	0.108
Waterfowl	0.362	0.293	0.166
P Ocean Fish	0.382	0.287	0.126
Shellfish	0.268	0.201	0.088
F Ocean Fish	0.229	0.172	0.076
Sports Fish	0.382	0.287	0.126
Upland Game Birds	0.369	0.299	0.145
Secondary Water	—	—	—

F = Fresh

P = Processed

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TABLE III-22

CALCULATED DIET FACTORS FOR AVERAGE ADULT, TEEN, AND CHILD IN RURAL-FARM HOUSEHOLDS OF NORTH CENTRAL U.S.

Food	Adult (A_i/Δ_i)	Teen (T_i/Δ_i)	Child (C_i/Δ_i)
F Berries	0.248	0.322	0.272
P Berries	0.261	0.339	0.287
F Tree Fruit	0.222	0.288	0.244
P Tree Fruit	0.261	0.339	0.287
F Melons	0.130	0.169	0.143
F Tropical Fruit	0.156	0.203	0.172
P Tropical Fruit	0.295	0.295	0.236
F Citrus Fruit	0.208	0.208	0.160
P Citrus Fruit	0.207	0.297	0.229
F Potatoes	0.276	0.193	0.124
P Potatoes	0.345	0.241	0.155
F Root Vegetables	0.107	0.107	0.072
P Root Vegetables	0.306	0.306	0.205
F Leafy Vegetables	0.245	0.166	0.103
P Leafy Vegetables	0.349	0.238	0.147
F Other Above Ground Veg.	0.223	0.167	0.098
P Other Above Ground Veg.	0.343	0.257	0.151
Miscellaneous Grain	0.242	0.363	0.315
Rice	0.242	0.363	0.315
Wheat	0.242	0.363	0.315
F Milk	0.216	0.410	0.346
Milk Products	0.314	0.304	0.188
Butter	0.322	0.322	0.161
Eggs	0.365	0.186	0.142
Beef and Lamb	0.312	0.175	0.106
F Pork	0.301	0.187	0.124
P Pork	0.319	0.198	0.131
Poultry	0.219	0.177	0.101
Waterfowl	0.337	0.273	0.155
P Ocean Fish	0.355	0.266	0.117
Shell Fish	0.249	0.186	0.082
F Ocean Fish	0.213	0.160	0.070
Sports Fish	0.355	0.266	0.117
Upland Games Birds	0.343	0.278	0.137
Secondary Water	—	—	—

F = Fresh

P = Processed

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CALCULATION OF MAXIMUM DIETS

Although maximum diets could not be directly established for the North Central Region, reasonable estimates of the ratio of maximum to average consumption for certain food categories were available from local dietary surveys.[121, 127] The ratios selected for use from these studies are tabulated in Table III-23. The ratios in Table III-23 were multiplied directly by the factors previously listed in Tables III-20, 21, and 22 for the average diets to obtain the factors for the maximum diets given in Tables III-23, 25, and 26.

The factors in Tables III-24 through III-26 when multiplied by the data in the LPM will convert lbs/week/household to lbs/week/person. As in the case of average consumption, the factor of 1.97 to convert lbs/week to kilograms/month has been entered into the dose calculation portion of the program.

TABLE III-23

ESTIMATED RATIOS OF MAXIMUM TO AVERAGE DIETS FOR CERTAIN FOODS[121,127]

Food Categories	Ratio Maximum to Average Consumption
1-13, 15-17	2.6 (all ages)
14, 18-20, 22-24	2.0 (all ages)
25-27	1.1 (all ages)
28	1.5 (all ages)
29, 33, 34	20. (all ages)
30, 31, 32	5. (all ages)
21	3. (adult)
21	2. (teen)
21	2. (child)

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TABLE III-24

CALCULATED DIET FACTORS FOR MAXIMUM ADULT, TEEN, AND CHILD IN URBAN HOUSEHOLDS OF NORTH CENTRAL U.S.

Food	Adult (A_i/Δ_i)	Teen (T_i/Δ_i)	Child (C_i/Δ_i)
F Berries	0.73	0.94	0.80
P Berries	0.76	0.99	0.84
F Tree Fruit	0.65	0.84	0.72
P Tree Fruit	0.76	0.99	0.84
F Melons	0.38	0.49	0.42
F Tropical Fruit	0.46	0.60	0.50
P Tropical Fruit	0.86	0.86	0.68
F Citrus Fruit	0.60	0.60	0.47
P Citrus Fruit	0.86	0.86	0.66
F Potatoes	0.79	0.55	0.35
P Potatoes	0.98	0.69	0.44
F Root Vegetables	0.31	0.31	0.21
P Root Vegetables	0.89	0.89	0.59
F Leafy Vegetables	0.54	0.37	0.23
P Leafy Vegetables	1.00	0.68	0.42
F Other Above Ground Veg.	0.64	0.48	0.28
P Other Above Ground Veg.	0.98	0.74	0.43
Miscellaneous Grain	0.55	0.82	0.71
Rice	0.55	0.82	0.71
Wheat	0.55	0.82	0.71
F Milk	0.74	0.94	0.79
Milk Products	0.70	0.68	0.42
Butter	0.72	0.72	0.36
Eggs	0.79	0.41	0.31
Beef and Lamb	0.37	0.21	0.13
F Pork	0.36	0.23	0.15
P Pork	0.38	0.24	0.16
Poultry	0.36	0.29	0.17
Waterfowl	7.4	6.0	3.4
P Ocean Fish	2.0	1.5	0.64
Shell Fish	1.4	1.0	0.45
F Ocean Fish	1.2	0.88	0.38
Sports Fish	7.8	5.9	2.6
Upland Game Birds	7.6	6.1	3.0
Secondary Water	--	--	--

F = Fresh

P = Processed

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TABLE III-25

CALCULATED DIET FACTORS FOR MAXIMUM ADULT, TEEN, AND CHILD IN RURAL NON-FARM HOUSEHOLDS OF NORTH CENTRAL U. S.

Food	Adult (A_i/Δ_i)	Teen (T_i/Δ_i)	Child (C_i/Δ_i)
F Berries	0.69	0.90	0.76
P Berries	0.73	0.95	0.80
F Tree Fruit	0.62	0.80	0.68
P Tree Fruit	0.73	0.95	0.80
F Melons	0.36	0.47	0.40
F Tropical Fruit	0.44	0.57	0.48
P Tropical Fruit	0.82	0.82	0.66
F Citrus Fruit	0.58	0.58	0.45
P Citrus Fruit	0.83	0.83	0.64
F Potatoes	0.77	0.54	0.35
P Potatoes	0.96	0.67	0.43
F Root Vegetables	0.30	0.30	0.20
P Root Vegetables	0.86	0.86	0.57
F Leafy Vegetables	0.52	0.36	0.22
P Leafy Vegetables	0.97	0.66	0.41
F Other Above Ground Veg.	0.62	0.47	0.27
P Other Above Ground Veg.	0.95	0.72	0.42
Miscellaneous Grain	0.52	0.78	0.68
Rice	0.52	0.78	0.68
Wheat	0.52	0.78	0.68
F Milk	0.47	0.88	0.74
Milk Products	0.67	0.65	0.40
Butter	0.69	0.69	0.34
Eggs	0.37	0.19	0.14
Beef and Lamb	0.37	0.21	0.14
F Pork	0.35	0.22	0.15
P Pork	0.38	0.23	0.15
Poultry	0.35	0.28	0.12
Waterfowl	7.2	5.9	3.3
P Ocean Fish	1.9	1.4	0.63
Shell Fish	1.3	1.0	0.44
F Ocean Fish	1.1	0.86	0.38
Sports Fish	7.6	5.7	2.5
Upland Game Birds	7.4	6.0	2.9
Secondary Water	--	--	--

F = Fresh

P = Processed

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TABLE III-26

CALCULATED DIET FACTORS FOR MAXIMUM ADULT, TEEN, AND CHILD IN RURAL-FARM HOUSEHOLDS OF NORTH CENTRAL U.S.

Food	Adult (A_i/Δ_i)	Teen (T_i/Δ_i)	Child (C_i/Δ_i)
F Berries	0.64	0.84	0.71
P Berries	0.68	0.88	0.75
F Tree Fruit	0.58	0.75	0.63
P Tree Fruit	0.68	0.88	0.75
F Melons	0.34	0.44	0.37
F Tropical Fruit	0.41	0.53	0.45
P Tropical Fruit	0.77	0.77	0.61
F Citrus Fruit	0.54	0.54	0.42
P Citrus Fruit	0.77	0.77	0.60
F Potatoes	0.72	0.50	0.32
P Potatoes	0.90	0.63	0.40
F Root Vegetables	0.28	0.28	0.19
P Root Vegetables	0.80	0.80	0.53
F Leafy Vegetables	0.49	0.33	0.21
P Leafy Vegetables	0.91	0.62	0.38
F Other Above Ground Veg.	0.58	0.43	0.25
P Other Above Ground Veg.	0.89	0.67	0.39
Miscellaneous Grain	0.48	0.73	0.62
Rice	0.48	0.73	0.62
Wheat	0.48	0.73	0.62
F Milk	0.65	0.82	0.69
Milk Products	0.63	0.61	0.38
Butter	0.64	0.64	0.32
Eggs	0.73	0.37	0.28
Beef and Lamb	0.40	0.23	0.14
F Pork	0.33	0.21	0.14
P Pork	0.35	0.22	0.14
Poultry	0.33	0.27	0.15
Waterfowl	6.7	5.5	3.1
P Ocean Fish	1.8	1.3	0.58
Shell Fish	1.2	0.93	0.41
F Ocean Fish	1.1	0.80	0.35
Sports Fish	7.1	5.3	2.3
Upland Game Birds	6.9	5.6	2.7
Secondary Water	--	--	--

F = Fresh

P = Processed

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CONSUMPTION OF FOODS

Consumption of Drinking Water

Total tap water intake including that mixed with frozen juices, canned soup, powdered milk, tea, and coffee has been studied for adults and children at Hanford.[121,127] Several studies of the intake of children principally in relation to proposals for fluoridation of water were reviewed by Walker, et al.[129] The ICRP[130] has defined the water intake of the Standard Man as 1.2 l/day of tap water plus 1.0 l/day of other fluids such as milk, juice, etc., plus 0.3 l/day of water created as an oxidation product of foods.

From these data, total tap water intake by the average and maximum persons was defined as listed in Table III-27.

TABLE III-27

MAXIMUM AND AVERAGE TAP WATER INTAKE OF ADULT, TEEN AND CHILD[121,127,129,130]

Age	Average liters/day	Average kg/mo	Maximum liters/day	Maximum kg/mo	Ratio of Maximum to Average
4 yrs	0.7	21.4	1.4	42.7	2.
14 yrs	0.7	21.4	1.4	42.7	2.
Adult	1.0	30.5	2.0	61.0	2.

As explained previously, the data in this table include the so-called secondary water, and were used directly in the dose calculations without further reference to the secondary water category set up as Item 35 in Table III-17.

Consumption of Waterfowl and Game Birds

Detailed data on populations and harvest of waterfowl are maintained by Federal agencies since such birds may migrate across several states. Data

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for duck and goose kill, number of hunters, and days of hunting for 1965 were selected[36] because this was the year covered in the survey of diets[24]. The waterfowl data were reported by state and hence covered a larger area than the North Central Region defined for the dose program; therefore, the bird harvest was weighted by the total population (as of 1960) in the eight states to yield an average consumption of 0.008 lb/wk/household. (The fact that some birds may have been given away by the hunter does not change the average consumption across a large area.) The data used to derive the average consumption of waterfowl are listed in Table III-28.

TABLE III-28

ESTIMATES OF AVERAGE WATERFOWL CONSUMPTION IN THE NORTH CENTRAL REGION FOR 1965[36]

State	Duck Bag	Goose Bag	1960 Population
Kansas	136,000	11,800	2,178,600
Nebraska	116,600	15,000	1,411,300
S. Dakota	197,600	58,900	680,500
Illinois	253,000	24,400	10,081,200
Iowa	215,900	37,400	2,757,500
Minnesota	831,100	35,100	3,413,900
Missouri	146,100	42,500	4,318,800
Wisconsin	618,100	59,100	3,951,800
TOTAL	2,514,000	284,200	28,790,000
Edible Weight/Bird[a], lbs.	1.0	5.0	
Total Edible Weight, lbs.	2,514,000	1,421,000	
Grand Total, lbs	3,940,000		
Ave. lbs/wk/household @ 3.3 person/household[24]	0.008		

(a) Based on local estimates.

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Data from the Washington State Department of Game for the period 1960-1964 and from local diet surveys at Hanford both indicate that the upland game bird consumption was about twice that for waterfowl. On the basis of the data in Table III-28, this factor yields an upland game bird consumption of 0.016 lb/wk/household for a total of 0.024 lb/wk. This value is probably a little high because the 1965 population (which was higher than that for 1960) should have been used to derive the average consumption from the total kill.

The diet data derived from Reference (24) indicated that total game bird consumption was 0.01 lb/wk in urban, 0.05 lb/wk in rural nonfarm, and 0.07 lb/wk in rural farm households. Weighting these values by the fraction of population in each type of household also yielded an average of 0.024 lb/wk/household in the North Central Region. However, these data are undoubtedly for dressed weight, which for ducks includes about 20 percent bones, and for geese about 30 percent bones[122]. A weighted (2/3 duck, 1/3 goose) fractional loss is about 23 percent for a net edible weight of 0.018 lb/wk/household. The above data on consumption of game birds were obtained by substraction of two categories. The exact meaning of "game birds" in Reference (24) is somewhat uncertain, but apparently includes both waterfowl and upland game birds.

In the absence of more accurate diet data from the household survey, it was felt best to use the value of 0.024 rather than the lower (and less conservative) estimate of 0.018 lb/wk/household. Distribution of the 0.024 pounds among the three types of households was, however, based upon the relative amounts stated above. The estimated consumption data as entered into the Living Patterns Model (LPM) are listed in Table III-29.

The fractional consumption by age group was calculated as explained previously in Section 4.1, and the results were entered in Tables III-20, 21, and 22. The maximum-to-average ratio was taken to be 20/1 based on local surveys. The fractional consumption for maximum individuals, listed in Tables III-24, 25, and 26 are therefore 20 times the corresponding

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values (for Items 29 and 34) listed in Tables III-20, 21, and 22.

TABLE III-29

GAME BIRD CONSUMPTION AS LISTED IN LIVING PATTERNS MODEL

Centroid Type	% Population [24]	lb/wk/Household Waterfowl (Item 29)	lb/wk/Household Game Birds (Item 34)
Urban	70	0.003	0.007
Rural Non-Farm	20	0.017	0.033
Rural Farm	10	0.023	0.047
Population Weighted Average		0.008	0.016

Consumption of Fresh Water Sports Fish

Several studies of fishing pressure and harvest have been made in the past decade in states that comprise the North Central Region.[33,37, 123-125] Data are available on number of fishing trips, hours per trip, catch per hour of various species, and whether the fishing was from the bank or from a boat or barge. Some of the surveys also determined the seasonal distribution of the fishing pressure and harvest. From these reports, it was estimated that about 10 percent of the population fishes, with an average catch of 0.5 fish/hr of effort during 18 trips per year at 5 hr/trip. These values yield an average of 45 fish/yr per fisherman or 4.5 fish/yr/person in the overall population. Based on the species most frequently harvested - catfish and panfish - a reasonable estimate of edible weight would be 0.5 lb/fish.[35] These data lead to an estimate of 0.15 lb/wk/household overall average.

Data from the North Central diet study[24] indicated that the pounds per week of fresh water fish entering the three household types were 0.29, Urban; 0.47, Rural Non-Farm; and 0.52, Rural Farm. The population weighted average from these later data is 0.44 lb/wk/household.

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This weight includes 50-60 percent of bones, head, tail, fins, and skin[122], depending upon species. Assuming the consumption data from the fish surveys are more accurate than that from the household diet study, the average consumption was taken to be 0.15 lb/wk/household. This value was then prorated to each household type on the basis of the data from the household survey and the fraction of population in each type. The final values for fish consumption entered into the LPM are given in Table III-30.

TABLE III-30

SPORTS FISH CONSUMPTION AS LISTED IN LIVING PATTERNS MODEL

Centroid Type	% Population	lb/wk/household
Urban	70	0.12
Rural Non-Farm	20	0.21
Rural Farm	10	0.22
Population Weighted Average		0.15

The calculation of fractional consumption by average persons in each age group was performed as explained previously (page 126) and is listed in Tables III-20, 21, and 22.

As with game birds, local surveys indicated that no significant number of persons consume more than 20 times the average sports fish consumption, so the three values for maximum fish consumers in Tables III-24, 25, and 26 are each 20 times those for the corresponding average person.

INHALATION RATES

The ICRP[130] has defined the inhalation rate of Standard Man as 20 m^3/day. This rate was adopted for both the average and maximum adult. Data on inhalation rate versus age are limited.[93, 131, 132] Values selected for this program were those derived by Rohwer & Kaye[133] from oxygen

consumption[134], oxygen concentration in ambient air (20.9%), and oxygen content of exhaled air.[135] The data of Rohwer and Kaye for male and female children were averaged to yield inhalation rates of 14 m^3/day for the teen (14 yr old) and 7.3 m^3/day for the child (4 yr old). Maximum and average rates were assumed to be similar.

RECREATION HABITS

Many of the same references used to estimate fish and game bird consumption also contained data on the location of various activities, where people who used certain sectors came from, and the hours spent in various activities versus season.[32,33,36,37,124] The data from these reports generally related only to persons 12 years and older. Data from local surveys[34, 128] were used to estimate the age distribution of recreation hours, and the ratio of maximum to average hours, and to sharpen estimates of hours for each separate category required for the LPM file.

The total aquatic recreation hours found in the region of interest was 50 hr/yr/person. One of the local surveys[128] performed at the Riverview district adjacent to Pasco, Washington, revealed a total of 42 hr/yr/person for persons 12 years and over. Therefore, the data from this later survey when multiplied by the ratio of 50 to 42 were used to estimate the average hours probably spent in various recreational activities by persons under 12.

The other local survey[34] involved an unusually active group of teenagers (12 to 17 yr) at Richland, Washington, whose total aquatic recreation time averaged 138 hr/yr/person. The hours spent in the various aquatic activities by this group were used as an indication of the maximum hours per person in each type of activity. The data from the two surveys when normalized by age were used to generate ratios of maximum to average hours spent in each of the aquatic recreational activities by teens. It was then assumed that the same ratios of maximum-to-average also held true for adults and children.

TABLE III-31

TIME SPENT BY PERSONS 12 YEARS AND OLDER IN VARIOUS RECREATIONAL ACTIVITIES, AS LISTED IN LIVING PATTERNS MODEL

(Average Hours/Month)

Month	Swimming	Boating[a]	Fishing[b]	Waterfowl Hunting[c]	Upland Game Bird Hunting[d]
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0.8	1.5	0	0
5	0	3.3	2.6	0	0
6	2.0	6.8	2.6	0	0
7	2.0	6.8	2.7	0	0
8	2.0	6.8	2.6	0	0
9	0	3.5	2.0	0	0
10	0	1.0	0.6	0.16	0.64
11	0	0	0	0.16	0.64
12	0	0	0	0.08	0.32
Total	6	29	14.6	0.4	1.6

(a) Includes water skiing, boating, sailing, canoeing, fishing from barge or boat.

(b) Bank fishing only.

(c) Based on 1970 regulation.

(d) Calculated as explained in text to be four times waterfowl hunting hours.

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The data on recreation hours entered into the LPM are given in Table III-31. The factors needed to convert these recorded hours to average and maximum hours per person type are listed in Table III-32.

TABLE III-32

FACTORS REQUIRED TO CONVERT HOURS OF RECREATION

IN THE LIVING PATTERNS MODEL TO HOURS PER PERSON

Person Type	Swimming	Boating	Fishing	Waterfowl Hunting	Upland Bird Hunting[a]
Child - avg.	2.0	0.57	0.65	0	0
- max.	4.7	1.0	0.94	0	0
Teen - avg.	3.2	1.0	3.2	0.6	(0.6)
- max.	7.5	1.8	4.6	2.0	(2.0)
Adult - avg.	0.57	1.0	0.57	1.1	(1.1)
- max.	1.3	1.8	0.82	3.7	(3.7)

(a) Assumed to be the same as for waterfowl.

The above procedure estimated the hours of recreation only for the four aquatic categories. The fifth category, Upland Game Bird Hunting, was not covered in sufficient detail in available reports but was estimated from the waterfowl hunting activity on the basis of local estimates that twice as many persons hunted upland birds as waterfowl, and that each hunting trip for upland birds lasted twice as long as a trip to hunt waterfowl. From this, the total hours per year spent hunting upland birds were taken to be four times that for waterfowl for all months and person types.

Differences between urban and rural households could not be determined from the available data and were ignored. Hopefully, these differences would not affect the final dose calculations significantly.

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Data on where sportsmen traveled to hunt and fish were taken from the recreation reports listed previously (page 143) for the North Central Region. In addition, maps were used to estimate the location of water that probably could be used for swimming (considering size of the body of water and existing pollution). The Mississippi River below the Twin Cities and below St. Louis, and the Missouri River below Omaha were assumed to be too polluted for swimming or boating. Because of the many lakes in South Dakota, Minnesota, and Wisconsin most recreation locations in those states were assumed to be within the centroid of residence. Boating and swimming (but not necessarily fishing) were assumed to occur at the same location. The recreation data indicated that the major portion of the time spent in swimming, boating and fishing occurred during short daily, overnight, or spare time trips.[32]

Location of swimming/boating furnished to the LPM was of two types: (a)a number code referring to the centroid where the recreation activity takes place or (b) a combination letter-number code referring to the river mile where the activity occurs. The letter code for river names is as follows:

MO - Missouri
MS - Mississippi
MI - Minnesota
DM - Des Moines
IL - Illinois
IO - Iowa

Upland game bird hunting was assumed to occur in the centroid of residence except for certain small urban areas where adjacent centroids were selected. When the centroids of hunting and residence were identical, a blank was left in the LPM table for centroid of hunting.

The location of waterfowl hunting was estimated from the data on location versus number killed,[36,123,136] and hunter travel information.[32]

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CALCULATION OF RADIATION DOSES

Radiation doses were calculated by multiplying a series of Dose Factors by the previously generated information on concentration of radionuclides in air, water, and foods, and the hours of exposure or consumption rate. Dose Factors were derived for each pathway - person type - organ - radionuclide combination.

The derivations of the equations and parameters required to calculate dose factors for the first year dose and dose commitment are discussed below.

External Exposure

The dose factors for external exposure were all derived on the assumption that the contaminated media were large enough in dimension to be considered an "infinite volume" relative to the range of the emitted radiations. Under this assumption the energy emitted per cc of media is equivalent to the energy absorbed per cc of media. All that is required then is to convert MeV per disintegration to rem and to correct for the differences in energy adsorption between air or water and tissue, and for physical geometry of each specific exposure situation.

Air Submersion

The dose from submersion in air is an external dose to either the skin only, or the skin and total body (including internal organs), depending upon the penetrating power of the radiation emitted from the airborne radionuclides. For purposes of this project, beta radiation was not considered to irradiate internal organs, and only radiation which could penetrate 7 mg/cm^2 of tissue (typical thickness of the basal layer) was considered to irradiate the skin. Ratios of surface to depth dose were estimated for each individual beta energy (or monoenergetic electron) by the methods given by Hine & Brownell[137] and summed for each nuclide. Gamma radiation dose at 5 cm depth in tissue was used for total-body dose and dose to internal organs.

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The 2π geometry was used for a person standing on the ground surrounded by a very large (half-infinite) hemisphere of contaminated gas for both beta and gamma radiation. This geometry follows from the half-infinite volume for gamma. For the beta with shorter ranges in air, the physical arrangement approaches the infinite volume (4π geometry). However, since the beta is of limited penetrating power, it will irradiate the skin from only one side, not two sides as with penetrating gamma radiation. The equation for calculating the dose factor for submersion is given in Equation (39).

$$(D.F.)_{submersion} = 8.87 \times 10^{-7} \ (\overline{E}_{\beta} + \overline{E}_{\gamma}) \qquad (39)$$

where

D.F. = the dose factor (mrem/hr per pCi/m^3)

$\overline{E}_{\beta}$ = the average beta energy per disintegration (MeV)

$\overline{E}_{\gamma}$ = the average gamma energy per disintegration (MeV)

The constant takes into consideration the density of air as well as the conversion from MeV to rem.

In application of this equation, and of the ones for dose from water immersion and standing on contaminated ground, the dose factors are independent of body size. This follows from an assumption that the presence of the person does not significantly perturb the radiation field.

The dose factors derived from air submersion are listed in Table III-33.

Contaminated Ground

Material deposited from the air or from irrigation water onto the ground represents a fairly large, nearly uniform, thin sheet of contamination. Dose factors for such a situation have been calculated for most important fission products by Soldat[138] for both beta and gamma radiation at surface, one foot, and three feet above the ground. A standard

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TABLE III-33

DOSE FACTORS FOR SUBMERSION IN AIR

(mrem/hr per pCi/m^3)[a]

Nuclide	Skin	Total-Body[b]	Nuclide	Skin	Total-Body[b]
H-3 (c)	0	0	Mo-99	5.8 E-7	2.2 E-7
N-13	1.4 E-6	8.5 E-7	Ru-103	4.9 E-7	4.1 E-7
C-14 (c)	3.5 E-9	0	Ru-106	1.6 E-6	1.7 E-7
Na-22	2.3 E-6	1.8 E-6	Te-132	2.3 E-7	1.8 E-7
Na-24	4.5 E-6	3.5 E-6	I-129	4.0 E-9	1.1 E-9
Ar-39 (d)	1.2 E-7	3.3 E-10	I-131	4.9 E-7	3.1 E-7
Ar-41	1.6 E-7	1.1 E-6	I-132	2.7 E-6	2.0 E-6
Cr-51	2.9 E-8	2.4 E-8	I-133	8.8 E-7	4.4 E-7
Mn-54	8.2 E-7	7.0 E-7	I-135	2.0 E-6	1.5 E-6
Fe-55 (d)	1.5 E-10	2.7 E-11	Xe-131m	4.8 E-8	2.8 E-9
Fe-59	1.2 E-6	1.0 E-6	Xe-133m	6.0 E-8	2.7 E-8
Co-58	1.1 E-6	8.2 E-7	Xe-133	6.9 E-8	2.5 E-8
Co-60	2.5 E-6	2.0 E-6	Xe-135m	5.0 E-7	3.5 E-7
Ni-63	0	0	Xe-135	4.9 E-7	2.1 E-7
Cu-64	2.8 E-7	1.7 E-7	Xe-138	1.7 E-6	1.2 E-6
Zn-65	5.6 E-7	4.9 E-7	Cs-138	3.0 E-6	1.8 E-6
Kr-85m	3.2 E-7	1.3 E-7	(Xe+Cs-138)	4.8 E-6	3.0 E-6
Kr-85 (d)	1.6 E-7	2.2 E-9	Cs-134	1.7 E-6	1.3 E-6
Kr-87	2.7 E-6	1.3 E-6	Cs-137	7.0 E-7	4.7 E-7
Kr-88	2.0 E-6	1.5 E-6	Ba-140	4.4 E-7	2.2 E-7
Rb-88	2.7 E-6	5.6 E-7	La-140	2.7 E-6	1.9 E-6
(kr+Rb-88)	4.7 E-6	2.1 E-6	Ce-141	1.5 E-7	5.9 E-8
Sr-89 (d)	4.9 E-7	2.1 E-7	Ce-144	4.1 E-8	1.4 E-8
Sr-90 (d)	1.3 E-7	2.4 E-10	Pr-144	1.2 E-6	2.6 E-8
Y-90	8.7 E-7	5.8 E-7	(Ce+Pr-144)	1.2 E-6	4.0 E-8
(Sr+Y-90)	1.1 E-6	6.0 E-9			
Zr-95	8.4 E-7	6.8 E-7			
Nb-95	7.5 E-7	6.4 E-7			

(a) Same factors apply for adult, teen, and child.
(b) Total-body factors also apply to internal organs
(c) Not including penetration of oxide into skin.
(d) Including bremstrahlung.

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height of three feet (one meter) was chosen as the appropriate point at which to calculate the dose factors. Only gamma radiation is considered important at this height. Not all of the contamination will be on the surface of the ground. There will be some sub-surface long-lived contamination mixed into the plow layer from previous years' deposition.

If the subsurface contamination were significant, a calculation of dose would have to be performed which considers the source to be a slab of finite thickness and infinite lateral dimensions. Such a calculation is given in the literature, but involves second order exponential integrals that would have to be solved for each energy increment present via a computer program. For the current purposes, the conservative assumption was made that all deposited material was on the surface; however, a factor of 0.5 was introduced into the equation to account for ground roughness and any small loss through heavy clothing.[139, 140]

However, the assumption of surface deposition is more nearly correct for unplowed fields, some of which are traversed by upland game bird hunters.

Similar considerations apply to the dose calculation for a person standing at the edge of a river on top of river sediments. To ensure that sufficient data are available for calculation of the dose if the thickness of the deposit were later found to be significant, the water transport program identifies not only the nuclide content of the river sediment but its thickness as well.

The equation for calculation of the Dose Factors for external exposure from contaminated ground or river bank is given below as Equation (40).

$$(D.F.)_{ground} = (0.5)(0.869) \sum_{i=1}^{n} (A_i)(R_i)(P_i) \qquad (40)$$

where

D.F. = the dose factor in units of mrem/hr per pCi/m^2

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A_i = Fractional abundance of photon (i) in the radionuclide under consideration.[141]

R_i = Exposure rate at 1 meter above infinite smooth plane (mrem/hr) contaminated to one pCi/m^2.[142]

P_i = Fraction of surface dose which penetrates to skin depth (7×10^{-3} cm) or total-body depth (5 cm) as the case may be.[143]

0.5 = Ground roughness factor

$$0.869 = \frac{\text{(rads in air)}}{\text{(R in air)}} \times 1 \left(\frac{\text{rem}}{\text{rad}}\right) \quad (143)$$

The resulting dose factors are tabulated in Table III-34.

Water Immersion

Dose from water immersion (swimming) will depend upon the amount of time spent in the water and the concentrations of the nuclides present at the location of the immersion. As for other external exposures the dose factors do not vary with person size. The hours of recreation were discussed previously (page 143). The assumption was made that the swimmer was completely submerged and surrounded on all sides by a large volume of water, even though he might spend most of his time near the surface. For gamma radiation, the physical arrangement leads to a 4π geometry. For beta radiation, the geometry is approximately 2π(as explained under air submersion), regardless of whether the person is near the surface or deeply submerged. The following equations can be used to calculate the dose factor for each nuclide.

$$(\text{D.F.})_{\text{water immersion}} = 2.13 \times 10^{-6} \left(\overline{E}_\gamma + \overline{E}_\beta/2\right) \quad (41)$$

where

D.F. = dose factor (mrem/hr per pCi/l)

$\overline{E}_\gamma$ = average gamma energy per disintegration (MeV)

$\overline{E}_\beta$ = average beta energy per disintegration (MeV)

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TABLE III-34

DOSE FACTORS FOR EXPOSURE WHILE STANDING ON CONTAMINATED GROUND OR RIVER BANK[a]

(mrem/hr per pCi/m^2)

Nuclide	Skin	Total Body[b]	Nuclide	Skin	Total Body[b]
H-3	0	0			
C-14	0	0	Ru-103[c]	4.2 E-9	3.6 E-9
Na-22	1.8 E-8	1.6 E-8	Ru-106[c]	1.8 E-9	1.5 E-9
Na-24	2.9 E-8	2.5 E-8	Te-132	2.0 E-9	1.7 E-9
Cr-51	2.6 E-10	2.2 E-10	I-129	9.6 E-12	7.0 E-12
Mn-54	6.8 E-9	5.8 E-9	I-131[c]	3.4 E-9	2.8 E-9
Fe-55	0	0	I-132	2.0 E-8	1.7 E-8
Fe-59	9.4 E-9	8.0 E-9	I-133	4.5 E-9	3.7 E-9
Co-58	8.2 E-9	7.0 E-9	I-135	1.4 E-8	1.2 E-8
Co-60	2.0 E-8	1.7 E-8	Cs-138 [d]	2.4 E-8	2.1 E-8
Ni-63	0	0	Cs-134	1.4 E-8	1.2 E-8
Cu-64	1.7 E-9	1.5 E-9	Cs-137	4.9 E-9	4.1 E-9
Zn-65	4.6 E-9	4.0 E-9	Ba-140	2.4 E-9	2.1 E-9
Rb-88	4.0 E-9	3.5 E-9	La-140	1.7 E-8	1.5 E-8
Sr-89	6.5 E-13	5.6 E-13	Ce-141	6.2 E-10	5.5 E-10
Sr-90	0	0	Ce-144	1.4 E-10	1.2 E-10
Zr-95	6.2 E-9	5.9 E-9	Pr-144	2.3 E-10	2.0 E-10
Nb-95	6.8 E-9	5.8 E-9	(Ce+Pr-144)[e]	3.7 E-10	3.2 E-10

(a) The same factors apply to adult, teen and child.

(b) Total body factors also apply to internal organs - bone, thyroid, GI tract, liver, lungs.

(c) Includes daughter radiations.

(d) Not on nuclide list but parent is.

(e) Use these factors for ^{144}Ce unless ^{144}Pr daughter concentration is given separately.

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Dose Factors were derived for skin and total-body exposure by using effective values of ($\overline{E}_\gamma$) and ($\overline{E}_\beta$), which account for the fractional penetration of the radiation to the skin depth (7×10^{-3} cm) and the total-body depth (5 cm). The dose factors for total-body were applied to internal organs also.

The factors derived from Equation (41) are tabulated in Table III-35.

Water surface exposure is received as a result of activities such as water skiing and boating. The dose factors will be about one-half of those tabulated in Table III-35 for water immersion.Although the factor of one-half ignores the loss of the radiation in the distance between the water surface and the center of the body of the person exposed or the shielding provided by a boat, compensation is made by the fact that a water skier spends a fraction of his time in the water.

Transpiration of Tritium

The dose to the total-body from transpiration of tritiated water through the skin could be calculated if a transpiration rate were known. However, a simpler method is to assume that the transpiration dose is equal to the inhalation dose from tritium. This simplified method was used. The transpiration pathway is, however, programmed into the Dose Calculation Model for possible future use.

Tritium was assumed to be transferred to most but not all parts of the body following transpiration. The total-body dose calculated for Tritium Transpiration was therefore applied to the liver and thyroid but not to the bone, lungs, or GI tract.

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TABLE III-35

DOSE FACTORS FOR IMMERSION IN WATER

(mrem/hr per pCi/liter)[a]

Nuclide	Skin	Total-Body[b]	Nuclide	Skin	Total-Body[b]
H-3[c]	0	0	Zr-95	1.8 E-6	1.5 E-6
N-13	2.6 E-6	1.9 E-6	Nb-95	1.6 E-6	1.4 E-6
C-14[c]	3.8 E-6	0	Mo-99	9.1 E-7	4.7 E-7
Na-22	4.8 E-6	4.0 E-6	Ru-103	1.1 E-6	8.9 E-7
Na-24	9.3 E-6	7.8 E-6	Ru-106	1.9 E-6	3.8 E-7
Cr-51	6.4 E-8	5.2 E-8	Te-132	4.8 E-7	4.0 E-7
Mn-54	1.8 E-6	1.5 E-6	I-129	6.1 E-9	2.1 E-9
Fe-55[d]	3.6 E-10	6.4 E-11	I-131	9.5 E-7	6.8 E-7
Fe-59	2.6 E-6	2.2 E-6	I-132	5.5 E-6	4.4 E-6
Co-58	2.3 E-6	1.8 E-6	I-133	1.5 E-6	9.6 E-7
Co-60	5.4 E-6	4.6 E-6	I-135	4.0 E-6	3.3 E-6
Ni-63	0	0	Cs-134	3.5 E-6	2.9 E-6
Cu-64	5.2 E-7	3.7 E-7	Cs-137	1.4 E-6	1.0 E-6
Zn-65	1.2 E-6	1.1 E-6	Ba-140	7.6 E-7	4.6 E-7
Sr-89[d]	5.4 E-7	4.6 E-9	La-140	5.3 E-6	4.1 E-6
Sr-90[d]	1.5 E-7	5.4 E-10	Ce-141	2.4 E-7	1.3 E-7
Y-90[d]	9.6 E-7	1.3 E-8	Ce-144	6.2 E-8	3.0 E-8
(r+Y-90)(d)(e)	1.1 E-6	1.3 E-8	Pr-144	1.3 E-6	5.6 E-8
			(Ce+Pr-144)[f]	1.4 E-6	8.6 E-8

(a) The same factors apply to adult, teen and child.

(b) Total-Body factors also apply to other internal organs.

(c) Not including penetration of oxide into skin.

(d) Includes bremstrahlung.

(e) Use these factors for ^{90}Sr unless ^{90}Y concentration is given separately.

(f) Use these factors for ^{140}Ce unless ^{144}Pr concentration is given separately.

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Internal Dose

Inhalation

The inhalation dose was calculated by multiplying the appropriate air concentration (pCi/m^3) times the person's breathing rate (m^3/hr), an occupancy factor (hours/month), and the dose factor (mrem/pCi intake). The air concentration is supplied by the Air Transport model and varies with nuclide, location and month. The occupancy factor of 24 hr/day x 30.5 days/month was used, assuming that the person spends the major portion of his time in the centroid where he resides.

The equations for calculation of internal Dose Factors were derived from the equations given in the ICRP[130] for calculation of the allowable Body Burdens and the Maximum Permissible Concentrations of radionuclides in air.

The Dose Factor varies with nuclide, person type and organ. A separate factor is required for the annual dose and the dose-commitment.

The Dose Factor for inhalation can be calculated from the following set of equations:

$$(D.F.)_{\substack{\text{inhalation,}\\ \text{internal organs}\\ \text{(Soluble only)}}} = \frac{0.074\ \varepsilon\tau f_a\ \left(1-e^{\frac{-0.693\ t}{\tau}}\right)}{m} \qquad (42)$$

$$(D.F.)_{\substack{\text{inhalation,}\\ \text{GI Tract-LLI}}} = \frac{0.0256\ \tau'\varepsilon f^* f_a\ \left(e^{\frac{-0.6932t'}{T_R}}\right)}{m} \qquad (43)$$

where

D.F. = dose factor (mrem/pCi inhaled)

ε = effective energy of decay of the specific nuclide in the specific organ under consideration (MeV/dis)

f* = fraction of the materials which escapes absorption in the GI tract ahead of the LLI. For insoluble material f* = $(1.0 - f_1)$ where (f_1) is defined by the ICRP[130] as the

fraction passing from the GI tract to the blood. If (f_1) was given as 1.0 (completely soluble nuclide), then (f^*) was taken as 0.05 rather than zero.[144]

f_a = the fraction of the inhaled material that reaches the organ under consideration. For the GI tract, (f_a) was taken as 0.5 for any soluble material and as 0.625 for any insoluble material.

τ = the effective half-life of the nuclide in the organ under consideration (days).

t = length of time over which the dose is calculated (days). For the present application, t is either 1 year or 50 years.

T_R = radioactive half-life of the nuclide under consideration (days).

t' = time of travel from mouth to entrance of LLI (days).

τ' = travel time through LLI (days).

m = mass of the organ (grams), or, for LLI, mass of contents.

Values of the parameters required for these equations were taken from the ICRP[130] for the adult. Adult values (with a few exceptions) for f_a, f_1, and τ were also used for the teen and child. Literature data on biological half-life of cesium in the total body versus age[145-148] indicated that an appropriate value for the 4 year old would be 20 days; for the 14 year old, it would be 30 days. Applying these to ^{134}Cs and ^{137}Cs yield values of τ for the child of 19 and 20 days, respectively; and for the teen, 29 and 30 days, respectively.

Values of (f_a) (f_w), biological half-life, and thyroid mass (m) selected from the literature are listed in Table III-36 below.

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TABLE III-36

VALUES OF PARAMETERS REQUIRED FOR CALCULATION OF RADIATION DOSE TO THE THYROID FROM RADIOIODINE

Parameter	4 Years	14 Years	Adult[130]	1 yr
f_a	0.23 ~~(133)~~	0.23 ~~(133)~~	0.23	0.23
f_w	~~0.5~~ 0.3 ~~(149)~~	~~0.37~~ 0.3 ~~(149)~~	0.3	0.3
Biological half-life days	20 ~~13.~~ (133,149)	50 ~~30.~~ (133)	~~138.~~ 100	20
m (grams)	5. (93,149-151)	15. (93,149-151)	20.	2.

Effective decay energies were derived for children's organs by utilizing the model of the ICRP; whereby, the nuclide is considered to be all located in the center of a spherical organ of effective radius.[130] The values of (x) were determined from organ weights, using the assumptions that (x) was proportional to the cube root of the organ weight and the proportionality factor was the same as that for the corresponding adult organ. Decay schemes choosen were those of Lederer, et al.[141] Average beta energies were estimated from the graphs of $\overline{E}/E_o$ given by Slack & Way.[152] Organ weights derived from the literature are listed in Table III-37.

TABLE III-37

ORGAN MASS AND EFFECTIVE RADIUS FOR CHILD AND TEEN

Organ	Child (4 yr) Mass (g)	Child (4 yr) Radius (cm)	Teen (14 yr) Mass (g)	Teen (14 yr) Radius (cm)	1 yr m (grams)	1 yr x (cm)
Total Body	16,400	20	49,000	27	7700	14
Thyroid	5	2	15	2.7	20	1.4
Bone	1,640	3	4,900	4	770	2.4
GI Tract, LLI[a]	35	3	100	4	16	2.4
Liver	530	7	1,200	9	200	5.
Lungs	300	7	580	8	110	5.

(a) Assumed to be proportional to total body weight.

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Appropriate values for absorption coefficients for muscle or bone were taken from the National Bureau of Standards Handbook 85.[143]

Values of parameters for the GI Tract were assumed to be proportional to the total body weight. The resulting values of mass and radius are given in Table III-37. Values of t' and τ' calculated on this basis were 0.12 and 0.18 days, respectively, for the child; and 0.36 and 0.50 days, respectively, for the teen.

It was also necessary to determine the relative solubility of the various airborne radionuclides in order to choose proper values of f_1 for calculating inhalation dose factors. Probable chemical and physical forms were determined for reactor and fuels separation plant releases, and then solubility was determined from data of the ICRP Task Group on Lung Dynamics.[153] The solubilities selected are tabulated in Table III-38.

TABLE III-38

SOLUBILITIES SELECTED FOR INHALED RADIONUCLIDES[153]

Nuclide	Solubility
H-3, C-14, Na-22, Na-24, I-129, I-131, I-132, I-133, I-135, Cs-134, Cs-137	Soluble
Mn-54, Fe-55, Fe-59, Co-58, Co-60, Ni-63, Sr-89, Sr-90, Zr-95, Nb-95, Ru-103, Ru-106, Te-132	Insoluble
Cr-51, Cu-64, Zn-65, Mo-99, Ba-140, La-140, Ce-141, Ce-144	Very Insoluble

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Ingestion

Equations for calculation of dose factors for ingestion were derived in a manner similar to those for inhalation and are given below:

$$(D.F.)_{\substack{\text{ingestion,}\\ \text{internal}\\ \text{organs}}} = \frac{0.074\ \varepsilon\tau f_w \left(1-e^{\frac{-0.693t}{\tau}}\right)}{m} \tag{44}$$

$$(D.F.)_{\substack{\text{ingestion,}\\ \text{GI-LLI}}} = \frac{0.0256\ \varepsilon\tau' f^* \left(e^{\frac{-0.693t'}{T_R}}\right)}{m} \tag{45}$$

where

f_w = the fraction of the ingested nuclide reaching the organ of interest.

The other symbols are the same as defined previously for Equations (42) and (43). The dose factors for ingestion are independent of the media ingested, and Equations (44) and (45) apply for both food and water. All nuclides in these media were assumed to be in soluble form.

Concentrations of the various nuclides in foods are those which exist at time of consumption, calculated from the Food Pathways Model and the various correction factors for physical losses and radioactive decay as explained previously.

Annual internal and external doses, calculated as discussed above with the value of (t) set to 365 days, can be summed to estimate the total dose in the year 2000 for each person type at each of the approximately 300 centroids. Utilization of a value of (t) of 50 years yields 50-year internal-dose commitment from material ingested during the year 2000. No external exposure was included in the dose commitments. Dose commitments for the child were calculated in three parts. They represented child, teen, and adult parameters, and time span; and then were summed. The three

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time periods were 4 through 11, 12 through 17, and 18 through 54 years. The two time periods used to calculate the dose commitment for the teen were 14 through 17 and 18 through 64 years. Because the external pathways are so significant for certain centroids, the anomolous situation is possible where the dose commitment appears to be less than the annual dose.

Radiation doses calculated for each of the approximately 300 centroids by the methods described previously can be used to calculate integrated population doses in units of man-rems in the year 2000, and man-rems over the succeeding 50 years (from internal dose only).

The dose (and dose commitment) for the average child in a given centroid, multiplied by the population of children (0-11 years) estimated for the year 2000 in that centroid, yields the integrated dose (and dose commitment) to children. Similarly, calculations for average teens (12-17 years) and average adults ($\geq$ 18 years) are also made. The sum of the three age-related integrated doses (and dose commitments) yields the integrated dose (and dose commitment) in man-rems for that centroid. The total doses and dose commitments for the North Central Region can be found by summing the appropriate values for each of the 300 centroids.

DOSE REPORT FORMAT

The computer program calculates the dose to each organ of each person type for each pathway of exposure. These doses are printed in the report by location. In addition, the contribution to the dose from internal and external sources is listed, as is the percent contribution from each nuclide. The printed report also contains a tabulation of the total dose to each organ of each person type from all pathways combined. Again, the total is divided into contributions from internal and external sources and into percent contributions from each nuclide. The above tabulations apply to both dose and dose commitment.

The integrated dose and dose commitment (man-rems) by centroid are listed next, with a grand total integrated dose and dose commitment for

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the entire region listed at the end of this section.

The final portion of the dose print-out is a table of contents generated by the computer as it keeps track of the items being printed.

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APPENDIX A

RADIONUCLIDE LIST

1083100

APPENDIX A

TABLE A-1

RADIONUCLIDES INCLUDED IN PROGRAM CALCULATIONS

Serial Number*	Nuclide	Half Life	Considered in Release Calculations	
			Air	Water
1	H-3	12.26 y	X	X
2	N-13	9.96 m	X	
3	C-14	5730. y	X	X
4	Na-22	2.6 y	X	X
5	Na-24	15.0 h	X	X
6	Ar-39	270. y	X	
7	Ar-41	1.83 h	X	
8	Cr-51	27.8 d		X
9	Mn-54	312. d		X
10	Fe-55	2.4 y		X
11	Fe-59	45. d		X
12	Co-58	71. d		X
13	Co-60	5.24 y		X
14	Ni-63	92. y		X
15	Cu-64	12.9 h		X
16	Zn-65	243. d		X
17	Kr-85m	4.4 h	X	
18	Kr-85	10.76 y	X	
19	Kr-87	76. m	X	
20	Kr-88	2.8 h	X	
21	Sr-89	50.6 d	X	X
22	Sr-90	28.8 y	X	X
23	Zr-95	65. y	X	X
24	Nb-95	35. d	X	X
25	Mo-99	67. h		X
26	Ru-103	40. d	X	X
27	Ru-106	1. y	X	X
28	Te-132	78. h	X	X

1083101

APPENDIX A

(Continued)

Serial Number*	Nuclide	Half Life	Considered in Release Calculations	
			Air	Water
29	I-129	1.6×10^7 y	X	X
30	I-131	8.05 d	X	X
31	I-132	2.3 h	X	X
32	I-133	21. h	X	X
33	I-135	6.7 h	X	X
34	Xe-131	12. d	X	
35	Xe-133m	2.3 d	X	
36	Xe-133	5.27 d	X	
37	Xe-135m	16. m	X	
38	Xe-135	9.2 h	X	
39	Xe-138	17. m	X	
40	Cs-134	2.1 y	X	X
41	Cs-137	30. y	X	X
42	Ba-140	12.8 d	X	X
43	La-140	40.2 h	X	X
44	Ce-141	32.5 d	X	X
45	Ce-144	285. d	X	X

* Order of consideration in computer programs.

1083102

APPENDIX B

1083103

SITE Code Listing

1083104

```
@ ELT COMN,7,711130, 52462

COMN* FCOPY
      LOGICAL DEBUG
      PARAMETER MAXPL=450            @ MAXIMUM PLANTS IN PROBLEM
      COMMON/BLK1/KYEAR,ARP,  KPLANT(MAXPL,2),MAXP,MINP,DEBUG,PLANT(MAXP
     1L),RPWR(24),RPWRM,KYR,NAME(MAXPL),WPLANT(MAXPL),POWER(42,24,2),
     2  MSU(24),            IYRFST,TITLE(12),INDEX(MAXPL)
      END
```

PROCEDURE NAME TABLE

COMN 00000000

1083105

```
» ELT MAIN,1,711150, 52462

1.          CALL INPUT
2.          CALL EXIT
3.          END
```


1083106

192

1083101

```
@ ELT INPUT,1,711130, 52464

      SUBROUTINE INPUT
      INCLUDE COMN
      DIMENSION  KNAME(4), KOMPAR(3)
      DATA KOMPAR / 1HW, 1HF, 1HL /, KEND / 3HEND/, KNAME /3HPWR,
     A 3HBWR, 6HFOSSIL, 5HLMFBR /, KBL / 1H /
      KYR = 31
      LWR = 0
      DEBUG = .FALSE.
      N5 = KBL
      IB = 0
      READ (5,8007) IX, TITLE
8007  FORMAT (I5, 12A6)
100   IA = IB + 1
101   READ(5,8001) N1,N2,N3,N4,A1
C
C     WHERE N1=NAME, N2=INDEX, N3=YEAR, N4=NUMBER, A1=WHOLE PLANT
C
      IF (N1 .EQ. KEND) GO TO 120
      IF (N4 .EQ. 0) GO TO 101
      IF (DEBUG) GO TO 102
      WRITE (6,8001) N1,N2,N3,  N4,A1
102   LOAD = 1
      FLD(0,6,N5) = FLD(18,6,N1)
      IF (KOMPAR(3) .EQ. N5) LOAD = 2
      FLD(6,30,N1) = FLD(6,30,KBL)
      IB = IA + N4 - 1
      DO 104 J=1,3
      IF (N1 .NE. KOMPAR(J) ) GO TO 104
      IF (N1 .EQ. KOMPAR(1) ) GO TO 1045
      N1 = KNAME(J+1)
      GO TO 1045
104   CONTINUE
```

```
1045  DO 105 J=IA,IB
      IF (N1 .NE. KOMPAR(1)) GO TO 1047
      LWR = LWR+1
      IF (0 .EQ. MOD(LWR,4)) GO TO 1046
      NAME(J) = KNAME(1)
      GO TO 1048
1046  NAME(J) = KNAME(2)
      GO TO 1048
1047  NAME(J) = N1
1048  IF (A1 .LT. .0001) A1 = 1.
      WPLANT(J) = A1
      KPLANT(J,1) = LOAD
      KPLANT(J,2) = N2
105   CONTINUE
      GO TO 100
120   MAXP = IB
      IF (DEBUG) GO TO 121
      DO 130 I=1,MAXP
      WRITE (6,8004) NAME(I), KPLANT(I,2), KPLANT(I,1), WPLANT(I)
130   CONTINUE
121   CALL SITE(IX)
8001  FORMAT (6X,A4,2(6X,I6),24X,I6,F12.3)
8004  FORMAT (10X, A6, 2I5, F7.3)
      END
```


1083108

10831109

```
@ ELT ORDER,1,711130, 52465

      SUBROUTINE ORDER(SORT,K,IROW,N1)
      DIMENSION SORT(30),K(30)
      JJ=IROW-1
      DO 20 I=1,IROW
      KK=0
      DO 10 J=1,JJ
      IF (N1 .EQ. 2) GO TO 5
      IF (SORT(J) .GE. SORT(J+1)) GO TO 10
      GO TO 6
    5 IF (SORT(J) .LE. SORT(J+1)) GO TO 10
    6 KK=1
      STORE=SORT(J)
      SORT(J)= SORT(J+1)
      SORT(J+1)=STORE
      NQ = K(J)
      K(J) = K(J+1)
      K(J+1) = NQ
   10 CONTINUE
      IF (KK .EQ.0) GO TO 21
   20 CONTINUE
   21 RETURN
      END
```

```
@ ELT SITE,1,711130, 52467

      SUBROUTINE SITE(IX)
      INCLUDE COMN
      DIMENSION ISITE(5),IPRI(4),IARRAY(8,MAXPL),ISORT(MAXPL),INAME(4,MA
     1XPL)
      DATA KFOS /6HFOSSIL/, KF /1HF/, KR /1HR/,KEND/6HENDATA/
      INTEGER RR
C       RR = 0 IF RUNNING ON NBS 1108, RR = -4 IF RUNNING ON CSC 1108
      RR = -4
      IB = 0
100   IA = IB+1
      READ (5,8002) IEND
      IF (IEND .EQ. KEND) GO TO 110
      READ(RR,8001) ISITE, INO, (IPRI(I),I=1,INO)
8001  FORMAT (3A5,A1,A4,5I5)
8002  FORMAT (A6)
      IF (DEBUG) GO TO 101
      WRITE (6,9101) ISITE, INO, (IPRI(I),I=1,INO)
9101  FORMAT (1X, 3A5, A1, 1X, A4, 5I5)
101   IB = IA+INO-1
      DO 105 J=IA,IB
      DO 103 K=1,5
      IARRAY (K,J) = ISITE(K)
103   CONTINUE
      IARRAY(6,J) = IPRI(J-IA+1)
105   CONTINUE
      GO TO 100
110   DO 120 I=1,MAXP
      ISORT(I) = KPLANT(I,2)
      INDEX(I) = I
120   CONTINUE
      K1 = 2
      CALL ORDER (ISORT,INDEX, MAXP, K1)
```

```
      MAXFS = 0
      MAXF = 0
      DO 121 J=1,IB
      IF (IARRAY(4,J) .EQ. KF) MAXFS = MAXFS+1
121   CONTINUE
      NFOS = 0
      NFOSS = 0
      DO 122 J=1,MAXP
      IF (NAME(J) .EQ. KFOS) MAXF = MAXF+1
122   CONTINUE
      DO 150 J=1,MAXP
      I = INDEX(J)
      INO = 10000
      DO 130 K=1,IB
      IF (NAME(I) .EQ. KFOS) GO TO 125
      IF (IARRAY(4,K) .EQ. KR) GO TO 130
      IF (NFOS .LT. MAXF +1  .AND.  IARRAY(4,K) .EQ. KF) GO TO 130
124   IF (INO .LT. IARRAY(6,K)) GO TO 130
      INO = IARRAY(6,K)
      KK = K
      GO TO 130
125   IF (NFOSS .GE. MAXFS) GO TO 124
      IF(INO .LT. IARRAY(6,K) .OR.  IARRAY(4,K) .NE. KF) GO TO 130
      KK = K
      INO = IARRAY(6,K)
130   CONTINUE
      IF (NAME(I) .EQ. KFOS) NFOS = NFOS + 1
      IF (IARRAY(4,KK) .EQ. KF) NFOSS = NFOSS + 1
      IARRAY(7,I) = IARRAY(5,KK)
      IARRAY(8,I) = IARRAY(6,KK)
      IARRAY(6,KK) = IARRAY(6,KK)+ 100000
      DO 140 K =1,3
      INAME(K,I) = IARRAY(K,KK)
140   CONTINUE
      INAME(4,I) = IARRAY(4,KK)
150   CONTINUE
```


1083111

```
      DO 160 J=1,MAXP
      IF (MOD(J,35) .EQ. 1)  WRITE(6,9001)  TITLE
      I = INDEX(J)
      WRITE (6,9002) (INAME(K,I),K=1,4),                IARRAY(7,I), NAME(
     $I), KPLANT(I,1), KPLANT(I,2), IARRAY(8,I), WPLANT(I)
      INO = 1
      IF (IX .EQ. 2) PUNCH 9003 NAME(I), (KPLANT(I,K),K=1,2),
     1   IARRAY(7,I),  INO,  WPLANT(I)
  160 CONTINUE
 9001 FORMAT (1H1,//, 35X, 12A6, ///)
 9002 FORMAT (1H ,43X, 3A5,A1,2X,A4,2X,A6,3I5,4X,F5.3)
 9003 FORMAT (6X,A6,4X,I6,6X,I6,6X,A4,14X,I6,F12.3)
      IF (DEBUG) CALL EXIT
      WRITE (6,8008)
 8008 FORMAT (1H1,'CONTROL RETURNED TO MAIN')
      CALL EXIT
      END

  END COR
```


10831112

197

MOPOSH Code Listing

1083113

```
@ FLT COMN,7,711111, 59010

      COMN* FCOPY
            LOGICAL DEBUG
            PARAMETER MAXPL=450            @ MAXIMUM PLANTS IN PROBLEM
            COMMON/BLK1/KYEAR,APP,  KPLANT(MAXPL,2),MAXP,MINP,DEBUG,PLANT(MAXP
           1L),RPWR(24),RPWRM,KYR,NAME(MAXPL),WPLANT(MAXPL),POWER(42,24,2),
           2  NSD(24), IZ,       IYRFST,TITLE(12),INDEX(MAXPL),KSITE(MAXPL)
            END


                                                    PROCEDURE NAME TABLE

COMN       00000000
```


1083114

200

```
@ ELT MCPOSH,1,711111, 59017

      INCLUDE COMN,LIST
      DIMENSION  TPWR(24),       KFLAG(24), RP(2), RPTOT(2), KTIME(2)
      DIMENSION RPOWER(MAXPL,24), PFMON(MAXPL) ,TPOWER(24),JFLAG(MAXPL)
     A , PSTORE(24)
      REAL  MINPR,MINPWR
      PFMAX = .799939                    @ BASE LOAD PLANT FACTOR
1     KSTART = 0                         @ START TIME FOR BASE PLANTS (100% POWER)
      PWR    = 1.                        @ TOTAL PLANT POWER
      HOURS  = 365.                      @ HOURS IN A PERIOD
      KK = 0
      ARP    = 0.                        @ AVERAGE REACTOR POWER FOR PLANT J1
      KSD    = 1                         @ FIRST PERIOD OF REFUELING SHUTDOWN
      KSDSAV = -2
      MINPWR = .500 * HOURS              @ MINIMUM POWER FOR BASE PLANT OPERATION
      RPWRM  = PWR * 730.                @ MAXIMUM POWER FOR ONE MONTH
      KYRLST = 32
      CALL INPUT
      KYEAR = 30
100   CALL SORTER
      TOTPWR = 0                         @ TOTAL POWER DEMAND FOR ONE YEAR
      DO 105 I=1,24
      TPWR(I) = 0
      TOTPWR = TOTPWR + POWER(KYEAR,I,1)
105   CONTINUE
      IF (DEBUG) GO TO 106
9201  FORMAT (1H+, 20X, 10F10.4)
      WRITE (6,9202)
9202   FORMAT ('0TOTPWR')
      WRITE (6,9201) TOTPWR
9203  FORMAT (1H+, 20X, 10I10)
106   DO 500 J2 = 1,MINP
      J1 = INDEX(J2)
```

```
C
C          CHECK FOR PERIODS VOID OF POWER DEMAND
C
      KPER   = 0                          @ TOTAL NUMBER OF PERIODS PLANT J1 OPERATES
      DO 110 I=1,24
      KFLAG(I) = 1
      MINPR = .04 * HOURS
      IF (J2 .EQ. MINP) MINPR = .001
      IF (PLANT(J1) .GT. PFMAX)MINPR = MINPWR
      IF (POWER(KYEAR,I,2) .LT. MINPR) KFLAG(I) = 0
      IF (KFLAG(I) .EQ. 1) KPER = KPER+1
110   CONTINUE
      IF (DEBUG) GO TO 111
      WRITE (6,9204)
9204  FORMAT ('0KPER')
      WRITE (6,9203) KPER
      WRITE (6,9205)
      WRITE (6,9206) (NSD(I),I=1,24)
9205  FORMAT ('0NSD')
9206  FORMAT (1H+, 10X, 24I5)
      WRITE (6,9207)
9207  FORMAT ('0KFLAG')
      WRITE (6,9206) (KFLAG(I),I=1,24)
C
C          IF PLANT OPERATES IN ALL PERIODS, GO TO 130 AND INSERT ARBITRARY
C          REFUELING SHUTDOWN
C
111   IF (KPER .EQ. 24) GO TO 130
C
C          OVERLAY REFUELING SHUTDOWN ON EXISTING LOW POWER DEMAND SHUTDOWN
C
      KBACK  = 1
      INC    = 2
      KSTOP  = 22
      LCHECK = 0
      JUMP = 1
```


1083116

```
      GO TO 120
113   KBACK  = 2
      JUMP = 2
      GO TO 120
114   INC    = 1
      KSTOP  = 23
      JUMP = 1
      KBACK  = 3
      GO TO 120
115   INC    = 0
      KSTOP  = 24
120   DO 122 I=1,KSTOP
      IFIX = I
      KEND = I + INC
      KCHECK = 0
      DO 121 J=IFIX,KEND,JUMP
      KCHECK = KCHECK + KFLAG(J)
121   CONTINUE
      IF (KCHECK .EQ. LCHECK) GO TO 125
122   CONTINUE
      GO TO (113,114,115), KBACK
125   IF (IFIX .GT. 22) IFIX = 22
      DO 127 I=1,3
      IF (KFLAG(IFIX+I-1) .NE. 0) KPER = KPER-1
127   CONTINUE
      KSD = IFIX
      IF (DEBUG) GO TO 129
       WRITE (6,9208)
9208  FORMAT ('0KSD')
      WRITE (6,9206) KSD
129   CONTINUE
130   KSD = MOD(KSDSAV+3,22)
      IF (KSD .EQ. 0) KSD = 22
      IF (PLANT(J1) .LT. PFMAX) GO TO 135
131   IF (KSD .GT. 22) KSD = 1
      IF (NSD(KSD) .EQ. 0 .AND. NSD(KSD+1) .EQ. 0 .AND. NSD(KSD+2) .EQ.
```


1083117

223

```
      1  0)  GO TO 135
132   KSD = KSD+1
      GO TO 131
135   DO 137 I=0,2
      IF (KFLAG(KSD+I) .NE. 0) KPER = KPER-1
      KFLAG(KSD+I) = 0
137   CONTINUE
      IF (DEBUG) GO TO 138
      WRITE (6,9204)
      WRITE (6,9203) KPER
      WRITE (6,9207)
      WRITE (6,9206) (KFLAG(I),I=1,24)
       WRITE (6,9208)
      WRITE (6,9206) KSD
138   KSDSAV=KSD
C
C         COMPUTE TOTAL POWER FOR THIS YEAR
C
      TOTPWR = TOTPWR - ARP
C
C         COMPUTE AVERAGE REACTOR POWER FOR REACTOR J1
C
      ARP = PWR * PLANT(J1) * 8760. * WPLANT(J1)
      IF (PLANT(J1) .LT. PFMAX) GO TO 300
C
C         COMPUTE OPERATING SCHEDULE FOR BASE LOADED PLANTS
C
200   KCHECK = MOD(KPER,2)          @ IS KPER ODD OR EVEN?
      DO 205 I=1,24
      IF (KFLAG(I) .EQ. 0) GO TO 205
      LSTART = I
      GO TO 206
205   CONTINUE
      WRITE (6,9101) NAME(J1),KYR  @ ERROR MESSAGE
9999  CALL EXIT
206   LCHECK = MOD(LSTART,2)
```


1083118

```
      IF (KSTART .EQ. LCHECK) GO TO 207        @ KSTART = DESIRED 100% START
      LCHECK = LSTART+1                        @ LCHECK = 100% START
      GO TO 208                                @ LSTART = FIRST PERIOD OF OPERAT.
207   LCHECK = LSTART                          @ SET KSTART FOR NEXT PLANT
208   KSTART = MOD(KSTART+1,2)
      KTIME(2) = KPER/2
      IF (LCHECK .NE. LSTART) GO TO 210
      IF (KCHECK .EQ. 1) KTIME(2) = KTIME(2) + 1
210   KTIME(1) = KPER - KTIME(2)
      RP(2) = PWR * HOURS * WPLANT(J1)
      RPTOT(2) = RP(2) * FLOAT(KTIME(2))
      RPTOT(1) = ARP - RPTOT(2)
      RP(1) = RPTOT(1) / FLOAT(KTIME(1))
      K = LCHECK - LSTART + 1
      DO 220 I=1,24
      RPWR(I) = 0                        @ REACTOR POWER FOR PERIOD I
      IF (KFLAG(I) .EQ. 0) GO TO 220
      K = MOD(K,2) + 1
      RPWR(I) = RP(K)
220   CONTINUE
221   K = 0
      DO 230 I=1,24
      IF (RPWR(I) .LT. POWER(KYEAR,I,2))GO TO 230
      STORE = RPWR(I) - POWER(KYEAR,I,2)
      IF (RP(2) .GT. RPWR(I)) GO TO 222
      WRITE (6,9102) KYR,  NAME(J1),POWER(KYEAR,I,2),RPWR(I), I  @ POWER ERROR
      GO TO 9999
222   RPWR(I) = RPWR(I) - STORE
      STORE = STORE / FLOAT(KTIME(1) - 1)
      DO 223 J=LSTART,24
      IF (RPWR(J) .GT. RP(2)-.001) GO TO 223
      IF (KFLAG(J) .EQ. 0) GO TO 223
      IF (J .EQ. I) GO TO 223
      RPWR(J) = RPWR(J) + STORE
223   CONTINUE
      K = 1
```


1083119

205

```
230   CONTINUE
      IF (K .EQ. 1) GO TO 221
235   IF (DEBUG) GO TO 239
      DO 238 I=1,24
      WRITE (6,9210) I
9210  FORMAT ('CRPWR' , I5)
      WRITE (6,9201) RPWR(I)
238   CONTINUE
239   CONTINUE
C                                                          HAS 3 PERIOD SHUT-
C          SUBTRACT PLANT POWER FROM PERIOD.               DOWN
C
      DO 240 I=1,24
      IF (PLANT(J1) .GT. PFMAX) GO TO 240
      POWER(KYEAR,I,2) = POWER(KYEAR,I,2) - RPWR(I)
      IF (DEBUG) GO TO 240
      WRITE (6,9209)  I
9209  FORMAT ('CPOWER' ,I5)
      WRITE (6,9201) POWER(KYEAR,I,2)
240   CONTINUE
      DO 250 I=1,24
      RPOWER(J1,I) = RPWR(I)
      TPWR(I) = TPWR(I) +RPWR(I)
250   CONTINUE
      IF (DEBUG) GO TO 500
      WRITE (6,9301) TPWR
9301  FORMAT ('C TPWR' / (12F10.2))
      GO TO 500
C
C          COMPUTE POWER FOR PEAK LOADED PLANT
C
300   PWRTOT =0
      DO 310 I=1,24
      RPWR(I) = 0
      IF (KFLAG(I) .EQ. 0) GO TO 310
      PWRTOT = PWRTOT + POWER(KYEAR,I,2)
```


1083120

202

```
310   CONTINUE
      RPWRP = RPWRM / 2. * WPLANT(J1)
      RPWRS = 0
      DO 320 I=1,24
      IF (KFLAG(I) .EQ. 0) GO TO 320
      RPWR(I) = POWER(KYEAR,I,2) / PWRTOT * ARP
      IF (RPWR(I) .LT. RPWRP) GO TO 320
      RPWRS = RPWRS + RPWR(I) - RPWRP
      RPWR(I) = RPWRP
320   CONTINUE
      IF (RPWRS .LT.  .01) GO TO 235
      PWRS = 0
      DO 330 I=1,24
      JFLAG(I) =0
      PSTORE(I) = 0
      IF (RPWR(I) .GT. RPWRP - .01  .OR.  RPWR(I) .LT. .01) GO TO 330
      JFLAG(I) = 1
      PSTORE(I) = AMIN1(RPWRP, POWER(KYEAR,I,2)) - RPWR(I)
      PWRS = PWRS + PSTORE(I)
330   CONTINUE
      IF ( PWRS .GT. RPWRS) GO TO 335
      WRITE (6,900) NAME(J1), KPLANT(J1,1)
      RPWRS = PWRS
335   DO 340 I=1,24
      IF (JFLAG(I) .EQ. 0)   GO TO 340
      RPWR(I) = RPWR(I) + PSTORE(I) / PWRS * RPWRS
340   CONTINUE
      GO TO 235
500   CONTINUE
      MINPR = .08 * HOURS
      DO 530 I=1,24
      PSTORE(I) = 0
      X = POWER(KYEAR,I,1) - TPWR(I)
      KK = 0
      DO 510 J2=1,MINP
      J1 = INDEX(J2)
```


1083121

```
      JFLAG(J1) = C
      RPCHK1 = RPWRM * WPLANT(J1) / 2.
      IF (X .LT. C) GO TO 505
      IF (RPOWER(J1,I) .LT. .C1  .OR.   RPOWER(J1,I) .GT.RPCHK1-.C1)
     A  GO TO 510
      PSTORE(I) = PSTORE(I) + RPCHK1 - RPOWER(J1,I)
      GO TO 508
505   IF (RPOWER(J1,I) .LT. MINPR) GO TO 51C
      PSTORE(I) = PSTORE(I) + RPOWER(J1,I)
508   JFLAG(J1) = 1
51C   CONTINUE
      TPWR(I) = C
      DO 52C J2=1,MINP
      J1 = INDEX(J2)
      IF (JFLAG(J1) .EQ. C) GO TO 52C
      RPCHK1 = RPWRM * WPLANT(J1) / 2.
      IF (X .GT. C) Y = RPCHK1 - RPOWER(J1,I)
      IF (X .LT. C) Y = RPOWER(J1,I)
      RPOWER(J1,I) = RPOWER(J1,I) + (Y/PSTORE(I)*X)
52C   CONTINUE
53C   CONTINUE
      DO 55C I=1,12
      I1 = I*2-1
      I2 = I1+1
      TPOWER(I) = POWER(KYEAR,I1,1) + POWER(KYEAR,I2,1)
      DO 535 J2=1,MINP
      J1 = INDEX(J2)
      RPOWER(J1,I) = RPOWER(J1,I1) + RPOWER(J1,I2)
      TPWR(I) = TPWR(I) + RPOWER(J1,I)
      PFMON(J1) = RPOWER(J1,I) / (RPWRM*WPLANT(J1))
535   CONTINUE
      DO 54C J2=1,MINP
      J1 = INDEX(J2)
      IF (MOD(J2,35) .EQ. 1) WRITE (6,9CC1) TITLE, KYR, MINP, I, TPOWER(
     $I), TPWR(I)
      WRITE(6,9CC2) NAME(J1), KSITE(J1), KPLANT(J1,2) , WPLANT(J1),
```


1083122

```
     Z  RPOWER(J1,I),  PFMON(J1), PLANT(J1), KPLANT(J2,1), J1, J2
540   CONTINUE
      IF (IZ .EQ. 0) GO TO 550
      DO 545 J2=1,MINP
      J1 = INDEX(J2)
      WRITE (1,9003) KSITE(J1), NAME(J1), PFMON(J1), KPLANT(J1,2), I
545   CONTINUE
550   CONTINUE
      GO TO 1
9101  FORMAT (1H1,'PLANT ' A6, ' CANNOT OPERATE IN ANY PERIOD OF YEAR 'I
     *4 )
9102  FORMAT (1H1,'FOR YEAR 'I4,' PLANT 'A6,' HAS INSUFFICIENT POWER DEM
     *AND TO OPERATE.' //  '  TOTAL POWER ='F10.2, // '  PLANT POWER ='
     *F10.2, // '  CHECK PERIOD 'I2 )
9003  FORMAT (I10,4X,A6, F10.4, 2I10)
9002  FORMAT (20X, A6,2X,I4,I6,10X,3F8.3, F10.3,3I10)
9001  FORMAT (1H1, 30X, 12A6, //, 17X 'YEAR ' I4, 3X 'TOTAL PLANTS ' I3,
     A  'PERIOD '  I2, 3X, 'POWER REQUIRED ' F12.2, 'POWER PRODUCED '
     B  F12.2 ,///)
9004  FORMAT ('0PLANT 'A6, ' CANNOT OPERATE AT LESS THAN 100% IN PERIOD'
     A  I3)
      END
```


10831123

10831124

```
@ ELT INPUT,1,711111, 59012

      SUBROUTINE INPUT
      INCLUDE COMN
      DATA KEND / 3HEND /
      KYR = 31
      LWR = 0
      DEBUG = .TRUE.
      READ (5,8007,END=9999) IZ, TITLE
 8007 FORMAT (I5, 12A6)
      IB = 1
 101  READ (5,8001) N1, N2, N3, N4, A1
C
C          WHERE N1=NAME, N2=LOAD, N3=YEAR, A1=FRACTIONAL PLAN T
C
      IF (N1 .EQ. KEND) GO TO 120
 1048 IF (A1 .LT. .0001) A1 = 1.
      NAME(IB) = N1
      KPLANT(IB,1) = N2
      KPLANT(IB,2) = N3
      KSITE(IB) = N4
      WPLANT(IB) = A1
      IB = IB+1
      GO TO 101
 120  MAXP = IB - 1
      IF (DEBUG) GO TO 121
      DO 130 I=1,MAXP
      WRITE (6,8004) NAME(I), KPLANT(I,2), KPLANT(I,1), WPLANT(I)
 130  CONTINUE
 121  READ (5,8002) PWR, (POWER(KYR,I,1), I=1,24,2)
      DO 1215 I=1,24,2
      POWER(KYR,I,1) = PWR * POWER(KYR,I,1) / 200.
      POWER(KYR,I+1,1) = POWER(KYR,I,1)
 1215 CONTINUE
```

```
      DO 122 I=1,24
      POWER(KYR,I,2) = POWER(KYR,I,1)
122   CONTINUE
      READ (5,8003) (NSD(I),I=1,24)
      IF (DEBUG) GO TO 150
      WRITE (6,9005) (POWER(KYR,I,1),I=1,24)
      WRITE (6,8006)
      WRITE (6,8003) (NSD(I),I=1,24)
150   RETURN
9999  WRITE (1,9001) KEND
      END FILE 1
      CALL EXIT
9001  FORMAT (14X, A6)
8001  FORMAT (6X,A6,4X,I6,6X,I6, 6X, I4, 20X, F12.3)
8002  FORMAT (2X, F18.8, 12F5.1)
8003  FORMAT (10X, 24I2)
8004  FORMAT (10X, A6, 2I5, F7.3)
8005  FORMAT ( 1H0, /// ' INPUT POWER' / , (1X 8F10.2))
8006  FORMAT ('CNO SHUT DOWN = 1')
      END
```


10831125

211

10831126

```
@ ELT ORDER,1,711111, 59013

      SUBROUTINE ORDER(SORT,K,IROW,N1)
      DIMENSION SORT(30),K(30)
      INTEGER  SORT, STORE
      JJ=IROW-1
      DO 20 I=1,IROW
      KK=0
      DO 10 J=1,JJ
      IF (N1 .EQ. 2) GO TO 5
      IF (SORT(J) .GE. SORT(J+1)) GO TO 10
      GO TO 6
    5 IF (SORT(J) .LE. SORT(J+1)) GO TO 10
    6 KK=1
      STORE=SORT(J)
      SORT(J)= SORT(J+1)
      SORT(J+1)=STORE
      NQ = K(J)
      K(J) = K(J+1)
      K(J+1) = NQ
   10 CONTINUE
      IF (KK .EQ.0) GO TO 21
   20 CONTINUE
   21 RETURN
      END
```

10831271

```
@ ELT SORTER,1,711111, 59C19

      SUBROUTINE SORTER
C         THIS SUBROUTINE CALCULATES THE PLANT FACTOR FOR EACH CURRENTLY
C         OPERATING PLANT, THEN CALLS ORDER TO PUT THE PLANTS IN DECREASING
C         ORDER BY PLANT FACTOR.
      INCLUDE COMN
      DIMENSION PF(3C,2), SORT(MAXPL)
      DATA PF /.73,.75,.77,.79,.8C,.8C,.8C,.8C,.8C,.8C,.8C,.3C,.8C,.8C,
     B.8C,.8C,.8C,.77,.71,.65,.59,.53,.45,.35,.283,.25,.217,.183,.15,
     C.117,.68,.7C,.72,.74,.75,.75,.75,.75,.75,.73,.69,.65,.61,.57,.53,
     D.49,.45,.4C2,.346,.29,.234,.178,.147,.141,.134,.128,.122,.116,
     E.1C9,.1C3 /
9C    KYEAR = KYEAR+1
      KYR = KYEAR + 1969
      WRITE (6,92C3)  KYEAR, KYR
92C3  FORMAT ('CKYEAR =' I6, '  KYR=' I6)
      WRITE (6,92C4) MAXP
92C4  FORMAT ('CMAXP =' I6)
1C1   DO 11C I=1,MAXP
      INDEX(I) = I
      K1 = KPLANT(I,2)
      K2 = KPLANT(I,1)
      K1 = KYEAR - K1 + 1
      IF (K1 .LE. 3C  .AND.  K1 .GT. C) GO TO 1C5
      PLANT(I) = C
      GO TO 1C7
1C5   PLANT(I) = PF(K1,K2)
1C7   SORT(I) = PLANT(I)
11C   CONTINUE
      K1 = 1
      CALL ORDER (SORT,INDEX,MAXP,K1)
      WRITE (6,92C1)
92C1  FORMAT ('CKPLANT')
```

```
      DO 115 I=1,MAXP
      IX = INDEX(I)
115   WRITE (6,9202) NAME(IX), KPLANT(IX,1), KPLANT(IX,2) ,PLANT(IX)
9202  FORMAT (1H  , A6, 2I10, F10.3)
121   MINP = MAXP
122   RETURN
      END
```


1083128

REPARE Code Listing

1083129

10831130

```
@ ELT COMN,7,710316, 53754

      COMN* FCOPY
            COMMON/G1/ IBUF(100),BUF(5000)
            COMMON/G2/HLF(50),TITLE(20),PLAT(200),PLON(200),PPVML(200),L(10)
           1 , PRVNM(3,200),PLTLN(4,200)                                    01/22/71
            COMMON /G3/ IPLANT(525,12),IPLTYP(525,12),PFMON(525,12)          03/16/71
           1   ,PLSUYR(525,12)                                              03/16/71
            COMMON /G4/ NOSITE(525),NSSITE(525)                              03/16/71
            COMMON /G5/ ID20(7),IDSIT(7)                                     03/16/71
            COMMON/G6/ BUFOUT(500,2)
            COMMON/G7/ INAI(50),INWI(50)
            COMMON /REP/ RMFRIS(100),PPURIS(100)
           1 , NSITRP(30),NUMSIT(30)                                         03/16/71
            DATA (INAI(I),I=1,35) / 1,2,3,4,5,6,7, 17,18,19,20,21,22,23,24   03/16/71
           1, 26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45 /  03/16/71
            DATA  (INWI(I),I=1,32) / 1, 3,4,5, 8,9,10,11,12,13,14,15,16,
           1  21,22,23,24,25,26,27,28,29,30,31,32,33, 40,41,42,43,44,45 /
            DATA TITLE / 20*6H       /
      C  ISOTOPE HALF-LIVES,SECS.     H3       N13      C14       NA22     NA24
            DATA (HLF(I),I=1,50) / 3.855E8,5.976E2,1.807E11,8.199E7,5.400E4
      C
      C         AR39     AR41     CR51     MN54     FE55     FE59     CO58     CO60
           1,8.515E9,6.588E3,2.402E6,2.696E7,7.569E7,3.888E6,6.134E6,1.652E8
      C
      C         NI63     CU64     ZN65     KR85M    KR85     KR87     KR88     SR89
           2,2.901E9,4.644E4,2.099E7,1.584E4,3.393E8,4.560E3,1.008E4,4.372E6
      C
      C         SR90     ZR95     NB95     MO99     RU103    RU106    TE132    I129
           3,9.082E8,5.616E6,3.024E6,2.412E5,3.456E6,3.154E7,2.808E5,5.046E14
      C
      C         I131     I132    I133     I135     XE131    XE133M   XE133    XE135M
           4,6.955E5,8.280E3,7.560E4,2.412E4,1.037E6,1.987E5,4.553E5,9.600E2
      C
```

```
33.     C        XE135    XE138    CS134    CS137    BA140    LA140    CE141    CE144
34.            5,3.312E4,1.02CE3,6.623E7,9.461E8,1.106E6,1.447E5,2.806E6,2.462E7
35.            6, 5*C.C  /
36.             END
```

PROCEDURE NAME TABLE

COMN CCCCCCCC

10831131

217

10831132

```
@ ELT RADREL,1,71C31E, 5376D                                    03/16/71

1.          CALL DATINP
2.          STOP
3.          END
```


218

10831133

```
@ ELT DATINP,1,711112, 40569

      SUBROUTINE DATINP                                                 C3/16/7
      INCLUDE COMN,LIST
  100 FORMAT (13A6,A2)
  200 FORMAT (16I5)                                                     C1/22/7
  210 FORMAT (I10,F10.0)                                                C1/22/7
  250 FORMAT (15X,A6/ (8E10.5) )
  300 FORMAT (16X,I4,I5,20X,2A6,A3,   F4.0,4F4.0)
  490 FORMAT ('0CLSTAT ERROR FOR GO TO , L(J)='I3,'  J='I3)
  500 FORMAT ('0END OF TAPE ON NTRAN WRITE , L(J)='I3,'  J='I3)
  510 FORMAT ('0DEVICE ERROR ON NTRAN WRITE ,L(J)='I3,'  J='I3)
  520 FORMAT ('0TRANSMISSION ABORTED ON NTRAN WRITE, L(J)='I3,' J='I3)
C                                                                       C1/22/7
      CALL EQPART (ID20,20,20,1)                                        C3/16/7
      READ (5,100) (TITLE(I),I=1,13)
      READ (5,200) NS,NM,NTI,NAI,NWI
      IBUF(1) = NS
      IBUF(2) = NM
      IBUF(3) = NTI
      IBUF(4) = NAI
      IBUF(5) = NWI
      NTP = 0
      DO 1000 IP=1,NS
      READ (5,300)  NSITE,NPPS,(PRVNM(K,IP),K=1,3),PRVML(IP), PLAD,PLAM,
     1  PLOD,PLOM
      IPS = IP
      DO 900 N  = 1,NPPS
      NOSITE(NTP+N ) = NSITE
      NSSITE(NTP+N) = NSITE
  900 CONTINUE
      NTP = NTP + NPPS
      PLAT(IP) = PLAD + PLAM/60.
      PLON(IP) = PLOD + PLOM/60.
```

```
      PLTLN(1,IP) = PLAT(IP)
      PLTLN(2,IP) = PLON(IP)
      PLTLN(3,IP) = 100.
 1000 CONTINUE                                                    01/22/71
 1100 CONTINUE
      IBUF(1) = IPS
      NS = IBUF(1)
      IBUF(6) = NTP
      READ (5,250) IRTM,(RMFRIS(I),I=1,100)
      READ (5,250) IRTP,(RPURIS(I),I=1,100)
      READ (5,200) NRP
      DO 1200 I=1,NRP                                             01/22/71
      READ (5,210) NSITRP(I),BUF(I)                               03/16/71
 1200 CONTINUE
      DO 1400 I=1,NS                                              01/22/71
      DO 1300 J=1,NRP
      IF (NSITRP(J) .NE. NOSITE(I) )  GO TO 1300
C        STORE REPROC. PLANT STARTUP DATE
      NUMSIT(J) = NSITRP(J)
C        STORE REPROC. PLANT SITE NO.
      PLTLN(4,I) = BUF(I)
 1300 CONTINUE
 1400 CONTINUE
      READ(5,100)  IREST
      IBUF(7) = IREST
      IF (IREST .EQ. 6HRESTAR)   CALL RESTAR
      CALL PLANTS
      READ (5,100) ISOURC
      IF (ISOURC .NE. 6HNEW SO)   GO TO 1500                      03/16/71
      CALL HEAD                                                   03/16/71
      CALL RELAIR                                                 01/22/71
      CALL RELWAT                                                 01/22/71
 1500 CONTINUE                                                    01/22/71
      RETURN                                                      03/16/71
      END
```

```
@ ELT DUMP,1,71C9C2, 42351

      DIMENSION BUF( 1CCC),IBUF( 1CCC)
      EQUIVALENCE (BUF(1),IBUF(1) )
      DIMENSION ARRAV(1CC,5C),NAP(1CC,4C),WRRAV(1CC,5C),NWP(1CC,4C)
     1 , PLTLN(2,2CC),SYM(5C),ARGS(5C),WRGS(5C)
      DATA (SYM(I),I=1,4C) /1H ,1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ
     1,1HK,1HL,1HM,1HN,1HC,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ
     2,1H+,1H-,1H.,1HC,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9              /
  1CC FORMAT (1X,2CA6)
  2CC FORMAT (1CI1C)
  3CC FORMAT (1CG12.5)
  4CC FORMAT ('1 FILE NO.' I3,' OF RADIATION RELEASE SOURCE MAP TAPE')
  5CC FORMAT ('C',I6,' RECORDS SKIPPED.')
  6CC FORMAT (1CX)
  7CC FORMAT ('1            AIR RELEASE RATES MAP'/ )
  71C FORMAT ('1          WATER RELEASE RATES MAP'/ )
  75C FORMAT (15(2X,A6) )
  76C FORMAT (15G8.3)
  79C FORMAT (1CX,9CA1)
  8CC FORMAT (1CX,9CA1,2X,2A1)
  9CC FORMAT ('C  NTRAN STATUS CHECK = ' I4,' ON FILE',I3,', RECORD',I4)
C
      READ (5,2CC) NARS,NARR, NWRS,NWRR
C
      NFILE = 1
      PRINT 4CC, NFILE
      PRINT 6CC
      NREC = 1
      CALL NTRAN (1,1C)
      CALL NTRAN (1,22)
      CALL NTRAN (1,2,2C,IBUF,LST)
 1CCC IF (LST+1) 9CCC,1CCC,15CC
 15CC PRINT 1CC, (IBUF(I),I=1,2C)
```


10831135

```
C
      PRINT 600
      NREC = 2
      CALL NTRAN (1,2,6,IBUF,LST)
 2000 IF (LST+1) 9000,2000,2500
 2500 PRINT 200, (IBUF(I),I=1,6)
      NTS = IBUF(1)
      NM = IBUF(2)
      NTI = IBUF(3)
      NAI = IBUF(4)
      NWI = IBUF(5)
      NTP = IBUF(6)
C
      CALL NTRAN(1,8,1)
      NFILE = 2
      PRINT 400, NFILE
      PRINT 600
C
      NREC = 1
      CALL NTRAN (1,2,NTI,BUF,LST)
 3000 IF (LST+1) 9000,3000,3500
 3500 PRINT 300, (BUF(I),I=1,NTI)
C
      CALL NTRAN (1,8,1)
      NFILE = 3
      PRINT 400, NFILE
      PRINT 600
C
      NREC = 1
      NTSWD = 4*NTS
      CALL NTRAN (1,2,NTSWD,BUF,LST)
 4000 IF (LST+1) 9000,4000,4500
 4500 PRINT 300, (BUF(I),I=1,NTSWD)
      DO 4600 I=1,NTS
      IC = 4*(I-1)
      PLTLN(1,I) = BUF(IC+1)
```


1083136

222

```
      PLTLN(2,I) = BUF(IC+2)
 4600 CONTINUE
      NRGS = 15
C
      CALL NTRAN (1,8,1)
      NFILE = 4
      PRINT 400, NFILE
      PRINT 600
C
      NREC = 1
      CALL NTRAN (1,2,NTS,BUF,LST)
 5000 IF (LST+1) 9000,5000,5500
 5500 PRINT 300, (BUF(I),I=1,NTS)
C
      PRINT 600
      NREC = 2
      NTSRW = 3*NTS
      CALL NTRAN (1,2,NTSRW,IBUF,LST)
 6000 IF (LST+1) 9000,6000,6500
 6500 PRINT 100, (IBUF(I),I=1,NTSRW)
C
      CALL NTRAN (1,8,1)
      NFILE = 5
      PRINT 400, NFILE
      NREC = NARS
      IF (NREC .EQ. 0)   GO TO 6700
      CALL NTRAN (1,7,NREC)
 6700 CONTINUE
      PRINT 500, NREC
      NAW = NAI + 4
      DO 7700 K=1,NARR
      PRINT 600
      NREC = NREC + 1
      CALL NTRAN (1,2,NAW,BUF,LST)
 7000 IF (LST+1) 9000,7000,7500
 7500 CONTINUE
```


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```
      PRINT 300, (BUF(I),I=1,NAW)
      J = MOD(K-1,NTS) + 1
      ILN = 90 - INT((PLTLN(2,J) - 80.)*3.)
      ILT = 40 - INT((PLTLN(1,J) - 30.)*2.) -1
      NAP(ILN,ILT) = NAP(ILN,ILT) + 1
      DO 7600 IS = 1,NAI
      ARRAV(ILN,ILT) = ARRAV(ILN,ILT) + BUF(IS)
 7600 CONTINUE
      ARRMAX = AMAX0(ARRMAX,ARRAV(ILN,ILT) )
 7700 CONTINUE
      DAR = ARRMAX/NRGS
      DO 7710 J=1,NRGS
      ARGS(J) = J*DAR
 7710 CONTINUE
      SYMN = 1HN
      SYME = 1HE
      SYMS = 1HS
      SYMW = 1HW
      DO 7750 ILN=1,90
      DO 7740 ILT=1,40
      ISYM = ARRAV(ILN,ILT)/DAR +.999999
      ARRAV(ILN,ILT) = SYM(ISYM+1)
      IF (ILN .EQ. 1)  ARRAV(ILN,ILT) = SYMW
      IF (ILN .EQ. 90) ARRAV(ILN,ILT) = SYME
      IF (ILT .EQ. 1 ) ARRAV(ILN,ILT) = SYMN
      IF (ILT .EQ. 40) ARRAV(ILN,ILT) = SYMS
 7740 CONTINUE
 7750 CONTINUE
      DO 7760 ILN=1,90
      IF (MOD(ILN,3) .EQ. 0)   GO TO 7755
      ARRAV(ILN,100) =  SYM(1)
      ARRAV(ILN, 99) =  SYM(1)
      ARRAV(ILN, 98) =  SYM(30)
      GO TO 7760
 7755 ILON = 110 - ILN/3
      ISYM = 31 + ILON/100
```


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```
      ARRAV(ILN,100) = SYM(ISYM)
      IF (ISYM .EQ. 31)   ARRAV(ILN,100) = SYM(1)
      ISYM = 31 + MOD(ILON/10,10)
      ARRAV(ILN,99) = SYM(ISYM)
      ISYM = 31 + MOD(ILON,10)
      ARRAV(ILN,98) = SYM(ISYM)
 7760 CONTINUE
      DO 7770 ILT=1,40
      IF (MOD(ILT,2) .EQ. 1)   GO TO 7765
      ARRAV(91,ILT) = SYM(1)
      ARRAV(92,ILT) = SYM(29)
      GO TO 7770
 7765 ILAT = 50 - (ILT-1)/2
      ISYM = 31 + MOD(ILAT/10,10)
      ARRAV(91,ILT) = SYM(ISYM)
      ISYM = 31 + MOD(ILAT,10)
      ARRAV(92,ILT) = SYM(ISYM )
 7770 CONTINUE
      PRINT 700
      PRINT 790,((ARRAV(I,J),I=1,90),J=100,98,-1)
      PRINT 800, ((ARRAV(I,J),I=1,92),J=1,40)
      PRINT 750, (SYM(I+1),I=1,NRGS)
      PRINT 760, (ARGS(I),I=1,NRGS)
C
 7800 CALL NTRAN (1,8,1)
      NFILE = 6
      PRINT 400 , NFILE
      NREC = NWRS
C
      IF (NREC .EQ. 0)   GO TO 7900
      CALL NTRAN (1,7,NREC)
 7900 CONTINUE
      PRINT 500, NREC
      DO 8700 K=1,NWRR
      PRINT 600
C
```


10831139

```
      NREC = NREC + 1
      CALL NTRAN (1,2,NWI,BUF,LST)
 8000 IF (LST+1) 9000,8000,8500
 8500 CONTINUE
      PRINT 300, (BUF(I),I=1,NWI)
      J = MOD(K-1,NTS) + 1
      ILN = 90 - INT((PLTLN(2,J) - 80.)*3.)
      ILT = 40 - INT((PLTLN(1,J) - 30.)*2.) -1
      NWP(ILN,ILT) = NWP(ILN,ILT) + 1
      DO 8600 IS = 1,NWI
      WRRAV(ILN,ILT) = WRRAV(ILN,ILT) + BUF(IS)
 8600 CONTINUE
      WRRMAX = AMAX0(WRRMAX,WRRAV(ILN,ILT) )
 8700 CONTINUE
      DWR = WRRMAX/NRGS
      DO 8710 J=1,NRGS
      WRGS(J) = J*DWR
 8710 CONTINUE
      DO 8750 ILN=1,90
      DO 8740 ILT=1,40
      ISYM = WRRAV(ILN,ILT)/DWR +.999999
      WRRAV(ILN,ILT) = SYM(ISYM+1)
      IF (ILN .EQ. 1)  WRRAV(ILN,ILT) = SYMW
      IF (ILN .EQ. 90) WRRAV(ILN,ILT) = SYME
      IF (ILT .EQ. 1 ) WRRAV(ILN,ILT) = SYMN
      IF (ILT .EQ. 40) WRRAV(ILN,ILT) = SYMS
 8740 CONTINUE
 8750 CONTINUE
      DO 8760 ILN=1,90
      IF (MOD(ILN,3) .EQ. 0)   GO TO 8755
      WRRAV(ILN,100) =  SYM(1)
      WRRAV(ILN, 99) =  SYM(1)
      WRRAV(ILN, 98) =  SYM(30)
      GO TO 8760
 8755 ILON = 110 - ILN/3
      ISYM = 31 + ILON/100
```


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```
      WRRAV(ILN,100) = SYM(ISYM)
      IF (ISYM .EQ. 31)   WRRAV(ILN,100) = SYM(1)
      ISYM = 31 + MOD(ILON/10,10)
      WRRAV(ILN,99) = SYM(ISYM)
      ISYM = 31 + MOD(ILON,10)
      WRRAV(ILN,98) = SYM(ISYM)
 8760 CONTINUE
      DO 8770 ILT=1,40
      IF (MOD(ILT,2) .EQ. 1)   GO TO 8765
      WRRAV(91,ILT) = SYM(1)
      WRRAV(92,ILT) = SYM(29)
      GO TO 8770
 8765 ILAT = 50 - (ILT-1)/2
      ISYM = 31 + MOD(ILAT/10,10)
      WRRAV(91,ILT) = SYM(ISYM)
      ISYM = 31 + MOD(ILAT,10)
      WRRAV(92,ILT) = SYM(ISYM )
 8770 CONTINUE
      PRINT 710
      PRINT 790,((WRRAV(I,J),I=1,90),J=100,98,-1)
      PRINT 800, ((WRRAV(I,J),I=1,92),J=1,40)
      PRINT 750, (SYM(I+1),I=1,NRGS)
      PRINT 760, (WRGS(I),I=1,NRGS)
C
 8800 CALL NTRAN (1,10)
      CALL EXIT
C
 9000 CONTINUE
      PRINT 900, LST,NFILE,NREC
      GO TO (9100,3500,4500,9200,7800,8800) , NFILE
 9100 GO TO (1500,2500) , NREC
 9200 GO TO (5500,6500) , NREC
      END
```


1083141

```
@ ELT EGPART,1,710316, 53756

      SUBROUTINE EGPART (IDAD,IFD,ILD,ND)
      DIMENSION IDAD(7)
      INCLUDE COMN
      CALL SETDR (IFD,131072,500000,IDAD)
      CALL SETDAR (5,0,IDSIT)
      RETURN
      END
```


1083142

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```
b ELT HEAD,1,710316, 53758

      SUBROUTINE HEAD                                                   01/22/71
      INCLUDE COMN,LIST
  200 FORMAT (5I5)
  490 FORMAT ('0LSTAT ERROR FOR GO TO , L(J)='I3,'  J='I3)
  500 FORMAT ('0END OF TAPE ON NTRAN WRITE , L(J)='I3,'  J=',I3)
  510 FORMAT ('0DEVICE ERROR ON NTRAN WRITE ,L(J)='I3,'  J=',I3)
  520 FORMAT ('0TRANSMISSION ABORTED ON NTRAN WRITE, L(J)=',I3,' J='I3)
C                                                                       01/22/71
      NS = IBUF(1)                                                      01/22/71
      NTI = IBUF(3)                                                     01/22/71
      J = 1
      CALL NTRAN (1,10)
C                                                                       03/16/71
      CALL NTRAN (1,1,20,TITLE,L(J) )                                   03/16/71
      PRINT 200, J,L(J)
 1300 IF (L(J)+1) 3000,1300,1400
C                                                                       03/16/71
 1400 CALL NTRAN (1,1,6,IBUF,L(J+1) )                                   03/16/71
      PRINT 200, J,L(J),J
      J = J + 1
      PRINT 200, J,L(J)
 1415 IF (L(J)+1) 3000,1415,1420
 1420 CALL NTRAN (1,9)
C                                                                       03/16/71
      CALL NTRAN (1,1,NTI,HLF,L(J+1) )                                  03/16/71
      PRINT 200, J,L(J),J
      J = J + 1
      PRINT 200, J,L(J)
 1510 IF (L(J)+1) 3000,1510,1520
 1520 CALL NTRAN (1,9)
C                                                                       03/16/71
      CALL NTRAN (1,1,4*NS,PLTLN,L(J+1) )                               03/16/71
```

```
      PRINT 200, J,L(J),J
      J = J + 1
      PRINT 200, J,L(J)
 1550 IF (L(J)+1) 3000,1550,1560
 1560 CALL NTRAN (1,9)
C                                                                       03/16/71
      CALL NTRAN (1,1,NS,PRVML,L(J+1) )                                 03/16/71
      PRINT 200, J,L(J),J
      J = J + 1
      PRINT 200, J,L(J)
 1570 IF (L(J)+1) 3000,1570,1580
C                                                                       03/16/71
 1580 CALL NTRAN (1,1,3*NS,PRVNM,L(J+1) )                               03/16/71
      PRINT 200, J,L(J),J
      J = J + 1
      PRINT 200, J,L(J)
 1590 IF (L(J)+1) 3000,1590,1600
 1600 CALL NTRAN (1,9)
      PRINT 200, J,L(J),J
      RETURN
 3000 LSTAT = L(J) + 5
      IF (LSTAT .LT. 1 .OR. LSTAT .GT. 3)   WRITE (6,490) L(J),J
      GO TO (5000,5100,5200), LSTAT
 5000 WRITE (6,500) L(J),J
      STOP
 5100 WRITE (6,510) L(J),J
      STOP
 5200 WRITE (6,520) L(J),J
      STOP
      END
```


1083144

```
@ ELT ICDA,1,710316, 5377C

      FUNCTION  ICDA(IPL,AG,PFM)
      INCLUDE COMN
      DIMENSION  IPLT(6),AGER(6),PFMR(10)
      DATA  IPLT  /36HPWR   BWR   PWRA  BWRA  LMFBR FOSSIL/
      DATA  AGER  / 5.,10.,15.,20.,25.,30. /
      DATA  PFMR  / .0,.2,.3,.4,.5,.6,.7,.8,.9,1.0  /
  100 FORMAT (' NO MATCH ON REACTOR TYPE ,'A6)
  200 FORMAT (' AGE OF 'G9.4,' IS OUTSIDE THE RANGE.')
  300 FORMAT (' PLANT FACTOR OF ',G9.4,' IS OUTSIDE THE RANGE.')
      DO 1000 I=1,6
      IF (IPL .EQ. IPLT(I) )   GO TO 1100
 1000 CONTINUE
      PRINT 100, IPL
      I = 7
 1100 IP = I
      DO 2000 I=1,6
      IF (AG .LE. AGER(I) )  GO TO 2100
 2000 CONTINUE
      PRINT 200, AG
 2100 IA = I
      AG = AGER(IA)
      DO 3000 I=1,10
      IF (PFM .LE. PFMR(I) )   GO TO 3100
 3000 CONTINUE
      PRINT 300, PFM
 3100 IL = I
      PFM = PFMR(IL)
      ICDA = 6*10*(IP-1) + 10*(IA-1) + (IL-1)
      IBUF(98) = IP
      IBUF(99) = IA
      IBUF(100) = IL
      RETURN
```


1083145

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END

33.

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```
@ ELT PLANTS,1,710316, 53764

      SUBROUTINE PLANTS
C                                                                       01/08/71
      COMMON RTYPE                                                      01/08/71
      INTEGER  RTYPE                                                    01/08/71
C                                                                       01/08/71
      DIMENSION  BUFIS(110)                                             01/08/71
      EQUIVALENCE (BUFIS(1),IRT),(BUFIS(2),PF),(BUFIS(3),AGE)           01/08/71
      INCLUDE COMN,LIST
  100 FORMAT (I10,4X,A6,F10.4,F10.0,I10)
  200 FORMAT (///15X,A6,2G10.4/45X,7G10.5/(10G12.5) )
  300 FORMAT (15X,A6,2G10.4/10X,7G10.5/(8G10.5) )
  400 FORMAT ('0PLANT NO.',I5,' DOES NOT MATCH ANY SITE NO.')           03/16/71
  500 FORMAT (' NTRAN ERROR, STATUS = ',I10,'   NN(PLANTS CARDS) = ',I10)
  600 FORMAT ('0',I10,' WORDS TRANSFERRED FROM UNIT',I3,' TO UNIT',I4)
  700 FORMAT (13A6,A2)                                                  03/16/71
C        100 ISOTOPES (50 AIR, 50 WATER)
C        5  REACTOR TYPES
C        6  AGE RANGES  0-4,5-9,10-14,15-19,20-24,25-30 (SET TO 0,5,ETC
C        10 PLANT FACTOR RANGES(0-.10,.11-.20,.21-.30,.....,.91-1.00)
C                                                                       03/16/71
      IN = 8
      READ (5,700) INEWPL                                               03/16/71
      IF (INEWPL .NE. 6HNEW PL)   GO TO 9000                            03/16/71
      NTP = IBUF(6)
      DO 3000 NN=1,10000
      READ(IN,100) IPLAN,IPLTY,PFMO,PLSUY,IMON
      IF (IMON .EQ. IPMON)   GO TO 1050
      IF (IPLTY .EQ. 6HEND   )  GO TO 9000                              03/16/71
C        RESTORE SITE NO. FOR EACH PLANT FOR NEXT MONTHS REPORTING
      DO 1000 N=1,NTP
      NOSITE(N) = NSSITE(N)
 1000 CONTINUE
```

```
      IPMON = IMON
 1C5D CONTINUE
      PLSUY = 1969. + PLSUY
      IF (PLSUY .LT. 1971.)    GO TO 3CDD
C        READ PLANTS MONTHLY LOAD FACTORS
C        DETERMINE WHICH PLANT NO. FROM SITE NO. AND NO. PLANTS / SITE
      IS = 0                                                          03/16/71
      NPS = 0                                                         03/16/71
      DO 1100 N=1,NTP
      IF (NPS .EQ. NSSITE(N) )   GO TO 1C6C                           03/16/71
      NPS = NSSITE(N)                                                 03/16/71
      IS = IS + 1                                                     03/16/71
 1C6C CONTINUE                                                        03/16/71
      IF (IPLAN .EQ. NOSITE(N) )    GO TO 1120
 11CC CONTINUE
      PRINT 4CC, IPLAN                                                03/16/71
      PRINT 1CC, IPLAN,IPLTY,PFMO,PLSUY,IMON                          03/16/71
      GO TO 3CCC
 1120 IR = N
      NOSITE(IR) = -NOSITE(IR)                                        03/16/71
      IPLANT(IR,IMON ) = IPLAN
      IF (IPLTY .EQ. 6HPWR    .AND. PLSUY .GE. 1985.)  IPLTY = 6HPWRA
      IF (IPLTY .EQ. 6HBWR    .AND. PLSUY .GE. 1985.)  IPLTY = 6HBWRA
      IPLTYP(IR,IMON ) = IPLTY
      PFMON(IR,IMON ) = PFMO
      PLSUYR(IR,IMON ) = PLSUY
      IF (PLTLN(4,IS) .EQ. 0.0)  PLTLN(4,IS) = PLSUY                  03/16/71
      IF (IPLTYP(IR,IMON) .EQ. 6HFOSSIL) PLTLN(4,IS) = 19CC.          03/16/71
      IF (IPLTYP(IR,IMON) .EQ. 6HFOSSIL)   GO TO 3CCC
C        CALCULATE DRUM ADDRESS FOR SEARCHING
      IRT = IPLTYP(IR,IMON)
      AGE = 2000. - PLSUYR(IR,IMON)
      PF = PFMON(IR,IMON)
      ID20(3) = ID20(1) + 110*ICDA(IRT,AGE,PF)
C        SEARCH DOSIS TABLE TO SEE IF DATA IS AVAILABLE
      CALL NTRAN (20,2,1, IRTDCK ,LST2C)
```


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```
 2000 IF (LST20+1) 2800,2000,2100
 2100 ID20(3) = ID20(3) - 1
C        INSERT IF STATEMENTS HERE TO MODIFY DOSIS DATA FROM RESTART TAPE03/16/71
      IF (IRT .EQ. IRTOCK)  GO TO 3000                                   03/16/71
C                                                                        03/16/71
C          NO DOSIS DATA AVAILABLE ON DRUM FILE,                         03/16/71
C             MUST CALL DOSIS TO OBTAIN DATA                             03/16/71
C                                                                        03/16/71
 2200 CONTINUE
      RTYPE = IRT
      CALL DOSIS (PF,AGE,BUFIS(11),BUFIS(61) )                           01/08/71
      IF (NN .GT. 30)   GO TO 2250                                       01/22/71
      PRINT 200, BUFIS                                                   03/16/71
 2250 CONTINUE
C          WRITE DOSIS OUTPUT TO DRUM FILE
      CALL NTRAN (20,1,110,BUFIS(1),LST20)
 2500 IF (LST20+1)  2800,2500,2900
 2800 PRINT 500, LST20,NN
 2900 IDEOF = MAXO(IDEOF,ID20(4) )
 3000 CONTINUE
 9000 CONTINUE
C     REWIND INPUT TAPE
      CALL NTRAN (IN,10)                                                 03/16/71
      READ (5,700) IWRITE                                                03/16/71
      IF (IWRITE .NE. 6HWRITE )   GO TO 9990                             03/16/71
C          WRITE DATA TAPE D FOR RESTART                                 03/16/71
      REWIND 7
      REWIND 20
      IN = 20
      IOUT = 7
      NWIN = IDEOF   - ID20(1)
      NWOUT = 0
 9050 NWTW = MIN0(5000,NWIN-NWOUT)
      CALL NTRAN (20,2,NWTW,BUF(1),LST20)
 9100 IF (LST20+1) 9200,9100,9300
 9200 PRINT 500,IN,NWOUT
```


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```
      GO TO 9900
 9300 CALL NTRAN (7,1,NWTW,BUF(1),LST1)
 9400 IF (LST1+1) 9500,9400,9600
 9500 PRINT 500,IOUT,NWOUT
      GO TO 9900
 9600 NWOUT = NWOUT + NWTW
      IF (NWOUT .LT. NWIN)   GO TO 9050
 9900 IF (LST1+1) 9910,9900,9920
 9910 PRINT 500,IN,NWOUT
 9920 CONTINUE
      WRITE (6,600) NWOUT,IN,IOUT
      CALL NTRAN (7,1,525*12*4,IPLANT(1,1),L7)                    03/16/71
 9930 IF (L7+1) 9940,9930,9950
 9940 NWOUT = -10
 9945 PRINT 500,IN,NWOUT
 9950 PRINT 600, L7,IN,IOUT                                       03/16/71
      CALL NTRAN (7,1,200*4,PLTLN(1,1),L7)                        03/16/71
 9952 IF (L7+1) 9953,9952,9955                                    03/16/71
 9953 NWOUT = -15                                                 03/16/71
      PRINT 500 , IOUT,NWOUT                                      03/16/71
 9955 PRINT 600, L7,IN,IOUT                                       03/16/71
      CALL NTRAN (7,1,6,IBUF(1),L7)
 9960 IF (L7+1) 9970,9960,9980
 9970 NWOUT = -20
      PRINT 500,IOUT,NWOUT
 9980 PRINT 600 , L7,IN,IOUT                                      03/16/71
      CALL NTRAN (7,9)                                            03/16/71
 9990 CONTINUE
      RETURN
      END
```


10831150

```
@ ELT RELAIR,1,711112, 40572

                                                                                  01/22/71
      SUBROUTINE RELAIR
      INCLUDE COMN,LIST
  100 FORMAT ('CNTRAN ERROR, STATUS='I3,' BUFFER='I3,'.RECORD BEING WRIT
     1TEN =' I5)
  110 FORMAT (3I10)                                                               01/22/71
  200 FORMAT ('C AIR  RECORD NO.'I5,'  SITE NO.'I6,'  MONTH',I3)                  01/22/71
  300 FORMAT (10G12.5)
      NS = IBUF(1)
      NM=IBUF(2)                                                                  01/22/71
      NAI = IBUF(4)                                                               03/16/71
      NAW = NAI + 4
      NTP = IBUF(6)
      L1 = 0
      IBS=1
      NREC = 0
      DO 4000 IM=1,NM
      IS = 1
      DO 500 IZ=1,50
  500 BUFOUT(IZ,IBS)=0
      DO 3000 IP=1,NTP
      IF (IPLTYP(IP,IM) .EQ. 0)   GO TO 2100
      IF (IPLTYP(IP,IM) .EQ. 6HFOSSIL) GO TO 2100
      IRT = IPLTYP(IP,IM)
      AGE = 2000. - PLSUYR(IP,IM)
      PF = PFMON(IP,IM)
      ID20(3) = ID20(1) + 110*ICDA(IRT,AGE,PF) * 10                               01/22/71
      ID20(3) = ID20(3) + 50
      CALL NTRAN (20,2,50,BUF(1),LST20)
 2000 IF (LST20+1) 5000,2000,2100
 2100 CONTINUE                                                                    03/16/71
      IF (IP .EQ. 1)   GO TO 2400                                                 03/16/71
      IF (NSSITE(IP) .EQ. NSSITE(IP-1) )   GO TO 2790
```

```
 2200 IF (L1+1) 5000,2200,2300
 2300 IBW = IBS
      NREC = NREC + 1
C     WRITE (6,200) NREC,NSSITE(IP-1),IM                                  01/22/71
C     PRINT 300 ,       (BUFOUT(NNN,IBW),NNN=1,NAI)                       01/22/71
      CALL NTRAN (1,1,NAW,BUFOUT(1,IBW),L1)                               03/16/71
      IBS=3-IBS
      IS = IS + 1
 2400 CONTINUE                                                            03/16/71
      DO 2500 IZ = 1,NAI                                                  01/22/71
      BUFOUT(IZ,IBS) = 0.0
 2500 CONTINUE
      DO 2600 IZ = 1,4                                                    03/16/71
      BUFOUT(NAI+IZ,IBS) = PLTLN(IZ,IS)                                   03/16/71
 2600 CONTINUE                                                            03/16/71
 2700 IF (IPLTYP(IP,IM) .EQ. 6HFOSSIL)   GO TO 3000
      DO 2720 IR = 1,30                                                   03/16/71
      IRP = IR                                                            01/22/71
      IF (NSSITE(IP) .EQ. NUMSIT(IR) )  GO TO 2725                        01/22/71
 2720 CONTINUE                                                            01/22/71
      GO TO 2790                                                          01/22/71
 2725 IF (NSSITE(IP) .NE. 1291)  GO TO 2740
C        RETRIEVE MFR PLANT RELEASES
      DO 2730 II=1,NAI                                                    01/22/71
      IJ = INAI(II) + 50                                                  01/22/71
      BUF(IJ) = 0.0
      BUFOUT(II,IBS) = RMFRIS(IJ)
 2730 CONTINUE                                                            01/22/71
      GO TO 2790                                                          01/22/71
 2740 CONTINUE                                                            01/22/71
C        RETRIEVE PUREX PLANT RELEASES
      DO 2760 II=1,NAI                                                    01/22/71
      IJ = INAI(II) + 50                                                  01/22/71
      BUF(IJ) = 0.0
      BUFOUT(II,IBS) = RPURIS(IJ)
 2760 CONTINUE                                                            01/22/71
```


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```
 2790 CONTINUE                                                          01/22/71
      IF (IPLTYP(IP,IM) .EQ. 6HFOSSIL)   GO TO 3000                     03/15/71
C
      IF (IPLTYP(IP,IM) .EQ. 0)    GO TO 3000
      DO 2800 II=1,NAI                                                  01/22/71
      IJ = INAI(II)                                                     01/22/71
      BUFOUT(II,IBS) = BUFOUT(II,IBS) + BUF(IJ)
 2800 CONTINUE
      DO 2900 IZ=1,50
      BUF(IZ) = 0.0
 2900 CONTINUE
 3000 CONTINUE
 3100 IF (L1+1) 5000,3100,3200
 3200 IBW = IBS
      CALL NTRAN (1,1,NAW,BUFOUT(1,IBW),L1)                             03/16/71
      NREC = NREC + 1
C     WRITE (6,200) NREC,NSSITE(IP),IM                                  01/22/71
C     PRINT 300 ,       (BUFOUT(NNN,IBW),NNN=1,NAI)                     01/22/71
      IBS=3-IBS
 4000 CONTINUE
 4100 IF (L1+1)  5000,4100,4500
 4500 CALL NTRAN (1,9)
      NW = 7                                                            03/16/71
      PRINT 110,  NW,L1,NREC                                            03/16/71
      RETURN
 5000 WRITE (6,100)  L1,IBW,NREC
      STOP
      END
```


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```
@ ELT RELWAT,1,711112, 40575

      SUBROUTINE RELWAT
      INCLUDE COMN,LIST
  100 FORMAT ('CNTRAN ERROR, STATUS='I3,' BUFFER='I3,' RECORD BEING WRIT
     1TEN ='  I5)
  110 FORMAT (3I10)
  200 FORMAT ('0 H20  RECORD NO.'I5,'  SITE NO.'I6,'  MONTH',I3)        01/22/71
  300 FORMAT (10G12.5)                                                  01/22/71
      NS = IBUF(1)
      NM=IBUF(2)
      NWI = IBUF(5)
      NTP = IBUF(6)
      L1 = 0
      IBS=1
      NREC = 0
      DO 4000 IM=1,NM
      IS = 1
      DO 500 IZ=1,50
  500 BUFOUT(IZ,IBS)=0
      DO 3000 IP=1,NTP
      IF (IPLTYP(IP,IM) .EQ. 0)   GO TO 2100
      IF (IPLTYP(IP,IM) .EQ. 6HFOSSIL) GO TO 2100
      IRT = IPLTYP(IP,IM)
      AGE = 2000. - PLSUYR(IP,IM)
      PF = PFMON(IP,IM)
      ID20(3) = ID20(1) + 110*ICDA(IRT,AGE,PF) + 10
      CALL NTRAN (20,2,50,BUF(1),LST20)
 2000 IF (LST20+1) 5000,2000,2100
 2100 CONTINUE
      IF (IP .EQ. 1) GO TO 2700
      IF (NSSITE(IP) .EQ. NSSITE(IP-1) )   GO TO 2790                   03/16/71
 2200 IF (L1+1) 5000,2200,2300
 2300 IBW = IBS
```


10831154

```
      NREC = NREC + 1
C     WRITE (6,200) NREC,NSSITE(IP-1),IM                                01/22/71
C     PRINT 300 ,       (BUFOUT(NNN,IBW),NNN=1,NWI)                     01/22/71
      CALL NTRAN (1,1,NWI,BUFOUT(1,IBW),L1)
      IBS=3-IBS
      IS = IS + 1
      DO 2500 IZ=1,NWI
      BUFOUT(IZ,IBS) = 0.0
 2500 CONTINUE
 2700 IF (IPLTYP(IP,IM) .EQ. 6HFOSSIL)   GO TO 3000
      DO 2720 IR = 1,30                                                 03/16/71
      IRP = IR                                                          01/22/71
      IF (NSSITE(IP) .EQ. NUMSIT(IR) )  GO TO 2725                      01/22/71
 2720 CONTINUE                                                          01/22/71
      GO TO 2790                                                        01/22/71
 2725 IF (NSSITE(IP) .NE. 1291)  GO TO 2740
C        RETRIEVE MFR PLANT RELEASES
      DO 2730 II=1,NWI                                                  01/22/71
      IJ = INWI(II)
      BUF(IJ) = 0.0
      BUFOUT(II,IBS) = RMFRIS(IJ)
 2730 CONTINUE                                                          01/22/71
      GO TO 2790                                                        01/22/71
 2740 CONTINUE                                                          01/22/71
C        RETRIEVE PUREX PLANT RELEASES
      DO 2760 II=1,NWI                                                  01/22/71
      IJ = INWI(II)
      BUF(IJ) = 0.0
      BUFOUT(II,IBS) = RPURIS(IJ)
 2760 CONTINUE                                                          01/22/71
 2790 CONTINUE                                                          01/22/71
      IF (IPLTYP(IP,IM) .EQ. 6HFOSSIL)   GO TO 3000                     03/16/71
C
      IF (IPLTYP(IP,IM) .EQ. C)    GO TO 3000
      DO 2800 II=1,NWI
      IJ = INWI(II)
```


10831155

```
      BUFOUT(II,IBS) = BUFOUT(II,IBS) + BUF(IJ)
 2800 CONTINUE
      DO 2900 IZ=1,50
      BUF(IZ) = 0.0
 2900 CONTINUE
 3000 CONTINUE
 3100 IF (L1+1) 5000,3100,3200
 3200 IBW = IBS
      CALL NTRAN (1,1,NWI,BUFOUT(1,IBW),L1)
      NREC = NREC + 1
C     WRITE (6,200) NREC,NSSITE(IP),IM                                  01/22/71
C     PRINT 300 ,       (BUFOUT(NNN,IBW),NNN=1,NWI)                     01/22/71
      IBS=3-IBS
 4000 CONTINUE
 4100 IF (L1+1)  5000,4100,4500
 4500 CALL NTRAN (1,9)
      NW = 8                                                            03/16/71
      PRINT 110,  NW,L1,NREC                                            03/16/71
      RETURN
 5000 WRITE (6,100)  L1,IBW,NREC
      STOP
      END
```


1083156

242

```
@ ELT RESTAR,1,710316, 53762

      SUBROUTINE RESTAR
      INCLUDE COMN,LIST
      IS=1
      LUD = 8                                                          03/16/71
   10 CALL NTRAN (LUD,2,5000,BUF,L7)                                   01/08/71
      IS=IS+1
   15 IF(L7+1) 100,15,20
   20 CALL NTRAN(20,1,L7,BUF,L20)
   25 IF(L20+1) 100,25,30
   30 IF(L7.EQ.5000) GO TO 10
C
      IS=0
      CALL NTRAN (LUD,2,525*12*4,IPLANT,L7)                            03/16/71
      CALL NTRAN (LUD,2,200*4,PLTLN(1,1),L7)                           03/16/71
C     CALL NTRAN (LUD,2,6,IBUF,L7)                                     03/16/71
   35 IF(L7+1) 100,35,40
   40 CALL NTRAN (LUD,8,1)                                             03/16/71
      RETURN                                                           01/08/71
C
  100 PRINT 110,IS,L7,L20
  110 FORMAT('0***ERROR****',3I10)
      RETURN 0
      END
```

DOSIS Code Listing

1083158

```
@ ELT SUPER,1,71012C, 33332

      INTEGER RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      INTEGER R
      DIMENSION TINV(50),TGASIN(50)
      DATA BWR/3HBWR/,PWR/3HPWR/,BWRA/4HBWRA/,PWRA/4HPWRA/,LMFBR/5HLMFBR
     X/
      R = 5
    1 READ(R,2)RTYPE,PF,AGE
    2 FORMAT(A5,2F10.3)
      CALL DOSIS(PF,AGE,TINV,TGASIN)
      GO TO 1
      END
```


1083159

2445

```
@ ELT ACTIVA,1,710300, 44590

      SUBROUTINE ACTIVA(ACC,PUG,PD,PF,ACTINV)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR,K1
      REAL K1
      DIMENSION ACTINV(50),K1(50),PVBWR(50),
     XPCBWR(50),PCCBWR(50), PVPWR(50), PCPWR(50), PCCPWR(50),
     XPVLMR(50),PCLMR(50),PCCLMR(50), VEGCPL(50), CLAD(50), CCCL(50)
     X,POWER1(50),POWER2(50),POWER3(50),POWER4(50),POWER5(50)
     X,POWER6(50),POWER7(50),POWER8(50),POWER9(50)
      DATA(PVBWR(I),I=1,45)/ 2*0., 4.0E1, 4*0., 3.0E3, 7.3E6,
     X 5.0E9, 1.36E8, 2.0E3, 1.12E11, 2.5E11, 10*0., 1.0E3, 20*0./
      DATA(PCBWR(I),I=1,45)/ 2*0., 3.1E2, 4*0., 2.0E3, 0.0E0,
     X 1.60E10, 3.75E8, 3.E10, 6.40E5, 3.15E10, 31*0./
      DATA(PCCBWR(I),I=1,45)/ 0., 1.02E7, 0., 6.11E-3, 0.05E6, 3.00E4,
     X 3.96E6, 7*0., .4, 2.50E3, 29*0./
      DATA(PVPWR(I),I=1,45)/ 2*0., 3.00E1, 4*0., 2.75E3, 3.07E7,
     X 4.90E10, 1.15E9, 8.78E7, 1.0E10, 2.00E10, 10*0., 1.0E3, 20*0./
      DATA(PCPWR(I),I=1,45)/ 2*0., 3.00E+2, 4*0., 7.0E3, 0.0E3,
     X 1.37E11, 8.69E9, 3.E11, 3.49E10, 5.70E3, 31*0./
      DATA(PCCPWR(I),I=1,45)/ 6.61E5, 2*0., 6.11E-3, 9.05E+6, 3.75E+4,
     X 2.47E6, 7*0., 0.4, 2.50E3, 29*0./
      DATA(PVLMR(I),I=1,45)/ 2*0.,1.67E3, 4*0., 7.0E9, 0., 6.57E9,
     X 1.57E8, 0., 1.96E9, 3.70E9, 10*0., 1.04E8, 20*0./
      DATA(PCLMR(I),I=1,45)/ 2*0., 4.00E2, 4*0., 1.0E3, 6.0E0,
     X 1.66E9, 3.87E7, 1.12E10, 4.50E8, 9.00E3, 10*0., 2.0E7, 20*0./
      DATA(PCCLMR(I),I=1,45)/ 3*0., 6.0E3, 7.0E3, 4.70E6, 6.70E3, 33*0./
      IF(RTYPE.EQ.BWR  ) VOLUME = 300000.
      IF(RTYPE.EQ.PWR  ) VOLUME = 360000.
      IF(RTYPE.EQ.BWRA ) VOLUME = 200000.
      IF(RTYPE.EQ.PWRA ) VOLUME = 320000.
      IF(RTYPE.EQ.LMFBR) VOLUME = 300000.
      IF(RTYPE.EQ.LMFBR) GO TO 100
```


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```
      IF(RTYPE.EQ.PWR) GO TO 50
      IF(RTYPE.EQ.PWRA) GO TO 50
C     BWR
C       -VESSEL ,WHICH INCLUDES THE SS SHIELD
      CORR = .618 E-5
      DO 5 I=1,LIMIT
      POWER1(I) = K1(I)*AGE*3.1536E7
      IF(POWER1(I).LT.-70.)POWER1(I) = -70.
      VESSEL(I) = PVBWR(I) * CORR * (1.-EXP(POWER1(I))) * PF / .037      10/16/70
    5 CONTINUE
C       - CLAD
      CORR =2.E-5
      TIMA = BUG*8.64E4 /(PF*PD*2.)
      DO 10  I=1,LIMIT
      POWER4(I) = K1(I)*TIMA
      IF(POWER4(I).LT.-70.)POWER4(I) = -70.
      CLAD(I)   = PCBWR(I) * CORR * (1.-EXP(POWER4(I))) * PF / .037      10/16/70
   10 CONTINUE
C       - COOLANT
      DO 25 I=1,LIMIT
      COOL(I) = PCOBWR(I) * PF / .037
   25 CONTINUE
      GO TO 130
   50 CONTINUE
C     PWR
C       -VESSEL
      CORR = .618 E-5
      DO 55 I=1,LIMIT
      POWER2(I) = K1(I)*AGE*3.1536E7
      IF(POWER2(I).LT.-70.)POWER2(I) = -70.
      VESSEL(I) = PVPWR(I) * CORR * (1.-EXP(POWER2(I))) * PF / .037      10/16/70
   55 CONTINUE
C       - CLAD
      CORR =2.E-5
      TIMA = BUG*8.64E4 /(PF*PD*2.)
      DO 60 I=1,LIMIT
```


1083161

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```
      POWER5(I) = K1(I)*TIMA
      IF(POWER5(I).LT.-70.)POWER5(I) = -70.
      CLAD(I)   = PCPWR(I) * CORR * (1.-EXP(POWER5(I))) * PF / .037      10/10/70
   90 CONTINUE
C        - COOLANT
      DO 30 I=1,LIMIT
      COOL(I) = PCOPWR(I) * PF / .037
   30 CONTINUE
      GO TO 130
  100 CONTINUE
C     LMFBR
C        - VESSEL
      CORR = .6130E-5
      DO 105 I=1,LIMIT
      POWER3(I) = K1(I)*ACE*3.1536E7
      IF(POWER3(I).LT.-70.)POWER3(I) = -70.
      VESSEL(I) = PVLMR(I) * CORR * (1.-EXP(POWER3(I))) * PF / .037      10/10/70
  105 CONTINUE
C        - CLAD
      CORR =2.E-5
      TIMA = BUG*8.64E4 /(PF*PD*2.)
      DO 110 I=1,LIMIT
      POWER6(I) = K1(I)*TIMA
      IF(POWER6(I).LT.-70.)POWER6(I) = -70.
      CLAD(I)   = PCLMR(I) * CORR * (1.-EXP(POWER6(I))) * PF / .037      10/10/70
  110 CONTINUE
C        - COOLANT
      DO 120 I=1,LIMIT
      POWER9(I) = K1(I)*AGE*3.1536E7
      IF(POWER9(I).LT.-70.)POWER9(I) = -70.
      COOL(I) = PCOLMR(I)          * (1.-EXP(POWER3(I))) * PF / .037      10/10/70
  120 CONTINUE
  130 CONTINUE
      DO 150 I=1,LIMIT
      ACTINV(I) = COOL(I) + CLAD(I) + VESSEL(I)
  150 CONTINUE
```


1083162

RETURN
END

IOS.
IOE.

1083163

249

1083164

```
@ ZLT BWRD,1,710315, 51161

      SUBROUTINE BWRD(TGASIN)
      DIMENSION TGASIN(50)
      DELAY = 70.* 60.
      CALL CMPNT(DELAY,TGASIN)
      RETURN
      END
```

```
@ ELT CHAR,1,710930, 04590

      SUBROUTINE CHAR(TGASIN)
      COMMON RTYPE,LIMIT
      DIMENSION TGASIN(50),DELAY(50),DF(50), CAUT(50)
      DATA(DELAY(I),I=1,45)/ 0., 5400., 3*0., 2*10800., 9*0., 4*54000.,
     X 7*0., 12*6.084E5, 5*0./
      DATA(DF(I),I=1,45)/5., 27*1., 5*10., 12*1./
      CALL VDELA(DELAY,TGASIN)
      DO 10 I=1,LIMIT
      CAUT(I) =  TGASIN(I) *(1.-1./DF(I))
      TGASIN(I) = TGASIN(I)/DF(I)
   10 CONTINUE
      RETURN
      END
```


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```
@ ELT CMPNT,1,710810, 59455

      SUBROUTINE CMPNT(DELAY,INVIN)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C  DECAY ROUTINE FOR EACH COMPONENT
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR,K1,K2,K3
      REAL INVIN,K1,K2,K3
      DIMENSION INVIN(50),K1(50),K2(50), K3(50),
     X POWER1(50), POWER2(50), POWER3(50), AMT(50), AMTP(50),          02/18/71
     X AMTPM(50), AMTO(50)                                             02/18/71
      DO 10 I=1,LIMIT                                                  02/18/71
      AMT(I)=INVIN(I)/K1(I)                                            02/18/71
   10 CONTINUE                                                         02/18/71
   40 DO 100 N=1,LIMIT
      POWER1(N)= K1(N) * DELAY
      POWER2(N)= K2(N) * DELAY
      POWER3(N) = K3(N) * DELAY
      IF(POWER1(N).LT.-70.) POWER1(N)= -70.
      IF(POWER2(N).LT.-70.) POWER2(N) =-70.
      IF(POWER3(N).LT.-70.) POWER3(N) =-70.
      AMTP(N) = 0.                                                     02/18/71
      AMTPM(N) = 0.                                                    02/18/71
      GO TO (1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,18,1,1,1,1,1,24,1,1,1,1,
     X1,1,31,1,1,34,35,36,37,38,1,1,1,1,43,1,1),N
   18 AMTP(N)=AMT(17)*.20                                              02/18/71
      GO TO 1
   24 AMTP(N)=AMT(23)                                                  02/18/71
      GO TO 1
   31 AMTP(N)=AMT(28)                                                  02/18/71
      GO TO 1
   34 AMTP(N)=AMT(30)*.01                                              02/18/71
      GO TO 1
   35 AMTP(N)=AMT(32)*.024                                             02/18/71
      GO TO 1
```


1083166

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```
      36 AMTP(N)=AMT(32)*.976                                           02/18/71
         AMTPM(N)=AMT(35)                                               02/18/71
         GO TO 1
      37 AMTP(N)=AMT(33)*.30                                            02/18/71
         GO TO 1
      38 AMTP(N)=AMT(33)*.70                                            02/18/71
         AMTPM(N) = AMT(37)                                             02/18/71
         GO TO 1
      43 AMTP(N)=AMT(42)                                                02/18/71
       1 CONTINUE
         AMTO(N)=AMT(N)*EXP(POWER1(N))+K2(N)/(K1(N)-K2(N))              02/18/71
        X*(EXP(POWER2(N))-EXP(POWER1(N)))*AMTP(N) + K3(N)/(K1(N)-K3(N))  02/18/71
        X*(EXP(POWER3(N))-EXP(POWER1(N)))*AMTPM(N)                      02/18/71
     100 CONTINUE
         DO 110 I=1,LIMIT                                               02/18/71
         INVIN(I) = AMTO(I) * K1(I)
     110 CONTINUE                                                       02/18/71
         RETURN
         END
```


10831b7

```
@ ELT COLANT,1,711026, 3536C

      SUBROUTINE COLANT(COOLIN, CONCP, TGINS,FLOW1,FLOW2,FLOW3,FLOW4,
     X RECYC,SLUDGE,DIST3,DLUT2)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR,K1,K2,K3
      REAL K1,K2,K3
      DIMENSION COOLIN(50), CONC(50), CONCP(50),
     X PCONC1(50), PCONC2(50), SPBWR(50), SPPWR(50), SPLM(50),          11/25/70
     X  K1(50), K2(50),
     X K3(50), TGINS(50), DF(50), DFLM(50),
     X RECYC(50),DIST3(50),SLUDGE(50),DLUT2(50)
      DATA(SPBWR(I),I=1,45)/ 1.C1E-3, 1., 3*C., 2*1., 9*C., 4*1.,
     X 4*5.E-6, 4*C., 5*3.6E-6, 6*1., 6*C./
      DATA(SPPWR(I),I=1,45)/ C., 1., 3*C., 2*1., 9*C., 4*1.,            11/25/70
     X 4*5.E-6, 4*C., 5*3.6E-6, 6*1., 6*C./
      DATA(SPLM(I),I=1,45)/.CCCCC1,1., .CCCC1,2*.CCC1, 2*1., 9*C.,      11/13/70
     X 4*1., 5*5.E-6, 2*5.E-8, 6*2.E-5, 6*1., 3*2.E-5, 4*C./
      DATA(DF(I),I=1,45)/7*1.,9*1C.,4*1.,4*1C.,1.1,8*1C.,6*1.,2*1.1,
     X 4*1C./
      DATA(DFLM(I),I=1,45)/ 1C., 1., 1C., 4*1., 9*1C., 4*1., 13*1C.,
     X 6*1., 6*1C./
      PWRD =  75.* 4./6C.
      BWRD = 8CC.
      CFLOW = 75.* 4./6C.
      ICOUNT =1.+ ICOUNT
    5 CONTINUE
   1C CONTINUE
   15 CONTINUE
      IF(RTYPE.EQ.BWR  )  V= 32CCCC.
      IF(RTYPE.EQ.PWR  )  V= 36CCCC.
      IF(RTYPE.EQ.BWRA )  V= 288CCC.
      IF(RTYPE.EQ.PWRA )  V= 324CCC.
      IF(RTYPE.EQ.LMFBR)  V= 3CCCCC.
```

```
      DO 100 I=1,LIMIT
      PCONC1(I) = 0.
      PCONC2(I) = 0.
      GO TO (1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,18,1,1,1,1,1,24,1,1,1,1,
     X1,1,31,1,1,34,35,36,37,38,1,1,1,1,43,1,1),I
   18 PCONC1(I)= CONC  (17) * .20
      GO TO 1
   24 PCONC1(I)= CONC  (23)
      GO TO 1
   31 PCONC1(I)= CONC  (28)
      GO TO 1
   34 PCONC1(I) = CONC(30) * .01
      GO TO 1
   35 PCONC1(I)= CONC  (32) *.024
      GO TO 1
   36 PCONC1(I)= CONC  (32) *.976
      PCONC2(I)= CONC  (35)
      GO TO 1
   37 PCONC1(I)= CONC  (33) *.30
      GO TO 1
   38 PCONC1(I)= CONC  (33) *.70
      PCONC2(I)= CONC  (37)
      GO TO 1
   43 PCONC1(I)= CONC  (42)
    1 CONTINUE
      IF(RTYPE.EQ.LMFBR) GO TO 70
      IF(RTYPE.EQ.PWR ) GO TO 60                                        11/25/70
      IF(RTYPE.EQ.PWRA) GO TO 60                                        11/25/70
      CONC(I) = (COOLIN(I)*(1.-SPBWR(I)) + RECYC(I) + PCONC1(I) *
     X (-K1(I)) *V* (1.-SPBWR(I )) + PCONC2(I) * (-K1(I)) *V*
     X (1.-SPBWR(I))) / (V*(-K1(I)) + FLOW2 + FLOW3/DIST3(I)
     X +BWRD *(1.-1./DF(I)))
      SLUDGE(I) = BWRD  * CONC(I) * (1.-1./DF(I))
      TGINS(I) = SPBWR(I) * COOLIN(I) + PCONC1(I) * (-K1(I))*V* SPBWR(I)
     X + PCONC2(I)*(-K1(I)) *V*SPBWR(I)
      GO TO 80                                                          11/25/70
```


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```
   60 CONTINUE
      CONC(I) = (COOLIN(I)*(1.-SPPWR(I)) + RECYC(I) + PCONC1(I) *
     X (-K1(I)) *V* (1.-SPPWR(I )) + PCONC2(I) * (-K1(I)) *V*
     X (1.-SPPWR(I))) / (V*(-K1(I)) + FLOW1 + FLOW2/DLUT2(I)
     X +PWRD *(1.-1./DF(I)))
      SLUDGE(I) = PWRD  * CONC(I) * (1.-1./DF(I))
      TGINS(I) = SPPWR(I) * COOLIN(I) + PCONC1(I) * (-K1(I))*V* SPPWR(I)
     X + PCONC2(I)*(-K1(I)) *V*SPPWR(I)
      GO TO 80
   70 CONTINUE
      CONC(I) = (COOLIN(I) * (1.-SPLM(I)) + PCONC1(I) *(-K1(I)) *V*
     X(1.-SPLM(I )) + PCONC2(I) * (-K1(I)) *V* (1.-SPLM(I )))/
     X( V*(-K1(I)) + CFLOW * (1.-1./DFLM(I)))
      SLUDGE(I) = CFLOW * CONC(I) *(1.-1./DFLM(I))
      TGINS(I) = SPLM (I) * COOLIN(I) + PCONC1(I) * (-K1(I))*V* SPLM (I)
     X + PCONC2(I) *(-K1(I)) *V*SPLM (I)
   80 CONTINUE
  100 CONTINUE
      DO 200 I=1,LIMIT
      CONCP(I) = CONC(I)
  200 CONTINUE
      RETURN
      END

 END CUR
```


1083170

256

```
@ ELT COLTNK,1,71C916, 51153

      SUBROUTINE COLTNK(TINV,TGIN1A)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C  WASTE COLLECTION TANK
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TINV(5C),TGIN1A(5C),CONC(5C)
      VOLLIQ = 25CCC.
      DELAY = 3C.* 8.64E4
      CALL CMPNT(DELAY,TINV)
      CALL VENT(TINV,TGIN1A)
      DO 1C I=1,LIMIT
      CONC(I) = TINV(I)* DELAY /VOLLIQ
   1C CONTINUE
      RETURN
      END
```


1083111

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```
@ ELT CRYO,1,7D1113, 51D99

      SUBROUTINE CRYO(TGFLO,TGIN5)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TGIN5(5D), VDELAY(5D), TGIN50(5D)
C 3D DAY DELAY
      DATA(VDELAY(I),I=1,45)/45*2.59E6/
      CALL VDELA(VDELAY,TGIN5,TGIN50)
      DO 1D I=1,LIMIT
      TGIN5(I)= TGIN50(I)
   1D CONTINUE
      RETURN
      END
```

```
@ ELT DEGAS,1,710924, 43279

      SUBROUTINE DEGAS(TINV,TGAS)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C  PWR DEGASER
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TINV(50), TGAS(50),CA(50)
      DATA(CA(I),I=1,45)/ 16*1., 4*0., 5*1., 3*.99999, 5*1., 6*0., 6*1./
      DO 100 I=1,LIMIT
      TGAS(I) = TINV(I) *(1.-CA(I))
      TINV(I) = TINV(I) - TGAS(I)
  100 CONTINUE
      RETURN
      END
```


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```
G ELT DELA,1,710923, 29184

      SUBROUTINE DELA(TGIN)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TGIN(50)
      DELAY = 8.64E+4 * 30.
      CALL CMPNT(DELAY,TGIN)
      RETURN
      END
```

```
@ ELT DEMIN,1,71C93C, 44591

      SUBROUTINE DEMIN(TINV,SLUDGE)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA
C  DEMINERALIZER
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA
      DIMENSION TINV(5C), DF(5C), SLUDGE(5C)
      DATA(DF(I),I=1,45)/ 7*1., 9*1C., 4*1., 5*1C., 2*1CC., 6*1C.,
     X 6*1., 6*1C./
      DO 1C I=1,LIMIT
      SLUDGE(I) = TINV(I)*(1.-1./DF(I))
      TINV(I) = TINV(I)/DF(I)
   1C CONTINUE
      RETURN
      END
```


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```
@ ELT DOSIS,1,711026,35359

      SUBROUTINE DOSIS (PF,AGE,TINV,TGASIN)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C     THE DOSIS PROGRAM SIMULATES THE STEADY STATE PERFORMANCE OF POWER
C     REACTOR FUEL AND RADIOACTIVE WASTE TREATMENT SYSTEMS. MANY OF THE
C     CHARACTERISTICS OF THE SYSTEM ARE FOUND IN THE DATA STATEMENTS
C     AND EQUATIONS IN THE SUBPROGRAMS WHICH ESTABLISH SUCH THINGS AS
C     THE EFFECTIVE VOLUME OF THE VARIOUS COMPONENTS. THE PROGRAM,THRU
C     THE USE OF MANY SUBPROGRAMS,IS DESIGNED TO FACILITATE CHANGES TO
C     IMPROVE THE PERFORMANCE CHARACTERIZATION OF THE COMPONENTS OR
C     PERMIT THE ADDITION OF NEW COMPONENTS. ONE SHOULD BECOME FAMILIAR
C     WITH BOTH FORTRAN PROGRAMMING AND THE PROCESSES BEING SIMULATED
C     TO APPRECIATE THE INHERENT ASSUMPTIONS IN THE PROGRAM AS WRITTEN
C     AND TO PERMIT HIM TO IMPROVE THE PROGRAM AS MORE DATA BECOMES
C     AVAILABLE.
C          NUMBER     ISOTOPE    HALFLIFE(SEC)
C            1         H3         3.888E08
C            2         N13        5.978E02
C            3         C14        1.807E11
C            4         NA22       8.189E07
C            5         NA24       5.400E04
C            6         AR39       8.815E09
C            7         AR41       6.588E03
C            8         CR51       2.402E06
C            9         MN54       2.696E07
C           10         FE55       7.569E07
C           11         FE59       3.588E06
C           12         CO58       9.134E05
C           13         CO60       1.652E08
C           14         NI63       2.301E09
C           15         CU64       4.344E04
C           16         ZN65       2.039E07
C           17         KR85M      1.524E04
```

```
C          18          KR85        3.393E08
C          19          KR87        4.560E03
C          20          KR88        1.008E04
C          21          SR89        4.372E06
C          22          SR90        9.082E08
C          23          ZR95        5.616E06
C          24          NB95        3.024E06
C          25          MO99        2.412E05
C          26          RU103       3.456E06
C          27          RU106       3.154E07
C          28          TE132       2.808E05
C          29          I129        5.046E14
C          30          I131        6.955E05

C          31          I132        8.280E03
C          32          I133        7.560E04
C          33          I135        2.412E04
C          34          XE131       1.037E06
C          35          XE133M      1.987E05
C          36          XE133       4.553E05
C          37          XE135M      9.600E02
C          38          XE135       3.312E04
C          39          XE138       1.020E03
C          40          CS134       6.623E07
C          41          CS137       9.461E08
C          42          BA140       1.106E06
C          43          LA140       1.447E05
C          44          CE141       2.806E06
C          45          CE144       2.462E07
C THE FOLLOWING IS A LIST OF THE VARIABLES AND THEIR MEANINGS
C
C     W = WRITE
C     LIMIT = DO LOOP LIMIT
C     RTYPE = REACTOR TYPE
C     NSTRM = TOTAL NUMBER OF INLET STREAMS TO ALL INLET COMPONENTS.NSTRM=1 TO 8
C     ISTRM(I)= COMPONENT NUMBER TO WHICH STREAM NUMBER I IS DIRECTED
```


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```
C     I=1 TO 8 ,ISTRM(I)=1 TO 4
C     FOR THE BWR SYSTEM
C        IF ISTRM(I)=1  ISTRM(I) GOES TO THE PHASE SEPARATOR
C        IF ISTRM(I)=2  ISTRM(I) GOES TO THE WASTE COLLECTION TANK
C        IF ISTRM(I)=3  ISTRM(I) GOES TO THE FLOOR DRAIN TANKS
C        IF ISTRM(I)=4  ISTRM(I) GOES TO THE WASTE NUETRALIZER TANK
C     FOR THE PWR SYSTEM
C        IF ISTRM(I)=1 ISTRM(I) GOES TO THE DRAIN TANK
C        IF ISTRM(I)=2 ISTRM(I) GOES TO THE FLOOR DRAIN
C     INVIN = INVENTORY VALUES TO NEXT COMPONENT
C     FLOWIN = FLOW TO THE NEXT COMPONENT
C     INVOUT = INVENTORY OUT (VALUE AFTER DECAY)
C     FLOW1 = TOTAL FLOW THROUGH PHASE SEPARATOR
C     FLOW2 = TOTAL FLOW THROUGH WASTE COLLECTION TANK
C     FLOW3 = TOTAL FLOW THROUGH FLOOR DRAIN TANKS
C     FLOW4 = TOTAL FLOW THROUGH WASTE NEUTRALIZER TANK
C     TINV1 = TOTAL INVENTORY THROUGH PHASE SEPARATOR
C     TINV2 = TOTAL INVENTORY THROUGH WASTE COLLECTION TANK
C     TINV3 = TOTAL INVENTORY THROUGH FLOOR DRAIN TANKS
C     TINV4 = TOTAL INVENTORY THROUGH WASTE NEUTRALIZER TANK
      COMMON BTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR,K1,K2,K3
      INTEGER R,W,RR,PROPT
      DIMENSION ISTRM(8),FLOWIN(8),TINV1(50),CONCP(50),
     XTINV2(50),TINV3(50),TINV4(50),TINV(50),ISOTOP(50)
     X,TGASIN(50),TGIN1(50),TGIN2(50),TGIN3(50),TGIN4(50),TGIN5(50)
     X,DIST1(50),DIST2(50),DIST3(50),DIST4(50),DLUT1(50),DLUT2(50)
     X,SMLINV(50),ACTINV(50),ICHECK(8),COOLIN(50),CONC(8,50)
     X,HAFLIF(50),FINV(50),FGASIN(50),FGIN1(50)
     X,K1(50),K2(50),K3(50)
     X,TGIN1A(50),TGIN1B(50),TGIN2A(50),TGIN2B(50),TGIN4A(50)
     X,TGIN4B(50),TGIN4C(50),TGIN1C(50)
     X,RECYC(50),CLUPS(50), SPCON1(50)
     X,DLUT3(50),DLUT4(50)
     X,TGIN3A(50),TGIN3B(50)
     X,SOLID(50), SOLID1(50), SOLID2(50),SOLID3(50),SOLID4(50)
     X,SOLID5(50),SOLID6(50), SOLID7(50),SOLID8(50), SOLID9(50)
```


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```
      X,TOTAL(50),GAMMA(50),DELTA(50)
       PROPT = 1
       DIMENSION  KA(45),KB(45),KC(45)                                  10/07/70
       DATA BWR/3HBWR/,PWR/3HPWR/,LMFBR/5HLMFBR/,BWRA/4HBWRA/,PWRA/4HPWRA
      X/
       DATA (ISOTOP(I),I=1,45) /5HH3   ,5HN13  ,5HC14  ,5HNA22 ,5HN[illegible] ,
      15HAR39 ,5HAR41 ,5HCR51 ,5HMN54 ,5HFE55 ,5HFE59 ,5HCO58 ,5HCO[illegible] ,
      25HNI63 ,5HCU64 ,5HZN65 ,5HKR85M,5HKR85 ,5HKR87 ,5HKR88 ,5HSR89 ,
      35HSR90 ,5HZR95 ,5HNB95 ,5HMO99 ,5HRU103,5HRU106,5HTE132,5HI129 ,
      45HI131 ,5HI132 ,5HI133 ,5HI135 ,5HXE131,6HXE133M,5HXE133,
      56HXE135M,5HXE135,5HXE138,5HCS134,5HCS137,5HBA140,5HLA140,
      65HCE141,5HCE144/
       DATA(KA(I),I=1,45)/-1.793E-09, -1.160E-03, -3.836E-12,-8.454E-09, 10/07/70
      A-1.284E-05, -8.141E-11, -1.052E-04, -2.886E-07,-2.571E-08,
      B-9.158E-09, -1.783E-07, -1.130E-07, -4.196E-09, - 2.389E-10
      C-1.493E-05, -3.302E-08, -4.376E-05, -2.043E-09, -1.520E-04,
      D-6.876E-05, -1.585E-07, -7.632E-10, -1.234E-07, -2.292E-07,
      E-2.874E-06, -2.006E-07, -2.198E-08, -2.468E-06, -1.374E-15,
      F-9.966E-07, -8.371E-05, -9.169E-06, -2.874E-05, -6.584E-07,
      G-3.488E-06, -1.522E-06, -7.220E-04, -2.093E-05, -5.796E-04,
      H-1.047E-08, -7.327E-10, -6.267E-07, -4.790E-06, -2.470E-07,
      I-2.815E-08/
       DATA(KB(I),I=1,45)/17*0.,-4.375E-05,5*0.,-1.234E-07,6*0.,        10/07/70
      X-2.468E-06,2*0.,-9.966E-07,2*-9.169E-07,2*-2.874E-05,4*0.,
      X-6.267E-07,2*0./
       DATA(KC(I),I=1,45)/35*0.,-3.488E-06,0.,-7.220E-04,7*0./          10/07/70
       DATA(DIST1(I),I=1,45)/ 1., 44*1000./
       DATA(DIST2(I),I=1,45)/ 1., 44*1000./
       DATA(DIST3(I),I=1,45)/ 1., 44*1000./
       DATA(DIST4(I),I=1,45)/ 1., 44*1000./
       DATA(DLUT1(I),I=1,45)/45*4.7E03/
       DATA(DLUT2(I),I=1,45)/45*4.7E03/
       DATA(DLUT3(I),I=1,45)/45*4.7E03/
       DATA(DLUT4(I),I=1,45)/45*4.7E03/
       DATA(SPCON1(I),I=1,45)/45*0./
       DATA (HAFLIF(I),I=1,45)/ 3.866E08, 5.976E02, 1.807E11, 8.199E07,
```


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```
      A5.4CCEC4, 8.515EC9 , 6.588EC3, 2.4C2EC6, 2.696EC7, 7.569EC7,
      B3.888EC6, 6.134EC6 , 1.652EC8, 2.901EC9, 4.644EC4, 2.C99EC7,
      C1.584EC4, 3.393EC8,  4.56CEC3, 1.CC8EC4, 4.372EC6, 9.C82EC5,
      D5.616EC6, 3.C24EC6,  2.412EC5, 3.456EC6, 3.154EC7, 2.8C8EC5,
      E5.C46E14, 6.955EC5,  8.28CEC3, 7.56CEC4, 2.412EC4, 1.037EC6,
      F1.937EC5, 4.553EC5,  9.6CCEC2, 3.312EC4, 1.C2CEC3, 5.623EC7,
      G9.461EC8, 1.1C6EC6,  1.447EC5, 2.8C6EC6, 2.462EC7/
  92C FORMAT('1',///,' REACTOR TYPE : ',A3,6CX,'CASE NO.',I3,//,
     X'  INLET STREAMS (PICO CURIES/SEC)')
  93C FORMAT('C                    PHASE SEPARATOR        WASTE COLLECTION TA
     XNK          FLOOR DRAIN          NEUTRALIZER TANK',/)
  94C FORMAT(' ',2X,A5,11X,1PE1C.4,15X,1PE1C.4,14X,1PE1C.4,11X,1PE1C.4)
  95C FORMAT('C',2X,'FLOW(LITERS/SEC)',1PE1C.4,15X,1PE1C.4,14X,1PE1C.4,
     X11X,1PE1C.4)
  9CP FORMAT('1',///,' REACTOR TYPE : ',A3,6CX,'CASE NO.',I3)
  91C FORMAT('C',     ' OUTLET STREAMS (PICO CURIES/SEC)',/,53X,
     X'CONTRIBUTIONS FROM :')
  92C FORMAT('C',22X,'TOTAL            PHASE SEPARATOR       WASTE COLLECTI
     XON TANK           FLOOR DRAIN        NEUTRALIZER TANK',/)
  93C FORMAT(' ',2X,A5,12X,1PE1C.4,11X,1PE1C.4,15X,1PE1C.4,14X,1PE1C.4,
     111X,1PE1C.4)
  95C FORMAT('C',2X,'FLOW (LITERS/SEC)',1PE1C.4,11X,1PE1C.4,15X,1PE1C.4
     1,14X,1PE1C.4,11X,1PE1C.4)
 1C55 FORMAT('1','TYPICAL ',A6,' 1CCC MWE PLANT RELEASES DURING OPERATIO
     XN AT',F5.7,' PLANT FACTOR')
 1C7C FORMAT(' ','ISOTOPE      HALF LIFE      COOLANT CONCENTRATION      LI
     XQUID RELEASES                    GASEOUS RELEASES')
 1C8C FORMAT(' ','              (SEC)          (PICOCURIES/LITER)        (P
     XICOCURIES/SEC)  FRACTION)   (PICOCURIES/SEC)  (FRACTION)')
 1C85 FORMAT(' ',2X,A5,5X,1PE1C.4,14X,1PE1C.4,8X,1PE1C.4,5X,1PE1C.4,5X,
     X 1PE1C.4,8X,1PE1C.4)
 1C92 FORMAT(' ',2X,'TOTAL RELEASES(PICOCURIES/SEC)',22X,1PE1C.4,19X,
     X1PE1C.4)
 111C FORMAT('1','MASS BALANCE CHECK')
 1111 FORMAT(' ','ISOTOPE      COOLIN     SOLID      TINV       TGASIN     TO
     XTAL')
```


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```
 1112 FORMAT(' ',A5,7X,5(1PE10.4))
 1114 FORMAT('1','ISOTOPE      SOLID1     SOLID2     SOLID3     SOLID4     SO
     XLID5     SOLID6     SOLID7     SOLID8     SOLID9')
 1115 FORMAT(' ',A5,5X,9(1PE10.4))
 5010 FORMAT('0                          DRAIN TANK                    FLOOR DRAIN',
     X/)
 5020 FORMAT(' ',2X,A5,11X,1PE10.4,15X,1PE10.4)
 5110 FORMAT('0                              TOTAL                    DRAIN TANK
     X          FLOOR DRAIN',/)
 5120 FORMAT(' ',2X,A5,12X,1PE10.4,11X,1PE10.4,15X,1PE10.4)
      DO 1 I=1,45                                                          10/07/70
      K1(I) = KA(I)                                                        10/07/70
      K2(I) = KB(I)                                                        10/07/70
      K3(I) = KC(I)                                                        10/07/70
    1 CONTINUE                                                             10/07/70
      R=5
      W = 6                                                                10/07/70
      RR=-4
      LIMIT = 45
      ICASE=0
      IF(RTYPE.EQ.PWR)    GO TO 2
      IF(RTYPE.EQ.PWR)    GO TO 4
      IF(RTYPE.EQ.PWRA)   GO TO 6
      IF(RTYPE.EQ.BWRA)   GO TO 8
      IF(RTYPE.EQ.LMFBR)  GO TO 10
C PWR INPUT VALUES
    2 ISTRM(1) = 1
      ISTRM(2) = 2
      ICHECK(1) = 0
      ICHECK(2) = 1
      FLOWIN(1) = .0473
      FLOWIN(2) =1.37
      NSTRM = 2
      NRELF = 3
      BWG = 30000.
      DO 3 I=1,35,
```


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```
      GO TO 11
C BWR INPUT VALUES
    4 ISTRM(1) = 1
      ISTRM(2) = 2
      ISTRM(3) = 3
      ISTRM(4) = 4
      ICHECK(1)= 2
      ICHECK(2)= 0
      ICHECK(3)= 1
      ICHECK(4)= 3
      FLOWIN(1)= 0.015
      FLOWIN(2)= 0.79
      FLOWIN(3)= 0.40
      FLOWIN(4)= 0.001
      NSTRM =4
      NRELF= 4
      BUG = 27500.
      PD  = 22.
      GO TO 11
C PWRA INPUT VALUES
    6 ISTRM(1) = 1
      ISTRM(2) = 2
      ICHECK(1) = 0
      ICHECK(2) = 1
      FLOWIN(1) =.0473
      FLOWIN(2) =1.37
      NSTRM = 2
      NRELF= 3
      BUG = 30000.
      PD = 39.
      GO TO 11
C BWRA INPUT VALUES
    8 ISTRM(1) = 1
      ISTRM(2) = 2
      ISTRM(3) = 3
      ISTRM(4) = 4
```


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```
      ICHECK(1) = 2
      ICHECK(2) = 0
      ICHECK(3) = 1
      ICHECK(4) = 3
      FLOWIN(1) = .015
      FLOWIN(2) = .79
      FLOWIN(3) = .40
      FLOWIN(4) = .001
      NSTRM = 4
      NRELF =4
      BUG = 27500.
      PD = 24.
      GO TO 11
C LMFBR INPUT VALUES
   10 NSTRM =0.
      NRELF = 5
      BUG = 80000.
      PD = 150.
   11 CONTINUE
      CALL SMALL (NRELF,BUG,PD,PF,SMLINV)
      CALL ACTIVA(AGE,BUG,PD,PF,ACTINV)
      DO 20 I=1,LIMIT
      COOLIN(I)=SMLINV(I)+ACTINV(I)
   20 CONTINUE
      DO 21 J=1,LIMIT
      TGIN1(J) = 0.
      TGIN1A(J) =0.
      TGIN1B(J) =0.
      TGIN1C(J) =0.
      TGIN2(J) = 0.
      TGIN2A(J) =0.
      TGIN2B(J) =0.
      TGIN3(J) = 0.
      TGIN3A(J) =0.
      TGIN3B(J) =0.
      TGIN4A(J) =0.
```


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```
      TGIN4B(J) =C.
      TGIN4C(J) =C.
      TGIN4(J) = C.
      TGIN5(J) = C.
      SOLID1(J) =C.
      SOLID2(J) =C.
      SOLID3(J) =C.
      SOLID4(J) =C.
      SOLID5(J) =C.
      SOLID6(J) =C.
      SOLID7(J) =C.
      SOLID8(J) =C.
      SOLID9(J) =C.
      GAMMA(J) = C.
      RECYC(J) = C.
   21 CONTINUE
      FLOW1 =C.
      FLOW2 =C.
      FLOW3 =C.
      FLOW4 =C.
      IF(NSTRM.EQ.0) GO TO 22
      DO 70 I=1,NSTRM
      JSTRM = ISTRM(I)
      GO TO (50,55,60,65),JSTRM
   50 FLOW1 = FLOW1 + FLOWIN(I)
      GO TO 70
   55 FLOW2 = FLOW2 + FLOWIN(I)
      GO TO 70
   60 FLOW3 = FLOW3 + FLOWIN(I)
      GO TO 70
   65 FLOW4 = FLOW4 + FLOWIN(I)
   70 CONTINUE
   22 CONTINUE
      DO 24 I=1,LIMIT
      DELTA(I) = RECYC(I)
      RECYC(I) = RECYC(I) + .5 *(RECYC(I)-GAMMA(I))
```


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```
      GAMMA(I) = DELTA(I)
   24 CONTINUE
      CALL COLANT(COOLIN,CONCP,TGINS,FLOW1,FLOW2,FLOW3,FLOW4,
     X RECYC,CLUPS,DIST3, DLUT2)
      DO 85 I=1,NSTRM
      DO 85 J=1,LIMIT
      CONC(I,J) = CONCP(J)
   85 CONTINUE
      ICASE=ICASE+1
      IF (RTYPE.EQ.LMFBR) GO TO 700
C  TEST  FOR  NUMBER OF STREAMS TO EACH COMPONENT -  SUM FLOWS AND INVENTORIES
C FOUR STREAM CONCENTRATION TYPES MAY BE INCLUDED:
C     1. PRIMARY COOLANT CONCENTRATIONS , ICHECK =0
C     2. PRIMARY COOLANT DILUTED BY A FACTOR, ICHECK = 1
C     3. COOLANT CLEANUP SYSTEM SLUDGE, ICHECK = 2
C     4. SPECIFIED CONCENTRATION, USING DATA  STATEMENT, ICHECK = 3
      FLOW1=0.0
      FLOW2=0.0
      FLOW3=0.0
      FLOW4=0.0
      DO 90 J=1,LIMIT
      TINV1(J)=0.0
      TINV2(J)=0.0
      TINV3(J)=0.0
      TINV4(J)=0.0
   90 CONTINUE
      DO 500 I=1,NSTRM
      JSTRM=ISTRM(I)
      GO TO (100,200,300,400),JSTRM
  100 FLOW1=FLOW1+FLOWIN(I)
      DO 150 J=1,LIMIT
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.BWR) CONC(I,J)= CONC(I,J)/DIST1(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.BWRA) CONC(I,J)=CONC(I,J)/DIST1(J)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.BWR ) CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.BWRA) CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.BWR ) CONC(I,J) = SPCON1(J)
```


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      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.BWRA) CONC(I,J) = SPCON1(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.PWR) CONC(I,J)= CONC(I,J)/DLUT1(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.PWRA) CONC(I,J)=CONC(I,J)/DLUT1(J)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.PWR )CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.PWRA)CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.PWR )CONC(I,J)=SPCON1(J)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.PWRA)CONC(I,J)=SPCON1(J)
      TINV1(J)=FLOWIN(I)*CONC(I,J)+TINV1(J)
  150 CONTINUE
      GO TO 500
  200 FLOW2=FLOW2+FLOWIN(I)
      DO 250 J=1,LIMIT
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.BWR) CONC(I,J)= CONC(I,J)/DIST2(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.BWRA) CONC(I,J)=CONC(I,J)/DIST2(J)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.BWR ) CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.BWRA) CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.BWR ) CONC(I,J) = SPCON1(J)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.BWRA) CONC(I,J) = SPCON1(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.PWR) CONC(I,J)= CONC(I,J)/DLUT2(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.PWRA) CONC(I,J)=CONC(I,J)/DLUT2(J)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.PWR )CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.PWRA)CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.PWR )CONC(I,J)=SPCON1(J)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.PWRA)CONC(I,J)=SPCON1(J)
      TINV2(J)=FLOWIN(I)*CONC(I,J)+TINV2(J)
  250 CONTINUE
      GO TO 500
  300 FLOW3=FLOW3+FLOWIN(I)
      DO 350 J=1,LIMIT
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.BWR )CONC(I,J)=CONC(I,J)/DIST3(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.BWRA)CONC(I,J)=CONC(I,J)/DIST3(J)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.BWR ) CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.BWRA) CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.BWR ) CONC(I,J)=SPCON1(J)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.BWRA) CONC(I,J)=SPCON1(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.PWR )CONC(I,J)=CONC(I,J)/DLUT3(J)
```


1083186

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      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.PWRA)CONC(I,J)=CONC(I,J)/DLUT3(J)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.PWR )CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.PWRA)CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.PWR )CONC(I,J)=SPCON1(J)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.PWRA)CONC(I,J)=SPCON1(J)
      TINV3(J)=FLOWIN(I)*CONC(I,J)+TINV3(J)
  350 CONTINUE
      GO TO 500
  400 FLOW4=FLOW4+FLOWIN(I)
      DO 450 J=1,LIMIT

      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.BWR )CONC(I,J)=CONC(I,J)/DIST4(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.BWRA)CONC(I,J)=CONC(I,J)/DIST4(J)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.BWR ) CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.BWRA) CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.BWR ) CONC(I,J)=SPCON1(J)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.BWRA) CONC(I,J)=SPCON1(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.PWR )CONC(I,J)=CONC(I,J)/DLUT4(J)
      IF(ICHECK(I).EQ.1.AND.RTYPE.EQ.PWRA)CONC(I,J)=CONC(I,J)/DLUT4(J)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.PWR )CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.2.AND.RTYPE.EQ.PWRA)CONC(I,J)=CLUPS(J)/FLOWIN(I)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.PWR )CONC(I,J)=SPCON1(J)
      IF(ICHECK(I).EQ.3.AND.RTYPE.EQ.PWRA)CONC(I,J)=SPCON1(J)
      TINV4(J)=FLOWIN(I)* CONC(I,J)+TINV4(J)
  450 CONTINUE
  500 CONTINUE
C  CHECK FOR REACTOR TYPE
      IF(RTYPE.EQ.PWR) GO TO 5000
      IF(RTYPE.EQ.PWRA) GO TO 5000
C     BWR LIQUID RADWASTE SYSTEM
C  CHECK FOR COMPONENT TYPE AND START FLOW THROUGH SYSTEM
  500 IF(FLOW1.EQ.0) GO TO 700
C
      CALL PHASEP(TINV1,TGIN1,SOLID1)
      CALL COLTNK( TINV1,TGIN1A)
      CALL FILTER(TINV1,SOLID2)
```


1083181

```
      CALL DEMIN( TINV1,SOLID3)
      CALL TANK1 ( TINV1,TGIN1B)
  700 IF(FLOW2.EQ.0) GO TO 800
      CALL COLTNK( TINV2,TGIN2A)
      CALL FILTER(TINV2,SOLID4)
      CALL DEMIN (TINV2,SOLID5)
      CALL TANK1 ( TINV2,TGIN2B)
  800 IF(FLOW3.EQ.0) GO TO 900
      CALL FLRDRN(TINV3,TGIN3A)
      CALL FILTER(TINV3,SOLID6)
      CALL TANK2(TINV3, TGIN3B)
  900 IF(FLOW4.EQ.0) GO TO 905
      CALL NEUTNK( TINV4,TGIN4A)
      CALL EVAP(TINV4,SOLID7)
      CALL COLTNK( TINV4,TGIN4B)
      CALL FILTER(TINV4,SOLID8)
      CALL DEMIN (TINV4,SOLID9)
      CALL TANK1 ( TINV4,TGIN4C)
  905 CONTINUE
      DO 907 I=1,LIMIT
      TINV(I)=TINV1(I)+TINV2(I)+TINV3(I)+TINV4(I)
C  OF THIS CLEANED-UP WASTE A PORTION IS RETURNED TO THE PRIMARY
C  COOLANT SYSTEM AND PART IS RELEASED
      RECYC(I) = 0.95 *(TINV1(I)+TINV2(I)+TINV4(I))
      TINV(I)=TINV(I)-RECYC(I)
      TGIN1(I) = TGIN1(I) + TGIN1A(I) + TGIN1B(I)
      TGIN2(I) = TGIN2A(I) + TGIN2B(I)
      TGIN3 (I) = TGIN3A(I) + TGIN3B(I)
      TGIN4(I) = TGIN4A(I) + TGIN4B(I) + TGIN4C(I)
      TGASIN(I) = TGIN1(I)+TGIN2(I)+TGIN3(I)+TGIN4(I)+TGIN5(I)
      SOLID(I) = SOLID1(I)+ SOLID2(I) + SOLID3(I) + SOLID4(I)+ SOLID5(I)
     X +SOLID6(I) + SOLID7(I) + SOLID8(I) + SOLID9(I)
  907 CONTINUE
      IF(ABS(RECYC(1)-GAMMA(1)).GT.100000.) GO TO 22
C   BWR GAS TREATMENT
      CALL BWRD(TGASIN)
```


1083188

```
      CALL CHAR(TGASIN)
      CALL GFILTR(TGASIN,SCLI07)
      TFLOW=FLOW1+FLOW2+FLOW3+FLOW4
      IF(PROPT.EQ.0) GO TO 1050
      WRITE(W,908)RTYPE,ICASE
      WRITE(W,910)
      WRITE(W,920)
      DO 940 I=1,LIMIT
      WRITE(W,930)ISOTOP(I),TINV(I),TINV1(I),TINV2(I),TINV3(I),TINV4(I)
  940 CONTINUE
      WRITE(W,950)TFLOW,FLOW1,FLOW2,FLOW3,FLOW4
      WRITE(W, 908)RTYPE,ICASE
      WRITE(W,1070)
 1050 CONTINUE
      IF(PROPT.EQ.1) GO TO 1060
      WRITE(W,1055) RTYPE,PF
      WRITE(W,1070)
 1060 CONTINUE
      WRITE(W,1080)
      TOT = 0.0
      TOTG = 0.0
      DO 1081 I=1,LIMIT
      TOT= TOT + TINV(I)
      TOTG = TOTG + TGASIN(I)
 1081 CONTINUE
      DO 1082 I=1,LIMIT
      FINV(I) = TINV(I) / TOT
      FGASIN(I) = TGASIN(I) / TOTG
 1082 CONTINUE
      DO 1090 I=1,LIMIT
      WRITE(W,1085)ISOTOP(I),HAFLIF(I),CONCP(I),TINV(I),FINV(I),TGASIN(I
     X),FGASIN(I)
 1090 CONTINUE
      WRITE(W,1092)TOT,TOTG
      IF(PROPT.EQ.0) GO TO 1150
      WRITE(W,1110)
```


1083169

```
      WRITE(W,1111)
      DO 1113 I=1,LIMIT
      TOTAL(I) = TINV(I) + SOLID(I) + TGASIN(I)
      WRITE(W,1112)ISOTOP(I),COOLIN(I),SOLID(I),TINV(I),TGASIN(I),
     X TOTAL(I)
 1113 CONTINUE
      WRITE(W,1114)
      DO 1116 I=1,LIMIT
      WRITE(W,1115)ISOTOP(I),SOLID1(I),SOLID2(I),SOLID3(I),SOLID4(I),
     XSOLID5(I),SOLID6(I),SOLID7(I),SOLID8(I),SOLID9(I)
 1116 CONTINUE
 1150 CONTINUE
      GO TO 9999
C  PWR
 5000 CONTINUE
C  CHECK FOR COMPONENT TYPE AND START FLOW THROUGH SYSTEM
      IF(FLOW1.EQ.0) GO TO 5100
      CALL COLTNK(TINV1,TGIN1)
      CALL DEGAS (TINV1,TGIN1A)
      CALL HOLDUP(TINV1,TGIN1B)
      CALL FILTER(TINV1,SOLID1)
      CALL DEMIN (TINV1,SOLID2)
      CALL EVAP (TINV1,SOLID3)
      CALL TANK3 (TINV1,TGIN1C)
 5100 IF(FLOW2.EQ.0.) GO TO 5200
      CALL DRNTNK(TINV2,TGIN2A)
      CALL FILTER(TINV2,SOLID4)
      CALL TANK4 (TINV2,TGIN2B)
 5200 IF(FLOW3.EQ.0.) GO TO 5300
 5300 IF(FLOW4.EQ.0.) GO TO 5400
 5400 CONTINUE
      DO 5410 I=1,LIMIT
      TGIN1(I) = TGIN1(I)+TGIN1A(I) + TGIN1B(I)+ TGIN1C(I)
      TGIN2(I) = TGIN2A(I) + TGIN2B(I)
      TGASIN(I) = TGIN1(I) + TGIN2(I) + TGIN5(I)
      TINV(I)=TINV1(I)+TINV2(I)
```


1083190

```
      RECYC(I) = .95 * TINV(I)
      TINV(I) = TINV(I) - RECYC(I)
      SOLID9(I) = CLUPS(I)
      SOLID(I) = SOLID1(I) + SOLID2(I) + SOLID3(I) + SOLID4(I)
     X + SOLID5(I) + SOLID6(I) + SOLID7(I) + SOLID8(I) + SOLID9(I)
541C  CONTINUE
      IF(ABS(RECYC(1)-GAMMA(1)).GT.1CCCCC.) GO TO 22
      CALL STANK(TGASIN)
      CALL GFILTR(TGASIN,SOLID7)
      TFLOW=FLOW1+FLOW2
      IF(PROPT.EQ.C) GC TO 545C
      WRITE(W,9C8)RTYPE,ICASE
      WRITE(W,91C)
      WRITE(W,511C)
      DO 543C I=1,LIMIT
      WRITE(W,512C) ISOTOP(I),TINV(I),TINV1(I),TINV2(I)
543C  CONTINUE
      WRITE(W,95C)TFLOW,FLCW1,FLOW2
      WRITE(W,9C8)RTYPE,ICASE
545C  CONTINUE
      IF(PROPT.EQ.1) GC TO 546C
      WRITE(W,1C55) RTYPE,PF
546C  CONTINUE
      TOT = C.C
      TOTG = C.C
      DO 55CC I=1,LIMIT
      TOT= TOT + TINV(I)
      TOTG = TOTG + TGASIN(I)
55CC  CONTINUE
      DO 551C I=1,LIMIT
      FGASIN(I) = TGASIN(I) / TCTG
      FINV(I) = TINV(I) / TOT
551C  CONTINUE
      WRITE(W,1C7C)
      WRITE(W,1C8C)
      DO 555C I=1,LIMIT
```


1083191

```
      WRITE(W,1C85)ISCTOP(I),HAFLIF(I),CONCP(I),TINV(I),FINV(I),TGASIN(I
     X),FGASIN(I)
 555C CONTINUE
      WRITE(W,1C92)TOT,TOTG
      IF(PROPT.EG.0) GO TO 6CCC
      WRITE(W,111C)
      WRITE(W,1111)
      DO 57CC I=1,LIMIT
      TOTAL(I) = TINV(I) + SOLID(I) + TGASIN(I)
      WRITE(W,1112) ISCTOP(I), COCLIN(I), SOLID(I), TINV(I), TGASIN(I),
     X TOTAL(I)
 57CC CONTINUE
      WRITE(W,1114)
      DO 571C I=1,LIMIT
      WRITE(W,1115) ISOTOP(I), SOLID1(I), SOLID2(I), SOLID3(I),SOLID4(I)
     X,SOLID5(I), SOLID6(I), SOLID7(I), SOLID8(I), SOLID9(I)
 571C CONTINUE
 6CCC CONTINUE
      GO TO 9995
C  LMFBR
 7CCC CONTINUE
      CALL DELA(TGIN5)
      CALL FREON(TGIN5,SOLID1)
      CALL GFILTR(TGIN5,SOLID2)
      CALL LMLIQ(TINV)
      WRITE(W,1C55) RTYPE,PF
      WRITE(W,1C7C)
      WRITE(W,1C8C)
      TOT = C.
      TOTG = C.C
      DO 7C71 I=1,LIMIT
      TGASIN(I) = TGIN5(I)                                          1C/C7/7C
      TOT = TOT + TINV(I)
      TOTG = TOTG + TGIN5(I)                                        1C/C7/7C
 7C71 CONTINUE
      DO 7C72 I=1,LIMIT
```


1083192

```
      FINV(I) = TINV(I)/ TOT
      FGIN1(I) = TGIN5(I) / TOTG                                        10/07/70
 7072 CONTINUE
 7073 CONTINUE
      DO 7080 I=1,LIMIT
      WRITE(W,1085) ISOTOP(I),HAFLIF(I), CONCP(I), TINV(I), FINV(I),
     X TGASIN(I), FGIN1(I)
 7080 CONTINUE
      WRITE(W,1092) TOT, TOTG
      WRITE(W,1110)
      WRITE(W,1111)
      DO 8000 I=1,LIMIT
      SOLID(I) = SOLID1(I) + SOLID2(I) + CLUPS(I)
      TOTAL(I) = SOLID(I) + TINV(I) + TGASIN(I)
      WRITE(W,1112) ISOTOP(I), COOLIN(I), SOLID(I),
     X TINV(I), TGASIN(I), TOTAL(I)
 8000 CONTINUE
 9995 CONTINUE
      RETURN
 9999 END
```


10831193

```
@ ELT DRNTNK,1,71C916, 51164

      SUBROUTINE DRNTNK(TINV,TGAS)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C PWR DRAIN TANK
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TINV(5C),TGAS(5C),CONC(5C)
      DELAY = 1C. *36CC.
      VOLLIQ = 3CCCC.
      CALL CMPNT(DELAY,TINV)
      CALL VENT (TINV, TGAS)
      DO 1C I=1,LIMIT
      CONC(I) = TINV(I) * DELAY /VOLLIQ
   1C CONTINUE
      RETURN
      END
```


1083194

220

```
@ ELT EVAP,1,710916, 51157

      SUBROUTINE EVAP(TINV,SLUDGE)
C  EVAPORATOR
      COMMON RTYPE,LIMIT
      DIMENSION TINV(50), DF(50), SLUDGE(50)
      DATA(DF(I),I=1,45)/ 2*1., 3*10., 2*1., 9*10., 4*1.,9*10.,6*10.,
     X 5*1., 6*10./
      DO 10 I=1,LIMIT
      SLUDGE(I)= TINV(I)*(1.-1./DF(I))
      TINV(I) = TINV(I)/DF(I)
   10 CONTINUE
      RETURN
      END
```


1083195

```
@ ELT FILTER,1,71093C, 44592

      SUBROUTINE FILTER(TINV,SLUDGE)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA
C  FILTER
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA
      DIMENSION TINV(50),DF(50),SLUDGE(50)
      DATA(DF(I),I=1,45)/ 2*1., 2., 4*1., 9*2., 4*1., 5*2., 2*10., 2.,
     X 11*1., 6*2./
      DO 10 I=1,LIMIT
      SLUDGE(I) = TINV(I) *(1.-1./DF(I))
      TINV(I) = TINV(I)/DF(I)
   10 CONTINUE
      RETURN
      END
```


1083196

282

```
@ ELT FLRDRN,1,71C916, 51164

      SUBROUTINE FLRDRN(TINV,TGAS)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C  FLOOR DRAIN TANK
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TINV(5C),TGAS(5C),CONC(5C)
      VOLLIG= 34CCC.
      DELAY =C.65 * 8.64E4
      CALL  MPNT(DELAY,TINV)
      CALL VENT (TINV,TGAS)
      DC 1C I=1,LIMIT
      CONC(I) = TINV(I) * DELAY/VOLLIQ
   1C CONTINUE
      RETURN
      END
```


1083197

```
@ ELT FREON,1,71C924, 43273

      SUBROUTINE FREON(TGIN,TRAP)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TGIN(50), DF(50), TRAP(50)
      DATA(DF(I),I=1,45)/ 16*1., 4*300., 13*1., 6*300., 6*1./
      DO 10 I=1,LIMIT
      TRAP (I) = TGIN(I) * (1.-1./DF(I))
      TGIN(I) = TGIN(I)/DF(I)
   10 CONTINUE
      RETURN
      END
```

1083199

```
@ ELT GFILTR,1,71C923, 29186

      SUBROUTINE GFILTR(TGAS,RESID)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TGAS(50),DF(50),RESID(50)
      DATA(DF(I),I=1,45)/ 7*1., 9*2., 4*1.,8*2.,5*1.,6*1.,6*2./
      DO 100 I=1,LIMIT
      RESID(I) = TGAS(I) *(1.-1./DF(I))
      TGAS(I)  = TGAS(I) / DF(I)
  100 CONTINUE
      RETURN
      END
```

```
@ ELT HOLDUP,1,710916, 51165

      SUBROUTINE HOLDUP(TINV,TGAS)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C  PWR HOLDUP TANK
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TINV(50),TGAS(50),CONC(50)
      DELAY = 10. * 3600.
      VOLLIQ= 1000.
      CALL CMPNT(DELAY,TINV)
      CALL VENT (TINV,TGAS)
      DO 10 I=1,LIMIT
      CONC(I) = TINV(I) * DELAY/VOLLIQ
   10 CONTINUE
      RETURN
      END
```


1083200

286

```
@ ELT LMLIQ,1,71C924, 43276

      SUBROUTINE LMLIQ(TINV)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TINV(5C), C1(5C)
      DATA(C1(I),I=1,45)/ 45*0./
      DO 1C I=1,LIMIT
      TINV(I) = C1(I)
   1C CONTINUE
      RETURN
      END
```


10832C1

```
@ ELT NEUTNK,1,710916, 51156

      SUBROUTINE NEUTNK(TINV,TGIN)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C  WASTE NEUTRALIZER TANK
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TINV(50),TGIN(50),CONC(50)
      DELAY = 24.* 3600.
      VOLLIQ = 44000.
      CALL CMPNT(DELAY,TINV)
      CALL VENT(TINV,TGIN)
      DO 10 I=1,LIMIT
      CONC(I) = TINV(I)*DELAY/VOLLIQ
   10 CONTINUE
      RETURN
      END
```


1083202

1083203

```
@ ELT PHASE?,1,/1[illegible], _ 1??

      SUBROUTINE PHASEP(TINV,TGIN1,BOT)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C  PHASE SEPARATOR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TINV(50),TGIN1(50),CONC(50),OVER(50),BOT(50),CA(50)
      DATA(CA(I),I=1,45)/ 7*1., 9*.01, 4*1., 13*.01, 6*1., 6*.01/
      DELAY =1000.
      CALL CMPNT(DELAY,TINV)
      VOLLIG= 1000.
      GASFLO= 10.
      CALL VENT(TINV,TGIN1)
      DO 10 I=1,LIMIT
      CONC(I) = TINV(I)* DELAY/VOLLIG
   10 CONTINUE
C     COMBINED EFFECT OF PHASE SEPARATOR AND CENTRIFUGE, INCLUDES
C     DEMINERALIZER BACKWASH TREATMENT AS WELL AS USED RESIN
C     HANDLING
      DO 30 I=1,LIMIT
      OVER(I) = CA(I)* TINV(I)
      BOT (I) =(1.-CA(I)) * TINV(I)
      TINV(I) = OVER(I)
   30 CONTINUE
      RETURN
      END
```

```
@ ELT SMALL,1,71C924, 43272

      SUBROUTINE SMALL (NRELF,BUG,PD,PF,SMLINV)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C  SMALL CALCULATES FISSION PRODUCT RELEASE FROM THE FUEL,THE
C  PROBABILITY  OF FUEL FAILURE AND THE RESULTING FISSION PRODUCT
C  RELEASE TO THE COOLANT
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR,K1,K2,K3
      DIMENSION BU(5), F(50), LHR(20), ISOR(50), ISOT(50),
     X LHRM(20), P(20), SMLINV(50), PART(20), RODF(20),FFRC(50),
     X DFF(50), FGDBF(5), D(50), TIME(5), K1(50),
     XYLWR(50),YLMFBR(50),G(50)
     X,LKTIME(5)
      REAL LKTIME
      REAL LHRMA,LHRM,LHR,ISOR,ISOT,K1
      DATA(PART(I),I=1,10)/.02,.16,.07,.06,.05,.05,.07,.10,.18,.15/
      DATA(YLWR(I),I=1,45)/.0001,15*0.,0.013,0.00299,0.0253,0.0756,
     A0.0476,0.0583,0.062,0.0641,0.0616,0.03,0.00339,0.0426,0.01,0.0291,
     B0.0426,0.0669,0.0617,0.00017,0.0016,0.0669,0.018,0.063,0.0[illegible],
     C0.0669,0.062,0.003,0.0534,0.061,0.054 /
      DATA(YLMFBR(I),I=1,45)/ .0001,15*0.,0.0069,0.00159,0.0114,0.014,
     A0.018,0.0211,0.053,0.053,0.0588,0.0585,0.047,0.035,0.012,0.034,
     B0.0376,0.057,0.063,0.0002,0.0014,0.057,0.022,0.058,0.05,0.057,
     C0.065,0.051,0.051,0.042,0.0353/
      DATA(DFF(I),I=1,45)/20*1.,1.09E-5, 2.70E-7, 1.54E-7, 6.32E-8,
     X 3.50E+1, 2*1., 1.32, 2*86.1, 2.62E+2, 9.32E+2, 3.59E+3, 6*1.,
     X .224, .92, 3.24E-5, .902E-5, .942E-8, .942E-8/
      DATA(RODF(I),I=1,10)/.01,.03,.06,.08,.11,.15,.17,.13,.11,.15/
      DATA BWR/3HBWR/,PWR/3HPWR/,BWRA/4HBWRA/,PWRA/4HPWRA/,LMFBR/5HLMFBR
     X/
      RELF= NRELF
      DO 50 I=1,LIMIT
      ISOT(I)=0.0
   50 CONTINUE
```

```
      IF(RTYPE.EQ.PWR)    LHRMA = 18.
      IF(RTYPE.EQ.BWR)    LHRMA = 18.
      IF(RTYPE.EQ.PWRA)   LHRMA = 20.
      IF(RTYPE.EQ.BWRA)   LHRMA = 20.
      IF(RTYPE.EQ.LMFBR)  LHRMA = 20.
      DO 70 I=1,50
      FFRC(I)=0.
   70 CONTINUE
      FFRS = .01
      PROB = .15
      PROB1 = PROB
      GO TO 110
  100 CONTINUE
      PROB = PROB1 + (FFRS - FFRC(L)) * 10.
      PROB1 = PROB
  110 CONTINUE
      DO 250 I=1,NRELF
      BU(I)=BUG*(2.*FLOAT(NRELF)-(2.*FLOAT(I)-1.))/(2.*FLOAT(NRELF))
      DO 200 II = 1,10
      L = II + (I-1)*10
      LHRM(II) = LHRMA * (1.-(FLOAT(II)-1.)/20.)
      P(II) =1.-EXP((BU(I)/BUG)**3.4*(LHRM(II)/LHRMA)**4*LOG(1.-PROB))
      FFRC( L   )=P(II) * RODF(II)/NRELF + FFRC(L-1)
  200 CONTINUE
  250 CONTINUE
      IF(ABS(FFRS-FFRC(L  )).GT.(FFRS*.01)) GO TO 100
      DO 1000 I=1,NRELF
      BU(I) = BUG * (2.* RELF - (2.* FLOAT(I) - 1.))/(2.* RELF)
      FGDBF(I) = EXP(.0002176 * (BU(I) -18000.))
      IF(FGDBF(I).GT.100.) FGDBF(I) = 100.
      TIME(I) = BU(I) * 8.64E4 / (PD * PF)
      LKTIME(I) = (BUG- BU(I)) * 8.64E4/ (PD * PF)
      DO 900 II=1,10
      LHRM(II) = LHRMA * (1. - (FLOAT(II) -1.)/20.)
      P(II) = 1.- EXP((BU(I)/BUG)**3.4*(LHRM(II)/LHRMA)**4*LOG(1.-PROB))
      DO 800 N=1,10
```


1083205

```
      LHR(N) = LHRM(II) * ( 1.- (FLOAT(N)-1.)/20.)
      DO 600 L=1,LIMIT
      D(L) = DFF(L) * FGDRF(I) * EXP(-.066045*LHR(N)*LHR(N)+2.7432 *
     XLHR(N) - 47.703)
      IF(RTYPE.EQ.LMFBR) GO TO 530
      G(L) = 9.51E19 * PF* YLWR(L)
      GO TO 535
  530 CONTINUE
      G(L) = 7.25E19 * PF* YLMFBR(L)
  535 CONTINUE
      GO TO (550,570,550,550,570,550,570,570,550,550,570,570,550,550,
     X570,550,570,550,570,570,570,550,570,570,570,570,550,570,550,570,
     X570,570,570,570,570,570,570,570,570,550,550,570,570,570,550),L
  550 CONTINUE
      F(L) = 4. * SQRT(D(L) * TIME(I)/3.1416)
      IF(F(L).GT.1.) F(L)=1.
      ISOR(L) = G(L)/3.7E-2*(1.-EXP(K1(L)*TIME(I)))*PART(N)*F(L)
     X /LKTIME(I)
      GO TO 590
  570 CONTINUE
      F(L) = 3. * SQRT(-D(L) / K1(L))
      ISOR(L) = G(L)/3.7E-2*F(L) * PART(N)
     X /LKTIME(I)
  590 CONTINUE
  600 CONTINUE
      ISOR(24) =(G(24) / .037 * (1. - EXP(K1(24) * TIME(I)))
     X + G(23)/ .037 *(1. + (K1(24)*EXP(K1(23) * TIME(I))
     X -K1(23) * EXP(K1(24) * TIME(I)) / -K1(24) + K1(23))))
     X * PART(N) * F(24)
     X /LKTIME(I)
      ISOR(29) =-K1(29)*G(29)*TIME(I)/3.7E-2*F(29)*PART(N)
     X /LKTIME(I)
      IF(RTYPE.EQ.LMFBR)GO TO 591
      A38 = G(38) / (-K1(38) + 2.91E13*2.75-18)
      ISOR(38) = - A38 * K1(38)/3.7E-2 * F(38) * PART(N)
     X /LKTIME(I)
```


1083206

```
  591 CONTINUE
      IF(RTYPE.EQ.LMFBR) GO TO 592
      G133 = 9.51E19 *PF * .0659
      ISOR(40) = -K1(40) *G133/(-K1(40)+ 3.96E-9) *(1.-(((-K1(40)+3.96
     XE-9)* EXP( -0.89E-9*TIME(I)) - 0.89E-9 * EXP(( K1(40)- 3.96E-9)*
     X TIME(I)))/ (-K1(40) + 3.96E-9 -.89E-9)))/ 3.7E-2
     X * F(40) * PART(N)
     X /LKTIME(I)
      GO TO 593
  592 CONTINUE
      G133 = 7.25E19 * PF * .0526
      ISOR(40) = G133 * (1.-( (-K1(40)* EXP(- 1.162E-9 *TIME(I)) -1.162
     XE-9 * EXP(K1(40)* TIME(I)))/ (-K1(40) + .360E-9 - 1.162E-9)))
     X / 3.7E-2 * F(40) * PART(N)
     X /LKTIME(I)
  593 CONTINUE
      DO 700 M=1,LIMIT
      ISOT(M) = ISOT(M)+ISOR(M) * P(II)*RODF(II)/RELF
  700 CONTINUE
  800 CONTINUE
  900 CONTINUE
 1000 CONTINUE
      DO 2000 I=1,LIMIT
      SMLINV(I) = ISOT(I)
 2000 CONTINUE
      RETURN
      END
```


1083201

```
@ ELT STANK,1,71C916, 51163

      SUBROUTINE STANK(TGAS)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR
      DIMENSION TGAS(5C)
      DELAY = 3C. * 8.64E4
      CALL CMPNT(DELAY,TGAS)
      RETURN
      END
```


1083208

294

```
@ ELT TANK1,1,71C916, 51152

      SUBROUTINE TANK1(TINV,TGIN1B)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA
C  TANK
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA
      DIMENSION TINV(5C),TGIN1B(5C),CONC(5C)
      DELAY =  1C.* 36CC.
      VOLLIQ =  68CCC.
      CALL CMPNT(DELAY,TINV)
      CALL VENT(TINV,TGIN1B)
      DO 1C I=1,LIMIT
      CONC(I) = TINV(I)*DELAY*VOLLIQ
   1C CONTINUE
      RETURN
      END
```


1083209

10832 10

```
@ ELT TANK2,1,710916, 51155

      SUBROUTINE TANK2(TINV,TGIN)
      COMMON RTYPE,LIMIT
      DIMENSION TINV(50),TGIN (50),CONC(50)
      DELAY = 12.* 3600.
      VOLLIQ = 68000.
      CALL CMPNT(DELAY,TINV)
      CALL VENT(TINV,TGIN)
      DO 10 I=1,LIMIT
      CONC(I) = TINV(I)*DELAY/VOLLIQ
   10 CONTINUE
      RETURN
      END
```

```
@ ELT TANK3,1,710316, 51167

      SUBROUTINE TANK3(TINV,TGAS)
      COMMON RTYPE,LIMIT
      DIMENSION TINV(50),TGAS(50),CONC(50)
      DELAY = 10. * 3600.
      VOLLIQ= 1000.
      CALL CMPNT(DELAY,TINV)
      CALL VENT (TINV,TGAS)
      DO 10 I=1,LIMIT
      CONC(I) = TINV(I)* DELAY/VOLLIQ
   10 CONTINUE
      RETURN
      END
```


1083211

```
@ ELT TANK4,1,710916, 51168

      SUBROUTINE TANK4(TINV,TGAS)
      COMMON RTYPE,LIMIT
      DIMENSION TINV(50),TGAS(50),CONC(50)
      DELAY = 10. * 3600.
      VOLLIQ = 1000.
      CALL CMPNT(DELAY,TINV)
      CALL VENT (TINV,TGAS)
      DO 10 I=1,LIMIT
      CONC(I) = TINV(I)* DELAY/VOLLIQ
   10 CONTINUE
      RETURN
      END
```

```
@ ELT VDELA,1,71C81C, 59462

      SUBROUTINE VDELA(VDELAY,INVIN)
      INTEGER RTYPE,BWR,PWR,BWRA,PWRA,LMFBR
C     DECAY ROUTINE FOR COMPONENTS WHERE DELAY IS A FUNCTION OF ISOTOPE
      COMMON RTYPE,LIMIT,BWR,PWR,BWRA,PWRA,LMFBR,K1,K2,K3
      REAL INVIN,K1,K2,K3
      DIMENSION INVIN(5C), K1(5C), K2(5C), K3(5C),
     X POWER1(5C), POWER2(5C), POWER3(5C), AMT(5C), AMTP(5C),          C2/18/71
     X AMTPM(5C), AMTO(5C)                                             C2/18/71
      DIMENSION VDELAY(5C)
      DO 1C I=1,LIMIT                                                  C2/18/71
      AMT(I)=INVIN(I)/K1(I)                                            C2/18/71
   1C CONTINUE                                                         C2/18/71
   4C DO 1CC N=1,LIMIT
      POWER1(N)= K1(N) * VDELAY(N)
      POWER2(N)= K2(N) * VDELAY(N)
      POWER3(N) = K3(N)* VDELAY(N)
      IF(POWER1(N).LT.-7C.) POWER1(N)= -7C.
      IF(POWER2(N).LT.-7C.) POWER2(N) =-7C.
      IF(POWER3(N).LT.-7C.) POWER3(N) =-7C.
      AMTP(N) = C.                                                     C2/18/71
      AMTPM(N) = C.                                                    C2/18/71
      GO TO (1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,18,1,1,1,1,1,24,1,1,1,1,
     X1,1,31,1,1,34,35,36,37,38,1,1,1,1,43,1,1),N
   18 AMTP(N)=AMT(17)*.2C                                              C2/18/71
      GO TO 1
   24 AMTP(N)=AMT(23)                                                  C2/18/71
      GO TO 1
   31 AMTP(N)=AMT(28)                                                  C2/18/71
      [illegible] TO 1
   [illegible] [illegible]AMT([illegible])*.C1                         C2/18/71
      [illegible]                                                      C2/18/71
```

```
      GO TO 1
   36 AMTP(N)=AMT(32)*.975                                          02/18/71
      AMTPM(N)=AMT(35)                                              02/18/71
      GO TO 1
   37 AMTP(N)=AMT(33)*.30                                           02/18/71
      GO TO 1
   38 AMTP(N)=AMT(33)*.70                                           02/18/71
      AMTPM(N) = AMT(37)                                            02/18/71
      GO TO 1
   43 AMTP(N)=AMT(42)                                               02/18/71
    1 CONTINUE
      AMTO(N)=AMT(N)*EXP(POWER1(N))+K2(N)/(K1(N)-K2(N))             02/18/71
     X*(EXP(POWER2(N))-EXP(POWER1(N)))*AMTP(N) + K3(N)/(K1(N)-K3(N))  02/18/71
     X*(EXP(POWER3(N))-EXP(POWER1(N)))*AMTPM(N)                     02/18/71
  100 CONTINUE
      DO 110 I=1,LIMIT                                              02/18/71
      INVIN(I)= AMTO(I) * K1(I)
  110 CONTINUE                                                      02/18/71
      RETURN
      END
```


1083214

```
@ ELT VENT,1,710924, 43279

      SUBROUTINE VENT(TINV,TGIN)
      COMMON RTYPE,LIMIT, LMFBR
      DIMENSION TINV(50), TGIN(50),  SEP(50)
      DATA(SEP(I),I=1,45)/ 0., 1., 3*0., 2*1., 9*0., 4*1., 8*0.,
     X 5*.001, 6*1., 6*0./
      DO 10 I=1,LIMIT
      TGIN(I) = TINV(I) * SEP(I)
      TINV(I) = TINV(I) - TGIN(I)
   10 CONTINUE
      RETURN
      END
```


1083215

RADREL Code Listing

1083216

```
@ ELT MAGIC,7,711112, 52533

      DM1*  FCOPY
            COMMON CINV(50),SINV(50),ISOTOP(50),MFRAIR(50),LOAD
            COMMON LIMIT,TYPE,PROPT,DATAIN,NONE,FULL,PART,TIME,FLOW          10/13/70
            INTEGER PROPT,DATAIN,FULL,PART,TYPE,TIME
            REAL LOAD,MFRAIR
            END
      DM2*  FCOPY
            COMMON K1(50), K2(50), K3(50), POWER1(50), POWER2(50), POWER3(50)
            REAL K1,K2,K3
            COMMON PINVA(50),PINVB(50)
            END
```

PROCEDURE NAME TABLE

DM1	00000000	DM2	00000124

1083217

303

1083218

```
@ FLT MAIN,1,711112, 52533

      INCLUDE DM1,LIST
C     DUMMY MAIN PROGRAM - INPUT OF 1800 TONNES OF LWR FUEL AND          10/17/7
C     750 TONNES OF FBR FUEL.  RESULTS IN FULL CAPACITY MFR              10/17/7
C     AND TWO FULL CAPACITY DUAL-PURPOSE PLANTS, EACH WITH 375 TONNES    10/17/7
C     FBR FUEL AND 750 TONNES OF LWR FUEL                                10/17/7
      INTEGER SITE
      DIMENSION AIR(50),WATER(50),AIRMFR(50)
      READ(5,10) TONLWR,TONFBR,KEY
   10 FORMAT(2E15.5,I5)
      CALL REPARE(AIR,WATER,AIRMFR,SITE,TONLWR,TONFBR)
      IF(KEY.EQ.1) GO TO 99
      PUNCH 20,(AIR(I),I=1,50)
      PUNCH 20,(WATER(I),I=1,50)
      PUNCH 20,(AIRMFR(I),I=1,50)
   20 FORMAT(8E10.5)
   99 CONTINUE
      WRITE(6,1) AIR(30),WATER(30),AIRMFR(30),SITE,TONLWR,TONFBR
    1 FORMAT(5X,3(2X,1PE12.4),I5,2(2X,1PE12.4))
      END
```

1083219

```
@ ELT ACCUM1,1,711112, 52542

      SUBROUTINE ACCUM1(FLOWIN,INV)
C     HIGH-LEVEL LIQUID WASTE CATCH TANK                                10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                        10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HACCUM1
      VOLUME =  3000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL  EVAPF(FLOWIN,INV)
      RETURN
      END
```

1083220

```
@ ELT ACCUM2,1,711112, 52544

      SUBROUTINE ACCUM2(FLOWIN,INV)
C     LOW-LEVEL LIQUID WASTE CATCH TANK                                  10/17/70
      INCLUDE CM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                         10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                         10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*3.E04,6*0.,6*3.E04/    10/01/70
      COMPNT = 6HACCUM2
      VOLUME =  1000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL CONCEN(FLOWIN,INV)
      RETURN
      END
```

1083221

```
@ ELT BLEACH,1,711112, 52539

      SUBROUTINE BLEACH(TONS,FUEL)
C     BLEACH SUBROUTINE MODELS THE PUREX TYPE DUAL-PURPOSE
C     REPROCESSING PLANT EFFLUENT SYSTEMS
      INCLUDE DM1,LIST
      INTEGER R,W,RR
      REAL INVONE,INV,INVINL,INVINF,INVOUT
      DIMENSION INVONE(50),INV(50),INVOUT(50),INVINL(50),INVINF(50)
C     LIGHT WATER REACTOR FUEL INVENTORY, CURIES/MTM FROM ORNL - 4451
      DATA(INVINL(I),I=1,45)/ 6.98E02,  0.0,      1.30E-03, 0.0,        10/01/70
    B     0.0,      0.0,      0.0,      3.10E03,  2.01E02,  1.86E03,    10/01/70
    C     5.64E01,  3.87E03,  6.22E03,  5.62E02,  0.0,      0.0,        10/01/70
    D     0.0,      1.13E04,  0.0,      0.0,      2.14E05,  7.69E04,    10/01/70
    E     5.24E05,  8.69E05,  0.0,      2.55E05,  4.59E05,  0.0,        10/01/70
    F     3.36E00,  3.81E02,  0.0,      0.0,      0.0,      1.06E02,    10/01/70
    G     0.0,      0.0,      0.0,      0.0,      0.0,      2.25E05,    10/01/70
    H     1.07E05,  1.11E04,  1.28E04,  2.05E05,  8.92E05/              10/01/70
C     FAST BREEDER REACTOR FUEL INVENTORY, CURIES/MTM
      DATA(INVINF(I),I=1,45)/ 9.36E02,  0.0,      5.84E-02, 0.0,        10/01/70
    A     0.0,      0.0,      0.0,      6.17E04,  1.50E05,  7.60E04,    10/01/70
    B     1.03E04,  4.10E05,  1.35E03,  6.78E01,      0.0,      0.0,    10/01/70
    C     0.0,      1.03E04,  0.0,      0.0,      9.50E05,  4.35E04,    10/01/70
    D     2.89E06,  2.85E06,  3.10E06,  2.97E06,  1.37E06,  2.50E06,    10/01/70
    E     5.24E-02, 1.79E06,  2.52E06,  0.0,      0.0,      1.84E04,    10/01/70
    F     8.06E04,  3.26E06,  0.0,      0.0,      0.0,      2.99E04,    10/01/70
    G     1.09E05,  2.65E05,  2.75E06,  2.80E06,  1.37E06/              10/01/70
   10 FORMAT(3A5,2E10.0)
   20 FORMAT(8E10.0)
   30 FORMAT('1'///1X,'PUREX-TYPE REPROCESSING MODEL',3X,F8.2,2X,'TONS',
     A2X,A3,5X,'PREPROCESSING COOLING PERIOD',2X,F10.0,2X,'DAYS')
   32 FORMAT('0'//22X,'INLET STREAM',26X,'OUTLET STREAM (PICO CURIES/SEC
     A)'//19X,'(PICO CURIES/SEC)',21X,'CANAL',26X,'STACK'/)
   34 FORMAT(' ',2X,A5,14X,1PE10.4,23X,1PE10.4,21X,1PE10.4)
```

```
   37 FORMAT('C  FLOW (LITERS/SEC)',2X,1PE10.4,23X,1PE10.4,21X,1PE10.4)
      R=5
      W=6
      RR=-4
      HOLD = 150.
      FHOLD = 150.                                                      11/09/70
      CFLOW = 0.
      SFLOW = 0.
      ICASE =0
C     LOGIC DECIDES WHICH FUEL INVENTORY TO USE, FAST OR LIGHT, ON
C     KEY FOR SWITCH VARIABLE FUEL....   FUEL = 1. FOR LWR PROCESSING   12/10/70
C                                        FUEL = 2. FOR FBR PROCESSING   12/10/70
C     FUEL=2. (FBR).
      NAME = 3HLWR
      IF(FUEL.GT.1.) NAME = 3HFBR
      IF(FUEL.GT.1.) GO TO 80
      CTIME = HOLD - 90.
C     CONVERSION OF FISSION PRODUCT INVENTORY TO PICOCURIES/SEC AND     12/10/70
C     INCLUSION OF 0.1 PER CENT OF ACTIVATION PRODUCTS CONTAINED IN FUEL12/10/70
      DO 28 I=1,LIMIT
      INV(I) = TONS * INVINL(I) * 31710.                                10/13/70
   28 CONTINUE
      GO TO 92
   80 CTIME = FHOLD                                                     11/09/70
      DO 29 I=1,LIMIT                                                   11/09/70
      INV(I) = TONS * INVINF(I) * 31710.                                10/13/70
   29 CONTINUE
   92 ICASE = ICASE + 1
      FLOSAV=FLOW
      DO 25 I=1,LIMIT
      K = I                                                             10/13/70
      IF(K.EQ.1) GO TO 23
      IF(K.GT.16) GO TO 23                                              10/13/70
      INV(I) = INV(I) / 1000.                                           10/13/70
   23 INVONE(I) = INV(I)                                                10/13/70
      CINV(I) = 0.
```


1083222

```
      SINV(I) = 0.
   25 CONTINUE
C     PREPROCESSING COOLING  PERIOD FOR FUEL GIVEN BY CTIME FROM
C     REPARE, (LWR) FUEL INVENTORY HAS BEEN PRECOOLED 90 DAYS, SO CTIME
      CALL COOL(INV,INVOUT,COMPNT,CTIME)
      IF(FUEL.GT.1.) GO TO 95                                          12/10/70
      CALL DISOLV(FLOSAV,INVOUT)                                       12/10/70
      GO TO 96                                                         12/10/70
   95 CALL VOLOXR(FLOSAV,INVOUT)                                       12/10/70
      CALL DISOLV(FLOWIN,INV)                                          12/10/70
   96 CONTINUE                                                         12/10/70
      IF(PROPT.EQ.NONE) GO TO 60                                       12/10/70
      WRITE(W,30) TONS,NAME,HOLD
      WRITE(W,32)
      DO 35 I=1,LIMIT
      WRITE(W,34) ISOTOP(I),INVONE(I),CINV(I),SINV(I)
   35 CONTINUE
      IF (DATAIN.EQ.TIME) GOTO 60
      WRITE(W,37) FLOSAV,CFLOW,SFLOW
   60 CONTINUE
  999 RETURN
      END
```


10832223

10832224

```
@ ELT BLENDR,1,711112, 52545

      SUBROUTINE BLENDR(FLOWIN,INV)
C     LOW-LEVEL LIQUID WASTE ASPHALT BLENDER                            10/17/70
      INCLUDE DMI,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45)/2*0.,3*.990,2*0.,9*.990,4*0.,2*.9,3*.990,2*.8, 10/13/70
     X6*.01,6*0.,6*.999/                                                10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HBLENDR
      VOLUME =  5000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      FLOW = FLOWIN
      CONST8 = 0.5
      FLOWIN = FLOW * CONST8
      CALL SCRBF2(FLOWIN,INV)
      RETURN
      END
```

1083225

```
@ ELT CALCIN,1,711112, 52547

      SUBROUTINE CALCIN(FLOWIN,INV)
C     HIGH-LEVEL LIQUID WASTE CALCINER                                  10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMFIN(50)                        10/01/70
      DATA(C1(I),I=1,45)/2*0.,3*.990,2*0.,9*.990,4*0.,2*.9,3*.990,2*.8, 10/13/70
     X6*.01,6*0.,6*.999/                                                10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMFIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HCALCIN
      VOLUME = 5000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I) * LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      FLOW = FLOWIN
      CONSTO = 0.5
      FLOWIN = FLOW * CONSTO
      CALL SCRUBF(FLOWIN,INV)
      RETURN
      END
```

1083226

```
I ELT CANAL,1,711112, 52548

      SUBROUTINE CANAL(FLOWIN,INVIN)
C  FINAL DISCHARGE CANAL
      INTEGER W
      REAL INVIN
      INCLUDE DM1,LIST
      DIMENSION INVIN(50)
    5 FORMAT('CFLOW = ',1PE10.4,'FROM CANAL')
   10 FORMAT(' INVENTORY FOR ISOTOPE NUMBER',I3,' = ',1PE12.4)
  500 FORMAT(8X,'ROUTINE',12X,'FLOWIN',10X,'DELAY',8X,'INV(1)',8X,      12/21/70
     A'INV(18)',10X,'INV(22)',8X,'INV(30)',9X,'INV(45)'//)              12/21/70
      W = 6
      DO 200 I=1,LIMIT
      CINV(I) = CINV(I) + INVIN(I)
  200 CONTINUE
      CFLOW = CFLOW + FLOWIN
      IF (PROPT.EQ.NONE) GO TO 600
      IF (PROPT.EQ.PART) GO TO 500
      PRINT 5,FLOWIN
      DO 100 I=1,LIMIT
      PRINT 10,I,INVIN(I)
  100 CONTINUE
      WRITE(W,500)
  600 CONTINUE
      RETURN
      END
```

```
@ ELT CONCEN,1,711112, 52550

      SUBROUTINE CONCEN(FLOWIN,INV)
C     LOW-LEVEL LIQUID WASTE CONCENTRATOR                                10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                         10/01/70
      DATA(C1(I),I=1,45)/45*0./                                          10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/    10/01/70
      COMPNT = 6HCONCEN
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL  TANK2(FLOWIN,INV)
      RETURN
      END
```


10832271

10832228

```
@ ELT CONDEN,1,711112, 52552

      SUBROUTINE CONDEN(FLOWIN,INV)
C     DISSOLVER OFF-GAS TRAIN CONDENSER
      INCLUDE DM1,LIST
      REAL INV,INVOUT,INVSAV
      INTEGER W                                                         11/09/70
      DIMENSION INV(50),INVOUT(50),INVSAV(50)
      DIMENSION EFF(50),C1(50),C2(50),P(50),TIMEIN(50)                  10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                        10/13/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA(P(I),I=1,45)/1*1.,1*.9999,14*.5,4*1.,5*.9,8*.9999,6*1.,6*.5/ 11/09/70
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HCONDEN
      ICHECK = 1                                                        10/13/70
      GO TO 10
C     CELL OFF-GAS TRAIN CONDENSER
      ENTRY CONDN2(FLOWIN,INV)
      W = 6                                                             11/09/70
      COMPNT = 6HCONDN2
      ICHECK = 2
   10 VOLUME = 575
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
      FLOW=FLOWIN
      CONST = .1
      FLOWIN = FLOW * CONST
      DO 200 I=1,LIMIT
      INVSAV(I)=INV(I)
      INV(I) = INVSAV(I) * P(I)
```

```
  200 CONTINUE
      IF(ICHECK.EQ. 1) GO TO 220
      CALL SCRUB2(FLOWIN,INV)
      GO TO 230
  220 CALL SCRUBR(FLOWIN,INV)
  230 CONTINUE
      FLOWIN = FLOW * (1.-CONST)
      DO 300 I=1,LIMIT
      INV(I) = INVSAV(I) * (1. - P(I))
  300 CONTINUE
      IF(ICHECK.EQ.1) GO TO 320
      CALL CTANK3(FLOWIN,INV)
      GO TO 330
  320 CALL CTANK(FLOWIN,INV)
  330 CONTINUE
      RETURN
      END
```


10833229

315

1083230

```
@ ELT CONDNF,1,711112, 52553

      SUBROUTINE CONDNF(FLOWIN,INV)                                     10/17/70
C     CELL OFF-GAS CONDENSER
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)                                      10/01/70
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/13/70
      DATA(C1(I),I=1,45)/2*1.,14*.5,4*1.,5*.5,2*.5,12*1.,6*.5/
      DATA(C2(I),I=1,45) /45*.0/                                        10/01/70
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/
      COMPNT = 6HCONDNF
   10 VOLUME =  1500.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CONST9 = 0.5
      FLOW=FLOWIN
      FLOWIN = FLOW * CONST9
      CALL SFILTR(FLOWIN,INV)
      RETURN
      END
```

```
@ ELT COOL,1,711112, 52555

      SUBROUTINE COOL(INVIN,INVOUT,COMPNT,CTIME)
C     DECAY ROUTINE FOR PREPROCESSING COOLING TIME IN PUREX-TYPE,        10/17/70
C     DUAL PURPOSE PLANTS                                                10/17/70
      INCLUDE DM1,LIST
      INCLUDE DM2,LIST
      INTEGER W
      REAL INVIN,INVOUT
      DIMENSION INVIN(50),INVOUT(50)
  900 FORMAT(10X,' PREPROCESSING COOLING TIME IS',2X,F4.0,2X,'DAYS')
  930 FORMAT(' INVENTORY FOR ISOTOPE NUMBER',I3,' = ',1PE12.4)
  940 FORMAT(8X,'ROUTINE',12X,'FLOWIN',10X,'DELAY',8X,'INV(1)',8X,       12/21/70
     A'INV(18)',10X,'INV(22)',8X,'INV(30)',9X,'INV(45)'//)               12/21/70
      COMPNT = 6HCOOLF
      W = 6
      DELA = CTIME * 86400.
   40 DO 100 N=1,LIMIT
      PINVA(N) = 0.0
      PINVB(N) = 0.0
      GO TO(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,18,1,1,1,1,1,24,1,1,1,1,1,
     X1,31,1,1,34,35,36,37,38,1,1,1,1 43,1,1),N
   18 PINVA(N) = INVIN(17) * 0.200
      GO TO 1
   24 PINVA(N) = INVIN(23)
      GO TO 1
   31 PINVA(N) = INVIN(28)
      GO TO 1
   34 PINVA(N) = INVIN(30) * 0.01                                         12/10/70
      GO TO 1
   35 PINVA(N) = INVIN(32) * 0.024
      GO TO 1
   36 PINVA(N) = INVIN(32) * 0.976
      PINVB(N) = INVIN(35)
```

```
      GO TO 1
   37 PINVA(N) = INVIN(33) * 0.300
      GO TO 1
   38 PINVA(N) = INVIN(33)  * 0.700
      PINVB(N) = INVIN(37)
      GO TO 1
   43 PINVA(N) = INVIN(42)
    1 CONTINUE
      POWER1(N) = K1(N) * DELA
      POWER2(N) = K2(N) * DELA
      POWER3(N) = K3(N) * DELA
      ELIM1 = -70.
      IF(POWER1(N).LT.ELIM1) POWER1(N) = ELIM1
      IF(POWER2(N).LT.ELIM1)POWER2(N) = ELIM1
      IF(POWER3(N).LT.ELIM1) POWER3(N) = ELIM1
      INVOUT(N)=INVIN(N)*EXP(POWER1(N))+(K2(N)/(K1(N)-K2(N)))*PINVA(N)*
     1 (EXP(POWER2(N)) - EXP(POWER1(N))) + (K3(N) / (K1(N) - K3(N))) *
     2 PINVB(N) * (EXP(POWER3(N)) - EXP(POWER1(N)))
  100 CONTINUE
      IF(PROPT.EQ.NONE)GO TO 600
      IF(PROPT.EQ.PART)GO TO 600
      WRITE(W,900)CTIME
      DO 920 I=1,LIMIT
      WRITE(W,930)I,INVOUT(I)
  920 CONTINUE
      WRITE(W,940)
  600 CONTINUE
      RETURN
      END
```


10832232

10832233

```
@ ELT COOLF,1,711112, 52558

      SUBROUTINE COOLF(INVIN,INVOUT,COMPNT,CTIME)
C     DECAY ROUTINE FOR PREPROCESSING COOLING TIME FOR THE MIDWEST      10/17/70
C     FUEL RECOVERY PLANT                                               10/17/70
      INTEGER W
      INCLUDE DM1,LIST
      INCLUDE DM2,LIST
      REAL INVIN,INVOUT
      DIMENSION INVIN(50),INVOUT(50)
  900 FORMAT(10X,' PREPROCESSING COOLING TIME IS',2X,F4.0,2X,'DAYS')
  930 FORMAT(' INVENTORY FOR ISOTOPE NUMBER',I3,' = ',E12.4)
  940 FORMAT(8X,'ROUTINE',12X,'FLOWIN',10X,'DELAY',8X,'INV(1)',8X,      12/21/70
     A'INV(18)',10X,'INV(22)',8X,'INV(30)',9X,'INV(45)'//)              12/21/70
      COMPNT = 6HCOOLF
      W = 6
      HOLD = CTIME - 90.                                                10/17/70
      DELA = HOLD * 86400.                                              10/17/70
   40 DO 100 N=1,LIMIT                                                  10/13/70
      PINVA(N) = 0.0
      PINVB(N) = 0.0
      GO TO(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,18,1,1,1,1,1,24,1,1,1,1,1,
     X1,31,1,1,34,35,36,37,38,1,1,1,1,43,1,1),N
   18 PINVA(N) = INVIN(17) * 0.200
      GO TO 1
   24 PINVA(N) = INVIN(23)
      GO TO 1
   31 PINVA(N) = INVIN(28)
      GO TO 1
   34 PINVA(N) = INVIN(30) * 0.01                                       12/10/70
      GO TO 1
   35 PINVA(N) = INVIN(32) * 0.024
      GO TO 1
   36 PINVA(N) = INVIN(32) * 0.976
```

```
      PINVB(N) = INVIN(35)
      GO TO 1
   37 PINVA(N) = INVIN(33) * 0.300
      GO TO 1
   38 PINVA(N) = INVIN(33)  * 0.700
      PINVB(N) = INVIN(37)
      GO TO 1
   43 PINVA(N) = INVIN(42)
    1 CONTINUE
      POWER1(N) = K1(N) * DELA
      POWER2(N) = K2(N) * DELA
      POWER3(N) = K3(N) * DELA
      ELIM1 = -70.
      IF(POWER1(N).LT.ELIM1) POWER1(N) = ELIM1
      IF(POWER2(N).LT.ELIM1)POWER2(N) = ELIM1
      IF(POWER3(N).LT.ELIM1) POWER3(N) = ELIM1
      INVOUT(N)=INVIN(N)*EXP(POWER1(N))+(K2(N)/(K1(N)-K2(N)))*PINVA(N)*
     1 (EXP(POWER2(N)) - EXP(POWER1(N))) + (K3(N) / (K1(N) - K3(N))) *
     2 PINVB(N) * (EXP(POWER3(N)) - EXP(POWER1(N)))
  100 CONTINUE
      IF(PROPT.EQ.NONE)GO TO 600
      IF(PROPT.EQ.PART)GO TO 600
      WRITE(W,900) HOLD
      DO 920 I=1,LIMIT
      WRITE(W,930)I,INVOUT(I)
  920 CONTINUE
      WRITE(W,940)
  600 CONTINUE
      RETURN
      END
```

10/17/70

10832234

10832235

```
@ ELT CTANK,1,711112, 52559

      SUBROUTINE CTANK(FLOWIN,INV)
C     LOW-LEVEL LIQUID WASTE CATCH TANK                                  10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                         10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                         10/13/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/    10/01/70
      COMPNT = 6HCTANK
      VOLUME = 700.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
  210 CALL EVAP(FLOWIN,INV)
      RETURN
      END
```

1083236

```
& ELT CTANK2,1,711112, 52561

      SUBROUTINE CTANK2(FLOWIN,INV)
C     LOW-LEVEL LIQUID WASTE CATCH TANK                                  10/17/70
      INCLUDE CM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                         10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                         10/13/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/    10/01/70
      COMPNT = 6HCTANK2
      VOLUME = 375.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
  220 CALL IONX(FLOWIN,INV)
      RETURN
      END
```

10832237

```
@ ELT CTANK3,1,711112, 52563

      SUBROUTINE CTANK3(FLOWIN,INV)
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA (C1(I),I=1,45)/45*.9/
      DATA (C2(I),I=1,45)/45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*9.E04/   10/01/70
      COMPNT = 6HCTANK3
      VOLUME = 500.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
  230 CALL EVAP2(FLOWIN,INV)
      RETURN
      END
```


323

10832238

```
@ ELT DECAY,1,711112, 52565

      SUBROUTINE DECAY(VOLUME,FLOWIN,INVIN,INVOUT,COMPNT,TIMEIN)
C  DECAY ROUTINE FOR EACH COMPONENT
      INTEGER W
      INCLUDE DM1,LIST
      INCLUDE DM2,LIST
      REAL INVIN,INVOUT
      DIMENSION INVOUT(50),INVIN(50),TIMEIN(50)                          10/01/70
  525 FORMAT(10X,A6,5X,7(3X,1PE12.4))                                    10/01/70
      W = 6
      DO 100 N=1,LIMIT                                                   10/01/70
      IF(DATAIN.EQ.TIME)GO TO 88
      DELA =VOLUME/FLOWIN
   88 DELA = TIMEIN(N)                                                   10/01/70
      PINVA(N) = 0.0
      PINVB(N) = 0.0
      GO TO(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,18,1,1,1,1,1,24,1,1,1,1,1,
     X1,31,1,1,34,35,36,37,38,1,1,1,1,43,1,1),N
   18 PINVA(N) = INVIN(17) * 0.200
      GO TO 1
   24 PINVA(N) = INVIN(23)
      GO TO 1
   31 PINVA(N) = INVIN(28)
      GO TO 1
   34 PINVA(N) = INVIN(30) * 0.01                                        12/10/70
      GO TO 1
   35 PINVA(N) = INVIN(32) * 0.024
      GO TO 1
   36 PINVA(N) = INVIN(32) * 0.976
      PINVB(N) = INVIN(30)
      GO TO 1
   37 PINVA(N) = INVIN(33) * 0.300
      GO TO 1
```

```
   38 PINVA(N) = INVIN(73)  * 0.700
      PINVB(N) = INVIN(37)
      GO TO 1
   43 PINVA(N) = INVIN(42)
    1 CONTINUE
      POWER1(N) = K1(N) * DELA
      POWER2(N) = K2(N) * DELA
      POWER3(N) = K3(N) * DELA
      ELIM1 = -70.
      IF(POWER1(N).LT.ELIM1) POWER1(N) = ELIM1
      IF(POWER2(N).LT.ELIM1)POWER2(N) = ELIM1
      IF(POWER3(N).LT.ELIM1) POWER3(N) = ELIM1
      INVOUT(N)=INVIN(N)*EXP(POWER1(N))+(K2(N)/(K1(N)-K2(N)))*PINVA(N)*
     1 (EXP(POWER2(N)) - EXP(POWER1(N))) + (K3(N) / (K1(N) - K3(N))) *
     2 PINVB(N) * (EXP(POWER3(N)) - EXP(POWER1(N)))
  100 CONTINUE
      IF(PROPT.EQ.NONE)GO TO 600
      IF(PROPT.EQ.PART)GO TO 600
  475 WRITE(W,525) COMPNT,FLOWIN,DELA,INVOUT(1),INVOUT(18),INVOUT(22),   10/01/70
     XINVOUT(30),INVOUT(45)                                              10/01/70
  600 CONTINUE
      RETURN
      END
```


10832239

1083240

```
@ ELT DELAY,1,711112, 52567

      SUBROUTINE DELAY(VOLUME,FLOWIN,INVIN,INVOUT,COMPNT,TIMEIN)
C  DECAY ROUTINE FOR EACH COMPONENT
      REAL INVIN,INVOUT
      INTEGER W
      INCLUDE DM1,LIST
      INCLUDE DM2,LIST
      DIMENSION INVIN(50),INVOUT(50),TIMEIN(50)                          10/01/70
  525 FORMAT(10X,A6,5X,7(3X,1PE12.4))                                    10/01/70
      W = 6
      DO 100 N=1,LIMIT                                                   10/01/70
      IF(DATAIN.EQ.TIME)GO TO 88
      DELA =VOLUME/FLOWIN
   88 DELA = TIMEIN(N)                                                   10/01/70
      PINVA(N) = 0.0
      PINVB(N) = 0.0
      GO TO(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,18,1,1,1,1,1,24,1,1,1,1,1,
     X1,31,1,1,34,35,36,37,38,1,1,1,1,43,1,1),N
   18 PINVA(N) = INVIN(17) * 0.200
      GO TO 1
   24 PINVA(N) = INVIN(23)
      GO TO 1
   31 PINVA(N) = INVIN(28)
      GO TO 1
   34 PINVA(N) = INVIN(30) * 0.01
      GO TO 1
   35 PINVA(N) = INVIN(32) * 0.024
      GO TO 1
   36 PINVA(N) = INVIN(32) * 0.976
      PINVB(N) = INVIN(35)
      GO TO 1
   37 PINVA(N) = INVIN(33) * 0.300
      GO TO 1
```

```
   38 PINVA(N) = INVIN(33)  * 0.700
      PINVB(N) = INVIN(37)
      GO TO 1
   43 PINVA(N) = INVIN(42)
    1 CONTINUE
      POWER1(N) = K1(N) * DELA
      POWER2(N) = K2(N) * DELA
      POWER3(N) = K3(N) * DELA
      ELIM1 = -70.
      IF(POWER1(N).LT.ELIM1) POWER1(N) = ELIM1
      IF(POWER2(N).LT.ELIM1)POWER2(N) = ELIM1
      IF(POWER3(N).LT.ELIM1) POWER3(N) = ELIM1
      INVOUT(N)=INVIN(N)*EXP(POWER1(N))+(K2(N)/(K1(N)-K2(N)))*PINVA(N)*
     1 (EXP(POWER2(N)) - EXP(POWER1(N))) + (K3(N) / (K1(N) - K3(N))) *
     2 PINVB(N) * (EXP(POWER3(N)) - EXP(POWER1(N)))
  100 CONTINUE
      IF(PROPT.EQ.NONE)GO TO 600
      IF(PROPT.EQ.PART)GO TO 600
  475 WRITE(W,525) COMPNT,FLOWIN,DELA,INVOUT(1),INVOUT(18),INVOUT(22),   10/01/70
     XINVOUT(30),INVOUT(45)                                              10/01/70
  600 CONTINUE
      RETURN
      END
```


10832411

327

1083242

```
@ ELT DISOLV,1,711112, 52568

      SUBROUTINE DISOLV(FLOWIN,INV)
C     MECHANICAL CHOP-ACID LEACH HEAD END SYSTEM                        10/17/70
      REAL INV,INVOUT,INVSAV,KONST
      INCLUDE CM1,LIST
      DIMENSION INV(50),INVOUT(50),INVSAV(50)
      DIMENSION EFF(50),C1(50),C2(50),P(50),TIMEIN(50)                  10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                        10/13/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA(P(I),I=1,45)/1.,.8,14*0.,4*1.,5*0.,2*.2,6*.8,6*1.,6*0./      10/13/70
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HDISOLV
      VOLUME = 575.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
      FLOW=FLOWIN
      KONST = .9
      FLOWIN = KONST * FLOW
      DO 200 I=1,LIMIT
      INVSAV(I)=INV(I)
      INV(I) = (1.-P(I))*INVSAV(I)
  200 CONTINUE
      CALL PUREX(FLOWIN,INV)
      FLOWIN = (1.-KONST)*FLOW
      DO 300 I=1,LIMIT
      INV(I) = P(I) * INVSAV(I)
  300 CONTINUE
      CALL NOBLOF(FLOWIN,INV)                                           12/07/70
      CALL CONDEN(FLOWIN,INV)
```

RET
END

.3.
34.

1083243

10832444

```
@ ELT EVAP,1,711112, 52569

      SUBROUTINE EVAP(FLOWIN,INV)
C     LOW-LEVEL LIQUID WASTE EVAPORATOR
      INCLUDE DM1,LIST
      REAL INV,INVOUT,INVSAV
      DIMENSION INV(50),INVOUT(50),INVSAV(50)
      DIMENSION EFF(50),C1(50),C2(50),S(50),TIMEIN(50)                  10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                        10/13/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA(S(I),I=1,45)/0.,15*.999,4*0.,7*.999,6*.99,6*0.,6*.999/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HEVAP
   10 VOLUME = 600.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INVSAV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      DO 200 I=1,LIMIT
      INV(I) = INVSAV(I) * (1. - S(I))
  200 CONTINUE
  220 CALL CTANK2(FLOWIN,INV)
      RETURN
      END
```

1083245

```
@ ELT EVAPF,1,711112, 52570

      SUBROUTINE EVAPF(FLOWIN,INV)
C     HIGH-LEVEL LIQUID WASTE EVAPORATOR                                10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT,INVST1,INVST2
      DIMENSION INV(50),INVOUT(50),INVST1(50),INVST2(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45)/1.,15*.1,4*1.,5*.1,2*.5,6*.99,6*1.,6*.1/       10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*3.E04/   10/01/70
      COMPNT = 6HEVAPF
   10 VOLUME =  1750.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INVST1(I) = INVOUT(I) * (1. - EFF(I))
      INVST2(I) = INVOUT(I) * EFF(I)
  100 CONTINUE
      FLOW=FLOWIN
      CONST4 = .5
      FLOWIN = FLOW * CONST4
      DO 200 I=1,LIMIT
      INV(I) = INVST1(I)
  200 CONTINUE
      CALL  TANK1(FLOWIN,INV)
      CONST5 = 0.5
      FLOWIN = FLOW * CONST5
      DO 300 I=1,LIMIT
      INV(I) = INVST2(I)
  300 CONTINUE
      CALL SCRUBF(FLOWIN,INV)
      RETURN
```

END

33.

1083241

```
@ ELT EVAP2,1,711112, 52572

      SUBROUTINE EVAP2(FLOWIN,INV)
C     HIGH-LEVEL LIQUID WASTE EVAPORATOR
      INCLUDE DM1,LIST
      REAL INV,INVOUT,INVSAV
      DIMENSION INV(50),INVOUT(50),INVSAV(50)
      DIMENSION EFF(50),C1(50),C2(50),S(50),TIMEIN(50)                  10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                        10/13/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA(S(I),I=1,45)/0.,15*.999,4*0.,7*.999,6*.99,6*0.,6*.999/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HEVAP2
   10 VOLUME = 600.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INVSAV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      DO 200 I=1,LIMIT
      INV(I) = INVSAV(I) * (1. - S(I))
  200 CONTINUE
      CALL CTANK(FLOWIN,INV)
      RETURN
      END
```

```
@ ELT FILTER,1,711112, 52573

      SUBROUTINE FILTER(FLOWIN,INV)
C     CELL OFF-GAS TRAIN ABSOLUTE FILTER
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                          10/01/70
      DATA(C1(I),I=1,45)/3*0.,13*.999,4*0.,7*.999,6*.9,6*0.,6*.999/
      DATA (C2(I),I=1,45)/45*.0/
      DATA(TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,7*8.E04,12*0.,6*8.E04/
      COMPNT = 6HFILTER
      VOLUME = 1000.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
      CALL PFILTR(FLOWIN,INV)
      RETURN
      END
```

```
@ ELT FLTRF2,1,711112, 52575

      SUBROUTINE FLTRF2(FLOWIN,INV)
C     DISSOLVER OFF-GAS ABSOLUTE FILTER
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45)/2*0.,14*.999,4*0.,2*.999,5*.9999,12*0.,6*.9999/
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HFLTRF2
      VOLUME =  5000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL SFILTR(FLOWIN,INV)
      RETURN
      END
```


1083249

```
@ ELT HEATER,1,711112, 52576

      SUBROUTINE HEATER(FLOWIN,INV)
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                        10/13/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HHEATER
      VOLUME = 200.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
      CALL FILTER(FLOWIN,INV)
      RETURN
      END
```


10832250

```
@ ELT IONX,1,711112, 52978

      SUBROUTINE IONX(FLOWIN,INV)
C     LOW-LEVEL LIQUID WASTE ION-EXCHANGER                              10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      COMPNT = 6HIONX
      DATA(C1(I),I=1,45)/3*0.,13*.9999,4*0.,13*.999,6*0.,6*.9999/       10/17/70
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      DATA (C2(I),I=1,45)/45*.0/
      VOLUME = 750.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
      CALL CANAL(FLOWIN,INV)
      RETURN
      END
```

10832252

```
@ ELT MFR,1,711112, 52541

      SUBROUTINE MFR(TONS)
C   MFR SUBROUTINE CONTROLS THE LOGIC FOR SIMULATING THE RADIOACTIVE EFFLUENT
C   RELEASE FROM A FLUORIDE-VOLATILITY PLANT WITH COMPONENT SUBROUTINES, WHICH
C    CALCULATES THE TOTAL ISOTOPE RELEASE RATE TO THE ATMOSPHERE
C
      INTEGER W,R
      INCLUDE DM1,LIST
      REAL INV,INVIN,INVOUT,INVONE
      DIMENSION INV(50),INVIN(50),INVOUT(50),INVONE(50)
C     LIGHT WATER REACTOR FUEL INVENTORY, CURIES/MTM
      DATA (INVIN(I),I=1,45)/6.98E02,  0.0,      1.30E-03,  0.0,          10/01/70
     F    0.0,       0.0,       0.0,       3.10E03,  2.01E02,  1.86E03,  10/01/70
     H    5.64E01,   3.87E03,   6.22E03,   5.62E02,  0.0,      0.0,      10/01/70
     A    0.0,       1.13E04,   0.0,       0.0,      2.14E05,  7.69E04,  10/01/70
     B    5.24E05,   8.69E05,   0.0,       2.55E05,  4.59E05,  0.0,      10/01/70
     C    3.36E00,   3.81E02,   0.0,       0.0,      0.0,      1.06E02,  10/01/70
     D    0.0,       0.0,       0.0,       0.0,      0.0,      2.25E05,  10/01/70
     E    1.07E05,   1.11E04,   1.28E04,   2.05E05,  8.92E05/           10/01/70
   10 FORMAT(3A5,2E10.0)
   20 FORMAT(8E10.0)
   30 FORMAT('1' /// 20X,'FLOURIDE-VOLATILITY REPROCESSING PLANT MODEL',
     A9X,F8.2,2X,'TONS',10X,'COOLING TIME OF',2X,F4.0,2X,'DAYS')         10/01/70
   32 FORMAT(1X//// 21X,'INLET STREAM',21X,'OUTLET STREAM' // 19X,        10/13/70
     X '(PICO CURIES/SEC)',15X,'(PICO CURIES/SEC)')                      10/13/70
   34 FORMAT(3X,A5,14X,1PE10.4,23X,1PE10.4)
   37 FORMAT('0  FLOW (LITERS/SEC)',2X,E10.4,23X,1PE10.4)
      R=5
      W=6
      CTIME = 150.                                                       10/13/70
      ICASE =0
      ICASE=ICASE+1
      FLOSAV=FLOW
```

```
C     CONVERSION OF FISSION PRODUCT INVENTORY TO PICOCURIES/SEC AND
C     INCLUSION OF 0.1 PER CENT OF ACTIVATION PRODUCTS CONTAINED
C     IN THE CLADDING
      DO 25 I=1,LIMIT
      INV(I) = TONS * INVIN(I) * 31710.                                 10/13/70
      K = I                                                             10/13/70
      IF(K.EQ.1) GO TO 23
      IF(K.GT.15) GO TO 23                                              10/13/70
      INV(I) = INV(I) / 1000.                                           10/13/70
   23 INVONE(I) = INV(I)                                                10/13/70
      SINV(I) = 0.
   25 CONTINUE
C     PREPROCESSING COOLING TIME IN DAYS (CTIME)
      CALL COOLF(INV,INVOUT,COMPNT,CTIME)
      CALL PROCES(FLOSAV,INVOUT)
   40 DO 100 N=1,LIMIT
      MFRAIR(I) = SINV(I)
  100 CONTINUE
      IF(PROPT.EQ.NONE) GO TO 60
      WRITE(W,30) TONS,CTIME
      WRITE(W,32)
      DO 35 I=1,LIMIT
C     SINV IS THE STACK EFFLUENT INVENTORY
      WRITE(W,34) ISOTOP(I),INVONE(I),SINV(I)
   35 CONTINUE
      IF(DATAIN.EQ.TIME)GO TO 60
      WRITE(W,37) FLOSAV,FLOW
   60 CONTINUE
   99 RETURN
      END
```


10832253

1083254

```
@ ELT NOBLDF,1,711112, 52579

      SUBROUTINE NOBLDF(FLOWIN,INV)
C  PROCESS  FOR  REMOVAL OF  NOBLE GAS ISOTOPES
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)
      DIMENSION INV(50),INVOUT(50)
      DATA(C1(I),I=1,45)/45*0./
      DATA(C2(I),I=1,45)/45*0./
      COMPNT = 6HNOBLDF
      VOLUME = 500
      CALL DELAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      RETURN
      END
```


340

1083255

```
@ ELT PFILTR,1,711112, 52580

      SUBROUTINE PFILTR(FLOWIN,INV)
C     DEEP-BED SAND FILTER                                              10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45)/3*0.,13*.999,4*0.,5*.99,2*.99999,6*.9,6*0.,    10/17/70
     X6*.999/                                                           10/17/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HPFILTR
      VOLUME = 2000.
      CALL XTRADF(FLOWIN,INV)                                           12/07/70
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
      CALL STACK(FLOWIN,INV)
      RETURN
      END
```

1083256

```
@ ELT PROCES,1,711J12, 52581

      SUBROUTINE PROCES(FLOWIN,INV)
C     MIDWEST FUEL RECOVERY PLANT AGUAFLUOR PROCESS                     10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT                                                   10/13/70
      DIMENSION INV(50),INVOUT(50),TIMEIN(50)                           10/13/70
      DIMENSION EFF(50),C1(50),C2(50),B(50),C(50),G(50)                 10/13/70
      DATA   (C(I),I=1,45)/.2,15*.85,4*0.,5*.85,2*.25,6*.1,6*0.,6*.85/  10/13/70
      DATA   (B(I),I=1,45)/.6,15*.1,4*0.,5*.1,2*.25,6*.1,6*0.,6*.1/     10/13/70
      DATA   (G(I),I=1,45)/.2,15*.05,4*1.,5*.05,2*.5,6*.8,6*1.,6*.05/   10/13/70
      DATA(C1(I),I=1,45)/45*0./                                         10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HPROCES
      VOLUME =  4000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
  100 CONTINUE
      FLOW=FLOWIN
      CONST1 = 0.33
      FLOWIN = FLOW * CONST1
      DO 200 I=1,LIMIT
      INV(I) = INVOUT(I) * (1. - EFF(I)) * C(I)                         10/13/70
  200 CONTINUE
      CALL ACCUM1(FLOWIN,INV)
      DO 250 I=1,LIMIT
  250 CONTINUE
      CONST2 = 0.33
      FLOWIN = FLOW * CONST2
      DO 300 I=1,LIMIT
      INV(I) = INVOUT(I) * (1. - EFF(I)) * G(I)                         10/13/70
```

```
  300 CONTINUE
      CALL ACCUM2(FLOWIN,INV)
      CONST3 = 0.33
      FLOWIN = FLOW * CONST3
      DO 400 I=1,LIMIT
      INV(I) = INVOUT(I) * (1. - EFF(I)) * G(I)                    10/13/70
  400 CONTINUE
      CALL SCRUBF(FLOWIN,INV)
      RETURN
      END
```


10832571

10832580

```
@ ELT PUREX,1,711112, 52583

      SUBROUTINE PUREX(FLOWIN,INV)
C     ''PUREX'' AQUEOUS SEPARATIONS PROCESS                              10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT,INVSAV
      DIMENSION INV(50),INVOUT(50),INVSAV(50)
      DIMENSION WHL(50),WLL(50),VOG(50),TIMEIN(50)                       10/01/70
      DATA (WHL(I),I=1,45)/.2,15*.85,4*0.,5*.85,2*.25,6*.1,6*0.,6*.85/   10/13/70
      DATA (WLL(I),I=1,45)/.6,15*.1,4*0.,5*.1,2*.25,6*.1,6*0.,6*.1/      10/13/70
      DATA (VOG(I),I=1,45)/.2,15*.05,4*1.,5*.05,2*.5,6*.8,6*1.,6*.05/    10/13/70
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*9.E04/    10/01/70
      COMPNT = 6HPUREX
      VOLUME = 2000.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      FLOW=FLOWIN
      FLOWIN = FLOW *.999
      DO 200 I=1,LIMIT
      INVSAV(I) = INVOUT(I)
      INV(I) = INVSAV(I) * VOG(I)
  200 CONTINUE
      CALL CONDN2(FLOWIN,INV)
      FLOWIN = FLOW * .0009
      DO 300 I=1,LIMIT
      INV(I) = INVSAV(I)*WLL(I)
  300 CONTINUE
      CALL CTANK(FLOWIN,INV)
      FLOWIN = FLOW* .0001
      DO 400 I=1,LIMIT
      INV(I) = INVSAV(I) * WHL(I)
  400 CONTINUE
      CALL CTANK3(FLOWIN,INV)
      RETURN
```

END

33.

1083259

34

```
@ ELT REPARE,1,711112, 52537

      SUBROUTINE REPARE(AIR,WATER,AIRMFR,SITE,TONLWR,TONFBR)
C     REPARE...REPROCESSING PLANT ALGORITHM FOR RADIONUCLIDE EFFLUENTS
C     THIS SUBROUTINE RECEIVES THE METRIC TONS OF LIGHT WATER AND
C     FAST BREEDER FUEL WHICH NEED TO BE REPROCESSED EACH YEAR.
C     THE NUMBER OF REPROCESSING PLANTS IS DETERMINED BY ALLOCATING
C     THE FUEL AS FOLLOWS...
C     1.  300 TONNES LWR FUEL TO MFR
C     2.  1500 TONNES LWR FUEL INCREMENTS TO BLEACH
C     3.  750 TONNE FBR FUEL INCREMENTS TO BLEACH
C     4.  REMAINING FUEL LOAD IS ASSIGNED TO BLEACH                    12/10/70
C     REPARE UTILIZES BLEACH AND MFR TO DETERMINE THE EFFLUENT RATE
C     IN PICOCURIES/SEC.  THE OUTPUT FROM REPARE CONSISTS OF THE
C     NUMBER OF REPROCESSING PLANTS REQUIRED, THE AIR RELEASES FROM
C     MFR, AND THE LIQUID AND AIR EFFLUENTS FROM THE 'TYPICAL'
C     DUAL-PURPOSE PLANT.
      INTEGER R,W,SITE,SITEF
      INCLUDE DM1,LIST
      INCLUDE DM2,LIST
      DIMENSION WATER(50), AIR(50), CINVL(50), SINVL(50),CINVF(50),
     1   SINVF(50),ISOAIR(50),  ISOWAT(50),ILISTA(50),ILISTW(50),SAIR(50)12/10/70
     2),SWATER(50),SAIRMF(50),AIRMFR(50)
      DATA (ISOTOP(I),I=1,45) /6HH3    ,6HN13   ,6HC14   ,6HNA22  ,      12/23/70
     16HNA24  ,6HAR39  ,6HAR41  ,6HCR51  ,6HMN54  ,6HFE55  ,6HFE59  ,    12/23/70
     26HCO58  ,6HCO60  ,6HNI63  ,6HCU64  ,6HZN65  ,6HKR85M ,6HKR85  ,    12/23/70
     36HKR87  ,6HKR88  ,6HSR89  ,6HSR90  ,6HZR95  ,6HNB95M ,6HMO99  ,    12/23/70
     46HRU103 ,6HRU106 ,6HTE132 ,6HI129  ,6HI131  ,6HI132M ,6HI133  ,    12/23/70
     56HI135M ,6HXE131M,6HXE133M,6HXE133 ,6HXE135 ,6HXE135M,6HXE138 ,    12/23/70
     66HCS134 ,6HCS137 ,6HBA140M,6HLA140 ,6HCE141 ,6HCE144 /              12/23/70
      DATA(K1(I),I=1,45)/-1.793E-09, -1.160E-03, -3.836E-12,-8.454E-09, 12/23/70
     A-1.284E-05, -8.141E-11, -1.052E-04, -2.886E-07, -2.571E-08,       12/23/70
     B-9.158E-09, -1.783E-07, -1.130E-07, -4.196E-09, - 2.389E-10,      12/23/70
     C-1.493E-05, -3.302E-08, -4.376E-05, -2.043E-09, -1.520E-04,       12/23/70
```

```
     D-6.876E-05, -1.585E-07, -7.632E-10, -1.234E-07, -2.292E-07,        12/23/70
     E-2.874E-06, -2.006E-07, -2.198E-08, -2.468E-06, -1.374E-15,        12/23/70
     F-9.966E-07, -8.371E-05, -9.169E-06, -2.874E-05, -6.684E-07,        12/23/70
     G-3.488E-06, -1.522E-06, -7.220E-04, -2.093E-05, -6.796E-04,        12/23/70
     H-1.047E-08, -7.327E-10, -6.267E-07, -4.790E-06, -2.470E-07,        12/23/70
     I-2.815E-08/                                                        12/23/70
      DATA(K2(I),I=1,45)/17*0.,-4.376E-05,5*0.,-1.234E-07,6*0.,          12/23/70
     A-2.468E-06,2*0.,-9.966E-07,2*-9.169E-07,2*-2.874E-05,4*0.,         12/23/70
     B-6.267E-07,2*0./                                                   12/23/70
      DATA(K3(I),I=1,45)/35*0.,-3.488E-06,0.,-7.220E-04,7*0./            12/23/70
      DATA(ILISTA(I),I=1,45)/1,16*0,18,27*0/                             12/10/70
      DATA(ILISTW(I),I=1,45)/29*0,30,15*0/                               12/10/70
      DATA/UNITA/1./UNITW/1./UNITMF/1./SUNITA/1./SUNITW/1./SUNTMF/1./    12/10/70
   65 FORMAT(10X,I3,5X,'REPROCESSING PLANTS ARE REQUIRED')
   66 FORMAT(5X,'REPROCESSING REQUIREMENTS ARE',2X,I2,2X,'PUREX PLANTS
     XAND THE MFR PLANT')
   70 FORMAT(5X,1PE12.4,7X,1PE12.4,9X,1PE12.4)
   71 FORMAT(14X,'AIR',14X,'WATER',14X,'AIR')
   72 FORMAT(8X,'(PCI/SEC)',10X,'(PCI/SEC)',10X,'(PCI/SEC)')
   73 FORMAT(12X,'PUREX',14X,'PUREX',14X,'MFR')
      FUEL = 1.
      R = 5
      W = 6
      SITE = 0
      SITEF = 0
      NONE = 1                                                           01/08/71
      PART = 2                                                           01/08/71
      FULL = 3                                                           01/08/71
      TIME = 1                                                           01/08/71
      PROPT = 3                                                          01/08/71
      LIMIT = 45                                                         01/08/71
      DATAIN = 1                                                         01/08/71
      FLOW = 0.                                                          01/08/71
      NORMAL = 5                                                         01/08/71
      NAMELIST/OPTION/PROPT,LIMIT,DA AIN,FLOW,NORMAL
      READ(R,OPTION)                                                     01/08/71
```


1083261

```
      DO  6 I=1,LIMIT
      CINVL(I) = 0.
      SINVL(I) = 0.
      CINVF(I) = 0.
      SINVF(I) = 0.
    6 CONTINUE
C     FUEL IS ALLOCATED TO MFR AND BLEACH
      IF(TONFBR.LE.750.) SITEF = 1
      IF(TONLWR.LE.300.) GO TO 25
      TONSIN = 300.
      SITE = 1
      CALL MFR(TONSIN)
      DO 8 I=1,LIMIT
      AIRMFR(I) = MFRAIR(I)
    8 CONTINUE
      TONLWR = TONLWR - 300.
   10 IF(TONLWR.LE.1500.) GO TO 30
      TONS = TONLWR
      TONLWR = TONS - 1500.
      TONSIN = 1500.
      SITE = SITE + 1
      CALL BLEACH(TONSIN,FUEL)
      DO 15 I=1,LIMIT
      CINVL(I) = CINVL(I) + CINV(I)
      SINVL(I) = SINVL(I) + SINV(I)
   15 CONTINUE
   20 GO TO 10
   25 SITE = 1
      CALL MFR(TONLWR)
      DO 9 I=1,LIMIT
      AIRMFR(I) = MFRAIR(I)
    9 CONTINUE
      GO TO 40
   30 SITE  = SITE + 1
      CALL BLEACH(TONLWR,FUEL)
      DO 35 I=1,LIMIT
```


1083262

```
      CINVL(I) = CINVL(I) + CINV(I)
      SINVL(I) = SINVL(I) + SINV(I)
   35 CONTINUE
   40 IF(TONFBR.LE.750.) GO TO 50
      FTONS = TONFBR
      TONFBR = FTONS - 750.
      TONSIN = 750.
      SITE = SITE + 1
      FUEL = 2.
      SITEF = SITEF + 1
      CALL BLEACH(TONSIN,FUEL)
      DO 41 I=1,LIMIT
      CINVF(I) = CINVF(I) + CINV(I)
      SINVF(I) = SINVF(I) + SINV(I)
   41 CONTINUE
   45 GO TO 40
   50 SITE = SITE + 1
      FUEL = 2.
      CALL BLEACH(TONFBR,FUEL)
      DO 55 I=1,LIMIT
      CINVF(I) = CINVF(I) + CINV(I)
      SINVF(I) = SINVF(I) + SINV(I)
   55 CONTINUE
      TONSUM = TONLWR + 2. * TONFBR
      IF(TONSUM.GT.1500.) GO TO 58
      SITE = SITE - 1
C                                                                       10/13/70
C***********************************************************************10/13/70
C                    FOR THE YEAR 2000 STUDY ONLY                       10/13/70
      IF(SITE.GT.9) SITE = 9                                            10/13/70
C***********************************************************************10/13/70
C                                                                       10/13/70
   58 M = SITE - 1
      IF(PROPT.EQ.NONE) GO TO 59                                        01/09/71
      WRITE(W,65) SITE
      WRITE(W,66) M
```


1083263

```
      WRITE(W,73)
      WRITE(W,71)
      WRITE(W,72)
   59 CONTINUE                                                          01/08/71
C     CALCULATION OF 'TYPICAL' DUAL-PURPOSE PLANT RELEASES
      DO 60 I=1,LIMIT
      WATER(I) = (CINVF(I) + CINVL(I)) / FLOAT(M)
      AIR(I)   = (SINVF(I) + SINVL(I)) / FLOAT(M)
      IF(PROFT.EQ.NONE) GO TO 61                                        01/08/71
      WRITE(W,70) AIR(I),WATER(I),AIRMFR(I)                             10/01/70
   61 CONTINUE                                                          01/08/71
   60 CONTINUE
      IF(NORMAL.EQ.1) GO TO 75                                          01/08/71
      WATER(0) =0.                                                      11/10/70
      AIR(0)   =0.                                                      11/10/70
      AIRMFR(0)=0.                                                      11/10/70
      DO 165 J=1,LIMIT                                                  12/07/70
      ISOWAT(J) = 6H                                                    12/07/70
      ISOAIR(J) = 6H                                                    12/07/70
  165 CONTINUE                                                          12/07/70
      STOTW = 0.                                                        11/10/70
      STOTA = 0.                                                        11/10/70
      STOTMF= 0.                                                        11/10/70
      TOTW = 0.                                                         12/07/70
      TOTA = 0.                                                         12/07/70
      TOTMFR = 0.                                                       12/07/70
      DO 80 N=1,LIMIT                                                   12/07/70
      TOTW = TOTW + WATER(N)                                            12/07/70
      TOTA = TOTA + AIR(N)                                              12/07/70
      TOTMFR = TOTMFR + AIRMFR(N)                                       12/07/70
   80 CONTINUE                                                          12/07/70
      IA = 1                                                            12/07/70
      DO 100 KI=1,LIMIT                                                 12/07/70
      L = ILISTW(KI)                                                    12/07/70
      IF(L.EQ.0)GO TO 100                                               11/10/70
      ISOWAT(IA) = ISOTOP(L)                                            12/07/70
```


1083264

```
      TOTW = TOTW - WATER(L)                                            11/10/70
      STOTW=STOTW + WATER(L)                                            11/10/70
      SWATER(L) = WATER(L)                                              12/07/70
      WATER(L) = 0.                                                     11/10/70
      IA = IA + 1                                                       12/07/70
  100 CONTINUE                                                          12/07/70
      IB = 1                                                            12/07/70
      DO 800 LI = 1,LIMIT                                               12/07/70
      LL = ILISTA(LI)                                                   12/07/70
      IF(LL.EQ.0)  GO TO 800                                            12/07/70
      ISOAIR(IB) = ISOTOP(LL)                                           12/07/70
      TOTA = TOTA - AIR(LL)                                             11/10/70
      STOTA=STOTA + AIR(LL)                                             11/10/70
      SAIR(LL) = AIR(LL)                                                12/07/70
      AIR(LL)=0.                                                        11/10/70
      TOTMFR = TOTMFR - AIRMFR(LL)                                      11/10/70
      STOTMF = STOTMF + AIRMFR(LL)                                      11/10/70
      SAIRMF(LL) = AIRMFR(LL)                                           12/07/70
      AIRMFR(LL) = 0.                                                   11/10/70
      IB = IB + 1                                                       12/07/70
  800 CONTINUE                                                          12/07/70
      DO 300 I=1,LIMIT                                                  11/10/70
      AIR(I)   =  AIR(I)  *(UNITA / TOTA)                               11/10/70
      WATER(I) = WATER(I) *(UNITW / TOTW)                               11/10/70
      AIRMFR(I)=AIRMFR(I) *(UNITMF/TOTMFR)                              11/10/70
      SAIR(I)  =  SAIR(I) *(SUNITA/STOTA)                               11/10/70
      SWATER(I)=SWATER(I) *(SUNITW/STOTW)                               11/10/70
      SAIRMF(I)=SAIRMF(I) *(SUNTMF/STOTMF)                              11/10/70
  300 CONTINUE                                                          11/10/70
      IF(PROPT.EQ.NONE) GO TO 75                                        01/08/71
      WRITE(W,500)                                                      12/07/70
  500 FORMAT(//,5X,'GROUP A INCLUDES',14X,'GROUP W INCLUDES',/)         12/23/70
      IF(IA.GT.IB) GO TO 501                                            01/08/71
      IC = IB                                                           01/08/71
      GO TO 502                                                         01/08/71
  501 IC = IA                                                           01/08/71
```


1083265

```
  502 DO 520 I=1,IC                                                     01/08/71
      WRITE(W,510) ISOAIR(I),ISOWAT(I)                                  12/07/70
  510 FORMAT(8X,A6,23X,A6,//)                                           12/23/70
  520 CONTINUE                                                          12/07/70
      WRITE(W,530)                                                      12/07/70
  530 FORMAT(16X,'PUREX AIR',20X,'PUREX WATER',20X,'MFR AIR',//,10X,    12/07/70
     A '(NORMALIZED)',20X,'(NORMALIZED)',20X,'(NORMALIZED)')            12/07/70
      WRITE(W,540)                                                      12/07/70
  540 FORMAT(//,5X,'TOTAL MINUS',5X,'GROUP A',10X,'TOTAL MINUS',5X,'GROU12/07/70
     2P W',10X,'TOTAL MINUS',5X,'GROUP A', /,7X,'GROUPA',10X,'ONLY',13X,12/07/70
     3'GROUP W',10X,'ONLY',10X,'GROUP A',10X,'ONLY')                    12/07/70
      DO 600 JJ=1,LIMIT                                                 11/10/70
      WRITE(W,700) AIR(JJ),SAIR(JJ),WATER(JJ),SWATER(JJ),AIRMFR(JJ),    11/10/70
     1SAIRMF(JJ),ISOTOP(JJ)                                             12/07/70
  700 FORMAT(6(4X,1PE12.4),5X,A6)                                       12/07/70
  600 CONTINUE                                                          11/10/70
   75 CONTINUE
 9999 RETURN
      END
```


1083266

```
@ ELT SCRBF2,1,711112, 52584

      SUBROUTINE SCRBF2(FLOWIN,INV)
C     CELL OFF-GAS CAUSTIC SCRUBBER                                     10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45)/2*1.,14*.5,4*1.,5*.99,2*.9,12*1.,6*.999/       10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 6HSCRBF2
   10 VOLUME =  1750.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL FLTRF1(FLOWIN,INV)
      RETURN
      END
```


1083261

1083268

```
@ ELT SCRUBF,1,711112, 52585

      SUBROUTINE SCRUBF(FLOWIN,INV)
C     DISSOLVER OFF-GAS CAUSTIC SCRUBBER                                10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT,INVST1,INVST2
      DIMENSION INV(50),INVOUT(50),INVST1(50),INVST2(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45)/2*1.,14*.5,4*1.,5*.99,2*.5,12*1.,6*.999/       10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = 8HSCRUBF
      VOLUME =  1000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INVST1(I) = INVOUT(I) * (1. - EFF(I))
      INVST2(I) = INVOUT(I) * EFF(I)
  100 CONTINUE
      FLOW = FLOWIN
      CONST6 = 0.5
      FLOWIN = FLOW * CONST6
      DO 400 I=1,LIMIT
      INV(I) = INVST1(I)
  400 CONTINUE
      CALL ACCUM2(FLOWIN,INV)
      FLOW = FLOWIN
      CONST7 = 0.5
      FLOWIN = FLOW * CONST7
      DO 300 I=1,LIMIT
      INV(I) = INVST2(I)
  300 CONTINUE
      CALL SILVRF(FLOWIN,INV)
```

```
33.          RETURN
34.          END
```

10832b9

```
@ ELT SCRUBR,1,711112, 52586

      SUBROUTINE SCRUBR(FLOWIN,INV)
C     DISSOLVER OFF-GAS TRAIN CAUSTIC SCRUBBER
      INCLUDE DM1,LIST
      REAL INV,INVOUT,INVSAV
      DIMENSION INV(50),INVOUT(50),INVSAV(50)
      DIMENSION EFF(50),C1(50),C2(50),SR(50),H(50),TIMEIN(50)          10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                       10/13/70
      DATA (C2(I),I=1,45)/45*.0/
      DATA(SR(I),I=1,45)/2*1.,14*.5,4*1.,5*.5,2*0.010,6*.05,6*1.,6*.5/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/  10/01/70
      COMPNT = 6HSCRUBR
      ICHECK = 1
      GO TO 10
C     CELL OFF-GAS TRAIN CAUSTIC SCRUBBER
      ENTRY SCRUB2(FLOWIN,INV)
      COMPNT = 6HSCRBR2
      ICHECK = 2
   10 VOLUME = 750.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      H(I) = SR(I)                                                     10/13/70
      EFF(I) = C1(I) - C2(I)*LOAD
      INVSAV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      IF(ICHECK.EQ. 1) GO TO 220
      DO 200 I=1,LIMIT
      INV(I) = INVSAV(I) * H(I)
  200 CONTINUE
      CALL HEATER(FLOWIN,INV)
      DO 300 I=1,LIMIT
      INV(I) = INVSAV(I) * (1. - H(I))
```

```
  300 CONTINUE
      GO TO 230
  220 DO 400 I=1,LIMIT
      INV(I) =,INVSAV(I) * SR(I)
  400 CONTINUE
      CALL SILVER(FLOWIN,INV)
      DO 500 I=1,LIMIT
      INV(I) = INVSAV(I) * (1. - SR(I))
  500 CONTINUE
  230 CALL CTANK(FLOWIN,INV)
      RETURN
      END
```


10832711

1083272

```
@ ELT SFILTR,1,711112, 52588

      SUBROUTINE SFILTR(FLOWIN,INV)
C     DEEP-BED SAND FILTER                                                10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                          10/01/70
      DATA(C1(I),I=1,45)/2*0.,14*.9999,4*0.,2*.9999,5*.9999,6*.9,6*0.,    10/17/70
     X6*.9999/                                                            10/17/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/     10/01/70
      COMPNT = EHSFILTR
      VOLUME = 10000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL STACKF(FLOWIN,INV)
      RETURN
      END
```

10832713

```
@ ELT SILVER,1,711112, 52589

      SUBROUTINE SILVER(FLOWIN,INV)
C     DISSOLVER OFF-GAS SILVER REACTOR                                  10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/70
      DATA(C1(I),I=1,45)/2*0.,14*.1,4*0.,5*.1,2*0.,6*.950,6*0.,6*.1/    10/13/70
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      DATA (C2(I),I=1,45)/45*.0/
      COMPNT = 6HSILVER
      VOLUME = 750.
      CALL DELAY(VOLUME,FLOWIN,INV,  INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I)*(1.-EFF(I))
  100 CONTINUE
      CALL PFILTR(FLOWIN,INV)
      RETURN
      END
```

1083274

```
@ ELT SILVRF,1,711112, 52590

      SUBROUTINE SILVRF(FLOWIN,INV)
C     DISSOLVER OFF-GAS TRAIN SILVER REACTOR                                10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                            10/01/70
      DATA(C1(I),I=1,45)/2*0.,14*.1,4*0.,5*.1,2*.1,6*.950,6*0.,6*.1/        10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/       10/01/70
      COMPNT = 6HSILVRF
      VOLUME=3000.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL FLTRF2(FLOWIN,INV)
      RETURN
      END
```

10832175

```
@ ELT STACK,1,711112, 52591

      SUBROUTINE STACK(FLOWIN,INV)
      INTEGER W
      REAL INV
      INCLUDE DM1,LIST
      DIMENSION INV(50)
    5 FORMAT('CFLOW = ',1PE10.4,'FROM STACK')
   10 FORMAT(' INVENTORY FOR ISOTOPE NUMBER',I3,' = ', 1PE12.4)
  500 FORMAT(8X,'ROUTINE',12X,'FLOWIN',10X,'DELAY',8X,'INV(1)',8X,        12/21/70
     A'INV(18)',10X,'INV(22)',8X,'INV(30)',9X,'INV(45)'//)                12/21/70
      W = 6
      DO 200 I=,LIMIT
      SINV(I) = SINV(I) + INV(I)
  200 CONTINUE
      IF(PROPT.EQ.NONE) GO TO 600
      IF(PROPT.EQ.PART) GO TO 600
      PRINT 5,FLOWIN
      DO 100 I=1,LIMIT
      PRINT 10,I,INV(I)
  100 CONTINUE
      SFLOW = SFLOW + FLOWIN
      WRITE(W,500)
  600 CONTINUE
      RETURN
      END
```

```
@ ELT STACKF,1,711112, 52592

      SUBROUTINE STACKF(FLOWIN,INV)
      INTEGER W
      INCLUDE OMI,LIST
      REAL INV
      DIMENSION INV(50)
    5 FORMAT('CFLOW = ',1PE10.4,'FROM STACK')
   10 FORMAT(' INVENTORY FOR ISOTOPE NUMBER',I3,' = ',1PE12.4)
  500 FORMAT(8X,'ROUTINE',12X,'FLOWIN',10X,'DELAY',8X,'INV(1)',8X,      12/21/70
     A'INV(18)',10X,'INV(22)',8X,'INV(30)',9X,'INV(45)'//)              12/21/70
      W = 6
      DO 200 I=,LIMIT
      SINV(I) = SINV(I) + INV(I)
      MFRAIR(I) = SINV(I)
  200 CONTINUE
      SFLOW = SFLOW + FLOWIN
      IF(PROPT.EQ.NONE)GO TO 600
      IF(PROPT.EQ.PART)GO TO 600
      PRINT 5,FLOWIN
      DO 100 I=1,LIMIT
      PRINT 10,I,INV(I)
      SINV(I) = SINV(I) + INV(I)
      MFRAIR(I) = SINV(I)
  100 CONTINUE
      WRITE(W,500)
  600 CONTINUE
      RETURN
      END
```

1083277

```
@ ELT TANK1,1,711112, 52593

      SUBROUTINE TANK1(FLOWIN,INV)
      INCLUDE CM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                        10/01/
      DATA(C1(I),I=1,45) /45*.0/                                        10/13/
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/   10/01/70
      COMPNT = EHTANK1
      VOLUME =  1500.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL CALCIN(FLOWIN,INV)
      RETURN
      END
```

10832 78

```
@ ELT TANK2,1,711112, 52594

      SUBROUTINE TANK2(FLOWIN,INV)
C     LOW-LEVEL LIQUID WASTE CATCH TANK                                  10/17/70
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)                         10/01/70
      DATA(C1(I),I=1,45) /45*.0/                                         10/13/70
      DATA(C2(I),I=1,45) /45*.0/
      DATA (TIMEIN(I),I=1,45)/0.,15*8.E04,4*0.,13*8.E04,6*0.,6*8.E04/    10/01/70
      COMPNT = 6HTANK2
      VOLUME =  1500.
      CALL DECAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      CALL BLENDR(FLOWIN,INV)
      RETURN
      END
```

```
@ ELT VOLOXR,1,711112, 52595

      SUBROUTINE VOLOXR(FLOWIN,INV)
C  PROPOSED  PRE-DISSOLUTION OXIDIZER FOR FBR PLANTS
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)
      DATA(TIMEIN(I),I=1,45)/45*0./
      DATA(C1(I),I=1,45)/45*0./
      DATA(C2(I),I=1,45)/45*0./
      COMPNT = 6HVOLOXR
      VOLUME = 500.
      CALL DELAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN / VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I) * LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      RETURN
      END
```


1083279

1083280

```
@ ELT XTRADF,1,711112, 52596

      SUBROUTINE XTRADF(FLOWIN,INV)
C  ADDITIONAL DECONTAMINATION FACTORS REQUIRED FOR FBR FUEL PROCESSING
      INCLUDE DM1,LIST
      REAL INV,INVOUT
      DIMENSION INV(50),INVOUT(50)
      DIMENSION EFF(50),C1(50),C2(50),TIMEIN(50)
      DATA(C1(I),I=1,45)/45*0./
      DATA(C2(I),I=1,45)/45*0./
      DATA(TIMEIN(I),I=1,45)/45*0./
      COMPNT = 6HXTRADF
      VOLUME = 500.
      CALL DELAY(VOLUME,FLOWIN,INV,INVOUT,COMPNT,TIMEIN)
      LOAD = FLOWIN/VOLUME
      DO 100 I=1,LIMIT
      EFF(I) = C1(I) - C2(I)*LOAD
      INV(I) = INVOUT(I) * (1. - EFF(I))
  100 CONTINUE
      RETURN
      END

END CUR
```

FIGURE Code Listing

1083281

1083282

```
@ ELT FIGURE,1,711113, 30051

      C
      C          PROGAM FIGURE
      C
            DIMENSION  KSDAK(34)
            DATA (KSDAK(I),I=1,34)/214,213,214,210,214,213,214,213,208,211,209
           1,213,212,214,212,214,212,213,215,215,213,213,215,215,215,215,1,215
           2,212,213,213,215,215,208/
      C
            DIMENSION KNEBR(52)
            DATA (KNEBR(I),I=1,52)/2,218,218,218,219,220,11,219,221,216,219,3,
           1219,4,5,221,217,218,218,6,18,218,218,221,13,219,7,8,17,218,15,221,
           212,14,219,216,220,16,217,9,220,220,218,219,221,219,218,10,219,221,
           3218,220/
      C
            DIMENSION KANSAS(27)
            DATA (KANSAS(I),I=1,27)/227,19,224,222,225,225,222,20,223,21,27,29
           14,225,22,23,227,225,223,225,226,28,225,24,25,29,225,26/
      C
            DIMENSION KMINN(68)
            DATA (KMINN(I),I=1,68)/132,114,111,264,126,125,265,133,119,137,257
           1,261,257,121,260,256,261,142,130,260,264,117,143,265,257,265,263,2
           266,258,136,123,263,262,118,261,258,257,135,131,263,122,262,128,256
           3,266,262,264,116,140,139,124,263,120,257,259,112,127,264,264,134,2
           460,265,141,115,261,129,113,138/
      C
            DIMENSION KIOWA(99)
            DATA (KIOWA(I),I=1,99)/103,108,83,295,99,91,64,250,63,248,79,249,2
           150,250,10[illegible],89,58,78,247,255,75,85,68,250,101,254,255,86,71,246,67,
           2246,84,247,249,109,250,249,100,249,246,249,97,96,247,81,253,92,88,
           362,251,66,87,251,246,72,65,94,253,[illegible]52,104,251,251,61,106,247,253,2
           45[illegible],197,70,74,[illegible]52,11[illegible],7[illegible],77,30,60,56,251,2[illegible],[illegible],[illegible]9,96,73,59,90,255
           5,[illegible]96,254,[illegible]5,1[illegible]5,93,2[illegible]3,[illegible]7,246,82,5[illegible],297,243/
```

```
C
      DIMENSION KMO(84)
      DATA (KMO(I),I=1,84)/229,228,237,230,241,241,30,31,238,48,241,34,2
     138,32,241,238,50,35,231,33,232,243,241,241,240,240,243,46,41,235,2
     240,229,240,233,241,237,238,36,43,233,239,236,232,239,52,229,229,23
     39,244,38,240,234,47,239,245,241,228,49,298,39,235,230,37,241,42,24
     40,51,230,231,241,40,44,45,54,232,239,239,239,240,299,53,243,240,24
     52/
C
      DIMENSION KWISC(43)
      DATA (KWISC(I),I=1,43)/271,267,272,273,157,269,149,162,151,150,156
     1,144,164,167,165,271,152,271,148,166,268,268,145,160,273,159,158,2
     267,147,273,163,153,273,155,300,273,273,270,161,273,154,273,146/
C
      DIMENSION KILL(74)
      DATA (KILL(I),I=1,74)/189,204,289,170,293,274,286,277,282,192,198,
     1  173,288,289,278,206,186,287,180,281,292,177,278,203,207,195,277,
     2181,179,182,178,175,278,276,196,185,171,188,193,194,199,279,284,28
     33,280,200,289,190,288,172,202,183,288,287,275,201,176,191,197,293,
     4285,289,279,168,187,291,280,290,174,205,169,184,301,302/
C NEXT IS FOOD CONSUMPTION DATA -  ALL IN POUNDS PER WEEK EXCEPT EGGS
C     WHICH IS IN DOZENS PER WEEK    -  ALL PER HOUSEHOLD
C
C ** INDEX  =  3 - RUF   RURAL  FARM
C           =  2 - RNF   RURAL NON-FARM
C           =  1 - URB   URBAN
C
      DIMENSION FOCON(3,35)
      DATA (FOCON(3,J),J=1,35)/ 1.29,  .12, 3.29, 3.83, 1.28, 2.07,  .28
     1, 3.14,10.77, 9.23,  .63, 1.96,  .17, 2.39,  .10, 4.91, 4.03, 1.39
     2,  .24,14.18,25.30, 5.23, 1.01, 3.72, 8.65, 2.00, 4.84, 2.50, .023
     3,  .40,  .05,  .10,  .22, .047,31.77/
C
      DATA (FOCON(2,J),J=1,35)/ 1.02,  .13, 2.26, 3.61,  .94, 1.61,  .29
     1, 2.81,12.37, 6.41,  .73, 1.68,  .19, 2.22,  .11, 3.64, 4.06, 1.02
     2,  .26,11.40,21.10, 4.15,  .50, 2.84, 6.22, 3.78, 4.15, 2.31, .017
```


1083283

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1083284

```
      3,  .45,  .09,  .05,  .21, .033,33.43/
C
       DATA (FOCON(1,J),J=1,35)/  .42,  .07, 1.88, 3.94, 1.61, 1.51,  .24
      1, 3.02,12.25, 4.92,  .72, 1.56,  .23, 2.15,  .16, 2.88, 3.99,  .83
      2,  .32, 9.92,19.18, 3.81,  .50, 2.53, 6.29, 3.91, 4.00, 2.74, .007
      3,  .45,  .06,  .05,  .12, .003,32.86/
C
C
C NEXT IS FAMILY SIZE
C      3.5 = URBAN
C      3.5 = RURAL NON-FARM
C      3.9 = RURAL FARM
C
       DIMENSION FSIZE(3)
       DATA (FSIZE(I),I=1,3)/ 3.5,3.5,3.9/
C
C
C NEXT IS FOR CENTROID LATITUDE AND LONGTITUDE  LOC(302,2)
C      FOOD SURPLUS OR DEFICIT   SURDEF(302,35)
C      FOOD PRODUCED   FOPRO(302,35)                LAST 2 ARE CHICAGO
C
       DIMENSION  LOC(302,2),SURDEF(302,35),FOPRO(302,35)
       DIMENSION FOUSE(302,35)
C
C NEXT IS PERCENT HOME PRODUCED
C
       DIMENSION HOME(3,35)
       DATA (HOME(1,I),I=1,35)/ 32*0.,3*1.00/
       DATA (HOME(2,I),I=1,35)/ .50, .00, .31, .00, .11,2*.00, .02, .00,
      1 .11, .00, .24, .00, .14, .00, .48,4*.00, .07, .00, .04, .08,3*.00
      2, .12,4*.00,3*1.00/
       DATA (HOME(3,I),I=1,35)/ .77, .00, .50, .00, .08,2*.00, .04, .00,
      1 .16, .00, .38, .00, .29, .00, .76,4*.00, .56, .04, .15, .41, .64,
      2 .62,      .19, .46,4*.00,3*1.00/
C
C NEXT CENTROID POPULATION  IPOP(302)  TO NEAREST 100
```

```
C
      DIMENSION IPOP(302)
      DATA (IPOP(I),I=1,50)/  865,  289,  122,  325, 3435,  358, 1553,
     1      251,  313,  121,  178,  165,   63,   54,   91,  139,   84,
     2       87,  209,  437,  288, 1438,  485,  419, 1413, 1855,  103,
     3      120,   66,  552,  906,  297,  408,  420,  875, 6227,  234,
     4      295,  351,  530,  446,  466,  664, 7035, 7500,  365,  105,
     5      239,  109,   87/
      DATA (IPOP(I),I=51,100)/       81,  148,   88,  121, 1078,  831,
     1      478,  499,  493, 2663,  380,  352,  211, 1225, 1369,  537,
     2      800,  551, 1191,  338,  446,  442,  264,  188,  185,  147,
     3      239,  186,  212,  142,  132,  217,  160,  286,  220,  185,
     4      207,  208,  178,  214,  234,  164,  194,  103,  461,  182,
     5      176,  158,  109,  136/
      DATA (IPOP(I),I=101,150)/     241,  179,  109,  123,  208,  130,
     1      145,   75,  103,  210,  173,  803,  299,  859,  524, 4225,
     2     8429,  244,  214,  219,  783,  231,  199,  390,  277,  444,
     3      250,  655,  409,  379,  485,  122,  279,  231,  266,  133,
     4      163,  155,  232,  217,  160,  238,  166,  583,  889,  591,
     5      370,  725,  367,  632/
      DATA (IPOP(I),I=151,200)/    2221,  501, 1139,  524,  291,  262,
     1      451,  225,   73,  312,  257,  164,  177,  444,  196,  181,
     2      259,  462, 2098,  203,  842,  381,  517,  599,  387, 1510,
     3      493, 1108,  175,  224,  921,  613, 1890,  246,  289,  420,
     4      998,  839,  685,  366, 1465,  372, 1183,  435,  170, 2247,
     5     2625,  240,  393,  155/
      DATA (IPOP(I),I=201,250)/     300,  192,  422,  161,  461,  393,
     1      323,  283,  167,  200,  202,  362,  772,  446,  836,  352,
     2      394,  775,  891,  621,  533,  228,  394,  161,  813,  129,
     3      173,  333,  649,  648,  277,  659,  482,  138,  376,  190,
     4      171,  463,  653,  626,  960,  142,  374,   73,  111,  805,
     5      629,  223, 1091, 1173/
      DATA (IPOP(I),I=251,302)/    1001,  245,  242,  190,  681,  703,
     1      865,  489,  162,  633,  813,  596,  518,  559,  769,  215,
     2      592,  422,  315,  234,  402,  142, 1074,  376,   46,  337,
     3      413,  905,  215,  387,  246,  145,   92,  152,   64,   59,
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```
      4      380,  458,  687,  135,  176,   82,  149,  113,  160,  137,
      5      103,  146,  205,  362,51297, 3135/
C
C STATE LOCATOR    ,
C
      DIMENSION KWHAT(8)
      DATA (KWHAT(I),I=1,8)/50,14,26,16,24,42,28,17/
C
C
C FOOD PRODUCTION CONVERSION CARDS WILL HAVE LINK BETWEEN FOOD
C      PRODUCTION AND FOOD TYPE FOR TAPE
C      *** THERE ARE 42 CARDS TO BE READ
C
C     KFOTP(42) IS TAPE NUMBER FOOD
C     KFOPRD(42) IS PRODUCTION NUMBER FOOD
C     KFOSTE(8,42)IS CONVERSION FACTOR BY STATE (8) AND TYPE (42)
C
      DIMENSION KFOTP(42),KFOPRD(42), FOSTE(8,42)
      DIMENSION  KFOOD(500)
C
C
C THIS NEXT IS CENTROID CLASSIFICATION
C      1 = URBAN              URB
C      2 = RURAL NON-FARM     RNF
C      3 = RURAL FARM         RUF
C
      DIMENSION ID(302)
      DATA (ID(I),I=1,302)/ 9*1, 3*2, 3*3,   2, 2*3, 8*1, 3*3,17*1, 2*2,
     1  3*3,   2,   3,   2,18*1, 7*2,   3,14*2,   1,   2,   3,   2, 2*3,
     2  2*2, 2*3, 3*2, 2*3,   2,21*1,   3, 3*2,   3,   2, 2*3, 2*2, 2*3,
     3 11*1,13*2,40*1, 4*2, 4*3, 2*2, 4*3, 3*2, 3*3, 9*2, 9*3, 6*2, 4*3,
     4  7*2, 4*3, 4*2, 3*3, 2*2,   1,17*2,   3, 2*2,   3, 3*2, 2*1/
C
C
  100 FORMAT(I2,I3,15X,8F5.0)
  105 FORMAT(3X,2I4,5X,2I4,5X,2I4,5X,2I4,5X,2I4,5X,2I4,4X )
```


1083286

```
  110 FORMAT(I2,I3,2X,7I10/(7X,7I10) )
      LV = -4
      DO 5 I=1,8
      DO 5 J=1,42
    5 FOSTE(I,J) = 0.
C
C FIRST READ FOOD CONVERSION FACTORS FOR FOOD PRODUCED
C
      DO 10 I= 1,42
      READ (5,100)KFOTP(I),KFOPRD(I),( FOSTE(J,I),J=1,8)
   10 CONTINUE
C
C NEXT READ CENTROID LATITUDE AND LONGTITUDE
C
      READ (5,105)((LOC(I,J),J=1,2),I=1,300)
      LOC(301,1) = 4252
      LOC(301,2) = 8738
      LOC(302,1) = 4252
      LOC(302,2) = 8738
C
C NEXT FIND OUT HOW MUCH FOOD REQUIRED
C     THE REQUIRED ARRAY WILL BE REDUCED BY HOME PRODUCED WHEN
C     FIGURING DEFICIT OR SURPLUS  BECAUSE TOTAL FOOD PRODUCTION IS
C     WHAT WAS PRODUCED FOR SALE
C
      DO 20 I=1,302
      J = ID(I)
      DO 18 K=1,35
      FEAT = FOCON(J,K) * 52.
      FOUSE(I,K)=(FEAT-(FEAT*HOME(J,K)))*((IPOP(I)*100.)/FSIZE(J))
   18 CONTINUE
   20 CONTINUE
C
C NEXT READ IN FOOD PRODUCED
C
   22 READ (5,110) KST,KNO
```


1083287

```
      IF (KST .EQ. 98) GO TO 50
   23 READ (5,110) KSTA,KFP,(KFOOD(J),J=1,KNO)
      IF (KSTA .EQ. 0) GO TO 22
      DO 25 I=1,8
      IF (KSTA .EQ. KWHAT(I))GO TO 26
   25 CONTINUE
      GO TO 23
   26 CONTINUE
C THAT WILL FIND WHAT STATE WE ARE IN
C
C  ***  I  IS NOW THE STATE INDEX FOR PRODUCTION CONVERSION KFOSTE(I,42)
C              NOW FIND FOOD
      DO 27 J=1,42
      IF(KFP .EQ. KFOPRD(J)) GO TO 28
   27 CONTINUE
  200 FORMAT(1H ,'DID NOT FIND A FOOD TYPE.  KSTA = ',I2,' KFP = ',I3 )
      WRITE (6,200)KSTA,KFP
      GO TO 23
   28 CONTINUE
C
C NOW WE KNOW STATE AND FOOD    I = STATE   J = FOOD
C
C  NEXT CONVERT TO POUNDS AND STORE IN FOPRO(302,35)
C
      M = KFOTP(J)
      GO TO (30,32,34,36,38,40,42,44), I
   30 DO 31 L=1,43
      K = KWISC(L)
   31 FOPRO(K,M) = FOPRO(K,M) + (KFOOD(L) * FOSTE(I,J) )
      GO TO 23
   32 DO 33 L=1,74
      K = KILL(L)
   33 FOPRO(K,M) = FOPRO(K,M) + (KFOOD(L) * FOSTE(I,J) )
      GO TO 23
   34 DO 35 L=1,84
      K = KMO(L)
```


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```
   35 FOPRO(K,M) = FOPRO(K,M) + (KFOOD(L) * FOSTE(I,J) )
      GO TO 23
   36 DO 37 L=1,99
      K = KIOWA(L)
   37 FOPRO(K,M) = FOPRO(K,M) + (KFOOD(L) * FOSTE(I,J) )
      GO TO 23
   38 DO 39 L=1,68
      K = KMINN(L)
   39 FOPRO(K,M) = FOPRO(K,M) + (KFOOD(L) * FOSTE(I,J) )
      GO TO 23
   40 DO 41 L=1,34
      K = KSDAK(L)
   41 FOPRO(K,M) = FOPRO(K,M) + (KFOOD(L) * FOSTE(I,J) )
      GO TO 23
   42 DO 43 L=1,52
      K = KNEBR(L)
   43 FOPRO(K,M) = FOPRO(K,M) + (KFOOD(L) * FOSTE(I,J) )
      GO TO 23
   44 DO 45 L=1,27
      K = KANSAS(L)
   45 FOPRO(K,M) = FOPRO(K,M) + (KFOOD(L) * FOSTE(I,J) )
      GO TO 23
C
C  NOW DONE WITH FOOD PRODUSTION        $$  NEXT DEFICIT OR SURPLUS
C
   50 DO 55 I=1,35
      DO 55 J=1,302
      DIFF = FOPRO(J,I)/FOUSE(J,I)
      IF (DIFF .GT. 1.1 .OR. DIFF .LT. .9) SURDEF(J,I) = FOPRO(J,I) -
     1 FOUSE(J,I)
   55 CONTINUE
C
C
      DO 60 I=1,302
      K = I
      WRITE (6,115) K
```


1083289

```
  115 FORMAT(1H1,16HCENTROID NUMBER ,I3)
      DO 60 J=1,35
      WRITE(6,120)  J, FOPRO(I,J), FOUSE(I,J), SURDEF(I,J)
  120 FORMAT(1H ,10HFOOD TYPE ,I2,6X,F20.1,6X,F20.1,6X,F20.1)
      L = J
      IF(L.EQ.2.OR.L.EQ.4)  GO TO 65
      IF(L.EQ.11.OR.L.EQ.13)  GO TO 65
      IF(L.EQ.15.OR.L.EQ.17)  GO TO 65
      IF(L.EQ.22.OR.L.EQ.27)  GO TO 65
      GO TO 60
   65 TOTAL = SURDEF(I,J) + SURDEF(I,J-1)
      WRITE(6,125)  TOTAL
  125 FORMAT(1H ,90X,F20.1)
   60 CONTINUE
C
C NEXT GET READY FOR PUNCHING CARDS     FIRST GET HOME PRODUCED BACK IN
C
      DO 75 J=1,28
      GO TO (69,75,69,75,69,75,75,75,75,69,75,69,75,69,75,69,75,69,75,69
     1,69,75,69,69,69,69,75,69),J
   69 DO 70 I=1,302
      K = ID(I)
      IF (K.EQ. 1) GO TO 70
      FOUSE(I,J) = FOUSE(I,J)/(1.0 - HOME(K,J))
   70 CONTINUE
   75 CONTINUE
C
C HOME PRODUCED ADDED TO PRODUCED AND CONSUMED
C
C NOW USE FRESH FOR PROCESSED IF FRESH HAS A SURPLUS AND PUNCH
C
      DO 80 J=1,28
      K = J
      IF (K.GT.5.AND.K.LT.10.OR.K.EQ.19) GO TO 80
      DO 79 I=1,302
      IF (SURDEF(I,J) .LT. 0.0) GO TO 79
```

```
      IF (K.EQ.1.OR.K.EQ.3.OR.K.EQ.10.OR.K.EQ.12) GO TO 76
      IF (K.EQ.14.OR.K.EQ.16.OR.K.EQ.21.OR.K.EQ.26) GO TO 76
      GO TO 78
   76 FOOL = SURDEF(I,J) + SURDEF(I,J+1)
      IF (FOOL .GT. 0.0) GO TO 77
      SURDEF(I,J+1) = SURDEF(I,J+1) + SURDEF(I,J)
      SURDEF(I,J) = 0.
      GO TO 79
   77 SURDEF(I,J) = SURDEF(I,J) + SURDEF(I,J+1)
      SURDEF(I,J+1) = 0.
   78 IF (SURDEF(I,J) .LT. 0.) WRITE (1,800)I,J,FOUSE(I,J),SURDEF(I,J)
  800 FORMAT(I3,6X,I2,6X,F20.1,6X,F20.1)
      IF (SURDEF(I,J) .GT. 0.) WRITE (1,800)I,J,FOUSE(I,J),SURDEF(I,J)
   79 CONTINUE
   80 CONTINUE
      END FILE 1
      CALL EXIT
      END

  END CUR
```


108329

378

TRANS Code Listing

1083292

1083293

```
) ELT TRANS,1,711113, 30047

      C
      C       PROGRAM TRANS
      C
              DATA LUI /5/, LUO /6/
              DIMENSION TITLE(12)
              DIMENSION CTR(325), X(325)
              INTEGER CTR
              DIMENSION DLT(325), MLT(325), DLN(325), MLN(325)
              REAL NAUT
              DIMENSION NAUT(25000)
              DATA ZIP /0.0/
              INTEGER DLT, MLT, DLN, MLN
              DIMENSION LD(325), LS(325)
              INTEGER PRCT
              INTEGER TO, PR, FR
              DIMENSION TO(1500), PR(1500), FR(1500)
              DATA LUT /13/
              LOGICAL TAPE
              INTEGER FT
              DIMENSION XD(325)
              DIMENSION MAP(1000)
              LOGICAL MINI
              DATA LUZ /8/
              DATA LPT /5/
              DATA NINE /999/
              LOGICAL FLIP
      C
              CALL ETIME
              READ (LUI,5) (TITLE(I), I = 1,12)
            5 FORMAT(12A6)
              WRITE (LUO,10)
           10 FORMAT(2H1)
```

```
      WRITE (LUO,5) (TITLE(I), I = 1,12)
      WRITE (LUO,15)
   15 FORMAT(1H0)
   20 FORMAT(12I6)
   25 FORMAT(6I12)
   30 FORMAT(6F12.2)
   35 FORMAT(4(6X, I6, F12.2))
   40 FORMAT(I6, 6X, F12.2, 6X, I6, 6X, I6)
      READ (LUI,20) NFT
      READ (LUI,45) TAPE
      READ (LUI,45) MINI
   45 FORMAT(L5)
      IF (TAPE) LPT = 1
      IF (TAPE) WRITE (LUT,5) (TITLE(I), I = 1,12)
      READ (LUI,30) DIST
C
      K = 0
      READ (LUI,55) NCTR
   50 CONTINUE
      K = K + 6
      J = K - 5
      READ (LUI,55) ((CTR(I), DLT(I), MLT(I), DLN(I), MLN(I)), I = J,K)
   55 FORMAT(6(I3, 2I2, 2I2, 2X))
      IF (K .LT. NCTR) GO TO 50
      WRITE (LUO,10)
      WRITE (LUO,20) NCTR
      WRITE (LUO,15)
      DO 60 I = 1,NCTR
      IF (CTR(I) .EQ. NINE) CTR(I) = NCTR
      WRITE (LUO,25) CTR(I), DLT(I), MLT(I), DLN(I), MLN(I)
   60 CONTINUE
C
  900 CONTINUE
      WRITE (LUO,10)
      CALL ETIMEI(NSEC)
      WRITE (LUO,20) NSEC
```


1083294

```
      WRITE (LUO,15)
      I = 0
  100 CONTINUE
      I = I + 1
      READ (LPT,105) CTR(I), FT, XD(I), X(I)
      IF (CTR(I) .EQ. NINE) CTR(I) = NCTR
      IF (CTR(I) .EQ. NINE) X(I) = ZIP
      IF (I .EQ. 1) LT = FT
  105 FORMAT(I3, 6X, I2, 6X, F20.1, 6X, F20.1)
  106 FORMAT(I6, 6X, I2, 6X, F20.1, 6X, F20.1)
      IF (CTR(I) .EQ. 0) GO TO 110
      LP = CTR(I)
      MAP(LP) = I
      WRITE (LUO,106) CTR(I), FT, XD(I), X(I)
      GO TO 100
  110 CONTINUE
      FT = LT
      NT = I - 1
C
      XX = 0.0
      DO 120 I = 1,NT
      XX = XX + X(I)
  120 CONTINUE
      WRITE (LUO,15)
      WRITE (LUO,31) XX
   31 FORMAT(F20.2)
C
      IL = 0
      XX = 6.2832 / 360.0
      XY = 1.0 / 60.0
      XZ = 21600.0 / 6.2832
      ILJL = 0
C
C      I IMPLIES DEFICIT
C      J IMPLIES SURPLUS
C
```


1083295

```
      DO 200 K = 1,NT
      IF (X(K) .GT. ZIP) GO TO 200
      IL = IL + 1
      LD(IL) = CTR(K)
      I = CTR(K)
      JL = 0
      DO 190 L = 1,NT
      IF (X(L) .LE. ZIP) GO TO 190
      JL = JL + 1
      LS(JL) = CTR(L)
      J = CTR(L)
      PLTI = FLOAT(DLT(I)) + FLOAT(MLT(I)) * XY
      PLTI = PLTI * XX
      PLNI = FLOAT(DLN(I)) + FLOAT(MLN(I)) * XY
      PLNI = PLNI * XX
      PLTJ = FLOAT(DLT(J)) + FLOAT(MLT(J)) * XY
      PLTJ = PLTJ * XX
      PLNJ = FLOAT(DLN(J)) + FLOAT(MLN(J)) * XY
      PLNJ = PLNJ * XX
      DN = ABS(PLNJ - PLNI)
      DQ = (1.0 - PLTJ ** 2 / 2.0) * (DN - DN ** 3 / 6.0)
      DR = DQ + DQ ** 3 / 6.0
      DU = (1.0 - DN ** 2 / 2.0) / (PLTJ + PLTJ ** 3 / 3.0)
      TU = 1.0 / DU
      IF (TU ** 2 .LT. 1.0) DV = TU - TU ** 3 / 3.0
      IF (TU ** 2 .GT. 1.0) DV = 1.57 - 1.0 / TU
      TU = PLTI - DV
      DC = (1.0 - DR ** 2 / 2.0) * (1.0 - TU ** 2 / 2.0)
      TU = SQRT(1.0 - DC ** 2)
      DD = TU + TU ** 3 / 6.0
      TEST = DD * XZ
      ILJL = ILJL + 1
      IF (ILJL .EQ. 25000) STOP 2
      NAUT(ILJL) = TEST
  190 CONTINUE
      JT = JL
```


1083296

```
  200 CONTINUE
      IT = IL
C
      IF (MINI) GO TO 710
      WRITE (LUO,10)
      DO 220 I = 1,IT
      WRITE (LUO,15)
      WRITE (LUO,25) LO(I)
      DO 210 J = 1,JT
      JZ = (I - 1) * JT + J
      WRITE (LUO,35) LS(J), NAUT(JZ)
  210 CONTINUE
  220 CONTINUE
      WRITE (LUO,10)
  710 CONTINUE
C
      FLIP = .FALSE.
      XX = 0.0
      IC = 0
      IK = 0
      LZ = IT * JT
  250 CONTINUE
      IF (FLIP) GO TO 965
      ZZ = 10000.0
      DO 300 I = 1,IT
      DO 290 J = 1,JT
      K = I
      L = J
      KL = (I - 1) * JT + J
      IF (NAUT(KL) .GT. ZZ) GO TO 290
      IF (NAUT(KL) .LE. XX) GO TO 290
      IX = K
      JX = L
      ZZ = NAUT(KL)
  290 CONTINUE
  300 CONTINUE
```


1083291

```
      IF (ZZ .LT. DIST) GO TO 975
      FLIP = .TRUE.
      IX = 0
      IC = LZ - IT
      GO TO 250
  965 CONTINUE
      IC = IC + 1
      IX = IX + 1
      JX = JT
  975 CONTINUE
      XX = ZZ
      IX = LO(IX)
      JX = LS(JX)
      IS = MAP(IX)
      JS = MAP(JX)
      T = X(IS) + X(JS)
      IF (T .GE. ZIP) GO TO 350
C      SURPLUS IS LT DEFICIT
      TRANS = X(JS)
      X(JS) = ZIP
      X(IS) = T
      PRCT = IFIX (100.0 * TRANS / XD(IS))
      IS = IX
      JS = JX
      IF (MINI) GO TO 720
      WRITE (LUO,40) IS, TRANS, JS, PRCT
  720 CONTINUE
      GO TO 400
  350 CONTINUE
C      SURPLUS IS GE DEFICIT
      TRANS = - X(IS)
      IF (X(IS) .EQ. ZIP) TRANS = ZIP
      X(IS) = ZIP
      X(JS) = T
      PRCT = IFIX (100.0 * TRANS / XD(IS))
      IS = IX
```


1083298

```
      JS = JX
      IF (MINI) GO TO 730
      WRITE (LUO,40) IS, TRANS, JS, PRCT
  730 CONTINUE
  400 CONTINUE
C
      IF (PRCT .EQ. 0) GO TO 450
      IK = IK + 1
      IF (IK .EQ. 1500) STOP 1
      TO(IK) = IS
      PR(IK) = PRCT
      FR(IK) = JS
  450 CONTINUE
      IF (IC .GE. LZ) GO TO 500
      GO TO 250
C
  500 CONTINUE
      WRITE (LUO,10)
      DO 850 I = 1,IT
      DO 800 J = 1,IK
      IF (TO(J) .NE. LD(I)) GO TO 800
      IF (FR(J) .EQ. NCTR) FR(J) = NINE
      WRITE (LUO,860) TO(J), FT, FR(J), PR(J)
      IF (TAPE) WRITE (LUT,860) TO(J), FT, FR(J), PR(J)
  860 FORMAT(4I12)
  800 CONTINUE
  850 CONTINUE
      IF (TAPE) WRITE(LUT,15)
      IF (TAPE) END FILE LUT
C
      WRITE (LUO,10)
      DO 600 I = 1,NT
      IF (X(I) .LE. ZIP) GO TO 600
      LA = CTR(I)
      MA = I
      IF (LA .E . NCTR) LA = NINE
```


10832299

```
      WRITE (LUO,106) LA, FT, X(MA)
      IF (TAPE) WRITE (LUZ,105) LA, FT, X(MA)
  600 CONTINUE
      IF (TAPE) WRITE (LUZ,15)
      IF (TAPE) END FILE LUZ
C
      IF (FT .EQ. NFT) GO TO 950
      GO TO 900
  950 CONTINUE
      CALL EXIT
      END
```


10833300

ARTRAN Code Listing

1083301

10833302

```
@ ELT COMON,7,711118, 41916

      KKOM* FCOPY
            PARAMETER NSRC=185,NCITY=300,NNUC=35,NMNN=12,NDAU=7,NMOT=7,INOM=2
            PARAMETER IREC=6,ISECT=16,INUM=7,NDR=21,NTOT=NCITY*NNUC
            PARAMETER NLIST=NNUC+4

            COMMON AIRACC(NTOT),GNDMON(NTOT),WEA(NMNN),GNDTOT(NTOT)
            COMMON WX(IREC,ISECT,INOM),QZ(NLIST),GROUND(INOM,NNUC)
            COMMON MOTHER(NNUC),MOTHR1(NNUC),P(NNUC),PER(NNUC,NDAU)
            COMMON ALMDA(NNUC),KDAUGH(NNUC),KDAUG1(NNUC),MDAUGT(NNUC)
            COMMON MDAUG1(NNUC),FARWAY(NCITY),NOU(IREC),CNTR(2)
            COMMON AW(NCITY,NDAU),AW1(NCITY,NDAU),AIR(INOM,NNUC)

            COMMON/NTABZZ/D1(7),D2(7),D3(7),D4(7),D5(7),D6(7)
            COMMON LUNIT,INOUT,ITYPE,INC,INC1,IDL,NOMON,KDEL,NB1,NB2,NB3,NB4
            COMMON NIN,NOUT,NOUT25,IN1,IN2,IN3,IN4,IEXIT,NB5,NB6

            COMMON WINDAY,WINNIT,SUMDAY,SUMNIT,WDALVL,WNTLVL
            COMMON SDALVL,SNTLVL,NUCMIN,NUCMAX
            COMMON SORCLA,SORCLO,YRDIF,YEARMX,YEAR,TIMIN,TIMAX,TEND,TMAXX
            COMMON NODTS,MINTIM,MAXTIM,MINMON,MAXMON,MONOUT,TIME,SCTOYR
            COMMON MINNUC,MAXNUC,MINSRC,MAXSRC,MNCITY,MXCITY,NLAST,MAXCIT
            COMMON NO,H,HE,N,ICY,IS,MON,NSTRT,NDR,MAXY,NOPRNT,INTO,DFLT
            COMMON GNDCON,RAIN,DWET,DV,DDRY,SIGMA,STAB,DIST,MET
            COMMON CONMIN,DISMAX,TOTACC,ACCUMU,PX,U,F,FRAIN,PCNT,PI1,PI2
            COMMON RECOVR,NEWMON,ZRO,AIN,ALL,BASIC,CIN,DEBUG,SIN,SKIPC

            INTEGER AIN,ALL,BASIC,CIN,DEBUG,RECOVR,SIN,SKIPC,STAB
            INTEGER D1,D2,D3,D4,D5,D6

            END
```

10833503

```
@ ELT ARTRAN,1,711120, 53339

      C      MAIN PROGRAM.
      C      THIS IS MAIN PROCESSOR.  CALCULATES AND WRITES CENTROID CONCEN-
      C     TRATIONS TO DRUM, FROM CALCULATIONS IN ROUTINE AND SUBPROGRAMS
      C     ACCESSED BY CALL.  THE CALCULATIONS ARE: AIR CONCENTRATION AT EACH
      C     CENTROID, DRY DEPOSITION, WET DEPOSITION, BUILDUP OVER LONG TERM.
      C     OPERATION ITERATION SCHEME IS:  MONTH, SOURCE, CENTROID, STABILITY
      C     CLASS, NUCLIDE.  THEN DRUM SORT FOR OUTPUT.
      C
      C       JDRUM IS FOR NBS 1108 SOFTWARE.
      C
      C
            INCLUDE KKOM,LIST
            DIMENSION ICITY(2)
            DIMENSION SIGM(2)
            DIMENSION IBUF(6)
            DIMENSION DAY(12)
            DIMENSION JDRUM(7,6)
            EQUIVALENCE(JDRUM,IDRUM)
            DIMENSION IDRUM(42)
            EQUIVALENCE(IDRUM( 1),D1(1))
            EQUIVALENCE(IDRUM( 8),D2(1))
            EQUIVALENCE(IDRUM(15),D3(1))
            EQUIVALENCE(IDRUM(22),D4(1))
            EQUIVALENCE(IDRUM(29),D5(1))
            EQUIVALENCE(IDRUM(36),D6(1))
            DATA (DAY(I),I=1,12)/31.,28.,31.,30.,31.,30.,31.,31.,30.,31.,30.,
           1     31./
            CALL TRAP ($1010)
            ICITY(1)=0
            ICITY(2)=0
            QZERO=1.0E-20
            IEND=99999
```

```
      CALL TIME  (T,SEC)
      BLANK=0.0
      IDR=0
      ITEN=10
      EIGHTY=80.
      WINDAY=5000.
      WINNIT=8000.
      SUMDAY=20000.
      SUMNIT=40000.
      WDALVL=800.
      WNTLVL=300.
      SDALVL=1000.
      SNTLVL=500.
      CALL TEST
      TOWNDA=2.*WINDAY
      TOWNNT=2.*WINNIT
      TOSMDA=2.*SUMDAY
      TOSMNT=2.*SUMNIT
      WDA465=WDALVL*0.465
      WDA335=WDALVL*0.335
      WNT465=WNTLVL*0.465
      WNT335=WNTLVL*0.335
      SDA465=SDALVL*0.465
      SDA335=SDALVL*0.335
      SNT465=SNTLVL*0.465
      SNT335=SNTLVL*0.335
      WDA8=0.8*WDALVL
      WNT8=0.8*WNTLVL
      SDA8=0.8*SDALVL
      SNT8=0.8*SNTLVL
C
C      SET DRUMS FOR NBS 1108 COMPUTER
C
      CALL EQPART (JDRUM,11,16,2)
      MAXCIT=MXCITY
      MAXWAY=MAXSRC*MXCITY
```


10833304

```
      MAXY=MXCITY*MAXNUC
C           RESTART PROCEDURE
      IF (RECOVR.EQ.0) GO TO 100
C           SKIPC.EQ.2 READ TO DRUM
C           SKIPC.EQ.1 READ TO TAPE
C           KEYS.EQ.10 CALL UNTRAP
      KEYS=-10
      CALL RECYCL (SKIPC,KEYS,$1000)
      MINMON=NEWMON
100   DUMY=DUMY
C
C      CONSTANT FOR AIRCON CALCULATION
C
C      B=SQRT(2)/SQRT(PI)*PI/NUMBER OF SECTORS(16)
C
      PI=3.14159625
      B=(SQRT(2./PI))/(2.*PI/16.)
C
C      SECONDS IN DAY 3600 * 24 = 8.68E4
C
      YRDIF=40.
      SECDA=8.68E4
      ZRO=-1.E-25
      ITEND=IFIX(TEND)
      DO 110 I=1972,2004,4
110   IF (ITEND.EQ.I) DAY(2)=29.
      ICIT1=MNCITY
      ICIT2=MXCITY
C
C     ITERATE OVER MONTHS
C
      CALL TIMER (2,SEC1)
      WRITE (NOUT,1050) SEC1
      ISO=1
      DO 880 MON=1,MAXMON
      CALL TCHEK (IEXIT,$1020)
```


10833305

```
      GO TO (120,120,120,130,130,130,130,130,130,120,120,120), MON
12    ISEASN=1
      GO TO 140
130   ISEASN=2
140   DUMY=DUMY
      WRITE (6,1060) MON
      SECMO=SECDA*DAY(MON)
C
C      CORE HOUSEKEEPING
C
      DO 150 I=1,MAXY
      GNDMON(I)=0.0
      GNDTOT(I)=0.0
150   AIRACC(I)=0.0
      IF (MON.LT.MINMON) CALL ADVTAP (5810)
      IF (MON.GT.MAXMON) GO TO 890
C
C     ITERATE OVER SOURCES
C
      DO 800 IS=1,MAXSRC
      CALL METEOR
      IF (IS.LT.MINSRC) GO TO 790
      IF (IS.EQ.MINSRC.AND.MON.GT.MINMON) CALL TESTER
      IF (MON.GT.MINMON) GO TO 160
      GO TO 200
160   IDRUM(24)=((IS-1)*MAXCIT)+IDRUM(22)
      D4(3)=IDRUM(24)
      CALL NTRAN (NOU(4),2,MAXCIT,FARWAY,LFAR)
      LFAR=LFAR
170   IF (LFAR+1) 180,170,190
180   WRITE (NOUT,1070) MON,IS,LFAR
      RETURN 0
190   DUMY=DUMY
      NN=NOU(4)
      REWIND NN
200   DUMY=DUMY
```


1083306

```
C
C     COMPUTE DURATION OF SOURCE OPERATION
C
      TIME=QZ(39)
      H=QZ(38)
      HE=-(H**2)*0.5
      IF (TIME.LE.BLANK) TIME=1989.
      IF (TIME.LE.1902.) GO TO 790
      IF (TIME.GT.TEND) GO TO 740
      YEAR=TEND-TIME-(12.-MON)/12.
      IF (TEND.EQ.TIME) YEAR=ABS(YEAR)
      IF (YEAR.GT.YRDIF) YEAR=30.
      IF (YEAR.LT.ZRO) YEAR=.1
C
C      DURING PASSES FOR MONTH 1 CONTROL ARRAY ICITY(1,1) IS FILLED.
C      SUBSEQUENT PASSES USE THIS ARRAY TO SET LOOP LIMITS FOR
C          DO 480 IC = ICIT1,ICIT2
C
      IF (MON.GT.MINMON) GO TO 210
      GO TO 250
210   ICRUM(31)=ICRUM(29)+((IS-1)*50)
      CALL NTRAN (NOU(5),2,6,IBUF,LX)
      LX=LX
220   IF (LX+1) 230,220,240
230   WRITE (NOUT,1080) MON,IS,LX
      STOP
240   ICIT1=IBUF(2)
      ICIT2=IBUF(3)
250   DUMY=DUMY
      IF (IS.GT.MAXSRC) GO TO 810
C
C      ITERATION LOOP FOR CENTROIDS
C
      DO 680 ICY=MNCITY,MXCITY
C
C
```


10833301

```
      IF (ICY.GT.MXCITY) GO TO 730
      IF (ICY.LT.ICIT1) GO TO 680
      IF (ICY.GT.ICIT2) GO TO 690
C
C       PROCEDURE TO ELIMINATE REDUNDANT DISTANCE CALCULATIONS
C
      IF (MON.GT.MINMON) GO TO 340
C           PROCEDURE TO ELIMINATE UNNECESSARY ITERATIONS FOR CENTROID LI
C
C      SET SECTOR AND DISTANCE
C
      DLA=111.0
      DLO=82.2
      IDRUM(38)=((ICY-1)*50)+NB6
      CALL NTRAN (NOU(6),2,2,CNTR,LX)
      LX=LX
  260 IF (LX+1) 270,260,280
  270 WRITE (NOUT,1040) ICY,LX
      STOP
  280 DUMY=DUMY
      DLAT=(SORCLA-CNTR(1))*DLA
      DLON=(SORCLO-CNTR(2))*DLO
      DIST=SQRT(DLAT**2+DLON**2)*1000.
      IF (DLAT.EQ.0.0.AND.DLON.EQ.0.0) GO TO 320
      IF (DLAT.GT.0.0.AND.DLON.LT.0.0) LSEC=1
      IF (DLAT.LT.0.0.AND.DLON.LT.0.0) LSEC=2
      IF (DLAT.LT.0.0.AND.DLON.GT.0.0) LSEC=3
      IF (DLAT.GT.0.0.AND.DLON.GT.0.0) LSEC=4
      YABX=ABS(DLAT)
      XABX=ABS(DLON)
      ARG=YABX/XABX
      GO TO (290,300,300,300), LSEC
  290 ANGL=90.-(ATAN(ARG)*57.295779)
      GO TO 310
  300 ANGL=ATAN(ARG)*57.295779
  310 IF (ANGL.LE.11.25) IANG=1
```


1083308

```
      IF (ANGL.GT.11.25.AND.ANGL.LE.33.75) IANG=2
      IF (ANGL.GT.33.75.AND.ANGL.LE.56.25) IANG=3
      IF (ANGL.GT.56.25.AND.ANGL.LE.78.75) IANG=4
      IF (ANGL.GT.78.75) IANG=5
      IF (LSEC.EQ.1) ISEC=IANG
      IF (LSEC.EQ.2) ISEC=IANG+4
      IF (LSEC.EQ.3) ISEC=IANG+8
      IF (LSEC.EQ.4) ISEC=IANG+12
      IF (ISEC.EQ.17) ISEC=1
      GO TO 330
  320 ISEC=1
  330 J=ISEC
C
C      CHECK FOR SOURCE TO CENTROID DISTANCE. IF TOO DISTANT GO TO NEXT.
C
      IF (DIST.GT.DISMAX) J=17
C
C      FILL CONTROL ARRAY - PACKED -
C
      FARWAY(ICY)=FLOAT(J*1.E7)
      FARWAY(ICY)=FARWAY(ICY)+DIST
  340 J=IFIX(FARWAY(ICY)*1.E-7)
      IF (J.GE.17) GO TO 680
      DIST=FARWAY(ICY)-FLOAT(J*1.E7)
C
C      CALCULATE SIGMA - Z
C
      GO TO (350,450), ISEASN
  350 X1=DIST-WINDAY
      X2=DIST-WINNIT
      X3=DIST-TOWNDA
      X4=DIST-TOWNIT
      IF (X1) 360,370,370
  360 CALL SIGZ
      SIGM(1)=SIGMA
      GO TO 400
```

10833310

```
370     IF (X3) 380,380,390
380     SIGM(1)=WDA465+(X1/WINDAY)*WDA335
        GO TO 400
390     SIGM(1)=WDA8
400     IF (X2) 410,420,420
410     CALL SIGZ
        SIGM(2)=SIGMA
        GO TO 550
420     IF (X4) 430,430,440
430     SIGM(2)=WNT465+(X2/WINNIT)*WNT335
        GO TO 550
440     SIGM(2)=WNT8
        GO TO 550
450     X1=DIST-SUMDAY
        X2=DIST-SUMNIT
        X3=DIST-TUSMDA
        X4=DIST-TUSMNT
        IF (X1) 460,470,470
460     CALL SIGZ
        SIGM(1)=SIGMA
        GO TO 500
470     IF (X3) 480,480,490
480     SIGM(1)=SDA465+(X1/SUMDAY)*SDA335
        GO TO 500
490     SIGM(1)=SDA8
500     IF (X2) 510,520,520
510     CALL SIGZ
        SIGM(2)=SIGMA
        GO TO 560
520     IF (X4) 530,530,540
530     SIGM(2)=SNT465+(X2/SUMNIT)*SNT335
        GO TO 560
540     SIGM(2)=SNT8
        GO TO 560
550     IF (SIGM(1).LE.BLANK.OR.SIGM(1).GT.WINDAY) SIGM(1)=WDA8
        IF (SIGM(2).LE.BLANK.OR.SIGM(2).GT.WINNIT) SIGM(2)=WNT8
```

```
      GO TO 570
560   IF (SIGM(1).LE.BLANK.OR.SIGM(1).GT.SUMDAY) SIGM(1)=SDA8
      IF (SIGM(2).LE.BLANK.OR.SIGM(2).GT.SUMNIT) SIGM(2)=SNT8
570   DUMY=DUMY
C
C      SET ARRAY FOR CENTROID CALL - FIRST MONTH ONLY
C
      IF (MON.GT.MINMON) GO TO 600
      IF (ICITY(1)) 580,580,590
580   ICITY(1)=ICY
      GO TO 600
590   ICITY(2)=ICY
600   DUMY=DUMY
C
C      COMMENCE COMPUTATIONAL LOOPS
C
C      SET METEOROLOGY AS FUNCTION OF SECTOR ANGLE
C
      PCNT=0.
      FRAIN=0.
      F=0.
      DO 610 IWW=1,INOM
      F=F+WX(2,J,IWW)
      FRAIN=FRAIN+WX(4,J,IWW)
      PCNT=PCNT+WX(5,J,IWW)
610   CONTINUE
      DO 650 IWX=1,INOM
      SIGMA=SIGM(IWX)
C
C      SET VARIABLES
C
C
C      INOM IS STABILITY CLASSES TO BE CONSIDERED
C
C      IF IMON IS 2 NIGHT/DAY ONLY - BASIC .EQ. 0.0
C      IF INOM IS 7 PASQUILL CLASSES  -  BASIC .NE. 0.0
```

```
C
      U=WX(1,J,IWX)
C
C      Z EQUAL TRAVEL TIME
C
      Z=DIST/U
      RAIN=WX(3,J,IWX)
      STAB=IFIX(WX(5,J,IWX))
      TNAVAL=SECMO*PCNT*F
C
C      ITERATE OVER NUCLIDES
C
      DO 640 INU=NUCMIN,NUCMAX
      N=INU
C
C      SUBROUTINES FOR DEPLETION COEFFICIENTS
C
      CALL DELDRY
      CALL DELWET
C
C      GET SOURCE TERM FOR PLANT AND NUCLIDE
C
C      IF.LT. ZERO GO TO NEXT
C
      Q=QZ(INU)*F
      IF (Q.LT.QZERO) GO TO 640
C
C      CORRECT FOR RADIOACTIVE DECAY AND TRAVEL TIME
C
C      CHECK EXPONENT
C
      REXP=ALMDA(INU)*Z
      REXP=ABS(REXP)
      IF (REXP.GT.EIGHTY) REXP=EIGHTY
C
C      EFFECTIVE SOURCE WHEN CORRECTED FOR RADIOACTIVE DECAY OVER TVL TM
```


1083312

```
C
      QR=Q*EXP(-REXP)
C
C      CALCULATE UPWIND DEPOSITION BY DRY AND WET PROCESS
C
C      CHECK EXPONENT
C
      DEXP=DDRY
      WEXP=DWET*Z
      DEXP=ABS(DEXP)
      WEXP=ABS(WEXP)
      IF (DEXP.GT.EIGHTY) DEXP=EIGHTY
      IF (WEXP.GT.EIGHTY) WEXP=EIGHTY
C
C      SOURCE STRENGTH AFTER DRY DEPOSITION DEPLETION
C
      QD=QR*EXP(-DEXP)
C
C      SOURCE STRENGTH AFTER WET DEPOSITION
C
      IF (WEXP.LE.ZRO) GO TO 620
      QW=(QR*FRAIN)*EXP(-WEXP)
      GO TO 630
620   QW=0.0
630   DUMY=DUMY
C
C      EFFECTIVE SOURCE - QEFF
C
      QEFF=QD-QW
      IF (QEFF.LT.ZRO) QEFF=0.0
      IF (QEFF.EQ.0.0) GO TO 640
C
C      INITIAL AIR CONCENTRATION AT CENTROID
C
      CHIBAR=(B*(QEFF/(U*DIST*SIGMA)))*EXP(HE/SIGMA**2)
      IF (CHIBAR.LE.CONMIN) GO TO 640
```


1083313

```
C
C      DRY DEPOSITION / SQUARE METER AT CENTROID
C
C      EFFECTIVE TIME FOR DRY DEPOSITION
C
      DRYTIM=TMAVAL-Z
      IF (DRYTIM.LE.ZRO) DRYTIM=0.0
      DRYDEP=CHIBAR*DV
      CHIBAR=CHIBAR-DRYDEP
      DRYCON=DRYDEP*DRYTIM
      IF (CHIBAR.LE.CONMIN) GO TO 640
      IF (DRYCON.LE.ZRO) DRYCON=0.0
C
C      WET DEPOSITION / SQUARE METER AT CENTROID
C
      WETTIM=DRYTIM*FRAIN
      IF (WETTIM.LE.ZRO) WETTIM=0.0
      WETDEP=CHIBAR*DWET
      WETCON=WETDEP*WETTIM
      CHIBAR=CHIBAR-WETDEP
      IF (CHIBAR.LE.CONMIN) GO TO 640
      IF (WETCON.LE.ZRO) WETCON=0.0
C
C      ACCUMULATE AIR AND GROUND CONCENTRATIONS AS A FUNCTION OF NUCLIDE
C
      GROUND(IWX,INU)=WETCON+DRYCON
      AIR(IWX,INU)=CHIBAR
  640 CONTINUE
  650 CONTINUE
      DO 670 NNU=NUCMIN,NUCMAX
      GNDCON=0.
      AIRCON=0.
      DO 660 IXX=1,INOM
      AIRCON=AIRCON+AIR(IXX,NNU)
      GNDCON=GNDCON+GROUND(IXX,NNU)
  660 CONTINUE
```


1083314

401

```
      INTO=((ICY-1)*MAXNUC)+NNU
      GNDMON(INTO)=GNDMON(INTO)+GNDCON
      AIRACC(INTO)=AIRACC(INTO)+AIRCON
      CALL CONCEN
  670 CONTINUE
  680 CONTINUE
  690 DUMY=DUMY
C
C      WRITE CITY ARRAY TO DRUM
C
      IF (MON.GT.MINMON) GO TO 750
      IDRUM(31)=IDRUM(29)+((IS-1)*50)
      D5(3)=IDRUM(31)
      IBUF(2)=ICITY(1)
      IBUF(3)=ICITY(2)
      CALL NTRAN (NOU(5),1,6,IBUF,LY)
      LY=LY
  700 IF (LY+1) 710,700,720
  710 WRITE (NOUT,1090) MON,IS,LY
  720 DUMY=DUMY
      ICITY(1)=0
      ICITY(2)=
      GO TO 750
  730 WRITE (NOUT,1100) ICY,IS,MON
      GO TO 790
  740 WRITE (NOUT,1110) I,J,TIME,TEND
  750 DUMY=DUMY
      IF (MON.GT.MINMON) GO TO 780
      IDRUM(24)=((IS-1)*MAXCIT)+IDRUM(22)
      CALL NTRAN (NOU(4),1,MAXCIT,FARWAY,MFAR)
      MFAR=MFAR
  760 IF (MFAR+1) 770,760,780
  770 WRITE (NOUT,1190) MON,IS,MFAR
      RETURN 0
  780 DUMY=DUMY
      NN=NOU(4)
```


10833115

```
      REWIND NN
790   DUMY=DUMY
      CALL TIMER (1,TIM)
      SEC=TIM-SEC
      WRITE (NOUT,1120) MON,IS,SEC
      SEC=TIM
      IF (IS.EQ.MAXSRC) GO TO 800
C
C      CALL NEXT SOURCE INPUT
C
      CALL TESTER
800   CONTINUE
C
C      DRUM AND CORE HOUSEKEEPING
C
810   DUMY=DUMY
      CALL NTRAN (NOU(1),1,MAXY,GNDMON(1),LS0)
      CALL NTRAN (NOU(2),1,MAXY,AIRACC(1),LS1)
      CALL NTRAN (NOU(3),1,MAXY,GNDTOT(1),LS2)
      LS2=LS2
820   IF (LS2+1) 830,820,840
830   WRITE (NOUT,1130) LS2
      RETURN 0
840   DUMY=DUMY
      CALL TIMER (2,SEC2)
      SEC=SEC2-SEC1
      WRITE (NOUT,1140) MON,SEC
      SEC1=SEC2
      IF (MONOUT-1) 850,850,860
850   WRITE (NOUT,1150) MON,IS
      WRITE (NOUT,1160) (GNDMON(I),I=1,MAXY)
      WRITE (NOUT,1170) MON,IS
      WRITE (NOUT,1160) (AIRACC(I),I=1,MAXY)
      WRITE (NOUT,1180) MON,IS
      WRITE (NOUT,1160) (GNDTOT(I),I=1,MAXY)
860   DUMY=DUMY
```


1083316

```
      IF (DEBUG.LT.0.0) GO TO 870
      GO TO 880
870   DUMY=DUMY
      INX=0
880   CONTINUE
C
C      END OF CALCULATION LOOPS.  HOUSEKEEPING BEFORE SORT.
C
890   DUMY=DUMY
      DO 900 I=1,NNUC
900   QZ(I)=0.0
      DO 910 I=1,7
      IDRUM(I)=D1(I)
      IDRUM(I+7)=D2(I)
910   IDRUM(I+14)=D3(I)
      DO 920 I=1,MAXY
      GNDMON(I)=0.0
      GNDTOT(I)=0.0
920   AIRACC(I)=0.0
      ITEN=10
      DO 930 I=1,4
      II=ITEN+I
      NOU(I)=II
      REWIND II
930   CONTINUE
      IF (IN2.GT.0) CALL NTRAN (IN2,11)
      IF (IN3.GT.0) CALL NTRAN (IN3,11)
      IF (IN4.GT.0) CALL NTRAN (IN4,11)
      NO=13*NNUC
C
C      START SORT AND OUTPUT.  PRINT CHOICE.
C
      IF (NOPRNT-1) 950,940,940
940   WRITE (NOUT,1200)
      WRITE (NOUT,1210) YEARMX
950   DUMY=DUMY
```

```
      ALL=0
      NDR=3
      NSTRT=D3(1)
      MM=MAXNUC+MXCITY
      KEEL=50
      IHOUT=2
      ITYPE=7
      LUNIT=NOU(3)
      CALL SORT
      IF (NOPRNT-1) 970,960,960
960   WRITE (NOUT,1220)
970   DUMY=DUMY
      ALL=9
      NDR=1
      NSTRT=D1(1)
      ITYPE=6
      LUNIT=NOU(1)
      CALL SORT
      IF (NOPRNT-1) 990,980,980
980   WRITE (NOUT,1230)
990   DUMY=DUMY
      ALL=9
      NDR=2
      NSTRT=D2(1)
      ITYPE=1
      LUNIT=NOU(2)
      CALL SORT
C
C      SET LAST FILE RECORD KEY NUMBERS
C
      CALL ZEROUT (NOUT25,NOUT,WWET)
1000  END FILE NOUT25
      DUMY=DUMY
      REWIND NOUT25
      STOP
C      CALL PANIC STOP-KEYS POSITIVE-READ FROM DRUM
```


1083318

```
1010  KEYS=10
      GO TO 1030
1020  KEYS=20
1030  CALL RECYCL (1,KEYS,$1000)
      STOP
C
C
C
1040  FORMAT (1H ,'BOMB IN READ CITY AT',I4,' STAT',I3)
1050  FORMAT (1H ,'** BEFORE LOOP **',F20.4)
1060  FORMAT (1H ,T50,'MONTH',I4)
1070  FORMAT (1H1,',** READ ERROR IN FARWAY ARRAY FOR MONTH',I4,' SOURCE
     1',I5,' STATUS',I4/)
1080  FORMAT (1H ,'READ ERROR FOR CITY ARRAY AT MONTH',I4,' SOURCE',I4,'
     1 STATUS',I4/)
1090  FORMAT (1H ,'WRITE ERROR FOR CITY ARRAY AT MONTH',I4,' SOURCE',I4,
     1' STATUS',I4/)
1100  FORMAT (1H /'  -CAUTION- CENTROID LOOP LIMIT EXCEEDED ALLOWABLE.
     1VALUE WAS',I6,' AT SOURCE',I5,' MONTH',I4/)
1110  FORMAT (1H ,T10,'**CAUTION** SOURCE TIME',F6.0,' STUDY YEAR',F6.0/
     1)
1120  FORMAT (1H ,T20,'NOW AT MONTH',I4,' SOURCE',I5,' TIME',F12.4)
1130  FORMAT (1H1,'** WRITE ERROR ** STATUS',I4)
1140  FORMAT (1H ,T10,'END OF LOOP FOR MONTH',I3,' THIS LOOP REQUIRED',F
     112.4,' SECONDS')
1150  FORMAT (1H /' DATA FOR GROUND DEPOSITION FOR END OF PASS FOR MONTH
     1',I3,' SOURCE',I4//)
1160  FORMAT (1X,13E10.3)
1170  FORMAT (1H /' DATA FOR AIR CONCENTRATION FOR END OF PASS FOR MONTH
     1',I3,' SOURCE',I4//)
1180  FORMAT (1H /' DATA FOR YEARLY ACCUMULATION FOR END OF PASS FOR MON
     1TH',I3,' SOURCE',I4/)
1190  FORMAT (1H1,'** WRITE ERROR IN FARWAY ARRAY FOR MONTH',I4,', SOURC
     1E',I5,', STATUS',I4/)
1200  FORMAT ('0*****GROUND DEPOSITION IN PICO-CURIES PER SQUARE METER *
     1****')
```

```
 1210  FORMAT ('0 ACCUMULATION UP TO THE YEAR ',F7.0)
 1220  FORMAT (10 /,' ACCUMULATION FOR STUDY YEAR')
 1230  FORMAT ('0***** AIR CONCENTRATION IN PICO-CURIES PER CUBIC METER *
      1**** ')
       END

. LIST ACCUM
```


10833320

1083321

```
@ ELT ACCUM,1,711118, 41937

      SUBROUTINE ACCUM (YEAR,ALMBDA,BLMDA,B,A,C,P,CLMBDA)
C
C      THIS ROUTINE COMPUTES THE ACCUMULATED DEPOSITION FROM THE MONTHLY
C      CONTRIBUTION OF A NUCLIDE AT A CENTROID FROM A SOURCE BY ACCOUNTI
C      FOR A YEARLY WASH AWAY COEFFICIENT (P), BUILD-UP OVER THE NUMBER
C      OF YEARS THE SOURCE HAS BEEN IN OPERATION (YEAR), CONTRIBUTION
C      BY AT MOST TWO MOTHERS AND RADIO-ACTIVE DECAY .
C
      YP1=YEAR+1
      P1=P**YP1
      PR=P**YEAR
      BT=BLMDA*YEAR
      BT1=BLMDA*YP1
      AT=ALMBDA*YEAR
      CT=CLMBDA*YEAR
      EXB1=P1/EXP(BT1)
      EXB=P/EXP(BLMDA)
      EXAN=PR/EXP(AT)
      EXA=P/EXP(ALMBDA)
      EXBN=PR/EXP(BT)
      EXCN=PR/EXP(CT)
      EXC=P/EXP(CLMBDA)
      B=B*(1-EXB1)/(1-EXB)+(P*A*ALMBDA/(BLMDA-ALMBDA))*((1.0-EXAN)/(1.0-
     1EXA)-(1.0-EXBN)/(1.0-EXB))+(P*C*CLMBDA/(BLMDA-CLMBDA))*((1.0-EXCN)
     2/(1.0-EXC)-(1.0-EXBN)/(1.0-EXB))
      RETURN
      END

/. LIST ADVTAP
```

10833322

```
. ELT ADVTAP,1,711118, 41952

      SUBROUTINE ADVTAP (S)
      INCLUDE KKOM,LIST
      IF (IN4.GT.0) CALL NTRAN (IN4,7,MAXSRC)
      IF (IN2.GT.0) CALL NTRAN (IN2,7,MAXSRC)
      DO 120 I=1,3
      CALL NTRAN (NOU(I),1,MAXY,GNDMON,L)
      L=L
  100 IF (L+1) 110,100,120
  110 WRITE (NOUT,130) L
      RETURN 0
  120 CONTINUE
      RETURN 1
C
C
  130 FORMAT (1H ,'WRITE ERROR IN ADVTAP.  STATUS',I4/)
      END

. LIST CONTEN
```

1083323

```
ELT CONCEN,1,711118, 41935

      SUBROUTINE CONCEN
C
C      THIS ROUTINE CALCULATES MOTHER-DAUGHTER CONTRIBUTIONS.  ANOTHER
C      ROUTINE IS CALLED TO CALCULATE BUILDUP
C
      INCLUDE KKOM,LIST
C
C      ZERO OUT MOTHER TO DAUGHTER CONTRIBUTIONS FOR ALL SOURCES.
C
C      SET SWITCH FOR WALK AROUND
C
      IF (ICY.GT.1) GO TO 110
      DO 100 I=1,NDAU
      DO 100 J=1,NCITY
      AW(J,I)=0.0
100   AW1(J,I)=0.0
110   DUMY=DUMY
      CON=1.0
C
C      SET DEPOSITION FOR CURRENT NUCLIDE
C
      DEPO=GNDCON
C
C      CHANGE DECAY CONSTANT FROM 1/SEC. TO 1/YEAR.
C
      ALMY=ALMDA(N)*SCTOYR
C
      YP1=YEAR+1
      IF (ALMY*YP1.GT.80.) ALMY=80./YP1
C      CHECK FOR DAUGHTER FOR CURRENT NUCLIDE
C
      MD=MDAUGT(N)
```

```
      IF (MD) 170,170,120
120   MDD=KDAUGH(MD)
      IF (MDD) 170,170,130
130   DEP1=AW(ICY,MDD)
      AW(ICY,MDD)=PER(N,MDD)*DEPO+DEP1
      MD1=KDAUG1(N)
      IF (MD1) 140,140,150
140   DEP2=0.0
      GO TO 170
150   MD11=KDAUG1(MD1)
      IF (MD11) 170,170,160
160   DEP2=AW1(ICY,MD11)
      AW1(ICY,MD11)=PER(N,MD11)*DEPO+DEP2
170   NN=MOTHER(N)
      IF (NN) 280,280,180
180   ALM1=ALMDA(NN)*SCTOYR
      IF (ALM1*YP1.GT.80.) ALM1=80./YP1
      N1=MOTHR1(N)
      IF (N1) 200,200,190
190   ALM2=ALMDA(N1)*SCTOYR
      IF (ALM2*YP1.GT.80.) ALM2=80./YP1
      GO TO 210
200   ALM2=0.0
210   M=KDAUGH(N)
      M1=KDAUG1(N)
      IF (M) 220,220,230
220   AA=0.0
      GO TO 240
230   AA=AW(ICY,M)
240   IF (M1) 250,250,260
250   CC=0.0
      GO TO 270
260   CC=AW1(ICY,M1)
270   PX=P(N)
      IPX=IFIX(PX*100.)
      IF (IPX.LE.0) GO TO 290
```


10833324

```
      CALL ACCUM (YEAR,ALM1,ALMY,DEPO,AA,CC,PX,ALM2)
      GO TO 310
  280 DUMY=DUMY
      PX=P(N)
      IPX=IFIX(PX*100.)
      IF (IPX.EQ.0) GO TO 320
      IF (ALMY*YP1.LT.80.) GO TO 300
  290 CON=1.0
      GO TO 310
  300 DUMY=DUMY
      CON=(1.0-(PX**YP1)/EXP(ALMY*YP1))/(1.0-PX/EXP(ALMY))
  310 DEPO=CON*DEPO
      GNDTOT(INTO)=GNDTOT(INTO)+DEPO
      RETURN
  320 GNDTOT(INTO)=0.0
      RETURN
      END
```

. LIST DELAY

1083325

413.

1083326

. ELT DELDRY,1,711118, 41947

```
      SUBROUTINE DELDRY
C
C                THIS SUBROUTINE IS INTENDED TO DEVELOPE APPROPRIATE
C                DEPOSITION COEFFICIENTS FOR DRY DEPOSITION.
C                PROGRAM DIRECTION FOR VARIOUS ISOTOPIC VARIABLES IS
C                THROUGH FIRST ELEMENT OF CALL LIST WHICH IDENTIFIES
C                ISOTOPE BEING CONSIDERED.  THIS INTEGER IS TO BE
C                DEFINED BY CALLING PROGRAM.
C                DRY DEPOSITION IS A FUNCTION OF DEPOSITION VELOCITY.
C                DRY DEPOSITION COEFFICIENT MUST HAVE DIMENSIONS OF SEC
C                TO MINUS ONE.  THIS MAY BE OBTAINED BY CONSIDERING
C                DELDRY AS A FUNCTION OF TRAVEL DISTANCE 'X'.  THEN
C                FROM X = UBAR * TIME WE HAVE DELDRY = DEPVEL / U * T.
C                THIS IS VARIABLE DEVEL IN THIS PROGRAM.
C                VALUE IS RETURNED TO CALLING PROGRAM BY LAST CALL
C                LIST ELEMENT.
C     * * * *
C
C      FOR NORMAL OPERATION STAB .EQ. 2 FOR DAY, STAB.EQ. 3 FOR NIGHT
C
      INCLUDE KKOM,LIST
      REAL VD(4,2)
      DATA (VD(1,I),I=1,2)/6.0E-4,8.0E-3/
     1     (VD(2,I),I=1,2)/3.0E-4,4.6E-3/,
     2     (VD(3,I),I=1,2)/2.2E-4,3.4E-3/,
     3     (VD(4,I),I=1,2)/1.5E-4,2.4E-3/
      I=0
      J=0
      ISO=N
      IF (ISO.EQ.4.OR.ISO.EQ.5.OR.ISO.EQ.12.OR.ISO.EQ.13.OR.ISO.EQ.14.OR
     1.ISO.EQ.15.OR.ISO.EQ.16.OR.ISO.EQ.17.OR.ISO.EQ.32.OR.ISO.EQ.33.OR.
     2ISO.EQ.34.OR.ISO.EQ.35) I=1
```

```
      IF (ISO.EQ.18.OR.ISO.EQ.19.OR.ISO.EQ.20.OR.ISO.EQ.21.OR.ISO.EQ.22.
     1OR.ISO.EQ.23.OR.ISO.EQ.30.OR.ISO.EQ.31) I=2
      IF (I-1) 100,110,110
  100 DDRY=0.0
      DV=0.0
      RETURN
  110 IF (STAB.EQ.1.OR.STAB.EQ.2) J=1
      IF (STAB.EQ.3) J=2
      IF (STAB.EQ.4) J=3
      IF (STAB.EQ.5.OR.STAB.EQ.6.OR.STAB.EQ.7) J=4
      DDRY=VD(J,I)
      DV=DDRY/U
      RETURN
      END
```

1). LIST DELWET

1083327

414

10833328

. ELT DELWET,1,711118, 41949

```
      SUBROUTINE DELWET
C     *
C              CALCULATION OF WET DEPOSITION COEFFICIENTS FOR ISOTOPES
C              IN A LIST.  ISOTOPIC IDENTIFICATION IS BY NUMERICAL VALUE
C              OF ISO WHICH IS THE SPECIFIC LOCATION OF THE PARTICULAR
C              MATERIAL IN THE REFERENCED LIST.
C              RAIN IS PRECIPITATION RATE
C              A GO TO STATEMENT FOR ISOTOPES DIRECTS PROGRAM FLOW FOR
C              PROPER SOLUTION, I.E., GASEOUS OR PARTICULATE.
C     *
C                   VALUES OF -Y- COEFF OF MOLECULAR DIFFUSION (FROM
C                   'KNOWN' EXPERIMENTAL DATA ARE.  H3 0.634 CM2/SEC
C              NO2 0.147 -FROM THEORY- CO2 0.139.  OTHER GASES DO NOT
C              WASHOUT.
C     *
C                   PARTICULATE MATTER IS WASHED OUT AS A FUNCTION OF
C                   RR / K WHERE K = 4 X 10E4
C     *
C              IF GO TO 10 ISOTOPE IS NOT WASHED OUT.  GO TO 20 IS GAS.
C              GO TO 30 IS PARTICULATE.
C     *
      INCLUDE KKOM,LIST
      ISO=N
      TWELV=12.7
      ZERO=0.0
      IF (RAIN.LE.ZERO) GO TO 100
      IF (RAIN.GT.TWELV) RAIN=TWELV
      ALR=ALOG(RAIN)
      CO1=0.60206
      CO2=-7.6009
      PEXP=ALR*CO1+CO2
      IF (PEXP.GT.10.0) PEXP=10.0
```


415

```
      GO TO (110,110,110,160,160,100,100,100,100,100,100,160,160,160,160
     1,160,160,160,160,160,160,160,160,100,100,100,100,100,100,160,160,1
     260,160,160,160), ISO
100   DWET=0.
      RETURN
110   IF (ISO-2) 120,130,140
120   YVAL=0.634
      GO TO 150
130   YVAL=0.147
      GO TO 150
140   YVAL=0.139
150   DWET=YVAL*EXP(PEXP)
      RETURN
160   RS=RAIN/3600.
      RI=RAIN*0.1
      RM=(0.49*RI**0.15)/2.
      VR=8000.*RM
      RNU=1.827E-4
      DS=1.2
      DWET=(RS/2.*RM)*((0.8/(8000.*(RM**2)))*(1.+0.8*(((8000.*(RM**2)/RN
     1U)*0.5)*(RNU/DS))))
      RETURN
      END
```

11. LIST LOPART

10833329

10833330

```
ELT EQPART,1,711116, 5950

1.            SUBROUTINE EQPART(IDRUM,I,J,K)
2.      C       THIS DUMMY SUBROUTINE RESERVED FOR NBS 1108 USE.
3.      C       WHEN THIS MODE OF OPERATION IS CHOSEN THIS ROUTINE
4.      C       SHOULD BE DELETED DURING THE INITIAL CUR OPERATION
5.      C       TO READ IN THE PCF.
6.            RETURN
7.            END

1/. LIST METEOR
```

1083331

```
. ELT METEOR,1,711118, 41932

      SUBROUTINE METEOR
C
C      THIS ROUTINE READS AND CLASSIFIES METEOROLOGICAL DATA FROM TAPE.
C
      INCLUDE KKOM,LIST
      IF (IN4.GT.0) GO TO 100
      IF (IN4.EQ.0.AND.KNTR.GT.1) RETURN
      KNTR=2
      IF (IN4.EQ.0) GO TO 130
C
C      READ ATMOSPHERIC TAPE FOR CURRENT SOURCE METEOROLOGY
C
100   DUMY=DUMY
      CALL NTRAN (IN4,2,MET,WX(1,1,1),L)
      L=L
110   IF (L+1) 120,110,170
120   WRITE (NOUT,190) MON,IS,L
      RETURN 0
130   DUMY=DUMY
      IGO=0
      L1=1
      L2=2
      L3=3
      L4=4
      L5=5
      L6=6
      DO 160 I=1,2
      DO 160 J=1,16
      IGO=IGO+1
      IF (IGO-17) 150,140,150
140   L1=7
      L2=8
```

```
      L3=9
      L4=10
      L5=11
      L6=12
150   WX(1,J,I)=WEA(L1)
      WX(2,J,I)=WEA(L2)
      WX(3,J,I)=WEA(L3)
      WX(4,J,I)=WEA(L4)
      WX(5,J,I)=WEA(L5)
      WX(6,J,I)=WEA(L6)
160   CONTINUE
170   DUMY=DUMY
      IF (AIN.EQ.0) RETURN
      WRITE (NOUT,200)
      WRITE (NOUT,210) MON,IS
      DO 180 J=1,ISECT
      ANG=(J-1)*22.5
      U=WX(1,J,1)
      U1=WX(1,J,2)
      F=WX(2,J,1)
      F1=WX(2,J,2)
      R=WX(3,J,1)
      R1=WX(3,J,2)
      FR=WX(4,J,1)
      FR1=WX(4,J,2)
      PC=WX(5,J,1)
      S=WX(6,J,1)
      S1=WX(6,J,2)
      WRITE (NOUT,220) ANG,U,F,R,FR,PC,S,U1,F1,R1,FR1,PC,S1
180   CONTINUE
      WRITE (NOUT,230)
      RETURN
C
C
190   FORMAT (1H ,' READ ERROR FOR METEOROLOGY AT MONTH',I4,' SOURCE',I5
     1,' STATUS',I4/)
```


10833332

```
  200   FORMAT (1H1,50X,'INPUT FROM ATMOSPHERIC TAPE'//)
  210   FORMAT (1H ,5X,'MONTH',I4,5X,'SOURCE',I5/5X,'ANGLE',5X,'SPEED',3X,
       1'AZIMUTH',6X,'STAB',5X,'SPEED',3X,'AZIMUTH',6X,'RAIN',3X,'PERCENT'
       2,6X,'PCNT',6X,'STAB'/)
  220   FORMAT (1X,2F10.0,4F10.3,2F10.0,4F10.3,F10.0)
  230   FORMAT (1H //)
        END
```

1. . LIST OUTT

1083333

10833334

```
@ ELT NTAB$,1,711116, 55831

NTABZZ      INFO 2 2
$(2)  .          ASSIGNMENT          UNIT        COMMENT
D1        RES      7                 . THIS SLEUTH ELEMENT, OR
D2        RES      7                 . OTHER MACHINE DEPENDENT
D3        RES      7                 . ELEMENT, IS REQUIRED
D4        RES      7                 . FOR MASS STORAGE AND
D5        RES      7                 . RETRIEVAL OF DATA FOR
D6        RES      7                 . PROCESSING OF CODE.
          +        5                 . -4 CHANGE TO -4 FOR NBS
          +        3                 . -3 PUNCH
          +        2                 . -2 PRINTER
          +        1                 . -1 CARD READER
NTAB$*    +        4                 . 0 CONSOLE
          +        'A'               . 1 TAPE A
          +        'E'               . 2 TAPE E
          +        'B'               . 3 TAPE B
          +        'F'               . 4 TAPE F
          +        1                 . 5 CARD READER
          +        2                 . 6 PRINTER
          +        'D'               . 7 TAPE D
          +        'H'               . 8 TAPE H
          +        'A'               . 9 TAPE A
          +        'E'               . 10 TAPE E
          +        D1                . NOU(1) DRUM FILE
          +        D2                . NOU(2) DRUM FILE
          +        D3                . NOU(3) DRUM FILE
          +        D4                . NOU(4) DRUM FILE
          +        D5                . NOU(5) DRUM FILE
          +        D6                . NOU(6) DRUM FILE
NTAB$$*                              .
          END                        .
```

1083335

```
$ ELT OUTT,1,711118, 41944

      SUBROUTINE OUTT (I,WWET)
C
C     THIS ROUTINE OUTPUTS BOTH ACCUMULATED AND MONTHLY DEPOSITION
C     TO TAPE AND PRINTER FOR ALL POPULATION CENTROIDS.
C
      INCLUDE KKOM,LIST
      DIMENSION NUCLID(NNUC,3)
      DIMENSION WWET(NMNN,NNUC)
      DIMENSION MONTH(12)
      DIMENSION IDRUM(7,5)
      EQUIVALENCE (IDRUM(1,1),D1(1))
      EQUIVALENCE (IDRUM(1,2),D2(1))
      EQUIVALENCE (IDRUM(1,3),D3(1))
      EQUIVALENCE (IDRUM(1,4),D4(1))
      EQUIVALENCE (IDRUM(1,5),D5(1))
      DATA (NUCLID( 1,K),K=1,3)/18HTRITIUM            /
      DATA (NUCLID( 2,K),K=1,3)/18HNITROGEN-13        /
      DATA (NUCLID( 3,K),K=1,3)/18HCARBON-14          /
      DATA (NUCLID( 4,K),K=1,3)/18HSODIUM-22          /
      DATA (NUCLID( 5,K),K=1,3)/18HSODIUM-24          /
      DATA (NUCLID( 6,K),K=1,3)/18HARGON-39           /
      DATA (NUCLID( 7,K),K=1,3)/18HARGON-41           /
      DATA (NUCLID( 8,K),K=1,3)/18HKRYPTON-85M        /
      DATA (NUCLID( 9,K),K=1,3)/18HKRYPTON-85         /
      DATA (NUCLID(10,K),K=1,3)/18HKRYPTON-87         /
      DATA (NUCLID(11,K),K=1,3)/18HKRYPTON-88         /
      DATA (NUCLID(12,K),K=1,3)/18HSTRONTIUM-89       /
      DATA (NUCLID(13,K),K=1,3)/18HSTRONTIUM-90       /
      DATA (NUCLID(14,K),K=1,3)/18HZIRCONIUM-95       /
      DATA (NUCLID(15,K),K=1,3)/18HNIOBIUM-95         /
      DATA (NUCLID(16,K),K=1,3)/18HRUTHENIUM-103      /
      DATA (NUCLID(17,K),K=1,3)/18HRUTHENIUM-106      /
```

```
      DATA (NUCLID(18,K),K=1,3)/18HTELLURIUM-132     /
      DATA (NUCLID(19,K),K=1,3)/18HIODINE-129        /
      DATA (NUCLID(20,K),K=1,3)/18HIODINE-131        /
      DATA (NUCLID(21,K),K=1,3)/18HIODINE-132        /
      DATA (NUCLID(22,K),K=1,3)/18HIODINE-133        /
      DATA (NUCLID(23,K),K=1,3)/18HIODINE-135        /
      DATA (NUCLID(24,K),K=1,3)/18HXENON-131         /
      DATA (NUCLID(25,K),K=1,3)/18HXENON-133M        /
      DATA (NUCLID(26,K),K=1,3)/18HXENON-133         /
      DATA (NUCLID(27,K),K=1,3)/18HXENON-135M        /
      DATA (NUCLID(28,K),K=1,3)/18HXENON-135         /
      DATA (NUCLID(29,K),K=1,3)/18HXENON-138         /
      DATA (NUCLID(30,K),K=1,3)/18HCESIUM-134        /
      DATA (NUCLID(31,K),K=1,3)/18HCESIUM-137        /
      DATA (NUCLID(32,K),K=1,3)/18HBARIUM-140        /
      DATA (NUCLID(33,K),K=1,3)/18HLANTHANUM-140     /
      DATA (NUCLID(34,K),K=1,3)/18HCERIUM-141        /
      DATA (NUCLID(35,K),K=1,3)/18HCERIUM-144        /
      BLANK=0.0
      IF (ALL.GT.0) GO TO 120
C
C     ACCUMULATE THE DEPOSITION UP TO THE YEAR 'YEARMX'  BY SUMMING  THE
C     MONTHLY BUILD-UP'S UP TO THE YEAR  YEARMX
C
      MX=MAXMON-1
      DO 100 KN=MINNUC,MAXNUC
      DO 100 KM=MINMON,MX
100   WWET(1,KN)=WWET(1,KN)+WWET(KM,KN)
C
C     OUTPUT ACCUMULATED DEPOSITION TO TAPE
C
      DO 110 KN=MINNUC,MAXNUC
      DO 110 KM=MINMON,MAXMON
110   WWET(KM,KN)=WWET(1,KN)
      WRITE (NOUT25) I,ITYPE,BLANK,NO,(NU,(WWET(MO,NU),MO=1,12),NU=1,NNU
     1C)
```


1083336

1083331

```
      GO TO 130
120   WRITE (NOUT25) I,ITYPE,BLANK,NO,(NU,(WWET(MO,NU),MO=1,12),NU=1,NNU
     1C)
130   DUMY=DUMY
      IF (NOPRNT.LE.0) RETURN
      WRITE (NOUT,190) I
      IF (ALL.GT.0) GO TO 150
      DO 140 NU=NUCMIN,NUCMAX
      IF (WWET(1,NU).LE.ZRO) WWET(1,NU)=0.0
140   WRITE (NOUT,210) (NUCLID(NU,J),J=1,3),WWET(1,NU)
      RETURN
150   DUMY=DUMY
      III=0
      DO 160 II=MINMON,MAXMON
      III=III+1
160   MONTH(III)=II
      WRITE (NOUT,200) (MONTH(II),II=MINMON,MAXMON)
      DO 180 NU=NUCMIN,NUCMAX
      DO 170 MON=MINMON,MAXMON
170   IF (WWET(MON,NU).LE.ZRO) WWET(MON,NU)=0.0
      WRITE (NOUT,210) ((NUCLID(NU,J),J=1,3),(WWET(MU,NU),MU=MINMON,MAXM
     10N))
180   CONTINUE
      RETURN
C
C
190   FORMAT ('0CENTROID  ',I5)
200   FORMAT ('0 MONTH ..... ',12I9)
210   FORMAT (' ',3A6,12E9.3)
      END
```

14. LIST RECYCL

10833338

```
@ ELT RECYCL,1,711120, 53347

      SUBROUTINE RECYCL (I,KEY,$)
      INCLUDE KKOM,LIST
      DIMENSION ID(42),BUF(NTOT),WHAT(2)
      EQUIVALENCE(ID( 1),D1(1))
      EQUIVALENCE(ID( 8),D2(1))
      EQUIVALENCE(ID(15),D3(1))
      EQUIVALENCE(ID(22),D4(1))
      EQUIVALENCE(ID(29),D5(1))
      EQUIVALENCE(ID(36),D6(1))
      EQUIVALENCE(BUF,AIRACC)
      DATA(WHAT(II),II=1,2)/'WRITE ','READ  '/
C     IF(I.EQ.1)DRUM TO TAPE
C     IF(I.EQ.2) TAPE TO DRUM
      KNTR=1
      M=2
      N=1
      IF (I-1) 100,100,170
100   LIN=NOU(4)
      LIN=NOUT25
      GO TO 240
110   LIN=NOU(5)
      GO TO 240
120   LIN=NOU(6)
      GO TO 240
130   IF (KEY) 380,140,140
140   LIN=NOU(1)
      GO TO 240
150   LIN=NOU(2)
      GO TO 240
160   LIN=NOU(3)
      GO TO 240
170   LIN=IN3
```

```
      LOUT=NOU(4)
      GO TO 240
180   LOUT=NOU(5)
      GO TO 240
190   LOUT=NOU(6)
      GO TO 240
200   IF (KEY) 380,210,210
210   LOUT=NOU(1)
      GO TO 240
220   LOUT=NOU(2)
      GO TO 240
230   LOUT=NOU(3)
240   GO TO (250,260,270,280,290,300,310), KNTR
250   I1=NB4+1
      I2=24
      INC=MAXCIT
      GO TO 320
260   I1=NB5+1
      I2=31
      INC=50
      GO TO 320
270   I1=NB6
      I2=38
      GO TO 320
280   IF (KEY) 380,290,290
290   I1=NB1
      I2=3
      INC=NTOT
      GO TO 320
300   I1=NB2
      I2=10
      GO TO 320
310   I1=NB3
      I2=17
320   DO 370 IS=1,MAXSRC
      ID(I2)=((IS-1)*INC)+I1
```


1083339

424

```
      K=2
      CALL NTRAN (LIN,2,INC,BUF,LL)
      LL=LL
330   IF (LL+1) 340,330,350
340   WRITE (NOUT,410) IS,WHAT(K),LL
      RETURN 3
350   K=1
      CALL NTRAN (LOUT,1,INC,BUF,LL)
      LL=LL
360   IF (LL+1) 340,360,370
370   CONTINUE
      KNTR=KNTR+1
      IF (KNTR.GT.6) GO TO 380
      IF (I.EQ.1) IGO=KNTR
      IF (I.EQ.2) IGO=KNTR+6
      GO TO (100,110,120,130,150,160,170,180,190,200,220,230), KNTR
380   IF (KEY) 390,400,400
390   CALL NTRAN (NOUT25,10)
      RETURN
400   CALL UNTRAP
      RETURN 3
C
C
410   FORMAT (1H ,'BOMBOUT AT SOURCE NO.',I4,' DURING',A6,' OPERATION.
     1STATUS',I3)
      END
```

15. LIST SIGZ

1083340

1083341

```
@ ELT SIGZ,1,711118, 41939

      SUBROUTINE SIGZ
C
C      THIS ROUTINE, IN TWO PARTS, COMPUTES SIGMA-Z, AS A FUNCTION OF
C      DOWNWIND DISTANCE AND PASQUILL STABILITY CLASS.  PART 1 IS A FULL
C      CALCULATION.  PART 2 IS A CLACULATION FOR DISTANCES .GT. 100000
C      METERS.
C
      INCLUDE KKOM,LIST
      REAL ZTAB(31,7),DOST(31)
      DATA(DOST(K),K=1,31)/  100.,  150.,  200.,  300.,  400.,  500.,
     1  600.,  700.,  800.,  900., 1000., 1500., 2000., 3000., 4000.,
     2 5000., 6000., 7000., 8000., 9000., 10000., 15000.,20000.,30000.,
     340000.,50000.,60000.,70000.,80000.,90000.,100000./
      DATA(ZTAB(1 ,J),J=1,6)/  15.0,   9.8,   7.3,   4.7,   2.9,   1.4/
     1    (ZTAB(2 ,J),J=1,6)/  23.0,  15.0,  11.0,   6.7,   4.6,   2.2/
     2    (ZTAB(3 ,J),J=1,6)/  33.0,  20.0,  14.0,   7.6,   5.7,   3.1/
     3    (ZTAB(4 ,J),J=1,6)/  55.0,  30.0,  21.0,  12.0,   7.3,   4.7/
     4    (ZTAB(5 ,J),J=1,6)/  82.0,  43.0,  28.0,  16.0,  11.0,   6.2/
     5    (ZTAB(6 ,J),J=1,6)/ 102.0,  53.0,  35.0,  19.0,  13.0,   7.6/
     6    (ZTAB(7 ,J),J=1,6)/ 170.0,  66.0,  43.0,  22.0,  15.0,   9.0/
     7    (ZTAB(8 ,J),J=1,6)/ 230.0,  80.0,  47.0,  24.5,  17.0,  10.0/
     8    (ZTAB(9 ,J),J=1,6)/ 310.0,  93.0,  54.0,  27.0,  19.0,  11.0/
     9    (ZTAB(10,J),J=1,6)/ 400.0, 110.0,  60.0,  30.0,  20.0,  12.0/
     $    (ZTAB(11,J),J=1,6)/ 540.0, 125.0,  66.0,  33.0,  22.0,  13.0/
     $    (ZTAB(12,J),J=1,6)/1000.0, 225.0,  95.0,  43.0,  30.0,  18.0/
     $    (ZTAB(13,J),J=1,6)/1000.0, 360.0, 120.0,  52.0,  36.0,  22.0/
     $    (ZTAB(14,J),J=1,6)/1000.0, 820.0, 170.0,  70.0,  47.0,  27.0/
     $    (ZTAB(15,J),J=1,6)/1000.0,1000.0, 220.0,  86.0,  54.0,  34.0/
     $    (ZTAB(16,J),J=1,6)/1000.0,1000.0, 260.0,  97.0,  62.0,  35.0/
     $    (ZTAB(17,J),J=1,6)/1000.0,1000.0, 300.0, 110.0,  66.0,  38.0/
     $    (ZTAB(18,J),J=1,6)/1000.1,1000.0, 335.0, 120.0,  72.0,  41.0/
      DATA(ZTAB(19,J),J=1,6)/1000.0,1000.0, 370.0, 125.0,  76.0,  43.0/
```


4/27

```
     1    (ZTAB(20,J),J=1,6)/1000.0,1000.0, 405.0, 135.0,  80.0,  45.0/
     2    (ZTAB(21,J),J=1,6)/1000.0,1000.0, 440.0, 140.0,  84.0,  47.0/
     3    (ZTAB(22,J),J=1,6)/1000.0,1000.0, 590.0, 175.0, 100.0,  54.0/
     4    (ZTAB(23,J),J=1,6)/1000.0,1000.0, 730.0, 200.0, 110.0,  59.0/
     5    (ZTAB(24,J),J=1,6)/1000.0,1000.0, 970.0, 250.0, 130.0,  66.0/
     6    (ZTAB(25,J),J=1,6)/1000.0,1000.0,1000.0, 280.0, 140.0,  72.0/
     7    (ZTAB(26,J),J=1,6)/1000.0,1000.0,1000.0, 320.0, 145.0,  77.0/
     8    (ZTAB(27,J),J=1,6)/1000.0,1000.0,1000.0, 350.0, 150.0,  80.0/
     9    (ZTAB(28,J),J=1,6)/1000.0,1000.0,1000.0, 375.0, 155.0,  84.0/
     $    (ZTAB(29,J),J=1,6)/1000.0,1000.0,1000.0, 400.0, 160.0,  87.0/
     $    (ZTAB(30,J),J=1,6)/1000.0,1000.0,1000.0, 430.0, 165.0,  90.0/
     $    (ZTAB(31,J),J=1,6)/1000.0,1000.0,1000.0, 440.0, 170.0,  92.0/
      DO 100 I=1,31
      J=I+1
      IF (DIST.GT.DOST(J)) GO TO 100
      FAR=DOST(J)
      CLS=DOST(I)
      BIGZ=ZTAB(J,STAB)
      SMLZ=ZTAB(J,STAB)
      XINC=DIST-CLS
      XDIF=FAR-CLS
      ZDIF=BIGZ-SMLZ
      SIGMA=((XINC/XDIF)*ZDIF)+SMLZ
  100 CONTINUE
      RETURN
      END
```

ready. LIST SORT

10833342

1083343

```
@ ELT SORT,1,711118, 41941

      SUBROUTINE SORT
C
C     THIS ROUTINE EXTRACTS INFORMATION FROM DRUM AND RE-ARRANGES IT
C     FOR OUTPUT TO TAPE.
C     THIS ROUTINE ACCESSES AN OUTPUT ROUTINE FOR CENTROID DEPOSITION
C
      INCLUDE KKOM,LIST
      DIMENSION WWET(NMNN,NNUC)
      EQUIVALENCE (WWET,GNDTOT)
      DIMENSION PUT(NNUC)
      EQUIVALENCE (PUT,QZ)
      DIMENSION JDRUM(7,6)
      EQUIVALENCE(JDRUM,IDRUM)
      DIMENSION IDRUM(42)
      EQUIVALENCE(IDRUM( 1),D1(1))
      EQUIVALENCE(IDRUM( 8),D2(1))
      EQUIVALENCE(IDRUM(15),D3(1))
      EQUIVALENCE(IDRUM(22),D4(1))
      EQUIVALENCE(IDRUM(29),D5(1))
      EQUIVALENCE(IDRUM(36),D6(1))
      DO 100 I=1,12
      DO 100 J=1,NNUC
  100 WWET(I,J)=0.0
      DO 200 IC=MNCITY,MXCITY
      NSTART=((IC-1)*MAXNUC)+NSTRT
      LO=0
      DO 190 MO=MINMON,MAXMON
      LO=LO+1
      KGO=((LO-1)*MAXY)+NSTART
      IF (NDR-2) 110,120,130
  110 IDRUM(3)=KGO
      D1(3)=KGO
```

```
      GO TO 140
120   IDRUM(10)=KGO
      D2(3)=KGO
      GO TO 140
130   IDRUM(17)=KGO
      D3(3)=KGO
140   DUMY=DUMY
      CALL NTRAN (LUNIT,2,MAXNUC,PUT,LX)
      LX=LX
150   IF (LX+1) 160,150,170
160   WRITE (NOUT,210) LX,MO,IC,LUNIT
      RETURN 0
170   DUMY=DUMY
      DO 180 NU=MINNUC,MAXNUC
      IF (PUT(NU).LE.ZRO) PUT(NU)=0.0
180   WWET(MO,NU)=PUT(NU)
190   CONTINUE
      CALL OUTT (IC,WWET)
      KADV=1
200   CONTINUE
      RETURN
C
C
210   FORMAT (1H ,'**READ ERROR, STATUS',I4,' FOR MONTH',I3,' FOR CENTRO
     1ID',I4,' FROM UNIT',I3/)
      END
```

17. LIST TCHEK

1083344

10833345

```
Q ELT TCHEK,1,701221, 51256

 1.      . CALL TCHEK(I,$N)
 2.      . IF TIME REMAINING FOR EXECTION IS LE I (SEC), TRANSFER TO $N
 3.              NBPR     .
 4.      MCR$B   EQU      07520
 5.      TCHEK*  L        A0,MCR$+12
 6.              L        A1,MCR$B
 7.              DSL      A1,36
 8.              DI,M     A1,5000
 9.              TZ       A0
10.              AN       A0,A1
11.              AN       A0,*0,B11
12.              TG       A0,(0)
13.              J        3,B11
14.              J        *1,B11
15.              END

1n. LIST TEST
```

1083346

```
@ ELT TEST,1,711120, 53367

      SUBROUTINE TEST
C
C     THIS ROUTINE READS THE INPUT NECESSARY FOR THE OPERATION OF THE
C     ATMOSPHERIC DISPERSION MODEL, AND PERFORMS APPROPRIATE CONVERSION
C     OF UNITS.  IT ALSO LISTS THE INPUT IF THE FOLLOWING VARIABLES ARE
C     GREATER  THAN ZERO.
C
C
C     CIN  > 0. CAUSES THE POPULATION CENTROID TAPE TO BE LISTED
C
C     SIN  > 0.0 CAUSES THE SOURCE   TAPE TO BE LISTED.
C
C     AIN  > 0.0 CAUSES THE ATMOSPHERIC TAPE  TO BE LISTED
C
C
      INCLUDE KKOM,LIST
      DIMENSION JDRUM(7,6)
      EQUIVALENCE(JDRUM,IDRUM)
      DIMENSION IDRUM(42)
      EQUIVALENCE(IDRUM( 1),D1(1))
      EQUIVALENCE(IDRUM( 8),D2(1))
      EQUIVALENCE(IDRUM(15),D3(1))
      EQUIVALENCE(IDRUM(22),D4(1))
      EQUIVALENCE(IDRUM(29),D5(1))
      EQUIVALENCE(IDRUM(36),D6(1))
      DIMENSION HOLD(45)
      EQUIVALENCE (HOLD,GNDMON)
      DIMENSION CITYLA(NCITY),CITYLO(NCITY)
      EQUIVALENCE(CITYLA,AW)
      EQUIVALENCE(CITYLO,AW1)
      DIMENSION PRR(10)
      DIMENSION IBUF(6)
```

```
      DIMENSION PLANT1(20),PLANT2(20)
      DIMENSION TITLE(20)
      PARAMETER KZERO = 0
      DATA (MOTHER(I),I=1,NNUC)/8*KZERO,8,5*KZERO,14,9*KZERO,22,22,23,
     1     23,4*KZERO,32,2*KZERO/
      DATA (MOTHR1(I),I=1,NNUC)/24*KZERO,26,0,28,8*KZERO/
      DATA(PRR(I),I=1,10)/.2,1.,.024,1.,.986,.3,1.,.7,1.,1./
      DATA(P(I),I=1,35)/0.,1.,1.,.97,.97,0.,0.,0.,0.,0.,0.,.97,.97,.97,
     1 .97,.97,.97,.65,.65,.65,.65,.65,.65,0.,0.,0.,0.,0.,0.,.97,.97,
     2 .97,.97,.97,.97/
      DO 100 I=1,NNUC
      DO 100 J=1,NDAU
100   PER(I,J)=0.0
C
C     PROGRAM CONTROL VARIABLES
C
      AIN=0
      AL2=0.693147
      BASIC=0
      CIN=0
      CONMIN=1.E-20
      DEBUG=0
      DISMAX=3.E5
      H=100.
      HE=H**2*0.5
      ICX=0
      IEXIT=700
      IMX=0
      IS=1
      ITC=0
      MAXCIT=300
      MET=192
      ITEN=10
      MAXMON=12
      MAXNUC=35
      MAXSRC=185
```


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```
      MINMON=1
      MINNUC=1
      MINSRC=1
      MNCITY=1
      MON=1
      MONOUT=10
      MXCITY=300
      NAME=0
      NEW=0
      NIN=5
      NEWMON=0
      NOPRNT=0
      NOUT=6
      NSTART=600000
      NTHETA=16
      NUCMAX=35
      NUCMIN=1
      PI1=2.5066
      PI2=0.02187
      RECOVR=0
      SIN=0
      SKIPC=0
      TEND=2000.
      Y1=1960.
C      TAPE UNIT E
      NOUT25=2
C        TAPE D
      IN2=7
C          TAPE F
      IN3=0
C        TAPE B
      IN4=3
C      INITIALIZE SIGMA SUBROUTINE
C
      CALL SIGZ
      ND5=15
```


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```
      NAMELIST/OPERAT/AIN,BASIC,CIN,CONMIN,DEBUG,DISMAX,IEXIT,IN1,IN2,
     1 IN3,IN4,MINMON,MAXMON,MINNUC,MAXNUC,MINSRC,MAXSRC,MNCITY,MXCITY,
     2 MONOUT,NAME,NEWMON,NEWLOC,NIN,NOPRNT,NOUT,NOUT25,NSTART,PRR,
     3 RECOVR,SIN,SKIPC,SDALVL,SNTLVL,SUMDAY,SUMNIT,TEND,TIMNEW,WINDAY,
     4 WINNIT,WDALVL,NUCMIN,NUCMAX,MET,Y1,CITYLA,CITYLO
      READ (NIN,OPERAT)
      IF (NAME.EQ.0) WRITE (NOUT,OPERAT)
      IF (DEBUG.GE.0) GO TO 110
      NAMELIST/BUG/ALMDA,H,PLANT1,PLANT2,QZ,WEA
      READ (NIN,BUG)
      WRITE (NOUT,BUG)
  110 DUMY=DUMY
      NOMON=MAXMON
      YRDIF=TEND-Y1
      YEARMX=TEND
      LLL=1
      DO 120 I=1,NNUC
      IF (MOTHER(I).LT.1) GO TO 120
      II=MOTHER(I)
      J=J+1
      MDAUGT(II)=I
      KDAUGH(I)=J
      PER(II,J)=PRR(LLL)
      LLL=LLL+1
      IF (MOTHR1(I).LT.1) GO TO 120
      I1=MOTHR1(I)
      MDAUGT(I1)=I
      KDAUG1(I)=J
      PER(I1,J)=PRR(LLL)
      LLL=LLL+1
  120 CONTINUE
      THETA=360./NTHETA
      NORDAY=1
      DEBUG=0
      DO 130 I=1,6
      ISET=I
```


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```
      NOU(I)=ISET+ITEN
  130 CONTINUE
C
C      ESTABLISH POINTER ARRAYS
      ICX=0
      INC1=NNUC*NCITY*NMNN+10
      NB1=NSTART
      NB2=NB1+INC1
      NB3=NB2+INC1
      NB4=NB3+INC1
      MAXWAY=NCITY*NSRC+1000
      NB5=NB4+(MAXWAY+10)
      NB6=(NB5+(NCITY*50))+1000
      IDRUM(1)=NB1+1
      IDRUM(2)=NB1+INC1
      IDRUM(3)=NB1+1
      IDRUM(8)=NB2+1
      IDRUM(9)=NB2+INC1
      IDRUM(10)=NB2+1
      IDRUM(15)=NB3+1
      IDRUM(16)=NB3+INC1
      IDRUM(17)=NB3+1
      IDRUM(22)=NB4+1
      IDRUM(23)=NB4+MAXWAY
      IDRUM(24)=NB4+1
      IDRUM(29)=NB5+1
      IDRUM(30)=NB5+20000
      IDRUM(31)=NB5+1
      IDRUM(36)=NB6+1
      IDRUM(37)=NB6+30000
      IDRUM(38)=NB6+1
      DO 140 I=1,7
      D1(I)=IDRUM(I)
      D2(I)=IDRUM(I+7)
      D3(I)=IDRUM(I+14)
      D4(I)=IDRUM(I+21)
```


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```
      D5(I)=IDRUM(I+28)
140   D6(I)=IDRUM(I+35)
      DO 170 I=1,MXCITY
      D6(3)=((I-1)*50)+NB6
      CNTR(1)=CITYLA(I)
      CNTR(2)=CITYLO(I)
      CALL NTRAN (NOU(6),1,2,CNTR,LL)
      LL=LL
150   IF (LL+1) 160,150,170
160   WRITE (NOUT,470) I,LL
      RETURN 0
170   CONTINUE
      DO 180 I=1,MXCITY
      CITYLA(I)=0.
180   CITYLO(I)=0.
      DEBUG=0
      MAXY=NCITY*NNUC
      DO 190 I=1,NTOT
      GNDMON(I)=0.0
      GNDTOT(I)=0.0
190   AIRACC(I)=0.0
      DO 220 I=1,NMNN
      CALL NTRAN (NOU(1),1,MAXY,GNDMON(1),L0)
      CALL NTRAN (NOU(2),1,MAXY,AIRACC(1),L1)
      CALL NTRAN (NOU(3),1,MAXY,GNDTOT(1),L2)
200   IF (L2+1) 210,200,220
210   WRITE (NOUT,480) L2
      RETURN 0
220   CONTINUE
      DO 230 I=1,NCITY
230   FARWAY(I)=0.0
      DO 260 I=1,MAXSRC
      CALL NTRAN (NOU(4),1,MAXCIT,FARWAY,IFAR)
      IFAR=IFAR
240   IF (IFAR+1) 250,240,260
250   WRITE (NOUT,490) IFAR
```


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```
      RETURN 0
260   CONTINUE
      ND=NOU(1)
      REWIND ND
      ND=NOU(2)
      REWIND ND
      ND=NOU(3)
      REWIND ND
      ND=NOU(4)
      REWIND ND
      REWIND ND5
      KOUNT=-1
C
C     READ SOURCE LOCATIONS AND EMISSIONS FOR ALL NUCLIDES FOR CURRENT
C     MONTH
C
      IF (DEBUG.LT.0) GO TO 360
      CALL NTRAN (IN2,2,20,TITLE,L1)
270   IF (L1+1) 280,270,290
280   WRITE (NOUT,500) L1,IN2
      RETURN 0
290   CALL NTRAN (IN2,2,6,IBUF,L2)
300   IF (L2+1) 310,300,320
310   WRITE (NOUT,500) L2,IN2
      RETURN 0
320   DUMY=DUMY
      CALL NTRAN (IN2,8,1)
      CALL NTRAN (IN2,2,45,HOLD,L3)
330   IF (L3+1) 340,330,350
340   WRITE (NOUT,500) L3,IN2
      RETURN 0
350   CALL NTRAN (IN2,8,1)
      CALL NTRAN (IN2,8,2)
360   DUMY=DUMY
      KXT=0
      DO 370 I=1,45
```

```
      IF (I.EQ.8.OR.I.EQ.9.OR.I.EQ.10.OR.I.EQ.11.OR.I.EQ.12.OR.I.EQ.13.0
     1R.I.EQ.14.OR.I.EQ.15.OR.I.EQ.16.OR.I.EQ.25) GO TO 370
      KXT=KXT+1
      ALMDA(KXT)=AL2/HOLD(I)
370   CONTINUE
      DO 380 I=1,45
      GNDMON(I)=0.0
380   HOLD(I)=0.0
C
C          THIS IS TESTER ENTRY POINT
C
      ENTRY TESTER
C
      INUC=MAXNUC+4
      LNU=MAXNUC
      LN1=LNU+1
      LN2=LNU+2
      LN3=LNU+3
      LN4=LNU+4
      NSOURC=MAXSRC
      IF (DEBUG.GE.0) GO TO 390
      IMX=IMX+1
      SORCLA=PLANT1(IMX)
      SORCLO=PLANT2(IMX)
      GO TO 430
390   DUMY=DUMY
C
C     READ SOURCE TAPE
C
      CALL NTRAN (IN2,2,INUC,QZ,L6)
400   IF (L6+1) 410,400,420
410   WRITE (NOUT,500) L6,IN2
      RETURN 0
420   DUMY=DUMY
      SORCLA=QZ(LN1)
      SORCLO=QZ(LN2)
```


10833353

450

```
      H=QZ(LN3)
      TIME=QZ(LN4)
  430 DUMY=DUMY
      IF (SIN.EQ.0) GO TO 460
      WRITE (NOUT,510) ISR,MAN
      IF (SIN.LT.0) GO TO 440
      WRITE (NOUT,520)
      WRITE (NOUT,530) NSOURC,MAXNUC,NOMON
  440 MAN=MON
      ISR=IS
      IF (SIN.LT.0) GO TO 450
      WRITE (NOUT,540)
      WRITE (NOUT,560) (ALMDA(NU),NU=1,MAXNUC)
  450 DUMY=DUMY
      WRITE (NOUT,550)
      WRITE (NOUT,560) (QZ(NU),NU=1,MAXNUC)
      WRITE (NOUT,570)
  460 DUMY=DUMY
      RETURN
C
C
C
  470 FORMAT (1H ,'BOMB IN WRITE FOR CITY',I4,' STAT',I3)
  480 FORMAT (1H1,'ERROR IN ZERO WRITE TO DRUM.  STATUS',I3)
  490 FORMAT (1H1,'FARWAY ERROR IN TEST. STATUS',I4)
  500 FORMAT ('0READ ERROR OF ',I5,'  ENCOUNTERED AT UNIT ',I5)
  510 FORMAT (1H ,T10,'INPUT FROM NUCLIDE SOURCE TAPE FOR SOURCE',I5,'
     1MONTH',I5//)
  520 FORMAT ('0 NO. OF SOURCES     NO. OF NUCLIDES   NO. OF MONTHS ')
  530 FORMAT (' ',I10,'           ',I10,'        ',I10)
  540 FORMAT (1H ,'    DECAY COEFFICIENT - SEC-1'/)
  550 FORMAT (1H ,'        EMISSION RATE - PICO CURIES SEC-1'/)
  560 FORMAT (1X,13(1PE10.2))
  570 FORMAT (1H //)
      END
```


1083354

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1083355

```
@ ELT TRAP,1,701221, 51257

 1.          REGNAM
 2.     TRAP*     SX     B11,T2
 3.               LX     B12,0,B11      .GET RETURN ADDRESS
 4.               SX,1   B12,T1
 5.               LMJ    B11,MSEA$
 6.               +      0,MIERR$
 7.     T1        J      $
 8.               LX     B11,T2
 9.               J      2,B11
10.     T2        +      0
11.               END

20. LIST UNTRAP
```

```
Q ELT UNTRAP,1,701221, 51257

1.          REGNAM
2.     UNTRAP*  SX     B11,T1
3.              LMJ    B11,MREA$
4.              +      0,MIALL$
5.              LX     B11,T1
6.              J      1,B11
7.     T1       +      0
8.              END

END CUR
```


1083356

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WTRAN Code Listing

1083357

1083358

```
@ ELT PROC,7,710125, 67226

      MCOM* FCOPY
            PARAMETER LFLOW=200,LNI=400,LMAP=200,LISO=32,LM=12,LR=10
            PARAMETER LC=300,LCENT=300
            COMMON NTI,NTO,NTD,NRO,NPG ,NPR ,NI,LRS,M4,BNK,NTF,NMAP,KMAP,NTT
            COMMON TAU,SUR,VOL,UM,DM,NTISO,NTB,NTU,NTA,NTR,KREP
            COMMON NR,PTOBS,REACK,ROFFK,SURK
            COMMON RNAME(3,LMAP),RCODE(LMAP),CODEM(LMAP),RMILEM(LMAP),
           1IBASIN(LMAP),IDIST(LMAP),SEGM(LMAP),ISED(LMAP)
            COMMON NFLOW,FT(200,15)
            COMMON NREACT,KERR,KFLOW,NTS,NT1,NT2,NT3,NT4,NT5,NT6,NT7,NT8
            COMMON KRN(LC),RMK(LC),KCNT(LC),KTYPE(LC),DRNK(LC)
            COMMON NA,NRAIN,CNT(3,LCENT),NRS,N21,MREAC,SRM,KSITE,KOFF,RBMILE,
           .TOTS,REACTM,TM,JMAP
            COMMON/SHARE/S(LNI),V(LNI),RC(LNI),RM(LNI)
            COMMON/SHARE/BS(LM),S1(LM),S2(LM),FIN(LM),FOUT(LM),SB(LM)
            COMMON/SHARE/BC(LISO,LM),C(LISO,LM),CS(LISO,LM),DS(LISO,LM),
           .RUNOF(LISO,LM),WATSUR(LISO,LM),REACTA(LISO,LM),RI(LISO,LM),
           .BD(LISO,LM),D(LISO,LM)
            COMMON/SHARE/RJ(2273),R(LM,LCENT)
            COMMON NTE,MIX,IREACT,RIVEND,IRIV(100),ARIVM(100),KRIV,KRIVT,JRIV,
           .JRIVT,IPOP(300),POPNO,IRUN
            COMMON JPGNDW,JPOP(300)
            COMMON/OVRBK/FLOOD(200,7),KFLOOD,JFLOOD,MFLOOD,MM(12)
            COMMON/TRIB/TMILE,MMT,MTT,F1(LM),SED(LM),CCW(LISO,LM),
           1CCS(LISO,LM),MAPT(100),RMT(100)
            COMMON/ISO/NTOPE,HL(LISO),MDAU(LISO),SYM(LISO),DIST(LISO),
           .NISO(LISO)
            COMMON /MON/FTM,FTM2,FTM3,MO(12),ZZ(100)
            COMMON /CENT/NCENT,KCENT,DU(50)
            COMMON /NTABZZ/NTAB(50),ND1(7),ND2(7),ND3(7),ND4(7),ND5(7),
           1ND6(7),ND7(42)
            END
```

```
@ ELT MAIN,1,710224, 36497

      DIMENSION FZ(7)
      INCLUDE MCOM
      DATA BK/'      '/
C
C**       MAIN PROGRAM FOR 'RADIONUCLIDE WATER TRANSPORT MODEL
C
C**            READS AND PROCESSES CONTROL CARDS
C**            SETS UP DATA LINKAGE FOR INTERFACES WITH
C*                  REACTOR MODEL
C*                  ATMOSPHERIC MODEL
C*                  DOSE CALCULATION PROGRAM
C
      BNK = BK
      NTI =  5            @ SYSTEM INPUT
      NTO =  6            @ SYSTEM OUTPUT
C
C THR FOLLOWING DATA IS IN PCF ELEMENT MISS
C FOR DETAILS SEE ELEMENT INPUT
C
C RMAP DATA  ENDED WITH BLANK CARD
C POPCNT DATA  ENDED WITH BLANK CARD
C GNDM DATA  LENGTH SET BY VARIABLE NRAIN IN MAIN
C FLREAD DATA  ENDED WITH BLANK CARD
C RBDPTS DATA  ENDED WITH BLANK CARD
C RSED DATA  ENDED WITH BLANK CARD
C RUNPTS DATA  ENDED WITH BLANK CARD
C
C RMAP AND GNDM DATA MUST BE IN ORDER WITHIN THE SETS
C OTHER SETS ARE SORTED BY THE PROGRAM
C
C I/O UNITS FOR THESE DATA
C RMAP - NTD
```


1083359

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```
C POPCNT - NTU
C GNDM - NTF AND NRO
C FLREAD - NTF
C RBDPTS - NTD
C RSED - NTS
C RUNPTS - NTS
C
      NTD=24
      NTU=24
      NTF=24
      NTS=24
      NRO=24
C
C LOCATE MISS IN PCF AND PUT DRUM POINTERS INTO FZ
C MISS SIGNALED WITH @ DAT MISS,0 CARD
C
      CALL SETDAR(24,0,FZ)
C
      M4 = -4
      NRAIN = 300        @ NUMBER OF CENTROIDS
C
C SET UP DRUM FOR RUNOFF POINT FILE
      N21=21
C SET UP DRUM FOR RIVER SECTION CARDS
      NRS=17
C
C**       SETUP DRUM FILE FOR REACTOR INPUT DATA
      NTR = 18
      NREACT = 1
C
      NTA =  7       @ ATMOSPHERIC INPUT DATA UNIT        'TAPE D'
C
C NTT CURRENTLY DRUM
      NTT = 15        @ TRIBUTARY SCRATCH TAPE
C
      NTB=4  @ DOSE TAPE (F)
```


1083360

```
      NTE=2     @   DOSIS TAPE (E)
C
C
C**       SETUP F432 FILE FOR STORAGE OF ATMOSPHERIC DATA
C**       FOR UP TO 300 CENTROIDS,32 ISOTOPES,12 MONTHS
C DRUM UNIT 20 CURRENTLY USED
C
C


C
      KMAP = 0                          @ RIVER MAP POINTER
C
C
C**       RMAP - READS AND PROCESSES MAP OF THE TRIBUTARY SYSTEM
      CALL RMAP
C
C**       ISODEF    READS AND PROCESSES ISOTOPE DEFINITION CARDS
      CALL ISODEF
C*        POPCNT    READS AND PROCESSES POPULATION CENTER TAPE
      CALL POPCNT
C
C PROCESS DOSIS TAPE FOR FILE 6
C
      CALL DOSIS6
C
      NPR = 40/(NTOPE + 3)     @ NO. OF REPORTS/PAGE
C READ OVER BED DATA
      CALL OVRBED
C READ REPORT POINTS
      CALL CONTRL
C
      CALL GNDM    @  COMPUTE GROUND WATER CONCENTRATIONS
C READ RIVER FLOWS
      CALL FLREAD
C
C
```


10833561

```
C READ AND PROCESS RIVER DESCRIPTION DATA
      CALL RBDPTS(NTD,NRS,NTO,RCODE,NMAP,RNAME)
C
C
C READ SEDIMENT DATA
      CALL RSED
C
C READ AND PROCESS RUNOFF POINT DATA
      CALL RUNPTS(NTS,N21,NTO,RCODE,NMAP)
C
      KOFF = 1              @ REACTOR FILE READ INDICATOR
      CALL RREACT         @ READ 1ST REACTOR DATA
C
C
      KCENT = 1            @ POPULATION CENTER TAPE COUNT
      NR = NMAP
C SIMULATION EXECUTIVE ROUTINE
      CALL WTRAN
C
 1100 CONTINUE
C PUT DUMMY RECORD ON DOSE TAPE FOR DOSE PROGRAM
      DO 1101 I=1,LM
      DO 1101 J=1,NTOPE
 1101 BD(J,I)=0.0
      J=13*NTOPE
      I=99999
      WRITE(NTB) I,I,I,J,(NISO(K),(BD(K,L),L=1,LM) ,K=1,NTOPE)
C
      END FILE NTB
      REWIND NTB
C REWIND DOSE TAPE WITH INTERLOCK
      CALL NTRAN(NTB,11)
      STOP
      END
```


1083362

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10833363

```
ELT ATOW,1,710223, 59506

      INTEGER FUNCTION ATOW(I)
C
C AIR ISOTOPE NO. IN, WATER ISOTOPE NO. OUT
C
      DIMENSION LIST(45)
      DATA LIST/1,0,2,3,4,6*0,14,15,16,17,19,20,21,22,23,24,25,26,6*0,
     .27,28,29,30,31,32,10*0/
C
      ATOW=LIST(I)
C
      RETURN
C
      END
```

10833364

```
@ ELT BACKGD,1,710329, 30048

      SUBROUTINE BACKGD
C
C CALCULATE BACKGROUND CONCENTRATIONS
C
      PARAMETER LISO=32
      COMMON/NTABZZ/SPACE(51),ND(3)
      COMMON/ONE/NTE,NTA,NTD,NTD2,LAIR,K,NTOPE,NSITE,NTO,NTI
      COMMON/TWO/VSWEEP,VTOTAL,TIME,VILL,DIFFUS,DEPTH,VELOC
      COMMON/THREE/SURF(20),ALAT(50),ALON(50)
      COMMON/FOUR/CR(LISO),CA(LISO),CT(LISO),SYM(LISO),NISO(LISO),
     .HALFL(LISO),MOTHER(LISO)
      COMMON/FIVE/A(LISO,12),B(12,LISO)
      REWIND NTD
C
C REACTORS
C
      DO 1 I=1,NTOPE
    1 CR(I)=0.0
      DO 7 I=1,K
      CALL NTRAN(NTD,2,12*NTOPE,A,L17)
    2 IF(L17+1) 9999,2,
      DO 3 J=1,NTOPE
    3 CA(J)=0.0
      DO 5 J=1,NTOPE
      DO 4 L=1,12
    4 CA(J)=CA(J)+A(J,L)
    5 CA(J)=CA(J)/12.
      DO 6 J=1,NTOPE
      TERM1=VSWEEP+HALFL(J)*VTOTAL
      TERM2=1.-EXP(-(VSWEEP/VTOTAL+HALFL(J))*TIME)
      CR(J)=CR(J)+CA(J)*TERM2/TERM1
      IF(MOTHER(J)) 6,6,
```

```
      L=MOTHER(J)
      TERM3=HALFL(L)*CA(L)/(VSWEEP+VTOTAL*HALFL(L))
      TERM2=1.-TERM2
      TERM4=EXP(-(HALFL(L)+VSWEEP/VTOTAL)*TIME)
      CR(J)=CR(J)+TERM3*VTOTAL/TERM1*TERM2
      CR(J)=CR(J)-TERM3/(HALFL(J)-HALFL(L))*(TERM4-TERM2)
    6 CONTINUE
    7 CONTINUE
      DO 8 I=1,NTOPE
    8 CT(I)=CR(I)
C
C ATMOSPHERE
C
      REWIND NTD2
      DO 9 I=1,NTOPE
    9 CR(I)=0.0
      DO 15 I=1,LAIR
      CALL NTRAN(NTD2,2,12*NTOPE,B,L17)
   10 IF(L17+1) 9999,10,
      DO 11 J=1,NTOPE
   11 CA(J)=0.0
      DO 13 J=1,NTOPE
      DO 12 L=1,12
   12 CA(J)=CA(J)+B(L,J)
   13 CA(J)=CA(J)/12.*SURF(I)/86400./30.
      DO 14 J=1,NTOPE
      TERM1=VSWEEP+HALFL(J)*VTOTAL
      TERM2=1.-EXP(-(VSWEEP/VTOTAL+HALFL(J))*TIME)
      CR(J)=CR(J)+CA(J)*TERM2/TERM1
      IF(MOTHER(J)) 14,14,
      L=MOTHER(J)
      TERM3=HALFL(L)*CA(L)/(VSWEEP+VTOTAL*HALFL(L))
      TRM2=1.-TERM2
      TERM4=EXP(-(HALFL(L)+VSWEEP/VTOTAL)*TIME)
      CR(J)=CR(J)+TERM3*VTOTAL/TERM1*TERM2
      CR(J)=CR(J)-TERM3/(HALFL(J)-HALFL(L))*(TERM4-TERM2)
```


1083365

```
   14 CONTINUE
   15 CONTINUE
      DO 16 I=1,NTOPE
   16 CA(I)=CT(I)+CR(I)
C
C PRINT BACKGROUND DATA
C
      WRITE(NTO,17)
   17 FORMAT('1BACKGROUND CONCENTRATIONS'/T13,'WATER'T25,'AIR'T35,'TOTAL
     .'/T2,'ISOTOPE'T11,'PCI/FT**3'T22,'PCI/FT**3'T33,'PCI/FT**3')
      DO 19 I=1,NTOPE
      WRITE(NTO,18) SYM(I),CT(I),CR(I),CA(I)
   18 FORMAT(1XA6,3E11.4)
   19 CONTINUE
      RETURN
 9999 RETURN 0
      END
```


10833366

10833361

```
@ ELT BSED,1,710125, 67215

      SUBROUTINE BSED
C
C CALCULATE DEPOSITION TO OR SCOURING FROM RIVER BED
C ADJUST PCI/SEC ACCORDINGLY
C SUM UP LM LAYERS OF RADIOACTIVITY (IF THERE)
C
      DIMENSION SSSSB(12)
      DIMENSION SSB(12),SSSB(12)
      INCLUDE MCOM
      EQUIVALENCE (SSB,RJ),(SSSB,RJ(13))
      EQUIVALENCE (SSSSB,RJ(26))
C
C TURN ON NO SEDIMENT SIGNAL
      JUMP=0
C
      DO 5 M=1,LM
      SSSB(M)=1.
C S1 IS UPSTREAM SEDIMENT PPM
C S2 IS DOWNSTREAM SEDIMENT PPM
      BS(M)=(S1(M)-S2(M))*1.E-6
      IF(BS(M)) ,,2
C SCOURING
      DO 1 L=1,NTOPE
    1 BD(L,M)=0.0
      GO TO 4
C DEPOSITION
    2 DO 3 L=1,NTOPE
      DS(L,M)=CS(L,M)*BS(M)/(DIST(L)*S1(M)*1.E-6+1.) @ KG/SEC
      WATSUR(L,M)=DS(L,M)/SUR*86400.*MO(M) @ KG/MONTH-M**2
C REDUCE PCI'S/SEC BY DEPOSITION AMOUNT
      C(L,M)=C(L,M)-DS(L,M)
      CS(L,M)=CS(L,M)-DS(L,M)*DIST(L)
```

```
    3 BD(L,M)=0.0
C TURN OFF NO SEDIMENT SIGNAL
      JUMP=1
C
    4 BS(M)=BS(M)*86400.*MO(M)*FIN(M)*1.E+3  @  KG/MONTH
      SB(M)=BS(M)/SUR  @  KG/MONTH-M**2
    5 SSSSB(M)=SB(M)
C
C IF NO SEDIMENT - QUIT
C
      IF(JUMP.EQ.0) GO TO 18
C
C SUM UP LM LAYERS
C IF SCOURING, RESUSPEND OLD LAYERS
C
      DO 17 M=1,LM
      DO 9 I=1,LM
      SSB(I)=SSSSB(I)
    9 SSSB(I)=SSB(I)/SB(I)
C SECONDS DECAY FOR LAYER
      TAU=0.0
C COUNT OF LAYERS CALCULATED
      J=0
C FIRST MONTH FOR NO DEPOSIT OR SCOUR
      ISAVE=0
C START WORKING DOWN THRU LAYERS UNTIL SCOURING FOUND
      M1=M+1
      DO 7 N=1,LM
      M1=M1-1
      IF(M1.EQ.0) M1=LM
      IF(SB(M1)) 8,107,
C THIS IS A LEGITIMATE LAYER
      CALL DECAY(TAU,WATSUR(1,M1),BC(1,M1))
      J=J+1
      DO 6 L=1,NTOPE
    6 BD(L,M)=BD(L,M)+BC(L,M1)
```

```
      GO TO 7
  107 IF(ISAVE) ,,7
      ISAVE=M1
    7 TAU=TAU+86400.*30.
C
C HAVE WE FOUND LM LAYERS
C
      IF(J-LM) ,17,17
       M1=ISAVE
      GO TO 14
C
C SORT THRU TIME TO FIND WHICH LAYERS ARE REALLY THERE
C
    8 K=M1
      I=K
      RAU=TAU
      SAU=TAU
      GO TO 11
   10 K=K-1
      RAU=RAU+86400.*30.
      IF(K.EQ.0) K=LM
      IF(K.EQ.M1) GO TO 14
      IF(SSB(K)) ,10,10
      SAU=RAU
      I=K
   11 I=I-1
      SAU=SAU+86400.*30.
      IF(I.EQ.0) I=LM
      IF(I.EQ.M1) GO TO 14
      IF(SSB(I)) 11,11,
      IF(SSB(I)+SSB(K)) ,,111
      SSB(K)=SSB(K)+SSB(I)
      SSB(I)=0.0
      GO TO 211
  111 SSB(I)=SSB(I)+SSB(K)
      SSB(K)=0.0
```


10833b9

```
  211 IF(K.NE.M) GO TO 13
      CALL DECAY(SAU,DS(1,I),BC(1,I))
      SSSSB(I)=SSB(I)
      SSSSB(K)=0.0
C SCOURED LAYER RESUSPENDED
      DO 12 L=1,NTOPE
      C(L,K)=C(L,K)+BC(L,I)*(SSSB(I)-SSB(I)/SB(I))
   12 CS(L,K)=CS(L,K)+BC(L,I)*(SSSB(I)-SSB(I)/SB(I))*DIST(L)
      SSSB(I)=SSB(I)/SB(I)
   13 IF(SSB(K)) 11,10,10
C
C CAN NOW ADD LAYERS
C
   14 LOOP=0
      I=M1
   15 LOOP=LOOP+1
      TAU=TAU+86400.*30.
C 144 NEEDED IF ONLY 1 MONTH DEPOSITS/YEAR AND 12 LAYERS DESIRED
      IF(LOOP.GT.144) GO TO 17
      I=I-1
      IF(I.EQ.0) I=LM
      IF(SSB(I)) 15,15,
C LEGITIMATE LAYER FOUND
      CALL DECAY(TAU,WATSUR(1,I),BC(1,I))
      DO 16 L=1,NTOPE
   16 BD(L,M)=BD(L,M)+BC(L,I)*SSB(I)/SB(I)
      J=J+1
C DO WE HAVE ENOUGH LAYERS
      IF(J-LM) 15,,
   17 CONTINUE
C
   18 RETURN
C
      END
```


1083370

10833711

```
@ ELT BTOW,1,710317, 30167

      INTEGER FUNCTION BTOW(I)
C
C AIR ISOTOPE NO. IN, WATER ISOTOPE NO. OUT
C
      DIMENSION LIST(45)
      DATA LIST/1,0,2,3,4,6*0,14,15,16,17,19,20,21,22,23,24,25,26,6*0,
     .27,28,29,30,31,32,10*0/
C
      BTOW=LIST(I)
C
      RETURN
C
      END
```


462

```
@ ELT CONST,1,710125, 67226

      BLOCK DATA
      INCLUDE MCOM
C
C**       DAYS PER MONTH
C
      DATA (MO(I),I=1,12)/31,28,31,30,31,30,31,31,30,31,30,31/
C
C
C         FTM        0.30480   METER/FOOT
C         FTM2       0.09290  (METER/FOOT)**2
C         FTM3       0.02819  (METER/FOOT)**3
      DATA FTM,FTM2,FTM3/0.3048,0.09290,0.02819/
C
      DATA (MM(I),I=1,12)/'JAN','FEB','MAR','APR','MAY','JUN','JUL',
     .'AUG','SEP','OCT','NOV','DEC'/
      END
```

```
@ ELT CONTRL,1,710224, 41161

      SUBROUTINE CONTRL
C
C THIS MODULE CONTROLS REPORTS
C
      INTEGER POPNO
      INCLUDE MCOM
      DIMENSION WORD(2,7)
      DIMENSION I9(12),R9(11)
      EQUIVALENCE (A,RJ),(B,RJ(2)),(I9,RJ(3)),(R9,RJ(16))
      DATA WORD/'POPULATION  REACTORS    TRIBUTARY MITRIBUTARY ENRIVER P
     .OINTSRUNOFF      SURFACE WATE'/
      JPGNDW=0
      IRUN=0
      MIX=0
      IREACT=0
      RIVEND=0.0
      IRIV(1)=1000
      ARIVM(1)=100000.
      POPNO=0
      KRIV=0
      JRIV=0
C
C CARD INPUT
C FIRST 18 CHARACTERS MUST BE ONE OF THE FOLLOWING(LEFT ADJUSTED)
C 1) POPULATION
C 2) REACTORS
C 3) TRIBUTARY MIX
C 4) TRIBUTARY END
C 5) RIVER POINTS
C 6) RUNOFF
C 7) SURFACE WATER
C 8)          (BLANK ENDS INPUT TO THIS MODULE)
```


10833713

```
C IF 1),REMAINDER OF CARD 12I5, STARTING IN COLUMN 21. POPULATION CENTERS FOR
C       WHICH REPORTS WANTED - IF POPULATION CENTER 1000 IS FIRST, ALL POPULATION
C       CENTERS ARE TRIGGERED
C IF 2), REST OF CARD IGNORED. ALL REACTOR PLANTS REPORTED.
C IF 3), REST OF CARD IGNORED. ALL SIDESTREAM ENTRIES INTO MAIN STREAM REPORTED
C IF 4), REST OF CARD IGNORED. ALL TRIBUTARY END RESULTS REPORTED.
C IF 5), REST OF CARD STARTING IN COLUMN 21 A2(RIVER CODE) 3X,11F5.1(RIVER MILES
C       ). REPORTS GIVEN FOR UP TO 300 SUCH POINTS.
C IF 6), REST  OF CARD IGNORED. RUNOFF POINTS REPORTED.
C IF 7), REST OF CARD STARTING IN COLUMN 21 12I5, POPULATION CENTERS FOR WHICH
C       GROUND WATER REPORTS WANTED. UP TO 300 ALLOWED.
C       IF POPULATION CENTER 1000 IS FOUND FIRST, ALL POPULATION CENTERS ARE
C       TRIGGERED
C
    1 READ(NTI,2) A,B
    2 FORMAT(2A6)
      DO 16 I=1,7
      IF(A.NE.WORD(1,I)) GO TO 16
      IF(B.NE.WORD(2,I)) GO TO 16
      GO TO(6,4,3,5,9,20,21),I
   21 READ(M4,7) I9
      DO 22 J=1,12
      IF(I9(1).EQ.1000) GO TO 23
      IF(I9(J)) 1,1,
C COUNT OF CENTRIODS
      JPGNDW=JPGNDW+1
C LIST OF CENTRIODS
      JPOP(JPGNDW)=I9(J)
   22 CONTINUE
      GO TO 1
C ALL CENTROIDS WANTED
   23 DO 24 J=1,NRAIN
   24 JPOP(J)=J
      JPGNDW=NRAIN
      GO TO 1
C TURN ON RUNOFF POINTS
```


1083314

```
   20 IRUN=100
      GO TO 1
C TURN ON TRIBUTARY MIX POINTS
    3 MIX=100
      GO TO 1
C TURN ON REACTOR POINTS
    4 IREACT=100
      GO TO 1
    5 RIVEND=100.
      GO TO 1
    6 READ(M4,7) I9
    7 FORMAT(20X12I5)
      DO 8 J=1,12
      IF(I9(1).EQ.1000) GO TO 108
      IF(I9(J).EQ.0) GO TO 1
C COUNT OF POPULATION CENTERS TO REPORT
      POPNO=POPNO+1
C LIST OF POPULATION CENTERS
      IPOP(POPNO)=I9(J)
    8 CONTINUE
      GO TO 1
C ALL POPULATION CENTERS WANTED
  108 DO 109 J=1,NCENT
  109 IPOP(J)=KCNT(J)
      POPNO=NCENT
      GO TO 1
    9 READ(M4,10) RIV,R9
   10 FORMAT(20XA2,3X11F5.1)
      DO 11 J=1,NMAP
      IF(RIV.EQ.RCODE(J)) GO TO 12
   11 CONTINUE
      GO TO 1
   12 DO 13 L=1,KRIV
      IF(J.EQ.IRIV(L)) GO TO 14
   13 CONTINUE
C COUNT OF RIVERS
```


10833375

```
      KRIV=KRIV+1
C LIST OF RIVERS
      IRIV(KRIV)=J
      GO TO 114
   14 JRIV=JRIV-1
  114 DO 15 L=1,11
      IF(SIGN(1.,R9(L))) 115,,
      JRIV=JRIV+1
C COUNT OF RIVER POINTS
   15 ARIVM(JRIV)=R9(L)
C LIST OF RIVER POINTS
  115 JRIV=JRIV+1
      ARIVM(JRIV)=1.E+6
      GO TO 1
   16 CONTINUE
   17 KRIVT=KRIV
      JRIVT=JRIV
      KRIV=1
      JRIV=1
      RETURN
      END
```


1083376

10833377

```
W ELT CROSS,1,710317, 30168

      INTEGER FUNCTION CROSS(I)
C
C                CROSS REFERENCE BETWEEN ISOTOPE NUMBER AND POSISION
C                IN ARRAYS
C
      COMMON/ONE/NTE,NTA,NTD,NTD2,LAIR,KKKKKK,NTOPE,NSITE,NTO,NTI
      COMMON/FOUR/CR(32),CA(32),CT(32),SYM(32),NISO(32),HF(32),MDAU(32)
C
C WHICH POSITION IN ARRAYS DOES THIS ISOTOPE GO
      DO 10 J=1,NTOPE
      IF(I-NISO(J))   ,20,
   10 CONTINUE
C THIS ISOTOPE NOT WANTED
      CROSS=0
      RETURN
   20 CROSS=J
      RETURN
      END
```

10833378

```
@ ELT DECAY,1,710126, 56274

      SUBROUTINE DECAY(SEC,A,B)
      INCLUDE MCOM
      DIMENSION A(35),B(35)
C
C       SEC       SECONDS DECAY
C         A          ARRAY OF ISOTOPES
C         B          RETURN ARRAY OF ISOTOPES - OKAY TO HAVE  B=A
C  MDAU = MOTHER ISOTOPE NO.
C
C SAVE INITIAL VALUES
      DO 200 I=1,NTOPE
  200 RJ(I+2200)=A(I)
      DO 100 I=1,NTOPE
      E=EXP(-HL(I)*SEC)
      IF(MDAU(I)) 50,50,
C
C THIS ISOTOPE HAS A MOTHER - FIND WHERE IN LIST IT IS
      J=MDAU(I)
      DO 10 K=1,NTOPE
      IF(J-NISO(K))    ,20,
   10 CONTINUE
C PHONEY MOTHER ISOTOPE NO.
      GO TO 50
   20 J= K
C**                    MOTHER  -  DAUGHTER
C
      F=EXP(-HL(J)*SEC)
      B(I)=RJ(J+2200)*(F-E)*HL(J)/(HL(I)-HL(J))+RJ(I+2200)*E
      GO TO 100
C
   50 B(I) = A(I)*E
  100 CONTINUE
```

RETURN
END

33.
34.

1083379

10833380

```
@ ELT DOSE,1,710125, 67235

      SUBROUTINE DOSE
      INCLUDE MCOM
      DATA L10,L11,L12/10,11,12/
C
C*        10   DISOLVED MATERIAL IN RIVER                PCI/LIT
C*        10   SESPENDED MATERIAL IN RIVER               PCI/LIT
C*        12   RIVER BED SEDIMENT                        PCI/(SQ. METER)
C
      N = 13*NTOPE
      K = KCNT(KCENT)
C
      WRITE(NTB) K,L10,K,N,(NISO(I),(D(I,J),J=1,LM),I=1,NTOPE)
      WRITE(NTB) K,L11,K,N,(NISO(I),(DS(I,J),J=1,LM),I=1,NTOPE)
      WRITE(NTB) K,L12,K,N,(NISO(I),(BD(I,J),J=1,LM),I=1,NTOPE)
  100 RETURN
      END
```


A77

```
@ ELT DOSIS6,1,710125, 67239

      C
      C READ FIRST,FOURTH, AND SIXTH FILES OF DOSIS TAPE
      C GENERATE DRUM FILE OF SORTED DATA
      C
            SUBROUTINE DOSIS6
            LOGICAL THRU
            INCLUDE MCOM
            DIMENSION A(1480),IA(1480),NUM(LMAP),LIST(LMAP),LIST2(LMAP),
           .LIST3(LMAP),B(384)
            EQUIVALENCE(A,RJ,IA),(NUM,RJ(1471)),(LIST,RJ(1671)),
           .(LIST2,RJ(1871)),(LIST3,RJ(2071))
            EQUIVALENCE (RJ(385),B)
      C
      C READ FIRST FILE
      C
            CALL NTRAN(NTE,2,20,A,L17)
          1 IF(L17+1) 9999,1,
            CALL NTRAN(NTE,2,6,A,L17)
         99 IF(L17+1) 9999,99,
      C
      C NM=NUMBER OF MONTHS
      C NIS=NUMBER OF ISOTOPES
      C NP=NUMBER OF REACTORS
      C
            NP=IA(1)
            NM=IA(2)
            NIS=IA(5)
      C
      C SPACE TO FOURTH FILE
      C
            CALL NTRAN(NTE,8,3)
      C
```

```
C READ RIVER MILES AND RIVER NAMES
C A(1) THRU A(NP) ARE RIVER MILES
C A(NP+1) THRU A(4*NP) ARE RIVER NAMES (3 WORDS/NAME)
C
      CALL NTRAN(NTE,2,NP,A,L17)
  100 IF(L17+1) 9999,100,
      CALL NTRAN(NTE,2,3*NP,A(NP+1),L17)
  101 IF(L17+1) 9999,101,
C
C CREATE A LIST OF MAP NUMBERS FOR EACH RECORD IN FILE 6. IF NOT FOUND OR IF
C RIVER MILE NOT DEFINED, MARK AS MAP 1000.
C
      DO 4 I=1,NP
      IF(SIGN(1.,A(I))) 3,,
      L8=3*I-2+NP
      DO 2 J=1,NMAP
      IF(A(L8)-RNAME(1,J)) 2,,2
      IF(A(L8+1)-RNAME(2,J)) 2,,2
      LIST(I)=J
      GO TO 4
    2 CONTINUE
    3 LIST(I)=1000
    4 CONTINUE
C
C CREATE A GROUPED LIST OF WHERE IN PREVIOUS LIST MAP NO. 1 IS FOUND,FOLLOWED
C BY MAP NO. 2, ETC
C ALSO NUMBER OF EACH KIND OF MAP NO. (NUM(I))
C
      K=0
      K1=0
      DO 6 I=1,NMAP
      DO 5 J=1,NP
      IF(LIST(J).NE.I) GO TO 5
      K=K+1
      LIST2(K)=J
    5 CONTINUE
```


1083382

```
      NUM(I)=K-K1
    6 K1=K
      NTOTAL=K
C
C NOW SORT LIST2 GROUPS BY DESCENDING RIVER MILE
C
      K=1
      DO 11 I=1,NMAP
      K2=LIST2(K)
      K3=LIST2(K+1)
      IF(NUM(I)-2) 11,,7
      IF(A(K2).GE.A(K3)) GO TO 11
      LL=K2
      LIST2(K)=LIST2(K+1)
      LIST2(K+1)=LL
      GO TO 11
    7 J1=K
      KEEP=K
      J2=J1+NUM(I)-2
      L17=NUM(I)/2
      DO 10 L=1,L17
      THRU=.TRUE.
      DO 8 K=J1,J2
      K2=LIST2(K)
      K3=LIST2(K+1)
      IF(A(K2).GE.A(K3)) GO TO 8
      THRU=.FALSE.
      LL=K2
      LIST2(K)=LIST2(K+1)
      LIST2(K+1)=LL
    8 CONTINUE
      IF(THRU) GO TO 110
      THRU=.TRUE.
      J2=J2-1
      DO 9 K=J2,J1,-1
      K2=LIST2(K)
```


1083383

```
      K3=LIST2(K+1)
      IF(A(K2).GE.A(K3)) GO TO 9
      THRU=.FALSE.
      LL=K2
      LIST2(K)=LIST2(K+1)
      LIST2(K+1)=LL
    9 CONTINUE
      IF(THRU) GO TO 110
   10 J1=J1+1
  110 K=KEEP
   11 K=K+NUM(I)
C
C CREATE LIST OF DESIRED DRUM ADDRESSES FOR EACH RECORD TO BE KEPT
C ND4(1) IS STARTING ADDRESS (D4 IN NTAB$$)
C N IS FOR SITE,RIVER NAME,RIVER MILE,AND NTOPE*NM ISOTOPE,MONTH
C
   12 J1=ND4(1)
      N=NTOPE*NM+5
      DO 13 K=1,NTOTAL
      K2=LIST2(K)
      LIST3(K2)=J1
   13 J1=J1+N
C
C WRITE NON ISOTOPE DATA TO DRUM
C
      DO 16 I=1,NP
      IF(LIST(I)-500) ,16,16
   14 IF(L17+1) 9999,14,
      ND4(3)=LIST3(I)
      IA(1000)=I
      A(1004)=A(I)
      DO 15 J=1,3
      L7=3*I-3+J+NP
   15 A(J+1000)=A(L7)
      CALL NTRAN(NTR,1,5,A(1000),L17)
      LIST3(I)=LIST3(I)+5
```


10833884

```
   16 CONTINUE
C
C ADVANCE TAPE TO SIXTH FILE
C
  116 IF(L17+1) 9999,116,
      CALL NTRAN(NTE,8,2)
C
C READ ISOTOPE DATA, EDIT, AND SPRINKLE ON DRUM
C
      DO 1007 N=1,NM
      DO 1006 M=1,NP
      CALL NTRAN(NTE,2,NIS,A,L17)
 1000 IF(L17+1) 9999,1000,
      IF(LIST(M)-500) ,1006,1006
      DO 1001 I=1,NTOPE
 1001 B(I)=0.0
      DO 1004 I=1,NTOPE
      DO 1002 J=1,NIS
 1002 IF(NISO(I).EQ.J) GO TO 1003
      GO TO 1004
 1003 B(I)=A(J)
 1004 CONTINUE
      ND4(3)=LIST3(M)
      CALL NTRAN(NTR,1,NTOPE,B,L17)
 1005 IF(L17+1) 9999,1005,
      LIST3(M)=LIST3(M)+NTOPE
 1006 CONTINUE
 1007 CONTINUE
C
C REMOVE THOSE SITES THAT MAKE NO CONTRIBUTION
C
      J=ND4(1)
      K=ND4(1)
      THRU=.FALSE.
      J2=NTOPE*NM+5
      DO 2005 I=1,NTOTAL
```


1083385

```
      ND4(3)=J
      CALL NTRAN(NTR,2,J2,A,L17)
 2000 IF(L17+1) 9999,2000,
      DO 2001 L=6,J2
 2001 IF(A(L).GT.0.0) GO TO 2002
      THRU=.TRUE.
      GO TO 2005
 2002 IF(.NOT.THRU) GO TO 2004
      ND4(3)=K
      CALL NTRAN(NTR,1,J2,A,L17)
 2003 IF(L17+1) 9999,2003,
 2004 K=K+J2
 2005 J=J+J2
C
C SET END OF FILE IN PROPER PLACE
C
      ND4(4)=K
C
C REWIND DRUM
C
      ND4(3)=ND4(1)
C
C REWIND DOSIS TAPE WITH INTERLOCK
C
      CALL NTRAN(NTE,11)
C
      RETURN
C
C NTRAN ERROR
C
 9999 WRITE(NTO,9998)
 9998 FORMAT('0NTRAN ERROR IN DOSIS6')
      RETURN 0
C
      END
```


1083386

423

10833381

```
@ ELT ESODEF,1,710317, 30170

      SUBROUTINE ESODEF
C
C         ISOTOPE DEFINITION  - READS ISOTOPE DEFINITION CARDS
C
C
      PARAMETER LISO=32
      INTEGER CROSS
      COMMON/ONE/NTE,NTA,NTD,NTD2,LAIR,KKKKKK,NTOPE,NSITE,NTO,NTI
      COMMON/FOUR/CR(LISO),CA(LISO),CT(LISO),SYM(LISO),NISO(LISO),
     .HL(LISO),MDAU(LISO)
      DIMENSION DIST(LISO)
C
      WRITE(NTO,10)
   10 FORMAT('1 NO.'4X'SYM'6X'LAMBDA'4X'MOTHER'6X'DIST'//)
      DO 100 I=1,LISO
      READ(NTI,11)  NISO(I),SYM(I),HL(I),DIST(I),MDAU(I)
   11 FORMAT(I5,4X,A6,E11.3,9X,F10.0,I5)
      IF(NISO(I).LT.1) GO TO 120
      WRITE(NTO,12) NISO(I),SYM(I),HL(I),MDAU(I),DIST(I)
   12 FORMAT(I5,4XA6,E11.3,I7,F13.2)
  100 CONTINUE
      I=LISO+1
      READ(NTI  ,111)
  111 FORMAT( )
  120 NTOPE = I-1
      DO 130 I=1,NTOPE
  130 MDAU(I)=CROSS(MDAU(I))
      RETURN
      END
```

```
@ ELT FLDRPT,1,710125, 67194

      SUBROUTINE FLDRPT
C
C REPORTS FLOOD CALCULATIONS
C
      INCLUDE MCOM
      DATA TOTAL/'TOTAL'/
      K=1
C DO FOR EACH MONTH
      DO 8 M=1,LM
C IF FLOW LESS THAN CRITICAL FLOW SKIP TO END
      IF(FIN(M).LT.FLOOD(JFLOOD-1,4)) GO TO 8
C IF FLOOD HEIGHT SPECIFIED GO TO 1
      IF(FLOOD(JFLOOD-1,7)) ,,1
C CALCULATE FLOOD HEIGHT
      STAGE=FLOOD(JFLOOD-1,6)*((FIN(M)/FLOOD(JFLOOD-1,4))**FLOOD(JFLOOD-
     .1,5)-1.)
      GO TO 2
    1 STAGE=FLOOD(JFLOOD-1,7)
    2 FACTOR=.3048*STAGE*1.E-3*S1(M)
C SEDIMENT LAYER THICKNESS (MM)
      THICK=FACTOR*62.4/FLOOD(JFLOOD-1,3)
      T7=0.0
C CONVERT SEDIMENT PCI/KG TO PCI/M**2
      DO 3 J=1,NTOPE
      RJ(J)=WATSUR(J,M)*FACTOR
    3 T7=T7+RJ(J)
      IF(MOD(K-1,NPR).GT.0) GO TO 6
      WRITE(NTO,4) (RNAME(J,KMAP),J=1,3),DM
    4 FORMAT('1MONTHLY OVERBED DEPOSITION FOR '2A6,A3,' RIVER AT RIVER M
     .ILE'F6.1)
      WRITE(NTO,5)
    5 FORMAT(T21,'OVERBED'T32,'OVERBED'T53,'OVERBED'/
```


10833388

```
     .' MONTH'T12,'FLOW'T21,'SEDIMENT'T32,'SEDIMENT'T43,'ISOTOPE'T53,'SED
     .DIMENT'/T10,'M**3/SEC'T24,'MM'T33,'KG/M**2'T53,'PCI/M**2')
   6 WRITE(NTO,7) MM(M),FIN(M),THICK,FACTOR,(SYM(I),RJ(I),I=1,NTOPE),
     .TOTAL,T7
   7 FORMAT('0 'A3,1PE12.3,2E11.3,4XA6,E11.3/(T44,A6,E11.3))
     K=K+1
   8 CONTINUE
     RETURN
     END
```

1083390

```
@ ELT FLREAD,1,710125, 67233

      SUBROUTINE FLREAD
C     READS MONTHLY AVERAGE FLOW DATA
      INCLUDE MCOM
      DIMENSION H(14),LFT(200,15)
      EQUIVALENCE (FT,LFT)
      DO 100 I=1,200
C READ COMMENT CARD
      READ(NTF,3) H
    3 FORMAT(14A6)
      WRITE(NTO,4) H
    4 FORMAT(1X,14A6)
C READ TWO CARDS WITH RIVER FLOW DATA
      READ(NTF,5) ID,RC1,(FT(I,J),J=2,9)
    5 FORMAT(I6,A2,F5.1,2X,A1,6F8.0)
C BLANK CARD - END OF DATA
      IF(ID) 110,110,
      READ(NTF,5) ID1,RC2,RM2,C16,(FT(I,J),J=10,15)
C                 2 CARDS/YEAR WITH SAME RIVER CODE AND MILE NO.
C IF TWO CARDS DONT AGREE - ERROR
      IF(RC1.NE.RC2) GO TO 999
      IF(FT(I,2).NE.RM2) GO TO 999
C
C WHICH RIVER NO.
      DO 20 J=1,NMAP
      IF(RC1.EQ.RCODE(J))  GOTO 30
   20 CONTINUE
C ERROR
      GO TO 999
C
   30 LFT(I,1)=J
  100 CONTINUE
C THERE SHOULDN'T BE 200 RIVERS - ERROR
```

```
      GOTO 999
C
C**              BLANK CARD ENCOUNTERED - END FLOW CARD READ
C
  110 NFLOW = I - 1
C*                          SORT  FLOW TABLE
      CALL SORTF(NFLOW,200,15,FT)
C
      DO 130 I=1,NFLOW
      DO 120 J=4,15
C
C**        CONVERT FLOWS FROM KCFS TO M**3/SEC
C**              1 M**3      =  35.31 FT**3
C**               M**3/SEC   =  0.03531 KCFS
      FT(I,J)=28.32*FT(I,J)
C
  120 CONTINUE
      L=LFT(I,1)
      IF(MOD(I,15).NE.1) GOTO 125
      WRITE(NTO,117)
  117 FORMAT('1',T38,'GIVEN RIVER FLOWS IN CUBIC METERS PER SECOND')
      WRITE(NTO,116)
  116 FORMAT('0',T7,'RIVER',T23,'MILE',T36,'JAN/JUL',8X,'FEB/AUG',
     18X,'MAR/SEP',8X,'APR/OCT',8X,'MAY/NOV',8X,'JUN/DEC' )
  125 WRITE(NTO,126) (RNAME(K,L),K=1,3),FT(I,2),(FT(I,K),K=4,9),FT(I,3),
     .(FT(I,K),K=10,15)
  126 FORMAT('0 '2A6,A3,F10.1,1P6E15.3,3XA1/T28,6E15.3)
  130 CONTINUE
C
      RETURN
  999 WRITE(NTO,9991) ID,RC1,(FT(I,J),J=2,9)
 9991 FORMAT('0* ERROR ENCOUNTERED IN SUBROUTINE FREAD WHILE READING
     1FLOW CARDS'/ 1X,I6,A2,F5.1,2X,A1,6F8.2)
      RETURN 0
      END
```


1083391

```
@ ELT GNDM,1,710409, 46268

      SUBROUTINE GNDM
      INTEGER ATOW
      INCLUDE MCOM
      DIMENSION A(455),B(455),IA(455)
      EQUIVALENCE (A,IA,RJ),(B,RJ(456))
      DIMENSION  KK(LCENT)
      EQUIVALENCE (KK,RUNOF)
      DATA K14,K1,K2,LB/14,3*0/
C**       MAIN PROGRAM TO DETERMINE GROUND WATER CONCENTRATIONS
C
      DO 10 I=1,LCENT
   10 KK(I)=0
      MISO = (LM+1)*LISO
      CALL RUNO   @ DETERMINE RUNOFF AMOUNTS IN LITERS/(METER**2*MON)
C         R(12,300)     RUNOFF IN LITERS/(METER**2*MONTH)
C
      DO 1000 K=1,10000
C
      READ(NTA)            KCENT,KTYP ,DUM,NUM,    (A(I),I=1,NUM)
C LOOK FOR DUMMY RECORD FOR END OF INFO
      IF(KCENT-99999) ,1100,
C
      IF(KTYP.NE.6) GO TO 1000
      K1 = K1+1    @ NO. RECORDS PROCESSED
C
C         KTYP  = 2      SOIL CONTAMINATION FROM AIR  (DRY)
C         KTYP  = 3      SOIL CONTAMINATION FROM AIR  (WET)
C
   40 IF(LB+1) 9000,40,     @IF CHANNEL BUSY  -  WAIT
      ND6(3)=ND6(1)+(KCENT-1)*MISO
C
C**       REMOVE NON-WATER ISOTOPES
```


10833592

```
C
      JN = 0
      DO 100 I=1,NUM,13
      I1=ATOW(A(I))
      JA=KROSS(I1)
      IF(JA)  100,100,
      JM = JN + 1
      JN = JM + 12
      J1 = I - 1
      IA(I)=I1
C
      DO 20 J=JM,JN
      J1 = J1 +1
      B(J) = A(J1)
   20 CONTINUE
C
  100 CONTINUE
      N=JN
C
C
      KK(KCENT) = KTYP       @ FIRST RECORD FOR CENTROID  'KCENT'
      CALL NTRAN(20,1,N,B,LB)
  350 IF(LB+1) 9000,350,
C
 1000 CONTINUE
C
 1100 CONTINUE
      K9=K
      K=N/13
C
C FIND THOSE CENTROIDS WHOSE GROUND WATER COMES FROM ANOTHER CENTROID AND DECAY
C ISOTOPES BY TRAVEL TIME
C
C KSINK=CENTROID THAT DRINKS GROUND WATER
C KSORCE=CENTROID SUPPLYING THE GROUND WATER
C DELAY= DAYS TRAVEL TIME FROM SOURCE TO SINK
```


10833393

```
C BLANK KSINK SIGNALS END OF DATA
C
 2000 READ(NTI,2001) KSINK,KSORCE,DELAY
 2001 FORMAT(2I4,F5.0)
      IF(KSINK) 2010,2010,
      DELAY=DELAY*86400.
      ND6(3)=ND6(1)+(KSORCE-1)*MISO
      CALL NTRAN(20,2,N,A,L17)
 2002 IF(L17+1) 9000,2002,
C DIVIDE YEARLY PCI'S IN SOLUTION BY YEARLY RUNOFF
      L=0
      DO 2003 I=1,K
      L=L+1
      I1=KROSS(A(13*I-12))
C WATSUR(I,1)=ANNUAL RUNOFF
      DIS=   1./((DIST(I1)+1.)*WATSUR(KSORCE,1))
      B(I)=0.0
      ABC=EXP(-HL(I1)*DELAY)
      DO 2003 J=1,LM
      L=L+1
 2003 B(I)=B(I)+A(L)*DIS*ABC
C DECAY
C ARRANGE IN PROPER ORDER FOR DOSE TAPE
      L=0
      DO 2004 I=1,K
      L=L+1
      DO 2004 J=1,LM
      L=L+1
 2004 A(L)=B(I)
      K2=K2+1
       WRITE(NTB) KSINK,K14,DUM,N,(A(I),I=1,N)
      KK(KSINK)=0
C CHECK IF REPORT WANTED
      DO 2005 I=1,JPGNDW
 2005 IF(KSINK.EQ.JPOP(I)) GO TO 2006
      GO TO 2000
```


10833394

```
 2006 WRITE(NTO,2007) KSINK,(CNT(I,KSINK),I=1,3)
 2007 FORMAT('1 CENTROID'I6,5X3A6//
     .T30,'TRANSPORTED GROUND WATER CONCENTRATIONS'//
     .' SYMBOL  PCI/LIT'//)
      DO 2009 I=1,K
      I1=KROSS(A(13*I-12))
      WRITE(NTO,2008) SYM(I1),B(I)
 2008 FORMAT(1XA6,1PE9.3)
 2009 CONTINUE
      GO TO 2000
C
C THE REMAINING CENTROIDS DRINK SURFACE WATER
C
C SCHEME - INITIAL CONCENTRATION IS LAST YEARS PCI'S DECAYED APPROPRIATE NO.
C OF MONTHS DIVIDED BY YEARLY RUNOFF. EACH MONTH REMOVE MONTHLY RAINFALL/AN-
C NUAL RUNOFF * INITIAL CONC. AND ADD THIS MONTHS PCI'S/ANNUAL RUNOFF - THEN
C DECAY ONE MONTH FOR NEW INITIAL CONC. - REPEAT
C
 2010 DO 2021 I=1,300
      IF(KK(I)) ,2021,
      ND6(3)=ND6(1)+(I-1)*MISO
      CALL NTRAN(20,2,N,A,L17)
 2011 IF(L17+1) 9000,2011,
      DO 2012 J=1,LM
C D(J,1)=MONTHLY RAINFALL/ANNUAL RUNOFF
 2012 D(J,1)=R(J,I)/WATSUR(I,1)
      DO 2013 J=1,K
      I1=KROSS(A(13*J-12))
C     CS(J,1)=FRACTION OF ISOTOPE IN SOLUTION
      CS(J,1)=1./(DIST(I1)+1.)
      DO 2013 L=1,LM
      M=13*J-12+L
C  BC(J,L)=THIS MONTHS CONCENTRATION CONTRIBUTION
 2013 BC(J,L)=A(M)*CS(J,1)/WATSUR(I,1)
C FIND CONC. AT START OF YEAR
      ABC=1.
```


1083395

```
      DO 2014 L=12,1,-1
      C(L,1)=ABC*(1.-D(L,1))
 2014 ABC=C(L,1)
C DS(J,1)=INITIAL CONC OF ISOTOPE J
      DO 3001 J=1,K
      SUM=BC(J,12)
      I1=KROSS(A(13*J-12))
      ABC=1.-C(1,1)*EXP(-HL(I1)*86400.*30.*11)
      DO 3000 L=1,11
 3000 SUM=SUM+C(L,1)*BC(J,L)*EXP(-HL(I1)*86400.*30.*(12-L))
 3001 DS(J,1)=SUM/ABC
C MAKE MONTHLY ADJUSTMENTS AND REARRANGE FOR DOSE TAPE
      DO 2015 L=1,LM
      DO 2015 J=1,K
      I1=KROSS(A(13*J-12))
      DS(J,1)=DS(J,1)*EXP(-HL(I1)*86400.*30.)
      DS(J,1)=DS(J,1)+BC(J,L)-DS(J,1)*D(L,1)
      M=13*J-12+L
 2015 A(M)=DS(J,1)
      K2=K2+1
      WRITE(NTB) I,K14,DUM,N,(A(L),L=1,N)
C CHECK IF REPORT WANTED
      DO 2016 L=1,JPGNDW
 2016 IF(I.EQ.JPOP(L)) GO TO 2017
      GO TO 2021
 2017 WRITE(NTO,2018) I,(CNT(L,I),L=1,3),(MM(L),L=1,LM)
 2018 FORMAT('1 CENTRIOD'I6,5X3A6//
     .T30,'NON-TRANSPORTED GROUND AND SURFACE WATER CONCENTRATIONS (PCI/
     .LIT)'//
     .' SYMBOL'T14,A3,T24,A3,T34,A3,T44,A3,T54,A3,T64,A3,T74,A3,T84,A3,
     .T94,A3,T104,A3,T114,A3,T124,A3//)
      DO 2020 L=1,K
      I1=KROSS(A(13*L-12))
      M1=13*L-11
      M2=M1+11
      WRITE(NTO,2019) SYM(I1),(A(M),M=M1,M2)
```


10833396

```
 2019 FORMAT(1XA6,1PE13.3,11E10.3)
 2020 CONTINUE
 2021 CONTINUE
C
C REWIND ATMOSPHERIC TAPE WITH INTERLOCK
C
      CALL NTRAN(NTA,11)
C
C
      K=K9
      NA = N
      WRITE(NTO,1101) K2,K1,K,LB
 1101 FORMAT('0 GROUND WATER CALCULATION COMPLETE ',I10,' CENTROIDS',
     1' NO. RCDS =',I10,' NO. READS =',I10,' STATUS ='I10  ///)
      WRITE(NTO,9003)
 9003 FORMAT('1')
      RETURN
 9000 CONTINUE
      WRITE(NTO,9001) LB,N,NUM,KCENT,KTYP
 9001 FORMAT('0******NTRAN I/O ERROR ',5I10)
      WRITE(NTO,9002)  (A(I),I=1,NUM)
      WRITE(NTO,9002)   (B(I),I=1,N)
 9002 FORMAT(1X,I6,12E10.3)
      WRITE(NTO,1101) K2,K1,K,LB
      RETURN 0
      END
```


1083397

10833398

```
@ ELT ISODEF,1,710311, 49847

      SUBROUTINE ISODEF
C
C         ISOTOPE DEFINITION  - READS ISOTOPE DEFINITION CARDS
C
C
C
      INCLUDE MCOM
      WRITE(NTO,10)
   10 FORMAT('1 NO.'4X'SYM'6X'LAMBDA'4X'MOTHER'6X'DIST'//)
      DO 100 I=1,LISO
      READ(NTI,11)  NISO(I),SYM(I),HL(I),DIST(I),MDAU(I)
   11 FORMAT(I5,4X,A6,E11.3,9X,F10.0,I5)
      IF(NISO(I).LT.1) GO TO 120
      WRITE(NTO,12) NISO(I),SYM(I),HL(I),MDAU(I),DIST(I)
   12 FORMAT(I5,4XA6,E11.3,I7,F13.2)
  100 CONTINUE
      I=LISO+1
      READ(NTI  ,111)
  111 FORMAT( )
  120 NTOPE = I-1
      DO 130 I=1,NTOPE
  130 MDAU(I)=KROSS(MDAU(I))
      RETURN
      END
```

1083399

```
@ ELT KROSS,1,710125, 67241

      FUNCTION KROSS(I)
C
C                CROSS REFERENCE BETWEEN ISOTOPE NUMBER AND POSISION
C                IN ARRAYS
C
      INCLUDE MCOM
C
C WHICH POSITION IN ARRAYS DOES THIS ISOTOPE GO
      DO 10 J=1,NTOPE
      IF(I-NISO(J))    ,20,
   10 CONTINUE
C THIS ISOTOPE NOT WANTED
      KROSS = 0
      RETURN
   20 KROSS = J
      RETURN
      END
```


495

```
@ ELT LAKE,1,710329, 30046

      COMMON/ONE/NTE,NTA,NTD,NTD2,LAIR,K,NTOPE,NSITE,NTO,NTI
      COMMON/TWO/VSWEEP,VTOTAL,TIME,VILL,DIFFUS,DEPTH,VELOC
      COMMON/THREE/SURF(20),ALAT(50),ALON(50)
      NAIR=2
      NTE=2  @ TAPE E  REACTORS
      NTA=7  @ TAPE D  ATMOSPHERE
      NTD2=20
      NTD=18
      NTI=5  @ CARD READER
      NTO=6  @ PRINTER
C
C WHICH ISOTOPES ARE WANTED
C
      CALL ESODEF
      READ(NTI,1) VSWEEP,VTOTAL,TIME,VILL,VELOC,DIFFUS,DEPTH
    1 FORMAT(7E10.0)
      TIME=TIME*365.*24.*3600.
      READ(NTI,2) NAIR
    2 FORMAT(I2)
      READ(NTI,1) (SURF(I),I=1,NAIR)
C
C READ DOSIS AND ATMOSPHERIC TAPES
C
      CALL TAPES
C
C CALCULATE BACK GROUND
C
      CALL BACKGD
C
C CALCULATE CURRENT ADDITION TO BACKGROUND
C
      CALL NOW
```


1083400

```
33.      C
34.              STOP
35.              END
```

10834001

1083402

```
@ ELT MFLOW,1,710125, 67222

C
C                 DETERMINE FLOW AT A GIVEN MILE 'TM' ON THE CURRENT
C                      TRIBUTARY.
C
      SUBROUTINE MFLOW
C
C         TM          CURRENT RIVER MILE
C         FIN(.)      FLOW AT LAST POINT                    RETURN
C         FOUT(.)     FLOW AT CURRENT POINT 'TM'            RETURN
C
      INCLUDE MCOM
      DIMENSION LFT(200,15)
      EQUIVALENCE (LFT,FT)
      DIMENSION FEND(12),FBEG(12)
      DATA KFLOW,KF,LF/0,0,0/
C
      IF(KF - KMAP)    ,50,50
C
C**               NEW TRIBUTARY, NEW BASIN OR NEW SEGMENT
C
      IF(RCODE(KF) - RCODE(KMAP))    ,40,
C
C**               RESTART WITH NEW TRIBUTARY
C
      DO 10 I=1,LM
   10 FEND(I)=0.0
      ENDM = 100000.
      BEGM = -1.
      REND = 100000.
C                       NEW BASIN OR SEGMENT  (SAME RIVER)
   40 KF = KMAP
      GO TO 60
```

```
C
   50 IF(UM - REND) 90, ,
      IF(BEGM) 70,400,400
C
   60 IF(LF - KMAP)  90,70,
      IF(RCODE(LF) - RCODE(KMAP))  100,70,100
C
   70 REND=FT(KFLOW,2)
      IF(ENDM.LT.10000.)  BEGM = ENDM
      ENDM = REND
      D2 = 0.
      D1=FT(KFLOW,3)
      IF(FLD(0,6,D1).EQ.9.OR.FLD(0,6,D1).EQ.25) D2 = 1.
      DO 80 I = 1,LM
      FBEG(I) = FEND(I)
   80 FEND(I)=FT(KFLOW,I+3)+D2*FEND(I)
      GO TO 50
C
   90 KFLOW = KFLOW + 1
      IF(KFLOW - NFLOW)  ,  ,100
      LF=LFT(KFLOW,1)
      GO TO 60
C
  100 REND = 0.
      IF(ENDM - 10000.)  400, ,
C**
C**       ERROR  -  NO FLOW DEFINITION CARDS FOR THIS RIVER
C
      WRITE(NTO,111) (RNAME(I,KMAP),I=1,2),RC(KMAP),DM,
     1(RNAME(I,LF),I=1,2),RCODE(LF),RMILEM(LF)
  111 FORMAT('0**** MISSING FLOW DEFINITION CARDS FOR RIVER '
     12A6,5X,A2,5X,'AT MILE ', F10.1 /
     2'0  CURRENT LOCATION IN FLOW TABLE IS AT RIVER ',
     32A6,5X,A2,5X,'AT MILE ', F10.1 )
C
      DO 110 I =1,LM
```


1083403

```
      FBEG(I)  = 1.0
      FEND(I) = 1.0
  110 CONTINUE
      BEGM = 0.
      ENDM = 0.
      GO TO 400
C
C
C
C
  400 DO 410 I=1,LM
      FIN(I) = FEND(I)
      FOUT(I) = FEND(I)
  410 CONTINUE
C
      RETURN
      END
```


1083404

1083405

```
@ ELT NOW,1,710329, 30053

      SUBROUTINE NOW
      PARAMETER LISO=32
      REAL IN
      COMMON/ONE/NTE,NTA,NTD,NTD2,LAIR,K,NTOPE,NSITE,NTO,NTI
      COMMON/TWO/VSWEEP,VTOTAL,TIME,VILL,DIFFUS,DEPTH,VELOC
      COMMON/THREE/SURF(20),ALAT(50),ALON(50)
      COMMON/FOUR/CR(LISO),CA(LISO),CT(LISO),SYM(LISO),NISO(LISO),
     .HALFL(LISO),MOTHER(LISO)
      COMMON/FIVE/A(LISO,12),B(LISO,12),C(41)
C
C CALCULATION OF CURRENT OUTPUT
C
      REWIND NTD
      WRITE(NTO,101)
  101 FORMAT('1REACTOR LOCATIONS'/5X'LONGITUDE'11X'LATITUDE'/1X'DEGREES'
     .3X'MINUTES'3X'DEGREES'3X'MINUTES')
      DO 1 J=1,12
      DO 1 I=1,NTOPE
    1 B(I,J)=0.0
      DO 18 I=1,K
      CALL NTRAN(NTD,2,12*NTOPE,A,L17)
    2 IF(L17+1) 9999,2,
      IF(ALON(I).LT.87.) GO TO 18
      IJK=ALON(I)
      ABC=IJK
      LMN=(ALON(I)-ABC)*60.
      KJI=ALAT(I)
      ABC=KJI
      NML=(ALAT(I)-ABC)*60.
      WRITE(NTO,102) IJK,LMN,KJI,NML
  102 FORMAT(I6,3I10)
      IF(ALAT(I).LT.41.88) GO TO 3
```

```
      LM=1
      LH=3
      LM2=11
      LH2=12
      DISTAN=69.*5280.*(ALAT(I)-41.88)
      GO TO 7
    3 LM=4
      LH=10
      LM2=0
      DISTAN=69.*5280.*(41.88-ALAT(I))
    7 DELX=DISTAN/40.
      DT=DELX/VELOC
      DELY=SQRT(4.*DIFFUS*DT)
      TERM=DIFFUS*DELX/(VELOC*DELY*DELY)
      VOL=DELX*DELY*DEPTH/DT
      DO 17 J=1,NTOPE
    8 DO 15 L=LM,LH
      DO 9 M=1,41
    9 C(M)=CA(J)
      C(1)=C(1)+A(J,L)/VOL
      IF(MOTHER(J)) ,,10
      DECAY=EXP(-HALFL(J)*DT)
      GO TO 11
   10 JJ=MOTHER(J)
      ABC=(CA(JJ)+A(JJ,L))*HALFL(JJ)/((CA(J)+A(J,L))*(HALFL(J)-HALFL(JJ)))
     .))
      DECAY=(1.-ABC)*EXP(-HALFL(J)*DT)+ABC*EXP(-HALFL(JJ)*DT)
   11 OUT=TERM*(C(1)-C(2))
      C(2)=C(2)+OUT
      C(1)=C(1)-OUT
      DO 14 M=2,40
      OUT=TERM*(C(M)-C(M+1))
      C(M+1)=C(M+1)+OUT
      DO 12 LL=M,2,-1
      IN=-TERM*(C(LL)-C(LL-1))
      C(LL)=C(LL)+IN-OUT
```


1083406

```
   12 OUT=IN
      C(1)=C(1)-OUT
      DO 13 LL=1,M
   13 C(LL)=C(LL)*DECAY
   14 CONTINUE
   15 B(J,L)=B(J,L)+VILL*C(1)
      IF(LM2) 16,17,
      III=LH
      II=LM
      LM=LM2
      LH=LH2
      LM2=-10
      GO TO 8
   16 LH2=LH
      LM2=LM
      LM=II
      LH=III
   17 CONTINUE
   18 CONTINUE
C
C PRINT RESULTS
C
      DO 22 I=1,NTOPE,13
      WRITE(NTO,19)
   19 FORMAT('1CURRENT PCI/SEC'/' ISOTOPE'T18,'JAN/JUL'T38,'FEB/AUG'T58,
     .'MAR/SEP'T78,'APR/OCT'T98,'MAY/NOV'T118,'JUN/DEC')
      J2=MIN0(I+12,NTOPE)
      DO 21 J=I,J2
      WRITE(NTO,20) SYM(J),(B(J,L),L=1,12)
   20 FORMAT('0'A6,E18.5,5E20.5/5X6E20.5)
   21 CONTINUE
   22 CONTINUE
C
C REARRANGE FOR PUNCHING
C
      DO 25 I=1,LISO
```


1083407

```
      DO 25 J=1,12
   25 A(I,J)=0.0
      DO 26 J=1,NTOPE
      M=NISO(J)
      DO 26 I=1,12
   26 A(M,I)=B(J,I)
      PUNCH 27,(I,(A(I,L),L=1,12),I=1,LISO)
   27 FORMAT(I10,6E10.5/6E10.5)
      RETURN
 9999 RETURN 0
      END
```


1083408

```
w ELT NTAB$,1,710125, 67245

NTABZZ  INFO  2 2
$(2) .        ASSIGNMENT   LOG UNIT
        +         5       .  -4     REREAD OR REWRITE IN CORE
        +         3       .  -3     CARD PUNCH
        +         2       .  -2     PRINTER
        +         1       .  -1     CARD READER
NTAB$*  +         4       .   0     CONSOLE
        +         'A'     .   1
        +         'E'     .   2
        +         'B'     .   3
        +         'F'     .   4
        +         1       .   5     CARD READER
        +         2       .   6     PRINTER
        +         'D'     .   7
        +         'H'     .   8
        +         'A'     .   9
        +         'E'     .  10
        +         'B'     .  11
        +         'F'     .  12
        +         'C'     .  13
        +         'G'     .  14
        +         D1      .  15     TRIBUTARY SCRATCH FILE  'NTT'
        +         D2      .  16     ATMOSHERIC DATA FILE   'NAA'
        +         D3      .  17     RIVER SECTION DISC FILE 'NRS'
        +         D4      .  18     REACTOR SOURCE DATA FILE  'NTR'
        +         D5      .  19     OUTPUT TO DOSE CALC MOD  'NTB'
        +         D6      .  20     RAINFALL AND RUNOFF FILE
        +         D7      .  21
        +         D7      .  22
        +         D7      .  23
        +         D7      .  24
        +         D7      .  25
```


1083409

```
33.                RES      20        . 26-45
34.      NTAB$$*    .
35.      D1        +      02400000          . TRIBUTARY SCRATCH FILE       'NTT'
36.                +      02600000
37.                +      02400000
38.                RES    4
39.      D2        +      02600000          . ATMOSHERIC DATA FILE         'NAA'
40.                +      03200000
41.                +      02600000
42.                RES    4
43.      D3        +      03200000          . RIVER DISCRIPTION FILE       'NRS'
44.                +      03300000
45.                +      03200000
46.                RES    4
47.      D4        +      03300000          . REACTOR SOURCE DATA FILE     'NTR'
48.                +      03600000
49.                +      03300000
50.                RES    4
51.      D5        +      03600000        .       OUTPUT TO DOSE (NTB)
52.                +      04000000
53.                +      03600000
54.                RES    4
55.      D6        +      04000000        .       RAINFALL AND RUNOFF
56.                +      04400000
57.                +      04000000
58.                RES    4
59.      D7        +      04400000        .       RIVER POINTS FOR RUNOFF
60.                +      05000000
61.                +      04400000
62.                RES    35          . RESERVED FOR EXPANSION
63.              END
```


1083410

```
@ ELT OBS,1,710125, 67236

      SUBROUTINE OBS(NTYPE)
C                NTYPE  = 1      IF BEFORE INJECTION POINT
C                         2      IF AFTER INJECTION POINT
C
C         DETERMINE POINTS TO OUTPUT DATA, AND GET INFORMATION
C         FROM THE MASTER TAPE.
C         NEXT PT. OF THE MASTER TAPE IS 'PTOBS'
C         ALSO  CODE FOR TYPE(S) OF OUTPUT.
C
      INTEGER POPNO
      INCLUDE MCOM
      GO TO (100,200),NTYPE
C
C         SETUP POPULATION CENTER POINT FOR TRIBUTARY 'KMAP'
C
  100 IF(KMAP-KRN(KCENT))  180,120,
      IF(KCENT-NCENT)  ,180,180
  110 KCENT = KCENT + 1
      GO TO 100
C
  120 PTOBS = RMK(KCENT)
      N1 = 1                @ POP. CENTER POINTS ON TRIBUTARY 'KMAP'
      RETURN
  180 PTOBS = -1.               @ NO POP. CENTER POINT ON TRIBUTARY
      N1 = 2
      RETURN
C
C
C            CHECK TRIBUTARY MILE 'UM'  FOR POP. CENTER POINT
C
  200 GO TO (210,300),N1
  210 IF(UM - PTOBS - .001)  , ,300
```


1083411

```
      KREP = 2      @  TURN LIVING PATERNS INDICATOR ON
      DO 220 I=1,POPNO
      IF(IPOP(I).NE.KCNT(KCENT)) GO TO 220
      CALL REPORT
      GO TO 221
  220 CONTINUE
  221 CONTINUE
      CALL DOSE
      KREP = 0      @8 TURN LIVING PATERNS INDICATOR OFF
      IF(KCENT.LT.NCENT) GO TO 110
      GO TO 180
  300 RETURN
      END
```


1083412

```
@ ELT OVRBED,1,710125, 67244

      SUBROUTINE OVRBED
C
C READ FLOOD DATA CARDS
C
      DIMENSION LFLOOD(200,7)
      INCLUDE MCOM
      EQUIVALENCE(LFLOOD,FLOOD)
      K=0
C
C READ CARDS, BLANK FIRST FIELD IS SIGNAL FOR END OF INPUT TO THIS MODULE
C
C RIVC=RIVER CODE
C RIVM=RIVER MILE
C STAGEO=NORMAL STAGE (FT)
C QO=NORMAL RIVER FLOW (KCFS)
C STAGEC=CRITICAL STAGE (FT)
C PC=PERCENT CLAY IN SEDIMENT
C PM=PERCENT SILT IN SEDIMENT
C PS=PERCENT SAND IN SEDIMENT
C EXPO IS EXPONENT IN STAGE=NORMAL STAGE*(FLOW/NORMAL FLOW)**EXPO
C IF OVERBD IS ZERO - OVER BANK HEIGHT IS CALCULATED
C IF OVERBD IS NOT ZERO - OVER BANK HEIGHT IS OVERBD (FT)
      DO 4 I=1,200
      READ(NTI,1) RIVC,RIVM,STAGEO,QO,STAGEC,PC,PM,PS,EXPO,OVERBD
    1 FORMAT(A2,F6.1,8F9.1)
      IF(RIVC.EQ.' ') GO TO 5
      DO 2 J=1,NMAP
    2 IF(RIVC.EQ.RCODE(J)) GO TO 3
C NO MATCH - IGNORE THIS CARD
      GO TO 4
    3 K=K+1
      LFLOOD(K,1)=J  @  RIVER NO.
```


10834113

510

```
      FLOOD(K,2)=RIVM  @ RIVER MILE
      FLOOD(K,3)=.4*PC+.72*PM+.97*PS @ SEDIMENT =/FT**3
      FLOOD(K,4)=Q0*28.32*(STAGEC/STAGEO)**EXPO @ CRITICAL FLOW M**3/SEC
      FLOOD(K,5)=EXPO
      FLOOD(K,6)=STAGEC  @  CRITICAL STAGE  FT
      FLOOD(K,7)=OVERBD @ INPUT FLOOD DEPTH RATHER THAN CALC  FT
    4 CONTINUE
    5 CALL SORTF(K,200,7,FLOOD)
      KFLOOD=K
      RETURN
      END
```


108341 4

```
@ ELT POPCNT,1,710125, 67220

      SUBROUTINE POPCNT
      INCLUDE MCOM
      DIMENSION CENT(3)
C
C         READS POPULATION CENTER TAPE
C
C**           ALL TYPE 2 CARDS ARE PROCESSED   'DRINGING WATER'
C*               COL 38 = A       DRINKING WATER FROM RIVER
C*               COL 38 = B       DRINKING WATER FROW GROUND WATER
C
C**           PROCESSES ALL CARDS WITH NON-BLANK RIVER MILE
C
C**          ZERO CENTROID NUMBER ENDS INPUT
C
C**           ALL OTHER CARDS ARE IGNORED
C
C
C
      KCENT=0.    @ RECORD COUNTER
C
      DO 100 K=1,10000
C
      READ(NTU,11) K1,K2
   11 FORMAT(I3,1XI2)
      IF(K1) 120,120,
      IF(K2.NE.1) GO TO 100   @ ACCEPT ONLY CARD TYPE 1
      READ(M4,13) K1,K2,CENT,RM1,R1,R2,T1
   13 FORMAT(I3,1X,I2,2X,3A6,32X,F4.0,1X,2A6,1X,I1)
      IF(K1.GT.LCENT) GO TO 15
      CNT(1,K1) = CENT(1)
      CNT(2,K1) = CENT(2)
      CNT(3,K1) = CENT(3)
```


1083415

```
   15 CONTINUE
C          IF RIVER MILE FIELD IS BLANK SKIP CARD
C
      IF(RM1.EQ.-0.) GO TO 100
C
C**        RIVER MILE NOT BLANK  -  REQUIRES PROCESSING
C
      KCENT = KCENT + 1
      KCNT(KCENT) = K1
      KTYPE(KCENT) = K2
      RMK(KCENT) = RM1
      DRNK(KCENT) = T1
C
C       .
C
      DO 20 KMAP=1,NMAP
      IF(RNAME(1,KMAP).NE.R1) GO TO 20
      IF(RNAME(2,KMAP).NE.R2) GO TO 20
C
C
      KRN(KCENT) = KMAP
      GO TO 100
   20 CONTINUE
C**             ERROR **  NO MATCH OF RIVER NAME
C
      WRITE(NTO,21) K1,K2,RM1,R1,R2    ,T1
   21 FORMAT('0*** ERROR*** POPULATION CENTER RIVER NAME INVALID  '//
     15X,2I5,F10.1,2A6,    1X,I2)
      RETURN 0
  100 CONTINUE
C
  120 NCENT = KCENT
      CALL SORTF( NCENT,LC,5,KRN)
      WRITE(NTO,121)
  121 FORMAT('1',T48,'POPULATION CENTER RECORDS'  //
     .T4,'RIVER NAME'T22,'R. MILE'T32,'CENTER NAME'T53,'CENTER'
```


1083416

```
     .T62,'DRINK'/)
C
      DO 150 K=1,NCENT
      KMAP = KRN(K)
      IF(MOD(K,44).EQ.0) WRITE(NTO,121)
      K1=KCNT(K)
      IF(K1-LCENT) ,,123
      WRITE(NTO,122) (RNAME(J,KMAP),J=1,3),RMK(K),(CNT(J,K1),J=1,3),KCNT
     .(K),DRNK(K)
  122 FORMAT(3X2A6,A3,F10.1,3X3A6,I7,I8)
      GO TO 150
  123 WRITE(NTO,124) (RNAME(J,KMAP),J=1,3),RMK(K),KCNT(K),DRNK(K)
  124 FORMAT(3X2A6,A3,F10.1,21XI7,I8)
  150 CONTINUE
      PTOBS = RMK(1)
      KCENT = 1
      RETURN
      END
```


1083417

1083418

```
@ ELT RBAS,1,710125, 67230

      SUBROUTINE RBAS
      INCLUDE MCOM
      DATA KEOF,IMAP,RMB/1,0,10000./
      DIMENSION A(455)
      EQUIVALENCE (A,RJ,R1),(A(2),RM1),(A(3),IAI)
C
C
C
      DO 10 M=1,LM     @ CLEAR RUNOF ARRAY
      DO 10 I=1,NTOPE
      RUNOF(I,M) = 0.
   10 CONTINUE
C
      GO TO (20,400),KEOF
C
   20 IF(IMAP-KMAP) 60, ,400
      IF(RMB-DM) 400, ,
      RBMILE = RMB
      ND6(3)=ND6(1)+(ICNT-1)*(LM+1)*LISO
      CALL NTRAN(20,2,NA,A,LB)
   40 IF(LB+1) 9000,40,
C
      DO 50 K=1,NA,13
      K1=KROSS(A(K))
      K2=K+1
      K3=K2+11
      J = 1
      DO 45 I =K2,K3
      RUNOF(K1,J) = RUNOF(K1,J) + AR*A(I)
      J = J + 1
   45 CONTINUE
   50 CONTINUE
```

```
      RMB = 0.
      NT4=2    @  TURN ON RUNOFF INDICATOR
C
C
C**       AR= AREA IN SQ.MILES = SQ.METERS*MONTH/SECONDS
C**       A      AIR CONCENTRATION      PCI/(SQ.METER*MONTH)
C**       2.592E6     SECONDS/MONTH
C**       2.59E6     SQ.METERS/SQ.MILE
C**       AR*A(I)          PCI/SEC
C
   60 IF(ND7(3).GE.ND7(4)) GO TO 300
      CALL NTRAN(N21,2,4,A,LB)
   61 IF(LB+1) 9000,61,
C
      DO 70 I=1,NMAP
      IF(RCODE(I).EQ.R1) GO TO 80
   70 CONTINUE
      GO TO 60
C
   80 IMAP = I
      RMB = RM1
      ICNT=IAI
      AR=A(4)
      GO TO 20
C
  300 KEOF = 2
  400 RETURN
 9000 WRITE(NTO,9001) LB,ICNT,NA,IMAP,KMAP,KEOF,(A(I),I=1,NA,13)
 9001 FORMAT('0*******************NTRAN READ ERRRO IN RBAS' /
     1'LB ICNT IMAP KMAP KEOF A(1) ',8I10/(1X,10I10))
      RETURN 0
      END
```


1083419

1083420

```
@ ELT RBDPTS,1,710125, 67210

      SUBROUTINE RBDPTS(NTD,NRS,NTO,RCODE,NMAP,RNAME)
C
C THIS MODULE READS RIVER SECTION CARDS, SORTS, AND WRITES DRUM FOR MODULE
C RBED
C
C NTD,NRS, AND NTO ARE I/O UNITS FROM MAIN
C NMAP,RCODE, AND RNAME ARE FROM MODULE RMAP
C
C NI IS NUMBER OF RIVER SECTIONS FOR EACH RIVER
C  W1=UPSTREAM SURFACE WIDTH  FEET
C W2=UPSTREAM BOTTOM WIDTH  FEET
C W3=DOWNSTREAM SURFACE WIDTH  FEET
C W4=DOWNSTREAM BOTTOM WIDTH  FEET
C D1=UPSTREAM DEPTH  FEET
C D2=DOWNSTREAM DEPTH  FEET
C EL=SECTION LENGTH  FEET
C RC=RIVER CODE
C RM=RIVER MILE  MILE
C S IS RIVER SURFACE
C V IS RIVER VOLUME
C
      DIMENSION RCODE(2),RNAME(3,2)
      COMMON/NTABZZ/NTAB(50),ND1(7),ND2(7),ND3(7),ND4(7),ND5(7),ND6(7),
     .ND7(42)
      COMMON/SHARE/ALL(2400,4),NI(200),RRC(200)
      DIMENSION RM(2400),V(2400),S(2400),IA(2400)
      EQUIVALENCE (ALL,IA),(ALL(1,2),RM),(ALL(1,3),S),(ALL(1,4),V)
      DO 100 I=1,NMAP
  100 NI(I)=0
      I=0
    1 I=I+1
      READ(NTD,2) W1,W2,W3,W4,D1,D2,EL,RC,RM(I)
```

```
    2 FORMAT(7E10.0,1XA2,F5.1)
      IF(W1) 5,5,
      DO 3 K=1,NMAP
    3 IF(RC.EQ.RCODE(K)) GO TO 4
      I=I-1
      GO TO 1
    4 NI(K)=NI(K)+1
      IA(I)=K
      IF(W2.LT.1.E-6) W2=W1
      IF(W3.LT.1.E-6) W3=W1
      IF(W4.LT.1.E-6) W4=W2
      IF(D2.LT.1.E-6) D2=D1
      A1=(W1+W2)*D1/2.
      A2=((W3+W4-W1-W2)*D1+(W1+W2)*(D2-D1))/(4.*EL)
      A3=((W3+W4-W1-W2)*(D2-D1))/(6.*EL*EL)
      S(I)=(W1+W3)*EL/2.
      V(I)=((A3*EL+A2)*EL+A1)*EL
      GO TO 1
    5 I=I-1
C SEE IF EACH RIVER HAS RIVER SECTIONS
      DO 6 K=1,NMAP
    6 IF(NI(K).EQ.0) GO TO 9997
C SORT ASCENDING RIVER NO. AND DESCENDING RIVER MILE
      CALL SORTF(I,2400,4,ALL)
C REARRANGE AND WRITE ON DRUM
      J1=1
      DO 9 K=1,NMAP
      IA(1)=NI(K)
      ALL (2,1)=RCODE(K)
      J2=J1-1+NI(K)
      DO 7 J=J1,J2
      L=J-J1+3
      ALL(L,1)=RM(J)
      L=L+NI(K)
      ALL(L,1)=S(J)
      L=L+NI(K)
```


1083421

```
      7 ALL(L,1)=V(J)
        CALL NTRAN(NRS,1,3*NI(K)+2,ALL,L17)
      8 IF(L17+1) 9999,8,
      9 J1=J1+NI(K)
C REWIND DRUM
        ND3(3)=ND3(1)
        RETURN
 9999 WRITE(NTO,9998)
 9998 FORMAT('1NTRAN ERROR IN RBDPTS')
        GO TO 10
 9997 WRITE(NTO,9996) (RNAME(J,K),J=1,3)
 9996 FORMAT('1RIVER SECTION CARDS MISSING FOR '3A6)
   10 RETURN 0
        END
```


1083422

319

10834423

```
@ ELT RBED,1,710125, 67206

      SUBROUTINE RBED
      INCLUDE MCOM
      EQUIVALENCE (IAI,RJ)
      NI=0
      IF(ND3(3).GE.ND3(4)) GO TO 4
C READ NO. OF SECTIONS (NI) AND RIVER CODE(RC) FOR THIS RIVER
      CALL NTRAN(NRS,2,2,RJ,L17)
    1 IF(L17+1) 9999,1,
      NI=IAI
      CRRR=RJ(2)
C READ RIVER MILE (RM), RIVER SURFACE (S), RIVER VOLUME (V)
      CALL NTRAN(NRS,2,3*NI,RJ,L17)
    2 IF(L17+1) 9999,2,
      DO 3 I=1,NI
      RC(I)=CRRR
      RM(I)=RJ(I)
      L=NI+I
      S(I)=RJ(L)*FTM2
      L=L+NI
    3 V(I)=RJ(L)*FTM3
    4 RETURN
 9999 WRITE(9998)
 9998 FORMAT('1NTRAN ERROR IN RBED')
      RETURN 0
      END
      RETURN
      END
```

1083424

```
@ ELT REACT,1,710125, 67221

      SUBROUTINE REACT(L1)
      INCLUDE MCOM
C
C**       RETURNS REACTOR OUTPUT TO THE RIVER
C              L1   1    INITIALIZE ROUTINE FOR A TRIBUTARY
C              L1   2    NEXT REACTOR ON THE SAME TRIBUTARY
C
C
      DIMENSION RII(2)
      EQUIVALENCE (RII,RI)
      REACTM = -1.
      IF(KOFF.LT.1) GO TO 300
      GO TO (100,110),L1
C
  100 MMAP = KMAP
  110 IF(MREAC-MMAP)  ,130,300
      IF(KOFF.LT.1) GO TO 300
      CALL RREACT
C
      GO TO 110
  130 REACTM = SRM
C
      I=1
      DO 140 M=1,LM
      DO 140 J=1,NTOPE
      REACTA(J,M)=RII(I)
  140 I=I+1
      IF(KOFF.LT.1) GO TO 300
      CALL RREACT
  300 RETURN
      END
```

```
@ ELT REPORT,1,710125, 67243

      SUBROUTINE REPORT
      INCLUDE MCOM
      DATA TOTAL/'TOTAL'/
C
C         PRINT REPORTS
C
C
C
      K = KCNT(KCENT)
      IF(K-300) ,,2
      DO 1 I=1,3
    1 RJ(I)=CNT(I,K)
      GO TO 4
    2 DO 3 I=1,3
    3 RJ(I)=BNK
    4 CONTINUE
      DO 100 M=1,LM
      T1 = 0.
      T2 = 0.
      T3 = 0.
      T4 = 0.
      T5 = 0.
      T6 = 0.
      DO 20 J = 1,NTOPE
      T1=T1+D(J,M)
      T2=T2+WATSUR(J,M)
      T4=T4+BD(J,M)
      T5 = T5 + RUNOF(J,M)          @ TOTAL ISO. FROM RUNOFF
      T6 = T6 + REACTA(J,M)         @ TOTAL ISO. FROM REACTOR
   20 CONTINUE
      T3 = T2*S1(M)*1.E-6 @TOTAL SUSPENDED ISOTOPES IN WATER    PCI/LIT
C
```


1083425

```
C
      IF(MOD(M-1,NPR).GT.0)  GO TO 30
      IF(KREP-1) 22,48,
      WRITE(NTO,11) (RJ(J),J=1,3),K,(RNAME(J,KMAP),J=1,3),
     1UM,KTYPE(KCENT),DRNK(KCENT)
   11 FORMAT('1'3A6,2X'CENTROID'I7,8X2A6,A3,'   RIVER MILE'
     .F10.1,'   TYPE 'I5,'   DRINK  'I6/)
C
      WRITE(NTO,21)
   21 FORMAT( T26,'BED',T37,'SUSPENDED' ,T93,'BED'   /
     1'  MONTH     FLOW',8X,'SEDIMENT    SEDIMENT    ISOTOPE',4X,
     2'DISSOLVED  SUSPENDED-SEDIMENT  SEDIMENT   RUNOFF    REACTOR' /
     3T11,'M**3/SEC      KG/M**2',7X,'PPM',T60,'PCI/LIT     PCI/LIT',
     43X,'PCI/KG    PCI/M**2  PCI/LIT   PCI/LIT'    )
      GO TO 30
   22 GO TO (220,24,26,28),NT4
  220 CONTINUE
      WRITE(NTO,23) (RNAME(J,KMAP),J=1,3),DM
   23 FORMAT('1TRIBUTARY MIX'T18,2A6,A3,T39,'RIVER   MILE'F7.1)
      WRITE(NTO,21)
      GO TO 30
   24 WRITE(NTO,25) (RNAME(J,KMAP),J=1,3),DM
   25 FORMAT('1RUNOFF'T18,2A6,A3,T39,'RIVER   MILE'F7.1)
      WRITE(NTO,21)
      GO TO 30
   26 WRITE(NTO,27) (RNAME(J,KMAP),J=1,3),DM
   27 FORMAT('1TRIBUTARY END'T18,2A6,A3,T39,'RIVER   MILE'F7.1)
      WRITE(NTO,21)
      GO TO 30
   28 WRITE(NTO,29) (RNAME(J,KMAP),J=1,3),DM
   29 FORMAT('1'T18,2A6,A3,T39,'RIVER   MILE'F7.1)
      WRITE(NTO,21)
C
   30 WRITE(NTO,31)
   31 FORMAT('0')
      IF(KREP.EQ.1)  GO TO 50
```


1083426

```
C**                 NO REACTOR AT THIS POINT
      WRITE(NTO,41) MM(M),FIN(M),SB(M),S1(M),(SYM(I),D(I,M),DS(I,M),
     .WATSUR(I,M),BD(I,M),RUNOF(I,M),I=1,NTOPE),TOTAL,T1,T3,T2,T4,T5
   41 FORMAT(2X,A3,1PE14.3,E13.3,E12.3,5X,A6,4X,5E10.3/
     1(T50,A6,4X,5E10.3))
      GO TO 100
C**                       REACTOR INCLUDED
   48 WRITE( NTO,49) (RNAME(J,KMAP),J=1,3),DM
   49 FORMAT('1NUCLEAR SITE'T25,2A6,A3,T45,'RIVER   MILE'F7.1)
      WRITE(NTO,21)
      WRITE(NTO,31)
   50 CONTINUE
      WRITE(NTO,51) MM(M),FIN(M),SB(M),S1(M),(SYM(I),D(I,M),DS(I,M),
     .WATSUR(I,M),BD(I,M),RUNOF(I,M),REACTA(I,M),I=1,NTOPE),TOTAL,T1,T3,
     .T2,T4,T5,T6
   51 FORMAT(2X,A3,1PE14.3,E13.3,E12.3,5X,A6,4X,6E10.3/
     1(T50,A6,4X,6E10.3))
  100 CONTINUE
      NT4=0
      RETURN
      END
```


1083427

10834 28

```
@ ELT RMAP,1,710125, 67240

      SUBROUTINE RMAP
      INCLUDE MCOM
      DIMENSION A(11),B(42),TYPE(2)
      DATA AAA,RIVER/'$     ','RIVER'/
      WRITE(NTO,201)
  201 FORMAT('0')
      L = 1
      READ(NTD,11,END=120,ERR=130) C1,RIV,TYPE,A
      IF(C1.NE.AAA) GO TO 9999
      IF(RIV.NE. RIVER ) GO TO 9999
      READ(NTD,12) B
      WRITE(NTO,13) C1,RIV,TYPE,A,B
      GO TO 50
C
   12 FORMAT(14A6)
   13 FORMAT(1X,A1,A5,2A6,11A6/(1X,14A6))
C
C                RIVER MAP
C
   50 DO 70 I=1,200
      READ(NTD,51) (RNAME(J,I),J=1,3),RCODE(I),CODEM(I),RMILEM(I),
     1IBASIN(I),IDIST(I),ISED(I),SEGM(I)
   51 FORMAT(2A6,A4,A2,4X,A2,F8.1,I6,I6,I8,F12.1)
      IF(RNAME(1,I).EQ.BNK) GOTO 75
      WRITE(NTO,200) (RNAME(J,I),J=1,2),RCODE(I),CODEM(I),RMILEM(I),
     .IBASIN(I),IDIST(I),ISED(I),SEGM(I)
  200 FORMAT(1X2A6,3XA2,5XA2,F7.1,I6,I7,I8,F12.1)
   70 CONTINUE
C
   75 NMAP = I-1
      WRITE(NTO,203)
  203 FORMAT('1')
```

```
 1000 RETURN
  120 WRITE(NTO,121) C1,RIV,TYPE,A
  121 FORMAT('0*** EOF ENCOUNTERED IN SUBROUTINE RMAP, READING RIVER
     1DESCRIPTION CARDS' /
     25X,A1,A5,13A6)
      RETURN
   11 FORMAT(A1,A5,13A6)
  130 WRITE(NTO,131) C1,RIV,TYPE,A
  131 FORMAT('0** ERROR ENCOUNTERED WHILE READING FROM SUBROUTINE RMAP'/
     25X,A1,A5,13A6)
      RETURN 0
 1100 CONTINUE
 9999 WRITE(NTO,999) C1,RIV,TYPE,A
  999 FORMAT('0** RIVER DEFINITION ERROR ** '
     1A1,A5,2A6,11A6)
      RETURN 0
      END
```


1083429

1083430

```
@ ELT RREACT,1,710125, 67216

      SUBROUTINE RREACT
      INCLUDE MCOM
C
C         READ REACTOR TAPE -      PICOCURIES/SEC RELEASE TO WATER
C              NREACT    NO. OF REACTORS
C
C
C
      EQUIVALENCE(RJ(2),R1),(RJ(3),R2)
      EQUIVALENCE (SITE,KSITE)
C
C
      N=NTOPE*LM
C CHECK END OF FILE
   10 IF(ND4(3).GE.ND4(4)) GO TO 1000
C READ NEXT REACTOR DATA
      CALL NTRAN(NTR,2,5,RJ,L17)
    1 IF(L17+1) 9999,1,
      SITE=RJ(1)
C SAVE RIVER MILE
      SRM=RJ(5)
      CALL NTRAN(NTR,2,N,RI,L17)
    2 IF(L17+1) 9999,2,
C
C MATCH SITE AND RIVER
      DO 100 K=1,NMAP
      IF(RNAME(1,K).NE.R1)   GO TO 100
      IF(RNAME(2,K).EQ.R2) GO TO 200
  100 CONTINUE
C
C
C                NO RIVER FOUND
```

```
C
      WRITE(NTO,101)
  101 FORMAT('1ERROR - NO MATCH OF REACTOR SITE RIVER AND RIVER MAP')
      WRITE(NTO,102) R1,R2,RJ(4)
  102 FORMAT(1X3A6)
      RETURN 0
C
C SAVE RIVER NO.
  200 MREAC = K
      RETURN
C
 1000 KOFF = -1
      RETURN
 9999 WRITE(NTO,9998)
 9998 FORMAT('0NTRAN ERROR IN RREACT')
      RETURN 0
      END
```


1083431

10834432

```
W ELT RSED,1,710125, 67207

      SUBROUTINE RSED
      INCLUDE MCOM
      DIMENSION A(100),B(100),SM(100),MS(100)
      DIMENSION ABC(400)
      EQUIVALENCE(ABC,MS),(ABC(101),SM),(ABC(201),A),(ABC(301),B)
C
      DO 100 I=1,100
    5 READ(NTS,11) CO,SM(I),A(I),B(I)
   11 FORMAT(A2,F5.0,1X,F7.2,F6.2,F6.1)
      DO 10 J=1,NMAP
      IF(RCODE(J).EQ.CO)  GO TO 20
   10 CONTINUE
      NS= I-1
      GO TO 201
   20 MS(I) = J
  100 CONTINUE
      NS=100
  201 CONTINUE
      CALL SORTF(NS,100,4,ABC)
      ISTART=1
  101 RETURN
C
C
      ENTRY SEDP
      DO 205 I=ISTART,NS
      IF(MS(I)-KMAP) ,207,
  205 CONTINUE
C NO DATA FOR THIS RIVER
      DO 206 M=1,LM
      S1(M)=S2(M)
  206 S2(M)=0.0
      GO TO 101
```

```
C ARE THERE MORE DATA FOR THIS RIVER
  207 DO 208 J=I,NS
      IF(MS(J)-KMAP) 209,,209
  208 CONTINUE
      J=NS
      GO TO 210
  209 J=J-1
  210 IF(I-J) ,212,212
C FIND NEAREST UPSTREAM POINT
      DO 211 K=J,I,-1
      IF(SM(K)-DM) ,213,213
  211 CONTINUE
  212 K=I
  213 DO 215 M=1,LM
      S1(M)=S2(M)
      IF(FIN(M)) ,,214
      S2(M)=0.0
      GO TO 215
  214 S2(M)=EXP(A(K)+B(K)*ALOG(.03531*FIN(M)))  @ PPM
  215 CONTINUE
      ISTART=K
      GO TO 101
      END
```


1083433

```
@ ELT RUNO,1,710611, 72926

      SUBROUTINE RUNO
      INCLUDE MCOM
      DIMENSION RU(LCENT)
      EQUIVALENCE(RU,WATSUR)
C
      READ(NRO,11) (RU(I),I=1,NRAIN) @ RUNOFF IN INCHES BY CENTROID
   11 FORMAT(12F5.0)
      READ(NRO,13)  ((R(I,J),I=1,12),J=1,NRAIN)  @ RAINFALL IN INCHES
C**             RAINFALL BY MONTH BY CENTROID   (INCHES)
   13 FORMAT(10X,12F5.2)
C
      DO 100 K=1,NRAIN
      SUM = 0.
      DO 50 I=1,12
      SUM = SUM + R(I,K)      @ INCHES RAINFALL
   50 CONTINUE
C
C
C         R(I,K)     MONTH RAINFALL CENTROID K   INCHES (AS READ)
C         RU(K)      ANNUAL RUNOFF FOR CENTROID K IN  INCHES
      RU(K)=RU(K)*25.4     @ LITERS/SQ METER
      SUM=RU(K)/SUM
      DO 60 I=1,12
      R(I,K) = SUM*R(I,K)    @ MILIMETERS RUNOFF  = LITERS/(SQ METER)
   60 CONTINUE
C
C         R(I,K)     MONTHLY RUNOFF CENTROID K   LITERS/(SQ METER)
C
  100 CONTINUE
      RETURN
      END
```


10834 34

```
@ ELT RUNPTS,1,710125, 67208

      SUBROUTINE RUNPTS(NTS,N21,NTO,RCODE,NMAP)
C
C THIS MODULE READS THE DATA THAT MATCHES ATMOSPHERIC DATA TO A RIVER AND RIVER
C MILE, SORTS, AND PUTS ON DRUM FOR MODULE RBAS
C
C R1=RIVER CODE
C RM1=RIVER MILE
C ICNT=ATMOSPHERIC CENTROID
C AR=SQUARE MILES ASSOCIATED WITH THIS CENTROID
C NMAP AND RCODE ARE FROM MODULE RMAP
C NTS,N21,AND NTO ARE I/O UNITS FROM MAIN
C BLANK CARD ENDS INPUT TO THIS MODULE
C
      DIMENSION RCODE(2)
      COMMON/NTABZZ/NTAB(50),ND1(7),ND2(7),ND3(7),ND4(7),ND5(7),ND6(7),
     .ND7(42)
      COMMON/SHARE/IIA(2000),B(2000),IA(2000),AA(2000),A(2000)
      DIMENSION ALL(2000,5)
      EQUIVALENCE (ALL,IIA)
      I=0
    1 READ(NTS,2) R1,RM1,ICNT,AR
    2 FORMAT(A2,F4.0,4XI5,E10.0)
      IF(ICNT) 5,5,
C IS THIS RIVER ON MAP
      DO 3 K=1,NMAP
      IF(R1-RCODE(K)) 3,4,3
    3 CONTINUE
      GO TO 1
    4 I=I+1
      IIA(I)=K
      A(I)=R1
      B(I)=RM1
```


1083435

```
      IA(I)=ICNT
      AA(I)=AR
      GO TO 1
C SORT ASCENDING RIVER NO. AND DESCENDING RIVER MILE
    5 CALL SORTF(I,2000,5,ALL)
C REARRANGE
      L=0
      J2=666
      K=I/J2
      IF(J2*K.LT.I) K=K+1
      DO 8 N=1,K
      IF(N.EQ.K) J2=I-L
      DO 6 J=1,J2
      L=L+1
      ALL(4*J-3,1)=ALL(L,5)
      ALL(4*J-2,1)=ALL(L,2)
      ALL(4*J-1,1)=ALL(L,3)
    6 ALL(4*J,1)=ALL(L,4)
      M=4*J2
C WRITE ON DRUM
      CALL NTRAN(N21,1,M,ALL,L17)
    7 IF(L17+1) 9999,7,
    8 CONTINUE
C REWIND DRUM
      ND7(3)=ND7(1)
      RETURN
 9999 WRITE(NTO,9998)
 9998 FORMAT('1NTRAN ERROR IN RUNPTS')
      RETURN 0
      END
```


1083436

10834037

```
ELT SORTF,1,710125, 67198

      SUBROUTINE SORTF(N,L,M,A)
      INTEGER A
      LOGICAL THRU
      DIMENSION A(L,M)
      DEFINE IA(I)=A(I,1)
      DEFINE AA(I)=A(I,2)
      IF(N-2) 8,,
      N2=N/2
      J1=1
      J2=N-1
      DO 7 I=1,N2
      THRU=.TRUE.
      DO 3 J=J1,J2
      IF(IA(J)-IA(J+1)) 3,,1
      IF(AA(J)-AA(J+1)) ,3,3
    1 THRU=.FALSE.
      DO 2 K=1,M
      ABLE=A(J,K)
      A(J,K)=A(J+1,K)
    2 A(J+1,K)=ABLE
    3 CONTINUE
      IF(THRU) GO TO 8
      THRU=.TRUE.
      J2=J2-1
      DO 6 J=J2,J1,-1
      IF(IA(J)-IA(J+1)) 6,,4
      IF(AA(J)-AA(J+1)) ,6,6
    4 THRU=.FALSE.
      DO 5 K=1,M
      ABLE=A(J,K)
      A(J,K)=A(J+1,K)
    5 A(J+1,K)=ABLE
```

```
    6 CONTINUE
      IF(THRU) GO TO 8
    7 J1=J1+1
    8 RETURN
      END
```


10834138

```
@ ELT TAPES,1,710329, 30051

      SUBROUTINE TAPES
      PARAMETER LISO=32
      INTEGER BTOW,CROSS
      COMMON/NTABZZ/SPACE(51),ND(7)
      COMMON/ONE/NTE,NTA,NTD,NTD2,LAIR,K,NTOPE,NSITE,NTO,NTI
      COMMON/THREE/SURF(20),ALAT(50),ALON(50)
      COMMON/FOUR/CR(LISO),CA(LISO),CT(LISO),SYM(LISO),NISO(LISO),
     .HALFL(LISO),MOTHER(LISO)
      COMMON/FIVE/WHERE(9000),A(1000),B(1000),LIST(50),LISTA(50)
      DIMENSION IA(1000)
      EQUIVALENCE(A,IA)
      DATA IDENT/'LAKE M'/
C
C READ FIRST FILE OF DOSIS TAPE
C
      CALL NTRAN(NTE,2,20,A,L17)
    1 IF(L17+1) 9999,1,
      CALL NTRAN(NTE,2,6,A,L17)
    2 IF(L17+1) 9999,2,
      NP=IA(1)  @ NO. OF SITES
      NM=IA(2)   @ NO. OF MONTHS
      NIS=IA(5)  @ NO. OF ISOTOPES TO WATER
C
C SPACE TO THIRD FILE
C
      CALL NTRAN(NTE,8,2)
C
C READ LATITUDE AND LONGITUDE
C
      CALL NTRAN(NTE,2,4*NP,WHERE,L17)
    3 IF(L17+1) 9999,3,
C
```


1083439

```
C SPACE TO FOURTH FILE
C
      CALL NTRAN(NTE,8,1)
C
C READ RIVER MILES AND RIVER NAMES
C
      CALL NTRAN(NTE,2,NP,A,L17)
    4 IF(L17+1) 9999,4,
      CALL NTRAN(NTE,2,3*NP,A,L17)
    5 IF(L17+1) 9999,5,
C
C LOCATE LAKE MICHIGAN SITES
C
      K=0
      DO 6 I=1,NP
      L8=3*I-2
      IF(IA(L8)-IDENT) 6,,6
      K=K+1
      LIST(K)=I
      ALAT(K)=WHERE(4*I-3)
      ALON(K)=WHERE(4*I-2)
    6 CONTINUE
      LIST(K+1)=0
C
C CREATE STARTING DRUM ADDRESSES FOR EACH SITE
C
      N=ND(1)
      DO 7 I=1,K
      LISTA(I)=N
    7 N=N+12*NTOPE
C
C ADVANCE TAPE TO SIXTH FILE
C
      CALL NTRAN(NTE,8,2)
C
C READ ISOTOPE DATA, EDIT, AND SPRINKLE ON DRUM
```


1083440

```
C
      DO 15 N=1,NM
      KK=1
       DO 14 M=1,NP
      CALL NTRAN(NTE,2,NIS,A,L17)
    8 IF(L17+1) 9999,8,
      IF(M-LIST(KK)) 14,,14
      ND(3)=LISTA(KK)
      DO 9 I=1,NTOPE
    9 B(I)=0.0
      DO 12 I=1,NTOPE
      DO 10 J=1,NIS
   10 IF(NISO(I).EQ.J) GO TO 11
      GO TO 12
   11 B(I)=A(J)
   12 CONTINUE
      CALL NTRAN(NTD,1,NTOPE,B,L17)
   13 IF(L17+1) 9999,13,
      LISTA(KK)=LISTA(KK)+NTOPE
      KK=KK+1
   14 CONTINUE
   15 CONTINUE
C
C REWIND DOSIS TAPE WITH INTERLOCK
C
      CALL NTRAN(NTE,11)
C
C READ ATMOSPHERIC TAPE
C
      DO 19 L=1,10000
      READ(NTA) KCENT,KTYP,DUM,NUM,(A(I),I=1,NUM)
C
C LOOK FOR END OF DATA
C
      IF(KCENT-99999) ,20,20
C
```


1083441

```
C ONLY TYPE 6 DESIRED
C
      IF(KTYP.NE.6) GO TO 19
C
C REMOVE NON WATER ISOTOPES
C
      NT12=NTOPE*12
      DO 100 I=1,NT12
  100 B(I)=0.0
      DO 17 I=1,NUM,13
      I1=BTOW(A(I))
      JA=CROSS(I1)
      IF(JA) 17,17,
      JM=(JA-1)*12+1
      JN=JM+11
      J1=I
      DO 16 J=JM,JN
      J1=J1+1
   16 B(J)=A(J1)
   17 CONTINUE
      CALL NTRAN(NTD2,1,12*NTOPE,B,L17)
   18 IF(L17+1) 9999,18,
   19 CONTINUE
C
C REWIND ATMOSPHERIC TAPE WITH INTERLOCK
C
   20 LAIR=L-1
      CALL NTRAN (NTA,11)
      RETURN
 9999 RETURN 0
      END
```


1083442

```
@ ELT TRIBU,1,710125, 67218

      SUBROUTINE TRIBU(TM,IR)
C
      INCLUDE MCOM
      EQUIVALENCE(F1,A)
      DIMENSION A(867)
      DATA KT/0/
C         HANDLE TRIBUTARY INTERFACES WITH THE MAINSTREAM
C              1    TEST FOR TRIBUTARIES
C              2    READ TRIBUTARY INFORMATION FOR CURRENT STREAM
C              3    STORE TRIBUTARY OUTPUT RECORD   (AT END OT TRIBUTARY
C                        SETUP TAPE FOR READING PROPER TRIBUTARY
C
      GO TO (200,300,100),IR
C     SAVE ALL BUT LAST TRIBUTARY
  100 IF(KMAP.EQ.NMAP) RETURN
C
C**       WRITE TRIBUTARY TERMINAL FLOWS, CONCENTRATION, AND SEDIMENT
C**       CONCENTRATIONS TO SCRATCH TAPE  'NTT'
      KT = KT +1   @ TRIBUTARY COUNT
C         FIND MAINSTREAM
C
      DO 110 I=1,LM
      SED(I) = S2(I)
      F1(I)  = FOUT(I)
      DO 110 J=1,LISO
      CCW(J,I)=C(J,I)
      CCS(J,I)=CS(J,I)
  110 CONTINUE
      DO 120 I=KMAP,NMAP
      IF(RCODE(I).EQ.CODEM(KMAP)) GO TO 130
  120 CONTINUE
      KT = KT-1   @SCRATCH      TRIBUTARY
```


1083443

```
      RETURN
  130 MAPT(KT) = I          @   SAVE TRIBUTARY
C*******                 SAVE TRIBUTARY                 ************
      RMT(KT) = RMILEM(KMAP)    @MAINSTREAM ENTRY POINT
C
      N792=2*LM*(1+LISO)
      ND1(3)=ND1(1)+(KT-1)*N792
      CALL NTRAN(NTT,1,N792,A,LB)
  135 IF(LB+1) 999,135,
      TM=-100.
C
  150 RETURN
C
C
C                 AT UPSTREAM END OF RIVER - CHECK FOR TRIBUTARIES
C
  200 TM=-100.
      DO 220 I=1,KT
      IF(MAPT(I)-KMAP)   ,230,
  220 CONTINUE
C
C*****              NO TRIBUTARIES
C
      TMILE = 0.
      MMT = 0
      RETURN
  230 TMILE = RMT(I)   @   TRIB ENTERS MAINSTREAM HERE
      TM = TMILE
      MMT = MAPT(I)    @
      LOC = I    @   CURRENT POSITION IN TRIB TABLE
      ND1(3)=ND1(1)+(I-1)*N792
      CALL NTRAN(NTT,2,N792,A,LB)
  235 IF(LB+1) 999,235,
      RETURN
C
C
```


1083444

```
C
  300 DO 350 M=1,LM
      DO 340 I=1,NTOPE
      C(I,M)=C(I,M)+CCW(I,M)
      CS(I,M)=CS(I,M)+CCS(I,M)
  340 CONTINUE
      S2(M)=S2(M)+SED(M)*F1(M)/FIN(M)
  350 CONTINUE
      MAPT(LOC) = -KMAP    @ MARK TRIB USED
C
      NT4=1        @   REPORT INDICATOR ON
      GO TO 200
  999 WRITE(6,991)
  991 FORMAT('0   ************** ERROR********')
      RETURN
      END
```


1083445

1083446

```
@ ELT WTRAN,1,710329, 30045

      SUBROUTINE WTRAN
C
C
C
      INCLUDE MCOM
C
      DIMENSION LFLOOD(200,7)
      DIMENSION ISO(LISO),A(LISO,LM)
      DATA RILL/'ILLINO'/
      EQUIVALENCE (RJ,ISO),(RJ(100),A)
      EQUIVALENCE(LFLOOD,FLOOD)
C
C
C
      KMAP = 0
      JFLOOD=1
      MFLOOD=0
C
C DO FOR EACH RIVER
C
      DO 5000 KR=1,NR
      KREP = 0
      KUSED=0
      KMAP = KMAP + 1
      IF(KMAP-NMAP)  ,    ,6010
C READ RIVER SECTION CARDS
      CALL RBED
      IF(NI)  6020,6020,
C SET UP STARTING SEDIMENT PPM
      DM=SEGM(KR)
      CALL SEDP
C
```

```
      CALL OBS(1)   @ SETUP POPULATION CENTER POINT FOR TRIBUTARY
C
      CALL REACT(1)
      RM(NI+1) = 0.
      IF(CODEM(KMAP).EQ.RC(1))  RM(NI+1) = RMILEM(KMAP)
C
C
C IF ILLINOIS RIVER, START OUT WITH LAKE MICHIGAN CONCENTRATIONS
C
      IF(RNAME(1,KMAP).NE.RILL) GO TO 99
      READ(NTD,97) (ISO(L),(A(L,LL),LL=1,12),L=1,LISO)
   97 FORMAT(I10,6E10.5/6E10.5)
      DO 98 I=1,NTOPE
      L=NISO(I)
      DO 98 LL=1,12
      C(I,LL)=A(L,LL)
   98 CS(I,LL)=C(I,LL)*DIST(I)
      GO TO 101
   99 CONTINUE
      DO 100 M=1,LM
      DO 100 J=1,LISO
      C(J,M)=0.0  @  PCI/SEC
      CS(J,M)=0.0  @ PCI/SEC*DIST(J)
  100 CONTINUE
  101 CONTINUE
C
      CALL TRIBU(TM,1)    @ TEST FOR TRIBUTARY AND SET TAPE FOR READ
C
C DO FOR EACH RIVER SECTION OF CURRENT RIVER
      DO 2000 K=1,NI
C
      IF(RC(K).NE.RCODE(KMAP)) GO TO 6030
      IF(CODEM(KMAP).NE.RC(K)) GO TO 200
      IF(RMILEM(KMAP).LT.RM(K))  GOTO 200
C
C**       CHANGE RIVER BASINS - SAME RIVER AND SAME RIVER CODE
```


1083447

```
C
      KMAP = KMAP + 1
      IF(KMAP-NMAP)    , ,6040
      RM(NI+1) = 0.
      IF(CODEM(KMAP).EQ.RC(1))  RM(NI+1) = RMILEM(KMAP)
C
C
  200 UMD = RM(K)                    @ UPSTREAM RIVER MILE (R.SECTION CRD)
      DMD = RM(K+1)
      EL = UMD - DMD                 @                                    MILE
      UM = UMD
C
C SET DOWNSTREAM POINT TO SECTION END
C
  210 DM = DMD
C DETERMINE IF POPULATION CENTER,REACTOR,TRIBUTARY,OR FLOOD POINT IS BETWEEN
C UPSTREAM AND DOWN STREAM POINT. IF SO ADJUST DOWNSTREAM POINT TO PROPER
C PLACE
      IF(PTOBS.LT.UM)   DM = AMAX1(DMD,PTOBS)
      IF(REACTM.LT.UM)  DM = AMAX1(DM,REACTM)
      IF(TM.LT.UM)  DM = AMAX1(DM,TM)
      IF(IRIV(KRIV)-KMAP) 209,,209
      IF(ARIVM(JRIV).LT.UM) DM=AMAX1(DM,ARIVM(JRIV))
  209 CONTINUE
      IF(JFLOOD.GT.KFLOOD) GO TO 211
      IF(KMAP-LFLOOD(JFLOOD,1)) 211,,211
      IF(DM-FLOOD(JFLOOD,2)) ,,211
      DM=FLOOD(JFLOOD,2)
      MFLOOD=1
      JFLOOD=JFLOOD+1
  211 CONTINUE
C DETERMINE FLOW
      CALL MFLOW
      CALL RBAS     @ DETERMINES RUNOFF TO RIVER BASINS
      DX = UM - DM
      VOL = DX/EL*V(K)
```


1083448

```
      SUR = DX/EL*S(K)
C
C                 REACTOR CONTRIBUTION
C
      IF(REACTM-DM) 400,,
C
      DO 300 M=1,LM
      DO 300 J=1,NTOPE
      C(J,M)=C(J,M)+REACTA(J,M)
      IF(DIST(J)) 300,300,
      CS(J,M)=CS(J,M)+REACTA(J,M)*DIST(J)
  300 REACTA(J,M)=1.E-3*REACTA(J,M)/FIN(M)
      KREP = 1
C
  400 CONTINUE
      IF(NT4.NE.2) GO TO 501
C
C RUNOFF POINT
      DO 500 M=1,LM
      DO 500 J=1,NTOPE
      C(J,M)=C(J,M)+RUNOF(J,M)
      IF(DIST(J))  500,500,
      CS(J,M)=CS(J,M)+RUNOF(J,M)*DIST(J)
  500 RUNOF(J,M)=1.E-3*RUNOF(J,M)/FIN(M)
C
C IF TRIBUTARY - ADD IN
  501 IF(TM.EQ.DM) CALL TRIBU(TM,2)
C
C DETERMINE SEDIMENT RATE
      CALL SEDP
C
C DETERMINE BED SEDIMENT DATA
      CALL BSED            @ DETERMINE BED SEDIMENT
C
C CALCULATE DATA FOR REPORT
      DO 502 I=1,LM
```


1083449

1083450

```
      FACTOR=1.E+3*FIN(I)
      FACTER=S1(I)*1.E-6*FACTOR
      DO 502 J=1,LISO
      FACTAR=1./(DIST(J)*FACTER+FACTOR)
      D(J,I)=C(J,I)*FACTAR      @ DISSOLVED PCI/LIT
      WATSUR(J,I)=CS(J,I)*FACTAR  @ SUSPENDED PCI/KG
  502 DS(J,I)=S1(I)*1.E-6*WATSUR(J,I)
C DETERMINE WHAT REPORT IF ANY
      IF(KREP.NE.1) GO TO 520
      IF(IREACT.GT.0) CALL REPORT
      CALL REACT(2)
      GO TO 530
  520 CALL OBS(2)
  530 KREP=0
      IF(MFLOOD) 531,531,
      CALL FLDRPT
      MFLOOD=0
  531 CONTINUE
      KREP = 0              @ TURN REACTOR INDICATOR OFF
      IF(NT4.EQ.1.AND.MIX.GT.0) CALL REPORT
      IF(NT4.EQ.2.AND.IRUN.GT.0) CALL REPORT
      IF(IRIV(KRIV).NE.KMAP) GO TO 540
      IF(ARIVM(JRIV)-DM) 540,,540
      IF(JRIV.LT.JRIVT) JRIV=JRIV+1
      KUSED=1
      NT4=4
      CALL REPORT
  540 CONTINUE
C
C
C
C          TRANSPORT
C
      DO 600 M=1,LM
      TAU = VOL/FIN(M)                    @ FLOW TIME IN SECONDS
      CALL DECAY(TAU,C(1,M),C(1,M))
```

```
      CALL DECAY(TAU,CS(1,M),CS(1,M))
  600 CONTINUE
C
C
C
      UM = DM
C IF NOT RIVER SECTION END, CONTINUE ON THIS RIVER SECTION
      IF(DM.GT.DMD+.1)   GO TO 210
C GET NEXT RIVER SECTION
 2000 CONTINUE
C THRU WITH RIVER
      NT4=3
      IF(RIVEND.GT.0.0) CALL REPORT
      NT4=0
      IF(KUSED.EQ.0) GO TO 1999
      JRIV=JRIV+1
      IF(KRIV.LT.KRIVT) KRIV=KRIV+1
 1999 CONTINUE
C
C          SAVE THIS TRIBUTARY IF IT IS NOT LAST TRIBUTARY
      IF(NR.EQ.KR)  GOTO 5000
      CALL TRIBU(TM,3)   @ SAVE END VALUE FOR THIS STREAM
      WRITE(NTO,2001) KMAP,(RNAME(J,KMAP),J=1,3)
 2001 FORMAT('0 SAVE TRIBUTARY  ',I5,2X,2A6,A3)
C
C GET NEXT RIVER
 5000 CONTINUE
C
      WRITE(NTO,5001) KR,NR,KMAP,NMAP
 5001 FORMAT('0 COMPLETED - KR,NR,KMAP,NMAP 5000  ',4I10)
      RETURN
 6010 CONTINUE
      WRITE(NTO,6011) KMAP,NMAP,KR,K,NI
 6011 FORMAT('0 COMPLETED  KMAP> NMAP  ',6I10)
      RETURN
 6020 CONTINUE
```

```
      WRITE(NTO,6021) KMAP,NMAP,KR,NR
 6021 FORMAT('0 COMPLETED RIVER PROCESSING - KMAP,NMAP,KR,NR  ',4I10)
      RETURN
C
C
 6030 CONTINUE
      WRITE(NTO,6031) K,KMAP,NR,NMAP,RC(K),RCODE(KMAP)
 6031 FORMAT('0  RIVER CODES DO NOT MATCH - K,KMAP,NR,NMAP,RC(K),RCODE(K
     1MAP) '/ 4I10,5X,2A6)
      RETURN
 6040 CONTINUE
      WRITE(NTO,6041) KMAP,NMAP,KR,K,NI
 6041 FORMAT('1  COMPLETED  KMAP>NMAP  6040 ',6I10)
      WRITE(NTO,6001) KMAP,NMAP,NI,K,RC(K),RCODE(KMAP)
 6001 FORMAT('0***** ERROR -  KMAP  NMAP  NI  K   RC(K)  RCODE(KMAP)'/
     110X,4I10,10X,A6,5X,A6)
      RETURN
      END
```


1083452

DOSE Code Listing

1083453

```
@ ELT TABLE1,7,711115, 62792

      TABLE1* FCOPY
            INTEGER CARD
            INTEGER CENTER
            INTEGER DRUM
            INTEGER REPORT
            INTEGER REREAD
            COMMON/NTABDR/ FT(7)
            COMMON DATE(2)
            COMMON DT(2,3000)
            COMMON IO(20)
            COMMON TOTALS(12,8),IPAGE
            COMMON DS1(50,6,7,2)
            COMMON DS2(50,6,7,2)
            COMMON DS3(50,6,7,2)
            COMMON DS4(50,6,7,2)
            COMMON DF(2,1000)
            COMMON ALOSS(2,600)
            COMMON COMB(2,600)
            COMMON C(2,600)
            COMMON H(2,72)
            COMMON D(2,72)
            COMMON L(1000)
            COMMON LD
            COMMON LSD
            COMMON M(50)
            COMMON TOTALA(12),PERSON(3),TIME(6,3)
            EQUIVALENCE (CARD,IO(4))
            EQUIVALENCE(CENTER,IO(17))
            EQUIVALENCE (DRUM,IO(2))
            EQUIVALENCE (REPORT,IO(1))
            EQUIVALENCE (REREAD,IO(3))
      C     C--CONCENTRATION DATA
```


1083454

```
C      D--DIET DATA
C      DATE--DATE FROM PARAMETER CARD
C      DF--DOSE FACTOR DATA
C      DS1,DS2,DS3,DS4--REPORT ARRAYS  INTERNAL,EXTERNAL,TOTAL INTERNAL,
C                      --TOTAL EXTERNAL
C      DT--DICTIONARY TABLE
C      FT--FILE TABLE FOR DRUM FILES
C      H--HABIT DATA
C      IO--LOGICAL UNITS FOR IO
C        --IO(1) REPORT UNIT,IO(2) DRUM UNIT,IO(3) REREAD UNIT,
C        --IO(4) CARD READER,IO(5)-IO(10) CARD IMAGE FROM TAPE,
C        --IO(11)-IO(16) BINARY RECORDS FROM TAPE
C        --IO(17) POPULATION FILE UNIT
C        --IO(1)-IO(4) ARE EQUIVALENCED WITH REPORT,DRUM,REREAD AND CARD
C        --IO(18) RESTART TAPE UNIT
C        --RESPECTIVELY
C      L--NUMBER OF DATA TABLES INPUT BY LOCATION
C      LD--NUMBER OF ENTRIES IN DICTIONARY
C      LSD--LENGTH OF SCRATCH DRUM DICTIONARY
C      M--MISCELLANEOUS
C       --M(1) SWITCH TO TURN ON ALL REPORTS
C       --M(2) SWITCH TO TURN ON ONLY DETAILED TOTAL REPORTS
C        --M(3) PROGRAM RESTART SWITCH
       END
```

PROCEDURE NAME TABLE

TABLE1 DCCDCDDC

1083455

```
@ ELT TABLE2,7,711115, 62793

      TABLE2* FCOPY
      C          COMMON BLOCK TO CONTAIN ARRAYS REQUIRED FOR THE FOOD CHAIN
            PARAMETER NONUCL=50, NOPATH=40, NTOTAL=50
            INTEGER REPEAT,APPEAR,HARVST
            REAL LIFE12
            DIMENSION LIFE12(NONUCL), HAF12R(NONUCL), HAF12E(NONUCL),
           X ACCUMF(NONUCL), MAP( NTOTAL), YIELDF(NOPATH), HARVST(NOPATH),
           X APPEAR(NOPATH), TRANSL(NOPATH),ITYP( NTOTAL),
           X CONCFA(NONUCL,NOPATH), RATE(12,NOPATH), QUANT1(12,6),
           X QUANT2(12,6), QUANT3(12,6), QUANTW(12,6), RETNTR(NONUCL,6),
           X TRANSF(NONUCL,6) , DECAY(NTOTAL), REPEAT(NTOTAL), BREATH(6)
            DIMENSION CONC2(2,600),CONC3(2,600),CONC4(2,600),CONC5(2,600)
      C          EXPLANATION OF TABLES AND PARAMETERS
      C          LIFE12     RADIOLOGICAL 1/2 LIFE
      C          HAF12R     LAMBDA RADIOLOGICAL  =0.693/TR
      C          HAF12E     EFFECTIVE HALF LIFE   = 0.693(TR+T4)
      C          CONCFA     CONCENTRATION FACTORS
      C          YIELDF     YIELD FACTORS
      C          HARVST     MONTH OF HARVEST
      C          APPEAR     MONTH OF APPEARANCE
      C          TRANSL     TRANSLOCATION FACTORS
      C          ACCUMF     ACCUMULATION FACTORS
      C          NONUCL     NUMBER OF NUCLIDES
      C          RATE       IRRIGATION RATE
      C          RETENT     PLANT RETENTION FACTOR
      C          MAP        MAPPING TABLE BETWEEN PATH NUMBER AND FOOD CHAIN
      C                          ENTRIES
      C          NOPATH     NUMBER OF DISTINCT FOOD PATHS
      C          QUANTW     MONTHLY WATER INTAKE VECTOR(CC/)
      C          BREATH     COW BREATHING RATE
      C          QUANT1     QUANTITY OF FORAGE TYPE FOOD ANIMAL CONSUMES
      C          QUANT2     QUANTITY OF FIRST CROP CONSUMED BY ANIMAL
```


1083456

553

```
C          QUANT3    QUANTITY OF SECOND CROP CONSUMED BY ANIMAL
C          RETNTB    BREATHING RETENTION FACTORS
C          TRANSF    TRANSFER COEFFECIENTS FROM ANIMAL INTAKE TO FOOD
C          DECAY     TIME IN DAYS THAT FOOD IS TO BE DECAYED
C          REPEAT    NUMBER OF MONTHS OF HARVEST
      DIMENSION EQUIV(8400),E2(4200)
C     EQUIV IS ACTUALLY EQUIVALENCED TO DS1 AND DS2
      EQUIVALENCE(EQUIV,DS1),(E2,DS3)
      EQUIVALENCE(CONC2(1,1),EQUIV(1)),(CONC3(1,1),EQUIV(1201))
      EQUIVALENCE(CONC4(1,1),EQUIV(2401)),            (CONC5(1,1),
     XEQUIV(3601))
      EQUIVALENCE (E2(0001),LIFE12(1))    ,    (E2(0051),HAF12R(1)) ,
     X            (E2(0101),HAF12E(1))   ,    (E2(0151),ACCUMF(1)) ,
     X            (E2(0201),MAP(1))      ,    (E2(0251),YIELDF(1)) ,
     X            (E2(0301),HARVST(1))   ,    (E2(0351),APPEAR(1)) ,
     X            (E2(0401),TRANSL(1))   ,    (E2(0451),ITYP(1))   ,
     X            (E2(0501),CONCFA(1,1)),     (E2(2551),RATE(1,1)) ,
     X            (E2(0301),QUANT1(1,1)),     (E2(3111),QUANT2(1,1)),
     X            (E2(0321),QUANT3(1,1)),     (E2(3301),QUANTW(1,1)),
     X            (E2(0341),RETNTB(1,1)),     (E2(3701),TRANSF(1,1)),
     X            (E2(0401),DECAY(1))    ,    (E2(4051),REPEAT(1)) ,
     X            (E2(0410),BREATH(1))   ,    (E2(4107),PERCN4)    ,
     X            (E2(0411),PERCN3)       ,(E2(4115),RETENT)
      END
```

PROCEDURE NAME TABLE

TABLE2 00000000

1083457

```
@ ELT DOSE,1,711115, E2795

      C     MAIN PROGRAM FOR DOSE CALCULATION PROGRAM
      C
            INTEGER FT
            INCLUDE TABLE1,LIST
            CALL TIMER (1,7)
      C     READ PARAMETER CARDS
            CALL PARAM
      C     SKIP APPROPRIATE NUMBER OF FILES ON LIVING PATTERN TAPE
            IF (IO(17).EQ.CARD) GO TO 100
            K=1
            IF (M(3).NE.' ') K=2
            CALL NTRAN (IO(17),8,K)
      100   CONTINUE
      C     DIET AND STARTF ARE NOT CALLED WHEN INPUT DATA HAS ALREADY BEEN
      C     WRITTEN TO RESTART TAPE
            IF (M(3).NE.' ') GO TO 110
            CALL DIET
            CALL STARTF
      110   CONTINUE
      C     READ INPUT DATA AND BUILD TABLES ON DRUM
            CALL READER
      C     CALCULATE PERCENT OF DRUM USED
      C     CALCULATE DOSE FOR PATHWAYS
            CALL DRIVER
            CALL TIMER (1,6)
            CALL SUMMRY
            PDU=(FLOAT(M(44)-FT(1))/FLOAT(FT(2)-FT(1)))*100.0
            WRITE (REPORT,120) PDU
            CALL TIMER (2,6)
            CALL TIMER (1,8)
            STOP
      C
```


1083458

```
33.      120   FORMAT ('1PERCENT OF ALLOCATED DRUM AREA USED WAS ',F8.4)
34.            END
```

1083459

1083460

```
@ ELT CALC,1,711115, 62838

      SUBROUTINE CALC (CONC,LENCON,DIET,LENDIE,DOSEF,LENDSF,CODE,ISECND)
C                THIS SUBROUTINE CALCULATES THE DOSE INCURRED.
C          EXPLANATION OF CALL LIST-
C          CONC       CONCENTRATION TABLE
C          LENCON     NUMBER OF ENTRIES IN THE CONCENTRATION TABLE
C          DIET       COMBINED DIET AND HABIT TABLE
C          LENDIE     NUMBER OF ENTRIES IN COMBINED TABLE
C          DOSEF      DOSE FACTOR TABLE
C          LENDSF     NUMBER OF ENTRIES IN DOSE FACTOR TABLE
C          CODE       1= INTERNAL DOSE    2=   EXTERNAL DOSE
C          ISECND     1=DOSE  2=DOSE COMMITTMENT
      INCLUDE TABLE1,LIST
      DIMENSION CONC(2,1),DIET(2,1),DOSEF(2,1),ID(7),IC(51)
      INTEGER CODE
      ISCS=1
C                INITIALIZE THE LAST ENTRY TABLES ID AND IC
      DO 110 I=1,51
      IC(I)=0
      IF (I-7) 100,100,110
100   ID(I)=0
110   CONTINUE
C                LOAD THE ID TABLE WITH THE LAST ENTRY FOR EACH TYPE OF
C          PERSON IN THE DIET TABLE
      ICODE=0
      DO 120 I=1,LENDIE
      ICODE=FLD(0,12,DIET(1,I))
120   ID(ICODE+1)=I
C                LOAD THE IC TABLE WITH THE LAST ENTRY FOR EACH NUCLIDE
C          IN THE CONCENTRATION
      ICODE=0
      DO 130 I=1,LENCON
      ICODE=FLD(0,12,CONC(1,I))
```

```
130   IC(ICODE+1)=I
C                CALCULATE THE DOSE. PROCEED THROUGH THE DOSE FACTOR TABLE
C            ONE ENTRY AT A TIME. FIRST SET THE INDICES FOR THE COMBINED
C            TABLE, THEN DIET TABLE.
      DO 300 I=1,LENDSF
C                NOW LOOP THROUGH THE COMBINED TABLE AND SET THE INDICES
C            FOR THE CONCENTRATION TABLE.
      ICODE=FLD(0,12,DOSEF(1,I))
140   IFD=ID(ICODE+1)
C                IF THE LAST INDEX FOR THE LOOP IS ZERO THEN THERE ARE NO
C            ENTRIES IN THE COMBINED TABLE. BYPASS CALCULATION.
      IF (IFD) 280,280,150
150   JCODE=FLD(12,12,DOSEF(1,I))
      IFC=IC(JCODE+1)
C                IF THE LAST INDEX IS ZERO THERE ARE NO ENTRIES IN THE
C            CONCENTRATION TABLE FOR THIS ISOTOPE. BYPASS CALCULATION.
      IF (IFC) 270,270,160
160   LCODE=FLD(24,12,DOSEF(1,I))
C                IF THE FIRST INDEX FOR THE LOOP IS ZERO THEN A PRECEEDING
C            NONZERO ENTRY MUST BE FOUND.
      DO 170 N=ICODE,1,-1
      IF (ID(N)) 170,170,180
170   CONTINUE
180   ISD=ID(N)+1
C                IF THE FIRST INDEX IS ZERO THEN A NONZERO PRECEEDING
C            VALUE MUST BE FOUND.
      DO 190 N=JCODE,1,-1
      IF (IC(N)) 190,190,200
190   CONTINUE
200   ISC=IC(N)+1
      DO 260 J=ISD,IFD
      ISC=MAX(ISCS,IC(N)+1)
      MONTHD=FLD(12,12,DIET(1,J))
C                NOW LOOP THROUG THE CONCENTRATION TABLE.  THE MONTH OF
C            THE COMBINED TABLE ENTRY AND THE CONCENTRATION DATA MUST MATCH
      DO 250 K=ISC,IFC
```


1083461

```
      MONTHC=FLO(12,12,CONC(1,K))
      IF (MONTHC-MONTHD) 250,210,240
C                    ADD DOSE INTO INTERNAL OR EXTERNAL TOTAL
210   IF (CODE-1) 220,220,230
220   DS1(JCODE,ICODE,LCODE,ISECND)=DS1(JCODE,ICODE,LCODE,ISECND)+DOSEF(
     12,I)*DIET(2,J)*CONC(2,K)
      GO TO 250
230   DS2(JCODE,ICODE,LCODE,ISECND)=DS2(JCODE,ICODE,LCODE,ISECND)+DOSEF(
     12,I)*DIET(2,J)*CONC(2,K)
      GO TO 250
240   ISCS=K
      GO TO 260
250   CONTINUE
260   CONTINUE
270   ISCS=1
280   IF (MOD(ICODE,2)) 290,300,290
290   ICODE=ICODE+1
      GO TO 140
300   CONTINUE
      RETURN
      END
```


1083462

```
@ ELT CROP,1,711115, 62842

      SUBROUTINE CROP (CENTRD,YIELD,CONCF,APEAR,HARVES,TRANS,CONC,LENGTH
     1,PERCN1,RATEI)
C         THIS SUBROUTINE CALCULATES THE CONCENTRATION IN FOOD CROPS(FOR
C         BOTH MEN AND LIVESTOCK) ACCORDING TO THE FORMULA IN THE FOOD
C         CHAIN DESCRCIPTION BY R.D. HARR.
C         AT THIS TIME ONLY THE CONCENTRATION AT THE MONTH OF HARVEST IS
C         CALCULATED
C         EXPLANATION OF CALL LIST
C              PERCN1     PERCENT OF TOTAL PRODUCTION IRRIGATED(INTEGER)
C              CENTRD     CENTROID NUMBER OF CROP LOCATION
C              YIELD      YIELD FACTOR FOR THIS TYPE OF CROP
C              CONCF      CONCENTRATION FACTORS
C              APEAR      MONTH OF APPEARANCE
C              HARVES     MONTH OF HARVEST
C              TRANS      TRANSLOCATION FACTOR
C              CONC       TABLE CONTAINING CONCENTRATIONS IN FOOD
C              LENGTH     NUMBER OF ENTRIES IN ABOVE TABLE
C              RATEI      MONTHLY IRRIGATION RATES
      INTEGER CENTRD,APEAR,HARVES,CODE,PERCN1
      DIMENSION CONCF(1),CONC(2,1),RATEI(1)
      DATA CODE/0/
      INCLUDE TABLE1,LIST
      INCLUDE TABLE2,LIST
      EQUIVALENCE(IDEBUG,M(50))
C         SET UP AREAS FOR DEPOSITION CONCENTRATION TABLES
      DIMENSION CONC6(3600),CONC7(3600),KOUNTT(2,105),LENGC6(3),
     1 LENGC7(3) ,E4(4200)
      EQUIVALENCE (EQUIV(4801),CONC6(1)),(E4,DS4),(E4(1),CONC7(1)) ,
     1(KOUNTT(1,1),E4(3601)),(E4(3900), LENGC6(1)),(E4(3910), LENGC7(1))
      LENCOM=0
      IF (PERCN1.EQ.0) GO TO 120
C         OBTAIN THE IRRIGATION WATER CONCENTRATION FOR THIS YEAR
```

```
      CALL GET (KEYS(CODE,CENTRD,14),COMB,LENCOM)
      IF (LENCOM) 100,100,110
100   WRITE (REPORT,250) ,CENTRD
      GO TO 120
C         MULTIPLY BY THE IRRIGATION RATE
110   CALL MULT3 (RATEI,COMB,LENCOM)
C         MULTIPLY BY THE % OF TOTAL PRODUCTION IRRIGATED
      CALL MULT1 (PERCN1/100.0,COMB,LENCOM)
120   J=0
      DO 130 I=1,3
      J=I
      INDEX=(I-1)*1200+1
      IF (CENTRD-KOUNTT(2,I)) 130,160,130
130   CONTINUE
      CALL GET (KEYS(CODE,CENTRD,6),DF,LENGDF)
      J=0
      IF (LENGDF) 140,140,150
140   WRITE (REPORT,260) CENTRD
150   CALL MERGE (COMB,LENCOM,DF,LENGDF,ALOSS,LENLOS)
      GO TO 170
160   IF (IDEBUG.EQ.1) CALL DUMP (CONC6(INDEX),LENGC6(J))
      CALL MERGE (COMB,LENCOM,CONC6(INDEX),LENGC6(J),ALOSS,LENLOS)
170   CONTINUE
      IF (IDEBUG.EQ.1) CALL DUMP (ALOSS,LENLOS)
C         CALCULATE THE DEPOSITION CONCENTRATION AT HARVEST
      CALL DECAY1 (ALOSS,LENLOS,APEAR,HARVES)
      IF (IDEBUG.EQ.1) CALL DUMP (ALOSS,LENLOS)
C         MULTIPLY BY RT/Y
      DUMMY=RETENT*TRANS/YIELD
      CALL MULT1 (DUMMY,ALOSS,LENLOS)
      IF (IDEBUG.EQ.1) CALL DUMP (ALOSS,LENLOS)
      LENCOM=0
      IF (PERCN1) 180,190,180
C         OBTAIN LONG TERM IRRIGATION WATER CONTAMINATION
180   CALL GET (KEYS(CODE,CENTRD,13),COMB,LENCOM)
C     IF(LENCOM) 600,600,600 *** REDUNDANT,MUTED 3/15/71 B W BENTLEY
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1083464

551

```
      WRITE (REPORT,270) CENTRD
C         MULTIPLY BY THE PERCENT OF TOTAL PRODUCTION IRRIGATED
      CALL MULT1 (PERCNI/100.0,COMB,LENCOM)
      IF (IDEBUG.EQ.1) CALL DUMP (COMB,LENCOM)
190   IF (J) 230,200,230
200   CALL GET (KEYS(CODE,CENTRD,7),DF,LENGDF)
      IF (LENGDF) 210,210,220
210   WRITE (REPORT,280) CENTRD
      IF (IDEBUG.EQ.1) CALL DUMP (DF,LENGDF)
220   CALL MERGE (DF,LENGDF,COMB,LENCOM,C,LENCON)
      GO TO 240
230   IF (IDEBUG.EQ.1) CALL DUMP (CONC7(INDEX),LENGC7(J))
      CALL MERGE (COMB,LENCOM,CONC7(INDEX),LENGC7(J),C,LENCON)
240   CONTINUE
      IF (IDEBUG.EQ.1) CALL DUMP (C,LENCON)
C         REMOVE ALL ENTRIES IN THIS TABLE EXCEPT FOR MONTH OF HARVEST
      CALL ZERO1 (HARVES,C,LENCON)
      IF (IDEBUG.EQ.1) CALL DUMP (C,LENCON)
C         MULTIPLY BY THE CONCENTRATION FACTORS
      CALL MULT2 (CONCF,C,LENCON)
      IF (IDEBUG.EQ.1) CALL DUMP (C,LENCON)
C         ADD THIS TABLE AND THE CURRENT DEPOSITION CONCENTRATION
      CALL MERGE (C,LENCON,ALOSS,LENLOS,CONC,LENGTH)
      IF (IDEBUG.EQ.1) CALL DUMP (CONC,LENGTH)
      RETURN
C
250   FORMAT (' CURRENT YEAR IRRIGATION WATER CONCENTRATION NOT AVAILABL
     1EFOR CROP CONCENTRATION CALCULATION. CENTROID NUMBER IS ',I3)
260   FORMAT (' CURRENT AIR DEPOSITION NOT AVAILABLE FOR CROP CALCULATIO
     1N AT CENTROID NUMBER ',I3)
270   FORMAT (' LONG TERM IRRIGATION WATER CONTAMINATION NOT AVAILABLE F
     1OR CROP CONCENTRATION CALCULATION. CENTROID NUMBER IS ',I3)
280   FORMAT (' LONG TERM AIR DEPOSITION NOT AVAILABLE FOR CROP CALCULAT
     1ION AT CENTROID NUMBER ',I3)
      END
```


10834465

1083466

```
@ ELT DECAY1,1,711115, 62808

      SUBROUTINE DECAY1 (CONC,LENGTH,APEAR,HARVES)
C         CALCULATE THE TOTAL DEPOSITION ON THE LEAVES OF A  PLANT
C         AT THE TIME OF HARVEST GIVEN THE DEPOSITION, THE MONTH OF
C         HARVEST AND THE MONTH OF APPEARANCE WITH THE FOLLOWING
C         FORMULA-
C         SUM FROM A TO H OF CM*EXP(-LAMBDAE(M-A)*30.5
C
C         EXPLANATION OF CALL LIST
C              CONC      DEPOSITION TABLE
C              LENGTH    NUMBER OF ENTRIES IN ABOVE
C              APEAR     NO. OF MONTH OF APPEARANCE
C              HARVES    NO. OF MONTH OF HARVEST
      INTEGER APEAR,HARVES
      DIMENSION CONC(2,1)
      INCLUDE TABLE1,LIST
      INCLUDE TABLE2,LIST
      IF (LENGTH) 100,130,100
100   ISOOLD=0
      KOUNT=0
      DO 120 N=1,LENGTH
      ISONEW=FLD(0,12,CONC(1,N))
      MONTH=FLD(12,12,CONC(1,N))
C         IS THE MONTH OF THIS ENTRY BETWEEN THE MONTH OF APPEARANCE
C              AND THE MONTH OF HARVEST?
      IF (MONTH.LT.APEAR.OR.MONTH.GT.HARVES) GO TO 120
C         IF THE ISOTOPE CODE HAS CHANGED START A NEW ENTRY IN THE TABLE
      IF (ISONEW.EQ.ISOOLD) GO TO 110
      KOUNT=KOUNT+1
      FLD(0,12,CONC(1,KOUNT))=ISONEW
      FLD(12,12,CONC(1,KOUNT))=HARVES
      FLD(24,12,CONC(1,KOUNT))=0
      ISOOLD=ISONEW
```

```
      IF (N.NE.1) CONC(2,KOUNT)=0.0
C        DECAY THE DEPOSITION FOR THIS MONTH AND ADD IT TO THE ACCUMUL-
C        ATED DEPOSITION
110   CONC(2,KOUNT)=CONC(2,KOUNT)+CONC(2,N)*EXP(-HAF12E(ISONEW)*(HARVES-
     1MONTH)*30.5)
120   CONTINUE
      LENGTH=KOUNT
130   RETURN
      END
```


1083467

1083468

```
@ ELT DECAY2,1,711115, 62809

      SUBROUTINE DECAY2 (TABLE,LENGTH)
C         SUBROUTINE TO CALCULATE THE THE CONCENTRATION OF RADIONUCLIDES
C         IN CROPS FOR MONTHS OTHER THAN THE MONTH OF HARVEST BY USING
C         THE FORMULA  CM=CH*EXP(LAMBDAR*T*30.5) WHERE CH IS THE
C         CONCENTRATION AT MONTH OF HARVEST, T IS THE NUMBER OF MONTHS
C         BETWEEN HARVEST AND THE MONTH OF INTEREST
C
C         EXPLANATION OF CALL LIST
C              TABLE     TABLE CONTAINING CONCENTRATIONS
C              LENGTH    NUMBER OF ENTRIES IN TABLE
      INCLUDE TABLE1,LIST
      INCLUDE TABLE2,LIST
      DIMENSION TABLE(2,1)
      IF (LENGTH) 100,170,100
  100 MONTH=FLD(12,12,TABLE(1,1))
C         MOVE DATA TO END OF TABLE
      DO 110 I=1,LENGTH
      INDEX1=I+11*LENGTH
      TABLE(1,INDEX1)=TABLE(1,I)
  110 TABLE(2,INDEX1)=TABLE(2,I)
C         NOW DECAY DATA FOR OTHER MONTHS
      INDEX2=0
      DO 160 J=1,LENGTH
      INDEX1=11*LENGTH+J
      ISOTOP=FLD(0,12,TABLE(1,INDEX1))
      DO 160 K=1,12
      IF (K-MONTH) 120,130,130
  120 N=12
      GO TO 140
  130 N=0
  140 EXP2=EXP(-HAF12R(ISOTOP)*(K+N-MONTH)*30.5)
      IF (EXP2) 150,160,150
```

```
      150   INDEX2=INDEX2+1
            TABLE(1,INDEX2)=TABLE(1,INDEX1)
            FLD(12,12,TABLE(1,INDEX2))=K
            TABLE(2,INDEX2)=TABLE(2,INDEX1)*EXP2
      160   CONTINUE
            LENGTH=INDEX2
      170   RETURN
            END
```


1083469

1083470

```
@ ELT DECAY3,1,711115, 62811

      SUBROUTINE DECAY3 (TABLE,LENGTH,DAYS)
C         SUBROUTINE TO DECAY A CONCENTRATION TABLE BY A FACTOR
C              EXPRESSED IN DAYS.
C         EXPLANATION OF CALL LIST
C              TABLE      CONCENTRATION TABLE
C              LENGTH     NUMBER OF ENTRIES IN TABLE
C              DAYS       NUMBER OF DAYS OF DECAY
      DIMENSION TABLE(2,1)
      INCLUDE TABLE1,LIST
      INCLUDE TABLE2,LIST
      IF (LENGTH) 100,130,100
100   KOUNT=0
      DO 120 I=1,LENGTH
      ISOTOP=FLD(0,12,TABLE(1,I))
      EXP2=EXP(-HAF12R(ISOTOP)*DAYS)
      IF (EXP2) 110,120,110
110   KOUNT=KOUNT+1
      TABLE(1,KOUNT)=TABLE(1,I)
      TABLE(2,KOUNT)=TABLE(2,I)*EXP2
120   CONTINUE
      LENGTH=KOUNT
130   RETURN
      END
```

```
@ ELT DECAY4,1,711115, 62813

      SUBROUTINE DECAY4 (TABLE,LENGTH)
C         SUBROUTINE TO EXPAND A ONE MONTH TABLE TO 12 MONTHS
C         EXPLANATION OF CALL LIST
C              TABLE      CONCENTRATION TABLE
C              LENGTH     NUMBER OF ENTRIES IN THE TABLE
      INCLUDE TABLE1,LIST
      INCLUDE TABLE2,LIST
      DIMENSION TABLE(2,1)
      IF (LENGTH) 100,160,100
C         MOVE PRESENT ENTRIES IN TABLE TO POSITIONS THEY WILL OCCUPY IN
C         EXPANDED TABLE
100   MONTH=FLD(12,12,TABLE(1,1))
      DO 110 I=LENGTH,1,-1
      INDEX=MONTH+12*(I-1)
      TABLE(1,INDEX)=TABLE(1,I)
110   TABLE(2,INDEX)=TABLE(2,I)
C         NOW CALCULATE DECAYED VALUES
      DO 150 J=1,LENGTH
      INDEX1=(J-1)*12+MONTH
      ISOTOP=FLD(0,12,TABLE(1,INDEX1))
      DO 150 K=1,12
      IF (K-MONTH) 120,150,130
120   N=12
      GO TO 140
130   N=0
140   INDEX2=(J-1)*12+K
      TABLE(1,INDEX2)=TABLE(1,INDEX1)
      FLD(12,12,TABLE(1,INDEX2))=K
      TABLE(2,INDEX2)=TABLE(2,INDEX1)
150   CONTINUE
      LENGTH=LENGTH*12
160   RETURN
```


1083471

33-

END

33.

10834473

```
@ ELT DIET,1,711115, 62827

      SUBROUTINE DIET
C     THIS ROUTINE READS WEEKLY HOUSEHOLD CONSUMPTION DATA AND
C     COMPUTES MONTHLY DIET DATA FOR USE BY DOSE CALCULATION
      INTEGER TYPE
      REAL INFO
      REAL KEYS
      REAL MONTH
      INCLUDE TABLE1, LIST
      DIMENSION MONTH(12,35),AMWATR(6,3)
      DIMENSION FRACT(6,3,35),IDENT(3),INFO(7),DIETS(3,35),REC(14)
      DIMENSION OVRLAY(4200)
      EQUIVALENCE (DS1,OVRLAY)
      EQUIVALENCE (OVRLAY(   1),MONTH),(OVRLAY( 421),AMWATR),
     1            (OVRLAY( 439),FRACT),(OVRLAY(1069),IDENT ),
     2            (OVRLAY(1072),INFO ),(OVRLAY(1079),DIETS ),
     3            (OVRLAY(1164),REC  )
C     AMWATR--CONTAINS CONSUMPTION OF DRINKING WATER IN LITERS FOR
C             EACH PERSON TYPE BY POPULATION TYPE
C     MONTH--CONTAINS FRACTION TO MULTIPLY WEEKLY HOUSEHOLD DATA BY TO
C            OBTAIN MONTHLY HOUSEHOLD DATA IN KG OR LITERS
C     FRACT--CONTAINS FRACTION TO MULTIPY MONTHLY HOUSEHOLD COMSUMPTION
C            DATA BY TO OBTAIN DIET BY PERSON TYPE
C     PROGRAM CONSTANTS SUPPLIED BY JK SOLDAT, OCTOBER 1970
C     AMWATR INCLUDES BOTH PRIMARY AND SECONDARY WATER
C     FRACT HAS BEEN ZEROED TO EXCLUDE SECONDARY WATER FROM
C     LIVING PATTERN TAPE
      DATA ((AMWATR(I,J),J=1,3),I=1,6)/3*21.35,3*42.70,
     1                                 3*21.35,3*42.70,
     2                                 3*30.50,3*61.00/
C     1.97 IS CONVERSION FACTOR FOR LBS/WK TO KG/MO OR KG/L
C     52.  IS CONVERSION FACTOR FOR DOZ. EGGS/WK TO EGGS/MONTH
      DATA ((MONTH(I,J),I=1,12),J=1,35)/276*1.97,12*52.0,132*1.97/
```

```
C     AVERAGE INDIVIDUALS
C           URBAN                    RURAL NON FARM          RURAL FARM
      DATA (((FRACT(I,J,K),I=1,5,2),J=1,3),K= 1,18)/
     1  0.307,0.362,0.279,  0.292,0.345,0.266,  0.272,0.322,0.242,
     2  0.323,0.381,0.293,  0.308,0.364,0.280,  0.287,0.339,0.261,
     3  0.275,0.324,0.249,  0.261,0.309,0.238,  0.244,0.288,0.222,
     4  0.323,0.381,0.293,  0.308,0.364,0.280,  0.287,0.339,0.261,
     5  0.162,0.190,0.146,  0.154,0.182,0.140,  0.143,0.169,0.130,
     6  0.194,0.229,0.176,  0.185,0.218,0.168,  0.172,0.203,0.156,
     7  0.263,0.329,0.329,  0.253,0.316,0.316,  0.236,0.295,0.295,
     8  0.179,0.231,0.231,  0.172,0.223,0.223,  0.160,0.208,0.208,
     9  0.255,0.331,0.331,  0.245,0.319,0.319,  0.229,0.297,0.297,
     $  0.136,0.212,0.303,  0.133,0.206,0.295,  0.124,0.193,0.276,
     $  0.170,0.265,0.379,  0.166,0.258,0.369,  0.155,0.241,0.345,
     $  0.080,0.119,0.119,  0.077,0.115,0.115,  0.072,0.107,0.107,
     $  0.228,0.341,0.341,  0.220,0.329,0.329,  0.205,0.306,0.306,
     $  0.113,0.183,0.268,  0.110,0.178,0.262,  0.103,0.166,0.245,
     $  0.161,0.261,0.384,  0.157,0.254,0.373,  0.147,0.238,0.349,
     $  0.108,0.184,0.245,  0.105,0.179,0.239,  0.098,0.167,0.223,
     $  0.166,0.283,0.377,  0.162,0.275,0.367,  0.151,0.257,0.343,
     $  0.356,0.411,0.274,  0.338,0.390,0.260,  0.315,0.363,0.242/
      DATA (((FRACT(I,J,K),I=1,5,2),J=1,3),K=19,35)/
     1  0.356,0.411,0.274,  0.338,0.390,0.260,  0.315,0.363,0.242,
     2  0.356,0.411,0.274,  0.338,0.390,0.260,  0.315,0.363,0.242,
     3  0.395,0.469,0.247,  0.372,0.442,0.233,  0.346,0.410,0.216,
     4  0.209,0.338,0.349,  0.202,0.327,0.337,  0.188,0.304,0.314,
     5  0.179,0.358,0.358,  0.174,0.347,0.347,  0.161,0.322,0.322,
     6  0.155,0.203,0.397,  0.071,0.093,0.183,  0.142,0.186,0.365,
     7  0.116,0.191,0.340,  0.113,0.187,0.333,  0.106,0.175,0.312,
     8  0.135,0.205,0.330,  0.132,0.200,0.322,  0.124,0.187,0.301,
     9  0.143,0.216,0.349,  0.140,0.211,0.341,  0.131,0.198,0.319,
     $  0.111,0.196,0.242,  0.108,0.190,0.235,  0.101,0.177,0.219,
     $  0.171,0.301,0.372,  0.166,0.293,0.362,  0.155,0.273,0.337,
     $  0.129,0.293,0.391,  0.126,0.287,0.382,  0.117,0.266,0.355,
     $  0.090,0.205,0.274,  0.088,0.201,0.268,  0.082,0.186,0.249,
     $  0.077,0.176,0.235,  0.076,0.172,0.229,  0.070,0.160,0.213,
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      $  0.129,0.293,0.391,  0.126,0.287,0.382,  0.117,0.266,0.355,
      $  0.152,0.307,0.379,  0.145,0.299,0.369,  0.137,0.278,0.343,
      $9*0.0/
C      MAXIMUM INDIVIDUALS
C            URBAN                RURAL NON FARM       RURAL FARM
       DATA (((FRACT(I,J,K),I=2,6,2),J=1,3),K= 1,18)/
      1  0.800,0.940,0.730,  0.760,0.900,0.690,  0.710,0.840,0.640,
      2  0.840,0.990,0.760,  0.800,0.950,0.730,  0.750,0.880,0.680,
      3  0.720,0.840,0.650,  0.680,0.800,0.620,  0.630,0.750,0.580,
      4  0.840,0.990,0.760,  0.800,0.950,0.730,  0.750,0.880,0.680,
      5  0.420,0.490,0.380,  0.400,0.470,0.360,  0.370,0.440,0.340,
      6  0.500,0.600,0.460,  0.480,0.570,0.440,  0.450,0.530,0.410,
      7  0.680,0.860,0.860,  0.660,0.820,0.820,  0.610,0.770,0.770,
      8  0.470,0.600,0.600,  0.450,0.580,0.580,  0.420,0.540,0.540,
      9  0.660,0.860,0.860,  0.640,0.830,0.830,  0.600,0.770,0.770,
      $  0.350,0.550,0.790,  0.350,0.540,0.770,  0.320,0.500,0.720,
      $  0.440,0.690,0.980,  0.430,0.670,0.960,  0.400,0.630,0.900,
      $  0.210,0.310,0.310,  0.200,0.300,0.300,  0.190,0.230,0.230,
      $  0.590,0.890,0.890,  0.570,0.860,0.860,  0.530,0.800,0.800,
      $  0.230,0.370,0.540,  0.220,0.360,0.520,  0.210,0.330,0.490,
      $  0.420,0.680,1.000,  0.410,0.660,0.970,  0.380,0.620,0.910,
      $  0.280,0.480,0.640,  0.270,0.470,0.620,  0.250,0.430,0.580,
      $  0.430,0.740,0.980,  0.420,0.720,0.950,  0.390,0.670,0.890,
      $  0.710,0.820,0.550,  0.680,0.780,0.520,  0.620,0.730,0.480/
       DATA (((FRACT(I,J,K),I=2,6,2),J=1,3),K=19,35)/
      1  0.710,0.820,0.550,  0.680,0.780,0.520,  0.620,0.730,0.480,
      2  0.710,0.820,0.550,  0.680,0.780,0.520,  0.620,0.730,0.480,
      3  0.790,0.940,0.740,  0.740,0.880,0.470,  0.690,0.820,0.650,
      4  0.420,0.680,0.700,  0.400,0.650,0.670,  0.380,0.610,0.630,
      5  0.360,0.720,0.720,  0.340,0.690,0.690,  0.320,0.640,0.640,
      6  0.310,0.410,0.790,  0.140,0.190,0.370,  0.280,0.370,0.730,
      7  0.130,0.210,0.370,  0.140,0.210,0.370,  0.140,0.230,0.400,
      8  0.150,0.230,0.360,  0.150,0.220,0.350,  0.140,0.210,0.330,
      9  0.160,0.240,0.380,  0.150,0.230,0.380,  0.140,0.220,0.350,
      $  0.170,0.290,0.360,  0.120,0.280,0.350,  0.150,0.270,0.330,
      $  3.400,6.000,7.400,  3.300,5.900,7.200,  3.100,5.500,6.700,
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      $  0.640,1.500,2.000,  0.630,1.400,1.900,  0.580,1.300,1.800,
      $  0.450,1.000,1.400,  0.440,1.000,1.300,  0.410,0.930,1.200,
      $  0.380,0.880,1.200,  0.380,0.860,1.100,  0.350,0.800,1.100,
      $  2.500,5.900,7.800,  2.500,5.700,7.600,  2.300,5.300,7.100,
      $  3.000,6.100,7.600,  2.900,6.000,7.400,  2.700,5.600,6.900,
      $9*0.0/
       DATA DIETS/105*0.0/
100   READ (CENTER,210,ERR=120,END=130) IDENT,INFO
      IF (IDENT(3)-2) 240,100,240
  240 IF(IDENT(1).EQ.'URB')TYPE=1
      IF(IDENT(1).EQ.'RNF')TYPE=2
      IF(IDENT(1).EQ.'RUF')TYPE=3
      INDX=(IDENT(2)-1)*7
      DO 110 I=1,7
110   DIETS(TYPE,INDX+I)=INFO(I)
      GO TO 100
120   READ (REREAD,220) REC
      WRITE (REPORT,230) REC
      GO TO 100
C     ALL DIET INFORMATION HAS BEEN READ
C     COMPUTE DIET TABLES BY FOOD,POPULATION TYPE
130   CONTINUE
C     LOOP FOR EACH FOOD AND POPULATION TYPE
      DO 200 I=1,35
      DO 200 J=1,3
      KNT=0
C     LOOP FOR EACH PERSON TYPE AND MONTH
      DO 180 K=1,6
      DO 180 N=1,12
      KNT=KNT+1
C     LOAD DIET TABLE
      IF (I-35) 140,150,140
140   D(2,KNT)=FRACT(K,J,I)*MONTH(N,1)*DIETS(J,I)
      GO TO 160
C     ADD DRINKING WATER TO SECONDARY WATER
150   D(2,KNT)=FRACT(K,J,I)*MONTH(N,1)*DIETS(J,I)+AMWATR(K,J)
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      160   CONTINUE
            D(1,KNT)=KEYS(K,N,C)
            IF (D(2,KNT)) 170,170,180
      170   KNT=KNT-1
      180   CONTINUE
            IF (KNT) 200,200,190
      190   CALL TAPE (KEYS(2,J,I+10),D,KNT*2)
      200   CONTINUE
            RETURN
      C
      210   FORMAT (A3,I2,I5,7F10.0)
      220   FORMAT (13A6,A2)
      230   FORMAT ('0INPUT ERROR-FOLLOWING DIET CARD IGNORED'/1X,13A6,A2)
            END
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10834178

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@ ELT DOSERP,1,711115, 62836

      SUBROUTINE DOSERP (PATH,LOCAT,CODE)
C
C                THIS SUBROUTINE WRITES THE PRINTED REPORTS FROM THE DOSE
C           TABLES. CALL LIST IS AS FOLLOWS-
C                PATH    3 WORD PATH NAME
C                LOCAT   3 WORD LOCATION NAME
C                CODE    1=INTERNAL PATH 2=EXTERNAL PATH 3=SEVERAL PATHS
      INCLUDE TABLE1,LIST
      INTEGER CODE
      DIMENSION TOTAL(3,12),FMT(29,3),FMT2(29),PATH(3),ORGAN(3,10),
     1ITOTAL( 3,12),ISOTOP(50),IYES(3),TOTAL4(12),
     2LOCAT(3)    ,ITS(12,8)
      DATA MAX/45/,IPAGE/0/
      EQUIVALENCE(TOTAL,ITOTAL),(FM1,FMT(1,1)),(FM2,FMT(1,2))
     1,(FM3,FMT(1,3)) ,(ITS,TOTALS)
      LINES=0
      DATA (FMT(I,1),I=1,29)/'(11H   INTERNAL            ,2X,',
     111*'       ,2X  ,',',E7.2  )'/
      DATA (FMT(I,2),I=1,29)/'(11H   EXTERNAL            ,2X,',
     111*'       ,2X  ,',',      )'/
      DATA (FMT(I,3),I=1,29)/'(11H   TOTAL               ,2X,',
     111*'       ,2X  ,',',      )'/
      DATA (FMT2(I) ,I=1,29)/'(7H     %    ,            A6,    ',
     111*'       ,2X  ,',',      )'/
      DATA (ISOTOP(I),I=1,50)/
     1     'H3    ','N13   ','C14   ','NA22  ','NA24  ',
     2     'AR39  ','AR41  ','CR51  ','MN54  ','FE55  ',
     3     'FE59  ','CO58  ','CO60  ','NI63  ','CU64  ',
     4     'ZN65  ','KR85M ','KR85  ','KR87  ','KR88  ',
     5     'SR89  ','SR90  ','ZR95  ','NB95  ','MO99  ',
     6     'RU103 ','RU106 ','TE132 ','I129  ','I131  ',
     7     'I132  ','I133  ','I135  ','XE131 ','XE133M',
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      8     'XE133 ','XE135M','XE135 ','XE138 ','CS134 ',
      9     'CS137 ','BA140 ','LA140 ','CE141 ','CE144 ',
     $      '      ','      ','      ','      ','      '/
      DATA (ORGAN(I,01),I=1,3)/ 'TOTAL BODY        '/
      DATA (ORGAN(I,02),I=1,3)/ 'GI TRACT(LLI)     '/
      DATA (ORGAN(I,03),I=1,3)/ 'THYROID           '/
      DATA (ORGAN(I,04),I=1,3)/ 'BONE              '/
      DATA (ORGAN(I,05),I=1,3)/ 'LUNGS             '/
      DATA (ORGAN(I,06),I=1,3)/ 'SKIN              '/
      DATA (ORGAN(I,07),I=1,3)/ 'LIVER             '/
      DIMENSION IPRES(50)
C               SINCE THE REPORTS ARE WRITTEN IN ORDER OF ORGAN NUMBER
C         LOOP THROUGH ORGAN CODES.
      LINES=99
      DO 550 I=1,7
      DO 100 K=1,3
      IYES(K)=0
      DO 100 J=1,12
100   TOTAL(K,J)=0.0
      GO TO (110,140,170), CODE
C         INTERNAL
110   DO 130 I1=1,2
      I2=I1-1
      DO 130 J=1,6
      DO 130 K=1,50
      IF (DS1(K,J,I,I1)) 120,130,120
120   DS3(K,J,I,I1)=DS3(K,J,I,I1)+DS1(K,J,I,I1)
      IPRES(K)=1
      TOTAL(1,I2*6+J)=TOTAL(1,I2*6+J)+DS1(K,J,I,I1)
130   CONTINUE
      ISTART=1
      ISTOP=1
      GO TO 270
C         EXTERNAL
140   DO 160 I1=1,2
      I2=I1-1
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      DO 160 J=1,6
      DO 160 K=1,50
      IF (DS2(K,J,I,I1)) 150,160,150
150   DS4(K,J,I,I1)=DS4(K,J,I,I1)+DS2(K,J,I,I1)
      IPRES(K)=1
      TOTAL(2,I2*6+J)=TOTAL(2,I2*6+J)+DS2(K,J,I,I1)
160   CONTINUE
      ISTART=2
      ISTOP=2
      GO TO 270
170   DO 220 I1=1,2
      I2=I1-1
      DO 220 J=1,6
      DO 220 K=1,50
C         SET UP TABLES WHEN ONLY TOTAL REPORTS ARE TO BE WRITTEN
      IF (M(1).NE.' ') GO TO 180
      DS3(K,J,I,I1)=DS1(K,J,I,I1)
      DS1(K,J,I,I1)=0.0
      DS4(K,J,I,I1)=DS2(K,J,I,I1)
      DS2(K,J,I,I1)=0.0
180   IF (M(1).NE.' '.OR.M(2).NE.' ') DS1(K,J,I,I1)=DS3(K,J,I,I1)+DS4(K,
     1J,I,I1)
      IF (DS3(K,J,I,I1)) 190,200,190
190   IPRES(K)=1
      TOTAL(1,I2*6+J)=TOTAL(1,I2*6+J)+DS3(K,J,I,I1)
      DS3(K,J,I,I1)=0.0
200   IF (DS4(K,J,I,I1)) 210,220,210
210   IPRES(K)=1
      TOTAL(2,I2*6+J)=TOTAL(2,I2*6+J)+DS4(K,J,I,I1)
      DS4(K,J,I,I1)=0.0
220   CONTINUE
      ISTART=1
      ISTOP=3
      DO 230 K=1,12
230   TOTAL(3,K)=TOTAL(2,K)+TOTAL(1,K)
      KOUNT=0
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      DO 240 I1=0,6,6
      DO 240 I2=1,2
      DO 240 I3=I2,6,2
      KOUNT=KOUNT+1
24C   TOTALS(KOUNT,I)=TOTAL(3,I1+I3)
      IF (I-1) 26C,25C,26C
25C   ITS(1,8)=LOCAT(1)
      ITS(2,8)=LOCAT(2)
      ITS(3,8)=LOCAT(3)
      TOTALS(5,8)=TOTALS(1,I)*PERSON(1)
      TOTALS(6,8)=TOTALS(2,I)*PERSON(2)
      TOTALS(7,8)=TOTALS(3,I)*PERSON(3)
      TOTALS(8,8)=TOTALS(7,I)*PERSON(1)
      TOTALS(9,8)=TOTALS(8,I)*PERSON(2)
      TOTALS(10,8)=TOTALS(9,I)*PERSON(3)
26C   IF (M(1).NE.' ') GO TO 27C
      IF (M(2).EQ.' ') GO TO 56C
C               PREPARE AND WRITE TOTALS
C               WRITE THE TOTALS BY TYPE OF PERSON FOR INTERNAL,EXTERNAL
C          AND TOTAL DOSES
27C   DO 34C M1=ISTART,ISTOP
      DO 34C N1=0,6,6
      DO 3CC N=1,5,2
      IF (TOTAL(M1,N+N1)) 28C,29C,28C
28C   FMT(5+N+2*N1,M1)='1PE8.2'
      IYES(M1)=1
      GO TO 3CC
29C   TOTAL(M1,N+N1)=' '
      FMT(5+N+2*N1,M1)='2X,A6'
3CC   CONTINUE
      DO 33C N=2,6,2
      IF (TOTAL(M1,N+N1)) 31C,32C,31C
31C   FMT(10+N+2*N1,M1)='1PE8.2'
      IYES(M1)=1
      GO TO 33C
32C   TOTAL(M1,N+N1)=' '
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      FMT(10+N+2*N1,M1)='2X,A6'
330   CONTINUE
340   CONTINUE
C                WRITE A HEADING FOR THIS REPORT
      IF (IYES(1).EQ.C.AND.IYES(2).EQ.C.AND.IYES(3).EQ.C) GO TO 550
C     SKIP TO NEW PAGE IF THERE IS NOT ROOM TO PRINT TOTALS AND AT LEAST
C     ONE ISOTOPES CONTRIBUTION
      IADD=IYES(1)+IYES(2)+IYES(3)+3
      IF (MAX-LINES-IADD) 350,350,360
350   IPAGE=IPAGE+1
      WRITE (REPORT,570) PATH,LOCAT,DATE,IPAGE,(ORGAN(J,I),J=1,3)
      LINES=0
      GO TO 370
360   CONTINUE
      WRITE (REPORT,580) (ORGAN(J,I),J=1,3)
      LINES=LINES+1
370   CONTINUE
      IF (IYES(1).NE.0) WRITE (REPORT,FM1) (TOTAL(1,N),N=1,6,2),(TOTAL(1
     1,N),N=2,6,2),(TOTAL(1,N),N=7,12,2),(TOTAL(1,N),N=8,12,2)
      IF (IYES(2).NE.0) WRITE (REPORT,FM2) (TOTAL(2,N),N=1,6,2),(TOTAL(2
     1,N),N=2,6,2),(TOTAL(2,N),N=7,12,2),(TOTAL(2,N),N=8,12,2)
      IF (IYES(3).NE.0) WRITE (REPORT,FM3) (TOTAL(3,N),N=1,6,2),(TOTAL(3
     1,N),N=2,6,2),(TOTAL(3,N),N=7,12,2),(TOTAL(3,N),N=8,12,2)
C                WRITE HEADING FOR % CONTRIBUTION BY EACH NUCLIDE
      WRITE (REPORT,590)
      LINES=LINES+IYES(1)+IYES(2)+IYES(3)+1
C                LOOP THROUGH ISOTOPECODES CALCULATING PERCENTAGE OF TOTAL
C          DOSE FOR EACH NUCLIDE
      DO 540 J=1,50
      IF (IPRES(J)) 380,540,380
380   IPRES(J)=0
      GO TO (390,430,470), CODE
390   KOUNT=0
      DO 420 I1=1,2
      I2=I1-1
      DO 420 K2=1,2
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      DO 420 K=K2,6,2
      IF (DS1(J,K,I,I1)) 400,410,400
400   KOUNT=KOUNT+1
      TOTAL4(KOUNT)=(DS1(J,K,I,I1)/TOTAL(1,I2*6+K))*100.0
      FMT2(5*K2+K+12*I2)='1PE8.2'
      DS1(J,K,I,I1)=0.0
      GO TO 420
410   FMT2(5*K2+K+12*I2)='8X'
420   CONTINUE
      GO TO 510
430   KOUNT=0
      DO 460 I1=1,2
      I2=I1-1
      DO 460 K2=1,2
      DO 460 K=K2,6,2
      IF (DS2(J,K,I,I1)) 440,450,440
440   KOUNT=KOUNT+1
      TOTAL4(KOUNT)=(DS2(J,K,I,I1)/TOTAL(2,I2*6+K))*100.0
      FMT2(5*K2+K+12*I2)='1PE8.2'
      DS2(J,K,I,I1)=0.0
      GO TO 460
450   FMT2(5*K2+K+12*I2)='8X'
460   CONTINUE
      GO TO 510
470   KOUNT=0
      DO 500 I1=1,2
      I2=I1-1
      DO 500 K2=1,2
      DO 500 K=K2,6,2
      IF (DS1(J,K,I,I1)) 480,490,480
480   KOUNT=KOUNT+1
      TOTAL4(KOUNT)=(DS1(J,K,I,I1)/TOTAL(3,I2*6+K))*100.0
      FMT2(5*K2+K+12*I2)='F8.3'
      DS1(J,K,I,I1)=0.0
      GO TO 500
490   FMT2(5*K2+K+12*I2)='8X'
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500   CONTINUE
510   LINES=LINES+1
C                IS A PAGE HEADING REQUIRED?
      IF (MAX-LINES) 520,520,530
520   IPAGE=IPAGE+1
      LINES=0
      WRITE (REPORT,570) PATH,LOCAT,DATE,IPAGE,(ORGAN(J1,I),J1=1,3)
530   WRITE (REPORT,FMT2) ISOTOP(J),(TOTAL4(K),K=1,KOUNT)
540   CONTINUE
550   CONTINUE
560   CONTINUE
      RETURN
C
570   FORMAT (1H1,8X,'DOSE FROM ',3A6,2X,'IN MREM     ',18X,4X,3A6,11X,'
     1     ',2A6,2X,'PAGE ',I5/33X,'D O S E',30X,'***',16X,'D O S E  C O
     2M M I T M E N T'/1X,2A6,A3,2(5X,'AVERAGE INDIVIDUAL',12X,'MAXIMUM
     3INDIVIDUAL',7X)/11X,4(5X,'CHILD  TEENAGER     ADULT'))
580   FORMAT (1H ,2A6,A3,2X,19('------'))
590   FORMAT ('             ')
      END
```


1083484

```
@ ELT DUMP,1,711115, 62843

      SUBROUTINE DUMP (TABLE,LENGTH)
C         THIS SUBROUTINE DUMPS THE TABLES
C         EXPLANATION OF CALL LIST
C              TABLE     TABLE TO BE DUMPED
C              LENGTH    NUMBER OF ENTRIES IN TABLE
      DIMENSION TABLE(1)
      INCLUDE TABLE1,LIST
C     IF(LENGTH) ,110, *** REDUNDANT, MUTED 3/15/71 B W BENTLEY
100   RETURN
      END
```


1083485

```
@ ELT FOOD,1,711115, 62806

      SUBROUTINE FOOD (PATH)
C         SUBROUTINE TO CALCULATE THE FOOD CONCENTRATIONS FOR ONE
C         POPULATION CENTROID AT A TIME
C
C         EXPLANATION OF CALL LIST
C         PATH      PATH TABLE
      INCLUDE TABLE2,LIST
      INCLUDE TABLE1,LIST
      DIMENSION PATH(26,1)
      INTEGER PATH,CODE
      DATA CODE/0/
      EQUIVALENCE(IDEBUG,M(50))
C         SET UP AREAS FOR DEPOSITION CONCENTRATION TABLES
      DIMENSION CONC6(3600),CONC7(3600),KOUNTT(2,105),LENGC6(3),
     1 LENGC7(3) ,E4(4200)
      EQUIVALENCE (EQUIV(4801),CONC6(1)),(E4,DS4),(E4(1),CONC7(1)) ,
     1(KOUNTT(1,1),E4(3601)),(E4(3900), LENGC6(1)),(E4(3910), LENGC7(1))
C         OBTAIN TABLES RHAT HAVE BEEN STORED ON RHE DRUM
      CALL GET (KEYS(98,0,0),DS3,IDUM)
C         COUNT THE NUMBER OF TIMES EACH CENTROID IS REFERENCED
      KOUNTT(1,1)=0
      KOUNTT(2,1)=0
      ISTART=1
      IEND=1
      DO 160 I=11,45
      IF (I-43) 100,160,100
  100 IF (I-39) 110,160,110
  110 DO 150 J=1,3
      INDEX=(J-1)*4+14
      IF (PATH(INDEX,I)) 120,150,120
  120 DO 130 K=ISTART,IEND
      N=K
```


1083486

```
      IF (KOUNTT(2,K)-PATH(INDEX,I)) 130,140,130
130   CONTINUE
      IF (IEND.NE.1) IEND=IEND+1
      KOUNTT(2,IEND)=PATH(INDEX,I)
      KOUNTT(1,IEND)=1
      GO TO 150
140   KOUNTT(1,N)=KOUNTT(1,N)+1
150   CONTINUE
160   CONTINUE
C         SORT THE TABLE OF COUNTS ON THE FIRST WORD
      CALL SORTER (KOUNTT,2,IEND)
C         MOVE THE LAST THREE ENTRIES TO THE FIRST THREE POSITIONS IN
C         THE TABLE
      KSTART=MAX(0,IEND-3)
      DO 170 I=1,3
      KOUNTT(1,I)=KOUNTT(1,KSTART+I)
      IF (I.GT.IEND) KOUNTT(1,I)=0
      KOUNTT(2,I)=KOUNTT(2,KSTART+I)
      IF (I.GT.IEND) KOUNTT(2,I)=0
170   CONTINUE
C         NOW OBTAIN THE 3 MOST FREQUENTLY USED DEPOSTION TABLES
      DO 190 I=1,3
      KNDEX=(I-1)*1200+1
      IF (KOUNTT(2,I)) 180,190,180
180   CALL GET (KEYS(0,KOUNTT(2,I),6),CONC6(KNDEX),LENGC6(I))
      CALL GET (KEYS(0,KOUNTT(2,I),7),CONC7(KNDEX),LENGC7(I))
190   CONTINUE
C         LOOP THROUGH THE PATH TABLE IGNORING ANY ENTRY THAT DOES NOT
C         PERTAIN TO FOOD.
      DO 630 L1=1,45
      L2=PATH(1,L1)
      IF (MAP(L2)) 200,630,200
200   N=MAP(L2)
C         SET DEBUG SWITCHES FOR SOME FOOD PATHS
      IF (L2.EQ.11) IDEBUG=1
      IF (L2.EQ.31) IDEBUG=1
```


1083481

```
      IF (L2.EQ.12) IDEBUG=1
      IF (L2.EQ.32) IDEBUG=1
      IF (L2.EQ.33) IDEBUG=1
      IF (L2.EQ.43) IDEBUG=1
C         LOOP FOR THE FIRST SOURCE
      DO 550 M1=1,3
      INDEX=(M1-1)*4+14
      LENGC2=0
      GO TO (210,230,230), M1
210   IF (PATH(INDEX,L1)) 220,520,220
220   IF (PATH(INDEX,L1)-999) 250,520,250
230   IF (PATH(INDEX,L1)) 240,550,240
240   IF (PATH(INDEX,L1)-999) 250,550,250
C         CALCULATE A CONCENTRATION. WHAT TYPE OF FOOD IS THIS
250   IDUMX=PATH(26,L1)
      GO TO (260,340,430,430,430,430,430,430,340), IDUMX
C         THIS FOOD PATH IS FOR FISH. OBTAIN SUSPENDED H2O CONCENTRATION
260   IF (L2.EQ.43) INDEX9=PATH(1,5)
      IF (L2.EQ.39) INDEX9=PATH(1,9)
      IF (PATH(4,INDEX9)-7) 280,270,280
C         USE GROUNDWATER CONCENTRATION
270   CALL GET (KEYS(CODE,PATH(INDEX,L1),14),CONC2,LENGC2)
      GO TO 330
280   CALL GET (KEYS(CODE,PATH(INDEX,L1),11),COMB,LENCOM)
      IF (LENCOM) 290,290,300
290   WRITE (REPORT,660) PATH(INDEX,L1)
C         OBTAINED DISOLVED H2O CONCENTRATION.
300   CALL GET (KEYS(CODE,PATH(INDEX,L1),10),ALOSS,LENLOS)
      IF (LENLOS) 310,310,320
310   WRITE (REPORT,670) PATH(INDEX,L1)
C         ADD THESE CONCENTRATIONS TOGETHER
320   CALL MERGE (COMB,LENCOM,ALOSS,LENLOS,CONC2,LENGC2)
C         MULTIPLY BY THE FISH CONCENTRATION FACTORS
330   CALL MULT2 (CONCFA(1,N),CONC2,LENGC2)
      GO TO 490
C         CALCULATE A FOOD CROP CONCENTRATION AT MONTH OF HARVEST
```


1083488

```
C          DETERMINE THE NUMBER OF MONTHS OF HARVEST FOR THIS CROP
34C   IF (PATH(26,L1)-2) 36C,35C,36C
35C   NUM=1
      GO TO 37C
36C   NUM=REPEAT(N)
C          NOW CALCULATE A CONCENTRATION FOR EACH MONTH OF HARVEST
37C   DO 42C L2=1,NUM
      L3=L2-1
      CALL CROP (PATH(INDEX,L1),YIELDF(N),CONCFA(1,N),APPEAR(N),HARVST(N
     1)+L3,TRANSL(N),CONC3,LENGC3,PATH(INDEX+2,L1),RATE(1,N))
      IF (L2-1) 4CC,38C,4CC
C          SINCE THIS IS THE FIRST TIME MOVE CONC2 TO CONC3
38C   DO 39C L4=1,LENGC3
      CONC2(1,L4)=CONC3(1,L4)
39C   CONC2(2,L4)=CONC3(2,L4)
      LENGC2=LENGC3
      GO TO 42C
C          ADD TABLE CALCULATED THIS TIME TO PREVIOUS TABLE
4CC   CALL MERGE (CONC2,LENGC2,CONC3,LENGC3,CONC4,LENGC4)
C          NOW MOVE TO CONC2 SO IT CAN BE ADDED AGAIN IF REQUIRED
      DO 41C L4=1,LENGC4
      CONC2(1,L4)=CONC4(1,L4)
41C   CONC2(2,L4)=CONC4(2,L4)
      LENGC2=LENGC4
42C   CONTINUE
      GO TO 49C
C          CALCULATE A MEAT(SAME AS MILK) CONCENTRATION. FIRST FORAGE
C               TYPE CONCENTRATION
43C   LE=PATH(26,L1)-2
      CALL FORAGE (QUANT1(1,L6),YIELDF(2),PATH(INDEX,L1),CONCFA(1,2),CON
     1C2,LENGC2,RATE(1,2),C)
      IF (IDEBUG.EQ.1) CALL DUMP (CONC2,LENGC2)
C          CALCULATE THE FIRST CROP CONCENTRATION.(GRAIN FOR MILK)
      CALL CROP (PATH(INDEX,L1),YIELDF(2+1),CONCFA(1,2+1),APPEAR(2+1),HA
     1RVST(2+1),TRANSL(2+1),CONC3,LENGC3,PATH(INDEX+2,L1),RATE(1,2+1))
C          MULTIPLY BY DECAY FACTOR BETWEEN HARVEST AND CONSUMPTION
```


1083489

```
      CALL DECAY2 (CONC3,LENGC3)
C         MULTIPLY BY MONTHLY INTAKE VECTOR FOR FIRST CROP
      CALL MULT3 (QUANT2(1,L6),CONC3,LENGC3)
      IF (IDEBUG.EQ.1) CALL DUMP (CONC3,LENGC3)
C         ADD FORAGE AND FIRST CROP INTAKES
      CALL MERGE (CONC2,LENGC2,CONC3,LENGC3,CONC4,LENGC4)
C         DETERMINE IF THIS ANIMAL CONSUMES THIS TYPE OF CROP
      SUM=0.0
      DO 440 IZ=1,12
440   SUM=SUM+QUANT3(IZ,L6)
      LENGC2=0
      IF (SUM) 450,460,450
C         CALCULATE A SECOND CROP CONCENTRATION(STORED FEED FOR MILK)
450   CALL CROP (PATH(INDEX,L1),YIELDF(2+2),CONCFA(1,2+2),APPEAR(2+2),HA
     1RVST(2+2),TRANSL(2+2),CONC2,LENGC2,PATH(INDEX+2,L1),RATE(1,2+2))
C         MULTIPLY BY DECAY FACTOR BETWEEN HARVEST AND CONSUMPTION
      CALL DECAY2 (CONC2,LENGC2)
C         MULTIPLY BY MONTHLY INTAKE VECTOR FOR SECOND CROP
      CALL MULT3 (QUANT3(1,L6),CONC2,LENGC2)
      IF (IDEBUG.EQ.1) CALL DUMP (CONC2,LENGC2)
C         ADD TO PREVIOUS INTAKE
460   CALL MERGE (CONC2,LENGC2,CONC4,LENGC4,CONC3,LENGC3)
C         CALCULATE INTAKE FROM H2O CONSUMPTION. SOURCE IS GROUNDWATER
      CALL GET (KEYS(CODE,PATH(INDEX,L1),14),CONC2,LENGC2)
C         MULTIPLY BY MONTHLY INTAKE RATE
      CALL MULT3 (QUANTW(1,L6),CONC2,LENGC2)
      IF (IDEBUG.EQ.1) CALL DUMP (CONC2,LENGC2)
C         ADD TO OTHER INTAKE
      CALL MERGE (CONC2,LENGC2,CONC3,LENGC3,CONC4,LENGC4)
      LENGC3=0
      IF (BREATH(L6)) 470,480,470
C         CALCULATE THE INTAKE FROM BREATHING AIR.
470   CALL GET (KEYS(0,PATH(INDEX,L1),1),CONC3,LENGC3)
C         MULTIPLY BY THE BREATHING RATE
      CALL MULT1 (BREATH(L6),CONC3,LENGC3)
C         MULTIPLY BY THE INHALATION FACTOR
```


1083490

```
177.            CALL MULT2 (RETNTB(1,L6),CONC3,LENGC3)
179.            IF (IDEBUG.EQ.1) CALL DUMP (CONC3,LENGC3)
179.     C          ADD THIS INTAKE TO PREVIOUS INTAKE
180.     480    CALL MERGE (CONC3,LENGC3,CONC4,LENGC4,CONC2,LENGC2)
181.            IF (IDEBUG.EQ.1) CALL DUMP (CONC2,LENGC2)
182.     C          MULTIPLY BY THE TRANSFER COEFFECIENT
183.            CALL MULT2 (TRANSF(1,L6),CONC2,LENGC2)
184.            IF (IDEBUG.EQ.1) CALL DUMP (CONC2,LENGC2)
185.     C
186.     C          MULTIPLY BY THE PERCENT OF TOTAL FROM THIS SOURCE.
187.     490    DUMMY=PATH(INDEX+1,L1)/100.0
188.            CALL MULT1 (DUMMY,CONC2,LENGC2)
189.     C          IF THIS IS THE FIRST TIME THROUGH SAVE THE TABLE.
190.            IF (M1-1) 530,500,530
191.     500    DO 510 I=1,LENGC2
192.            CONC5(1,I)=CONC2(1,I)
193.     510    CONC5(2,I)=CONC2(2,I)
194.     520    LENGC5=LENGC2
195.            GO TO 550
196.     C          ADD TABLES TOGETHER
197.     530    CALL MERGE (CONC5,LENGC5,CONC2,LENGC2,CONC3,LENGC3)
198.     C          MOVE CONC3 TO CONC5
199.            DO 540 L8=1,LENGC3
200.            CONC5(1,L8)=CONC3(1,L8)
201.     540    CONC5(2,L8)=CONC3(2,L8)
202.            LENGC5=LENGC3
203.     550    CONTINUE
204.            IF (IDEBUG.EQ.1) CALL DUMP (CONC5,LENGC5)
205.     C          IF THIS FOOD HAS A UNIQUE HARVEST MONTH DECAY CONCENTRATIONS
206.     C               FOR THE REST OF THE YEAR
207.            IF (PATH(26,L1)-2) 570,560,570
208.     560    CALL DECAY2 (CONC5,LENGC5)
209.            IF (IDEBUG.EQ.1) CALL DUMP (CONC5,LENGC5)
210.     C          IF THERE IS A FIXED DECAY BEFORE CONSUMPTION REDUCE
211.     C               CONCENTRATION
212.     570    IF (DECAY(L1)) 580,590,580
```


1083491

```
580   CALL DECAY3 (CONC5,LENGC5,DECAY(L1))
      IF (IDEBUG.EQ.1) CALL DUMP (CONC5,LENGC5)
C         IF THE FOOD HAS MORE THAN ONE MONTH OF HARVEST EXPAND THE
C         TABLE
590   IF (PATH(28,L1)-9) 610,600,610
600   CALL DECAY4 (CONC5,LENGC5)
      IF (IDEBUG.EQ.1) CALL DUMP (CONC5,LENGC5)
C         PUT CONCENTRATION TABLE ON DRUM
610   IF (LENGC5) 620,630,620
620   LGTH5=LENGC5*2
      CALL PUT (KEYS(CODE,PATH(12,L1),PATH(4,L1)),CONC5,LGTH5)
      IDEBUG=0
630   CONTINUE
C         ZERO THE DS TABLES THAT HAVE BEEN USED IN THE FOOD CHAIN
      DO 650 I=1,8400
      EQUIV(I)=0.0
      IF (I-4200) 640,640,650
640   E2(I)=0.0
      E4(I)=0.0
650   CONTINUE
      RETURN
C
660   FORMAT (' RIVER WATER CONCENTRATION(SUSPENDED) NOT AVAILABLE FOR F
     1ISH CALCULATION. CENTROID NUMBER IS ',I3)
670   FORMAT (' RIVER WATER CONCENTRATION(DISOLVED) NOT AVAILABLE FOR FI
     1SH CALCULATION. CENTROID NUMBER IS ',I3)
      END
```


1083492

```
@ ELT FPRSRT,1,711115, 62824

      SUBROUTINE FPRSRT (D1,D2,D3,D4,D5,D6,D7)
C               CODE TO REPLACE THE FPRSRT SORTING PACKAGE
      INCLUDE TABLE1,LIST
      DIMENSION ITABLE(12),ICORE(12,14CC)
      EQUIVALENCE(DS1,ICORE)
      RETURN
      ENTRY FFILE(FILTBL,ITABLE)
C               ENTRY POINT TO RECIEVE RECORDS INTO THE SORT
      KOUNT=KOUNT+1
      IF (KOUNT-7CC) 1CC,1CC,12C
1CC   DO 11C I=1,12
11C   ICORE(I,KOUNT)=ITABLE(I)
      GO TO 13C
C               THE TABLE IS HALF FULL PLACE IT ON THE DRUM
12C   JTABLE=JTABLE+1
      CALL SORTC (ICORE,12,7CC)
      CALL PUT (KEYS(1CC1,JTABLE,0),ICORE,84CC)
      KOUNT=1
      GO TO 1CC
C               RETURN TO MAIN PROGRAM
13C   RETURN
      ENTRY FEMPTY(FILTBL)
C               ENTRY POINT TO PERFORM THE SORT FUNCTION
      IF (JTABLE) 14C,14C,15C
C               THERE IS ONLY ONE BLOCK- SORT IT
14C   CALL SORTC (ICORE,12,KOUNT)
      JTABLE=JTABLE+1
      CALL PUT (KEYS(1CC1,1,C),ICORE,12*KOUNT)
      RETURN
15C   JTABLE=JTABLE+1
      CALL SORTC (ICORE,12,KOUNT)
C               SORT THE DATA BY BRINGING THE BLOCKS INTO CORE AND
```

```
C                 SORTING THEM TOGETHER
      CALL PUT (KEYS(1001,JTABLE,0),ICORE(1,1),12*KOUNT)
      DO 170 I=2,JTABLE
      CALL GET (KEYS(1001,I,0),ICORE(1,1),LENGTH)
      LENGTH=LENGTH/6
      IM1=I-1
      DO 160 J=IM1,1,-1
      CALL GET (KEYS(1001,J,I-2),ICORE(1,1+LENGTH),DUMMY)
C                 SORT TABLE
      CALL SORTC (ICORE,12,700+LENGTH)
C                 PUT LAST  PART OF TABLE BACK ON DRUM
      CALL PUT (KEYS(1001,J+1,I-1),ICORE(1,701),12*LENGTH)
      LENGTH=700
160   CONTINUE
C                 PUT FIRSTPART OF ARRAY BACK ON DRUM
      CALL PUT (KEYS(1001,1,IM1),ICORE(1,1),8400)
170   CONTINUE
      KOUNT2=1
      KOUNT3=1
      RETURN
      ENTRY FMERGE(FILTBL,ITABLE)
      GO TO 180
      ENTRY FGET(FILTBL,ITABLE, S)
C                 ENTRY POINT TO RETURN RECORDS FROM THE SORT
180   IF (KOUNT2-KOUNT4) 210,210,190
C                 LAST RECORD?
190   IF (KOUNT3-JTABLE) 200,200,230
C                 NO- OBTAIN BLOCK
200   CALL GET (KEYS(1001,KOUNT3,JTABLE-1),ICORE(1,1),KOUNT4)
      KOUNT4=KOUNT4/6
      KOUNT3=KOUNT3+1
      KOUNT2=1
C                 OBTAIN RECORD FROM BLOCK
210   DO 220 I=1,12
220   ITABLE(I)=ICORE(I,KOUNT2)
      KOUNT2=KOUNT2+1
```


1083494

```
      RETURN
230   RETURN 3
C               SUBROUTINE TO SORT DATA IN CORE
      SUBROUTINE SORTC (ICORE,ITEMS,LGTH)
      DIMENSION ICORE(12,1400)
      LENGT=LGTH-1
      IF (LENGT) 240,290,240
240   DO 280 I=1,LENGT
      K=I
250   CALL SRTKEY (ICORE(1,K),ICORE(1,K+1),$280,$260)
260   DO 270 J=1,ITEMS
      ISAVE=ICORE(J,K+1)
      ICORE(J,K+1)=ICORE(J,K)
      ICORE(J,K)=ISAVE
270   CONTINUE
      K=K-1
      IF (K) 250,280,250
280   CONTINUE
290   RETURN
      END
```


1083495

```
@ ELT GET,1,711115, 62798

      SUBROUTINE GET (KEY,ARRAY,LGTH)
C
C     SUBROUTINE TO RETRIEVE TABLES FROM DRUM
C
C     EXPLANATION OF CALL LIST
C     KEY--WORD TO IDENTIFY TABLE BEING SEARCHED FOR
C     ARRAY--ARRAY TO READ TABLE INTO
C     LGTH--1/2 NUMBER OF WORDS IN TABLE,0 IF NO TABLE IS FOUND
      INTEGER BEGIN
      INTEGER DT
      INTEGER END
      INTEGER FT
      DIMENSION ARRAY(1)
      INCLUDE TABLE1,LIST
      CALL TIMER (1,1)
      MID=1
C     CHECK FOR KEY BEING OUTSIDE BOUNDS OF DICTIONARY
      IF (KEY-DT(1,1)) 180,210,100
100   MID=LD
      IF (KEY-DT(1,LD)) 110,210,180
110   BEGIN=1
      END=LD
C     BINARY SEARCH OF DICTIONARY
120   MID=(END-BEGIN)/2
      IF (MID-1) 160,160,130
130   MID=MID+BEGIN
C     COMPARE MIDDLE VALUE OF REMAINING HALF WITH KEY
      IF (KEY-DT(1,MID)) 140,210,150
140   END=MID
      GO TO 120
150   BEGIN=MID
      GO TO 120
```


1083496

```
C       SEARCH REMAINING DICTIONARY ENTRIES
16C     DO 17D I=BEGIN,END
        MID=I
        IF (KEY-DT(1,MID)) 18D,21C,17C
17C     CONTINUE
C       KEY WAS NOT IN DICTIONARY
18C     CONTINUE
        LGTH=0
C       SEARCH SCRATCH AREA OF DICTIONARY FOR KEY
        IF (LSD) 19C,23C,19C
19C     BEGIN=LD+1
        END=LD+LSD
        DO 2DD I=BEGIN,END
        MID=I
        IF (KEY-DT(1,MID)) 2DD,21C,2DD
2DD     CONTINUE
        GO TO 23D
C       KEY WAS FOUND IN DICTIONARY
C       SET ADDRESS OF NEXT READ ON DRUM TO 2ND DICTIONARY ENTRY
21C     FT(3)=FLD(0,21,DT(2,MID))
        LGTH=FLD(21,15,DT(2,MID))
C       READ TABLE FROM DRUM
        CALL NTRAN (DRUM,2,LGTH,ARRAY,LSTAT)
22C     IF (LSTAT.EQ.-1) GO TO 22C
        IF (LSTAT.NE.LGTH) RETURN 0
        LGTH=LGTH/2
23C     CALL TIMER (2,1)
        RETURN
        END
```


1083491

1083498

```
@ ELT KEYS,1,711115, 62796

      FUNCTION KEYS(I,J,K)
C
C     FUNCTION TO CONSTRUCT DICTIONARY AND TABLE KEYS
C
C     EXPLANATION OF CALL LIST
C     I--INTEGER VALUE TO BE STORED IN 1ST 3RD OF WORD
C     J--INTEGER VALUE TO BE STORED IN 2ND 3RD OF WORD
C     K--INTEGER VALUE TO BE STORED IN 3RD 3RD OF WORD
      FLD(0,12,KEYS)=IABS(I)
      FLD(12,12,KEYS)=IABS(J)
      FLD(24,12,KEYS)=IABS(K)
      RETURN
      END
```

1083499

```
@ ELT MERGE,1,711115, 62801

      SUBROUTINE MERGE (T1,T1LENG,T2,T2LENG,T3,T3COUN)
C         THIS ROUTINE MERGES TWO TABLES TOGETHER ADDING MATCHING
C         ENTRIES TO PRODUCE A THIRD TABLE.
C         EXPLANATION OF CALL LIST
C         T1          TABLE1
C         T1LENG      NUMBER OF ENTRIES IN TABLE1
C         T2          TABLE2
C         T2LENG      NUMBER OF ENTRIES IN TABLE2
C         T3          NEW TABLE
C         T3COUN      NUMBER OF ENTRIES IN NEW TABLE
      DIMENSION T1(2,1),T2(2,1),T3(2,1)
      EQUIVALENCE (ITT1,TT1),(ITT2,TT2)
      INTEGER T1COUN,T2COUN,T3COUN,T1LENG,T2LENG
      T1COUN=1
      T2COUN=1
      T3COUN=0
C         TEST FOR ZERO LENGTH TABLES
      IF (T1LENG.EQ.0.AND.T2LENG.EQ.0) GO TO 230
      IF (T1LENG) 140,140,100
100   IF (T2LENG) 210,210
C         COMPARE THE TABLE1 AND TABLE2 ENTRIES
110   TT1=T1(1,T1COUN)
      TT2=T2(1,T2COUN)
      IF (ITT1-ITT2) 120,170,190
120   T3COUN=T3COUN+1
      T3(1,T3COUN)=T1(1,T1COUN)
      T3(2,T3COUN)=T1(2,T1COUN)
      T1COUN=T1COUN+1
      IF (T1LENG-T1COUN) 130,110,110
130   IF (T2COUN-T2LENG) 140,140,160
C         MOVE REMAINDER OF T2 TO T3
140   DO 150 I=T2COUN,T2LENG
```

```
      T3COUN=T3COUN+1
      T3(1,T3COUN)=T2(1,I)
150   T3(2,T3COUN)=T2(2,I)
160   GO TO 230
C         ENTRIES HAVE SAME ID SO ADD THEM
170   T3COUN=T3COUN+1
      T3(1,T3COUN)=T1(1,T1COUN)
      T3(2,T3COUN)=T1(2,T1COUN)+T2(2,T2COUN)
      T1COUN=T1COUN+1
      T2COUN=T2COUN+1
      IF (T1COUN-T1LENG) 180,180,130
180   IF (T2COUN-T2LENG) 110,110,200
C         MOVE T2 TO T3
190   T3COUN=T3COUN+1
      T3(1,T3COUN)=T2(1,T2COUN)
      T3(2,T3COUN)=T2(2,T2COUN)
      T2COUN=T2COUN+1
      IF (T2LENG-T2COUN) 200,110,110
200   IF (T1COUN-T1LENG)  , ,230
C        MOVE REMAINDER OF T1 TO T3
210   DO 220 I=T1COUN,T1LENG
      T3COUN=T3COUN+1
      T3(1,T3COUN)=T1(1,I)
220   T3(2,T3COUN)=T1(2,I)
230   RETURN
      END
```


1083500

```
@ ELT MULT1,1,711115, 62814

      SUBROUTINE MULT1 (CONST,TABLE,LENGTH)
C         SUBROUTINE TO MULTIPLY A CONCENTRATION TABLE BY A CONSTANT
C
C         EXPLANATION OF CALL LIST
C              CONST     REAL CONSTANT
C              TABLE     CONCENTRATION TABLE
C              LENGTH    NUMBER OF ENTRIES IN TABLE
      DIMENSION TABLE(2,1)
      IF (LENGTH) 100,140,100
100   IF (CONST) 120,110,120
110   LENGTH=0
      GO TO 140
120   DO 130 N=1,LENGTH
130   TABLE(2,N)=TABLE(2,N)*CONST
140   RETURN
      END
```


1083501

1083502

```
@ ELT MULT2,1,711115, 62815

      SUBROUTINE MULT2 (VECTOR,TABLE,LENGTH)
C         SUBROUTINE TO MULTIPY A CONCENTRATION TABLE BY A VECTOR THAT
C         VARIES BY NUCLIDE
C         EXPLANATION OF CALL LIST
C              VECTOR    VECTOR WITH ONE POSITION FOR EACH NUCLIDE
C              TABLE     CONCENTRATION TABLE
C              LENGTH    NUMBER OF ENTRIES IN TABLE. CHANGED BY ROUTINE
      DIMENSION VECTOR(1),TABLE(2,1)
      IF (LENGTH) 100,130,100
100   KOUNT=0
      DO 120 N=1,LENGTH
      ISOTOP=FLD(0,12,TABLE(1,N))
      IF (TABLE(2,N)*VECTOR(ISOTOP)) 110,120,110
110   KOUNT=KOUNT+1
      TABLE(1,KOUNT)=TABLE(1,N)
      TABLE(2,KOUNT)=TABLE(2,N)*VECTOR(ISOTOP)
120   CONTINUE
      LENGTH=KOUNT
130   RETURN
      END
```

10835503

```
@ ELT MULT3,1,711115, 62816

      SUBROUTINE MULT3 (VECTOR,TABLE,LENGTH)
C         SUBROUTINE TO MULTIPY A CONCENTRATION TABLE BY A VECTOR THAT
C         VARIES BY MONTH
C
C         EXPLANATION OF CALL LIST
C              VECTOR    12 POSITION VECTOR
C              TABLE     CONCENTRATION TABLE
C              LENGTH    NUMBER OF ENTRIES IN TABLE
      DIMENSION TABLE(2,1),VECTOR(1)
      IF (LENGTH) 100,130,100
100   KOUNT=0
      DO 120 I=1,LENGTH
      MONTH=FLD(12,12,TABLE(1,I))
      IF (TABLE(2,I)*VECTOR(MONTH)) 110,120,110
110   KOUNT=KOUNT+1
      TABLE(1,KOUNT)=TABLE(1,I)
      TABLE(2,KOUNT)=TABLE(2,I)*VECTOR(MONTH)
120   CONTINUE
      LENGTH=KOUNT
130   RETURN
      END
```

```
@ ELT NTABS,1,711115, 62794

NTABZZ  INFO 2 2
S(2) .
        + 5          . REREAD
        + 3          . PUNCH
        + 2          . PRINTER
        + 1          . CARD READER
NTABS*  + 4          . CONSOLE
I DO 4 , + 'A'+I-1   . TAPES A-D
        + 1          . CARD READER
        + 2          . PRINTER
I DO 22 , + 'E'+I-1  . TAPES E-Z
        + DRUM1      . DRUM
NTABSS* .
NTABDR  INFO 2 3
S(3) .
DRUM1   + CC40CCCC
        + C5CCCCCC
        + CC40CCCC
        RES 4
        END
```


1083504

10835505

```
@ ELT PARAM,1,711115, 62829

      SUBROUTINE PARAM
      INCLUDE TABLE1,LIST
      DIMENSION IMAGE(14)
      DIMENSION IOTABL(27)
C     IOTABL CONTAINS NUMERIC UNIT DESIGNATION FOR TAPE UNITS A-Z
C     INITIALIZE IOTABL--ENTRY 1 MUST ALWAYS BE 0
C                       --ENTRIES 2-27 CONTAIN NUMERIC UNIT DESIGNATION
C                       --OF TAPE UNITS A-Z
      DATA IOTABL/ 0, 1, 2, 3, 4, 7, 8, 9,10,11,12,13,14,15,16,17,18,19,
     120,21,22,23,24,25,26,27,28/
C     INITIALIZE IO UNITS
      DATA IO(1)/6/
      DATA IO(2)/29/
      DATA IO(3)/-4/
      DATA IO(4)/5/
      DATA LAST/'LAST'/
      DATA L/1000*0/
C     READ PARAMETER CARD
C     COLUMNS 1-12 OF PARAMETER CONTAINS ALPHA NUMERIC DATE TO BE USED
C     ON REPORT HEADINGS;  COLUMNS 13-18 CONTAIN ALPHA UNIT
C     DESIGNATIONS FOR CARD IMAGE INPUT DATA;  AND COLUMNS 19-24
C     CONTAIN ALPHA UNIT DESIGNATIONS FOR BINARY INPUT DATA.
C     COLUMN 25 CONTAINS ALPHA UNIT DESIGNATION OF UNIT TO READ
C     POPULATION FILE FROM
C     COLUMN 26 ALPHA UNIT ASSIGNED TO RESTART TAPE
C     COLUMN 27-NON BLANK CAUSES PROGRAM TO READ RESTART TAPE
      READ (CARD,180) DATE,(IO(I),I=5,18),M(3)
C     DETERMINE TAPE UNITS TO BE USED THIS PROCESSING
      DO 130 I=5,18
      J=FLD(0,6,IO(I))-4
      IF (J) 120,120,100
100   IF (J-26) 110,110,120
```

```
      110   IO(I)=IOTABL(J)
            GO TO 130
      C     UNIT DESIGNATION UNDEFINED
      120   CONTINUE
            WRITE (REPORT,190) IO(I)
            STOP
      130   CONTINUE
      C     POPULATION FILE IS ASSIGNED TO CARD READER WHEN UNIT IS NOT
      C     SPECIFIED ON PARAMETER
            IF (IO(17).EQ.0) IO(17)=IO(4)
      140   CONTINUE
      C     READ PARAMETER CARD TO DETERMINE LOCATIONS AT WHICH TO PERFORM
      C     CALCULATIONS
      C     FIRST 50 COLUMNS OF EACH CARD CORRESPOND TO LOCATION CODES
      C     DOSE IS CALCULATED FOR LOCATIONS WHOSE CORRESPONDING COLUMN
      C     CONTAINS A NUMERIC DIGIT OTHER THAN 0
      C     1=CALCULATE DOSE
      C     2=CALCULATE DOSE AND PRINT OUT DETAILED REPORTS
      C     3=CALCULATE DOSE AND PRINT OUT TOTAL REPORTS ONLY
      C     4-6 SAME AS 1-3 BUT A SUMMARY REPORT IS PRODUCED FOR CENTROIDS
      C         THAT HAVE BEEN PROCESSED TO THAT POINT
      C     SUMMARY REPORT IS PRODUCED AT END OF JOB IN ALL CASES
            READ (CARD,200) NOCRD,LAST1
            IF (NOCRD) 150,170,150
      150   IF (NOCRD-20) 160,160,170
      160   J=NOCRD*50
            I=J-49
            READ (REREAD,210) (L(K),K=I,J)
      C     'LAST' IN COLUMNS 75-78 SIGNALS END OF CALCULATION PARAMETERS
            IF (LAST1.NE.LAST) GO TO 140
            RETURN
      C     CALCULATION PARAMETER IN ERROR
      170   CONTINUE
            READ (REREAD,220) IMAGE
            WRITE (REPORT,230) IMAGE
            STOP
```


1083506

633

```
C
180   FORMAT (2A6,15A1)
190   FORMAT ('CUNIT ',A1,' WAS NOT DEFINED IN I/O TABLE')
200   FORMAT (72X,I2,A6)
210   FORMAT (50I1)
220   FORMAT (13A6,A2)
230   FORMAT ('CCALCULATION PARAMETER IN ERROR'/1X,13A6,A2)
      END
```


1083507

1083508

```
@ ELT PERCEN,1,710811, 57665

      SUBROUTINE PERCEN(PATH,LOCATE,PCODE)
C         THIS SUBROUTINE WRITES THE PATHWAY PERCENTAGE REPORTS.
C         EXPLANATION OF CALL LIST
C              PATH       PATH TABLE
C              LOCATE     THREE WORD CENTROID LOCATION
C              PCODE      =1 FOR INDIVIDUAL CENTROID,=2 FOR COMPOSITE
      INCLUDE TABLE1,LIST
      INTEGER PCODE ,P,Q,Z
      COMMON/PERCNT/K,PERCN1(46,3,14),I
      DIMENSION LOCATE(3),PERSOM(3),FMT(30),TLINE(14),TOTAL(3)
      DIMENSION PATH(26,1),PERCN2(46,3,14)
      DATA PERSOM/ 'CHILD','TEEN','ADULT'/, TOTAL /'TOTAL              '/
      DATA (FMT(I),I=1,30)/'(1X,3A6,1X,',6,'1PE7.2,1X,  ',
     1'1PE7.2,2X,  ',6*'1PE7.2,1X,  ','1PE7.2)     '/
C         IS A SUMMARY REPORT REQUIRED?
      IF(PCODE.EQ.1) GO TO 100
      DO 50 L1=1,45
      DO 50 L2=1,3
      DO 50 L3=1,14
   50 PERCN1(L1,L2,L3)=PERCN2(L1,L2,L3)
C         PLACE RELEVANT TOTALS IN PERCN1(46,X,X)
  100 DO 30 P=1,14
      DO  30 N=1,3
      PERCN1(46,N,P)=0.0
      DO 30 Z=1,45
   30 PERCN1(46,N,P)=PERCN1(46,N,P)+PERCN1(Z,N,P)
      IF(PCODE.EQ.2) GO TO 200
C         DOES THE REPORT OPTION FOR THIS CENTROID CALL FOR NO REPORTS?
      IF(L(I).EQ.1.OR.L(I).EQ.4) GO TO 525
C         LOOP FOR EACH PERSON
  200 DO  510 J=1,3
C         WRITE THE HEADING
```

```
      IPAGE=IPAGE+1
      WRITE(REPORT,201) PERSOM(J),LOCATE,DATE,IPAGE
  201 FORMAT('1PERCENT OF DOSE BY PATHWAY  ',A6,3X,3A6,5X, 'D O S E
     1  ** DOSE COMMITTMENT     ',2A6,'        PAGE ',I5,/,
     2'   PATHWAY NAME      T BODY  GI-LLI  THYROID BONE    LUNGS   SKIN
     3   LIVER     T BODY  GI-LLI  THYROID BONE    LUNGS   SKIN    LIVER'
     4,/)
C          WRITE TOTALS
      DO  250 P=1,14
      IF(PERCN1(46,J,P))    ,220,
      TLINE(P)=PERCN1(46,J,P)
      FMT(1+2*P)='1PE7.2'
      GO TO 250
  220 TLINE(P)='       '
      FMT(1+2*P)='1X,A6 '
  250 CONTINUE
      WRITE(REPORT,FMT) TOTAL,TLINE
C          NOW WRITE ONE LINE FOR EACH PATHWAY THAT HAS NON-ZERO
C          CONTRIBUTION
      DO 500 Q=1,45
      DO 300 P=1,14
      IF(PERCN1(Q,J,P))  325,,325
  300 CONTINUE
      GO TO 500
  325 DO 350 P=1,14
      IF(PERCN1(Q,J,P))    ,330,
      TLINE(P)=(PERCN1(Q,J,P)/PERCN1(46,J,P))*100.0
      FMT(1+2*P)='1PE7.2'
      GO TO 350
  330 TLINE(P)='       '
      FMT(1+2*P)='1X,A6'
  350 CONTINUE
      WRITE(REPORT,FMT) (PATH(P,Q),P=9,11),TLINE
  500 CONTINUE
  510 CONTINUE
C          IS THIS TIME FOR SUMMARY REPORT?
```


1083509

```
  525 IF(PCODE.EQ.2) GO TO 750
  550 DO 600 L1=1,45
      DO 600 L2=1,3
      DO 600 L3=1,14
  600 PERCN2(L1,L2,L3) = PERCN2(L1,L2,L3)+PERCN1(L1,L2,L3)
C         ZERO THE TABLE THAT IS TO REMAIN IN CORE
  750 DO 800 L1=1,46
      DO 800 L2=1,3
      DO 800 L3=1,14
  800 PERCN1(L1,L2,L3)=0.0
      RETURN
      END
```


10835 10

```
@ ELT POPFIL,1,711115, 62857

      SUBROUTINE POPFIL (ICENTR,LOCATE,IPATH,TYPE,EOF,$)
C     ICENTR--POPULATION CENTER CODE TO SEARCH FILE FOR
C     LOCATE--NAME OF POPULATION CENTER
C     IPATH--PATH TABLE FROM DRIVER
C     TYPE--POPULATION TYPE
C     EOF--SWITCH TO SIGNAL WHEN END OF FILE HAS BEEN ENCOUNTERED
      INCLUDE TABLE1, LIST
      INTEGER TYPE
      DIMENSION IPATH(26,45)
      DIMENSION IH(2,72),INFO(30),RINFO(30),HF(3,6,5)
      DIMENSION REC(14)
      DIMENSION RATIO(3)
      DIMENSION IRR(16800),LOCATE(3)
      EQUIVALENCE (DS1,IRR)
      EQUIVALENCE (H,IH),(INFO,RINFO)
C     HF--CONTAINS FRACTION OF GIVEN RECREATION HOURS/MO TO ASSIGN TO
C       --PERSON TYPES IN EACH CENTROID
C     RECREATION TYPE 1-SWIMMING,2-BOATING AND SKIING,3-FISHING,
C     4-WATERFOWL HUNTING,5-UPLAND GAMEBIRD HUNTING
      DATA (((HF(I,J,K),J=1,6),I=1,3),K=1,5)/
     1 2.00,4.70,3.20,7.50,0.57,1.30,
     2 2.00,4.70,3.20,7.50,0.57,1.30,
     3 2.00,4.70,3.20,7.50,0.57,1.30,
     4 0.57,1.00,1.00,1.80,1.00,1.80,
     5 0.57,1.00,1.00,1.80,1.00,1.80,
     6 0.57,1.00,1.00,1.80,1.00,1.80,
     7 0.65,0.94,3.20,4.60,0.57,0.82,
     8 0.65,0.94,3.20,4.60,0.57,0.82,
     9 0.65,0.94,3.20,4.60,0.57,0.82,
     $ 0.00,0.00,0.60,2.00,1.10,3.70,
     $ 0.00,0.00,0.60,2.00,1.10,3.70,
     $ 0.00,0.00,0.60,2.00,1.10,3.70,
```


10835111

```
      $ 0.00,0.00,0.60,2.00,1.10,3.70,
      $ 0.00,0.00,0.60,2.00,1.10,3.70,
      $ 0.00,0.00,0.60,2.00,1.10,3.70/
      DATA NISHL/0/
C     RATIO(1)--PERCENT POPULATION UNDER 12
C     RATO(2)--PERCENT POPULATION BETWEEN 12 AND 18
C     RATIO(3)--PERCENT POPULATION OVER 18
      DATA RATIO/.27,.12,.61/
      IFIRST=0
      KNT=0
      IF (NISHL.EQ.1) CALL SET
      IF (NISHL) 130,100,130
100   READ (CENTER,710) (INFO(I),I=1,2)
      IF (NISHL) 110,460,110
110   IF (KNT) 180,120,180
120   IF (INFO(2)-1) 100,140,100
130   IF (INFO(2)-1) 450,140,450
140   IF (INFO(1)-ICENTR) 100,150,520
150   READ (REREAD,730) LOCATE,POPULT,(INFO(I),I=3,5)
      KNT=1
      DO 160 I=1,3
      PERSON(I)=POPULT*RATIO(I)
160   CONTINUE
      IF(INFO(3).EQ.'URB')TYPE=1
      IF(INFO(3).EQ.'RNF')TYPE=2
      IF(INFO(3).EQ.'RUF')TYPE=3
C     ZERO PATH TABLE AS NEEDED
      DO 170 J=1,45
      IPATH(12,J)=ICENTR
      DO 170 I=13,25
      IPATH(I,J)=0
170   CONTINUE
      IPATH(4,5)=0
      IPATH(4,9)=0
      IPATH(13,6)=0
      IPATH(4,6)=0
```


10835 12

```
      IPATH(13,7)=0
      IPATH(4,6)=0
C     BUILD PATH TABLE ENTRIES FOR DRINKING WATER
      IPATH(8,45)=0
C     USE GROUND WATER FOR WATER SOURCES 2 THROUGH 4
      IF (INFO(4).GE.'2') IPATH(4,45)=14
      IF (INFO(4).EQ.'1') IPATH(4,45)=10
      IF (INFO(5).EQ.'3'.OR.INFO(5).EQ.'4') IPATH(8,45)=10
      IF (INFO(5).EQ.'3'.AND.INFO(4).EQ.'1') IPATH(13,45)=11
      GO TO 100
C     READ CARD TYPES 2 OR 3 FOR CENTROID
190   CONTINUE
      IF (INFO(1)-ICENTR) 540,190,540
190   IJMP=INFO(2)-1
      GO TO (200,350), IJMP
C     CARD TYPE 2--HABIT
200   CONTINUE
      READ (REREAD,740) (INFO(I),I=3,17)
      IJMP=INFO(3)
      GO TO (210,230,250,270,290), IJMP
C     SWIMMING
210   CONTINUE
      IPATH(12,6)=INFO(4)
      IPATH(4,6)=14
      IF (INFO(5)) 220,300,220
220   IPATH(13,6)=11
      IPATH(4,6)=10
      GO TO 300
C     BOATING AND SKIING
230   CONTINUE
      IPATH(12,7)=INFO(4)
      IPATH(4,7)=14
      IF (INFO(5)) 240,300,240
240   IPATH(13,7)=11
      IPATH(4,7)=10
      GO TO 300
```


10835113

```
C     FISHING
250   CONTINUE
      IPATH(12,5)=INFO(4)
      IPATH(14,43)=INFO(4)
      IPATH(15,43)=100
      IPATH(4,5)=7
      IF (INFO(5)) 260,300,260
260   IPATH(4,5)=12
      GO TO 300
C     WATERFOWL HUNTING
270   CONTINUE
      IPATH(12,9)=INFO(4)
      IPATH(14,39)=INFO(4)
      IPATH(15,39)=100
      IPATH(4,9)=7
      IF (INFO(5)) 280,300,280
280   IPATH(4,9)=12
      GO TO 300
C     UPLAND GAME BIRD HINTING
290   CONTINUE
      IPATH(12,4)=INFO(4)
      IPATH(14,44)=INFO(4)
      IPATH(15,44)=100
C     BUILD HABIT DATA TABLE
300   CONTINUE
      NO=0
      K=INFO(3)
      DO 320 I=1,6
      DO 320 J=1,12
      NO=NO+1
      IH(1,NO)=KEYS(I,J,0)
      H(2,NO)=RINFO(J+5)*HF(TYPE,I,K)
      IF (H(2,NO)) 310,310,320
310   NO=NO-1
320   CONTINUE
      IF (NO) 330,340,330
```


1083514

```
      330   CALL PUT (KEYS(3,TYPE,K),H,NO*2)
      340   CONTINUE
            KNT=KNT+1
            GO TO 100
      C     CARD TYPE 3--FOOD SOURCE DATA
      350   CONTINUE
            READ (REREAD,750) (INFO(I),I=3,22)
      C     COMPUTE FOOD PATH TABLE FOR FOOD PATHS
            DO 440 I=3,22,5
            IF (INFO(I)) 360,440,360
      C     SPORTS FISH, WATERFOWL AND UPLAND GAME BIRDS
      C     SHOULD NEVER BE INDICATED ON CARD TYPE 3
      360   IF (INFO(I)-29) 370,440,370
      370   IF (INFO(I)-33) 380,440,380
      380   IF (INFO(I)-34) 390,440,390
      390   IFD=INFO(I)
            IF (IFD.LE.35.AND.IFD.GT.0) GO TO 400
            PRINT 760, LOCATE,(INFO(IZ),IZ=3,22)
            READ (REREAD,780) REC
            PRINT 770, REC
            RETURN 0
      400   CONTINUE
            INDX=I+1
            DO 430 J=14,21,4
            IF (INFO(INDX)) 410,420,410
      410   IPATH(J,IFD+10)=INFO(INDX)
            IPATH(J+1,IFD+10)=INFO(INDX+1)
      420   CONTINUE
            INDX=INDX+2
      430   CONTINUE
      440   CONTINUE
            KNT=KNT+1
            GO TO 100
      450   CONTINUE
            READ (REREAD,790) REC
            IF (IFIRST.EQ.0) WRITE (REPORT,810)
```


1083515

```
      IFIRST=1
      WRITE (REPORT,800) REC
      GO TO 100
C     IRRIGATION DATA
460   CONTINUE
      IF (INFO(2)-4) 490,470,490
470   READ (REREAD,720) (INFO(I),I=3,30)
      DO 480 I=3,30,2
      IF(INFO(I))471,480,471
  471 KNT=KNT+1
      IRR(KNT)=KEYS(INFO(I),INFO(1),INFO(I+1))
490   CONTINUE
      GO TO 100
490   CONTINUE
      IF (KNT) 510,510,500
500   LIRR=KNT
      CALL SORTER (IRR,1,KNT)
      CALL PUT (KEYS(98,98,C),IRR,KNT+1)
510   CONTINUE
      CALL SET
      IFIRST=1
      NISHL=1
      KNT=0
      GO TO 130
520   CONTINUE
      WRITE (REPORT,820) ICENTR
      RETURN 6
      EOF=1.0
      IF (NISHL) 530,520,530
530   IF (KNT) 540,520,540
540   CONTINUE
      DO 590 I=1,35
C     SKIP FOR SPORTS FISH, WATERFOWL, AND UPLAND GAMEBIRD FOOD PATHWAYS
      IF (I-29) 550,590,550
550   IF (I-33) 560,590,560
560   IF (I-34) 570,590,570
```


10835 16

```
570   INDX=I+10
C     COMPUTE PERCENT OF FOODS PRODUCED LOCALLY
      LOCAL=100-IPATH(15,INDX)+IPATH(19,INDX)
      IF (LOCAL) 580,590,580
580   IPATH(22,INDX)=ICENTR
      IPATH(23,INDX)=LOCAL
590   CONTINUE
      IF (IFIRST) 600,600,620
600   IF (LIRR) 610,700,610
610   CALL GET (KEYS(98,98,0),IRR,IDUM)
620   CONTINUE
      IF (LIRR) 630,700,630
C     DETERMINE PERCENT IRRIGATED
630   DO 690 I=1,LIRR
      DO 680 J=1,35
      IF (FLD(0,12,IRR(I))-J) 690,640,680
640   DO 670 K=14,22,4
      IF (IPATH(K,J+10)) 670,670,650
650   IF (FLD(12,12,IRR(I))-IPATH(K,J+10)) 670,660,670
660   IPATH(K+2,J+10)=FLD(24,12,IRR(I))
670   CONTINUE
680   CONTINUE
690   CONTINUE
700   CONTINUE
      RETURN
C
710   FORMAT (I3,1X,I2)
720   FORMAT (9X,14(1X,2I2))
730   FORMAT (8X,3A6,10X,F8.0,1X,A3,28X,2A1)
740   FORMAT (7X,I2,10X,I3,1X,I4,3X,12F3.0)
750   FORMAT (6X,4(I4,1X,2I3,1X,2I3))
760   FORMAT (' POPFIL READ ERROR***',3A6,20I4)
770   FORMAT (1H ,14A6)
780   FORMAT (14A6)
790   FORMAT (13A6,A2)
800   FORMAT (' CARD READ ERROR ON POPULATION FILE--CARD IGNORED'/1X,13A
```


1083517

```
249.            16,A2)
250.      81C    FORMAT ('1')
251.      82C    FORMAT ('1CENTRIOD ',I4,' NOT FOUND ON POPULATION FILE')
252.             END

   END CUR
```


10835 18

1083519

```
@ ELT READER,1,711115, 62846

      SUBROUTINE READER
C
C     SUBROUTINE TO READ INPUT DATA, AND BUILD AND STORE TABLES
C
      EXTERNAL SRTKEY
      INTEGER DF
      INTEGER DT
      INCLUDE TABLE1,LIST
      DIMENSION MAPA(35),MAPW(32)
      DIMENSION ISEL(50)
      DIMENSION CORE(16800),ST(10),REC(14),IREC(14)
      DIMENSION ICORE(16800)
C     NOTE CORE IS ACTUALLY EQUIVALENCED WITH ALL THE REPORT ARRAYS
C     AS ITS LENGTH OCCUPIES ALL OF DS1,DS2,DS3 AND DS4
      EQUIVALENCE (CORE,DS1)
      EQUIVALENCE (ICORE,CORE)
      EQUIVALENCE (REC,IREC)
      DATA MAPA/ 1,2,3,4,5,6,7,17,18,19,20,21,22,23,24,26,27,28,29,30,
     1           31,32,33,34,35,36,37,38,39,40,41,42,43,44,45/
      DATA MAPW/ 1, 3, 4, 5, 8, 9,10,11,12,13,14,15,16,21,22,
     1          23,24,25,26,27,28,29,30,31,32,33,40,41,42,43,
     2          44,45/
      DATA KNT/0/
      DATA NOIN/0/
      DATA NOUT/0/
C     READ ISOTOPE SELECTION CARD
      READ (CARD,720) ISEL
      IF (M(3).NE.' ') GO TO 600
C     DRUM SORT USES LAST HALF OF DRUM AREA ALLOCATED FOR STORAGE
C     OF TABLES
      CALL FPRSRT (ST,12,SRTKEY,CORE,16800,632000,500000)
      CALL SET
```

```
      CALL PUT (KEYS(99,99,99),L,1000)
      DO 100 I=1,1000
100   L(I)=0
      DO 130 I=1,7
C     DETERMINE UNIT TO READ CARD IMAGE INPUT FROM
C     FIRST UNIT IS ALWAYS CARD READER
      IF (IO(I+3)) 110,130,110
110   LU=IO(I+3)
120   CONTINUE
      READ (LU,690) (REC(J),J=1,12)
C     STORE INPUT RECORD IN SORT FILE
      CALL FFILE (ST,REC)
C     COUNT RECORDS PUT INTO SORT
      NOIN=NOIN+1
      GO TO 120
C     ERROR IN INPUT
C     REREAD CARD AND PRINT OUT
      READ (REREAD,700) REC
      WRITE (REPORT,710) REC
      GO TO 120
130   CONTINUE
      CALL FEMPTY (ST)
C     GET FIRST RECORD FROM SORT FILE
      CALL FMERGE (ST,IREC)
      GO TO 150
140   CONTINUE
C     GET ANOTHER RECORD FROM SORT
C     GO TO 500 WHEN LAST SORT RECORD HAS BEEN PROCESSED
      CALL FGET (ST,IREC,$390)
150   CONTINUE
C     INCREMENT COUNT OF RECORDS RECEIVED FROM SORT
      NOUT=NOUT+1
C     CHECK VALUE OF DATA CATEGORY
C     0=CONCENTRATION DATA
C     1=DOSE FACTOR DATA
C     2=DIET DATA
```


1083520

```
C     3=HABIT DATA
C     4=LOSS FACTORS
C     5=DOSE COMMITTMENT DATA
      IF (IREC(5).NE.1.AND.IREC(5).NE.5) GO TO 160
C     DATA CATEGORY 1 AND 5(DOSE AND DOSE COMMITMENT FACTORS)
C     DICTIONARY KEYS ARE 1,ITEM CODE(DOSE TABLE NO.) AND 0
      NOW=KEYS(IREC(5),IREC(1),0)
      GO TO 230
C     DATA CATEGORY 0,2 ,3 OR 4
160   CONTINUE
C     DICTIONARY KEYS ARE DATA CATEGORY,LOCATION AND TYPE OF DATA CODE
      NOW=KEYS(IREC(5),IREC(1),IREC(2))
C     TRANSFORM ISOTOPE CODES FROM AIR AND WATER MODELS TO
C     CODES USED BY DOSE MODEL
      IF (IREC(5)) 230,170,230
170   ISO=IREC(3)
      IF (IREC(2)-5) 180,180,200
180   IREC(3)=MAPA(ISO)
      IF (IREC(2)-1) 190,230,190
190   LOC=IREC(1)
      L(LOC)=1
      GO TO 230
200   CONTINUE
      IF (IREC(2)-10) 230,210,210
210   IF (IREC(2)-14) 220,220,230
220   IREC(3)=MAPW(ISO)
230   CONTINUE
      IF (KNT) 240,260,240
240   IF (LAST-NOW) 250,260,250
C     TABLE IS COMPLETED
C     WRITE TABLE TO TAPE
250   CALL TAPE (LAST,DF,KNT*2)
      KNT=0
260   CONTINUE
C     DETERMINE DATA CATEGORY
      IF (IREC(5).NE.1.AND.IREC(5).NE.5) GO TO 290
```

1083521

```
C     DATA CATEGORY 1 AND 5(DOSE AND DOSE COMMITMENT FACTORS)
C     BUILD TABLE
      DO 280 I=1,7
C     IGNORE 0 DATA
      IF (REC(I+5)) 270,280,270
270   KNT=KNT+1
C     CONSTRUCT TABLE ENTRIES
C     IREC(2) IS PERSON CODE
C     IREC(3) IS ISOTOPE CODE
C     I IS ORGAN CODE
C     IREC(I+5) IS DATA VALUE FOR ITH ORGAN
      DF(1,KNT)=KEYS(IREC(2),IREC(3),I)
      DF(2,KNT)=IREC(I+5)
280   CONTINUE
      GO TO 380
C     DATA CATEGORY 0,2,3 OR 4
C     BUILD TABLE
290   CONTINUE
      IF (REC(12)) 300,320,300
C     USE VALUE IN REC(12) FOR ALL MONTHS ON CARD
300   DO 310 I=1,6
      REC(I+5)=REC(12)
310   CONTINUE
320   CONTINUE
      DO 370 I=1,6
C     IGNORE 0 DATA
      IF (REC(I+5)) 330,370,330
330   KNT=KNT+1
C     DETERMINE MONTH CODE
C     CARD 1 CONTAINS DATA FOR JANUARY TO FEBRUARY
C     CARD 2 CONTAINS DATA FOR JUNE TO DECEMBER
      IF (IREC(4)-1) 350,340,350
340   MONTH=I
      GO TO 360
350   CONTINUE
      MONTH=I+6
```


1083522

```
360   CONTINUE
C     IREC(3) IS ISOTOPE CODE
C     MONTH IS MONTH CODE
C     IREC(I+5) IS DATA VALUE FOR MONTH
      DF(1,KNT)=KEYS(IREC(3),MONTH,0)
      DF(2,KNT)=IREC(I+5)
370   CONTINUE
380   CONTINUE
      LAST=NOW
      GO TO 140
390   CONTINUE
      IF (KNT) 400,410,400
C     WRITE LAST TABLE BUILT FROM CARD INPUT TO TAPE
400   CALL TAPE (LAST,DF,KNT*2)
410   CONTINUE
      KNT=0
      IF (NOIN-NOUT) 420,430,420
C     NUMBER OF RECORDS INTO SORT DIFFERS FROM RECORDS OUT OF SORT
420   RETURN 0
430   CONTINUE
C     READ BINARY TAPE INPUT
C     BINARY RECORDS ARE ALWAYS CONCENTRATION DATA
      DO 550 I=1,6
C     DETERMINE UNITS TO READ BINARY INPUT FROM
      IF (IO(I+10)) 440,550,440
440   LU=IO(I+10)
450   CONTINUE
      READ (LU) (IREC(J),J=1,3),LGTH,(CORE(J),J=1,LGTH)
      IF (IREC(1).EQ.99999) GO TO 550
C     SORT RECORDS BY ISOTOPE CODE
      CALL SORTER (CORE,13,LGTH/13)
      KNT=0
C     BUILD TABLE
      DO 530 J=1,LGTH,13
C     TRANSFORM ISOTOPE CODES FROM AIR AND WATER MODELS TO
C     CODES USED BY DOSE MODEL
```


10835523

```
      ISO=ICORE(J)
      IF (IREC(2)-5) 460,460,480
460   ICORE(J)=MAPA(ISO)
      IF (IREC(2)-1) 470,510,470
470   LOC=IREC(1)
      L(LOC)=1
      GO TO 510
480   CONTINUE
      IF (IREC(2)-10) 510,490,490
490   IF (IREC(2)-14) 500,500,510
500   ICORE(J)=MAPW(ISO)
510   CONTINUE
      DO 530 K=1,12
C     IGNORE 0 DATA
      IF (CORE(J+K)) 520,530,520
520   KNT=KNT+1
C     ICORE(J) IS ISOTOPE CODE
C     K IS MONTH CODE
C     ICORE(J+K) IS DATA VALUE FOR KTH MONTH
      DF(1,KNT)=KEYS(ICORE(J),K,0)
      DF(2,KNT)=ICORE(J+K)
530   CONTINUE
C     IREC(1) IS LOCATION CODE
C     IREC(2) IS TYPE OF DATA CODE
      IF (KNT) 540,450,540
C     WRITE TABLE TO DRUM
C     WRITE TABLE TO TAPE
540   CALL TAPE (KEYS(0,IREC(1),IREC(2)),DF,2*KNT)
      GO TO 450
550   CONTINUE
      LD=LSD
      LSD=0
      CALL SORTER (DT,2,LD)
C     SUM WET AND DRY DEPOSITION TABLES
      DO 590 I=1,1000
      IF (L(I)) 560,590,560
```


1083524

```
      560   DO 580 J=2,5,2
            CALL GET (KEYS(C,I,J),CORE,L1)
            CALL GET (KEYS(C,I,J+1),CORE(697),L2)
            CALL MERGE (CORE,L1,CORE(697),L2,CORE(1393),L3)
            IF (L3) 570,580,570
      570   IF (J.EQ.2) K=6
            IF (J.EQ.4) K=7
            CALL TAPE (KEYS(C,I,K),CORE(1393),L3*2)
      580   CONTINUE
      590   CONTINUE
            CALL GET (KEYS(99,99,99),L,L4)
            LD=0
            CALL RESET
            NUMDM1=99999
            NUMDM2=1
            NUMDM3=1
            LU=IO(18)
            WRITE (LU) NUMDM1,NUMDM2,NUMDM3
            CALL NTRAN (IO(18),9)
            CALL NTRAN (IO(18),10)
      C     PUT ALL INPUT DATA ON DRUM
      600   CONTINUE
            LU=IO(18)
      610   READ (LU) KEY,LEN,(CORE(I),I=1,LEN)
            IF (KEY.EQ.99999) GO TO 680
            ICK=FLD(0,12,KEY)
            IF (ICK.EQ.0.OR.ICK.EQ.4) GO TO 620
            IF (ICK.EQ.1.OR.ICK.EQ.5) GO TO 630
            CALL PUT (KEY,CORE,LEN)
            GO TO 610
      620   N1=0
            GO TO 640
      630   N1=12
      640   CONTINUE
            KNT=0
            DO 660 I=1,LEN,2
```


1083525

```
      ISO=FLD(N1,12,ICORE(I))
      IF (ISEL(ISO)) 650,660,650
650   KNT=KNT+1
      CORE(KNT)=CORE(I)
      KNT=KNT+1
      CORE(KNT)=CORE(I+1)
660   CONTINUE
      IF (KNT) 670,610,670
670   CALL PUT (KEY,CORE,KNT)
      GO TO 610
680   CONTINUE
      CALL NTRAN (IO(18),10)
C     SORT DICTIONARY
      CALL SORTER (DT,2,LD)
      RETURN
C
690   FORMAT (I3,I2,I3,2I1,7F10.0)
700   FORMAT (13A6,A2)
710   FORMAT ('0INPUT ERROR-FOLLOWING CARD IGNORED'/1X,13A6,A2)
720   FORMAT (50I1)
      END
```


1083526

10835271

```
@ ELT SORTER,1,711115, 62818

      SUBROUTINE SORTER (IARRAY,ITEMS,LGTH)
C
C     SUBROUTINE TO SORT RECORDS STORED IN AN ARRAY
C     SORTS ON FIRST WORD OF EACH RECORD
C
C     EXPLANATION OF CALL LIST
C     IARRAY--ARRAY CONTAINING RECORDS TO BE SORTED
C     ITEMS--NO OF ITEMS CONTAINED IN EACH RECORD
C     LGTH--NO OF RECORDS CONTAINED IN ARRAY
      DIMENSION IARRAY(ITEMS,LGTH)
      LENGTH=LGTH-1
      IF (LENGTH) 100,150,100
100   DO 140 I=1,LENGTH
      K=I
110   IF (IARRAY(1,K)-IARRAY(1,K+1)) 140,140,120
120   DO 130 J=1,ITEMS
      ISAVE=IARRAY(J,K+1)
      IARRAY(J,K+1)=IARRAY(J,K)
      IARRAY(J,K)=ISAVE
130   CONTINUE
      K=K-1
      IF (K) 110,140,110
140   CONTINUE
150   RETURN
      END
```

10835528

```
@ ELT SRTKEY,1,711115, 62824

      SUBROUTINE SRTKEY (LOC1,LOC2,S,S)
C
C     SUBROUTINE USED BY FPRSRT TO COMPARE RECORDS
C
C     MAJOR SORT IS BY DATA CATEGORY
C     MINOR SORT BY LOCATION OR ITEM CODE(DOSE TABLE NO.),ISOTOPE OR
C     PERSON(DOSE FACT), TYPE DATA CODE OR ISOTOPE(DOSE FACT)
      DIMENSION LOC1(1),LOC2(1)
      IF (LOC1(5)-LOC2(5)) 120,100,130
100   DO 110 I=1,4
      IF (LOC1(I)-LOC2(I)) 120,110,130
110   CONTINUE
120   RETURN 3
130   RETURN 4
      END
```

```
@ ELT STARTF,1,711115, 6285C

      SUBROUTINE STARTF
C         THIS SUBROUTINE PERFORMS ALL INITIALIZATION REQUIRED FOR THE
C         FOOD CHAIN CALCULATIONS
      INCLUDE TABLE1,LIST
      INCLUDE TABLE2,LIST
C         FILL IN THE DECAY TIMES BETWEEN HARVEST AND CONSUMPTION
      DATA DECAY/     C.0, C.C, C.C, C.0, C.0, C.0, 0.0, 0.C, C.C, 0.0,
     1                4.C, C.0,1C.C, 0.C, 7.0, C.C, C.0, 0.0, C.C, 0.C,
     2                C.0,1C.C, C.0, 7.C, C.C, 5.0, C.0, 0.0, C.C, 0.C,
     3                3.C,2C.C,1C.C, 7.C,2C.C,2C.C,3C.0, 5.0, 7.C, 0.C,
     4                0.C, C.C, 3.0, 2.C, 0.C, C.C, C.0, 0.0, C.C, 0.C  /
C         LOAD RADIOLOGICAL HALF LIVES. SOURCE IS LIST BY KEN WISE DATED
C         AUGUST 4 1970
      DATA LIFE12 /   4474.54,6.9167E-3,2.09144E6,948.958  , 0.625   ,
     1                98553.2 , C.07625 , 27.8009 , 312.037 ,876.042  ,
     2                    45., 70.9954 , 1912.04 , 33576.4 ,  C.5375 ,
     3                242.94  , 0.183333, 3927.08 ,5.2777E-2,C.116667 ,
     4                50.6019 ,  10511.6,      65. ,    35.   , 2.73167 ,
     5                    4C. ,  365.046,    3.25  , 5.84C3E9, 8.04977 ,
     6               9.5833E-2,  0.875  , C.279167,12.0023  , 2.23977 ,
     7               5.24653  , 1.111E-2, .3833333,1.18C6E-2,766.551  ,
     8               1C95C.2  ,12.8CC9  ,1.67477  , 32.4769 ,284.954    ,
     9                   0.   ,    C.   ,    C.   ,    C.   ,    C.    /
C         LOAD IRRIGATION RATE. CONSTANT DURING GROWING SEASON
C         IRRIGATION RATE FOR BERRIES
      DATA (RATE(I,2C),I=1,12)/
     1  C.C       , 0.C      , 11C.0    , 11C.C    , 110.C    , 0.C      ,
     2  0.C       , 0.C      , C.0      , 0.C      , C.0      , C.0      /
C         TREE FRUIT IRRIGATION RATE
      DATA (RATE(I,21),I=1,12)/
     1  C.C       , 0.C      , C.C      , C.0      , C.0      , 11C.0    ,
     2  11C.C     , 110.C    , 11C.C    , C.0      , C.0      , C.C      /
```


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C          MELON IRRIGATION RATE
      DATA (RATE(I,22),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 0.0       , 110.0     , 110.0     ,
     2     110.0     , 110.0     , 0.0       , 0.0       , 0.0       , 0.0       /
C          POTATO IRRIGATION RATE
      DATA (RATE(I,23),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 0.0       , 0.0       , 110.0     ,
     2     110.0     , 110.0     , 110.0     , 0.0       , 0.0       , 0.0       /
C          ROOT VEGETABLE IRRIGATION RATE
      DATA (RATE(I,24),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 0.0       , 0.0       , 110.0     ,
     2     110.0     , 110.0     , 110.0     , 0.0       , 0.0       , 0.0       /
C          GREEN LEAFY VEGETABLE IRRIGATION RATE
      DATA (RATE(I,25),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 0.0       , 0.0       , 110.0     ,
     2     110.0     , 110.0     , 110.0     , 0.0       , 0.0       , 0.0       /
C          OTHER ABOVE GROUND VEGETABLE IRRIGATION RATE
      DATA (RATE(I,26),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 0.0       , 0.0       , 110.0     ,
     2     110.0     , 110.0     , 0.0       , 0.0       , 0.0       , 0.0       /
C          GRAIN IRRIGATION RATE
      DATA (RATE(I,26),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 110.0     , 110.0     , 110.0     ,
     2     110.0     , 0.0       , 0.0       , 0.0       , 0.0       , 0.0       /
C          WHEAT IRRIGATION RATE
      DATA (RATE(I,27),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 110.0     , 110.0     , 110.0     ,
     2     110.0     , 0.0       , 0.0       , 0.0       , 0.0       , 0.0       /
C          FORAGE IRRIGATION RATE
      DATA (RATE(I,2),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 0.0       , 0.0       , 0.0       ,
     2     0.0       , 0.0       , 0.0       , 0.0       , 0.0       , 0.0       /
C          GRAIN IRRIGATION RATE
      DATA (RATE(I,3),I=1,12)/
     1     0.0       , 0.0       , 0.0       , 110.0     , 110.0     , 110.0     ,
     2     110.0     , 0.0       , 0.0       , 0.0       , 0.0       , 0.0       /
```


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C          STORED FEED IRRIGATION RATE
      DATA (RATE(I,4),I=1,12)/
     1    0.0       , 0.0       , 0.0       , 110.0     , 110.0     , 110.0     ,
     2    110.0     , 0.0       , 0.0       , 0.0       , 0.0       , 0.0       /
C          SET THE PLANT RETENTION FACTOR TO  0.25
      DATA  RETENT /0.25/
      DATA TRANSL(1)/1.0/
C          SET UP DUMMY RETENTION FACTORS FOR COWS
      DATA (RETNTB(I,1),I=1,NONUCL)/NONUCL*1.0/
      DATA MAP/   0,   0,   0,   0,   0,   0,   0,   0,   0,           0,
     1           20,  20,  21,  21,  22,   0,   0,   0,   0,          23,
     2           23,  24,  24,  25,  25,  26,  26,  27,  28,          29,
     3            2,   2,   2,   5,   8,  11,  11,  14,  30,           0,
     4            0,   0,  30,  17,   0,   0,   0,   0,   0,           0/
C          CONCENTRATION FACTORS FOR ALL TERESSTIAL PLANTS
      DATA (CONCFA(I,1),I=1,50)/
     1    2.0E-01   ,  0.0      ,  5.5E+00,  5.0E-02, 5.0E-02 ,
     2          0.0 ,  0.0      ,  2.5E-04,  2.9E-02, 4.0E-04 ,
     3    4.0E-04   ,  9.4E-03,  9.4E-03,  1.9E+00, 1.3E-01 ,
     4    4.0E-01   ,  0.0      ,  0.0      ,  0.0      , 0.0       ,
     5    2.0E-01   ,  2.0E-01,  1.7E-04,  9.4E-03, 1.3E-01 ,
     6    1.0E-02   ,  1.0E-02,  1.3E+00,  2.0E-02, 2.0E-02 ,
     7    2.0E-02   ,  2.0E-02,  2.0E-02,  0.0      , 0.0       ,
     8    0.0       ,  0.0      ,  0.0      ,  0.0      , 2.0E-03 ,
     9    2.0E-03   ,  5.0E-03,  2.5E-03,  5.0E-04, 5.0E-04 ,
     $    0.0       ,  0.0      ,  0.0      ,  0.0      ,0.0        /
C          CONCENTRATION FACTORS FOR LEAFY VEGETABLES
      DATA (CONCFA(I,25),I=1,50)/
     1    0.0       , 0.0       , 0.0       , 0.0       , 0.0       ,
     2    0.0       , 0.0       , 0.0       , 0.0       , 1.5E-04 ,
     3    1.5E-04   , 0.0       , 0.0       , 0.0       , 0.0       ,
     4    0.0       , 0.0       , 0.0       , 0.0       , 0.0       ,
     5    3.2E-01   , 3.2E-01 , 0.0       , 0.0       , 0.0       ,
     6    3.8E-03   , 3.8E-03 , 0.0       , 0.0       , 0.0       ,
     7    0.0       , 0.0       , 0.0       , 0.0       , 0.0       ,
     8    0.0       , 0.0       , 0.0       , 0.0       , 1.9E-02 ,
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     9    1.9E-02  , 0.0      , 0.0      , 7.5E-04 , 7.5E-04 ,
     $    0.0      , 0.0      , 0.0      , 0.0     , 0.0     /
C         CONCENTRATION FACTORS FOR OTHER ABOVE GROUND VEGETABLES
      DATA (CONCFA(I,26),I=1,50)/
     1    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     2    0.0      ,  0.0     ,  0.0     ,  0.0    , 2.7E-04 ,
     3    2.7E-04  ,  1.3E-03,  1.3E-03,  0.0    , 0.0     ,
     4    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     5    1.5E-01  , 1.5E-01  , 0.0      , 0.0     , 0.0     ,
     6    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     7    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     8    0.0      , 0.0      , 0.0      , 0.0     , 1.9E-02 ,
     9    1.9E-02  , 0.0      , 0.0      , 6.8E-03 , 6.8E-03 ,
     $    0.0      , 0.0      , 0.0      , 0.0     , 0.0     /
C         CONCENTRATION FACTORS FOR POTATOES
      DATA (CONCFA(I,23),I=1,50)/
     1    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     2    0.0      , 0.0      , 0.0      , 0.0     , 2.9E-04 ,
     3    2.9E-04  , 0.0      , 0.0      , 0.0     , 0.0     ,
     4    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     5    2.7E-02  , 2.7E-02  , 0.0      , 0.0     , 0.0     ,
     6    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     7    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     8    0.0      , 0.0      , 0.0      , 0.0     , 1.9E-02 ,
     9    1.9E-02  , 0.0      , 0.0      , 6.8E-03 , 6.8E-03 ,
     $    0.0      , 0.0      , 0.0      , 0.0     , 0.0     /
C         CONCENTRATION FACTORS FOR BERRIES
      DATA (CONCFA(I,20),I=1,50)/
     1    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     2    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     3    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     4    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     5    1.2E-01  , 1.2E-01  , 0.0      , 0.0     , 0.0     ,
     6    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     7    0.0      , 0.0      , 0.0      , 0.0     , 0.0     ,
     8    0.0      , 0.0      , 0.0      , 0.0     , 7.8E-02 ,
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```
     9    7.8E-02  , 0.0      , 0.0      , 0.0      , 0.0      ,
     $    0.0      , 0.0      , 0.0      , 0.0      , 0.0      /
C         CONCENTRATION FACTORS FOR FORAGE
      DATA (CONCFA(I,02),I=1,50)/
     1    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     2    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     3    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     4    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     5    1.0E+00  , 1.0E+00  , 0.0      , 0.0      , 0.0      ,
     6    4.0E-02  , 4.0E-02  , 0.0      , 0.0      , 0.0      ,
     7    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     8    0.0      , 0.0      , 0.0      , 0.0      , 4.0E-02  ,
     9    4.0E-02  , 0.0      , 0.0      , 0.0      , 4.0      ,
     $    0.0      , 0.0      , 0.0      , 0.0      , 0.0      /
C         CONCENTRATION FACTORS FOR STORED FEED
      DATA (CONCFA(I,04),I=1,50)/
     1    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     2    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     3    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     4    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     5    1.0E+00  , 1.0E+00  , 0.0      , 0.0      , 0.0      ,
     6    4.0E-02  , 4.0E-02  , 0.0      , 0.0      , 0.0      ,
     7    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     8    0.0      , 0.0      , 0.0      , 0.0      , 4.0E-02  ,
     9    4.0E-02  , 0.0      , 0.0      , 0.0      , 0.0      ,
     $    0.0      , 0.0      , 0.0      , 0.0      , 0.0      /
C         CONCENTRATION FACTORS FOR GRAIN
      DATA (CONCFA(I,03),I=1,50)/
     1    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     2    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     3    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     4    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     5    6.4E-02  , 6.4E-02  , 0.0      , 0.0      , 0.0      ,
     6    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     7    0.0      , 0.0      , 0.0      , 0.0      , 0.0      ,
     8    0.0      , 0.0      , 0.0      , 0.0      , 6.4E-04  ,
```


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      9     6.4E-04  , 0.0     , 0.0     , 2.6E-03 , 2.6E-03 ,
      $     0.0      , 0.0     , 0.0     , 0.0     , 0.0     /
C           CONCENTRATION FACTORS FOR ROOT VEGETABLES
       DATA (CONCFA(I,24),I=1,50)/
      1     0.0      , 0.0     , 0.0     , 0.0     , 0.0     ,
      2     0.0      , 0.0     , 0.0     , 0.0     , 2.7E-04 ,
      3     2.7E-04  , 1.8E-03 , 1.8E-03 , 0.0     , 0.0     ,
      4     0.0      , 0.0     , 0.0     , 0.0     , 0.0     ,
      5     1.5E-01  , 1.5E-01 , 0.0     , 0.0     , 0.0     ,
      6     0.0      , 0.0     , 0.0     , 0.0     , 0.0     ,
      7     0.0      , 0.0     , 0.0     , 0.0     , 0.0     ,
      8     0.0      , 0.0     , 0.0     , 0.0     , 6.2E-03 ,
      9     6.2E-03  , 0.0     , 0.0     , 0.0     , 0.0     ,
      $     0.0      , 0.0     , 0.0     , 0.0     , 0.0     /
C           CONCENTRATION FACTORS FOR FISH
       DATA (CONCFA(I,30),I=1,50)/
      1     1.0E+00  , 0.0     , 4.6E+03 , 3.3E+01 , 3.3E+01 ,
      2     2.0E+02  , 0.0     , 0.0     , 1.0E+03 , 5.0E+03 ,
      3     5.0E+03  , 5.0E+03 , 5.0E+03 , 4.0E+01 , 5.0E+01 ,
      4     1.5E+02  , 0.0     , 0.0     , 0.0     , 0.0     ,
      5     1.0E+00  , 1.0E+00 , 1.0E+01 , 3.0E+04 , 1.0E+02 ,
      6     5.0E+00  , 5.0E+00 , 0.0     , 5.0E+00 , 5.0E+00 ,
      7     5.0E+00  , 5.0E+00 , 5.0E+00 , 0.0     , 0.0     ,
      8     0.0      , 0.0     , 0.0     , 0.0     , 1.0E+03 ,
      9     1.0E+03  , 2.0E+01 , 1.0E+02 , 5.0E+01 , 5.0E+01 ,
      $     0.0      , 0.0     , 0.0     , 0.0     , 0.0     /
C           TRANSFER COEFFECIENTS FOR POULTRY
       DATA (TRANSF(I,4),I=1,50)/
      1      1.0E+00  , 0.0     , 1.0E+00 , 1.0E-02 , 0.0     ,
      2      0.0      , 0.0     , 0.0     , 1.0E-03 , 1.0E-03 ,
      3      1.0E-03  , 1.0E-03 , 1.0E-03 , 1.0E-03 , 2.0E-03 ,
      4      2.0E-03  , 0.0     , 0.0     , 0.0     , 0.0     ,
      5      9.0E-04  , 9.0E-04 , 1.0E-04 , 1.0E-04 , 2.0E-03 ,
      6      3.0E-04  , 3.0E-04 , 1.0E-02 , 4.0E-03 , 4.0E-03 ,
      7      4.0E-03  , 4.0E-03 , 4.0E-03 , 0.0     , 0.0     ,
      8      0.0      , 0.0     , 0.0     , 0.0     , 4.0E-03 ,
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     9      4.CE-C1  , 5.DE-C4 , 4.CE-C3 , 6.DE-C4 , 6.CE-C4 ,
     $      0.C      , C.C     , G.C     , C.C     , 0.C     /
C          TRANSFER COEFFECIENTS FOR EGGS
      DATA (TRANSF(I,6),I=1,50)/
     1      1.CE+CC  , 0.0     , 1.CE-C2 , 1.CE-C2 , 0.C     ,
     2      0.0      , C.C     , 0.C     , 5.DE-C3 , 5.DE-C3 ,
     3      5.CE-C3  , 5.CE-C3 , 5.CE-C3 , 5.CE-C3 , 1.CE-C2 ,
     4      2.DE-C4  , C.C     , 0.C     , C.C     , 0.C     ,
     5      2.DE-C2  , 2.DE-C2 , 6.CE-C5 , 6.CE-C5 , 2.CE-C2 ,
     6      2.CE-C4  , 2.DE-C4 , 2.CE-C2 , 8.CE-C2 , 8.CE-C2 ,
     7      8.CE-C2  , 8.DE-C2 , 8.CE-C2 , C.C     , 0.C     ,
     8      0.0      , C.C     , C.C     , C.C     , 3.CE-C2 ,
     9      3.CE-C2  , 2.DE-C2 , 1.CE-C4 , 1.CE-C4 , 1.CE-C4 ,
     $      C.C      , C.C     , C.C     , C.C     , C.C     /
C          TRANSFER COEFFECIENTS FOR BEEF
      DATA (TRANSF(I,2),I=1,50)/
     1      1.DE+CC  , 0.0     , 1.CE+CC , 5.CE-C2 , C.C     ,
     2      0.0      , C.C     , C.C     , 5.DE-C3 , 1.DE-C3 ,
     3      1.DE-C3  , 1.CE-C3 , 1.CE-C3 , 1.CE-C3 , 2.DE-C3 ,
     4      2.CE-C3  , C.C     , 0.C     , C.C     , C.C     ,
     5      2.DE-C3  , 2.DE-C3 , 5.CE-C4 , 5.CE-C4 , 1.CE-C2 ,
     6      1.DE-C3  , 1.DE-C3 , 5.CE-C3 , 2.DE-C2 , 2.CE-C2 ,
     7      2.DE-C2  , 2.CE-C2 , 2.CE-C2 , C.C     , C.C     ,
     8      0.0      , C.C     , 0.C     , C.C     , 3.DE-C2 ,
     9      3.CE-C2  , 5.CE-C4 , 5.CE-C3 , 1.CE-C3 , 1.CE-C3 ,
     $      C.C      , C.C     , C.C     , C.C     , C.C     /
C          TRANSFER COEFFECIENTS FOR PORK
      DATA (TRANSF(I,3),I=1,50)/
     1      1.CE+CC  , C.C     , 1.CE+CC , 1.CE-C1 , C.C     ,
     2      C.C      , C.C     , C.C     , 1.CE-C2 , 5.CE-C3 ,
     3      5.CE-C3  , 5.CE-C3 , 5.CE-C3 , 5.CE-C3 , 5.CE-C3 ,
     4      5.CE-C3  , C.C     , C.C     , C.C     , C.C     ,
     5      8.CE-C3  , 8.CE-C3 , 1.CE-C3 , 1.CE-C3 , 2.CE-C2 ,
     6      5.CE-C3  , 5.CE-C3 , 1.CE-C2 , 9.CE-C2 , 9.CE-C2 ,
     7      9.CE-C2  , 9.CE-C2 , 9.CE-C2 , C.C     , 0.C     ,
     8      C.C      , C.C     , C.C     , C.C     , 4.CE-C2 ,
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      9     4.0E-02  , 2.0E-03 , 1.0E-02 , 5.0E-03 , 5.0E-03 ,
      $     0.0      , 0.0     , 0.0     , 0.0     , 0.0     /
C           YIELD FACTORS
      DATA  YIELDF /
      1     1.0      , 1.8E+00 , 3.5E-01 , 2.3E+00 , 1.8E+00 ,
      2     3.5E-01  , 2.3E+00 , 0.0     , 3.5E-01 , 2.3E+00 ,
      3     0.0      , 3.5E-01 , 2.3E+00 , 0.0     , 3.5E-01 ,
      4     0.0      , 0.0     , 3.5E-01 , 0.0     , 2.7E+00 ,
      5     1.7E+00  , 8.3E-01 , 1.8E00  , 4.0E+00 , 1.5E+00 ,
      6     7.0E+00  , 3.4E-01 , 3.4E-01 , 3.4E-01 , 0.0     ,
      7     0.0      , 0.0     , 0.0     , 0.0     , 0.0     ,
      8     0.0      , 0.0     , 0.0     , 0.0     , 0.0     /
C           MONTH OF APPEARANCE  FOR CROPS
      DATA APPEAR  /
      1     04       , 00      , 04      , 04      , 00      ,
      2     00       , 00      , 00      , 04      , 04      ,
      3     00       , 04      , 04      , 00      , 04      ,
      4     04       , 00      , 04      , 04      , 03      ,
      5     06       , 05      , 06      , 06      , 06      ,
      6     06       , 04      , 04      , 04      , 00      ,
      7     00       , 00      , 00      , 00      , 00      ,
      8     00       , 00      , 00      , 00      , 00      /
C           MONTH OF HARVEST FOR CROPS
      DATA HARVST/
      1     04       , 00      , 07      , 07      , 00      ,
      2     07       , 07      , 00      , 07      , 07      ,
      3     00       , 07      , 07      , 00      , 07      ,
      4     07       , 00      , 07      , 07      , 05      ,
      5     09       , 08      , 09      , 09      , 09      ,
      6     08       , 07      , 07      , 07      , 00      ,
      7     00       , 00      , 00      , 00      , 00      ,
      8     00       , 00      , 00      , 00      , 00      /
C           QUANTITY OF WATER CONSUMPTION FOR ANIMALS
      DATA QUANTW /
      1     7.5E+01  , 7.5E+01 , 7.5E+01 , 3.0E+01 , 3.0E+01 , 4.0E+01  ,
      2     5.0E+01  , 5.0E+01 , 7.5E+01 , 7.5E+01 , 7.5E+01 , 7.5E+01  ,
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      3     5.0E+01 , 5.0E+01 , 5.0E+01 , 5.0E+01 , 5.0E+01 , 5.0E+01 ,
      4     5.0E+01 , 5.0E+01 , 5.0E+01 , 5.0E+01 , 5.0E+01 , 5.0E+01 ,
      5     1.0E+01 , 1.0E+01 , 1.0E+01 , 1.0E+01 , 1.0E+01 , 1.0E+01 ,
      6     1.0E+01 , 1.0E+01 , 1.0E+01 , 1.0E+01 , 1.0E+01 , 1.0E+01 ,
      7     3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 ,
      8     3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 ,
      9     3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 ,
      $     3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 ,
      $     3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 ,
      $     3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 , 3.0E-01 /
C           FORAGE INTAKE FOR ANIMALS
      DATA QUANT1/
      1     0.0     , 0.0     , 0.0     , 0.0     , 6.5E+01 , 6.5E+01 ,
      2     5.5E+01 , 4.5E+01 , 4.5E+01 , 0.0     , 0.0     , 0.0     ,
      3     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     ,
      4     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     ,
      5     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     ,
      6     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     ,
      7     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     ,
      8     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     ,
      9     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     ,
      $     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     ,
      $     0.0     , 0.0     , 0.0     , 0.0     , 0.0     , 0.0     /
C           GRAIN INTAKE FOR ANIMALS
      DATA QUANT2/
      1     3.6E+00 , 3.6E+00 , 3.6E+00 , 3.6E+00 , 3.6E+00 , 3.6E+00 ,
      2     3.6E+00 , 3.6E+00 , 3.6E+00 , 3.6E+00 , 3.6E+00 , 3.6E+00 ,
      3     1.4E+01 , 1.4E+01 , 1.4E+01 , 1.4E+01 , 1.4E+01 , 1.4E+01 ,
      4     1.4E+01 , 1.4E+01 , 1.4E+01 , 1.4E+01 , 1.4E+01 , 1.4E+01 ,
      5     3.4E+00 , 3.4E+00 , 3.4E+00 , 3.4E+00 , 3.4E+00 , 3.4E+00 ,
      6     3.4E+00 , 3.4E+00 , 3.4E+00 , 3.4E+00 , 3.4E+00 , 3.4E+00 ,
      7     1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 ,
      8     1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 ,
      9     1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 ,
      $     1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 ,
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     $     1.2E-01  , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01   ,
     $     1.2E-01  , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01 , 1.2E-01   /
C          STORED FEED INTAKE RATES FOR ANIMALS
      DATA QUANT3 /
     1     4.3E+01  , 4.3E+01 , 4.3E+01 , 4.3E+01 , 0.0     , 0.0      ,
     2     1.3E+01  , 3.0E+01 , 3.0E+01 , 4.3E+01 , 4.3E+01 , 4.3E+01  ,
     3     5.4E+01  , 5.4E+01 , 5.4E+01 , 5.4E+01 , 5.4E+01 , 5.4E+01  ,
     4     5.4E+01  , 5.4E+01 , 5.4E+01 , 5.4E+01 , 5.4E+01 , 5.4E+01  ,
     5     8.0E-01  , 8.0E-01 , 8.0E-01 , 8.0E-01 , 8.0E-01 , 8.0E-01  ,
     6     8.0E-01  , 8.0E-01 , 8.0E-01 , 8.0E-01 , 8.0E-01 , 8.0E-01  ,
     7     0.0      , 0.0     , 0.0     , 0.0     , 0.0     , 0.0      ,
     8     0.0      , 0.0     , 0.0     , 0.0     , 0.0     , 0.0      ,
     9     0.0      , 0.0     , 0.0     , 0.0     , 0.0     , 0.0      ,
     $     0.0      , 0.0     , 0.0     , 0.0     , 0.0     , 0.0      ,
     $     0.0      , 0.0     , 0.0     , 0.0     , 0.0     , 0.0      ,
     $     0.0      , 0.0     , 0.0     , 0.0     , 0.0     , 0.0      /
C          COEFFECIENTS OF  SECRETION FOR MILK
      DATA (TRANSF(I,1),I=1,50)/
     1     2.0E-02  , 2.2E-02 , 1.5E-02 , 5.0E-02 , 5.0E-02 ,
     2     0.0      , 0.0     , 2.2E-03 , 2.5E-04 , 1.2E-03 ,
     3     1.2E-03  , 1.0E-03 , 1.0E-03 , 6.7E-03 , 1.4E-02 ,
     4     3.0E-02  , 0.0     , 0.0     , 0.0     , 0.0     ,
     5     1.0E-03  , 1.0E-03 , 5.0E-06 , 2.5E-03 , 7.5E-03 ,
     6     1.0E-06  , 1.0E-06 , 1.0E-03 , 1.0E-02 , 1.2E-02 ,
     7     1.0E-02  , 1.0E-02 , 1.0E-02 , 0.0     , 0.0     ,
     8     0.0      , 0.0     , 0.0     , 0.0     , 5.0E-03 ,
     9     5.0E-03  , 6.0E-04 , 5.0E-06 , 2.0E-05 , 2.0E-05 ,
     $     0.0      , 0.0     , 0.0     , 0.0     , 0.0     /
C          SINCE WE HAVE A UNIQUE MONTH OF HARVEST FOR ALL CROPS SET THE
C          NUMBER OF MONTHS OF HARVEST TO ONE
      DATA REPEAT/ NTOTAL*1 /
C          CALCULATE LAMBDA R =0.693/TR
      DO 100 I=1,NONUCL
100   HAF12R(I)=0.693/LIFE12(I)
C          CALCULATE LAMBDA E =0.693/(TR*TB/(TR+TB)
      DO 110 I=1,NONUCL
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11C   HAF12E(I)=C.693/((LIFE12(I)*14)/(LIFE12(I)+14))
C         CALCULATE THE ACCUMULATION COEFFECIENTS M THAT ARE USED IN
C         THE FORAGE CALCULATION   M=(1-EXP(LAMBDAE*T)/LAMBDAE
      DO 12C I=1,NONUCL
12C   ACCUMF(I)=(1-EXP(-HAF12E(I)*3C.D))/HAF12E(I)
C         INFORMATION IS NOT AVAILABLE AT THE PRESENT TIME FOR CERTAIN
C         QUANTITIES. THEREFORE REPLACE THE ZERO VALUES IN THE TABLES
C         WITH THE VALUES IN THE FIRST POSITION OF THE TABLE
      DO 16C I=2,NOPATH
      IF (YIELDF(I).EQ.C.C) YIELDF(I)=YIELDF(1)
      IF (HARVST(I).EQ.C.C) HARVST(I)=HARVST(1)
      IF (APPEAR(I).EQ.C.C) APPEAR(I)=APPEAR(1)
      IF (I-3C) 13C,15C,13C
13C   DO 14C J=1,NONUCL
      IF (CONCFA(J,I).EQ.C.) CONCFA(J,I)=CONCFA(J,1)
14C   CONTINUE
15C   CONTINUE
16C   CONTINUE
      DO 17C I=2,NOPATH
17C   IF (TRANSL(I).EQ.C) TRANSL(I)=TRANSL(1)
C         DIVIDE CONCENTRATION FACTORS BY 224
      DO 18C I=1,NONUCL
      DO 18C J=1,NOPATH
18C   CONCFA(I,J)=CONCFA(I,J)/224.C
      CALL TAPE (KEYS(98,C,C),DS3,42CC)
      RETURN
      END
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@ ELT SUMMRY,1,711115, 62953

      SUBROUTINE SUMMRY
C         THIS SUBROUTINE WRITES THE SUMMARY REPORTS
      INCLUDE TABLE1,LIST
      DIMENSION  ORGAN(3,10),ITABL6(10,1000),FMT2(30)
      DIMENSION TABLE8(12,8),TABLE(12,1000),TABLE6(10,1000),FMT3(17)
      DIMENSION CORE(22000)
      EQUIVALENCE(DS1,CORE),(CORE,TABLE),(CORE(12001),TABLE6)
      DATA (FMT2(I),I=1,29)/'(1X,2A6,A6,   I5,1X,          ' ,
     111*'      ,1X  ,',',      )     '/
      DATA MAX/45/,K/0/
      DATA (FMT3(I),I=1,17)/'(1X,2A6,A6,3X,I5   ,2X  ',3*',1X,  F9.0  ',
     1',11X ,F9.0  ',2*',1X,  F9.0  ',')' /
      EQUIVALENCE(ITABL6,TABLE6)
      DATA (ORGAN(I,01),I=1,3)/'TOTAL BODY        '/
      DATA (ORGAN(I,02),I=1,3)/'GI TRACT(LLI)     '/
      DATA (ORGAN(I,03),I=1,3)/'THYROID           '/
      DATA (ORGAN(I,04),I=1,3)/'BONE              '/
      DATA (ORGAN(I,05),I=1,3)/'LUNGS             '/
      DATA (ORGAN(I,06),I=1,3)/'SKIN              '/
      DATA (ORGAN(I,07),I=1,3)/'LIVER             '/
      LINES=99
      DO 230 I2=1,7
      K=0
      DO 140 I=1,1000
      IF (L(I)) 100,140,100
  100 CALL GET (KEYS(99,I,0),TABLE8,LENGTH)
      IF (LENGTH) 140,140,110
  110 K=K+1
      DO 120 I1=1,12
  120 TABLE(I1,K)=TABLE8(I1,I2)
      DO 130 I1=1,10
  130 TABLE6(I1,K)=TABLE8(I1,8)
```

```
      ITABL6(4,K)=TABLE6(4,K)
140   CONTINUE
      IF (K) 400,400,150
150   KK=K
C         WE HAVE AT LEAST ONE TABLE SO WRITE A SUMMARY REPORT
      KPLUS1=K+1
      IF (MAX-LINES-3) 170,160,160
160   WRITE (REPORT,430) (ORGAN(K,I2),K=1,3)
      LINES=LINES+1
      GO TO 180
170   LINES=LINES+3
180   DO 230 J=1,KK
      IF (MAX-LINES) 190,200,200
C         HEADING REQD
190   IPAGE=IPAGE+1
      WRITE (REPORT,410) DATE,IPAGE,(ORGAN(K,I2),K=1,3)
      LINES=5
C         FORMAT AND WRITE A LINE
200   IYES=0
      DO 210 K=1,12
      IF(TABLE(K,J))201,202,201
  201 IYES=1
      FMT2(4+2*K)='1PE8.3'
      GO TO 210
  202 FMT2(4+2*K)='2X,A6'
      TABLE(K,J)=' '
210   CONTINUE
      IF (IYES) 230,230,220
220   WRITE (REPORT,FMT2) (TABLE6(K,J),K=1,4),(TABLE(K,J),K=1,12)
      LINES=LINES+1
230   CONTINUE
C         WRITE THE INTEGRATED POPULATION DOSES BY CENTROID NUMBER
C         ZERO TABLE6(KPLUS1)
      DO 240 I=5,10
240   TABLE6(I,KPLUS1)=0.0
      ITABL6(4,KPLUS1)=0
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      LINES=99
      DO 360 I=1,KPLUS1
      IF (MAX-LINES) 250,260,260
C         WRITE A HEADING FOR THE REPORT
250   IPAGE=IPAGE+1
      WRITE (REPORT,420) DATE,IPAGE
      LINES=5
C         FORMAT AND WRITE A LINE
260   IF (ITABLE(4,I)) 270,280,270
270   FMT3(3)='X,I5'
      GO TO 290
280   FMT3(3)='X,A5'
      TABLE6(4,I)=' '
290   DO 320 J=5,10
      IF (TABLE6(J,I)) 300,310,300
300   IF (I.NE.KPLUS1) TABLE6(J,I)=TABLE6(J,I)*0.001
      IF (I.NE.KPLUS1) TABLE6(J,KPLUS1)=TABLE6(J,KPLUS1)+TABLE6(J,I)
      FMT3(2*J-4)='1PE9.3'
      IYES=1
      GO TO 320
310   FMT3(2*J-4)='3X,A6'
      TABLE6(J,I)=' '
320   CONTINUE
      IF (IYES) 360,360,330
330   IF (I-KPLUS1) 350,340,350
340   TABLE6(1,KPLUS1)='TOTAL '
      TABLE6(2,KPLUS1)='OF ABO'
      TABLE6(3,KPLUS1)='VE    '
350   WRITE (REPORT,FMT3) (TABLE6(J,I),J=1,10)
      LINES=LINES+1
360   CONTINUE
C         COMPUTE TOTALS
      TOTAL1=TABLE6(5,KPLUS1)+TABLE6(6,KPLUS1)+TABLE6(07,KPLUS1)
      TOTAL2=TABLE6(8,KPLUS1)+TABLE6(9,KPLUS1)+TABLE6(10,KPLUS1)
      IF (TOTAL1) 380,380,370
370   WRITE (REPORT,440) TOTAL1
```

10835542

```
      380   IF (TOTAL2) 400,400,390
      390   WRITE (REPORT,450) TOTAL2
      400   RETURN
      C
      410   FORMAT ('1',8X,'S U M M A R Y  R E P O R T',6X,18X,'INFORMATION BY
           1',' CENTROID NUMBER',9X,2A6,8X,'PAGE ',I5,/,45X,'D O S E',24X,'***
           2    D O S E  C O M M I T T M E N T',/,3X,3A6,2(9X,'AVERAGE INDIVID
           3UAL          MAXIMUM INDIVIDUAL'),/,1X,'    CENTROID   STARTING',4(
           44X,'CHILD TEENAGER    ADULT'),/,8X,'NAME   PAGE NO.')
      420   FORMAT ('1',8X,'INTEGRATED POPULATION DOSE AND DOSE COMMITTMENT BY
           1',' CENTROID NUMBER',23X,2A6,8X,'PAGE ',I5,//,'    CENTROID
           2STARTING  INTEGRATED POPULATION DOSE(MAN-REM','/YR)  INTEGRATED PO
           3PULATION DOSE COMMITTMENT(MAN-REM/50YRS)',/,'    NAME            PA
           4GE NO.        CHILD  TEENAGER     ADULT    ','            CHILD  TEE
           5NAGER     ADULT')
      430   FORMAT (1H ,2A6,A3,2X,19('------'))
      440   FORMAT ('0THE TOTAL INTEGRATED POPULATION DOSE IS',19X,1PE15.8)
      450   FORMAT ('0THE TOTAL INTEGRATED POPULATION DOSE COMMITTMENT IS',7X,
           1E15.8)
            END
```


1083543

1083544

```
@ ELT TAPE,1,711115, 62822

      SUBROUTINE TAPE (KEY,TABLE,LEN)
C     KEY--TABLE IDENTIFICATION WORD
C     TABLE--ARRAY TO BE WRITTEN
C     LEN--LENGTH OF ARRAY TO BE WRITTEN
      DIMENSION TABLE(1)
      INCLUDE TABLE1, LIST
      IF (FLD(0,12,KEY)) 160,100,160
100   IF (FLD(24,12,KEY)-2) 110,150,110
110   IF (FLD(24,12,KEY)-3) 120,150,120
120   IF (FLD(24,12,KEY)-4) 130,150,130
130   IF (FLD(24,12,KEY)-5) 140,150,140
140   GO TO 160
C     WRITE WET AND DRY DEPOSITION TABLES TO DRUM
150   CONTINUE
      CALL PUT (KEY,TABLE,LEN)
      RETURN
C     WRITE OTHER TABLES TO TAPE
160   CONTINUE
      LU=IO(18)
      WRITE (LU) KEY,LEN,(TABLE(I),I=1,LEN)
      RETURN
      END
```

10835545

```
@ ELT TCHECK,1,711115, 62819

. CALL TCHEK(I,$N)
. IF TIME REMAINING FOR EXECTION IS LE I (SEC), TRANSFER TO $N
          NBPR     .
MCR$B     EQU      07320
TCHEK*    L        AC,MCR$+12
          L        A1,MCR$B
          DSL      A1,36
          DI,M     A1,5000
          TZ       AC
          AN       AC,A1
          AN       AC,*0,B11
          TG       AC,(0)
          J        3,B11
          J        *1,B11
          END
```

```
@ ELT TIMER,1,711115, 62830

      SUBROUTINE TIMER (ICODE,JCODE)
C               EXPLANATION OF CALL LIST
C               ICODE      1=START 2=STOP
C               JCODE      1=GET  2=PUT  3=POPFIL 4=FOOD 5=DOSE 6=REPORT
C                          7=INITIALIZATION, 8=PRINT TIMES, 9=EXCLUDE
      INCLUDE TABLE1,LIST
      DIMENSION TIMET(5,6)
      IF (JCODE.EQ.9) GO TO 170
      IF (JCODE.EQ.8) GO TO 140
      IF (ICODE.EQ.2) GO TO 120
      IF (JCODE-3) 110,100,100
C         WE ARE STARTING OTHER THAN I/O
100   CALL ETIME
      ISW=JCODE-2
      GO TO 200
C         START I/O TIME
110   CALL ETIMEF (Z)
      TIMET(1,ISW)=TIMET(1,ISW)+Z
      CALL ETIME
      GO TO 200
C         WE HAVE A STOP
120   CALL ETIMEF (Z)
      IF (JCODE.GE.3) GO TO 130
C         END OF I/O TIME
      TIMET(JCODE*2+1,ISW)=TIMET(JCODE*2+1,ISW)+Z
      TIMET(JCODE*2,ISW)=TIMET(JCODE*2,ISW)+1.0
      CALL ETIME
      GO TO 200
C         END OF NON I/O TIME
130   TIMET(1,JCODE-2)=TIMET(1,JCODE-2)+Z
      GO TO 200
140   DO 150 I=1,5
```

```
      DO 150 J=1,5
150   TIMET(J,6)=TIMET(J,6)+TIMET(J,I)
      WRITE (REPORT,210) ((TIMET(I,J),I=1,5),J=1,6)
C         WRITE DATA TO PRINTER
C         NOW ZERO THE TIME TABLE
      DO 160 I=1,6
      DO 160 J=1,5
160   TIMET(I,J)=0.0
      GO TO 200
C         EXCLUDE THIS TIME
170   IF (ICODE-1) 190,180,190
180   CALL ETIMEF (Z)
      TIMET(1,ISW)=TIMET(1,ISW)+Z
      GO TO 200
190   CALL ETIME
200   RETURN
C
210   FORMAT ('1FUNCTION                                GET              PUT',/,'
     1      TIME     NO.     TIME  NO.     TIME',/,' POP FILE     ',F9.3,2(F8
     2.0,F9.3),/,' FOOD CHAIN  ',F9.3,2(F8.0,F9.3),/,' DOSE CALC    ',F9.
     33,2(F8.0,F9.3),/,' REPORTING    ',F9.3,2(F8.0,F9.3),/,' INIT IALIZE
     4 ',F9.3,2(F8.0,F9.3),/,' TOTAL        ',F9.3,2(F8.0,F9.3))
      END
```


10835471

1083548

```
@ ELT ZERO1,1,711115, 62817

      SUBROUTINE ZERO1 (MONTH,TABLE,LENGTH)
C         SUBROUTINE TO REMOVE ALL ENTRIES FROM A TABLE EXCEPT FOR ONE
C         MONTH
C
C         EXPLANATION OF CALL LIST
C              MONTH     MONTH TO BE RETAINED
C              TABLE     CONCENTRATION TABLE
C              LENGTH    NUMBER OF ENTRIES IN TABLE
      DIMENSION TABLE(2,1)
      IF (LENGTH) 100,130,100
100   KOUNT=0
      DO 120 N=1,LENGTH
      MONTH2=FLD(12,12,TABLE(1,N))
      IF (MONTH-MONTH2) 120,110,120
110   KOUNT=KOUNT+1
      TABLE(1,KOUNT)=TABLE(1,N)
      TABLE(2,KOUNT)=TABLE(2,N)
120   CONTINUE
      LENGTH=KOUNT
130   RETURN
      END
```

```
@ ELT PUT,1,710320, 62290

      SUBROUTINE PUT(AKEY,ARRAY,LGTH)
C
C     SUBROUTINE TO WRITE TABLES TO DRUM
C
C     EXPLANATION OF CALL LIST
C     AKEY--WORD TO STORE IN DICTIONARY TABLE(DT) TO IDENTIFY TABLE
C         --BEING WRITTEN TO DRUM
C     ARRAY--TABLE TO BE WRITTEN TO DRUM
C     LGTH--LENGTH OF TABLE TO BE WRITTEN TO DRUM
      REAL NEXT
      DIMENSION ARRAY(1)
      DATA LD/0/
      DATA NISHL/0/
      DATA ISCR/0/
      DATA LSD/0/
      INCLUDE TABLE1,LIST
      DIMENSION IFT(7)
      EQUIVALENCE(FT,IFT)
      CALL TIMER(1,2)
      IF(NISHL)25, ,25
      NEXT=FT(3)
      NISHL=1
   25 FT(3)=NEXT
      IF(ISCR) ,35,
      LSD=LSD+1
      GO TO 50
   35 LD=LD+1
   50 CONTINUE
      DT(1,LD+LSD)=AKEY
C     LOAD DICTIONARY WITH ABSOLUTE ADDRESS OF NEXT DRUM WRITE
      FLD( 0,21,DT(2,LD+LSD))=IFT(3)
      FLD(21,15,DT(2,LD+LSD))=LGTH
```

```
      CALL NTRAN(DRUM,1,LGTH,ARRAY,LSTAT)
   60 IF(LSTAT.EQ.-1) GO TO 60
      IF(LSTAT.NE.LGTH) RETURN 0
      CALL DUMP(ARRAY,LGTH/2)
      NEXT=FT(3)
      GO TO 100
C     SAVE STARTING DRUM ADDRESS OF SCRATCH AREA
      ENTRY SET
      IF(NISHL)125, ,125
      NEXT=FT(3)
      NISHL=1
  125 SAVE=NEXT
      ISCR=1
      RETURN
C     REMOVE REFERENCE TO SCRATCH AREA OF DRUM
C     SO THAT NON-SCRATCH AREA CAN BE WRITTEN TO
      ENTRY RESET
      LSD=0
      NEXT=SAVE
      ISCR=0
      M(44)=MAX(M(44),IFT(4))
      RETURN
  100 CALL TIMER(2,2)
      RETURN
      END
```


1083550

1083551

```
@ ELT DRIVER,1,710811, 57669

      SUBROUTINE DRIVER
C               DRIVING PROGRAM FOR DOSE CALCULATIONS
      INCLUDE TABLE1,LIST
      DIMENSION IERROR(6),PATH(26,45),IPATH(26,45)
      DIMENSION LOCAT(3)
      DIMENSION DC(2,1000)
      DIMENSION IOPT1(8),IOPT2(8)                                        08/11/71
      EQUIVALENCE(IPATH,PATH)
C     IOPT1 AND IOPT2 CONTAIN VALUES TO SET REPORT SWITCHES
      COMMON/PERCNT/KP,PERCN1(46,3,14),IP                                08/11/71
      DATA IOPT1/ ' ','X',' ',' ','X',' ',' ',' ' /                      08/11/71
      DATA IOPT2/ ' ',' ','X',' ',' ','X',' ',' '/                       08/11/71
C               EXPLANATION OF PATH TABLE
C         WORD       DESCRIPTION
C          01         PATH NUMBER  CORRESPONDS TO 'DOSE CHART'
C          02         TYPE OF PATH  1= AIR, 2=WATER ,3=FOOD
C          03         EXTERNAL CODE  EXTERNAL DOSE=2 ,INTERNAL DOSE=1
C          04         CONCENTRATION CODE  I.E. TYPE OF CONCENTRATION DATA
C          05         DIET CODE
C          06         HABIT CODE
C          07         DOSE FACTOR CODE
C          08         LOSS FACTORS
C          09-11      PATH DESCRIPTION( USED TO WRITE ERROR MESSAGES)
C          12         CENTROID NUMBER OF CONCENTRATION ITEM
C          13         WATER TREATMENT SWITCH
C          14         CENTROID NUMBER OF FOOD SOURCE 1
C          15         PERCENT OF TOTAL SUPPLY OBTAINED AT SOURCE 1
C          16         PERCENT OF TOTAL CROP IRRIGATED AT SOURCE 1
C          17         TYPE WATER USED FOR IRRIGATION AT SOURCE 1
C          18-21      REPEAT 14-17 FOR SOURCE 2
C          22-25      REPEAT 14-17 FOR SOURCE 3
C          26         TYPE FOOD
```

```
DATA(PATH(I,01),I=09,11)/'AIR SUBMERSION    '                    /
DATA(PATH(I,01),I=01,08)/ 01,  01,  02,  01,  00,  06,  03,    00/
DATA(PATH(I,02),I=09,11)/'H3 TRANSPIRATION  '                    /
DATA(PATH(I,02),I=01,08)/ 02,  01,  01,  01,  01,  06,  01,    00/
DATA(PATH(I,03),I=09,11)/'AIR INHALATION    '                    /
DATA(PATH(I,03),I=01,08)/ 03,  01,  01,  01,  01,  06,  04,    00/
DATA(PATH(I,04),I=09,11)/'UPLAND HUNTING    '                    /
DATA(PATH(I,04),I=01,08)/ 04,  02,  02,  07,  00,  05,  05,    00/
DATA(PATH(I,05),I=09,11)/'FISHING ON BANK   '                    /
DATA(PATH(I,05),I=01,08)/ 05,  02,  02,  00,  00,  03,  05,    00/
DATA(PATH(I,06),I=09,11)/'SWIMMING          '                    /
DATA(PATH(I,06),I=01,08)/ 06,  02,  02,  00,  00,  01,  06,    00/
DATA(PATH(I,07),I=09,11)/'BOATING & SKIING  '                    /
DATA(PATH(I,07),I=01,08)/ 07,  02,  02,  00,  00,  02,  08,    00/
DATA(PATH(I,08),I=09,11)/'EXPOSURE TO SOIL  '                    /
DATA(PATH(I,08),I=01,08)/ 08,  02,  02,  07,  00,  07,  05,    00/
DATA(PATH(I,09),I=09,11)/'WATERFOWL HUNTING '                    /
DATA(PATH(I,09),I=01,08)/ 09,  02,  02,  00,  00,  04,  05,    00/
DATA (PATH(I,11),I=9,11)/'FRESH BERRIES     '                    /
DATA (PATH(I,11),I=1,08)/ 11,  03,  01,  51,  11,  00,  07,    67/
DATA PATH(26,11)        /                                       9/
DATA (PATH(I,12),I=9,11)/'PROCESSED BERRIES '                    /
DATA (PATH(I,12),I=1,08)/ 12,  03,  01,  52,  12,  00,  07,    67/
DATA PATH(26,12)        /                                       2/
DATA (PATH(I,13),I=9,11)/'FRESH TREE FRUIT  '                    /
DATA (PATH(I,13),I=1,08)/ 13,  03,  01,  53,  13,  00,  07,    90/
DATA PATH(26,13)        /                                       9/
DATA (PATH(I,14),I=9,11)/'PROCESS TREE FRUIT'                    /
DATA (PATH(I,14),I=1,08)/ 14,  03,  01,  54,  14,  00,  07,    40/
DATA PATH(26,14)        /                                       2/
DATA (PATH(I,15),I=9,11)/'FRESH MELONS      '                    /
DATA (PATH(I,15),I=1,08)/ 15,  03,  01,  15,  15,  00,  07,    90/
DATA PATH(26,15)        /                                       9/
DATA (PATH(I,20),I=9,11)/'FRESH POTATOES    '                    /
DATA (PATH(I,20),I=1,08)/ 20,  03,  01,  20,  20,  00,  07,    75/
DATA PATH(26,20)        /                                       2/
```


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```
      DATA (PATH(I,21),I=9,11)/'PROCESSED POTATOES'                    /
      DATA (PATH(I,21),I=1,08)/ 21,  03,  01,  21,  21,  00,  07,    75/
      DATA PATH(26,21)         /                                      2/
      DATA (PATH(I,22),I=9,11)/'FRESH ROOT VEG.   '                    /
      DATA (PATH(I,22),I=1,08)/ 22,  03,  01,  22,  22,  00,  07,    75/
      DATA PATH(26,22)         /                                      9/
      DATA (PATH(I,23),I=9,11)/'PROCESSD ROOT VEG.'                    /
      DATA (PATH(I,23),I=1,08)/ 23,  03,  01,  23,  23,  00,  07,    75/
      DATA PATH(26,23)         /                                      2/
      DATA (PATH(I,24),I=9,11)/'FRESH GREEN LEAFY '                    /
      DATA (PATH(I,24),I=1,08)/ 24,  03,  01,  24,  24,  00,  07,    40/
      DATA PATH(26,24)         /                                      9/
      DATA (PATH(I,25),I=9,11)/'PROCES GREEN LEAFY'                    /
      DATA (PATH(I,25),I=1,08)/ 25,  03,  01,  25,  25,  00,  07,    40/
      DATA PATH(26,25)         /                                      2/
      DATA (PATH(I,26),I=9,11)/'FRESH OTHER VEG.  '                    /
      DATA (PATH(I,26),I=1,08)/ 26,  03,  01,  26,  26,  00,  07,    40/
      DATA PATH(26,26)         /                                      9/
      DATA (PATH(I,27),I=9,11)/'PROCESD OTHER VEG.'                    /
      DATA (PATH(I,27),I=1,08)/ 27,  03,  01,  27,  27,  00,  07,    40/
      DATA PATH(26,27)         /                                      2/
      DATA (PATH(I,28),I=9,11)/'GRAIN & GRAIN PROD'                    /
      DATA (PATH(I,28),I=1,08)/ 28,  03,  01,  28,  28,  00,  07,    15/
      DATA PATH(26,28)         /                                      2/
      DATA (PATH(I,29),I=9,11)/'RICE & RICE PROD  '                    /
      DATA (PATH(I,29),I=1,08)/ 29,  03,  01,  29,  29,  00,  07,    00/
      DATA PATH(26,29)         /                                      2/
      DATA (PATH(I,30),I=9,11)/'WHEAT & WHEAT PROD'                    /
      DATA (PATH(I,30),I=1,08)/ 30,  03,  01,  30,  30,  00,  07,    15/
      DATA PATH(26,30)         /                                      2/
      DATA (PATH(I,31),I=9,11)/'FRESH MILK        '                    /
      DATA (PATH(I,31),I=1,08)/ 31,  03,  01,  31,  31,  00,  07,    00/
      DATA PATH(26,31)         /                                      3/
      DATA (PATH(I,32),I=9,11)/'MILK PRODUCTS     '                    /
      DATA (PATH(I,32),I=1,08)/ 32,  03,  01,  32,  32,  00,  07,    00/
      DATA PATH(26,32)         /                                      3/
```


1083553

```
      DATA (PATH(I,33),I=9,11)/'BUTTER              '                    /
      DATA (PATH(I,33),I=1,08)/ 33,  03,  01,  33,  33,  00,  07,    00/
      DATA PATH(26,33)         /                                      3/
      DATA (PATH(I,35),I=9,11)/'BEEF AND LAMB       '                    /
      DATA (PATH(I,35),I=1,08)/ 35,  03,  01,  35,  35,  00,  07,    90/
      DATA PATH(26,35)         /                                      4/
      DATA (PATH(I,36),I=9,11)/'FRESH PORK          '                    /
      DATA (PATH(I,36),I=1,08)/ 36,  03,  01,  36,  36,  00,  07,    90/
      DATA PATH(26,36)         /                                      5/
      DATA (PATH(I,37),I=9,11)/'PROCESSED PORK      '                    /
      DATA (PATH(I,37),I=1,08)/ 37,  03,  01,  37,  37,  00,  07,    90/
      DATA PATH(26,37)         /                                      5/
      DATA (PATH(I,43),I=9,11)/'SPORTS FISH         '                    /
      DATA (PATH(I,43),I=1,08)/ 43,  03,  01,  43,  43,  00,  07,    80/
      DATA PATH(26,43)         /                                      1/
      DATA (PATH(I,45),I=9,11)/'DRINKING WATER      '                    /
      DATA (PATH(I,45),I=1,08)/ 45,  02,  01,  00,  45,  00,  07,    00/
      DATA (PATH(I,34),I=9,11)/'FRESH WHOLE EGGS    '                    /
      DATA (PATH(I,34),I=1,08)/ 34,  03,  01,  34,  34,  00,  07,    00/
      DATA PATH(26,34)         /                                      8/
      DATA (PATH(I,38),I=9,11)/'POULTRY             '                    /
      DATA (PATH(I,38),I=1,08)/ 38,  03,  01,  38,  38,  00,  07,    90/
      DATA PATH(26,38)         /                                      6/
      DATA (PATH(I,39),I=9,11)/'WATERFOWL           '                    /
      DATA (PATH(I,39),I=1,08)/ 39,  03,  01,  39,  39,  00,  07,    90/
      DATA PATH(26,39)         /                                      1/
      DATA (PATH(I,44),I=9,11)/'UPLAND GAME BIRDS '                      /
      DATA (PATH(I,44),I=1,08)/ 44,  03,  01,  44,  44,  00,  07,    90/
      DATA PATH(26,44)         /                                      6/
      DATA SKIP/0.0/
  101 FORMAT(' ',3A6,' DOSE NOT CALCULATED. ZERO OR MISSING TABLES ARE-'
     1,5(A6,2X))
  103 FORMAT(' ',3A6,' DOSE COMMITTMENT NOT CALCULATED. ZERO OR MISSING
     1TABLES ARE-',5(A6,2X))
  102 FORMAT(' ',3A6,'ARE IMPORTED FROM OUTSIDE THE STUDY AREA')
C                ZERO REPORT TABLES
```


1083554

```
      DO 1 K1=1,2
      DO 1  I=1,50
      DO 1  K=1,10
      DO 1  J=1,6
      DS1(I,J,K,K1)=0.0
      DS2(I,J,K,K1)=0.0
      DS3(I,J,K,K1)=0.0
    1 DS4(I,J,K,K1)=0.0
      DO 10 J=1,30
   10 IPATH(12,J)=0
      CALL TIMER(2,7)
      DO 9999 I=1,999
C               IS CALCULATION TO BE DONE AT THIS LOCATION
      IF(L(I)) ,9999,
      DO 20 II=1,8
      IF(L(I)-II)20, ,20
      M(1)=IOPT1(II)
      M(2)=IOPT2(II)
   20 CONTINUE
      IF(SKIP) , ,10000
C         CHECK TIME REMAINING
      CALL TCHEK(75,$10000)
      CALL TIMER(1,3)
      CALL POPFIL(I,LOCAT,PATH,TYPE,SKIP,$9999)
      CALL TIMER(2,3)
      CALL TCHEK(75,$10000)
      CALL TIMER(1,4)
      CALL FOOD(PATH)
      CALL TIMER(2,4)
      CALL TIMER(1,5)
      TOTALS(4,8)=IPAGE+1
C               LOOP FOR AIR,WATER AND FOOD PATHWAYS
      DO 300 J=1,3
      IFIRST=0
C               LOOP THROUGH PATH TABLE. BYPASS CALCULATIONS IF THIS IS
C         NOT THE PROPER KIND OF PATH.
```

10835556

```
      DO 200 K=1,45
      KP=K                                                              08/11/71
      IP=I                                                              08/11/71
      IF(IPATH(2,K)-J) 200, ,200
      IF(IPATH(12,K)-999)  ,200,
      KOUNT = 0
      ISECND=1
      ICALC=0
C               IF THERE IS A CONCENTRATION TABLE FOR THIS PATH  GET IT.
      IF(IPATH(4,K)) , 55,
      CALL GET(KEYS(0,IPATH(12,K),IPATH(4,K)),C,LENCON)
C               IF THERE IS NO CONCENTRATION TABLE  START BUILDING THE
C          ERROR MESSAGE
      IF(LENCON)  ,, 55
      KOUNT= KOUNT+1
      IERROR(KOUNT)= 'CONC'
   55 IF(IPATH(13,K))  ,70,
      CALL GET(KEYS(0,IPATH(12,K),IPATH(13,K)),ALOSS,LENLOS)
      IF(LENLOS) ,,60
      KOUNT = KOUNT+1
      IERROR(KOUNT)='CONC2'
      GO TO 70
   60 CALL MERGE(C,LENCON,ALOSS,LENLOS,COMB,LENCOM)
      DO 61 I2=1,LENCOM
      C(1,I2) = COMB(1,I2)
   61 C(2,I2) = COMB(2,I2)
      LENCON =LENCOM
C               IF THERE IS A LOSS TABLE FOR THIS PATH  GET  IT
   70 IF(IPATH(8,K))  ,110,
      CALL GET(KEYS(4,          1,IPATH(8,K)),ALOSS,LENLOS)
      IF(LENLOS) ,,90
      KOUNT=KOUNT+1
      IERROR(KOUNT)='LOSS'
C               MULTIPLY CONCENTRATION AND LOSS TABLES TOGETHER
      GO TO 110
   90 CALL MULT(C,LENCON,ALOSS,LENLOS,COMB,LENCOM)
```

```
C                 REPLACE CONCENTRATION TABLE WITH COMBINED TABLE
      LENCON=LENCOM
      IF(LENCOM)  110,110,
      DO 95 N=1,LENCOM
      C(1,N)=COMB(1,N)
   95 C(2,N)=COMB(2,N)
C                 IF THERE IS A DIET TABLE FOR THIS PATH  OBTAIN IT
  110 IF(IPATH(5,K))  ,120,
      CALL GET(KEYS(2,TYPE,IPATH(5,K)),D,LENDIE)
C                 IS TABLE PRESENT?
      IF(LENDIE) ,,120
      KOUNT = KOUNT+1
      IERROR(KOUNT)= 'DIET'
C                 IF THERE IS A HABIT TABLE FOR THIS PATH  OBTAIN IT
  120 IF(IPATH(6,K)) ,130,
      CALL GET(KEYS(3,TYPE,IPATH(6,K)),H,LENHAB)
C                 IS TABLE PRESENT?
      IF(LENHAB) ,,130
      KOUNT = KOUNT+1
      IERROR(KOUNT)='HABIT'
C                 IF THERE IS A DOSE FACTOR TABLE FOR THIS PATH. OBTAIN IT.
  130 IF(IPATH(7,K)) ,140,
      IF(IPATH(2,K)-2)  ,131,
      IF(IPATH(1,K)-11)  ,,135
  131 CALL GET(KEYS(1,IPATH(7,K),0),DF,LENDOS)
C                 IS TABLE PRESENT?
  135 IF(LENDOS) ,,140
      KOUNT= KOUNT+1
      IERROR(KOUNT)='DOSE F'
C                 IF THERE WERE ANY MISSING TABLES WRITE ERROR MESSAGE AND
C           BYPASS CALCULATIONS.
  140 IF(KOUNT) 150,150,
      IF(IFIRST.EQ.0) IFIRST=1
      IF(IPATH(14,K).EQ.999) GO TO 145
      WRITE(REPORT,101) (PATH(N,K),N=9,11),(IERROR(N),N=1,KOUNT)
  145 WRITE(REPORT,102) (PATH(N,K),N=9,11)
```


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```
      GO TO 165
C                IF BOTH DIET AND HABIT TABLES ARE PRESENT FOR THIS
C           PATH MULTIPLY THEM TOGETHER.
  150 ICALC=1
      IF(IPATH(5,K).EQ.0.OR.IPATH(6,K).EQ.0) GO TO 160
      CALL MULT(H,LENHAB,D,LENDIE,COMB,LENCOM)
C                CALCULATE DOSE FOR THIS PATH- COMBINED TABLE
      CALL CALC(C,LENCON,COMB,LENCOM,DF,LENDOS,IPATH(3,K),ISECND)
      GO TO 165
C                USE EITHER THE DIET OR THE HABIT TABLE AS APPROPRIATE
C           FOR THE DOSE CALCULATION
  160 IF(IPATH(5,K).NE.0) CALL CALC(C,LENCON,D,LENDIE,DF,LENDOS,
     1IPATH(3,K),ISECND)
      IF(IPATH(6,K).NE.0) CALL CALC(C,LENCON,H,LENHAB,DF,LENDOS,
     1IPATH(3,K),ISECND)
  165 IF(IPATH(3,K)-2)  ,175,
      IF(IPATH(1,K)-45)  ,166,
      IF(IPATH(1,K)-11)  ,,167
  166 CONTINUE
C           OBTAIN DOSE COMMITTMENT TABLE
      CALL GET(KEYS(5,IPATH(7,K),0),DC,LENGDC)
  167 ISECND=2
      IF(LENGDC) 168,168,
      IF(KOUNT)  ,,172
      ICALC=1
      IF(PATH(5,K).EQ.0.OR.PATH(6,K).EQ.0) GO TO 169
C           CALCULATE A DOSE USING THE COMBINED TABLE
      CALL CALC(C,LENCON,COMB,LENCOM,DC,LENGDC,IPATH(3,K),ISECND)
      GO TO 175
C           USE EITHER THE DIET OR THE HABIT TABLE
  169 IF(IPATH(5,K).NE.0) CALL CALC(C,LENCON,D,LENDIE,DC,LENGDC,
     X IPATH(3,K),ISECND)
      IF(IPATH(6,K).NE.0) CALL CALC(C,LENCON,H,LENHAB,DC,LENGDC,
     X IPATH(3,K),ISECND)
      GO TO 175
C                TABLE IS NOT PRESENT
```


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```
  168 IF(KOUNT.EQ.0) GO TO 170
      IF(IERROR(KOUNT).NE.'DOSE F') KOUNT=KOUNT+1
  170 IF(KOUNT.EQ.0) KOUNT=1
      IERROR(KOUNT)='DOSE C'
  172 CONTINUE
      IF(IFIRST.EQ.0) IFIRST=1
      IF(IPATH(14,K).EQ.999) GO TO 173
      WRITE(REPORT,103)(PATH(N,K),N=9,11),(IERROR(N),N=1,KOUNT)
  173 WRITE(REPORT,102) (PATH(N,K),N=9,11)
  175 IF(ICALC) 200,200,
      CALL TIMER(2,5)
      CALL TIMER(1,6)
      IF(M(1).NE.' ') CALL DOSERP(PATH(9,K),LOCAT,PATH(3,K))
      CALL TIMER(2,6)
      CALL TIMER(1,5)
  200 CONTINUE
  300 CONTINUE
C                 REPORT DOSE FOR ALL PATHWAYS
      CALL TIMER(2,5)
      CALL TIMER(1,6)
      CALL DOSERP('ALL PATHWAYS      ',LOCAT,3)
      CALL PERCEN(PATH,LOCAT,1)                                        08/11/71
      CALL RESET
      CALL PUT(KEYS( 99,I,0),TOTALS,96)
      CALL TIMER(2,6)
      IF(L(I).LT.4.OR.L(I).EQ.7) GO TO 9999                            08/11/71
      CALL PERCEN(PATH,'COMPOSITE         ',2)                         08/11/71
      CALL SUMMRY
 9999 CONTINUE
10000 CONTINUE
      CALL PERCEN(PATH,'COMPOSITE         ',2)                         08/11/71
      RETURN
      END
```

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```
@ ELT FORAGE,1,710416, 46007

      SUBROUTINE FORAGE( QUANT,YIELD ,CENTRD,CONCF ,INTAKE,LENGTH,RATEI,
     X PERCN1)
C         THIS SUBROUTINE CALCULATES THE RADIONUCLIDE INTAKE OF
C         LIVESTOCK FROM FRESH FORAGE BY THE FOLLOWING FORMULA-
C         I=Q(RM/Y*(D+EN) +B(FA+FN))
C         SEE ALSO THE FOOD PATHWAYS DESCRIPTION BY R.D. HARR
C         EXPLANATION OF CALL LIST
C              PERCN1    PERCENT OF PASTURE IRRIGATED
C              QUANT     MONTHLY CONSUMPTION VECTOR
C              YIELD     FORAGE YIELD FACTOR
C              CENTRD    CENTROID NUMBER OF SOURCE
C              INTAKE    INTAKE TABLE(CONCENTRATION FORMAT)
C              LENGTH    NUMBER OF ENTRIES IN TABLE
C              CONCF     CONCENTRATION FACTOR
C              RATEI     MONTHLY IRRIGATION RATE
C
      INCLUDE TABLE1,LIST
      INCLUDE TABLE2,LIST
      INTEGER CENTRD,CODE,PERCN1
      REAL INTAKE
      DIMENSION QUANT(1),CONCF(1), INTAKE(2,1),RATEI(1)
      DATA CODE/0/
      EQUIVALENCE(IDEBUG,M(50))
      LENGTH=0
      SUM=0.0
      DO 10 I=1,12
   10 SUM=SUM+QUANT(I)
      IF(SUM)  ,700,
      LENCOM=0
      IF(PERCN1) ,220,
C         OBTAIN THE IRRIGATION CONCENTRATIONS FOR THIS YEAR
      CALL GET(KEYS(CODE,CENTRD,14),COMB,LENCOM)
      IF(LENCOM) ,,200
```

```
      WRITE(REPORT,101)  CENTRD
  101 FORMAT(' ','CURRENT IRRIGATION TABLE MISSING FOR FORAGE CALCULATIO
     XN. CENTROID NUMBER IS ',I3)
C         MULTIPLY THE TABLE BY THE RATE OF IRRIGATION
  200 CALL MULT3(RATEI,COMB,LENCOM)
C         MULTIPLY BY THE % OF TOTAL IRRIGATED
      CALL MULT1(PERCN1/100.0,COMB,LENCOM)
C         OBTAIN THE DRY DEPOSITION FROM AIR FOR THE CURRENT YEAR
  220 CALL GET(KEYS(CODE,CENTRD,6),DF,LENGDF)
      IF(LENGDF) ,,400
      WRITE(REPORT,102) CENTRD
  102 FORMAT(' CURRENT AIR DEPOSITION      NOT AVAILABLE FOR FORAGE CALC
     XULATION. CENTROID NUMBER IS ',I3)
  400 CALL MERGE(DF,LENGDF,COMB,LENCOM,ALOSS,LENLOS)
C         MULTIPLY BY THE ACCUMULATION FACTORS
      CALL MULT2(ACCUMF,ALOSS,LENLOS)
C         MULTIPLY BY RETENTION FACTOR/ YIELD FACTOR
      DUMMY=RETENT/(YIELD*30.0)
      CALL MULT1(DUMMY,ALOSS,LENLOS)
      IF(IDEBUG.EQ.1) CALL DUMP(ALOSS,LENLOS)
C         OBTAIN THE LONG TERM DEPOSITION FROM AIR
      CALL GET(KEYS(CODE,CENTRD,7),COMB,LENCOM)
      IF(LENCOM) ,, 500
      WRITE(REPORT,104) CENTRD
  104 FORMAT(' LONG TERM AIR DEPOSITION NOT AVAILABLE FOR FORAGE CALCULA
     XTION. CENTROID NUMBER IS ',I3)
  500 LENGDF=0
      IF(PERCN1)  ,650,
C         OBTAIN THE LONG TERM CONTAMINATION FROM IRRIGATION WATER
C     CALL GET(KEYS(CODE,CENTRD,13),DF,LENGDF)
C     IF(LENGDF) 600,600,600 *** REDUNDANT,MUTED 3/15/71 B W BENTLEY
C     WRITE(REPORT,105) CENTRD
  105 FORMAT(' LONG TERM IRRIGATIONCONTAMINATION NOT AVAILABLE FOR FORAG
     XE CALCULATION. CENTROID NUMBER IS ',I3)
C         MULTIPLY BY THE PERCENT IRRIGATED
  600 CALL MULT1(PERCN1/100.0,DF,LENGDF)
```

```
C          ADD THESE TWO DEPOSITIONS TOGETHER
  650 CALL MERGE(COMB,LENCOM,DF,LENGDF,C,LENGTC)
C          MULTIPLY BY THE CONCENTRATION FACTOR VECTOR
      CALL MULT2(CONCF ,C,LENGTC)
      IF(IDEBUG.EQ.1) CALL DUMP(C,LENGTC)
C          ADD THIS TABLE TO THE CONTAMINATION FROM AIR
      CALL MERGE(C,LENGTC,ALOSS,LENLOS,INTAKE,LENGTH)
C          NOW MULTIPLY BY THE MONTHLY FORAGE INTAKE VECTOR
      CALL MULT3(QUANT,INTAKE,LENGTH)
      IF(IDEBUG.EQ.1) CALL DUMP(INTAKE,LENGTH)
  700 RETURN
      END
```


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```
@ ELT MULT,1,710320, 62296

      SUBROUTINE MULT(HABIT,LENHAB,DIET,LENDIE,COMB,LENCOM)
C               THIS SUBROUTINE MULTIPLIES THE HABIT AND THE DIET TABLES
C          TOGETHER TO OBTAIN THE COMBINED TABLE.
C          EXPLANATION OF CALL LIST-
C          HABIT      HABIT TABLE
C          LENHAB     NUMBER OF ENTRIES IN THE HABIT TABLE
C          DIET       DIET TABLE
C          LENDIE     NUMBER OF ENTRIES IN THE DIET TABLE
C          COMB       COMBINED TABLE
C          LENCOM     LENGTH OF COMBINED TABLE
      DIMENSION HABIT(2,1),DIET(2,1),COMB(2,1),ID(51)
      ISHS=1
C               INITIALIZE THE LENGTH OF THE COMBINED TABLE
      LENCOM=0
      IF(LENHAB.EQ.0.OR.LENDIE.EQ.0) GO TO 1010
C               SET UP THE ID TABLE TO CONTAIN THE LAST INDEX IN  THE
C          DIET TABLE FOR EACH TYPE OF PERSON.
      DO 50 I=1,51
   50 ID(I)=0
      DO 100 I=1,LENDIE
      ICODE= FLD(0,12,DIET(1,I))
  100 ID(ICODE+1)= I
C               NOW LOOP THROUGH THE HABIT TABLE ONE ENTRY AT A TIME AND
C          SET UP THE BEGINNING AND ENDING INDICES FOR THE DIET TABLE.
      DO 1000 I=1,LENHAB
      ICODE = FLD(0,12,HABIT(1,I))
      IFH = ID(ICODE+1)
C               IF THERE IS NO ENTRY IN THE INDEX TABLE FOR THIS PERSON
C          BYPASS THE CALCULATION.
      IF(IFH) 1000,1000,
      MONTHH = FLD(12,12,HABIT(1,I))
C               IF THE STARTING INDEX IS ZERO A PREVIOUS NONZERO ENTRY
```

```
C          MUST BE FOUND
      DO 200  N=ICODE,1,-1
      IF(ID(N)) ,,250
  200 CONTINUE
  250 ISH=ID(N)+1
      ISH = MAX(ISHS,ID(N)+1)
C                NOW LOOP THROUGH THE DIET TABLE. IF DIET AND HABIT MONTHS
C          MATCH  MULTIPLY THE DIET AND HABIT ENTRIES.
      DO 800 J=ISH,IFH
      MONTHD = FLD(12,12,DIET(1,J))
      IF(MONTHH-MONTHD)  600,,800
      LENCOM = LENCOM+1
      COMB(1,LENCOM) = HABIT(1,I)
      COMB(2,LENCOM) = HABIT(2,I)*DIET(2,J)
      GO TO 800
C                SAVE THE STARTING INDEX FOR THE DIET TABLE
  600 ISHS=J
      GO TO 1000
  800 CONTINUE
 1000 CONTINUE
 1010 RETURN
      END
```


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APPENDIX C

FISSION AND ACTIVATION PRODUCT GENERATION ANALYSIS

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APPENDIX C

FISSION AND ACTIVATION PRODUCT GENERATION ANALYSIS

The following paragraphs detail methods for calculating the generation rates of radioisotopes originating as fission or activation products in the operation of a nuclear reactor.

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FISSION PRODUCT GENERATION

I. ASSUMPTIONS

1. Isotopes with a determining half life of less than 15 days are at equilibrium.

2. Unless specifically mentioned, neutron transmutation effects are ignored.

3. Plant power is taken to be the plant factor times the rated power. Isotopes with short half lives will be at equilibrium with the true power which may be quite different from this definition since plant factor includes fractional operating time as well as fraction of rated power.

4. The analysis described herein is based on nominal plant ratings of 1000 MW electric (2500 MW_t for LMFBR's and 3050 MW_t for LWR's.)

II. ISOTOPIC GENERATION RATES

1. General Case

Isotopes which are not generated by neutron capture and whose decay parents are at equilibrium have a production rate determined only by the power, the isotopic fission yield, and the fuel.

$$G = \frac{F\ P_f\ Y}{100\ E_t}$$

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where:

G is the generation rate in atoms/sec.

P_f is the plant factor.

Y is the cumulative fission yield in percent.

F is the fission rate at 1000 MWe and is equal to 7.25×10^{19} fissions per sec for an LMFBR (^{239}Pu) and 9.51×10^{19} fissions per sec for a BWR or PWR (^{235}U).

E_t is the thermal efficiency.

2. Special Cases

a. ^{95}Nb has a decay parent (65 d ^{95}Zr) which may not be at equilibrium. Furthermore for the thermal reactors, there is a direct fission yield for ^{95}Nb. The generation rate for ^{95}Nb is given by:

$$G_{^{95}Nb} = G_{^{95}Zr}\left(1-e^{-t\lambda_{^{95}Zr}}\right) + G'_{^{95}Nb}$$

where:

$G_{^{95}Nb}$ is the generation rate for ^{95}Nb

$G'_{^{95}Nb}$ is the generation rate for ^{95}Nb due to the direct fission yield. It can be calculated from the expression for G by using the direct fission yield in place of the cumulative yield.

$\lambda_{^{95}Zr}$ is the decay constant for ^{95}Zr

t is the irradiation time of the fuel (see section III).

b. ^{134}Cs is produced primarily by neutron capture in stable ^{133}Cs which is continually building towards a burnout equilibrium. Thus:

$$G_{^{134}Cs} = G_{^{133}Cs}\left(1-e^{-\phi\sigma_{133}t}\right)$$

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where:

ϕ is the neutron flux level in neutrons/cm^2-sec.

ϕ_{133} is the ^{133}Cs capture cross section in cm^2.

$\phi_{133} = 30.6 \times 10^{-24} cm^2$ for either BWR or PWR.

$\phi_{133} = .438 \times 10^{-24}\ cm^2$ for an LMFBR on the assumption the spectrum is similar to that in FTR.

III. CLOSED SYSTEM INVENTORIES

1. Equilibrium Isotopes

For those isotopes at decay equilibrium, the decay rate must equal the generation rate. Thus

$$\lambda N = G$$

or

$$N = \frac{G}{\lambda}$$

where:

N is the total number of atoms of the isotope.

λ is the decay constant in $sec.^{-1}$.

G is the generation rate in atoms per sec.

λN, the decay rate in atoms per sec., may be converted to curies by dividing by 3.7×10^{10}.

2. Isotopes not at equilibrium.

All the non-equilibrium isotopes considered have parents which are at equilibrium except those specifically mentioned in the following section (Special Cases). These isotopes must have the equilibrium value reduced by the factor $1 - e^{-\lambda t}$ thus:

$$\lambda N = G(1 - e^{-\lambda t})$$

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or

$$N = \frac{G}{\lambda} (1 - e^{-\lambda t})$$

where:

t is the total elapsed time in seconds since fuel insertion.

t may be calculated from the fuel exposure by the following relation:

$$t = \frac{86400\ E}{P_s\ P_f}$$

where:

E is the fuel exposure in MWD/tonne.

P_s is the specific power at rated power, taken to be 150 MW/T for an LMFBR, 39 MW/T for a PWR, and 21 MW/T for a BWR.

P_f is the time average of the plant factor since fuel insertion.

3. Special Cases

a. ^{95}Nb has a decay parent (^{95}Zr) which is not at equilibrium. The decay rate is given by:

$$\lambda N = G'_{^{95}Nb} \left(1 - e^{-\lambda t}\right) + G_{^{95}Zr} \left[1 - \frac{\lambda e^{-t\lambda_{^{95}Zr}} - \lambda_{^{95}Zr}\ e^{-\lambda t}}{\lambda - \lambda_{^{95}Zr}}\right]$$

all symbols are previously defined.

b. ^{129}I has such a long half life (1.6×10^7 y) that the buildup is linear over a fuel lifetime. Thus:

$$N = G\ t$$

and

$$\lambda N = \lambda G\ t$$

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c. When ^{135}Xe is at equilibrium in thermal reactors, the combined decay and burnup rates determine the equilibrium inventory. Thus:

$$\lambda N + \phi\sigma N = G$$

where:

ϕ is the flux level in neutrons per cm^2-sec.

σ is the Xe capture cross section in cm^2. For BWR or PWR, $\sigma = 2.7 \times 10^{-18}\ cm^2$.

and:

$$N = \frac{G}{\lambda + \phi\sigma}$$

or:

$$\lambda N = \frac{\lambda\ G}{\lambda + \phi\sigma}$$

Note: For LMFBR's ^{135}Xe is at decay equilibrium. ($\sigma \simeq 10^{-25} cm^2$).

d. ^{134}Cs is produced by neutron capture in the stable fission product ^{133}Cs which of course is not at equilibrium. ^{134}Cs has no direct fission yield. The decay rate is given by:

$$\lambda N = \frac{\lambda\ G_{133}}{\lambda + \phi\sigma_{134}} \left[1 - \frac{(\lambda + \phi\sigma_{134})\ e^{-\phi\sigma_{133}t} - \phi\sigma_{133}\ e^{-(\lambda + \phi\sigma_{134})t}}{\lambda + \phi\sigma_{134} - \phi\sigma_{133}} \right]$$

where:

G_{133} is the generation rate for ^{133}Cs

σ_{133} is the capture cross section for ^{133}Cs

$\sigma_{133} = 30.6 \times 10^{-24}\ cm^2$ for BWR, PWR

$\sigma_{133} = 0.438 \times 10^{-24}\ cm^2$ for LMFBR

σ_{134} is the capture cross section for ^{134}Cs

$\sigma_{134} = 136 \times 10^{-24}\ cm^2$ for BWR, PWR

$\sigma_{134} = 0.136 \times 10^{-24}\ cm^2$ for LMFBR

other symbols as previously defined.

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e. The activities of certain isotopes after release or shutdown do not follow an exponential decay determined by their respective half life. The case of ^{135}Xe in a thermal reactor is a well known example. The inventory at shutdown is determined by the burnout rate as well as the decay rate. After shutdown, the inventory may thus increase. The decay rates of ^{95}Nb, ^{135m}Xe, and ^{140}La may be determined by the longer half lives of their respective parents.

IV. NUCLEAR DATA

The necessary nuclear data for the above calculations have been assembled and are shown in Table C-1. Half lives were taken from Reference (C-1). Those that are different from the master list values are marked with an asterisk. With the exception of tritium, fission yields were taken from the recent compilation of Meek and Rider[C-2]. The yield for tritium was taken from Reference (C-3).

C-1 C. M. Lederer, J. M. Hollander, and I. Perlman, "Table of Isotopes," sixth edition, John Wiley & Sons, 1967.

C-2 M. E. Meek and B. F. Rider, "Summary of Fission Product Yields for U^{235}, U^{238}, and Pu^{239}, and Pu^{241} at Thermal, Fission Spectrum, and 14 MeV Neutron Energies," General Electric Company, APED-5398-A, 1968.

C-3 "Environmental Effects of Producing Electric Power, Part I," Hearings Before the Joint Committee on Atomic Energy, U. S. Congress, U. S. Printing Office, 1969.

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TABLE C-1

FISSION PRODUCT GENERATION NUCLEAR DATA

Isotope	Half Life		Equilibrium	Cumulative Fission Yield, Per Cent LMFBR	BWR,PWR	Notes
H -3	12.26	y	no	0.01	0.01	
Kr-85 m	4.4	h	yes	0.69	1.30	
Kr-85	10.76	y	no	0.159	0.299	
Kr-87	76.	m	yes	1.14	2.53	Delayed neutrons ignored
Kr-88	2.8	h	yes	1.4	3.56	Delayed neutrons ignored
Sr-89	52.	d*	no ∇	1.8	4.76	Delayed neutrons ignored, volatile 15 m parent
Sr-90	28.1	y*	no	2.11	5.83	
Zr-95	65.	d	no	5.3	6.2	
Nb-95	35.	d	no †	5.3	6.41	65 d parent - special treatment
Mo-99	67.	h	yes	5.88	6.16	
Ru-103	39.6	d*	no	5.85	3.0	
Ru-106	367.	d*	no	4.7	0.399	Note yield difference
Te-132	78.	h	yes	3.5	4.26	
I -129	1.7×10^7	y*	no †	1.2	1.0	Linear buildup
I -131	8.05	d	yes	3.4	2.91	
I -132	2.3	h	yes	3.76	4.26	78 hr parent
I -133	21.	h	yes	5.7	6.69	
I -135	6.7	h	yes	6.3	6.17	
Xe-131 m	12.	d	yes ∇	0.020	0.017	Volatile 8 d parent
Xe-133 m	2.26	d	yes ∇	0.14	0.16	Volatile 21 h parent
Xe-133	5.27	d	yes ∇	5.7	6.69	Volatile 21 h, 2 d parents
Xe-135 m	15.6	m*	yes ∇ †	2.2	1.8	6.7 hr parent governs decay
Xe-135	9.2	h	yes ∇ †	6.8	6.3	Capture important, volatile 7 h parent
Xe-138	17.	m	yes	5.0	6.0	Delayed neutrons effect included in yield
Cs-134	2.05	y*	no †	0.0 (5.7^x)	0.0 (6.69^x)	Capture all important!
Cs-137	30.	y	no	6.5	6.20	
Ba-140	12.8	d	yes	5.1	6.30	
La-140	40.22	h*	yes †	5.1	6.34	13 d parent governs decay
Ce-141	33.	d*	no	4.2	6.1	
Ce-144	284.	d*	no	3.53	5.40	Hi energy daughter

* - Table of Isotopes Value - Master list different
† - Requires special treatment - see text
∇ - Volatile parent
x - Cs-133 yield

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HERMES CODE

ACTIVATION PRODUCT GENERATION

The inventory of an activation isotope is given by:

$$N = \frac{G}{\lambda} (1 - e^{-\lambda t})$$

where:

N is the atom inventory in the volume of interest

λ is the decay constant

t is the time since insertion in the neutron flux

G is the generation rate which can be expressed as:

$$G = P_f \int_V N_p(r) \int_E \phi(E,r)\ \sigma(E,r)\ drdE$$

where:

Pf is the plant factor

$N_p(r)$ is the atom density of the parent isotope

$\phi(E,r)$ is the neutron flux at rated power

$\sigma(E,r)$ is the activation cross section

The expression for G can be simplified for only a few special cases. One is the case of the thermal reactor and a reaction with a large thermal cross section. One may then write:

$$\phi(E,r) = \phi_{th}\ (r)$$

$$\sigma(E,r) = \sigma_{th}\ (r)$$

If one further assumes regionally homogeneous materials, the generation rate then reduces to:

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$$G = P_f \sum_{i=1}^{reg} N_p^i \sigma_{th}^i \int_{V_i} \phi_{th}^i(r)dr$$

$$= P_f \sum_{i=1}^{reg} N_p^i \sigma_{th}^i V^i \bar{\phi}_{th}^i$$

Thus, with the thermal cross section known, all that is required is the average thermal flux in the region(s) of interest. The threshhold reactions and the reactions in an LMFBR are not as amenable to simplification due to spectral sensitivity and gross spectral changes respectively.

It is possible to handle this energy as well as the spatial dependence adequately using locally available multigroup codes. For instance, the ^{24}Na value reported here is an extrapolation of Fast Test Reactor (FTR) results calculated with the multigroup diffusion code 2DBS. It is strongly suggested that such calculations be made for each of the reference designs for the necessary reactions. However, for the present, tractable simplifications for G are used. With the assumption of regionally homogeneous materials, we may write.

$$G = P_f \sum_{i=1}^{reg} N_p^i \int_{V_i} \int_E \phi(E,r)\ \sigma^i(E)\ drdE$$

Values of the double integral for many of the isotopes of interest were calculated for FTR using multigroup codes. These values, of course, involve the volumes typical of FTR. One may, however, define an average reaction rate per atom as:

$$\overline{\phi\sigma}^{\,i} = \frac{\int_{V_i} \int_E \phi(E,r)\ \sigma^i(E)\ drdE}{V_i}$$

then:

$$G = P_f \sum_{i=1}^{reg} N_p^i\ V^i\ \overline{\phi\sigma}^{\,i} \qquad (1)$$

Many of the enclosed values of $\phi\sigma$ for LMFBR (usually noticeable by lack of a one-group cross section) were taken from values of $\overline{\phi\sigma}$ for FTR.

The remainder of the $\phi\sigma$ values reported were formed from one-group estimated values: $\overline{\phi\sigma}^{\,i}$ above can be written:

$$\overline{\phi\sigma}^{\,i} = \frac{\int_{V_i} \int_E \phi(E,r)\ \sigma^i(E)\ drdE \quad \int_{V_i} \int_E \phi(E,r) drdE}{\int_{V_i} \int_E \phi(E,r) drdE \qquad\qquad V_i}$$

$$= \overline{\sigma}^{\,i}\ \overline{\phi}^{\,i}$$

Most of the threshhold reactions were handled this way. Values for $\overline{\sigma}$ and $\overline{\phi}$ above a standard 1.5 MeV threshhold were estimated.

Two values for $\phi\sigma$ are given, one for the vessel vicinity and one a "core" value which is really an average value to be used anywhere inside the vessel.

The necessary values for calculating the activation rates are given in Table C-2. No values for tritium production in lithium are

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given as it is assumed only ^{7}Li will be used. No values for argon production from radiative capture in the LMFBR cover gas above the pool were given as it was assumed this production rate was small compared to the production from impurity potassium in the pool.

TABLE C-2

ACTIVATION ISOTOPES PRODUCTION RATES

Isotope	How	Where	σ, barns		φσ (sec.$^{-1}$)					
					LMFBR		PWR		BWR	
			LMFBR	BWR,PWR	Core	Vessel	Core	Vessel*	Core	Vessel*
H-3	B-10 (n,t)	control	**2.5-2†	**2.5-2	6.63-12	-------	5.33-13	0	2.90-13	0
	Li (n,t)		--------	0	-------	-------	0	0	-------	-------
	H^2+n→t	water	--------	5.7-4	-------	-------	3.32-14	3.32-15	1.80-14	1.80-15
N-13	O-16 (p,α)	water, fuel	--------	-------	-------	-------	-------	-------	-------	-------
C-14	N-14 (n,p)	coolant	**5.-2	**5.-2	1.33-11	0	1.07-12	0	5.81-13	0
	C-13 (n,γ)	steel	Δ	9.-4	4.94-15	4.94-15	5.24-14	5.24-15	2.85-14	2.85-15
Na-22	Na-23 (n,2n)	coolant	Δ	-------	2.25+13γ	0	-------	-------	-------	-------
Na-24	Na-23 (n,γ)	coolant	Δ	-------	2.81+18γ	-------	-------	-------	-------	-------
Ar-39	Ar-40 (n,2n)	coolant	?	?	?	?	?	?	?	?
	Ar-38 (n,γ)	coolant covergas	Δ	0.8	4.39-12	4.39-12	4.66-11	4.66-12	2.53-11	2.53-12
	K-39 (n,p)	coolant	**5.-2	-------	1.33-11	0	-------	-------	-------	-------
Ar-41	Ar-40 (n,γ)	coolant covergas	Δ	0.723	3.96-12	3.96-12	4.21-11	4.21-12	2.29-11	2.29-12
	K-41 (n,p)	coolant	**0.001	-------	2.65-12	0	-------	-------	-------	-------
Cr-51	Cr-50 (n,γ)	steel	Δ	17.	9.32-11	9.32-11	9.89-10	9.89-11	5.38-10	5.38-11
Mn-54	Mn-55 (n,2n)	steel	0	0	0	0	0	0	0	0
	Fe-54 (n,p)	steel	**0.25	**0.25	6.63-11	0	5.33-12	2.50-14	2.90-12	1.36-14
Fe-55	Fe-54 (n,γ)	steel	Δ	2.9	1.59-11	1.59-11	1.69-10	1.69-11	9.17-11	9.17-12
Fe-59	Fe-58 (n,γ)	steel	Δ	1.2	6.58-12	6.58-12	6.98-11	6.98-12	3.79-11	3.79-12
Co-58	Ni-58 (n,p)	steel	**0.2	**0.2	5.30-11	0	4.26-12	2.00-14	2.31-12	1.09-14
	Co-59 (n,2n)	steel	**0.2	**0.2	5.30-11	0	4.26-12	2.00-14	2.31-12	1.09-14
Co-60	Co-59 (n,γ)	steel	Δ	37.	2.03-10	2.03-10	2.15-9	2.15-10	1.17-9	1.17-10
	Ni-60 (n,p)	steel	**0.002	**0.002	5.30-13	0	4.26-14	2.00-16	2.31-14	1.09-16
Ni-63	Ni-62 (n,γ)	steel	Δ	15.	8.22-11	8.22-11	8.73-10	8.73-11	4.74-10	4.74-11
Cu-64	Cu-63 (n,γ)	coolant	-------	4.5	-------	-------	2.61-10	2.61-11	1.42-10	1.42-11
Zn-65	Zn-64 (n,γ)	coolant	-------	0.46	-------	-------	2.67-11	2.67-12	1.45-11	1.45-12
Zr-95	Zr-94 (n,γ)	cladding	-------	0.08	-------	-------	4.66-12	4.66-13	2.53-12	2.53-13
Nb-95	Zr-95 decay	cladding	-------	-------	-------	-------	-------	-------	-------	-------
Mo-99	Mo-98 (n,γ)	steel	Δ	0.51	2.80-12	2.80-12	2.97-11	2.97-12	1.61-11	1.61-12

* φth at vessel assumed 0.1 of core average value
φ (E> 1.5 MeV) = 10^{11} PWR, 5.4 x 10^{10} BWR

** average above 1.5 MeV

† read as 2.5 x 10^{-2}

Δ One group σ not generated from multigroup set used to get φσ

γ Use N=1 to get φσN

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APPENDIX D

HERMES SUBELEMENT OPERATING INSTRUCTIONS

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APPENDIX D

HERMES SUBELEMENT OPERATING INSTRUCTIONS

I. RADREL OPERATING INSTRUCTIONS

The RADREL subelement of the HERMES code has the function of creating a radionuclide "source map" -- a data tape listing locations of all nuclear facilities in the area under study, and release rate data for each facility. Required input data for RADREL include an output tape from the MOPOSH code -- listing the startup date and month-by-month average plant factors for each power plant -- and data card decks providing (1) location data for each plant site and (2) reprocessing plant effluent rates from the REPARE code. The site data cards are described in Section VII of this appendix, and the output cards from REPARE are described in Section III.

In addition, four sets of control cards are required to operate RADREL. These control cards are described in Table D-1, and a sample deck as assembled for execution of this code is illustrated in Figure D-1.

The output tape from RADREL transmits data on nuclear plant site locations, plant characteristics, and radionuclide releases, to the transport codes ARTRAN and WTRAN. The structure of this tape is shown in Table D-2.

TABLE D-1

RADREL CONTROL CARD FORMATS

Control Card No. 1

FORMAT (5I5)

*CC 1-5	Number of sites
CC 6-10	Number of months
CC 11-15	Total number of isotopes
CC 16-20	Number of isotopes for air list
CC 21-25	Number of isotopes for water list

*CC indicates card column.

TABLE D-1

(continued)

Control Card No. 2

FORMAT (I5)

CC 1-5 An integer indicating the number of reprocessing plants in this study.

Control Deck No. 3 (multiple cards)

FORMAT (I10, F10.0)

CC 1-10 A four-digit coded integer designating the site for a reprocessing plant.

CC 11-20 Startup year for the reprocessing plant.

Control Deck No. 4 (4 cards)

FORMAT (13A6)

CC 1-6 are key Hollerith words controlling program actions. This deck must have four cards in the prescribed order. For clarity the alpha characters beyond the six key characters may form a statement, see below.

Don't RESTART RADREL with DOSIS DATA TAPE
NEW PLANT DATA
WRITE NEW TAPE
NEW SOURCE MAP WRITTEN

If the key words (6 characters) are other than those illustrated, then the resultant action is negative, i.e., the first card commands that the action to restart RADREL not be taken.

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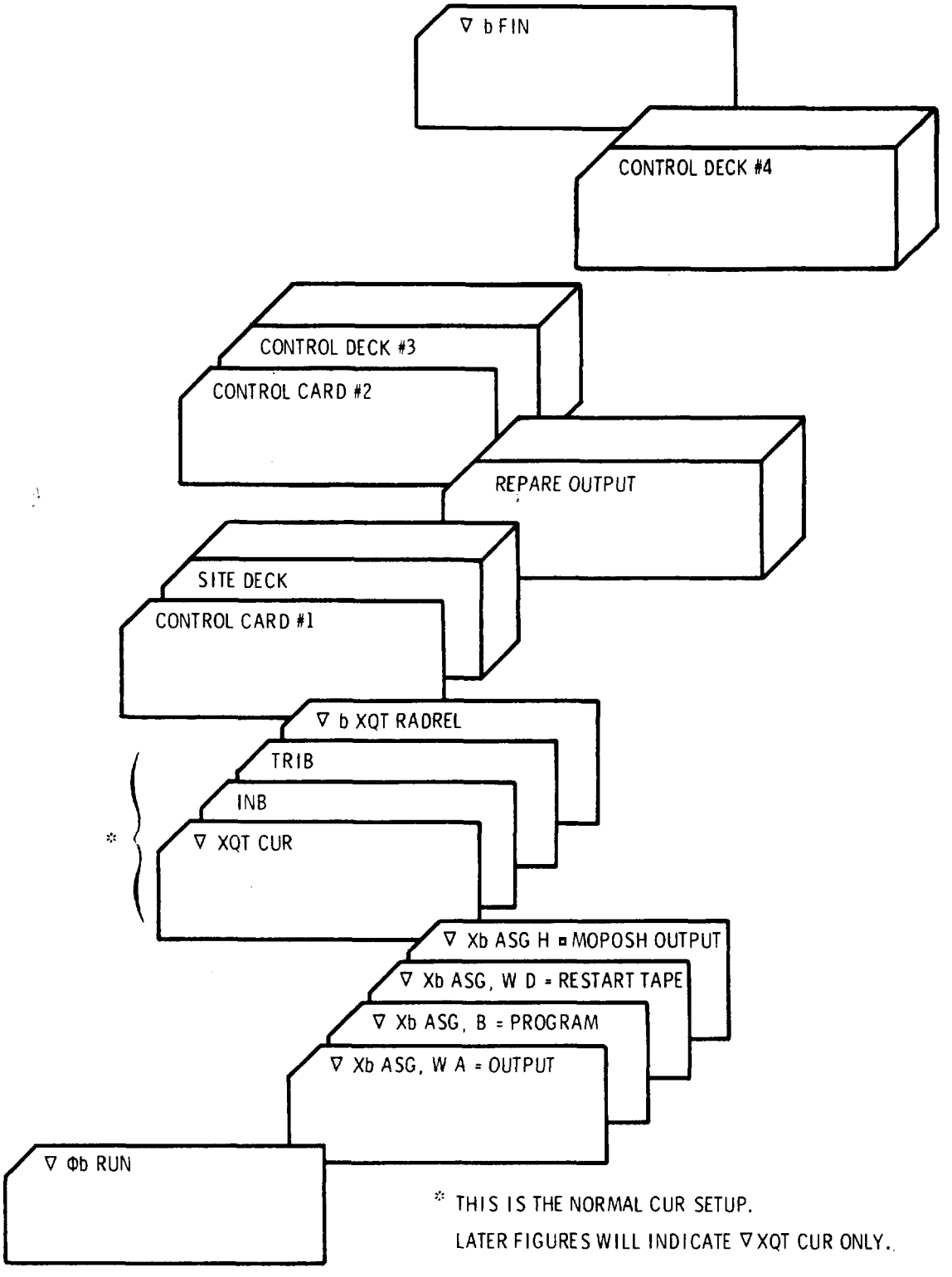

Figure D-1: Sample Deck for RADREL

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TABLE D-2

RADREL OUTPUT TAPE STRUCTURE

File No.	Record No.	Word No.	Statement Type	Description
1	1	1-20	Hollerith	Tape Title
	2	1	Integer	No. of sites included (n_s)
		2	"	No. of months of data (n_m)
		3	"	Total no. of isotopes included (n_i)
		4	"	No. of isotopes in air release data (n_a)
		5	"	No. of isotopes in water release data (n_w)
		6	"	Total no. of possible plants (n_p) (if all sites fully utilized)
		END OF FILE		
2	1	1	Real	Half-life (sec.) for Isotope 1
		.	.	.
		.	.	.
		.	.	.
		n_i	Real	Half-life (sec.) for Isotope n_i
		END OF FILE		
3	1	1	Real	Latitude of Site 1 (degrees)
		2	"	Longitude of Site 1 (degrees)
		.	.	.
		.	.	.
		.	.	.
		$2n_s-1$	"	Latitude of site n_s (degrees)
		$2n_s$	"	Longitude of site n_s (degrees)
		END OF FILE		
4	1	1	Real	River mile for site 1
		.	.	.
		.	.	.
		.	.	.
		n_s	Real	River mile for site n_s

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TABLE D-2

(continued)

File No.	Record No.	Word No.	Statement Type	Description
4	2	1-3	Hollerith	River name, site 1 (18 characters)
		4-6	"	River name, site 2
		.	.	.
		.	.	.
		.	.	.
		(to 3 n_s)	"	River name, site n_s
			END OF FILE	
				Releases to Air (pCi/sec)
5	1	1	Real	Isotope 1 Site 1 Month 1
		2	"	2 1 1
		n_a	"	n_a 1 1
		n_a+1	"	Latitude of Site 1 (degrees)
		n_a+2	"	Longitude of Site 1 (degrees)
		n_a+3	"	Stack Height, Site 1 (meters)
		n_a+4	"	Startup year, Site 1
				Releases to Air, (pCi/sec)
5	2	1	Real	Isotope 1, Site 2, Month 1
		.	.	.
		.	.	.
		.	.	.
		n_a	"	Isotope n_a, Site 2, Month 1
		.	"	.
		.	"	.
		.	"	.
		n_a+4	"	Startup Year, Site 2
	.			
	.			
	.			
	n_s	1	Real	Isotope 1 Site n_s, Month 1
		.	.	.
		.	.	.
		.	.	.

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File

TABLE D-2

(continued)

File No.	Record No.	Word No.	Statement Type	Description
5	n_s	n_a	Real	Isotope n_a Site n_s, Month 1
		n_a+4	"	Startup year, Site n_s
	n_s+1	1	Real	Isotope 1, Site 1, Month 2
		.	.	.
		.	.	.
		.	.	.
		n_a+4	"	Startup Year, Site 1
	$n_s n_m$	1	Real	Isotope 1, Site n_s, Month n_m
		.	.	.
		.	.	.
		.	.	.
		n_a+4	"	Startup Year, Site n_s
			END OF FILE	
6	1			Releases to Water (pCi/Sec)
		1	Real	Isotope 1, Site 1, Month 1
		2	"	2, 1, 1
		.	.	.
		.	.	.
		.	.	.
		n_w	"	n_w
	2	1	Real	1, 2, 1
		.	.	.
		.	.	.
		.	.	.
		n_w	"	n_w 2 1
	.			
	.			
	.			

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TABLE D-2

(continued)

File No.	Record No.	Word No.	Statement Type	Description			
6	n_s	1	Real	Isotope 1,	Site n_s,	Month 1	
		.	.	.	.	.	
		.	.	.	.	.	
		.	.	.	.	.	
		n_w	"	n_w,	n_s,	1	
	n_s+1	1	Real	Isotope 1,	Site 1,	Month 2	
		.	.	.	.	.	
		.	.	.	.	.	
		.	.	.	.	.	
		n_w	"	n_w,	1,	2	
	.	.	.	.	.	.	
	.	.	.	.	.	.	
	.	.	.	.	.	.	
	$n_s n_m$	1	Real	1,	n_s	n_m	
		.	.	.	.	.	
		.	.	.	.	.	
		.	.	.	.	.	
		n_w	"	n_w,	n_s	n_m	
			END OF FILE				

The RADREL output tape is a binary tape written by and accessed through the buffered input/output routine NTRAN[D-1].

D-1 "Univac 1108 User's Manual" Document CSC-6812-1, Computer Sciences Corporation, Richland, Washington, 1968.

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II. DOSIS OPERATING INSTRUCTIONS

The DOSIS code is designed to be operated either as a separate code or as a subroutine in RADREL. To execute DOSIS by itself, it is necessary to employ a "dummy" main program, SUPER, which is included on the DOSIS master tape; and to provide data cards specifying the type, plant factor, and age of the plant(s) to be investigated.

The card deck required for operation of DOSIS as a separate program is shown in Figure D-2. One data card should be included for each plant being investigated. Data card format is shown in Table D-3.

In its present form the DOSIS code is specifically tailored for use in the Upper Mississippi River Basin study; characteristics of reactor types included in this study are built into the code. If it is desired to use this code to examine a particular plant type in detail, the user may wish to remove the constants describing these characteristics from the code (refer to the DOSIS listing in Appendix B) and substitute READ statements to acquire the values of these parameters from an input deck. It may also be desirable to substitute READ statements for selected DATA statements in the code if the effect of component performance on plant effluent requires parameterization for examination in detail.

TABLE D-3

DOSIS DATA CARD FORMAT

FORMAT (A5, 2E10.3)

CC 1-5 Reactor type (RTYPE) designation. The code as now constituted accepts designations of BWR, PWR, BWRA ("A" designates "advanced"), PWRA, and LMFBR.

CC 6-15 Plant factor (PF) for the plant requested (as a fraction of unity).

CC-16-25 Plant age (AGE), in years since startup, used in the calculation of activation products from reactor vessel components.

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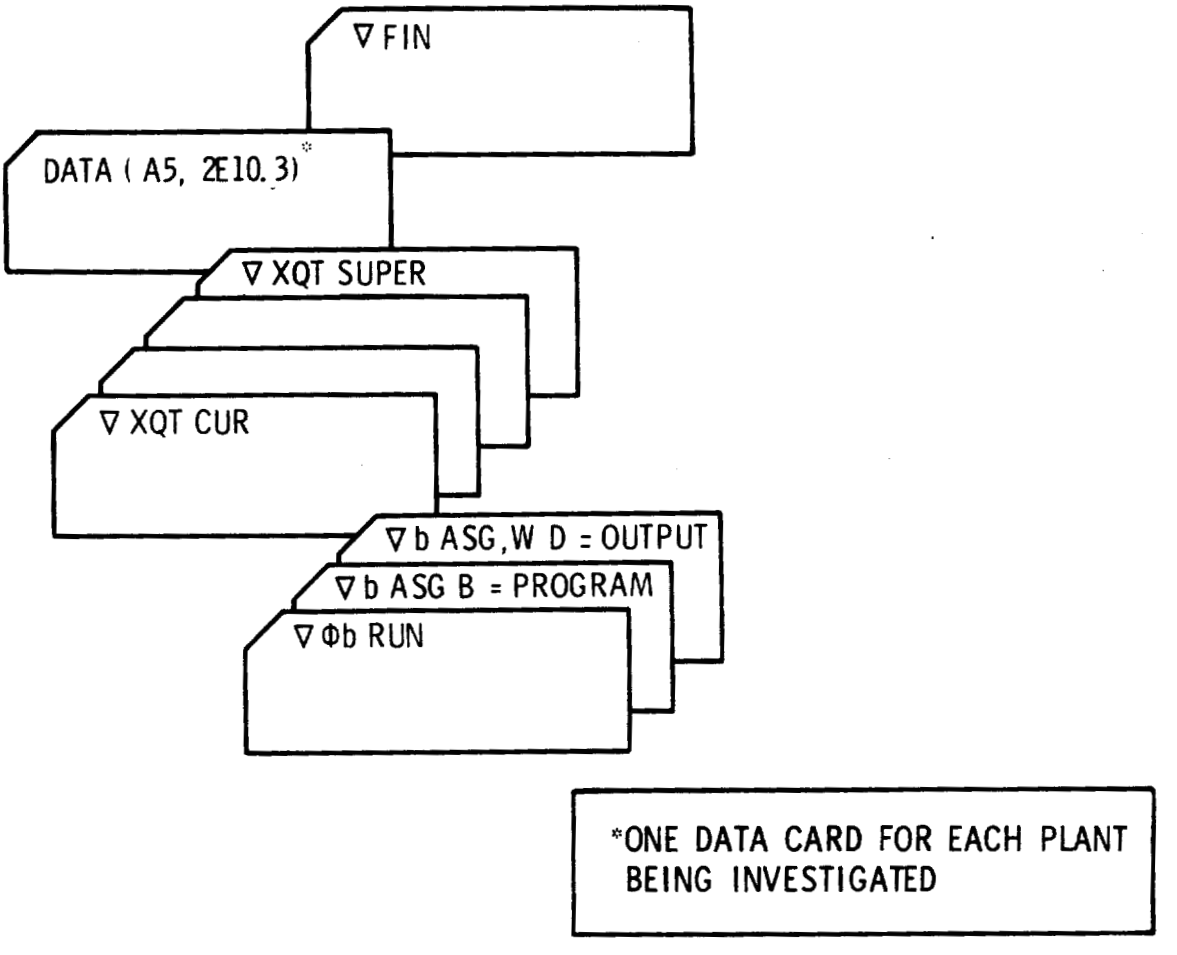

Figure D-2: Sample Desk for DOSIS

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III. REPARE OPERATING INSTRUCTIONS

The REPARE subelement of HERMES is normally used as an independently operated code; however, it is designed so that it may also be used as a subroutine of the user's main program.

Input data required for REPARE, supplied through data cards or through the user's main program are:

TONLWR - Yearly load, in metric tons, of LWR fuel to be processed.

TONFBR - Yearly load, in metric tons, of FBR fuel to be processed.

KEY - A control variable governing output format.

Output data, similarly, may be processed as punched cards or through return to the user's main program. The output data arguments are:

AIR - Computed release rates for stack effluent from a typical Purex-type plant, in picocuries/sec.

WATER - Computed release rates for low-level liquid effluent from a typical Purex-type plant, picocuries/sec.

AIRMFR - Computed release rates for stack effluent from the MFR plant, picocuries/sec.

SITE - The computed number of reprocessing plants (including the MFR plant) required to process the fuel load defined in the input data.

A sample deck for execution of REPARE is shown in Figure D-3; formats of the input and output data cards are indicated in Table D-4. Internal data statements within REPARE define plant and component characteristics and basic plant capacities (see Appendix B for a listing of the code). These may, of course, be changed by the user for specific case studies or for parameterization of component performance. As currently constituted, the code assumes annual plant capacities, based on LWR fuel, of 300 metric tons per year for the MFR, and 1500 metric tons per year for each Purex-type plant.

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Provisions have been made in REPARE to permit control of code operating parameters by means of NAMELIST data (for an explanation of NAMELIST, see Reference D-2). Two separate NAMELIST groups are provided. The first group, OPTION (Table D-5), permits selection of optional procedures for calculation and printout. The second, DANTOR (Table D-6), controls procedures for normalizing of data.

D-2 "UNIVAC 1108 Multi-Processor System FORTRAN V Programmers Reference," UP-4060 Rev. 1, Univac Division, Sperry Rand Corporation, 1969.

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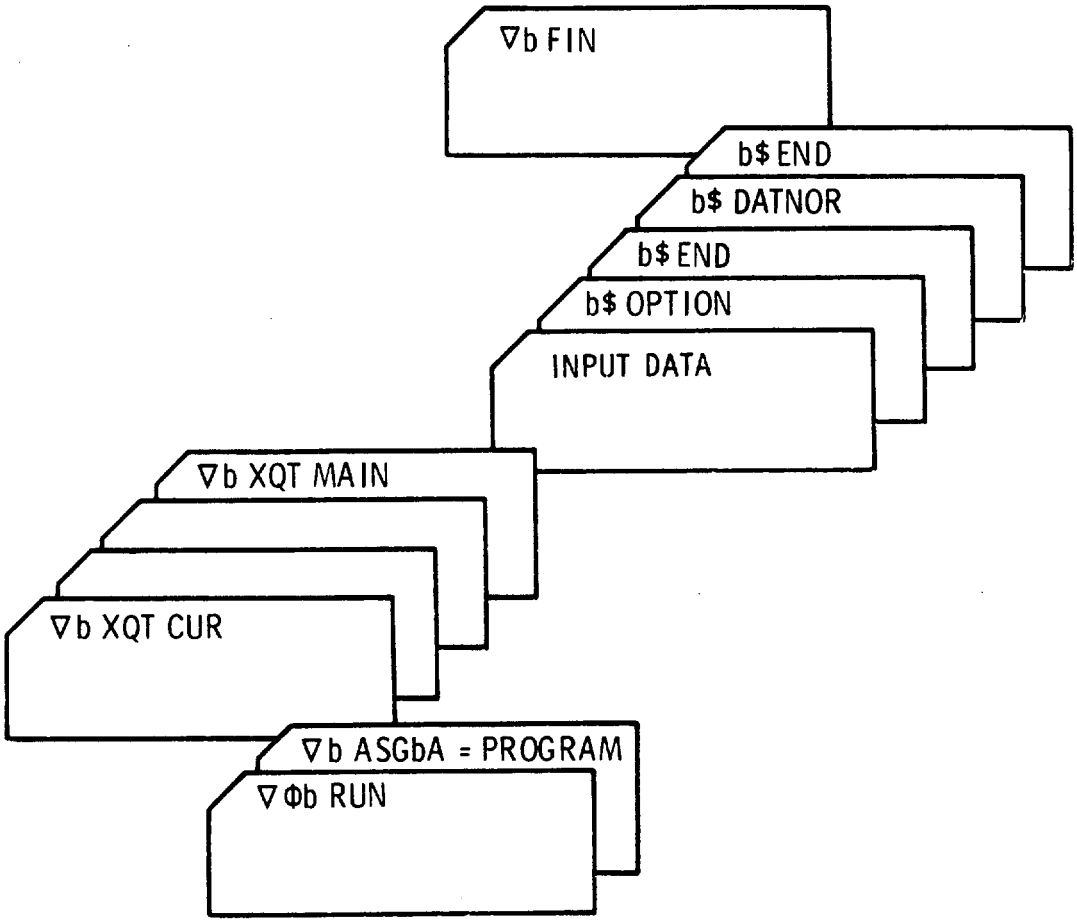

Figure D-3: Sample Deck for Repare

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TABLE D-4

REPARE DATA CARDS

A. Input Data Card (one card required)

FORMAT (2E15.5, I1)

CC 1-15	Metric tons LWR fuel to be processed annually
CC 16-30	Metric tons LMFBR fuel to be processed annually
CC 31	Integer value for control parameter KEY
	If KEY = 1, no punched output.
	If KEY ≠ 1, output cards are punched.

B. Output Data Cards from REPARE

FORMAT (8E10.5)

These cards contain release rate data calculated by REPARE. A deck of 25 cards is produced, containing 200 fields of data. The data are arranged as 4 sequential groups of 50 fields each. Currently, each group of 50 fields contains release data for 45 isotopes in their order of appearance in the Master List (Appendix A), followed by 5 unused fields which are recorded "zero". Data are grouped in the following sequence:

1. MFR water effluent*
2. MFR air effluent (AIRMFR)
3. Purex-type plant air effluent (AIR)
4. Purex-type plant water effluent (WATER)

---

* Required to conform to ARTRAN input format. Since MFR has no liquid effluent, these cards display 50 "zero" fields.

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TABLE D-5

NAMELIST OPTION

(See Reference D-2)

PROPT — An integer variable controlling printout

If PROPT = 1, no printout is produced

If PROPT = 2, summary data only is printed

If PROPT = 3, printout includes summaries and intermediate information.

If PROPT is excluded from the NAMELIST input, no printout is obtained.

FLOW — (Not currently available) Provisions have been made in REPARE to use the FLOW option to exercise component loading calculations; the FLOW variable specifies a representative flow (liters/sec.) entering a plant from the dissolver. An exact definition of component loading characteristics is needed before the option is used.

DATAIN — An integer variable controlling computation of holdup times. If DATAIN = 1, holdup times specified in DATA statements in each subroutine are used. If DATAIN ≠ 1, holdup times are computed from the FLOW variable and effective process volumes.

(Note: DATAIN = 1 must be specified until the FLOW option is available.)

LIMIT — An integer variable specifying the number of isotopes on the Master List (Appendix A), and used as a DO loop index limit.

Values for the variables in OPTION are internally defined as

PROMPT = 1

LIMIT = 45

DATAIN = 1

FLOW = 0

If NAMELIST OPTION cards are omitted, these values will be used.

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TABLE D-6

NAMELIST DATNOR

(See Reference D-2)

NORMAL	An integer variable controlling normalization of data. If NORMAL = 1, no normalization is performed, and no other DATNOR values need to be defined. If NORMAL ≠ 1, normalizing computations are made using defined values of the following variables.
UNITA	The reference release rate (picocuries/sec.) to which Purex-type air releases are to be normalized.
UNITW	The reference release rate (picocuries/sec.) for normalization of Purex-type water releases.
UNITMF	The reference release rate for MFR release normalization.
ILISTA	A subscripted variable defining isotopes (by Master List index number) in air releases which are to be grouped into a separate subset. The contributions of these isotopes will <u>not</u> be included in the main normalization calculations, but will be separately normalized.
ILISTW	A subscripted variable performing the same functions as ILISTA, except for radionuclides in water releases.
SUNITA	The referenced release rate (picocuries/sec.) to which Purex-type air releases of radionuclides <u>in the subset defined by ILISTA</u> are to be normalized.
SUNTMF	The referenced release rate (picocuries/sec.) for normalization of MFR releases of isotopes in the ILISTA subset.
SUNITW	The referenced release rate (picocuries/sec.) for normalization of water releases of isotopes in the subset defined by ILISTW.

When no NAMELIST DATNOR data are encountered, the DATNOR variables will be used with the following internally defined values:

```
NORMAL  = 5
UNITA   = 1
UNITW   = 1
UNITMF  = 1
SUNITA  = 1
SUNITW  = 1
SUNTMF  = 1
ILISTA  = 1, 16*0, 18, 27*0
ILISTW  =    29*0, 30, 15*0
```


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IV. ARTRAN OPERATING INSTRUCTIONS

Operation of the HERMES code subelement ARTRAN, for air transport calculations, requires input data tapes or cards providing required information on (1) meteorology of the study area, (2) locations of radionuclide effluent sources and rates of emission, and (3) locations of centroids where radionuclide concentration and deposition data must be calculated. In addition, the user must provide a set of data cards for the NAMELIST input. In this simplest case, the program may be executed with the sample card deck shown in Figure D-4.

Options for the NAMELIST OPERAT are given in Table D-7. An additional NAMELIST variable set, DEBUG (Table 8) is available for debugging runs. The DEBUG variable list may be activated by specifying a value less than zero for the variable DEBUG in the NAMELIST OPERAT. If this option is selected, the computer will accept the BUG input data set detailed in Figure D-5.

The input data to ARTRAN -- meteorological data, source data, and centroid locations -- may, if desired, be read from three separate tape drives, by properly specifying the values of the NAMELIST OPERAT values IN2, IN3, and IN4 (Table D-7). For use in the Upper Mississippi River Basin reference study, both the meteorological data for the study area and the centroid location data have been included as separate files on a master program tape; the OPERAT tape unit designators IN2 and IN4 have been set to select these files. If the data are introduced on separate tapes, values for IN2 and IN4 must be appropriately reset.

Input Data Format

Format requirements for the input data, whether the Master Tape data or the separate data tapes are used, is as follows:

a. Meteorological Data

Meteorological data are provided in binary form; data are read from the input tape through the buffered input/output routine,

NTRAN.[D-1] They are expressed as a binary array:

WX (IREC, ISECT, INOM)

where:

IREC is a limit variable designating the number of records for each data set.. Normally 6 records are used per set:

- Mean wind speed
- Percent frequency of direction
- Precipitation intensity
- Percent frequency of precipitation
- Stability class
- Percent probability of occurrence of designated stability class

ISECT is a limit variable designating the number of circular sectors (compass rose divisions) to be considered in the problem. Currently a 16-sector division is used.

INOM is a variable denoting the number of stability cases contained in the data. Usually two cases are used -- for day and night conditions -- although cases utilizing all 7 stability classes may be used if desired.

b. Radionuclide Source Data

Data on radionuclide source locations and emission rates are obtained from the output tape produced by the HERMES subelement RADREL. This also is a binary tape, accessed through NTRAN. Structure of the tape is indicated in Table D-2. Data used by ARTRAN include:

(1) Data used as control or limit variables:

- Total number of sources (plant sites) (File 1, Record 2, 1st word)

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- Total number of months of data (File 1, Record 2, 2nd word)
- Total number of radionuclides in air releases (File 1, (Record 2, 4th word)

(2) Half-lives of isotopes included in release data (File 2).

(3) Latitudes and longitudes of sources (File 3).

(4) Radionuclide release rate data (File 5).

The fourth and sixth files of the RADREL tape are not used by ARTRAN.

c. Centroid Location Data

The data on centroid location, currently obtained from the master program tape, may also be obtained from File No. 1 of the Living Patterns Model tape (Refer to Table D-12). In either case the data are recorded in card image format, with a format for each card format of:

6(I3, 4I2, 2X)

in which data for 6 centroids are included in each card image. Data for each centroid consist of :

Centroid identification number	(I3)
Latitude, degrees	(I2)
Latitude, minutes	(I2)
Longitude, degrees	(I2)
Longitude, minutes	(I2)

Since 2-character fields are provided for longitude and latitude data, longitudes of 100 degrees or greater will be recorded as 100 degrees less than the actual value. ARTRAN is coded to add 100 degrees to all longitude values less than 64 degrees. No anomalies will occur, since the 48 contiguous United States extend from (approximately) 67 degrees to 125 degrees west longitude.

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Master Program Tape

The master Program Tape, as was previously stated, contains the basic ARTRAN code, centroid location data for the Upper Mississippi River Basin study area, and meteorological data for the area. Because of its frequent use during development of the HERMES code, this tape was structured for protection against inadvertent data loss through errors in coding or operation. The tape contains sequentially:

(1) The basic ARTRAN code
    Two "end-of-file" markers
    A "dummy" file (1000 "zero" fields)
    An "end-of-file" marker

(2) Centroid location data
    Two "end-of-file" markers
    A second "dummy" file (1000 "zeros")
    An "end-of-file" marker

(3) Area meteorological data

ARTRAN is currently programmed to advance through the multiple end-of-file marks when using the Master Tape; use of a foreshortened tape version would require alteration of these routines.

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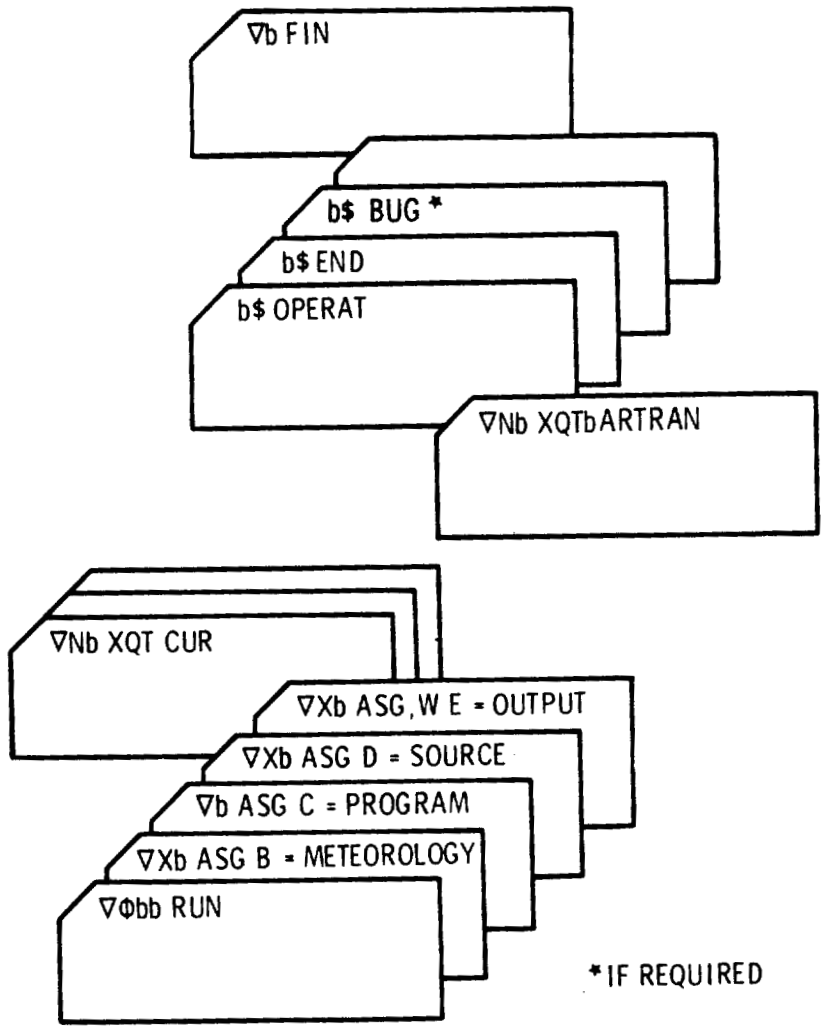

Figure D-4: Sample Deck for ARTRAN

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TABLE D-7

NAMELIST OPERAT

AIN - An integer variable for the logical switch controlling printing of the meteorological input data. The preset value of this variable is zero, which provides no printout. Any other positive integer entry will result in printout being furnished.

BASIC - An integer variable for the switch routines that control treatment of the meteorological data as regards Pasquill categories. The preset value is zero, which causes the program to operate in a two-stability category (3 for day and 4 for night) mode. Any positive value for BASIC in the NAMELIST will cause a shift to a seven-category (Pasquill) mode. This action would require a re-assembling of the meteorological data bank. This capability has been included to permit an expanded use of the code and is not suggested for activation at this time.

CIN - An integer variable, a logical switch controller for printing of the centroid tape data. It is preset to zero, to provide no printout. Any other positive value for CIN will result in printout being furnished.

COMNIN - A real variable used in the code as a lower-limit cutoff for air concentration values. It is preset in the code to 1.E-20.

DEBUG - An integer variable, for a logical switch permitting limited-data debug runs to be made. The preset value is zero; this, or any positive integer, bypasses the internal debug routines. Any negative value for DEBUG will activate them. All input data for debugging operations are via the NAMELIST BUG variables.

DISMAX - A real variable used to make logical decisions as to the need for performing calculations for diffusion and deposition. If the calculated distance from a source to a receptor exceeds the values of DISMAX, calculations are omitted for that source-receptor pair. DISMAX is preset for 3×10^5 meters (approximately 186 miles); other values may be entered through NAMELIST OPERAT.

1083600

TABLE D-7

(continued)

IEXIT - An integer variable used as a control limit for calculation errors. It is applicable as a check at each major iteration. If remaining run time is not sufficient to complete the problem, the run is terminated and stored for restart.

IN1, IN2, IN3, IN4, } Integer variables used to reset the tape drive unit designators for input data:

IN1 is reserved for special tape inputs, printed-output tapes, restart tapes, etc.

IN2 designates the logical unit for meteorological data input.

IN3 designates the logical unit for source data input.

IN4 designates the logical unit for input of centroid location data.

MINMON, MAXMON } - Integer variables serving as DO-loop limits for month-by-month iteration used in several parts of the code. They are preset to 1 and 12 respectively.

MINNUC, MAXNUC } - Integer variables serving as DO-loop limits for the number of nuclides to be considered in several parts of the code. They are preset to 1 and 35. Any other values may be used with the single proviso that MINNUC must be smaller than MAXNUC.

MINSRC, MAXSRC } - Integer variables used as DO-loop limits for iteration over nuclear facility sources. They are preset to 1 and 175 in the code. Other values may be used, if MINSRC is smaller than MAXSRC.

1083601

TABLE D-7

(continued)

MNCITY, MXCITY - Integer variables limiting the number of centroids over which iteration will be performed. They are preset to 1 and 300.

MANOUT - An integer variable acting as a logical switch operator, to control print of output data for each month. This variable is preset to zero which is the "no-print" mode.

NAME - An integer variable functioning as a logical switch operator to control the printing of the contents of the OPERAT NAMELIST. It is preset to zero which is the "print" mode. Any other value will delete this function.

NEWMON - An integer variable used to control the start-up of the program after processing through RECYCL. This variable should be set to the proper value for the next month's processing. (Restart procedures are discussed in the text of the report.)

NEWLOC - An integer array serving to input up to 10 new plant/site startup dates. This array is preset to zero. To use this capability selected plant/site numbers are entered into the array in ascending order, e.g., NEWLOC(1) = 1, 10, 37, 63, etc. The program automatically indexes through this array searching for a match between the particular source being considered and an identical number in the array. The program logic then assigns a new startup date as prescribed by the array TIMNEW, as discussed below.

NIN - The logical unit designator for the card reader. It is preset to 5; a change here will require a change in the NTZB$ subroutine to equate the new value of NIN to the proper unit, if cards are to be read.

1083602

TABLE D-7

(continued)

NOPRINT - This integer variable is, as its name suggests, a logical operation controlling a print option. The preset value of zero is the "no-print" option. A change, via the NAMELIST entry, to any positive integer will activate the print option for the total output.

NOUT - This variable designates the printer as logical unit 6. The comments as regards a change to NIN hold for this variable also.

NOUT25 - This integer variable sets the tape unit for output.

NSTART - This variable is the first drum address, on the UNIVAC 1108 at Richland. Other arrangements may be required at different sites.

PRR - This real array contains percentage values for mother/daughter decay branching ratios. The preset values are shown in the subroutine TEST (Appendix B).

RECOVR - An integer variable governing activation of the RECYCL subroutine of ARTRAN. If the ARTRAN run is inadvertently terminated prior to completion, RECYCL transfers information on the computer drum to a tape, permitting re-starting of the program. A preset value of zero for RECOVR bypasses this option; assigning of any other value will activate it.

SIN - This integer variable is a logical switch operator which controls the printing of data from the input source data tape. The preset value of SIN is zero, providing no printout. If SIN is specified as a negative integer, source emission rates will be listed, if positive, all input source data are printed.

1083603

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TABLE D-7

(continued)

SKIPC - An integer variable used as a logical switch operator controlling the printing of the calculated values for each iterative loop. It is preset to zero, the "no-print" condition. There is a counter incorporated in the code for use with this switch variable which permits a variable cycle print capability. For example, if every tenth calculation were desired this may be achieved by setting SKIPC to 10 , etc.

SDALVL, SNTLVL - Real variables defining the user-prescribed values for the mean limits of convective activity for the summer season. The second and third letters indicate the day or night cases. These are preset to 1000 and 500 meters, respectively.

SUMDAY, SUMMIT - Real variables defining the user prescribed values for the downwind distance at which the calculational procedures for sigma-z are to be changed, for summer daytime and nighttime conditions, respectively. The preset values are 20,000 and 40,000 meters.

TEND - A real variable designating the study year. It is preset to 2000.

TIMNEW - A real array containing the desired new startup date for the plant/site selected by the operator in NEWLOC. There must a one-to-one correspondence between the plant/site and date positions in these two arrays. For example, if the startup dates for two plant/sites whose sequence numbers were 11 and 174 were changed to 1984 and 1985, the required entries would be:

NEWLOC (1) = 11, 174,

TIMNEW (1) = 1984, 1985.

1083604

TABLE D-7

(continued)

WINDAY, WINNIT - Wintertime corollary variables to SUMDAY and SUMNIT. Preset values are 300 and 800 meters, respectively.

WDALVL, WNTLVL - These real variables are the winter corollaries for SDALVL and SNTLVL. The preset values are 5000 and 8000 meters.

Y1 - This real variable is used to designate the start year. It is preset to 1970.

TABLE D-8

ALMDA - An entry consisting of a number of values (should equal number of values for QZ, below), that represent the appropriate half-lives of the nuclides used in the debug case.

H - An entry here changes the preset value for stack height (100 meters).

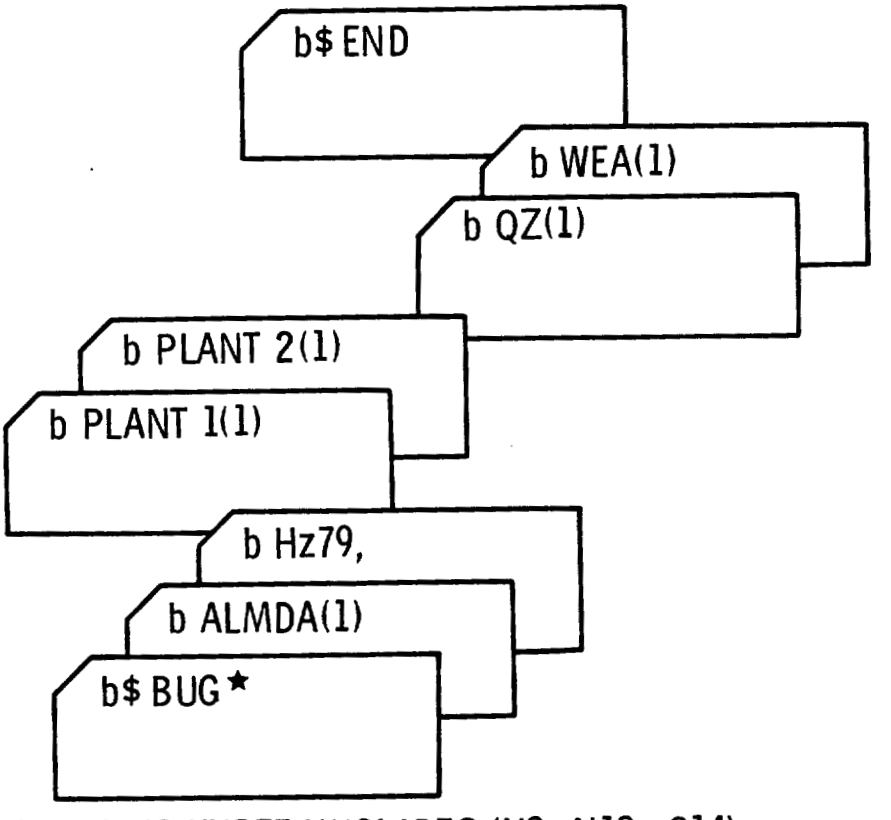
PLANT1, PLANT2 - These entries specify the latitude and longitude values (XXX.XX) for the nuclear facility sites to be used in the debug run.

QZ - The simulated release values for the debug run.

WEA - Input meteorology for the debug run.

The values for these variables are for a debug run; they serve to input sample data via cards, for program checkout. A sample deck is provided in Figure D-5.

1083605



★ASSUMING THREE NUCLIDES (H3, N13, C14), THREE CENTROIDS AND THREE SOURCES.

Figure D-5: Sample Deck for BUG

1083606

V. WTRAN OPERATING INSTRUCTIONS

The WATER TRANSPORT module of HERMES code, as indicated in the textual material, makes extensive use of data card input to accomplish the following actions:

- Define a study area river map.
- Set stream flow data.
- Define population center data, i.e., location and source of drinking water. These data may be input from either tape or cards.
- Set parameters for river bed characterisitcs of study area rivers.
- Input isotopic parameters.
- Define runoff characteristics of the various study area watersheds, as a function of centroid.
- Set up data read procedures for non-card input.
- Input equations for sediment deposition calculations, and associated locational data for output data requirements.
- Set parameters for calculations of flood characteristics of the study area rivers.
- Set switch variables for control of desired report writing.

Table D-9 gives the details of the information and format requirements for the data decks listed above. The WATER TRANSPORT code expects to find each data set terminated by a blank card; failure to satisfy this requirement will cause the computer to abort or produce invalid results. Figure D-6 illustrates a typical input card deck for execution of this HERMES subelement code.

1083607

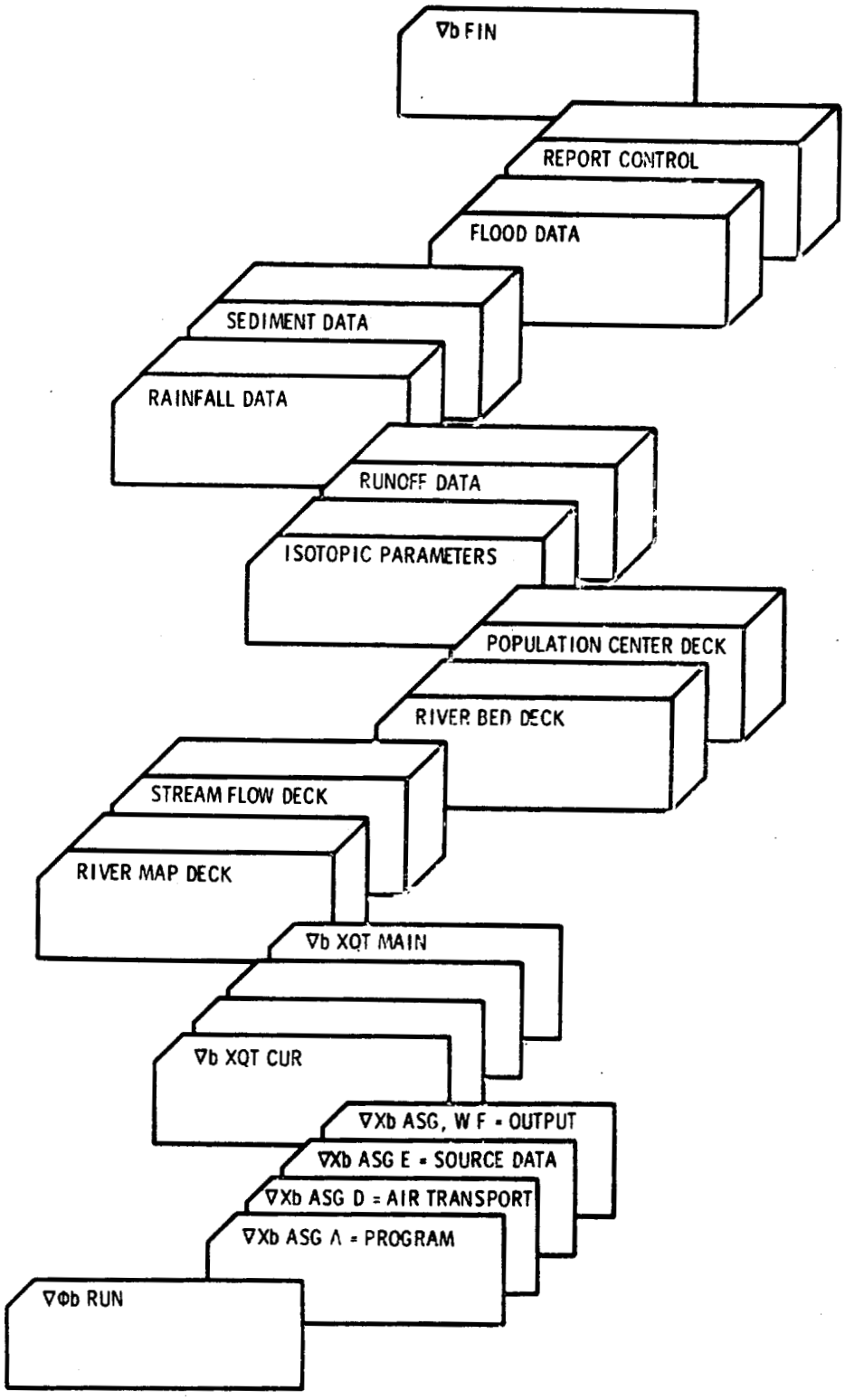


Figure D-6: Sample Deck for Water Transport (WTRAN)

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TABLE D-9

WATER TRANSPORT DATA CARDS

A. River Map Deck Data

1st Card starting in column 1 should contain $River Map

Following cards have format

(2A6,A4,A2,4X,A2,F8.1,216,I8,F12.1)

1st 3 Fields	River name (left adjusted)
4th Field	River code (left adjusted)*
5th Field	Mainstream code (left adjusted)
6th Field	Mainstream River Mile where this stream empties
7th Field	Not used
8th Field	Not used
9th Field	Not used
10th Field	River length (miles)

A blank card ends input to this module.

B. Monthly Flow Data Deck

Data in 3-card batches (except sign off, see below)

1st card format (14A6) (used solely for identification of next two cards)

2nd and 3rd cards format (I6,A2,F5.1,2XA1,6F8.0)

1st Field	Non-zero
2nd Field	River code
3rd Field	River mile
4th Field	If D or T, flows are to be additive to previous river mile flows; if anything else, flows are as read

5th through 10th Fields on second card - Jan. thru June flows (KCFS)
on third card - July thru Dec. flows (KCFS)

If 1st field of second card is zero or blank, a third card is not read and input to this module ends.

---

*The river code is a two-letter alphanumeric identification code defined on Page 75 of the report text.

1083609

TABLE D-9

(continued)

C. River Bed Data Deck

FORMAT (7E10.0,1X,A2,F.5.1)

1st Field	Upstrean river surface width (feet)
2nd Field	Upstream river bottom width (feet) if 0, 1st field used
3rd Field	Downstream surface width (feet) if 0, 1st field used.
4th Field	Downstream bottom width (feet) if 0, 2nd field used
5th Field	Upstream depth (feet)
6th Field	Downstream depth (feet) if 0, 5th field used
7th Field	Section length (feet)
8th Field	River code
9th Field	River mile

D. Population Center Data Deck

FORMAT (I3,1X,I2,2X,3A6,32X,F4.0,1X,2A6,1X,I1)

1st Field	Population center number
2nd Field	Type of record
3rd, 4th, 5th Fields	Center name
6th Field	River mile
	(Blank river mile causes card to be ignored except for name)
7th and 8th Fields	River name
9th Field	Source of drinking water

E. Isotope Data Deck

FORMAT (I5,4X,A6,E11.3,9X,F10.0,I5)

1st Field	Isotope number corresponding to water isotope list
2nd Field	Isotope symbol
3rd Field	Decay constant in 1/sec
4th Field	Distribution coefficient
5th Field	If isotope has a mother, mother isotope number

1083610

TABLE D-9

(continued)

F. Runoff Data Deck

FORMAT (A2,F4.0,4X,I5,E10.0)

1st Field River code

2nd Field River mile (effective location for entry of runoff)

3rd Field Centroid

4th Field Square miles associated with centroid

G. Rainfall and Groundwater Data Deck

(1) Runoff data - annual runoff in inches by centroid

FORMAT (12F5.0)

(Number of data determined by main-program-set variable NRAIN)

(2) Rain data - monthly rainfall (inches) by centroid

FORMAT (10X,I2,F5.2)

(Number of data determined by main-program-set variable NRAIN)

(3) Ground water calculations data

FORMAT (2I4,F5.0)

1st Field Centroid whose drinking water is ground water

2nd Field Centroid from which ground water comes

3rd Field Delay in days for travel time

H. Sediment Data Deck

FORMAT (A2,F5.0,1X,F7.2,F6.0,F6.1)

1st Field River code

2nd Field River mile

3rd Field A of equation below

4th Field B of equation below

PPM=EXP(A+B*ALOG(FLOW IN KCFS))

1083611

TABLE D-9

(continued)

I. Flood Data Input Deck

FORMAT (A2,F6.1,8F9.1)

1st Field	River code
2nd Field	River mile
3rd Field	Normal stage (feet)
4th Field	Normal flow (KCFS)
5th Field	Critical stage (feet)
6th Field	Percent clay in sediment
7th Field	Percent silt in sediment
8th Field	Percent sand in sediment
9th Field	Exponent in:

Stage-Normal Stage*(FLOW/NORMAL FLOW)**EXPONENT

10th Field	Specified water height above flood stage; if blank, flood height is calculated by above equation.

J. Report Control Deck

FORMAT VARIABLE

1st 2 Fields (2A6) - These fields matched against following list

1 - 'Population'

2 - 'Reactors'

3 - 'Tributary Mix'

4 - 'Tributary End'

5 - 'River Points'

6 - 'Runoff'

7 - 'Surface Water'

8 - (Blank or anything else)

If 1, remainder of card is (8X,I2,I5). The integers are population centers. If the first one is No. 1000, all population centers are triggered.

1083612

TABLE D-9

(continued)

If 2, rest of card ignored - all reactor sites are reported

If 3, rest of card ignored - all sidestream entries reported

If 4, rest of card ignored - all tributary end points reported

If 5, rest of card is 8X,A2,3X,11F5.1)

The A2 is river code (left adjusted); the F51's are river miles. These points will be reported.

If 6, rest of card ignored - all runoff points reported.

If 7, rest of card is 8X,12I5).Centroids for which ground water reports wanted. If the first one is 1000, all centroids are triggered.

If 8, signals end of input to this module.

1083613

7'5

VI. DOSE OPERATING INSTRUCTIONS

Much of the input data for the DOSE subelement of the HERMES code is supplied by tape from other subelements of the code. However, card input is required for certain data and control parameters, including:

- Processing parameters designating report heading date, input unit devices, and a restart key word.
- Calculational and report parameters.
- Nuclide selection for the calculation process.
- Identification code and concentration factors.
- Dose and dose commitment factors.

The data card content and format to satisfy these requirements are given in Table D-10. Sample input decks required to execute this code are illustrated in Figures D-7 and D-8.

TABLE D-10

DOSE CONTROL AND DATA CARDS

A. PROCESSING PARAMETER CARD

One processing parameter is required for each run. It is the first parameter card and specifies the type of processing, processing date and units on which data is input.

FORMAT (2A6,15A1)

cc 1-12	Alpha numeric date to appear in report headings.
cc 13-18	Alpha unit designations for card input data (up to 6 designations).
cc 19-24	Alpha unit designations for binary input data (up to 6 designations).
cc 25	Alpha unit designation for Living Patterns File.
cc 26	Alpha unit designation of Restart Tape.
cc 27	Restart indicator - if non-blank program, will restart from the restart tape.

1083614

TABLE D-10

(continued)

The alpha unit designation specifies which unit the data are to be placed on (i.e., A-Z).

Both the Living Patterns File and the Restart Tape are required for a normal start and a restart.

B. CALCULATIONS AND REPORT PARAMETER CARDS

Specifications for the type of reports to be produced for each population centroid at which a dose is calculated are contained on up to 20 of these parameters.

FORMAT (50I1,22X,I2,A6)

cc 1-50	Options for each centroid 1 = calculate dose only (no report) 2 = calculate dose and print detailed reports for each pathway 3 = calculate dose and print report for all pathways only 4 = calculate dose and print summary report for centroids calculated to this point 5 = calculate dose, print detailed reports and print summary up to this point 6 = calculate dose, and print report for all path-says and summary up to this point 7 = calculate dose and print only centroid path-way percentage report 8 = calculate dose and print both centroid and summary pathway percentage reports
cc 73-74	Number of parameter (1-20) The 1st card contains information for centroids 1-50, the 2nd for centroids 51-100, etc.

TABLE D-10

(continued)

cc 75-78	Contains the word "LAST" in the last parameter of this type

C. NUCLIDE SELECTION PARAMETER CARD

This parameter follows the calculation and report parameters. It determines the nuclides that will be included in the dose calculation.

FORMAT (50I1)

cc 1-50	Selection parameters for inclusion of nuclides in dose calculation (one nuclide per column). Nuclides ranked in columns according to position on MASTER LIST, Appendix A. If numeral 1 entered in column, nuclide is included in calculations; if column is blank, nuclide is not included.

D. LOSS FACTOR CARDS

(Also used optionally for air, water, food, soil, and sediment concentration data.)

Loss factor data are entered on these cards. Additionally, the same data deck may be used, rather than tape, to enter concentration data. There will be at most 2 cards for each isotope, for any one type of data at any one location.

FORMAT (I3,I2,I3,2I1,7F10.0)

cc 1-3	Location code
cc 4-5	Type of data code
cc 6-8	Isotope code
cc 9	Card number (1 for January thru June concentration data; 2 for July thru December concentration data)
cc 10	Blank or 0 for concentrations; 4 for loss factors

1083616

TABLE D-10

(continued)

cc 11-20	Concentration or loss factor right justified in field (I, E or F format)
cc 21-30	Concentration or loss factor right justified in field (I, E or F format)
cc 31-40	Concentration or loss factor right justified in field (I, E or F format)
cc 41-50	Concentration or loss factor right justifed in field (I, E or F format)
cc 51-60	Concentration or loss factor right justified in field (I, E or F format)
cc 61-70	Concentration or loss factor right justified in field (I, E or F format)
cc 71-80	Concentration or loss factor right justified in field (I, E or F format). (Used to record value to be used for all months when they are the same.)

Concentration Data Codes for CC 4-5

1	Air
2	Dry short term soil contamination from air
3	Wet short term soil contamination from air
4	Wet long term soil contamination from air
5	Dry long term soil contamination from air
6	Combined wet and dry short term deposition
7	Combined wet and dry long term deposition
8 - 9	Reserved for future use
10	Dissolved material in water
11	Suspended material in water
12	River bed sediment
13	Long term soil contamination from irrigation
14	Ground water

TABLE D-10

(continued)

E. DOSE FACTORS AND DOSE COMMITMENT FACTORS

Dose factors will be supplied as cards or card images on tape. Any card image which contains all zero dose factors should not be included.

FORMAT (I3,I2,I3,2I1,7F10.0)

cc 1-3	Item code
cc 4-5	Person code
cc 6-8	Isotope code
cc 9	Card number
cc 10	1 for dose factor; 5 for dose commitment factors
cc 11-20	Dose factor right justified in field (I, E or F format) Total Body
cc 21-30	Dose factor right justified in field (I, E or F format) GI Tract (LLI)
cc 31-40	Dose factor right justified in field (I, E or F format) Thyroid
cc 41-50	Dose factor right justified in field (I, E or F format) Bone
cc 51-60	Dose factor right justified in field (I, E or F format) Lungs
cc 61-70	Dose factor right justified in field (I, E or F format) Skin
cc 71-80	Dose factor right justified in field (I, E or F format) Liver

Person Codes

1	Average child	4	Maximum teenager
2	Maximum child	5	Average adult
3	Average teenager	6	Maximum adult

1083618

TABLE D-10

(continued)

Item Code for Dose Factors and Dose Commitment Factors

1	H_3 transpiration
3	Air submersion
4	Air inhalation
5	Deposition on ground
6	Water immersion
7	Ingestion of food and water

1083619

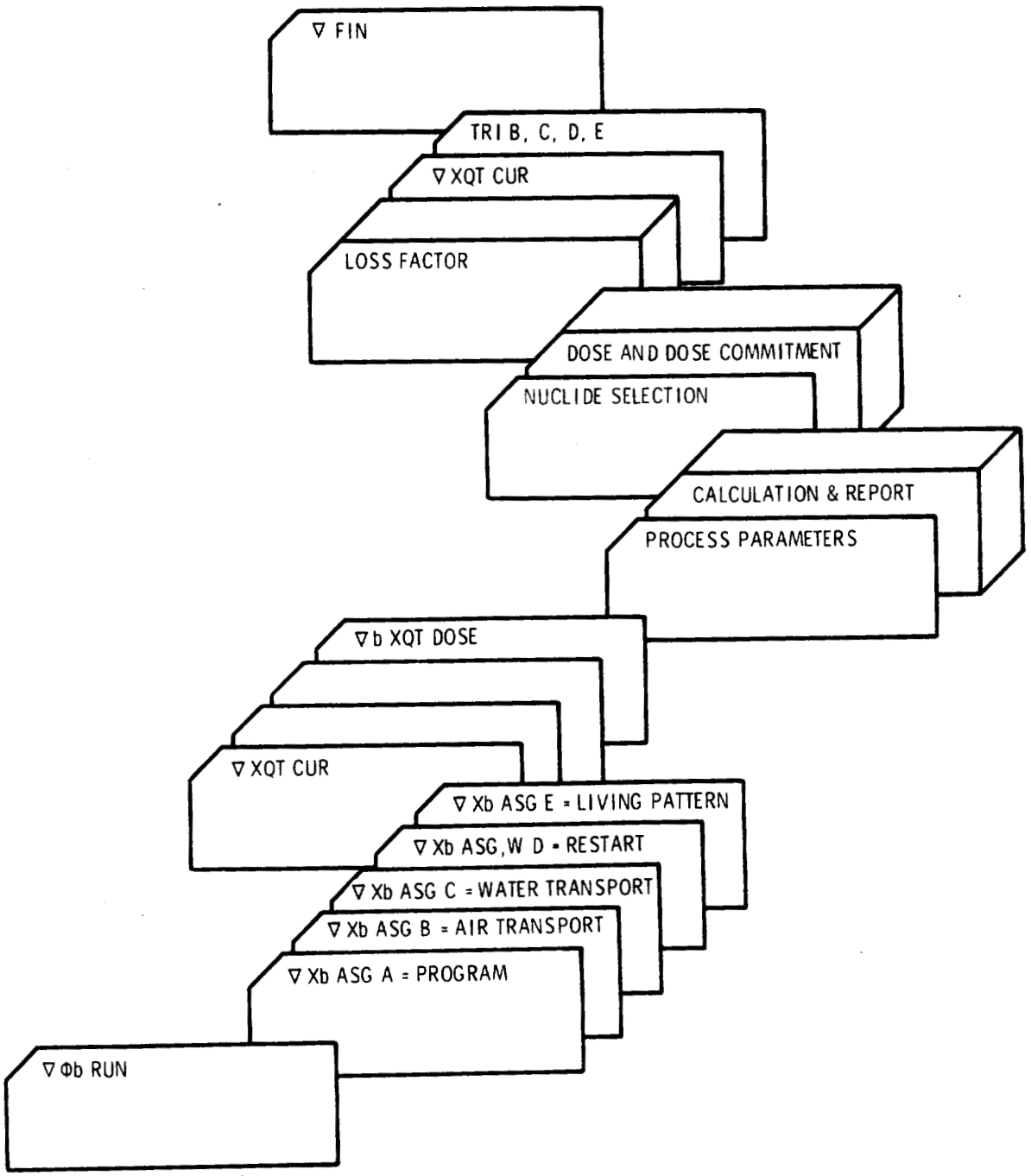

Figure D-7: Sample Deck for DOSE Code (Normal Start)

1083620

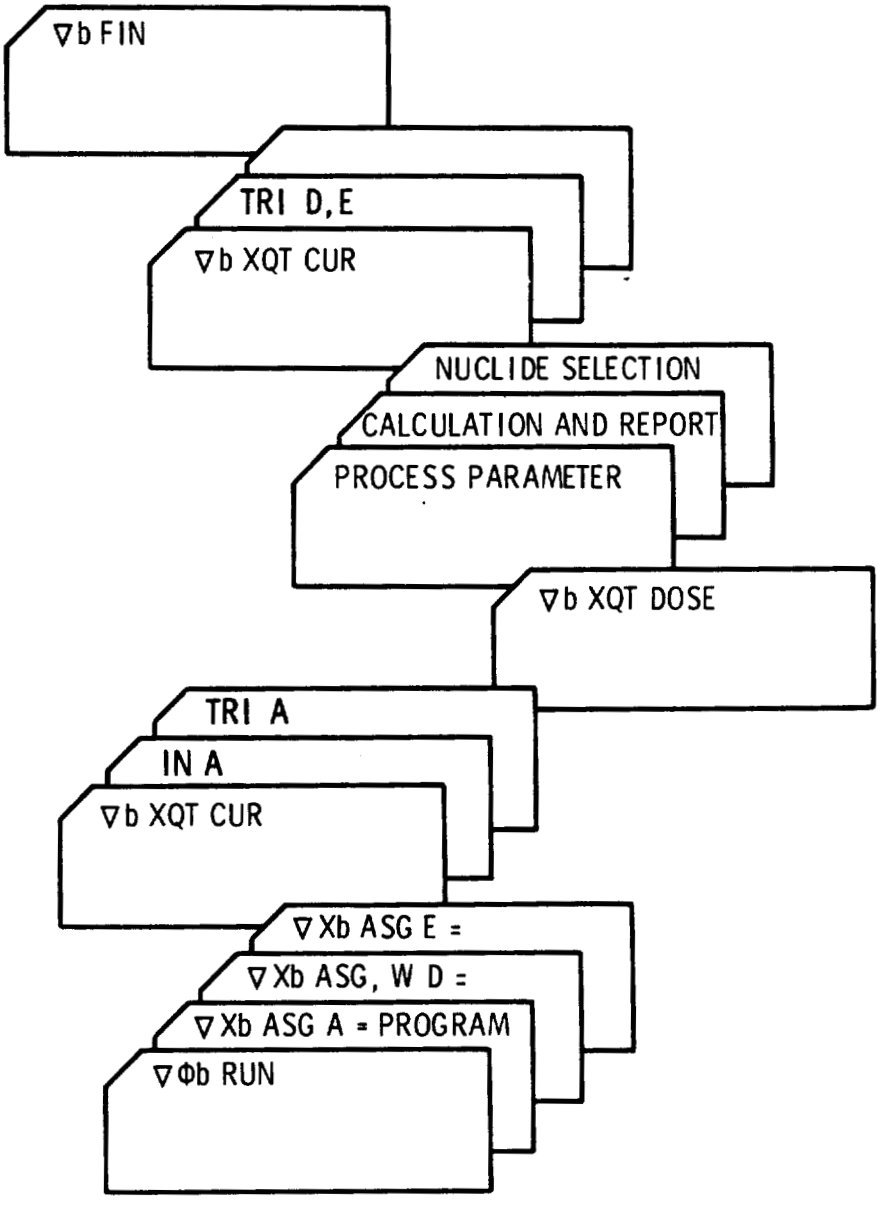

Figure D-8: Sample Deck for DOSE Code (Restart)

1083621

718

VII. SITE DATA FORMAT

Data defining the location and characteristics of sites for power plants and reprocessing plants, and priority data for plant selection by the SITE code, are entered on data cards having the format shown in Table D-11.

TABLE D-11

PLANT SITE DATA

FORMAT (2A6A3,A1,2I2,5A5,2A6A2,A1,5I4)

cc 1-15	Site name
cc 16	Flag Symbol: F = fossil plant site R = reprocessing plant site
cc 17-18	FPC Power Supply Area Number designation in which site is located
cc 19-20	Site serial number within PSA
cc 21-25	Maximum number of plants at site
cc 26-30	Priority number for plant #1
cc 31-35	" " " " #2
cc 36-40	" " " " #3
cc 41-45	" " " " #4
cc 46-59	Name of river or other water receiving liquid effluent
cc 60	Flag symbol: asterisk (*) if point of effluent is not within study area (used for plants in "air envelope" area).
cc 61-64	River Mile at site location
cc 65-68	Site latitude, degrees
cc 69-72	Site latitude, minutes
cc 73-76	Site longitude, degrees
cc 77-80	Site longitude, minutes

1083622

VIII. LIVING PATTERNS FORMAT

Living Patterns data are usually furnished on tape in card image format, the tape being produced by direct reading of data cards. Format for the tape, and for the input cards, is shown in Table D-12.

TABLE D-12

LIVING PATTERNS FORMAT

A. File No. 1 (Card Deck 1) - Centroid Location

FORMAT (6(I3,4I2,2X))

cc 1-3; 14-16 etc.	Centroid Number (6 per card)
cc 4-7; 17-20 etc.	Latitude (degrees, minutes)
cc 8-11; 21-24 etc.	Longitude (degrees, minutes)
cc 12-13; 25-26 etc.	Blank

B. File No. 2 (Card Deck 2) - Food Consumption Data

FORMAT (A3,I2,I5,7I10)

cc 1-3	Centroid type identifier (URB = Urban, RNF = Rural Non-farm, RUF = Rural Farm)
cc 4-5	Food Category Sequence (a digit from 1 to 35)
cc 6-10	Card type identifier, to identify type of data following. Type 1 signifies data on quantities of food consumed per household; type 2 signifies data on percentage of food consumption which is home-produced.
cc 11-80	(in groups of 10) Food consumption or home production data, by food category.

Notes:

Food type categories are listed in Table D-13. Data for seven food categories may be included on one card; thus for 35 food categories as used, 5 "type 1" and 5 "type 2" cards are required for each of the three centroid types. The "category sequence" identifier

1083623

TABLE D-12

(continued)

(columns 4 & 5) serves as a "counter" to identify the category for which data are presented.

All "type 1" cards are arranged in the deck ahead of the "type 2" cards. Both type 1 and type 2 cards are arranged sequentially by centroid type..

C. File No. 3 (Card Deck 3)

File No. 3 contains four types of data cards, arranged in the following sequence:

1. All "type 4" cards, arranged by centroid.
2. All other cards, arranged by centroid:
   a. one "type 1" card,
   b. 5 "type 2" cards,
   c. all "type 3" cards for the centroid.

Card type formats are as follows:

CARD TYPE 1

FORMAT (2I3,2X,3A6,1X,4I2,1X,4I2,1X,A3,1X,I8,1X,I4,1X,2A6,1X,2I1)

cc 1-3	Centroid number	
cc 4-6	Card type	
cc 9-26	Centroid name	
cc 28-31	Latitude of centroid	
cc 32-35	Longitude of centroid	
cc 37-44	Year 2000 population of centroid	
cc 46-48	Food consumption category	
cc 50-53	Latitude	Location of drinking water source.
cc 54-57	Longitude	
cc 59-62	River mile (if applicable) of drinking water source	
cc 64-75	River name (if applicable)	

1083624

TABLE D-12

(continued)

cc 77	Drinking water source code
	1 = river
	2 = ground
	3 = both
	4 = surface water
cc 78	Drinking water treatment
	1 = no treatment
	2 = filter
	3 = chemical
	4 = both filter and chemical

CARD TYPE 2 (5 per centroid)

FORMAT (2I3,1X,I2,10X,I3,1X,I4,3X,12I3,1X,2A6)

cc 1-3	Centroid number
cc 4-6	Card type
cc 8-9	Activity identifier
cc 20-22	Centroid of activity
cc 24-27	River mile (if activity on river)
cc 31-66	3 card column for each month of year - hours per month
cc 68-80	River name

The activity identifiers contemplated for use are as follows:

1	Swimming
2	Boating & water skiing
3	Fishing
4	Waterfowl hunting
5	Upland game bird hunting

1083625

TABLE D-12

(continued)

CARD TYPE 3 (Varying number per centroid)

FORMAT (I3,1X,I2,2X,4(2(I2,1X,I3,1X),I2,2X))

cc 1-3	Centroid number
cc 5-6	Card type
cc 9-10	Food type identifier
cc 12-14	Centroid number Source 1
cc 16-17	Percent of total consumption - Source 1
cc 19-21	Centroid number - Source 2
cc 23-24	Percent of total consumption - Source 2
cc 27-42	Repeat of 9-24 for different food
cc 45-60	Repeat of 9-24 for different food
cc 63-78	Repeat of 9-24 for different food

A food type will appear in card type three if a deficit exists for that Centroid (cc 1-3). A deficit exists if production is less than 10% of consumption, and a surplus exists if production exceeds consumption by more than 10%.

CARD 4 (Varying number per centroid)

FORMAT (I3,2(1X,I2)8(1X,2I2)

Card type 4 indicates to the user the percent of each food consumption category that is raised on irrigated land. If a food type is not irrigated no data will appear.

Card type 4 will be the first type of cards to appear in File 3.

The card layout is as follows:

cc 1-3	Centroid number	cc 13-14	Percent irrigated
cc 5-6	Card type	cc 15	Blank
cc 8-9	Card sequence number	cc 16-79	Repeat of 11-15
cc 11-12	Food type identifier		as needed.

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TABLE D-13

FOOD TYPE CATEGORIES

1. Fresh Berries
2. Processed Berries
3. Fresh Tree Fruit
4. Processed Tree Fruit
5. Fresh Melons
6. Fresh Tropical Fruit
7. Processed Tropical Fruit
8. Fresh Citrus Fruit
9. Processed Citrus Fruit
10. Fresh Potatoes
11. Processed Potatoes
12. Fresh Root Vegetables
13. Processed Root Vegetables
14. Fresh Green Leafy Vegetables
15. Processed Green Leafy Vegetables
16. Fresh Other Above-Ground Vegetables
17. Processed Other Above-Ground Vegetables
18. Grain & Grain Products
19. Rice & Rice Products
20. Wheat & Wheat Products
21. Fresh Milk
22. Processed Milk & Milk Products
23. Butter
24. Fresh Whole Eggs
25. Beef & Lamb
26. Fresh Pork
27. Processed Pork
28. Poultry
29. Game Birds
30. Processed Ocean Fish
31. Shell Fish
32. Fresh Fish
33. Sports Fish
34. Upland Game Birds
35. Secondary Water

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APPENDIX E

HERMES SUBELEMENT GLOSSARIES

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APPENDIX E

HERMES SUBELEMENT GLOSSARIES

Appendix E is a glossary of important terms used in the various subelement programs of the HERMES code. These data are provided, by subelement, in the same order as the listings in Appendix B. The terms within each subelement are in alphabetical order.

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SITE Glossary

IARRAY - Storage for site name, site type, site number and site priority number.

INAME - Name and site number of sited plant.

INDEX - Indexes of plants when sorted by year built.

INO - Number of plants built at a site.

IPRI - Priority numbers for a site.

ISITE - Name, type and number of a site.

ISORT - Plants sorted by year built.

KF - Alpha F

KFOSS - Alpha FOSSIL

KNAME - Alpha names PWR, BWR, FOSSIL, LMFBR

KOMPAR - Alpha letters W, F, L.

KPLANT - Storage for plant load factor type and year built.

KR - Alpha R

KYR - Year of problem, where 1 = 1970.

LOAD - Load factor type for a plant, 1 - base, 2 - peak.

LWR - Counter to determine which LWR's are PWR's or BWR's.

MAXF - Total fossil plants.

MAXFS - Total fossil sites

MAXP - Total number of plants to be sited.

NAME - Storage for plant names.

NFOS - Tally of fossil plants.

NFOSS - Tally of fossil sites.

ORDER - Subroutine to order numeric data.

SITE - Subroutine to site plants.

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SITE Glossary

SORT - Array that is ordered in Subroutine ORDER

TITLE - Case title

WPLANT - Storage for plant capacity in gigawatts.

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MOPOSH Glossary

ARP - Average reactor power for a plant.

HOURS - Hours in a period.

INDEX - Indexes of plants when ordered by plant factor.

INPUT - Subroutine to read card data.

KFLAG - Flag to indicate the periods when a particular plant does not operate due to low power demand.

KPER - Counter for the number of periods that a plant operates.

KPLANT - Storage for plant load factor type and year built.

KSD - Flag for first period of refuelling shutdown.

KSDSAV - Saves refuelling shutdown period for reference.

KSITE - Site number for location of plants.

KSTART - Desired start time for the period when a base plant operates at 100% of its power.

KSTOP - Number of periods to consider when checking for those periods in which a plant does not operate.

KTIME - Number of periods that a base plant operates at (1) 100% of power, and (2) less than 100% (but above zero).

KYEAR, KYR - Year index of problem where 1 is 1970, 31 is 2000.

KYRLST - Check to stop execution.

LCHECK - Period number for start of 100% power output by a base plant.

LSTART - First period of operation for a base plant.

LWR - Counter to determine which LWR's are PWR's and which are BWR's.

MAXP - Total number of plants in problem.

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MOPOSH Glossary

MINP - Total number of plants operating in year of interest.

MINPR - Minimum power below which a given plant will not operate.

MINPWR - Minimum power below which a base plant will not operate.

NAME - Plant name

NSD - Flag to indicate those periods in which a base plant cannot shut down because of high power demand.

ORDER - Subroutine to order a numeric array.

PF - Annual plant factors for a plant's life.

PFMAX - Plants operating with an annual plant factor above this limit are considered base loaded.

PFMON - Monthly plant factor.

PLANT - Plant factors for all plants.

POWER - Energy demand for each period.

PSTORE - Energy surplus per period

PWR - Total plant power (1 is 1000 megawatt plant).

PWRS - Annual energy surplus for region considered.

PWRTOT - Total energy demand for all periods in which a given peak-loaded plant operates

RPCHK1 - Plant maximum power for one period.

RPOWER - Total energy produced by one plant in one month.

RPTOT - Temporary storage to compute power for a base loaded plant.

RPWR - Temporary storage for a plant's power.

RPWRM - Maximum energy for a 1 gigawatt plant in one month.

RPWRP - Maximum energy for a plant for one period.

RPWRS - The additional energy available in one year, if all plants operated at full power.

SORTER - Subroutine to calculate plant factors for each plant and order all plants by plant factor.

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MOPOSH Glossary

TITLE - Case title.

TOTPWR - Total energy demand for one year.

TPOWER - Total energy produced per month

TPWR - Temporary storage for total energy produced in one year.

WPLANT - Fraction of one gigawatt plant.

RADREL Glossary

AGE - Plant age used for calling DOSIS.

AGER - Plant age range values, years.

BUF - Temporary data buffer.

BUFIS - Temporary data buffer for radiation releases and plant characteristics.

BUFOUT - Data storage for building radiation releases array for writing to tape.

DATINP - Subroutine - reads card input.

EQPART - Subroutine - sets drum addresses.

HEAD - Subroutine - writes first four files.

HLF - Isotope half-lives, seconds.

IBUF - Case indices, i.e., number of sites, number of isotopes, etc.

ICDA - Subroutine - calculates drum addresses.

ID20 - Drum address table for logical unit 20.

IDEOF - Largest drum address for logical unit 20.

II, IJ - Isotope index for air or water releases.

IM - Month index.

IMON - Month index on MOPOSH data.

IN - Logical unit number of MOPOSH input tape.

INAI - Index of air isotopes.

INEWPL - New plant data keyword
= NEW PL, read new plant data from MOPOSH tape.
≠ NEW PL, use plant data on restart tape.

INWI - Index of water isotopes.

IOUT - Logical unit number of restart output tape.

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RADREL Glossary

IP - Plant index.

IPL - Plant types available.

IPLAN - Site number of plant on MOPOSH data.

IPLANT - Site number of plants (ordered).

IPLTY - Plant type of plant on MOPOSH data.

IPLTYP - Plant type of plants (ordered by sites).

IPMON - Month on previous MOPOSH record read.

IR - Current matched site number.

IREST - Restart option keyword.
= RESTAR, read restart data tape.
≠ RESTAR, do not read restart data tape.

IRP - Current matched reprocessing site number.

IRT - Plant type used for calling DOSIS.

IRTDCK - Data availability check on drum.

IS - Site index.

ISOURC - Source map data tape keyword.
= NEW SO, write new source map data tape.
≠ NEW SO, don't write source map data tape.

IWRITE - Write restart tape option keyword.
= WRITE, write new restart data tape.
≠ WRITE, don't write new restart data tape.

LUD - Logical unit number of restart input tape.

NAI - Number of air isotopes.

NAW - Number of words written in air release record.

NM - Number of months.

NOSITE - Site number of each plant.
+ number, plant not assigned.
- number, plant has been assigned.

RADREL Glossary

NPPS - Number of total potential plants.

NREC - Records written counter.

NRP - Number of total reprocessing plants.

NS - Site index.

NSITE - Current site number.

NSITRP - Startup sequence of reprocessing plants.

NSSITE - Site number of each plant.

NTI - Number of total isotopes.

NTP - Number of total operating plants.

NUMSIT - Site number of reprocessing plants.

NWI - Number of water isotopes.

NWIN - Number of total words of data written to drum.

NWOUT - Number of words transferred from drum to restart tape.

PF - Plant factor used for calling DOSIS.

PFMO - Plant factor read from MOPOSH data.

PFMON - Plant factor of plants (ordered by sites).

PFMR - Plant factor range values.

PLAD - Site latitude in degrees, e.g. 41°.

PLAM - Site latitude in minutes, e.g., 30'.

PLANTS - Subroutine - reads monthly plant factors.

PLAT - Site latitude in degrees, (decimal) e.g., 41.50°.

PLOD - Site longitude in degrees

PLOM - Site longitude in minutes.

PLON - Site longitude in degrees (decimal).

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RADREL Glossary

PLUSY - Plant startup year on MOPOSH data.

PLSUYR - Plant startup year for all plants (ordered by sites)

PLTLN - Other site information
Word 1 = latitude, degrees
Word 2 = longitude, degrees
Word 3 = stack height, meters
Word 4 - first plant startup year

PRVML - River mile of each site location.

PRVNM - River name of each site location.

RELAIR - Subroutine - reads air release from drum and writes to tape.

RELWAT - Subroutine - reads water release for drum and writes to tape.

RESTAR - Subroutine - writes restart data tape.

RMFRIS - Radiation release rates to water and air from the MFR reprocessing plant at Morris, Illinois.

RPURIS - Radiation release rates to water and air from a Purex reprocessing plant.

RTYPE - Plant type used for calling DOSIS.

TITLE - Title for this case.

DOSIS GLOSSARY

ACTINV - Results from Activa subroutine

ACTIVA - Subroutine used to calculate activation products

AGE - Plant age

ALPHA, BETA - Variables used in calculating constants in fuel failure probability equation

BU - Burnup of part of fuel

BUG - Goal fuel burnup

BWR - Boiling water reactor

BWRA - Advanced boiling water reactor

BWRD - Boiling water reactor gas delay volume

C, C1, C2, CA Constants used in numerous subroutines for removal performance

CFLOW - Flow to coolant cleanup system for LMFBR

CHAR - Subroutine simulating charcoal delay bed

CLAD - Activation products coming from clad

CLUPS - Radionuclide material held up by coolant cleanup system

CMPNT - Subroutine to calculate decay for a component where holdup of all isotopes is the same.

COLANT - Subroutine that does mass balance on coolant

COLTNK - Subroutine for collection tank

CONC, CONCP Concentration of isotope in coolant

COOL - Activation products coming from coolant

COOLIN - Sum of activation and fission products entering coolant

CORR - Corrosion rates

CRYO - A subroutine which could be used to include a cryogenic gas treatment system.

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DOSIS Glossary

D - Diffusion coefficient

DEGAS - Subroutine for degasifier

DELA - Subroutine for delay of gas stream

DELAY - Delay time in various components

DEMIN - Subroutine for demineralizer

DFF - Calibration factor on diffusion coefficient

DFLOW - Flow to coolant cleanup demineralizer

DIST1, 2, 3, 4, - Distillation factors for various BWR streams

DLUT1, 2 - Dilution factors resulting from steam generator leakage for PWR systems

DOSIS - Main program name

DRNTNK - Subroutine for drain tank

EFF - Component removal efficiency

EFFC - Removal efficiency of LMFBR coolant cleanup system

EFFD - Removal efficiency of LWR coolant cleanup system

EVAP - Subroutine for evaporator

F - Release fraction from fuel

FGASIN - Functional value of total gas release

FGDBF - Fission gas diffusivity burnup factor

FGINI - Fraction of isotope in total gas release

FFRC - Calculated fuel failure rate (used in iterative calculation).

FFRS - Specified fuel failure rate

FILTER - Subroutine for liquid filter

FINV - Fraction of isotope in total liquid release

FLOSAV -
FLOW -
FLOW 1,2,3,4
FLOWIN -
} Liquid flows throughout systems

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DOSIS Glossary

FLRDRN - Subroutine for floor drain tank

FREON - Subroutine for freon absorption gas treatment system

G - Fission product generation rate

GASINV - Total gaseous release of an isotope

GFILTR - Subroutine for gas filter

HOLDUP - Subroutine for holdup tank

ICHECK - Variable used to indicate if stream is diluted or distilled

INVIN
INVOUT
INVSAV
ISOR
ISOT
ISOTOP
} Radionuclide flows at various points in the program

ISTRM
JSTRM
} Indexes on inlet streams used in setting up flows to the various tanks

K1, 2, 3 -Decay constants

KA,B,C -Decay constants

LHR -Linear heat rate of the axial segment of fuel being considered

LHRM -Maximum linear heat rate of the fuel in the radial core segment being considered

LHRMA -Maximum core linear heat rate

LIMIT -Number of radionuclides being considered

LMFBR -Liquid metal fast breeder reactor

LMLIQ -Subroutine for LMFBR liquid releases

LOAD -Component load, for use when component efficiency as a function of load is available

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DOSIS Glossary

NEUTNK	- Subroutine for neutralizer tank
NRELF	- The number of fractions the core is divided into for reloading
NSTRM	- The number of inlet streams
P	- The fuel failure probability in the radial segment being considered
P1,2	- The fraction of the fuel in each axial power step
PCBWR	- The constant for clad activation for BWR
PCLMR	- " " " " " " LMFBR
PCPWR	- " " " " " " PWR
PCOBWR	- " " " coolant " " BWR
PCOLMR	- " " " " " " LMFBR
PCOPWR	- " " " " " " PWR
PD	- Power density (MW/MT)
PF	- Plant factor
PFLOW	- Sum of flows with reactor coolant concentration
PHASEP	- Subroutine for phase separator and centrifuge
PINV	- Amount of parent
PINVM	- Amount of metastable parent
PROB	- Probability of fuel failure at goal burnup
PROPT	- Print option variable
PVBWR	- The constant for BWR vessel activation
PVLMR	- " " " LMFBR vessel activation
PVPWR	- " " " PWR vessel activation
PWR	- Pressurized water reactor
PWRA	- Advanced pressurized water reactor

DOSIS Glossary

R - Read logical unit

RECYC - Portion of treated radwastes returned to coolant

RELF - Number of reload fractions

RODF - The fraction of the core at each radial power considered

RTYPE - Reactor type

SLUDGE - Material held up for solid treatment

SMALL - Subroutine for fission product release

SMLINV - Results of small calculations

SOLID1-9 - Rates of radionuclide retention for solid waste handling

SPBWR - The split of gases off the BWR coolant

SPLM - " " " " " " LMFBR coolant

SPPWR - " " " " " " PWR coolant

SPCON1 - A variable available for use in specifying an input stream coolant concentration

STANK - Subroutine for the storage tank

TANK1-4 - Subroutines for a number of tanks

TFLOW - Total liquid flow

TGASIN, TGASO, TGFLO, TGIN, TGIN1-5, TGINV - Gas stream radionuclide rates at various points in program

TIMA, TIME - Time for decay calculation

TINV, TINV1-4 - Liquid stream radionuclide rates

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TOT, TOTG } Totals used for normalizing

TURNOV - Delay time in coolant

V - Volume

VDELA - Decay subroutine where holdup for radionuclides vary

VDELAY - Delay time as a function of isotope

VENT - Subroutine called for venting tank to gas system

VESSEL - Activation products from vessel

VOLUME - Volume

W - Write topical unit

YLMFBR - Fission yield in LMFBR

YLWR - Fission yield in light water reactors

REPARE Glossary

ACCUM1 - Subroutine - models the MFRP high-level liquid waste system accumulation tank.

ACCUM2 - Subroutine - models the MFRP low-level liquid waste system accumulation tank.

AIR( )* - Variable - transmits the stack effluent from BLEACH through REPARE argument list [pCi/sec]**

AIRMFR( ) - Variable - transmits the stack effluent from MFR through REPARE argument list [pCi/sec]

B( ) - Variable - fraction of isotope I which flows to MFR asphalt blender system from the separations process [ ].

BLEACH - Subroutine - models aqueous reprocessing plants which can accommodate LWR and/or FBR fuel.

BLENDR - Subroutine - models the MFRP asphalt blender for low-level liquid wastes.

C( ) - Variable - fraction of isotope I which flows to MFR waste calciner system from the separations process [ ]

C1( ) - Variable - parameter defined in each subroutine to characterize isotope removal efficiency [ ]

C2( ) - Variable - parameter defined in each subroutine to characterize load dependence of isotope removal efficiency (not presently used) [ ]

CALCIN - Subroutine - models the MFRP waste calciner.

CANAL - Subroutine - accumulates isotopic inventory contributions to low-level liquid waste effluent stream from BLEACH

CFLOW - Variable - represents cumulative flow contributions to low-level liquid waste effluent stream in BLEACH [liters/sec]

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REPARE Glossary

CINV( )	- Variable - contains cumulative value of isotopic inventory in BLEACH liquid effluent [pCi/sec]
CINVF( )	- Variable - contains cumulative value of liquid effluent inventory from FBR fuel reprocessing [pCi/sec]
CINVL( )	- Variable - contains cumulative value of liquid effluent inventory from LWR fuel reprocessing [pCi/sec]
COMPNT	- Variable - defined in each subroutine as six character alphanumeric name for the subroutine
CONCEN	- Subroutine - models the low-level liquid waste system concentrator in MFR
CONDEN	- Subroutine - models the dissolver off-gas system condenser in BLEACH
CONDN2	- Subroutine - models the vessel off-gas system condenser in BLEACH
CONDNF	- Subroutine - models the MFRP asphalt blender, off-gas condenser
CONST	- Variable - fraction of gas flow entering CONDEN which is not condensed [ ]
CONST0	- Variable - fraction of flow from CALCIN to SCRUBF [ ]
CONST1	- Variable - fraction of flow from PROCES to ACCUM1 [ ]
CONST2	- Variable - fraction of flow from PROCES to ACCUM2 [ ]
CONST3	- Variable - fraction of flow from PROCES to SCRUBF [ ]
CONST4	- Variable - fraction of flow from EVAPF to TANK1 [ ]
CONST5	- Variable - fraction of flow from EVAPF to SCRUBF [ ]
CONST6	- Variable - fraction of flow entering SCRUBF which is transferred to ACCUM2 [ ]
CONST7	- Variable - fraction of flow entering SCRUBF which is transferred to SILVRF [ ]

CONST8 - Variable - fraction of flow entering BLENDR which is transferred to SCRBF2 [ ]

CONST9 - Variable - fraction of flow from CONDNF to SFILTR [ ]

COOL - Subroutine - algorithm in BLEACH to compute inventory changes resulting from preprocessing cooling time

COOLF - Subroutine - algorithm in MFR to compute inventory changes resulting from preprocessing cooling time.

CTANK - Subroutine - models catch tank for low-level liquid treatment system in BLEACH

CTANK2 - Subroutine - models catch tank for evaporated low-level liquid waste in BLEACH

CTANK3 - Subroutine - models catch tank for high-level liquid treatment system in BLEACH

CTIME - Variable - preprocessing cooling time in either COOL or COOLF [days]

DATAIN - Variable - contains the integer value 1, used in test to determine if flow values should be printed out.

DECAY - Subroutine - algorithm in MFR to compute inventory decay during process module hold-up times.

DELA - Variable - contains time used for decay equations in COOL, COOLF, DECAY, DELAY [sec]

DELAY - Subroutine - algorithm in BLEACH to compute inventory decay during process module hold-up times.

DISOLV - Subroutine - models fuel dissolution for plants simulated by BLEACH

EFF( ) - Variable - value of removal efficiency for isotope I, used in most process module subroutines.

ELIM1 - Variable - limit for exponent in decay equation (-70) to assure that exponential algorithm in 1108 does not err code off for small exponents [ ]

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REPARE Glossary

EVAP	- Subroutine - models low-level liquid waste evaporator in BLEACH
EVAP2	- Subroutine - models high-level liquid waste evaporator in BLEACH
EVAPF	- Subroutine - models high-level liquid waste evaporator in BLEACH
FHOLD	- Variable - preprocessing cooling time for FBR fuel [days]
FILTER	- Subroutine - models vessel off-gas system filter in BLEACH
FLOSAV	- Variable - retains value of initial flow for comparison with effluent flow rates [liters/sec]
FLOW	- Variable - contains value of stream flow to subroutine whose CALL statement follows [liters/sec]
FLOWIN	- Variable - contains value of stream flow to subroutine whose CALL statement follows [liters/sec]
FLTRF1	- Subroutine - models scrubber gas filter in MFR asphalt blender system
FLTRF2	- Subroutine - models filter in MFR process off-gas system.
FTONS	- Variable - metric tons of fast fuel available to allocation routine in REPARE [tonnes]
FUEL	- Variable - a switch variable in BLEACH, fuel = 1 for LWR processing and 2 for FBR processing [ ]
FULL	- Variable - a switch variable for full printout, set equal to integer 3.
G ( )	- Variable - the fraction of input inventory to PROCESS which goes to the MFR process off-gas system
H ( )	- Variable - fraction of input inventory to the vessel off-gas scrubber which flows to HEATER [ ]
HEATER	- Subroutine - models the vessel off-gas heater in MFR
HOLD	- Variable - the value of adjusted cooling time (time-90 days) for MFR preprocessing delay algorithm [days]

IA - Variable - DO loop index, equals number of liquid effluent isotopes in normalized subset [ ]

IB - Variable - DO loop index, equal number of air effluent isotopes in normalized subset [ ]

IC - Variable - DO loop index, equal to greater of IA or IB [ ]

ICASE - Variable - integer counter to use in printout as case number [ ]

ICHECK - Variable - integer switch variable used in routing logic with multiple entry subroutines.

ILISTA( ) - Variable - list of Master List index numbers to be included in normalized air effluent subset [ ]

ILISTW( ) - Variable - list of Master List index numbers to be included in normalized water effluent subset [ ]

INV( ) - Variable - isotope inventory variable [pCi/sec]

INVIN( ) - Variable - isotope inventory variable [pCi/sec]

INVINF( ) - Variable-initial inventory for FBR fuel [Ci/Te]

INVINL( ) - Variable - initial inventory for LWR fuel (precooled 90 days) [Ci/Te]

INVONE( ) - Variable - isotope inventory variable [pCi/sec]

INVOUT( ) - Variable - isotope inventory variable [pCi/sec]

INVSAV( ) - Variable - isotope inventory variable [pCi/sec]

INVST1( ) - Variable - isotope inventory variable, stream 1 [pCi/sec]

INVST2( ) - Variable - isotope inventory variable, stream 2 [pCi/sec]

IONX - Subroutine - models low-level liquid waste ion exchanger in BLEACH

ISOAIR( ) - Variable - isotope inventory for air effluent subset from normalizing computation [ ]

ISOTOP( ) - Variable - Hollerith, alphanumeric names for isotopes on Master List [ ]

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ISOWAT( )	- Variable - isotope inventory for water effluent subset from normalizing computation [ ]
K1( )	- Variable - decay constants for isotopes on Master List [sec^{-1}]
K2( )	- Variable - decay constants for PINVA isotopes [sec^{-1}]
K3( )	- Variable - decay constants for PINVB isotopes [sec^{-1}]
KEY	- Variable - switch variable for punched card output, 1 for no cards, anything else for cards [ ]
KONST	- Variable - fraction of flow from DISOLV to PUREX [ ]
LIMIT	- Variable - integer do loop limit for calculations, set equal to number of isotopes in Master List [ ]
LOAD	- Variable - defines loading effects on efficiency for each subroutine [ ]
M	- Variable - number of dual-purpose reprocessing plant sites [ ]
MFR	- Subroutine - control subroutine for MFRP model
MFRAIR( )	- Variable - isotope inventory for MFR effluent transferred through block common [pCi/sec]
NAME	- Variable - contains 3 character Hollerith name for type of spent fuel, LWR or FBR
NOBLDF	- Subroutine - models noble gas removal equipment for MFR and BLEACH
NONE	- Variable - switch variable to indicate no printout, set equal to 1 [ ]
NORMAL	- Variable - switch variable for normalizing calculations, NORMAL = 1 bypasses calculations [ ]
OPTION	- Variable - name of printout, calculation option data namelist [ ]
P( )	- Variable - stream splitting fraction in DISOLV and CONDEN [ ]

PART	- Variable - switch variable for printed output of summary data, set equal to 2 [ ]
PFILTR	- Subroutine - models final off-gas filter in BLEACH
PINVA( )	- Variable - inventory for parent A in decay algorithms [atoms/sec]
PINVB( )	- Variable - inventory for parent B in decay algorithms [atoms/sec]
POWER1( )	- Variable - exponent for daughter in decay algorithm [ ]
POWER2( )	- Variable - exponent for parent A in decay algorithm [ ]
POWER3( )	- Variable - exponent for parent B in decay algorithm [ ]
PROCEQ	- Subroutine - models MFR separations process
PROPT	- Variable - namelist variable for printout options, 3 = full, 2 = part, 1 = none [ ]
PUREX	- Subroutine - models BLEACH separations process
R	- Variable - logical unit for card reader, integer [ ]
REPARE	- Subroutine - contains logic for fuel allocation to MFR and BLEACH, and normalizing algorithm
S	- Variable - stream splitting fraction in EVAP and EVAP2 [ ]
SAIR( )	- Variable - air effluent inventory subset from normalizing algorithm [ ]
SAIRMF( )	- Variable - MFR effluent inventory subset from normalizing [ ]
SCRBF2	- Subroutine - models MFR asphalt blender system off-gas scrubber
SCRUB2	- Subroutine - models BLEACH vessel off-gas system scrubber
SCRUBF	- Subroutine - models MFR process off-gas scrubber
SCRUBR	- Subroutine - models BLEACH dissolver off-gas scrubber

SFILTR - Subroutine - models MFR final off-gas filter

SFLOW - Variable - accumulates flow through stack from each treatment system [liters/sec]

SILVER - Subroutine - models off-gas silver reactor in BLEACH

SILVRF - Subroutine - models off-gas silver reactor in MFR

SINV( ) - Variable - isotope inventory for BLEACH air total effluent [pCi/sec]

SINVF( ) - Variable - isotope inventory for BLEACH air effluent from FBR processing [pCi/sec]

SINVL( ) - Variable - isotope inventory for BLEACH air effluent from LWR processing [pCi/sec]

SITE - Variable - number of total reprocessing sites required [ ]

SR( ) - Variable - fraction of inventory which is transferred from SCRUBR to SILVER [ ]

STACK - Subroutine - accumulates air effluent contributions from each treatment system in BLEACH

STACKF - Subroutine - accumulates MFR effluent from individual treatment system contributions

STOTA - Variable - total inventory for BLEACH air effluent [pCi/sec]

STOTMF - Variable - total inventory for MFR effluent [pCi/sec]

STOTW - Variable - total inventory for BLEACH liquid effluent [pCi/sec]

SUNITA - Variable - User input normalized value for BLEACH air effluent subset [ ]

SUNITW - Variable - user input normalized value for BLEACH water effluent subset [ ]

SUNTMF - Variable - user input normalized value for MFR effluent subset [ ]

SWATER( ) - Variable - water effluent inventory subset from normalizing algorithm [ ]

TANK1 - Subroutine - models evaporator catch tank in MFR calcining system.

TANK2 - Subroutine - models concentrator catch tank in MFR asphalt blender system

TIME - Variable - switch variable to determine whether decay times are input or calculated [ ]

TIMEIN( ) - Variable - input decay times for each subroutine [sec]

TONFBR - Variable - metric tons of FBR fuel to be reprocessed [tonnes]

TONLWR - Variable - metric tons of LWR fuel to be reprocessed [tonnes]

TONS - Variable - tons of fuel [tonnes]

TONSIN - Variable - tons of fuel input to MFR or BLEACH [tonnes]

TONSUM - Variable - total tons of equivalent LWR fuel [tonnes]

TOTA - Variable - total inventory of BLEACH air effluent [pCi/sec]

TOTMFR - Variable - total inventory of MFR effluent [pCi/sec]

TOTW - Variable - total inventory of BLEACH liquid effluent [pCi/sec]

UNITA - Variable - user input, normalized value for total BLEACH air effluent [pCi/sec]

UNITMF - Variable - user input, normalized value for total MFR effluent [pCi/sec]

UNITW - Variable - user input, normalized value for total BLEACH liquid effluent [pCi/sec]

VOG( ) - Variable - fraction of PUREX inventory transferred to vessel off-gas system [ ]

VOLOXR - Subroutine - models pre-dissolution oxidizer to remove volatiles in BLEACH

VOLUME	- Variable-effective volume of process module to compute holdup time from volume/flow [liters]
W	- Variable - logical unit for printer, integer [ ]
WATER( )	- Variable - isotope inventory for dual-purpose liquid effluent [pCi/sec]
WHL( )	- Variable - fraction of PUREX inventory transferred to the high-level liquid waste system [ ]
WLL( )	- Variable - fraction of PUREX inventory transferred to the low-level liquid waste system [ ]
XTRADF	- Subroutine - models additional filters for final off-gas in BLEACH

* parentheses denote subscripts, at this writing the maximum value, unless otherwise noted, is fifty.

** brackets contain the units for the variable, if the brackets are empty, [ ], the variable is a dimensionless decimal fraction.

FIGURE Glossary

DIFF - Variable that measures magnitude of food production over food consumed.

FEAT - Food consumed in one year per family.

FOCON - Food consumed in one week per family.

FOOL - Intermediate storage variable.

FOPRO - Food produced in one year in pounds.

FOSTE - Food conversion factor from X to pounds.

FOUSE - Total food consumed.

FSIZE - Size of family.

HOME - Home production factors.

ID - Food consumption category.

IPOP - Centroid population in 100's.

KANSAS -
KILL -
KIOWA -
KMINN - County to centroid conversion index.
KMO -
KNEBR -
KSDAK -
KWISC -

KFOOD - Food produced in one year.

KFOPRD - Food type index table (73 food types).

KFOTP - Food type index table (35 food types).

KST - End flag for food produced data.

KSTA - State index table read at execution.

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FIGURE Glossary

KWHAT - State index table (internal).

LOC - Latitude and longitude of dummy centroids.

LV - -4 Read buffer.

SURDEF - Surplus or deficit food.

TOTAL - Total of fresh and processed foods.

TRANS Glossary

CTR - Centroid number.

DIST - Maximum search distance.

DLN - Degrees longitude

DLT - Degrees latitude

FR - Centroid from which shipment is made.

FT - Food type being shipped.

LTR - Centroid number, read when inputting location.

MINI - Logical control variable read at execution.
- . FALSE - Detail distance calculations printed.
- . TRUE - Detail distance calculations not printed.

MLN - Minutes longitude.

MLT - Minutes latitude.

NCT - Control variable read at execution. Number of loops through search before checking time elapsed.

NCTR - Number of centroids read at execution.

NFT - Last food type to be transported } input at execution.
NSTRT - First food type to be transported

NTIME - Time desired to search before search distance is halved. Input at execution.

OUTAPE - Logical control variable input at execution.
- . TRUE - Solution to output tape C and printer.
- . FALSE - Print solution.

PER, PT - Percent of centroid deficit satisfied by the surplus centroid.

PR, PRCT - Percent of the centroid surplus shipped to the deficit centroid.

TITLE - Title of cases being solved.

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ARTRAN Glossary

ACCUM - Subroutine

ADVTAP - Subroutine

AIN - Print key meteorology data.

AIRACC - Array for monthly air concentration.

AIRCON - Calculated value for air concentration for each loop.

ALM1 -
ALM2 -
ALMBDA -
ALMDA -
ALMY
} Radioactive decay coefficient representations.

ARTRAN - Main program.

AW, AW1 } - Temporary storage arrays for long term ground concentration.

BLMDA - Decay coefficient

BUG - Namelist

CHIBAR - Calculated value of $\overline{\chi}$.

CITYLA, CITYLO } - Storage arrays for latitude and longitude of centroids.

CIN - Print key-centroid data

CLMBOA - Radioactive decay - variable.

CO1, CO2 } - Constants for wet deposition of gases.

CONCEN - Subroutine

COMMIN - A user set minimum value for concentration to be considered.

D1 -
D2 -
D3 - Drum control word arrays
D4 -
D5 -

DORY - Dry deposition coefficient

DEBUG - Process key for debug run data

DELDRY -
DELWET - Subroutines

DEP1
DEP2 - Calculated values of long term ground deposition.

DEXP - Dry deposition exponential

DISMAX - User set maximum distance to be considered.

DIST - Calculated distance source to centroid.

DLA -
DLO - Conversion factors degrees to kilometers

DLAT -
DLON - Calculated values of Cartesian coordinates difference.

DRYCON - Calculated value of dry deposition contribution for each loop.

DRYDEP -
DRYTIM - Intermediate values for dry deposition

DUMY - A dummy variable.

DV - Deposition velocity.

DWET - Wet deposition coefficient.

EQPART - Subroutine

ETIME -
ETIMEF - Timing routines.

FARWAY - Array of values of source to centroid distances.

FRAIN - Frequency of precipitation

GNOMON -
GNDTOT - Arrays for accumulation of monthly values of short and long term ground concentrations

H -
HE - Stock height variables

ARTRAN Glossary

ICIT1 -
ICIT2 -
ICITY -
} Control variables and array for setting DO loop limits.

ICY - Incrementing variable for centroid.

IDRUM - Drum array variable

IN1 -
IN2 -
IN3 -
IN4 -
} Logical unit designators for input data tape decks.

INC1 - Separation variable for drum files.

INTO - Incrementing variable for array position.

INU - Incrementing variable for nuclide.

IS - Incrementing variable for source.

ISEASW - Winter or summer season variable.

ISEC - Sector-indicating variable.

ISO - Subroutine source variable.

ITYPE - Designator variable for output record type.

IWX - Incrementing variable for stability type.

KDAVG1 -
KDAVG1+ -
} Array for storage of daughter definition data.

L1 -
L2 -
L3 -
L4 -
L5 -
L6 -
} Array positioning variables used in debug run.

MAXCIT - Maximum value for drum.

MAXMON - DO loop limit for month iteration.

MAXNUC - DO loop limit for nuclide iteration.

MAXSRC - DO loop limit for source iteration.

MAXWAY -
MAXY -
} Drum storage variables

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MDAUGT - Array for daughter data

METEOR - Subroutine

MINMON - DO loop start for month iteration.

MINNUC - DO loop start for nuclide iteration.

MINSRC - DO loop start for source iteration.

MNCITY - DO loop lower limit for centroid.

MON - Incrementing variable for month iteration.

MOTHER -
MOTHR1 - } Arrays for mother definition data.

MXCITY - DO loop limit for centroid iteration.

NAME - Print variable for Namelist OPERAT.

NEWMON - Array for changing date data on source tape.

NIN - Card reader.

NOPRINT - Print key for output.

NOUT - Printer

NOUT25 - Output tape deck.

NSTRT - Drum sort variable.

NU - Nuclide incrementing variable.

OPERAT - Namelist for normal operation.

OUTT - Subroutine

PLANT1 -
PLANT2 - } Card input arrays for debug.

POPUL - Namelist for change to centroid position data.

Q -
QD -
QEFF -
QR -
QS -
QW -
QZ - } Input & calculation variables for source strength.

RAIN - Precipitation rate.

RECOVR - Key for restart.

RECYCL - Subroutine.

REXP - Radioactive decay exponential.

SDA335 -
SDA465 -
SDA8 -
SDALVL - } Summer critical height variables.

SIGM -
SIGMA - } Sigma-3 variables

SIGZ - Subroutine

SIN - Key for print of source data.

SNT335 -
SNT465 -
SNT8 -
SNTLVL - } Summer night critical height variables.

SORCLA -
SORCLO - } Source latitude and longitude.

SORT - Subroutine

STAB - Stability category.

SUMDAY -
SUMNIT - } Summer critical distance variables.

TEND - Study year variable.

TEST - Subroutine

TUSMDA -
TUSMNT -
TUWWRA -
TUWNNT - } Critical distance variables.

WDA335 -
WDA465 -
WDA8 -
WDALVL - } Winter day critical height variables.

WEA - Input array of meteorological variables for debug.

WETCON -
WETDEP -
WETTIM -
} Wet concentration variables.

WEXP - Wet deposition exponential

WINDAY -
WINNIT -
} Winter critical distance variables.

WNT335 -
WNT465 -
WNT8 -
WNTLVL -
} Winter night critical height variables.

WWET - Temporary storage array for output.

WX - Meteorological data array.

ZEROUT - Subroutine.

WTRAN GLOSSARY

AA	- List of centroid areas
ALAT	- Latitude (degrees)
ALON	- Longitude (degrees)
AR	- Centroid area
ARIVM	- List of river miles
ATOW	- Function governing air-to-water isotope transfer calculations
BD	- River bed isotope concentration
BEGM	- Beginning river mile
BS	- River bed sediment rate
BSED	- Subroutine to calculate river bed deposition and scouring
C	- Concentration of dissolved isotope
CCS	- Concentration of suspended isotope
CCW	- Concentration of dissolved isotope
CENT, CNT	- Centroid name
CO	- River code
CODEM	- Mainstream code
CRRR	- River code
D1	- Upstream depth or data type indicator
D2	- Downstream depth
DECAY	- Subroutine for calculating radioactive decay
DELAY	- Ground water travel time
DIS	- Fraction dissolved

WTRAN Glossary

DIST	- Distribution coefficient (ratio of fraction of isotope dissolved to fraction suspended on sediment)
DM	- Downstream mile
DMD	- Downstream mile
DOSE	- Subroutine for reporting radionuclide concentrations
DOSIS6	- Subroutine for input of RADREL data
DRNK	- Drinking water type
DUM	- Dummy variable
DX	- Length of river section
EL	- River section length
ENDM	- Ending river mile
EXPO	- Exponent in stage calculation
F	- Decay term
F1	- Monthly flow
FBEG	- Upstream flow
FEND	- Downstream flow
FIN	- Upstream flow
FLDRPT	- Subroutine for flood calculations
FLOOD	- Flood flow
FLREAD	- Subroutine for flow data input
FOUT	- Downstream flow
FT	- Array of flow data
FTM2, FTM3	- Conversion factors
GNDM	- Subroutine for determining ground water calculations
H	- Dummy array
HL	- Decay constant for radionuclide

I1	- Isotope pointer
ICNT	- Centroid number
IMAP	- River pointer
IPOP	- List of centroids to report
IR	- Program flow indicator
IREACT	- Source report indicator
IRIV	- List of rivers to be reported
IRUN	- Runoff report indicator
ISAVE	- First month of no river bed deposits or scouring
ISODEF	- Subroutine for defining isotope data
ISTART	- Starting index for search
JA	- Isotope pointer
JFLOOD	- Flood data pointer
JPGNDW	- Number of data for drinking water reports
JPOP	- List of centroids for drinking water reports
JRIV	- Pointer to river report requests
JRIVT	- Number of rivers to report
JUMP	Signal for no river bed sediment (JUMP = 0 deletes sedimentation calculations JUMP = 1 includes sedimentation calculations)
K14	- Dose record type
KCENT	- Population center pointer
KCNT	- List of population centers
KEOF	- End of file signal
KF	- Current river index
KFLOOD	- Number of flood points

WTRAN Glossary

KFLOW	- River pointer
KK	- List of centroids found and not reported
KMAP	- River pointer
KOFF	- End of file signal
KR	- River pointer
KREP	- Report type indicator
KRIV	- List of rivers to report
KRIVT	- Number of rivers to report
KRN	- List of river numbers
KSINK	- Centroid for which ground water is to be reported
KSITE	- Dummy variable
KSORCE	- Centroid supplying ground water
KT	- Number of tributary data sets on drum
KTYP	- Type of record
KTYPE	- List of data
KUSED	- Signal to increase river report pointer
LB	- I/O status indicator
LC	- List length
LCENT	- List length
LF	- A value from the FT array
LFLOOD	- Array of flood data
LFT	- Array of flow data
LISO	- Number of isotopes (limit variable)
LIST	- List of river numbers
LIST2	- List of sorted site numbers
LIST3	- List of drum addresses

WTRAN Glossary

LM	- Number of months studied
LOC	- Current position in tributary table
LOOP	- Loop counter
M4	- I/O logical unit
MAPT	- List of tributaries
MDAU	- Mother isotope number
MFLOOD	- Count of flood data
MFLOW	- Subroutine for tributary flow calculations
MIX	- Report indicator for tributary mix points
MM	- Hollerith list of month names
MMAP	- River number at radionuclide source site
MMT	- Tributary river number
MO	- List of days in each month
MREAC	- River number at radionuclide source site
MS	- List of river numbers
N1	- Program flow indicator
N21	- I/O logical unit
NA	- Number of water isotopes from atmospheric data
NCENT	- Number of population centers
ND1, ND3, ND4, ND7,	- Drum pointer arrays
NFLOW	- Number of flow data sets
NI	- Number of river sections
NIS	- Number of isotopes
NISO	- List of water isotope numbers (serial list for arrays)
NM	- Number of months

NMAP - Number of rivers included in calculations

NP - Number of reactor sites

NPR - Number of print lines per page

NR - Number of rivers

NRAIN - Number of centroids

NREACT - Serial number of radionuclide source

NRO, NRS - I/O logical units

NS - Number of sediment data sets

NT4 - Report indicator

NTA, NTB, NTD, NTE, NTF, NTI, NTO - I/O logical units

NTOPE - Number of isotopes considered.

NTOTAL - Number of reactor sites

NTR - I/O logical unit

NTS, NTT, NTU - I/O logical units

NTYPE - Program flow indicator

NUM - List of number of sites on each river

OBS - Subroutine to check for locations where calculations are needed

OVERBD - Input overbed flood height

OVRBED - Subroutine for flood plain deposition calculations

PC - Percent clay in sediment

PM - Percent silt in sediment

POPCNT - Subroutine for reading Living Patterns Model tape

POPNO - Count of population centers to be reported

PS - Percent sand in sediment

PTOBS - Population center river mile

QO - Normal river flow

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WTRAN Glossary

R - Array of runoff data

R1 - River code or river name

R2 - River name

RAU - Decay time

RBAS - Subroutine calculating runoff contributions to rivers

RBDPTS - Subroutine for reading river section data

RBED - Subroutine for metric conversion

RBMILE - River mile

RC, RC1, RC2, RCODE - River code

REACT - Subroutine to account for radionuclide inputs to rivers at source sites

REACTA - Rate of radionuclide input from source

REACTM - River mile at radionuclide source site

REND - River section ending mile

REPORT - Subroutine to report calculated data

RI, RII - Isotope release rate from source

RIV, RIVC - River Code

RIVEND - Report signal

RIVM - River mile

RJ - Temporary storage

RM, RM1, RM2 - River mile

RMAP - Subroutine for river map data processing

RMB - River mile

RMILEM - River mile

RMK - List of river miles

RMT - River mile

RNAME - River name

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WTRAN Glossary

PREACT	- Subroutine to read and correlate plant site location and isotope release data
RSED	- Subroutine for sediment calculations
RU	- Annual rainfall
RUNO	- Subroutine for runoff calculations
RUNOF	- Rate of inflow of air-deposited isotope into river from surface runoff
RUNPTS	- Subroutine to correlate atmospheric code location data to river basin data
S	- River surface
S1	- Upstream suspended sediment
S2	- Downstream suspended sediment
SAU	- Decay time
SB	- Sediment rate
SEC	- Decay time
SED, SEDP	- Subroutine
SEGM	- River length
SITE	- Dummy variable
SORTF	- Subroutine for data sorting
SRM	- River mile
SSB, SSSB, SSSSB	- Depth of river sediment
STAGE	- Overbed river height
STAGEC	- River depth at start of flooding
STAGEO	- Normal river depth
SUM	- Sum
SUR, SURF	- River surface
SYM	- Isotope symbol
T1, T2, T3, T4, T5, T6, T7	- Totals

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WTRAN Glossary

TAU	- Decay time
THICK	- Overbed deposit thickness
THRU	- Finished sorting signal
TM, TMILE	- River mile
TRIBU	- Subroutine for correlating data for tributary streams
UM	- Upstream river mile
UMD	- Upstream river mile
V, VOL	- River section volume
W1, W2, W3, W4	River section dimensions
WATSUR	- Water surface

DOSE Glossary

A - Logical unit for tape assignment.

ACCUMF - Accumulation coefficient used in FORAGE to compute deposition loss through decay.

AKEY - Word to store in dictionary table (DT) to identify table being written to drum.

ALOSS - Table containing deposition concentrations for crops.

AMWATR - Contains consumption of drinking water in liters for each person type by population type.

APEAR - Month of appearance for food crops.

AR39 - Isotope identifier for Argon-39.

AR41 - Isotope identifier for Argon 41.

ARRAY - Array to contain table in GET and PUT.

BA140 - Isotope identifier for Barium-140.

BEGIN - Initial index for dictionary search in GET.

BONE - Title for bone dose reports.

BUTTER - Title for butter dose contributions.

C - Isotope concentrations in food crops.

C14 - Isotope identifier for Carbon-14.

CALC - Subroutine

CARD - Logical unit for card reader, defined in PARAM.

CE141 - Isotope identifier for Cerium-141.

CE144 - Isotope identifier for Cerium-144.

CENTER - Logical unit for living patterns tape.

CENTRD - Centroid number for food source.

CO58 - Isotope identifier for Cobalt-58.

CO60 - Isotope identifier for Cobalt-60.

CODE - Integer variable for switching codes.

COMB - Combined concentrations for food crops.

CONC - Food crop concentrations.

CONC2 - Food crop concentrations.

CONC3 - " " "

CONC4 - " " "

CONC5 - " " "

CONC6 - " " "

CONC7 - " " "

CONCFA - Concentration factors for plants.

CONST - A real constant used in MULTI.

CORE - Storage for binary input data.

CR51 - Isotope identifier for Chromium-51.

CROP - Subroutine

CS134 - Isotope identifier for Cesium-134.

CS137 - " " " " -137.

CU64 - " " " Copper-64.

D - Table for diet data for each person by population type.

D1 - FPRSRT argument

D2 - " "

D3 - " "

D4 - " "

D5 - " "

D6 - " "

D7 - " "

DATE - Date of report from parameter input card.

DOSE Glossary

DAYS - Time for decay calculation.

DC - Temporary storage for dose values.

DECAY - Decay time between harvest and consumption.

DECAY1 -
DECAY2 -
DECAY3 -
DECAY4 -
} Subroutine

DF - Dose factors for dose calculations from card input.

DIET - Subroutine

DIETS - Table for diet data from living patterns tape.

DOSERP - Subroutine

DRIVER - Subroutine

DRUM - Logical unit for drum storage.

DS1 -
DS2 -
DS3 -
DS4 -
} Dose tables for reports.

DT - Dictionary table for storage of arrays.

DUMMY - Interim storage variable.

DUMP - Subroutine.

E2 -
E4 -
E7 -
E8 -
E9 -
} Array to store dose calculation constants.

EOF - Variable to indicate end of living patterns tape.

ETIME - Internal clock routine for time checks.

ETIMEF - Internal clock routine for time checks.

EXP - Exponential for decay calculations.

EXP2 - " " " "

FE55 - Isotope identifier for Iron-55.

FE59 - Isotope identifier for Iron-59.

FEMPTY - Entry point in FPRSRT.

FFILE - " " " "

FGET - " " " "

FILTBL - Argument for FPRSRT.

FLD - Field function.

FLOAT - Internal floating point conversion function.

FM1 -
FM2 - } Variable formats for reports.
FM3 -

FMERGE - Entry point in FPRSRT.

FMT - Variable format array for reports.

FMT2 -
FMT3 - } Variable formats for reports.

FOOD - Subroutine

FORAGE - Subroutine

FPRSRT - Subroutine

FRACT - Contains fraction of monthly household consumption for diet by person type.

FT - Temporary storage in GET and PUT.

GET - Subroutine

H - Table for habit data in POPFIL.

HABIT - Table for habit data in MULT.

HAFIZE - Effective decay constant.

HAFIZR - Radiological decay constant.

HARVES - Month of harvest for crops.

HARVST - Data for month of harvest for crops.

HF - Fraction of recreation hours per month to assign to person types in each centroid.

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I - Indexing variable.

I1 - Indexing variable.

I129 - Isotope identifier for Iodine-129.

I131 - " " " " -131.

I132 - " " " " -132.

I133 - " " " " -133.

I135 - " " " " -135.

I2 -
I3 - } Indexing variable.

IABS - Internal function to determine absolute value.

IADD - Paging switch for reports.

IARRAY - Array containing records to be sorted in SORTER.

IC - Table with last entry for each nuclide in the concentration table.

ICALC - Switch for time check in DRIVER.

ICENTR - Population center code to search living patterns file.

ICK - Switch variable in READER.

ICODE - Dose table index for person type.

ICORE - Isotope index storage for mapping indexes between transport codes and DOSE.

ID - Table with last entry for each type of person in the diet table.

IDEBUG - Switch variable for calls to DUMP.

IDENT - Population types from living patterns tape.

IDUMX - Dummy switch variable in FOOD.

IEND - Dummy switch variable in FOOD.

IERROR - Variable for DOSE error message in DRIVER.

IFC - Switch variable defined by IC table.

IFD - " " " " ID " .

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IFH - Switch variable defined by ID table.

IFIRST - Switch variable for living patterns error messages.

IFT - Integer storage in PUT.

IH - Habit table containing dictionary keys.

IJMP - Switch variable for habit calculations in POPFIL.

IMAGE - Variable to write card image for parameter card erros.

INDEX -
INDEX1 -
INDEX2 -
INDEX9 -
INDX - } Integer variable for subscript calculations.

INFO - Storage for living patterns data.

INTAKE - Intake table for FORAGE.

IO - Array for logical units, set up in PARAM.

IOPT1 -
IOPT2 - } Report writing variable.

IOTABL - Table to set up logical units in PARAM.

IPAGE - Paging index for reports.

IPATH - Integer array of path data.

IPRES - Switch for percent of total dose calculations.

IREC - Variable to read in binary data in READER.

ISC - Index for first non-zero concentration data.

ISD - Index for first non-zero diet data.

ISECND - Switch for dose or dose commitment calculations.

ISEL - Table containing isotopes selected for calculation by input parameter card.

ISH - Index for first non-zero habit data.

ISO - Index for nuclide mapping between binary data input and master list.

ISONEW - Variable for new month of harvest concentration.

DOSE Glossary

ISOOLD - Variable for old month of harvest concentration.

ISOTOP - Isotope index variable.

ISTART - Index for start of dose totals reporting.

ISTOP - Index for end of dose totals reporting.

ISW - Argument for subroutine index in TIMER.

ITABL6 - Index for heading switch in SUMMARY.

ITABLE - Argument for table length in FPRSRT.

ITEMS - Number of items in each record in SORTER.

ITOTAL - Integer table equivalenced to TOTAL.

ITS - Integer equivalenced to TOTALS.

JCODE - Dose table index for isotope number.

JTABLE - Dictionary index for FPRSRT.

KEY - Centroid number in binary data read.

KEYS - Function subroutine.

KNDEX - Starting array value for most used deposition tables in FOOD.

KR85 - Isotope identifier for Krypton-85.

KR85M - Isotope identifier for Krypton-85m

KR87 - Isotope identifier for Krypton-87.

KR88 - Isotope identifier for Krypton-88.

L1 -
L2 -
L3 -
L4 -
L6 -
L8 -

} Variable array lengths used for call to GET.

LA140 - Isotope identifier for Lanthanum 140.

LAST1 - Variable for hollerith switch LAST read from final centroid parameter card.

LCODE - Dose table index for organ type.

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LD - Length of dictionary table.

LEN - Length of table in READER.

LENCOM - Length of a combined concentration table.

LENCON - Length of a concentration table.

LENDIE - Length of a diet table.

LENDOS - Length of a dose table.

LENDSF - Length of dose factors table.

LENGCi - Length of concentration tables, i from 2 through 7.

LENGDC - Length of dose commitment factors table.

LENGDF - Length of short term deposition concentrations table.

LENGTC - Length of total foodstuffs concentration table.

LENGTH - Length of concentration tables.

LENHAB - Length of habits table.

LENLOS - Length of loss factors table.

LGTH - Length of concentration tables.

LIFEIZ - Radiological half lives for isotopes.

LINES - Paging switch for reports.

LIVER - Identifier for liver dose reports.

LLI - Identifier for GI-Tract dose reports (Lower Large Intestine).

LOC - Centroid number for data input.

LOCAL - Centroid number for locally produced foodstuffs switch.

LOCATE - Centroid number from living patterns tape.

LOSS - Loss factor table.

LSD - Length of sorted dictionary table.

LSTAT - Status word for check of NTRAN operations.

LU - Logical unit for I/O statements.

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LUNGS - Identifier for lung dose reports.

MAP - Switch array for food calculations defined in STARTF used in FOOD.

MAPA - Array to change air isotope indices to master list indices.

MAPW - Array to change water isotope indices to master list indices.

MAX - Internal routine to determine largest number in an array.

MERGE - Subroutine.

MD - Middle index of an array for drum search in GET.

MN54 - Isotope identifier for Manganese-54.

MO99 - Isotope identifier for Molybdenum-99.

MOD - Internal routine.

MONTH - Month of calculation.

MONTHC - Month of concentration data.

MONTHD - Month of diet data.

MONTHH - Month of habit data.

MULT -
MULT1 -
MULT2 -
MULT3 - } Subroutine.

N13 - Isotope identifier for Nitrogen-13.

NA22 - Isotope identifier for Sodium-22

NA24 - Isotope identifier for Sodium-24.

NB95 - Isotope identifier for Niobium-95.

NI63 - Isotope identifier for Nickel-63.

NISHL - Switch variable in POPFIL.

NO - Array index for habit table in POPFIL.

NOCRD - Card number for centroid parameter cards.

NOIN - Number of records put in to SORTER.

NONUCL - Number of isotopes for loop limits.

DOSE Glossary

NOPATH - Number of paths for loop limits.

NOUT - Number of records out of SORTER.

NTOTAL - Number of retention factors.

NTRAN - Internal drum and tape utility routine.

NUM - Maximum number of harvest months.

NUMDMi - Dummy word for last record on binary data tapes, i from 1 through 3.

ORGAN - Hollerith constant for reports.

OVRLAY - Equivalenced storage array in DIET.

PARAM - Subroutine.

PERCN1 - Percent of total production irrigated.

PERSON - Number of people in an individual age category for a particular centroid.

POPFIL - Subroutine.

POPULT - Total population of a centroid from the living patterns tape.

PUT - Subroutine.

QUANT - Monthly consumption vector for livestock.

QUANT1 - Forage intake for animals.

QUANT2 - Grain intake for animals.

QUANT3 - Stored feed intake rates for animals.

QUANTW - Water consumption for animals.

RATE - Irrigation rate for food crops.

RATEI - Irrigation rate.

RATIO - Fraction of total centroid population in a particular age category.

READER - Subroutine.

REC - Input array for living patterns data.

REPEAT - Number of months of harvest.

REPORT - Logical unit for line printer.

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REREAD - Logical unit for reread.

RESET - Entry point in PUT for non-scratch area from drum.

RETENT - Plant retention factors.

RETNTB - Dummy retention factors for cows.

RICE - Identifier for rice dose reports.

RINFO - Real variable equivalenced to INFO.

RNF - Acronym to identify rural non-farm centroids.

RU103 - Isotope identifier for Ruthenium-103.

RU106 - Isotope identifier for Ruthenium-106.

RUF - Acronym to identify rural farm centroids.

SET - Entry point in PUT to save starting drum address.

SKIN - Identifier for skin dose reports.

SKIP - Switch to skip continued calculation if remaining time is insufficient.

SORTC - Subroutine.

SORTER - Subroutine.

SR89 - Isotope identifier for Strontium-89.

SR90 - Isotope identifier for Strontium-90.

SRTKEY - Subroutine.

STARTF - Subroutine.

SUMMARY - Subroutine.

Ti - Table i in MERGE, i from 1 through 3.

TiCOUN - Constants in MERGE, i from 1 through 3.

TILENG - Number of entries in table i in MERGE, i from 1 through 3.

TABLE - Data array.

TAPE - Subroutine.

TCHEK -Subroutine.

TE132 - Isotope identifier for Tellurium-132.

TIMER - Subroutine.

TIMET - Running tome storage.

TOTAL - Total dose array for summary reports.

TOTALS - Total dose times total population for integrated dose reports.

TRANS - Translocation factors for food crops.

TRANSF - Transfer coefficients for foodstuffs.

TRANSL - Translocation factors for foods.

TYPE - population type by relative population concentration.

URB - Acronym for urban population type.

VECTOR - Data array for multiplication subroutines MULT2, MULT3.

WHEAT - Identifier for wheat dose contributions.

XE131 - Isotope identifier for Xenon-131.

XE133 - Isotope identifier for Xenon-133.

XE133M - Isotope identifier for Xenon-133m.

XE135 - Isotope identifier for Xenon-135.

XE135M - Isotope identifier for Xenon-135m.

XE138 - Isotope identifier for Xenon-138.

YIELD - Yield factor for particular type of crop.

YIELDF - Data array for crop yield factors.

Z - Argument in time subroutines.

ZERO1 - Subroutine.

ZN65 - Isotope identifier for Zinc-65.

ZR95 - Isotope identifier for Zirconium-95.

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APPENDIX F

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Plant Site List

1083686

PLANT SITE LOCATIONS

UPPER MISSISSIPPI-LOWER MISSOURI STUDY AREA

10836871

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PSA	SITE NAME	SITE NO.	MAX NO. PLANTS	RECEIVING WATERS	RIVER MILE	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN
09	LOCUST POINT	0901	4	LAKE ERIE	*	41	37	83	06
09	DAVIS-BESSE	0902	4	LAKE ERIE	*	41	36	83	06
09	MITIWANGA	0903	4	LAKE ERIE	*	41	23	82	27
09	CRYSTAL ROCK	0904	4	LAKE ERIE	*	41	26	82	51
09	OKOLONA	0905F	2	MAUMEE	*	41	20	84	09
09	YELLOW BUD	0906	4	SCIOTO	*	39	30	83	00
09	SALT CREEK	0907	4	SCIOTO	*	39	09	82	52
09	SYCAMORE	0908F	3	SANDUSKY	*	40	59	83	12
11	FERMI	1101	4	LAKE ERIE	*	41	57	83	15
11	OAK PORT	1102	4	LAKE ERIE	*	41	58	83	15
11	FAIR HAVEN	1103	4	LAKE ST CLAIR	*	42	41	82	40
11	GRANDE POINTE	1104	4	ST CLAIR R	*	42	38	82	35
11	BICKFORD	1105	4	ST CLAIR R	*	42	46	82	29
11	AMADORE	1106	4	LAKE HURON	*	43	10	82	30
11	CROSWELL	1107	4	LAKE HURON	*	43	20	82	23
11	WISNER	1108	2	SAGINAW BAY	*	43	38	83	37
11	GUANICASSEE	1109	2	SAGINAW BAY	*	43	35	83	42
11	MIDLAND	1110	4	SWAN CREEK	*	43	35	84	13
11	PINCONNING	1111	2	SAGINAW BAY	*	43	48	83	56
11	KEEWAHDIN	1112	4	LAKE HURON	*	43	05	82	28
11	MONTAGUE	1113	2	LAKE MICHIGAN		43	28	86	27
11	MUSKEGON	1114	4	LAKE MICHIGAN		43	16	86	25
11	WEST OLIVE	1115	3	LAKE MICHIGAN		42	55	86	13
11	GANGES	1116	2	LAKE MICHIGAN		42	34	86	14
11	ONONDAGA	1117F	4	GRAND	*	42	27	84	34
12	FOREST DUNES	1201	4	LAKE MICHIGAN		42	18	86	20
12	THUNDER MTN	1202	4	LAKE MICHIGAN		42	15	86	21
12	LIVINGSTON	1203	4	LAKE MICHIGAN		42	00	86	33
12	LAKESIDE	1204	4	LAKE MICHIGAN		41	53	86	37
12	MICHIGAN CITY	1205	4	LAKE MICHIGAN		41	42	86	57
12	BAILLY STATION	1206	4	LAKE MICHIGAN		41	40	87	01
12	COLOMA	1207	4	LAKE MICHIGAN		42	11	86	25
12	OGDEN DUNES	1208	4	LAKE MICHIGAN		41	38	87	10

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PSA	SITE NAME	SITE NO.	MAX NO. PLANTS	RECEIVING WATERS	RIVER MILE	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN
12	DELPHI	1209F	2	TIPPECANOE	*	40	40	86	45
12	LAFAYETTE	1210F	2	WABASH	*	40	30	86	48
12	COVINGTON	1211F	3	WABASH	*	40	06	87	25
12	INDIANAPOLIS	1212	3	WHITE	*	39	30	86	23
12	TERRE HAUTE	1213	1	CATARACT LAKE	*	39	28	86	50
12	WORTHINGTON	1214F	2	WHITE	*	39	06	86	58
12	EVANSVILLE	1215	4	OHIO	*	37	54	87	53
12	VINCENNES	1216F	2	WABASH	*	38	31	87	41
12	FORT WAYNE	1217	3	MAUMEE	*	41	08	84	56
12	DAYTON	1218	2	MIAMI	*	39	37	84	17
12	CINCINNATI	1219	4	OHIO	*	39	07	84	47
12	ZIMMER	1220	4	OHIO	*	38	52	84	14
12	DEARBORN	1221	2	WHITEWATER	*	39	20	84	54
12	MIAMI	1222F	2	MIAMI	*	39	56	84	09
12	NEW RICHMOND	1223	4	OHIO	*	38	58	84	07
12	OLDHAM	1224F	4	OHIO	*	38	27	85	35
12	LOUISVILLE	1225F	4	OHIO	*	38	03	85	56
12	PALISADES	1226	2	LAKE MICHIGAN		42	20	86	19
12	COOK	1227	4	LAKE MICHIGAN		41	57	86	35
13	MENOMINEE	1301	2	LAKE MICHIGAN		45	20	87	25
13	KEWAUNEE	1302	3	LAKE MICHIGAN		44	21	87	32
13	GREEN BAY	1303	3	LAKE MICHIGAN		44	37	87	51
13	POINT BEACH	1304	4	LAKE MICHIGAN		44	17	87	33
13	OSHKOSH	1305	4	LAKE WINNEBAGO		43	57	88	29
13	SHEBOYGAN	1306	4	LAKE MICHIGAN		43	30	87	47
13	MILWAUKEE	1307	4	LAKE MICHIGAN		42	49	87	48
13	RACINE	1308	4	LAKE MICHIGAN		42	47	87	46
13	MADISON	1309	2	WISCONSIN	97	43	23	89	33
13	SAUK CITY	1310	2	WISCONSIN	78	43	15	89	49
13	WISCONSIN DELLS	1311F	2	WISCONSIN	132	43	40	89	48
14	ZION	1401	4	LAKE MICHIGAN		42	26	87	48
14	KENOSHA	1402	4	LAKE MICHIGAN		42	32	87	49
14	WAUKEGAN	1403	4	LAKE MICHIGAN		42	23	87	49

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PSA	SITE NAME	SITE NO.	MAX NO. PLANTS	RECEIVING WATERS	RIVER MILE	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN
14	EAST CHICAGO	1404	4	LAKE MICHIGAN		41	38	87	23
14	S W CHICAGO	1405	4	ILLINOIS	319	41	47	87	50
14	JOLIET	1406	4	ILLINOIS	296	41	39	88	4
14	KANKAKEE	1407	2	KANKAKEE	27	41	12	87	59
14	LA SALLE	1409	4	ILLINOIS	256	41	20	88	32
14	DRESDEN	1408	4	ILLINOIS	271	41	23	88	16
14	OSWEGO	1410	2	FOX(ILLINOIS)	40	41	42	88	22
14	OTTAWA	1411	4	ILLINOIS	234	41	20	88	57
14	PERU	1412	2	ILLINOIS	219	41	17	89	11
14	HENRY	1413	4	ILLINOIS	202	41	11	89	22
14	CORDOVA	1414	4	MISSISSIPPI	507	41	44	90	19
14	ROCKFORD	1415	3	ROCK	115	42	11	89	12
14	GALENA	1416	4	MISSISSIPPI	565	42	23	90	28
14	BURLINGTON	1417	4	MISSISSIPPI	419	40	59	90	56
15	FORT MADISON	1501F	4	MISSISSIPPI	376	40	33	91	26
15	HANNIBAL	1502	4	MISSISSIPPI	287	39	29	91	08
15	ST LOUIS	1503	4	MISSISSIPPI	162	38	24	90	13
15	WASHINGTON	1504	4	MISSOURI	61	38	32	90	53
15	ST CHARLES	1505	4	MISSOURI	41	38	43	90	36
15	ST PAUL	1506	4	MISSISSIPPI	235	38	53	90	44
15	JEFFERSON CITY	1507F	3	MISSOURI	165	38	46	92	25
15	ARROW ROCK	1508F	2	MISSOURI	207	39	01	92	56
16	GRAND RAPIDS	1601	2	MISSISSIPPI	1120	47	09	93	24
16	CLOQUET	1602	2	ST LOUIS	*	46	46	92	29
16	MONTICELLO	1603	4	MISSISSIPPI	898	45	20	93	50
16	PRAIRIE ISLAND	1604	4	MISSISSIPPI	798	44	37	92	38
16	NININGER	1605	4	MISSISSIPPI	820	44	46	92	56
16	POINT DOUGLAS	1606	4	ST. CROIX	4	44	48	92	48
16	OTSEGO	1607	4	MISSISSIPPI	890	45	12	93	41
16	JORDAN	1608	4	MINNESOTA	37	44	42	93	33
16	MANKATO	1609	3	MINNESOTA	91	44	15	94	00
16	SIOUX FALLS	1610	1	JAMES COMB	115	43	30	96	35
16	PRAIRIE DU CH	1611	1	WISCONSIN	12	43	04	90	58

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PSA	SITE NAME	SITE NO.	MAX NO. PLANTS	RECEIVING WATERS	RIVER MILE	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN
16	ONALASKA	1612	1	MISSISSIPPI	706	43	56	91	18
16	EAU CLAIRE	1613F	1	CHIPPEWA	75	44	57	91	18
17	INDEPENDENCE	1701	4	MISSOURI	335	39	10	94	10
17	ST JOSEPH	1702	3	MISSOURI	431	39	38	95	03
17	KANSAS CITY	1703	3	MISSOURI	392	39	17	94	49
17	SIOUX CITY	1704	3	MISSOURI	749	42	34	96	40
17	CLINTON	1705	3	MISSISSIPPI	528	41	58	90	11
17	DUANE ARNOLD	1706	2	CEDAR	100	42	06	91	46
17	IOWA CITY	1707	2	IOWA	106	41	46	91	40
17	DES MOINES	1708	4	DES MOINES	167	41	26	93	24
17	OAKVILLE	1709F	4	IOWA	6	41	05	91	04
17	MUSCATINE	1710	2	MISSISSIPPI	444	41	16	91	09
17	WILTON	1711	2	CEDAR	38	41	34	91	03
17	LE CLAIRE	1712	4	MISSISSIPPI	499	41	37	90	21
19	LEWISPORT	1901F	3	OHIO	*	37	58	86	52
19	MUHLENBERG	1902	1	GREEN	*	37	22	87	05
19	ROCK HAVEN	1903F	2	OHIO	*	37	59	86	02
20	PINCKNEY	2001	3	MISSISSIPPI	*	34	58	90	17
20	RANDOLPH	2002	4	MISSISSIPPI	*	35	31	89	54
20	FLORENCE	2003	3	TENNESSEE	*	34	49	87	54
20	PARSONS	2004	3	TENNESSEE	*	35	31	87	59
20	CLARKSVILLE	2005F	3	CUMBERLAND	*	36	27	87	28
20	SAUNDERSVILLE	2006F	3	CUMBERLAND	*	36	20	86	33
20	PADUCAH	2007	4	OHIO	*	37	06	88	26
20	MURRAY	2008	2	TENNESSEE	*	36	34	88	09
20	LINTON	2009F	2	CUMBERLAND	*	36	41	87	54
20	HOOKER'S BEND	2010	4	TENNESSEE	*	35	19	88	13
20	TIMMONS	2011F	3	DUCK	*	35	40	87	06
25	RUSSELLVILLE	2501	3	ARKANSAS	*	35	19	93	13
25	REDFIELD	2502	3	ARKANSAS	*	34	29	92	09
25	BATESVILLE	2503	2	WHITE	*	35	44	91	35
26	RIVERDALE	2601F	2	MISSOURI	*	47	33	101	21
26	BISMARCK	2602F	2	MISSOURI	*	46	41	100	43

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PSA	SITE NAME	SITE NO.	MAX NO. PLANTS	RECEIVING WATERS	RIVER MILE	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN
26	GRAND FORKS	2603	2	RED (NORTH)	*	47	50	96	59
27	MERCER	2701	1	MISSOURI	*	47	28	101	56
27	GARRISON	2702F	1	MISSOURI	*	47	30	101	26
27	MORTON	2703	1	MISSOURI	*	46	41	100	46
27	WYODAK	2704F	1	(WELLS)	*	44	17	105	22
27	PIERRE	2705F	1	MISSOURI	*	44	27	100	24
27	PICKSTOWN	2706F	1	MISSOURI	*	43	04	98	33
27	FRANKFORT	2707F	1	JAMES	*	44	52	98	32
28	NORTH PLATTE	2801	1	PLATTE	*	41	07	100	41
28	ST PAUL	2802	1	SOUTH LOUP	*	41	11	98	27
28	FORT CALHOUN	2803	2	MISSOURI	646	41	31	96	05
28	PLATTSMOUTH	2804	3	MISSOURI	583	40	54	95	50
28	COOPER	2805	2	MISSOURI	533	40	21	95	38
28	OTOE	2806	3	MISSOURI	566	40	45	95	54
29	LAWRENCE	2901	2	KANSAS	42	38	58	95	07
29	MANHATTAN	2902F	1	KANSAS	151	39	11	96	30
29	KANOPOLIS	2903F	1	SMOKY HILL	*	38	38	97	59
29	HUTCHINSON	2904F	1	ARKANSAS	*	38	00	97	55
29	WILSON	2905	1	SALINE	*	38	54	98	31
31	SCOTTSBLUFF	3101F	1	NORTH PLATTE	*	41	49	103	36
33	VINITA	3301	4	NEOSHO	*	36	38	94	53
33	WAGONER	3302F	3	NEOSHO	*	35	57	95	19
33	DIXBY	3303	4	ARKANSAS	*	35	56	95	51
33	FORT SMITH	3304	3	ARKANSAS	*	35	21	94	13
33	EUFAULA	3305F	3	CANADIAN	*	35	14	95	22
33	PONCA CITY	3306F	2	ARKANSAS	*	36	38	97	04
33	PAWNEE	3307	4	ARKANSAS	*	36	17	96	25
33	OILTON	3308F	2	CIMARRON	*	36	09	96	26
34	MULVANE	3401	2	ARKANSAS	*	37	28	97	14
34	WINFIELD	3402	2	ARKANSAS	*	37	09	97	06
34	PARSONS	3403	2	NEOSHO	*	37	18	95	07
34	BRANSON	3404	4	WHITE	*	36	40	93	13
34	BOLIVAR	3405F	2	OSAGE	210	37	48	93	23

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PSA	SITE NAME	SITE NO.	MAX NO. PLANTS	RECEIVING WATERS	RIVER MILE	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN
34	WARSAW	3406	2	OSAGE	156	38	16	93	21
40	WATERLOO	4001F	4	MISSISSIPPI	155	38	19	90	17
40	CHATAQUA	4002F	4	MISSISSIPPI	210	38	57	90	18
40	CARBONDALE	4003F	2	MISSISSIPPI	81	37	38	89	30
40	MOUNT CARMEL	4004	1	WABASH	*	38	21	87	50
40	DANVILLE	4005F	2	WABASH	*	40	05	87	25
40	DECATUR	4006	2	SANGAMON	130	39	48	88	55
40	PEORIA	4007	4	ILLINOIS	172	40	49	89	32
40	HAVANA	4008	4	ILLINOIS	107	40	08	90	11
40	PEKIN	4009F	4	ILLINOIS	141	40	33	89	50
14	MORRIS	1491R	1	ILLINOIS	271	41	23	88	17
40	OBED	4092R	1	SANGAMON	193	39	34	88	54
15	CENTRALIA	1593R	1	SALT	148	39	22	92	7
17	HUMBOLDT	1794R	1	DES MOINES	18	42	48	94	3
11	HARRISON	1195R	1	MUSKEGON	*	44	01	85	00
20	ALLENSVILLE	2096R	1	S FK RED	*	36	44	87	03
34	EL DORADO	3497R	1		*	37	49	96	33
28	LOUP CITY	2898R	1	MIDDLE LOUP	*	41	13	98	42
15	BARRY	1599R	1	MISSISSIPPI	278	39	29	91	08

THE SYMBOL /F/ FOLLOWING THE SITE NUMBER INDICATES THAT SITING OF A FOSSIL PLANT AT THAT SITE IS PREFERRED.

THE SYMBOL /R/ FOLLOWING THE SITE NUMBER INDICATES THAT THE PLANT IS A REPROCESSING PLANT

AN ASTERISK /*/ INDICATES THAT THE RECEIVING WATERS LIE OUTSIDE THE STUDY AREA.

Centroid List

1083694

CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
1	ILLINOIS	KANKAKEE	41.12	87.87	152800	URB	KANKAKEE		4	4
2	WISCONSIN	BEAVER DAM	43.47	88.83	87700	URB	GROUND WATER		2	4
3	WISCONSIN	FORT ATKINSON	42.93	88.83	91200	URB	GROUND WATER		2	1
4	WISCONSIN	ELKHORN	42.67	88.55	114900	URB	GROUND WATER		2	4
5	ILLINOIS	WOODSTOCK	42.32	88.45	327300	URB	GROUND WATER		2	4
6	ILLINOIS	BELVIDERE	42.27	88.85	43300	URB	GROUND WATER		2	3
7	ILLINOIS	DE KALB	41.93	88.75	155900	URB	GROUND WATER		2	1
8	ILLINOIS	YORKVILLE	41.63	88.45	61400	URB	GROUND WATER		2	3
9	ILLINOIS	MORRIS	41.37	88.42	37300	URB	GROUND WATER		2	1
10	ILLINOIS	OTTAWA	41.35	88.85	125500	URB	GROUND WATER		2	1
11	ILLINOIS	PIPER CITY	40.77	88.18	91800	RNF	GROUND WATER		2	1
12	ILLINOIS	BLOOMINGTON	40.48	88.98	144400	URB	LAKE BLOOMINGTON		4	4
13	ILLINOIS	CLEMENT	39.92	88.57	44400	RNF	GROUND WATER		2	4
14	ILLINOIS	DECATUR	39.85	88.95	181300	URB	LAKE DECATUR		3	4
15	ILLINOIS	HERRICK	39.22	88.98	54300	RNF	GROUND WATER		2	1
16	ILLINOIS	SALEM	38.63	88.95	30300	URB	KASKASKIA		4	4
17	ILLINOIS	MT. VERNON	38.32	88.90	28100	URB	RESERVOIR		4	4
18	ILLINOIS	BENTON	38.00	88.92	26700	URB	LAKE BENTON		4	4
19	ILLINOIS	MARION	37.73	88.93	44000	URB	RESERVOIR		4	4
20	WISCONSIN	GLEASON	45.30	89.50	37500	RNF	GROUND WATER		2	1

* - CENTROID CLASSIFICATION CODE
URB - URBAN
RNF - RURAL NON-FARM
RUF - RURAL FARM

(1) - COLUMN A IS RIVER MILE OF WATER SOURCE, IF APPLICABLE.
COLUMN B IS WATER SOURCE TYPE,
1 - RIVER
2 - GROUND
3 - BOTH
4 - SURFACE

COLUMN C IS WATER TREATMENT TYPE
1 - NONE
2 - FILTER
3 - CHEMICAL
4 - BOTH

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CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
21	WISCONSIN	WAUSAU	44.97	89.63	118300	URB	GROUND WATER	2	4	
22	WISCONSIN	STEVENS POINT	44.52	89.57	62000	URB	GROUND WATER	2	3	
23	WISCONSIN	WISCONSIN RAPID	44.38	89.82	96500	URB	GROUND WATER	2	4	
24	WISCONSIN	PORTAGE	43.55	89.47	52100	URB	GROUND WATER	2	4	
25	WISCONSIN	LELAND	43.33	89.95	44900	RNF	GROUND WATER	2	1	
26	WISCONSIN	MADISON	43.07	89.45	632600	URB	GROUND WATER	2	3	
27	WISCONSIN	JANESVILLE	42.68	89.02	205500	URB	GROUND WATER	2	3	
28	WISCONSIN	MONROE	42.60	89.63	27200	RNF	GROUND WATER	2	1	
29	ILLINOIS	FREEPORT	42.28	89.63	58500	URB	GROUND WATER	2	4	
30	ILLINOIS	ROCKFORD	42.27	89.10	492000	URB	GROUND WATER	2	3	
31	ILLINOIS	ROCHELLE	41.92	89.07	61400	URB	GROUND WATER	2	4	
32	ILLINOIS	DIXON	41.83	89.48	40800	URB	GROUND WATER	2	3	
33	ILLINOIS	STERLING	41.80	89.70	88600	URB	GROUND WATER	2	4	
34	ILLINOIS	PRINCETON	41.37	89.47	38600	RNF	GROUND WATER	2	4	
35	ILLINOIS	GRANVILLE	41.27	89.23	5900	RNF	GROUND WATER	2	3	
36	ILLINOIS	LACON	41.03	89.40	19300	RNF	GROUND WATER	2	1	
37	ILLINOIS	EUREKA	40.72	89.27	40400	URB	WALNUT CREEK	3	4	
38	ILLINOIS	PEORIA	40.70	89.60	245300	URB	GROUND WATER	2	4	
39	ILLINOIS	PEKIN	40.57	89.63	238300	URB	GROUND WATER	2	3	
40	ILLINOIS	LINCOLN	40.15	89.37	36700	URB	GROUND WATER	2	4	
41	ILLINOIS	PETERSBURG	40.02	89.85	8300	RNF	GROUND WATER	2	4	
42	ILLINOIS	SPRINGFIELD	39.78	89.65	215600	URB	LAKE SPRING.	4	4	
43	ILLINOIS	TAYLORVILLE	39.55	89.30	32500	URB	SANGAMON	3	4	
44	ILLINOIS	CARLINVILLE	39.28	89.88	43000	URB	CARLINVILLE	4	4	
45	ILLINOIS	NASHVILLE	38.35	89.38	11700	RNF	RESERVOIR	4	3	
46	ILLINOIS	SPARTA	38.13	89.70	28500	URB	MARYS	4	4	
47	ILLINOIS	PINCKNEYVILLE	38.07	89.38	15600	URB	BEAUCOUP CR	4	4	
48	ILLINOIS	MURPHYSBORO	37.77	89.33	78400	URB	BIG MUDDY	4	4	
49	MISSOURI	PERRYVILLE	37.73	89.87	12800	RNF	SALINE	4	4	
50	ILLINOIS	ANNA	37.47	89.25	11900	RNF	GROUND WATER	2	4	

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CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
51	MISSOURI	CAPE GIRARDEAU	37.30	89.53	63300	URB	MISSISSIPPI	52	1	4
52	ILLINOIS	OLIVE BRANCH	37.17	89.35	5700	URB	GROUND WATER		2	1
53	ILLINOIS	BREESE	38.62	89.53	34400	URB	SHOAL CREEK		4	4
54	WISCONSIN	PHILLIPS	45.68	90.40	96800	RUF	GROUND WATER		2	1
55	WISCONSIN	GREENWOOD	44.77	90.60	26700	RNF	GROUND WATER		2	3
56	WISCONSIN	MATHER	44.13	90.30	39400	RUF	GROUND WATER		2	1
57	WISCONSIN	TOMAH	43.98	90.50	36700	RNF	GROUND WATER		2	4
58	WISCONSIN	VIROQUA	43.57	90.90	18600	RNF	GROUND WATER		2	1
59	WISCONSIN	RICHLAND CENTER	43.33	90.38	14000	RNF	GROUND WATER		2	3
60	WISCONSIN	SENECA	43.27	90.97	12100	RNF	GROUND WATER		2	1
61	WISCONSIN	DODGEVILLE	42.97	90.13	10700	RNF	GROUND WATER		2	3
62	WISCONSIN	LANCASTER	42.68	90.72	57400	RNF	GROUND WATER		2	3
63	WISCONSIN	DARLINGTON	42.68	90.12	15900	RNF	GROUND WATER		2	3
64	IOWA	DUBUQUE	42.50	90.68	124400	URB	GROUND WATER		2	4
65	ILLINOIS	HANOVER	42.27	90.28	43400	RNF	GROUND WATER		2	1
66	IOWA	MAQUOKETA	42.07	90.67	22300	RNF	GROUND WATER		2	3
67	IOWA	CLINTON	41.83	90.20	70900	URB	GROUND WATER		2	3
68	IOWA	DAVENPORT	41.53	90.57	235800	URB	MISSISSIPPI	490	1	4
69	ILLINOIS	ROCK ISLAND	41.50	90.55	240000	URB	GROUND WATER		2	3
70	ILLINOIS	GENESCO	41.45	90.15	63300	URB	GROUND WATER		2	4
71	ILLINOIS	GALESBURG	40.95	90.37	70100	URB	GROUND WATER		2	4
72	ILLINOIS	MONMOUTH	40.92	90.65	37200	RNF	GROUND WATER		2	4
73	ILLINOIS	MEDIA	40.77	90.83	7100	RUF	GROUND WATER		2	1
74	ILLINOIS	CANTON	40.55	90.03	38400	URB	LAKE CANTON		4	4
75	ILLINOIS	MACOMB	40.45	90.67	44100	URB	LAMOINE		4	4
76	ILLINOIS	HAVANA	40.30	90.07	16400	RNF	GROUND WATER		2	1
77	ILLINOIS	RUSHVILLE	40.12	90.57	9600	RUF	GROUND WATER		2	3
78	ILLINOIS	VIRGINIA	39.95	90.22	12300	RNF	JOBS CREEK		3	4
79	ILLINOIS	JACKSONVILLE	39.73	90.23	34300	URB	LAKE		4	4
80	ILLINOIS	WINCHESTER	39.63	90.47	4500	RNF	GROUND WATER		2	4

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CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
81	ILLINOIS	PEARL	39.47	90.63	27400	RNF	GROUND WATER		2	3
82	ILLINOIS	HARDIN	39.17	90.62	3800	RNF	GROUND WATER		2	1
83	ILLINOIS	JERSEYVILLE	39.12	90.33	234400	URB	GROUND WATER		2	4
84	MISSOURI	TROY	38.98	90.98	22600	RNF	GROUND WATER		2	1
85	MISSOURI	ST. CHARLES	38.78	90.48	335800	URB	MISSOURI	29	1	4
86	ILLINOIS	GRANITE CITY	38.72	90.13	405600	URB	MISSISSIPPI	181	1	4
87	MISSOURI	ST. LOUIS	38.63	90.23	452600	URB	MISSISSIPPI	190	1	4
88	ILLINOIS	EAST ST. LOUIS	38.62	90.15	468400	URB	MISSISSIPPI	181	1	4
89	MISSOURI	KIRKWOOD	38.58	90.40	3334100	URB	MISSOURI	26	1	4
90	ILLINOIS	WATERLOO	38.33	90.15	28200	URB	FOUNTAIN CR		4	4
91	MISSOURI	FESTUS	38.23	90.38	335700	URB	GROUND WATER		2	3
92	MISSOURI	ZELL	37.95	90.15	14800	RNF	GROUND WATER		2	1
93	MISSOURI	FARMINGTON	37.78	90.42	36700	URB	GROUND WATER		2	1
94	WISCONSIN	CHIPPEWA FALLS	44.93	91.40	54700	RNF	GROUND WATER		2	1
95	WISCONSIN	MENOMONIE	44.87	91.92	29600	RNF	GROUND WATER		2	1
96	WISCONSIN	EAU CLAIRE	44.82	91.98	87800	URB	GROUND WATER		2	3
97	WISCONSIN	DURAND	44.63	91.97	5800	RNF	GROUND WATER		2	4
98	WISCONSIN	MODENA	44.47	91.80	11400	RUF	GROUND WATER		2	1
99	WISCONSIN	WHITEHALL	44.37	91.32	22400	RNF	GROUND WATER		2	4
100	MINNESOTA	WINONA	44.05	91.65	50000	URB	GROUND WATER		2	4
101	WISCONSIN	LA CROSSE	43.80	91.23	107300	URB	GROUND WATER		2	3
102	MINNESOTA	CALEDONIA	43.63	91.50	20500	RUF	GROUND WATER		2	1
103	IOWA	DECORAH	43.30	91.78	21000	RNF	GROUND WATER		2	3
104	IOWA	WAUKON	43.27	91.48	12600	RNF	GROUND WATER		2	3
105	IOWA	ELKADER	42.87	91.40	17200	RNF	GROUND WATER		2	1
106	IOWA	FAYETTE	42.83	91.80	24400	RNF	GROUND WATER		2	3
107	IOWA	ANAMOSA	42.60	91.28	19400	RNF	GROUND WATER		2	1
108	IOWA	MANCHESTER	42.48	91.45	18400	RNF	GROUND WATER		2	3
109	IOWA	INDEPENDENCE	42.47	91.90	22000	RNF	GROUND WATER		2	3
110	IOWA	CEDAR RAPIDS	41.98	91.65	290200	URB	CEDAR		3	4

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CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
111	IOWA	TIPTON	41.77	91.13	18100	RNF	GROUND WATER		2	3
112	IOWA	IOWA CITY	41.67	91.53	156000	URB	IOWA		3	4
113	IOWA	MUSCATINE	41.42	91.05	43100	URB	GROUND WATER		2	3
114	IOWA	WASHINGTON	41.30	91.68	17900	RNF	GROUND WATER		2	3
115	IOWA	WAPELLO	41.18	91.18	9700	RNF	GROUND WATER		2	4
116	IOWA	MT. PLEASANT	40.97	91.55	17800	RNF	GROUND WATER		2	4
117	IOWA	BURLINGTON	40.82	91.12	58700	URB	MISSISSIPPI	404	1	4
118	IOWA	FT. MADISON	40.63	91.33	42800	URB	MISSISSIPPI	382	1	4
119	MISSOURI	KAHOKA	40.42	91.72	6500	RUF	GROUND WATER		2	4
120	ILLINOIS	CARTHAGE	40.42	91.13	19900	RNF	LONG CREEK		3	4
121	ILLINOIS	QUINCY	39.93	91.40	75800	URB	MISSISSIPPI	327	1	4
122	MISSOURI	HANNIBAL	39.70	91.37	24200	URB	MISSISSIPPI	309	1	4
123	MISSOURI	CENTER	39.52	91.53	6100	RUF	GROUND WATER		2	1
124	MISSOURI	MEXICO	39.17	91.88	62200	RNF	GROUND WATER		2	4
125	MISSOURI	MONTGOMERY	38.98	91.50	9400	RUF	GROUND WATER		2	4
126	MISSOURI	FULTON	38.85	91.95	30100	RNF	GROUND WATER		2	1
127	MISSOURI	WARRENTON	38.82	91.15	11700	RUF	GROUND WATER		2	3
128	MISSOURI	WASHINGTON	38.55	91.02	87500	URB	GROUND WATER		2	1
129	MISSOURI	LINN	38.48	91.85	9300	RUF	GROUND WATER		2	1
130	MISSOURI	VIENNA	38.18	91.95	5300	RUF	GROUND WATER		2	1
131	MISSOURI	ST. JAMES	38.00	91.62	56200	RNF	GROUND WATER		2	1
132	MISSOURI	STEELVILLE	37.97	91.37	40000	RUF	GROUND WATER		2	1
133	MINNESOTA	CLOQUET	46.72	92.45	31600	RNF	GROUND WATER		2	3
134	MINNESOTA	HINCKLEY	46.02	92.95	16900	RUF	GROUND WATER		2	3
135	WISCONSIN	CUMBERLAND	45.53	92.02	58300	RNF	GROUND WATER		2	1
136	MINNESOTA	STILLWATER	45.05	92.82	257300	URB	GROUND WATER		2	1
137	WISCONSIN	BALDWIN	44.97	92.37	46900	RNF	GROUND WATER		2	1
138	WISCONSIN	ELLSWORTH	44.73	92.48	32400	RNF	GROUND WATER		2	1
139	MINNESOTA	ZUMBROTA	44.30	92.67	66600	RNF	GROUND WATER		2	1
140	MINNESOTA	ROCHESTER	44.02	92.47	154800	URB	GROUND WATER		2	3

CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
141	MINNESOTA	AUSTIN	43.67	92.97	51400	URB	GROUND WATER		2	3
142	MINNESOTA	PRESTON	43.67	92.08	18000	RUF	GROUND WATER		2	4
143	IOWA	CHARLES CITY	43.07	92.68	54300	RNF	GROUND WATER		2	4
144	IOWA	WAVERLY	42.73	92.48	28100	URB	GROUND WATER		2	3
145	IOWA	WATERLOO	42.50	92.35	219700	URB	GROUND WATER		2	3
146	IOWA	VINTON	42.17	92.02	22300	RNF	GROUND WATER		2	4
147	IOWA	MARSHALLTOWN	42.05	92.92	45900	URB	GROUND WATER		2	4
148	IOWA	TOLEDO	42.00	92.58	17400	RNF	GROUND WATER		2	4
149	IOWA	WILLIAMSBURG	41.67	92.02	13900	RNF	GROUND WATER		2	1
150	IOWA	FREMONT	41.22	92.43	85600	RNF	GROUND WATER		2	1
151	IOWA	OTTUMWA	41.02	92.42	39100	URB	DES MOINES		4	4
152	IOWA	TROY	40.75	92.20	11900	RUF	GROUND WATER		2	1
153	IOWA	CENTERVILLE	40.72	92.87	9000	RNF	RESERVOIR		4	4
154	MISSOURI	NOVELTY	40.02	92.20	42700	RUF	GROUND WATER		2	1
155	MISSOURI	COLUMBIA	38.95	92.33	187800	URB	GROUND WATER		2	3
156	MISSOURI	CALIFORNIA	38.63	92.57	8800	RNF	GROUND WATER		2	1
157	MISSOURI	JEFFERSON CITY	38.57	92.17	59500	URB	MISSOURI	144	1	4
158	MISSOURI	RICHLAND	37.87	92.40	348000	URB	GROUND WATER		2	3
159	MISSOURI	LEBANON	37.68	92.67	20900	RNF	GROUND WATER		2	1
160	MISSOURI	HARTVILLE	37.25	92.52	10300	RUF	GROUND WATER		2	1
161	MINNESOTA	PALISADE	46.72	93.50	6800	RUF	GROUND WATER		2	1
162	MINNESOTA	MILACA	45.75	93.65	117000	RNF	GROUND WATER		2	3
163	MINNESOTA	FOLEY	45.67	93.92	26700	URB	GROUND WATER		2	3
164	MINNESOTA	MONTICELLO	45.30	93.80	53100	URB	GROUND WATER		2	3
165	MINNESOTA	BLAINE	45.20	93.23	1050600	URB	GROUND WATER		2	3
166	MINNESOTA	MINNEAPOLIS	45.00	93.27	1605400	URB	MISSISSIPPI	859	1	4
167	MINNESOTA	ST. PAUL	44.95	93.10	727400	URB	MISSISSIPPI	863	1	4
168	MINNESOTA	SO. ST. PAUL	44.88	93.03	484500	URB	GROUND WATER		2	3
169	MINNESOTA	SHAKOPEE	44.80	93.53	66300	URB	GROUND WATER	25	2	3
170	MINNESOTA	CHASKA	44.78	93.60	44900	URB	GROUND WATER		2	4

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CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE		(1) A	B	C
171	MINNESOTA	LE SUEUR	44.47	93.92	23500	URB	GROUND WATER			2	1
172	MINNESOTA	ST. PETER	44.33	93.97	32500	URB	GROUND WATER			2	4
173	MINNESOTA	FARIBAULT	44.30	93.27	51900	URB	GROUND WATER			2	3
174	MINNESOTA	OWATONNA	44.08	93.22	35000	URB	GROUND WATER			2	3
175	MINNESOTA	WASECA	44.08	93.50	17900	RNF	GROUND WATER			2	3
176	MINNESOTA	ALBERT LEA	43.65	93.37	44500	URB	GROUND WATER			2	3
177	IOWA	KENSETT	43.35	93.23	6700	RUF	GROUND WATER			2	3
178	IOWA	MASON CITY	43.15	93.20	53900	URB	GROUND WATER			2	3
179	IOWA	IOWA FALLS	42.52	93.27	90500	RNF	GROUND WATER			2	4
180	IOWA	AMES	42.03	93.62	115300	URB	GROUND WATER			2	4
181	IOWA	NEWTON	41.70	93.05	38900	URB	GROUND WATER			2	3
182	IOWA	DALLAS CENTER	41.68	93.97	27000	RNF	GROUND WATER			2	4
183	IOWA	DES MOINES	41.60	93.62	404600	URB	RACOON			4	4
184	IOWA	INDIANOLA	41.37	93.57	41500	RNF	GROUND WATER			2	4
185	IOWA	LEON	40.73	93.75	38500	RUF	GROUND WATER			2	3
186	MISSOURI	BROOKFIELD	39.78	93.07	55300	RNF	YELLOW CREEK			4	4
187	MISSOURI	BRUNSWICK	39.43	93.13	30700	RUF	GROUND WATER			2	4
188	MISSOURI	MARSHALL	39.12	93.20	56700	RNF	GROUND WATER			2	4
189	MISSOURI	SEDALIA	38.70	93.23	33300	URB	RESERVOIR			3	4
190	MISSOURI	LEETON	38.58	93.70	62500	RNF	GROUND WATER			2	1
191	MISSOURI	ELDON	38.35	93.58	14900	RNF	GROUND WATER			2	1
192	MISSOURI	HERMITAGE	37.93	93.32	81700	RUF	GROUND WATER			2	1
193	MINNESOTA	BOY RIVER	47.17	94.12	71000	RUF	GROUND WATER			2	1
194	MINNESOTA	LITTLE FALLS	45.98	94.37	26200	RNF	GROUND WATER			2	4
195	MINNESOTA	LONG PRAIRIE	45.97	94.87	17000	RNF	GROUND WATER			2	4
196	MINNESOTA	ST. CLOUD	45.57	94.17	131500	URB	MISSISSIPPI		950	1	4
197	MINNESOTA	ATWATER	45.13	94.78	51100	RNF	GROUND WATER			2	1
198	MINNESOTA	HUTCHINSON	44.90	94.37	35100	URB	GROUND WATER			2	4
199	MINNESOTA	GAYLORD	44.55	94.22	14900	RNF	GROUND WATER			2	4
200	MINNESOTA	NEW ULM	44.32	94.47	32100	URB	GROUND WATER			2	4

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CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE		(1) A	B	C
201	MINNESOTA	MANKATO	44.17	94.00	76000	URB	GROUND WATER			2	3
202	MINNESOTA	TRIMONT	43.77	94.72	67800	RNF	GROUND WATER			2	1
203	IOWA	EMMETSBURG	43.10	94.68	10500	RNF	GROUND WATER			2	3
204	IOWA	ALGONA	43.07	94.23	67900	RNF	GROUND WATER			2	4
205	IOWA	POCAHONTAS	42.73	94.67	9900	RUF	GROUND WATER			2	1
206	IOWA	HUMBOLDT	42.72	94.22	11300	RNF	GROUND WATER			2	4
207	IOWA	FORT DODGE	42.50	94.18	55000	URB	GROUND WATER			2	4
208	IOWA	LAKE CITY	42.27	94.73	97100	RNF	GROUND WATER			2	4
209	IOWA	GUTHRIE CENTER	41.68	94.50	8500	RUF	GROUND WATER			2	1
210	IOWA	WINTERSET	41.33	94.02	9000	RUF	RESERVOIR			3	4
211	IOWA	GREENFIELD	41.30	94.45	6500	RUF	NODAWAY LAKE			3	4
212	IOWA	AUDUBON	41.72	94.93	7900	RUF	GROUND WATER			2	3
213	IOWA	CORNING	40.98	94.73	3900	RUF	NODAWAY			4	4
214	MISSOURI	MARYVILLE	40.35	94.87	29700	RNF	RESERVOIR			4	4
215	MISSOURI	BETHANY	40.27	94.03	32000	RUF	BIG CREEK			3	4
216	MISSOURI	ST. JOSEPH	39.77	94.85	78900	URB	MISSOURI		452	1	4
217	MISSOURI	LATHROP	39.55	94.33	25300	RNF	GROUND WATER			2	3
218	MISSOURI	WESTON	39.42	94.90	71600	URB	GROUND WATER			2	4
219	KANSAS	LEAVENWORTH	39.32	94.92	66608	URB	MISSOURI		397	1	4
220	MISSOURI	LIBERTY	39.25	94.42	497600	URB	GROUND WATER			2	4
221	KANSAS	KANSAS CITY	39.12	94.65	236500	URB	MISSOURI		374	1	4
222	MISSOURI	KANSAS CITY	39.07	94.58	870500	URB	MISSOURI		370	1	4
223	KANSAS	SHAWNEE	39.02	94.72	1414100	URB	GROUND WATER			2	4
224	MISSOURI	HARRISONVILLE	38.65	94.30	77000	URB	RESERVOIR			4	4
225	KANSAS	FT. SCOTT	37.83	94.70	10600	RNF	MARMITON			4	4
226	MISSOURI	NEVADA	37.83	94.35	13500	RNF	GROUND WATER			2	3
227	MINNESOTA	VINING	46.27	95.53	63900	RNF	GROUND WATER			2	1
228	MINNESOTA	MORRIS	45.58	95.92	42000	RUF	GROUND WATER			2	4
229	MINNESOTA	MONTEVIDEO	44.95	95.72	12700	RNF	GROUND WATER			2	3
230	MINNESOTA	OLIVIA	44.78	95.00	17400	RUF	GROUND WATER			2	4

CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
231	MINNESOTA	HAZEL RUN	44.75	95.72	10100	RUF	GROUND WATER		2	1
232	MINNESOTA	WABASSO	44.40	95.25	17500	RNF	GROUND WATER		2	3
233	MINNESOTA	SLAYTON	43.98	95.75	39400	RUF	GROUND WATER		2	4
234	IOWA	SPENCER	43.15	95.15	18500	RNF	GROUND WATER		2	4
235	IOWA	PRIMGHAR	43.08	95.63	15500	RNF	GROUND WATER		2	4
236	IOWA	CHEROKEE	42.75	95.55	14900	RNF	GROUND WATER		2	3
237	IOWA	STORMLAKE	42.65	95.20	21500	RNF	GROUND WATER		2	3
238	IOWA	MAPLETON	42.17	95.80	15500	RUF	GROUND WATER		2	1
239	IOWA	LOGAN	41.65	95.80	11100	RUF	GROUND WATER		2	3
240	IOWA	HARLAN	41.65	95.32	14100	RNF	GROUND WATER		2	3
241	IOWA	ATLANTIC	41.40	95.02	14900	RNF	GROUND WATER		2	4
242	NEBRASKA	OMAHA	41.27	95.93	605600	URB	MISSOURI	626	1	4
243	IOWA	COUNCIL BLUFFS	41.27	95.87	111000	URB	MISSOURI	619	1	4
244	NEBRASKA	BELLEVUE	41.13	95.90	395100	URB	GROUND WATER		2	4
245	IOWA	CRESTON	41.05	95.38	10700	RNF	RESERVOIR		4	4
246	IOWA	RED OAK	41.02	95.23	10500	RNF	GROUND WATER		2	3
247	IOWA	MALVERN	41.00	95.58	9200	RNF	GROUND WATER		2	
248	IOWA	SHENANDOAH	40.77	95.37	13600	RNF	GROUND WATER		2	4
249	IOWA	SIDNEY	40.75	95.65	6000	RUF	GROUND WATER		2	1
250	NEBRASKA	AUBURN	40.37	95.85	6000	RUF	GROUND WATER		2	4
251	MISSOURI	CRAIG	40.20	95.38	9500	RUF	GROUND WATER		2	4
252	NEBRASKA	FALLS CITY	40.07	95.60	7600	RNF	GROUND WATER		2	4
253	KANSAS	LEONA	39.78	95.32	14000	RNF	GROUND WATER		2	3
254	KANSAS	ATCHISON	39.57	95.12	15900	URB	MISSOURI	425	1	4
255	KANSAS	HOLTON	39.47	95.73	7900	RUF	RESERVOIR		3	4
256	KANSAS	OSKALOOSA	39.22	95.32	11000	RUF	RESERVOIR		4	4
257	KANSAS	TOPEKA	39.05	95.68	258800	URB	RESERVOIR		3	4
258	KANSAS	LAWRENCE	38.97	95.23	129700	URB	RESERVOIR		3	4
259	KANSAS	OTTAWA	38.62	95.27	37500	RNF	CYGNES		4	4
260	KANSAS	LYNDON	38.62	95.68	11500	RUF	SALT CREEK		4	4

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CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
261	KANSAS	GARNETT	38.28	95.23	10900	RUF	RESERVOIR	4	4	
262	SO. DAKOTA	MILBANK	45.22	96.63	22400	RUF	GROUND WATER	2	3	
263	MINNESOTA	MADISON	45.02	96.18	7800	RUF	GROUND WATER	2	4	
264	SO. DAKOTA	BROOKINGS	44.32	96.80	27700	RNF	GROUND WATER	2	4	
265	MINNESOTA	PIPESTONE	44.00	96.32	63000	RNF	GROUND WATER	2	3	
266	SO. DAKOTA	SIOUX FALLS	43.53	96.73	157300	URB	GROUND WATER	2	4	
267	IOWA	ROCK RAPIDS	43.43	96.17	18300	RUF	GROUND WATER	2	3	
268	IOWA	SIOUX CENTER	43.08	96.17	28100	RNF	GROUND WATER	2	4	
269	IOWA	LE MARS	42.78	96.17	24600	RNF	GROUND WATER	2	3	
270	IOWA	SIOUX CITY	42.48	96.40	97800	URB	GROUND WATER	2	3	
271	NEBRASKA	S. SIOUX CITY	42.47	96.42	17800	URB	GROUND WATER	2	4	
272	NEBRASKA	BLAIR	41.55	96.13	15300	RNF	GROUND WATER	2	4	
273	NEBRASKA	FREMONT	41.43	96.50	50300	URB	GROUND WATER	2	1	
274	NEBRASKA	LOUISVILLE	41.00	96.17	18800	RNF	GROUND WATER	2	1	
275	NEBRASKA	LINCOLN	40.82	96.68	273900	URB	GROUND WATER	2	4	
276	NEBRASKA	SYRACUSE	40.67	96.18	12000	RNF	GROUND WATER	2	1	
277	NEBRASKA	WILBUR	40.48	96.97	32800	RNF	GROUND WATER	2	1	
278	NEBRASKA	TECUMSEH	40.37	96.18	3700	RUF	GROUND WATER	2	1	
279	NEBRASKA	PAWNEE CITY	40.12	96.15	2100	RUF	GROUND WATER	2	4	
280	KANSAS	WESTMORELAND	39.40	96.42	9900	RUF	GROUND WATER	2	3	
281	KANSAS	MANHATTEN	39.18	96.58	154900	URB	GROUND WATER	2	4	
282	KANSAS	JUNCTION CITY	39.03	96.83	50100	URB	GROUND WATER	2	4	
283	KANSAS	ALMA	39.02	96.30	4400	RUF	GROUND WATER	2	3	
284	SO. DAKOTA	WATERTOWN	44.90	97.12	20500	RNF	LAKE KAMPESKA	3	4	
285	SO. DAKOTA	SALEM	43.73	97.38	62000	RUF	GROUND WATER	2	4	
286	SO. DAKOTA	VOLIN	42.38	97.18	38600	RNF	GROUND WATER	2	1	
287	NEBRASKA	WAYNE	42.23	97.02	64800	RUF	GROUND WATER	2	1	
288	NEBRASKA	NORFOLK	42.03	97.42	29400	URB	GROUND WATER	2	4	
289	NEBRASKA	COLUMBUS	41.43	97.35	40300	RNF	GROUND WATER	2	4	
290	NEBRASKA	SURPRISE	41.10	97.32	52300	RUF	GROUND WATER	2	1	

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CENTROID NUMBER	STATE	CENTROID NAME	LAT (DEG)	LONG (DEG)	POPUL YR 2000	CENTROID CLASS*	WATER SOURCE	(1) A	B	C
291	NEBRASKA	ONG	40.49	97.83	32900	RUF	GROUND WATER	2	1	
292	KANSAS	LINN	39.68	97.03	45600	RUF	GROUND WATER	2	4	
293	SO. DAKOTA	HITCHCOCK	44.63	98.42	42500	RUF	GROUND WATER	2	1	
294	SO. DAKOTA	MITCHELL	43.72	98.02	19200	RNF	LAKE MITCHELL	4	4	
295	SO. DAKOTA	PLATTE	43.38	98.35	33200	RUF	GROUND WATER	2	4	
296	NEBRASKA	BARTLETT	41.38	98.55	51600	RUF	GROUND WATER	2	1	
297	NEBRASKA	CENTRAL CITY	41.12	98.00	8200	RUF	GROUND WATER	2	1	
298	NEBRASKA	GRAND ISLAND	40.93	98.35	65200	URB	GROUND WATER	2	1	
299	NEBRASKA	AURORA	40.87	98.00	7700	RUF	GROUND WATER	2	1	
300	NEBRASKA	HASTINGS	40.58	98.38	37100	URB	GROUND WATER	2	1	

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