MONITOR: A Computer Model for Estimating the Costs of an Integral Monitored Retrievable Storage Facility

P. W. Reimus

N. L. Sevigny

M. E. Schutz

R. A. Heller

December 1986

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government of any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or Battelle Memorial Institute.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS Price Codes
Microfiche A01

Printed Copy

Pages	Price Codes
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
201-225	A010
226-250	A011
251-275	A012
276-300	A013

MONITOR: A COMPUTER MODEL FOR
ESTIMATING THE COSTS OF AN
INTEGRAL MONITORED RETRIEVABLE
STORAGE FACILITY

P. W. Reimus
N. L. Sevigny
M. E. Schutz
R. A. Heller(a)

December 1986

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RL0 1830

Pacific Northwest Laboratory
Richland, Washington 99352

(a) Affiliated with Boeing Computer
Services Richland, Inc.

ACKNOWLEDGMENTS

The development of this model was funded by the Monitored Retrievable Storage (MRS) program office at Pacific Northwest Laboratory (PNL) under sponsorship of the U.S. Department of Energy (DOE). The authors wish to thank the individuals who contributed to the development effort: technical leads M. R. Shay of PNL and P. G. Zambas of Golder Associates, Inc.; project manager J. F. Fletcher of PNL; and the model development team of M. E. Buxbaum and W. J. Suitt, Boeing Computer Services Richland, Inc.

SUMMARY

The MONITOR model is a FORTRAN 77 based computer code that provides parametric life-cycle cost estimates for a monitored retrievable storage (MRS) facility (a MRS facility that is capable of both storing and repackaging nuclear waste). The model was developed for the MRS program at Pacific Northwest Laboratory (PNL) as a tool that provides sophisticated and rapid comparisons of the costs associated with different MRS facility designs and different operating scenarios. This report essentially serves as a user's guide for the model.

MONITOR is very flexible in that it can estimate the costs of an MRS facility operating under almost any conceivable nuclear waste logistics scenario. The model can also accommodate input data of varying degrees of complexity and detail (ranging from very simple to more complex) which makes it ideal for use in the MRS program, where new designs and new cost data are frequently offered for consideration.

MONITOR can be run as an independent program, or it can be interfaced with the Waste System Transportation and Economic Simulation (WASTES) model, a program that simulates the movement of waste through a complete nuclear waste disposal system (Shay and Buxbaum 1986). The WASTES model drives the MONITOR model by providing it with the annual quantities of waste that are received, stored, and shipped at the MRS facility.

Three runs of MONITOR are documented in this report. Two of the runs are for Version 1 of the MONITOR code. Version 1 is a simulation which uses the costs developed by the Ralph M. Parsons Company in the 2A (backup) version of the MRS cost estimate. In one of these runs MONITOR was run as an independent model, and in the other run MONITOR was run using an input file generated by the WASTES model. The two runs correspond to identical cases, and the fact that they gave identical results verified that the code performed the same calculations in both modes of operation. The third run was made for Version 2 of the MONITOR code. Version 2 is a simulation which uses the costs developed by the Ralph M. Parsons Company in the 2B (integral) version of the MRS cost

estimate. This run was made with MONITOR being run as an independent model. The results of several cases have been verified by hand calculations.

CONTENTS

ACKNOWLEDGMENTS	iii
SUMMARY	v
1.0 INTRODUCTION	1.1
2.0 MODEL OVERVIEW	2.1
2.1 SCOPE OF THE MODEL	2.1
2.2 MODELING PHILOSOPHY	2.1
2.2.1 Construction Capital Costs	2.1
2.2.2 Storage Area Capital Costs	2.3
2.2.3 Operating Costs	2.4
2.2.4 Other Costs	2.6
3.0 MODEL MECHANICS	3.1
3.1 MAIN PROGRAM	3.1
3.2 RDFILE SUBROUTINE	3.1
3.3 INPBAS SUBROUTINE	3.3
3.4 MDSIGN SUBROUTINE	3.3
3.5 WSTFAC AND MWASTE SUBROUTINES	3.5
3.6 PKCALC SUBROUTINE	3.6
3.7 TIMERQ SUBROUTINE	3.6
3.8 FACREQ SUBROUTINE	3.9
3.9 DSNRD SUBROUTINE	3.13
3.10 PKREAD SUBROUTINE	3.14
3.11 CAPCST SUBROUTINE	3.14
3.12 CAPSTO SUBROUTINE	3.16
3.13 STOCST SUBROUTINE	3.17

3.14 LABREQ SUBROUTINE	3.20
3.15 MATCOS SUBROUTINE	3.22
3.16 LABCOS SUBROUTINE	3.23
3.17 EQPCST AND REPLAS SUBROUTINES	3.24
3.18 DECOM SUBROUTINE	3.27
3.19 DBOUT SUBROUTINE	3.27
3.20 CALCS SUBROUTINE	3.28
4.0 INPUT REQUIREMENTS	4.1
4.1 DESIGN THROUGHPUT FILE	4.1
4.2 FACILITY PERFORMANCE FILE	4.5
4.3 WASTE PROCESSING FACILITY FILE	4.11
4.4 WASTE STORAGE FACILITY FILE	4.16
4.5 WASTE LOGISTICS FILE	4.20
4.5.1 User-Generated File	4.20
4.5.2 File Generated by WASTES	4.21
4.6 PARAMETER STATEMENTS AND BLOCK DATA	4.21
4.6.1 PARAMETER Statements	4.21
4.6.2 Block Data	4.23
5.0 SAMPLE PROBLEMS (VERSION 1)	5.1
6.0 EXECUTION OF MONITOR FOR THE VERSION 2 DESIGN	6.1
7.0 SAMPLE PROBLEM (VERSION 2)	7.1
REFERENCES	R.1

FIGURES

3.1	Flow Diagram of the MONITOR Model	3.2
3.2	Logic in STOCST for Calculating Pack Requirements	3.18
3.3	Logic in LABCOS for Adjusting Labor Requirements	3.25

TABLES

2.1	Waste Processing Logical Units	2.2
2.2	Hot Cell Processing Stations	2.2
2.3	Storage Area Logical Units	2.3
3.1	Operations on Waste Arriving at the MRS Facility	3.8
3.2	Operations on Waste Leaving the MRS Facility	3.10
4.1	Cask Operations	4.7
4.2	Canister Operations	4.8
4.3	Pack Operations	4.9
4.4	Conversion Operations	4.9

1.0 INTRODUCTION

The MONITOR model is a FORTRAN 77 based computer code developed as a tool for parametrically estimating the costs of a monitored retrievable storage (MRS) facility concept. A MRS facility is a facility that is designed to provide temporary storage of radioactive waste generated at nuclear reactors and to repackage the waste (as received from reactors) into canisters compatible with geologic repository waste packages. The MRS facility, with its capability to both store and repackage waste, could serve as a vital component of the U.S. Department of Energy's nuclear waste disposal system.

The full input data requirements for MONITOR, if exercised, currently exceed data availabilities, but the model is flexible enough to be run using simplified data sets. MONITOR provides the user different ways to supply input data ranging from general to very specific cost breakdowns. This feature of the model makes it ideal for use in the MRS program because new (more complex) data are always being generated and "old" data are frequently being updated.

This report documents the philosophy behind MONITOR and also serves as a user's guide. The report contains the following:

- a discussion of the overall structure and philosophy of the MONITOR model (Section 2.0)
- a description of the algorithms that compose the model (Section 3.0)
- a detailed description of the input data requirements for the model (Section 4.0)
- description of the sample problems illustrating the procedure for running the model (Sections 5.0 and 7.0).

The full report in the PNL project files contains a number of appendices which are available on request. They are:

- sample input and output files (Appendixes A, B, F and G)
- a listing of all model variables and their descriptions (Appendix C)
- a listing of the complete MONITOR model (Appendixes D and E).

2.0 MODEL OVERVIEW

This chapter is intended to provide the reader with a general understanding of how MONITOR works without presenting a detailed discussion of model mechanics. A brief description of the capabilities and limitations of the model is given in Section 2.1. Section 2.2 describes the philosophy behind the model and defines key terms used throughout the rest of the report. The model mechanics (i.e., the algorithms and the FORTRAN subroutines) and the detailed input data requirements for the model are discussed in later chapters.

2.1 SCOPE OF THE MODEL

MONITOR is capable of parametrically estimating all costs directly associated with the construction, operation, maintenance, and decommissioning of an integral MRS facility. The model does not account for costs that are incurred prior to the start of facility construction (i.e., proposal preparation, siting, licensing, and pre-construction engineering costs). The model also does not account for transportation costs to or from the MRS facility or for costs associated with schedule slippages, accident scenarios, or any other occurrences for which allowance cannot reasonably be made. Since the model serves only as a tool for parametrically manipulating the input data, any cost item or factor not included in the input will not be accounted for in the model. Such cost considerations have been developed elsewhere in the MRS Program, and in several instances, models are available for their evaluation.

2.2 MODELING PHILOSOPHY

The approach that MONITOR uses to calculate the costs associated with an integral MRS facility is described here in simplified fashion. This section is divided into four subsections: construction capital costs, storage capital costs, operating costs, and other costs.

2.2.1 Construction Capital Costs

To calculate construction capital costs, MONITOR first calculates how many waste processing "logical units" are needed at the MRS facility. A logical unit is an installation or piece of equipment that represents the smallest

increment of waste processing capacity that can be added to the MRS facility without sacrificing assurance that the model will provide an accurate cost estimate (data to support further breakdown of costs currently do not exist). Table 2.1 provides a list of the different types of waste processing logical units at the MRS facility. As explained later in this document, the term "pack" used in Table 2.1 is a generic term that describes the containment packages in which waste canisters are stored at the MRS facility. These logical units represent fundamental units of capacity at the MRS facility, except for hot cells. The capacity of a hot cell depends on how many "processing stations" it contains (a design input). The processing stations that a hot cell can contain are listed in Table 2.2.

TABLE 2.1. Waste Processing Logical Units

1. Gate House Line
2. Washdown Line
3. Receiving Area
4. Unloading Crane
5. Pack Transporter
6. Transportable Cask Transporter
7. Pack Storage Crane
8. Transportable Cask Storage Crane
9. Hot Cell

TABLE 2.2. Hot Cell Processing Stations

1. Shielded Door
2. Inlet Port
3. Fuel Disassembly Station
4. Consolidation Station
5. Overpacking Station
6. Decontamination Station
7. Outlet Port
8. Shipping Port

The number of waste processing logical units needed at the MRS facility is calculated based on 1) the amount of receipts, shipments and holdup of waste that the user has specified the facility to be designed for and 2) the user-defined processing capacity associated with each logical unit (the annual receipts and shipments is divided by the annual capacity per logical unit to yield the number of logical units needed). The number of logical units needed is calculated for the initial construction of the facility and for each expansion that follows. This determines the processing capacity of the MRS facility during each of its years of operation (processing capacity can vary over the life of the facility).

The construction capital cost is calculated by multiplying the number of logical units by the cost per unit. Construction capital costs associated with expansions are based on the number of incremental logical units added to the MRS facility.

2.2.2 Storage Area Capital Costs

Storage area capital costs are calculated in MONITOR in a manner very similar to construction capital costs. First, the model calculates the number of storage area logical units needed at the MRS facility. ("Logical unit" has the same meaning here as in Section 2.1, except that it refers to incremental units of storage capacity, not processing capacity.) The different types of storage area logical units in the MRS facility are listed in Table 2.3. It should be noted that modular storage areas are intended to be a subset of aggregate storage areas (i.e., more than one modular storage area per aggregate storage area), and modular transportable cask storage areas are intended to be a subset of aggregate transportable cask storage areas. The user can specify the amount of storage capacity associated with each storage area logical unit.

TABLE 2.3. Storage Area Logical Units

1. Modular Storage Area
2. Modular Transportable Cask Storage Area
3. Aggregate Storage Area
4. Aggregate Transportable Cask Storage Area

Dependent upon how the user specifies these types of storage areas, they can encompass different amounts of the total storage area. For example, if the level of detail in the cost estimate is not very great, the whole storage area could be costed as a modular storage area. No cost would need to be applied to the aggregate storage area. Note that in the input and output files the key-word designating the "aggregate storage area" is "big storage area."

Storage area logical units are different from waste processing logical units in that they are added as needed during the life of the facility (not just during initial construction or during an expansion). The number of these logical units needed is dependent on the total inventory of waste being stored at the facility, not on the rate at which waste is being received or shipped. In some scenarios, this may mean that new storage area logical units are needed at the facility each year for several years in a row. The user can specify the number of storage area logical units that are to be constructed initially at the facility (so that some will be in place when the facility first starts operation). It should be noted that once constructed, storage areas can be filled, emptied, and refilled with waste several times, depending on the logistics of waste receipts and shipments at the MRS facility.

Storage area capital costs are calculated by multiplying the number of storage area logical units by their cost per unit.

2.2.3 Operating Costs

Operating costs are calculated based on the annual receipts and shipments at the MRS facility. The annual receipts and shipments can be either user specified or generated by the WASTES model, a program that simulates the movement of nuclear waste through a complete nuclear waste disposal system (Shay and Buxbaum 1986). Each year of operation the model calculates the number of logical units actually needed to process the receipts and shipments that have been specified for that year. If there are more logical units present than needed, the extra logical units remain idle. If there are less present than needed, an error message results.

Operating costs are split into two categories: labor costs and materials costs. The first step in calculating labor costs is to determine how many

workers are needed at the MRS facility in a given year. The number of workers needed is tied directly to the number of logical units that are needed (there are a certain number of workers per logical unit). The model allows the user to specify different numbers and different types of workers for each different logical unit. The user can also specify labor that is not tied to the logical units and is therefore independent of waste processing throughput or storage inventory (e.g., plant managers, doctors, and radiation specialists may fall in this category). The number of workers of a certain type can also be tied to the number of workers of another type. For example, the number of laundry personnel can be tied to the number of workers that work in radiation zones.

The end result is that, for each year of operation, the MRS facility may have a different labor requirement (a different number of workers). Before accepting the labor requirement for a given year, MONITOR looks back to the previous year and looks ahead over the next few years to see if the labor requirement in the current year is unusually high or low. If it is either, logic is employed to ensure that the uncharacteristic year is handled realistically (the model tries to avoid situations in which there is a year of lay-offs followed by a year of hiring, or vice versa). Finally, the number of workers of each type needed in a given year is multiplied by the annual cost per worker, and this is summed over all types of workers to yield a total labor cost for the year.

Materials costs are calculated by first determining annual material requirements (the number of different types of material units needed). The number of material units needed can be tied to 1) the number of units of waste processed, 2) the number of logical units needed, and/or 3) the number of workers needed. Material requirements can also be specified as independent of waste processing throughput or storage inventory (e.g., utilities needed to support a fire station). Material requirements for a given year are not checked for consistency with requirements from previous or future years in the way that labor requirements are, because the considerations made for labor do not apply to materials. Total material costs are calculated by multiplying the material requirements for each type of material by the cost per material unit and summing over all material types.

2.2.4 Other Costs

Other costs that are taken into account by MONITOR and the manner in which they are calculated are discussed below.

- Maintenance Costs: Annual maintenance costs can be calculated by the model in two ways. The first way is simply to take a percentage of the total capital cost associated with all the existing facilities in any given year and use this as the maintenance cost for that year. The second way is to specify the labor and material requirements associated with maintenance of the facility and let MONITOR calculate the costs based on the waste processing throughput and storage inventory of the facility during the year.
- Equipment Replacement Costs: Annual equipment replacement costs are calculated by taking a percentage of the total capital cost associated with all existing facilities in any given year. Alternatively, if the user knows the life expectancy of a major piece of equipment (either in years or in units of waste processed), MONITOR can calculate equipment replacement costs that are incurred exactly when the equipment needs replacement.
- Decommissioning Costs: Decommissioning costs are calculated strictly as a percentage of capital costs. Different percentages can be specified for radioactive and nonradioactive facilities, since decommissioning activities associated with these two types of facilities differ greatly.
- Consumables Costs: Annual consumables costs are calculated as a percentage of total labor costs in any given year of operations.
- General and Administrative Costs: Annual general and administrative costs are calculated as a percentage of total labor plus maintenance plus consumables costs in any given year of operations.

3.0 MODEL MECHANICS

MONITOR is a FORTRAN 77 based computer code developed on a Digital Equipment Corporation (DEC) VAX-11/780 computer that runs version 3.7 of the VMS operating system. The version that is described in this document has been converted to operation on a personal computer. This section describes all the major subroutines in the code and the operations that they perform.

3.1 MAIN PROGRAM (MONITOR)

The main program functions as a command module that calls each of the subroutines in the proper order. Each subroutine is a FORTRAN representation of one or more of the algorithms that compose the model.

A diagram showing the flow of logic in the main program is given in Figure 3.1. The program can be divided roughly into two parts. The first part contains logic for calculating the facility requirements associated with initial construction and any expansions, and the capital costs associated with these construction efforts. The second part calculates the storage, labor, material, and maintenance requirements and costs for each year of facility operation. Decommissioning costs are also calculated in the second part of the program.

3.2 RDFILE SUBROUTINE

The RDFILE subroutine reads in data specifying the following:

1. the design of the MRS facility, including the rate at which the facility is to process and store waste
2. the storage concept to be employed at the MRS facility
3. the destinations (up to three) to which the MRS facility is to ship waste.

The subroutine is called for initial construction and for each expansion of the facility (i.e., if there are two expansions, RDFILE will be called three times). The RDFILE subroutine serves to read in the design throughput data from a file with a user friendly format and then to place the data into the

FIGURE 3.1. Flow Diagram of the MONITOR Model

proper locations to execute the program. A detailed description of the data file that the subroutine reads and instructions for setting up the file are given in Section 4.1.

3.3 INPBAS SUBROUTINE

The INPBAS subroutine, called from the RDFILE subroutine, serves to read in all the facility performance data necessary to calculate the number of logical units needed at the facility. INPBAS also reads in data specifying the packaging/repackaging scheme for waste received at the MRS facility and for waste to be shipped from the facility to each final destination. Storage logistics corresponding to the storage concept chosen by the user are also read in. INPBAS is called only once from RDFILE (the first time RDFILE is executed), because none of the data read in by INPBAS changes when a facility expansion occurs.

3.4 MDSIGN SUBROUTINE

The MDSIGN subroutine takes the waste logistics data specified by the user and manipulates it according to the specified packaging/repackaging scheme to calculate the number of waste units to be processed. The logistics information contained in the design throughput data file defines the spent fuel receipts and shipments (including receipts that are to be shipped in the same year that they are received) in metric tons. These units are not amenable to calculating facility requirements because the waste processing stations operate on "bundles" rather than metric tons of waste, so MDSIGN converts the units to bundles.

Four categories of waste bundles are identified in the model: casks, canisters, conversions, and packs. Each category can be divided further into different types of bundles. Casks include all types of shipping casks (e.g., truck, rail, and transportable metal casks). "Canisters" is a generic term for the structure containing fuel rods or other radioactive waste. The definition of "canister" allows the user to flexibly define almost all waste packages, packaging and repackaging operations. Note that under this definition a fuel

assembly would be considered a "canister" and rod consolidation would be considered a conversion from one type of "canister" to another. This category arises because the time that it takes to complete some of the waste conversion processes is dependent not on the starting canister or final canister alone, but on the combination of the two canisters. For instance, consolidating a pressurized water reactor (PWR) assembly into a tuff repository package will probably take a different amount of time than consolidating either a PWR assembly into a salt repository package or a boiling water reactor (BWR) assembly into a tuff package. "Packs" is a generic term that describes the containment packages in which waste canisters are stored at the MRS facility. Examples of packs at a concrete cask MRS facility include spent fuel storage casks, remote-handled transuranic (RHTRU) waste storage casks, and high-level-waste (HLW) storage casks.

The receipt and shipment data supplied by the user (in metric tons) are placed into arrays that contain the following information:

1. the number of each type of waste-filled cask (e.g., truck, rail, or transportable metal casks) arriving at the facility
2. the number of each type of waste-filled cask leaving the facility
3. the number of each canister type (e.g., PWR assembly, BWR assembly, HLW canister, etc.) arriving at the facility
4. the number of canisters being converted to another type of canister on the way into the facility (e.g., a PWR assembly being consolidated into an MRS canister for storage). The information contained in this array includes the type of canister arriving at the facility and the type of canister into which the waste is being transferred
5. the number of each canister type being placed in the storage yard at the facility
6. the number of each canister type that is ready to be placed into storage but that will be shipped out of the facility the same year that it arrived

7. the number of each canister type either arriving at or being taken out of storage in the same year that it is to be shipped from the facility to one of the final destinations
8. the number of canisters being converted to another type of canister on the way out of the facility. The information contained in this array includes the type of canister being converted and the type of canister into which the waste is being transferred
9. the number of each type of canister actually being shipped out of the facility to one of the final destinations.

These arrays are used either directly or indirectly to drive the rest of the subroutines in the model.

MDSIGN is called for initial construction and for each expansion of the MRS facility. It is also called for each year of operations when the user (not the WASTES model) defines the annual waste logistics. The arrays are filled in separately for each expansion or each year, and no information is kept from one expansion or year to the next.

3.5 WSTFAC AND MWASTE SUBROUTINES

The WSTFAC and MWASTE subroutines work together during operating years to accomplish the same objectives as MDSIGN when the annual waste logistics data file is generated by the WASTES model. The file generated by WASTES differs from the file generated by the user in that instead of containing spent fuel receipt and shipment information in metric tons, it contains this information in number of PWR or BWR assemblies. Also, the WASTES model allows the relative amount of PWR and BWR fuel and the relative amount of waste shipped by truck or rail to vary annually. When this information is specified by the user, it must be the same for all years of operations.

WSTFAC and MWASTE take the receipt and shipment information in the form supplied by the WASTES model and fill in exactly the same arrays that MDSIGN fills in. The logic, however, is considerably different because the WASTES model currently tracks only two types of "canisters," PWR and BWR assemblies, to be received and shipped from the MRS facility and therefore does not account

for any repackaging that the waste undergoes at the facility. WSTFAC calculates all the conversion factors necessary to convert the number of assemblies being received or shipped (or received and shipped in the same year) to the number of canisters and conversions associated with the MRS packaging/repackaging scheme specified by the user. MASTE then fills in the arrays. WSTFAC is called only once during execution of MONITOR because the waste factors do not change with time, but MASTE, like MDSIGN, is called for each year of operations.

3.6 PKCALC SUBROUTINE

To calculate the number of packs that are to be placed in or taken out of storage, the PKCALC subroutine takes the fifth, sixth, and seventh arrays (see page 3.4) filled in by MDSIGN or MASTE and manipulates them according to the storage logistics data read in by INPBAS. PKCALC does this for all expansions (including initial construction) and all years of facility operations. The following two arrays are filled in:

1. the number of each pack type being placed into storage
2. the number of each pack type being taken out of storage.

PKCALC also calculates the net number of packs needed for storage by subtracting item 2 from item 1. This value is used in subsequent subroutines to calculate storage requirements and costs.

3.7 TIMERQ SUBROUTINE

The TIMERQ subroutine takes the arrays filled in by MDSIGN (or MASTE) and PKCALC and calculates the total time required to process all waste at each of the logical units (or waste processing stations, in the case of hot cells) for each expansion or year. At least one waste operation, a discrete processing step that has an associated time, is performed at each logical unit. The waste operations are performed on units of waste that fall into one of the four categories of waste bundles. The washdown operation at the washdown lines, for instance, is performed on casks, and the canister decontamination operation at the decontamination stations is performed on canisters. The time required to

perform these operations is a function of the type of bundle being processed. It may take less time, for example, to wash down a truck cask than it does to wash down a rail cask.

Some logical units (or waste processing stations) are the focal point of several operations, each of which may be performed on different types of waste bundles. Inlet ports are a good example: casks are operated on when they are mated to the ports for unloading, and canisters are operated on when they are unloaded from the casks after mating. The total time that the inlet ports are used is the sum of these two time periods plus the time periods of any other operations occurring at the inlet ports.

A total of 45 waste operations have been identified at the MRS facility. Seventeen of these are associated with casks, 7 with canisters, 6 with conversions, and 15 with packs. Actually, there are 27 cask operations, but 10 of these apply only to transportable casks, which are stored intact at the facility in an area prepared for them. These 10 operations are essentially identical to 10 of the pack operations (although the time periods associated with them are generally different), so they are not considered unique operations.

The 45 waste operations can be roughly split into two categories: those operations dealing with waste that is arriving at the facility and those operations dealing with waste that is leaving (see Tables 3.1 and 3.2, respectively). Tables 3.1 and 3.2 also give the type of waste bundle on which each operation is performed, and the logical units (or waste processing stations) tied up by each operation. Some of the operations tie up more than one logical unit or processing station. The time that it takes to perform each waste operation (on each of the waste bundle types that the operation deals with) is specified by the user.

TIMERQ calculates the total time spent on each operation by multiplying the user specified time periods associated with each of the waste operations by the number of waste units being operated on. The sum of the total time periods for each of the operations that tie up a given logical unit (or waste processing station) is the total time required to process all the waste at that logical unit. For a given logical unit, this calculation is performed separately for waste arrival and departure.

TABLE 3.1. Operations on Waste Arriving at the MRS Facility

Operation	Type of Bundle Operated On	Logical Unit(s) or Waste Processing Station(s) Tied Up
1. Receive and inspect cask at gate	Cask	Gate house line
2. Wash down cask at R&H building	Cask	Washdown line
3. Prepare cask for offloading	Cask	Receiving area
4. Unload cask from transport onto port cart	Cask	Receiving area, unloading crane, inlet port
5. Inspect cask and take gas sample at inlet port	Cask	Inlet port
6. Conduct cask-dependent inlet port operations	Cask	Inlet port, shielded door
7. Unload assembly/canister from cask and place in lag storage	Canister	Inlet port, shielded door
8. Inspect and decontaminate cask	Cask	Inlet port
9. Unload empty cask from cart onto transport	Cask	Receiving area, unloading crane, inlet port
10. Prepare empty cask for discharge	Cask	Receiving area
11. Disassemble fuel assemblies	Conversion	Fuel disassembly station
12. Consolidate fuel rods	Conversion	Fuel disassembly station
13. Load received waste into canister	Conversion	Fuel disassembly station
14. Load nonfuel-bearing components into drums (and then load drums into "cages")	Conversion	Fuel disassembly station
15. Seal and weld canister	Conversion	Decontamination station
16. Overpack canister	Conversion	Overpacking station
17. Inspect and decontaminate canister	Canister	Decontamination station
18. Put canister in lag storage	Canister	Decontamination station
19. Load canister to pack at outlet port	Canister	Outlet port, pack transporter

TABLE 3.1. (contd)

Operation	Type of Bundle Operated On	Logical Unit(s) or Waste Processing Station(s) Tied Up
20. Conduct dependent outlet port operations	Pack	Outlet port, pack transporter
21. Prepare pack for storage	Transportable cask, pack	Storage area transporter, outlet port
22. Move transporter to storage area	Transportable cask, pack	Storage area transporter
23. Place pack on pad or in drywell	Transportable cask, pack	Storage area transporter, storage crane
24. Secure pack on pad or in drywell	Transportable cask, pack	Storage crane
25. Move transporter back to R&H building (pick up another pack on the way if appropriate)	Transportable cask, pack	Storage area transporter

TIMERQ is called each time either MDSIGN or MWASTE is called. The logical unit time requirements that it calculates are used to calculate capital and operating requirements and costs in subsequent subroutines.

3.8 FACREQ SUBROUTINE

The FACREQ subroutine uses the logical unit (or waste processing station) time requirements calculated in TIMERQ to calculate waste processing logical unit requirements for initial construction and each expansion of the facility.

The waste processing logical unit requirements for all logical units (except hot cells) are calculated by dividing the logical unit time requirements by the logical unit time availabilities:

$$\text{Number of logical units} = \frac{\text{Logical unit time requirement}}{\text{Logical unit time availability}} \quad (3.1)$$

TABLE 3.2. Operations on Waste Leaving the MRS Facility

Operation	Type of Bundle Operated On	Logical Unit(s) or Waste Processing Station(s) Tied Up
1. Prepare pack for removal from pad or drywell	Transportable cask, pack	Storage crane
2. Move transporter to pad or drywell	Transportable cask, pack	Storage area transporter
3. Load pack on transporter	Transportable cask, pack	Storage area transporter, storage crane
4. Move transporter to R&H building	Transportable cask, pack	Storage area transporter
5. Prepare pack for unloading	Transportable cask, pack	Storage area transporter, outlet port
6. Conduct pack-dependent outlet port operations	Pack	Pack transporter, outlet port
7. Unload canister from pack	Canister	Pack transporter, outlet port
8. Prepare pack for temporary storage	Pack	Pack transporter, outlet port
9. Move pack to temporary storage	Pack	Pack transporter
10. Place pack in temporary storage	Pack	Pack transporter, storage crane
11. Prepare canister for shipment (include contam. survey, decon., etc.)	Canister	Decontamination station
12. Prepare empty cask for off-loading	Cask	Receiving area
13. Unload empty cask from transport port cart	Cask	Receiving area, unloading crane, inlet port
14. Inspect cask, prepare ready for mating to cell	Cask	Inlet port

TABLE 3.2. (contd)

Operation	Type of Bundle Operated On	Logical Unit(s) or Waste Processing Station(s) Tied Up
15. Conduct cask-dependent inlet port unloading operations	Cask	Inlet port, shielded door
16. Load canister to shipping cask	Canister	Inlet port, shielded door
17. Prepare cask for shipping out	Cask	Inlet port
18. Unload cask from port cart onto transport	Cask	Receiving area, unloading crane, inlet port
19. Prepare cask for leaving	Cask	Receiving area
20. Send cask through gate	Cask	Gate house line

The time availability at each logical unit is calculated by multiplying the total number of hours that the facility operates in a year by the fraction of time that the logical unit is actually available for performing operations on waste (which takes into account lost time due to maintenance, equipment changeover, decontamination, and loss of worker productivity):

$$\text{Logical unit time availability} = \left(\text{Number of hours of operation in a year} \right) * \left(\text{Fraction of time that logical unit is available} \right) \quad (3.2)$$

If the calculated logical unit requirement is less than the minimum requirement specified by the user, the program will set the logical unit requirement equal to the minimum requirement. In all cases, the logical unit requirement is rounded up to the nearest integer.

To calculate the number of hot cells needed at the MRS facility, the model first calculates the number of hot cells needed based on each of the waste processing stations within the hot cells. To calculate this value for a particular station, the time required to process the waste at that station is divided by the time available to process the waste at that station:

$$\frac{\text{Number of waste processing stations}}{\text{Processing station time requirement}} = \frac{\text{Processing station time requirement}}{\text{Processing station time availability}} \quad (3.3)$$

The time available to process waste at a given station is calculated by the following equation:

$$\text{Processing station time availability} = \left(\frac{\text{Number of hours of operation in a year}}{\text{Number of hours of operation in a year}} \right) * \left(\frac{\text{Fraction of time that processing station is available}}{\text{Fraction of time that processing station is available}} \right) * \left(\frac{\text{Number of processing stations in a hot cell}}{\text{Number of processing stations in a hot cell}} \right) \quad (3.4)$$

The number of hot cells needed at the MRS facility is the maximum of the number of hot cells needed based on each of the stations. In effect, the number of hot cells is determined by the requirement of processing stations that form operational bottlenecks within the hot cells. The stations at which the bottlenecks form are determined by the design of the hot cells (i.e., how many of each station type are contained in a hot cell) and by the waste receipt and shipment data specified by the user. For example, if the user specifies that all waste receipts arrive by truck, it is very likely that the inlet ports will be the bottleneck in the hot cells, but if the user specifies all rail shipments, some other station will probably be the bottleneck. (Because the hot cells are generally designed for about a 30:70 truck/rail split of waste arriving at the facility, and since truck shipments take a longer amount of time at the inlet ports per metric ton of waste transported, a significant increase in the percentage of waste shipped by truck will result in a need for more inlet ports.) As with the other logical units, if the calculated number of hot cells is less than a user-specified minimum number of hot cells, the calculated number is adjusted upward to match the minimum. Also, the hot cell requirement is rounded up to the nearest integer.

After FACREQ has calculated the logical unit requirements for a given facility expansion (or initial construction), it compares the number of logical units needed in this expansion with the number of logical units that have been constructed in all previous expansions. The number of logical units added to the facility is the difference between these two numbers. If the logical unit

requirement for a given expansion is less than or equal to the number of logical units constructed in all previous expansions, no logical units (of that type) are added.

In addition to calculating the number of waste processing logical units to be added for each expansion, FACREQ also calculates the incremental increase in spent fuel receipt rate (metric tons per year) and the increase in the time required to manufacture the packs needed for waste storage. The latter quantity is the product of the net number of packs calculated in PKCALC and the unit time for manufacturing each pack. (This calculation is actually done in TIMERQ, but the comparison of the current time requirement and the previous time requirement is done in FACREQ.)

The incremental increase in spent fuel receipt rate is used to calculate the capital cost of adding more facilities that scale with receipt rate. The incremental increase in the time required to manufacture packs is used to calculate the cost of adding capacity to the pack manufacturing plant at the MRS facility. It should be noted that the pack manufacturing plant applies only to the concrete cask storage concept. The other storage concepts do not require a facility with significant capital costs for pack manufacturing.

3.9 DSNRD SUBROUTINE

The DSNRD subroutine reads in all data that are independent of the storage concept at the MRS facility. These data include:

- the capital costs and construction schedules associated with each of the logical units that do not deal with the storage of waste (including facilities that do not scale)
- a list of all material and labor types at the facility and their costs
- the material and labor requirements associated with each of the non-storage processing stations and logical units
- the minimum number of shifts at each of the nonstorage processing stations

- decommissioning cost factors and schedules
- other cost factors.

These data must be read in before any costs can be calculated.

3.10 PKREAD SUBROUTINE

The PKREAD subroutine reads in all the data that are dependent on the storage concept at the MRS facility, which includes:

- the capital costs and construction schedules associated with the storage area logical units
- the number of storage area logical units to be constructed initially
- the cost of each type of pack and the number of each type that are to be constructed initially
- the types and costs of pads on which the packs are stored
- the costs and expected lifetimes of storage area transporters and cranes
- the capital cost and construction schedule of the pack manufacturing facility (concrete casks only)
- the minimum number of shifts at each of the storage related processing stations
- decommissioning costs for packs
- the labor and material requirements associated with each of the storage area processing stations and logical units.

These data are contained in several files, each of which represents a different storage concept. For a given run of MONITOR, only one of these files is read.

3.11 CAPCST SUBROUTINE

The CAPCST subroutine calculates the capital costs associated with each of the following: gate house lines, washdown lines, unloading cranes, receiving

areas, hot cells, pack manufacturing facilities (concrete casks only), facilities that scale with spent fuel receipt rate, and facilities that do not scale. CAPCST does this for initial construction and each expansion of the MRS facility. Unlike the subroutines used to calculate facility requirements, CAPCST is called only once. It internally loops over all the expansions for which time and facility requirements were calculated.

For the gate house lines, washdown lines, and receiving areas, the cost read in by DSNRD (i.e., the data base cost) represents the cost of a building that contains two of each logical unit. The costs of the first two gate house lines, the first two washdown lines, and the first two receiving areas built at the MRS facility are therefore taken to be half the costs of these buildings. Each additional gate house line is assumed to cost 30% of the gate house building cost, and each additional washdown line or receiving area is assumed to cost 45% of the washdown building or receiving area cost.^(a)

In the case of unloading cranes and hot cells, each unit added to the facility has the same cost as any other unit, and there are no percentages applied.

The facilities that scale with spent fuel receipt rate are costed according to the following formulas:

If the receipt rate is less than 3600 metric tons (MTU) per year,

$$\text{Cost} = 0.65 * \text{Data Base Cost} * (\text{Receipt Rate}/1000.) ** 0.33^{(a)}$$

If the receipt rate is greater than or equal to 3600 MTU/year,

$$\text{Cost} = \text{Data Base Cost} * (\text{Receipt Rate}/3600.) ** 0.63^{(a)}$$

When calculating the cost of these facilities with each expansion, only the incremental cost is incurred.

(a) These percentages were recommended by the architect-engineer who designed and costed Version 2.A of the MRS facility concept. The percentages are currently hardwired into the code, so altering them would require a programming change rather than an input change.

The costs of facilities that do not scale with throughput are simply taken to be the data base cost read in by DSNRD. The costs associated with these facilities are calculated only for the initial construction of the facility, since these facilities are never expanded when the throughput capacity of the MRS facility is expanded.

The pack manufacturing facility (which is built only when the storage concept at the MRS facility is concrete casks) is costed according to the following formulas:

If the number of packs to be manufactured is less than or equal to 121,

$$\text{Cost} = 0.75 * \text{Data Base Cost}$$

If the number of packs to be manufactured is greater than 121 but less than 250,

$$\text{Cost} = 0.75 * \text{Data Base Cost} * (\# \text{ of Packs}/122.) ** 0.4$$

If the number of packs to be manufactured is greater than or equal to 250,

$$\text{Cost} = \text{Data Base Cost} * (\# \text{ of Packs}/250.) ** 0.85$$

These formulas were recommended by the MRS project architectural engineer, and the costs associated with expansions are the incremental costs of the additional pack manufacturing capacity needed for the new throughput rate.

All the capital costs mentioned here are spread out by CAPCST over a user-specified construction period that precedes the year that the expanded (or initial) capacity is to go into effect. The user can specify a different construction period for each of the logical units.

3.12 CAPSTO SUBROUTINE

The CAPSTO subroutine calculates the capital costs associated with the packs, pads, and storage areas (both modular and aggregate) that are initially constructed at the MRS facility. These costs are read in from the data file

read by PKREAD. The costs are calculated by multiplying the number of user-specified units initially constructed by the data base cost read from the file (i.e., no percentages are applied). The costs are spread over a user-specified construction period that precedes the initial startup of the facility.

CAPSTO also takes the number of packs, pads, and storage areas that the user specifies and places them in the proper locations so that when operations begin, these units are the first to be used for the storage of incoming waste.

3.13 STOCST SUBROUTINE

The STOCST subroutine is called each year that the MRS facility is in operation to calculate the costs of the packs, pads, and storage areas that must be added to satisfy waste storage requirements. STOCST also calculates the number of packs that are decommissioned in each year of operations.

All the calculations in STOCST are driven by the net number of either the packs or the transportable casks being stored at the MRS facility (as calculated in PKCALC). Figure 3.2 shows the logic employed by STOCST to calculate the number of packs that must be added to the facility (new packs) in a given year, the number of packs that will be available for use in the following year, the number of packs decommissioned during the year, and the number of packs that were previously decommissioned and are now being reactivated. Dividing the net number of packs by the number of packs that can be stored on a pad yields the net number of storage pads needed in a given year:

$$\text{Net number of storage pads} = \frac{\text{Net number of packs}}{\text{Number of packs per storage pad}} \quad (3.5)$$

The number of new storage pads and available storage pads is calculated from the net number of storage pads in essentially the same way that the number of new and available packs were calculated from net packs. In the case of storage pads, however, it is assumed that there is no decommissioning during the operating years of the facility.

The net number of transportable casks stored at the facility is used to calculate the net number of transportable cask pads needed in a given year.

FIGURE 3.2. Logic in STOCST for Calculating Pack Requirements

This in turn is used to calculate the number of new and available transportable cask pads. The methodology used here is the same as that used to calculate the number of new and available storage pads from the net number of packs.

STOCST continuously updates the total number of storage pads and transportable cask pads being used at a given time during the life of the facility. By dividing the total number of pads (for either packs or transportable casks) in use by a user-specified number of pads per modular storage area, the number of modular storage areas and modular transportable cask storage areas needed at a given time can be calculated. If there are not enough modular storage areas to accommodate all the pads in use, a new modular storage area is added to the facility.

For any given year, STOCST calculates the number of existing modular storage areas and the number of modular storage areas that are in use. The latter number is used in subsequent subroutines to calculate component labor and material requirements.

The number of aggregate storage areas in use at a given time is calculated by dividing the number of modular storage areas in use by the number of modular storage areas per aggregate storage area (a user-specified quantity). If there are not enough aggregate storage areas to accommodate all the modular storage areas, a new aggregate storage area is added to the facility. As with modular storage areas, the number of aggregate storage areas in use and in existence is calculated each year.

Once all the pack, pad, and storage area requirements are calculated, STOCST calculates the capital costs associated with each requirement. The costs in a given year are calculated by multiplying the number of units that are required in that year by a unit cost. The user has the option, however, of having the pack and pad costs calculated directly from the labor and materials costs required to construct the packs/pads. In this case, the pack and pad costs are calculated in the subroutines that calculate labor and material requirements and costs (LABREQ, LABCOS, and MATCOS).

It should be noted that the data the user specifies may sometimes lead to unrealistic scenarios in the expansion of storage areas. For example, if an

extra pad is required in the last year that waste is received at the facility, another modular storage area may need to be built, which may in turn require that another aggregate storage area be built. If the aggregate storage areas are very large and costly, a very large cost may be associated with storing that extra amount of waste that caused the extra pad to be needed. The user can circumvent this problem by specifying smaller storage areas, but then there is the problem of having to find data for something that probably has not been designed or costed. This is only one example illustrating the dilemma that the user may be faced with when specifying the design characteristics of the MRS facility.

3.14 LABREQ SUBROUTINE

The LABREQ subroutine calculates the labor requirements associated with each of the processing stations and logical units at the MRS facility. The calculations are made for each year of operations.

LABREQ first calculates the number of shifts required at each processing station to process all the waste. This is accomplished by dividing the time requirements at each station, as calculated in TIMERQ, by the total number of hours that a shift operates in a year and then dividing this value by the processing station availability specified by the user. If the number of shifts calculated in this way is less than the user-specified minimum number of shifts (at a given type of station), the number of shifts is adjusted upward to match this minimum.

LABREQ also calculates the number of waste processing logical units required to be in service to process all the waste. It does this in the same way that waste processing logical unit requirements were calculated in FACREQ (the same equations are used except that here the time requirements are associated with actual receipts, not design receipts). LABREQ does not calculate the number of storage area logical units in service, since these are calculated in STOCST.

LABREQ checks to see if the number of logical units required to be in service exceeds the number that have actually been built prior to the current

year of operations. If so, it prints an error message that the waste throughput in the current year exceeds the capabilities of the facility and that more logical units are needed.

It should be noted that the number of hot cells needed to process all the waste arriving at and leaving the facility are calculated separately in LABREQ and then added to yield the total number of hot cells needed in a given year. This separation is made because a hot cell cannot be used to simultaneously receive and ship waste. By separating the number of cells required for processing receipts and the number required for processing shipments, the program leaves open the possibility of specifying a lag time for converting cells from one mode of operation to the other that is a function of the relative number of cells required for each mode. This is not currently done in the program because of a lack of data to support it. At the present time, the time that it takes to convert a cell is assumed to be accounted for by the hot cell processing station availabilities specified by the user.

Once the number of processing shift stations and the number of logical units required to be in service to process all the waste are calculated, it is relatively straightforward to calculate labor requirements at the MRS facility (for the current year). To obtain the shift station labor requirement, the number of shift stations is multiplied by the number of workers per shift station. This is done for each of the user-specified labor types that are being used at each station.

To calculate the labor requirement associated with a given logical unit, the number of logical units in service is multiplied by the number of workers per logical unit for each of the labor types specified at that logical unit. In this case, however, the user can specify that a different set of labor requirements be associated with each additional logical unit needed at the facility. For instance, one hot cell may require a crew of 10 maintenance personnel, but when a second hot cell is added, only 2 more maintenance personnel need to be added due to economies of scale. These types of economies of scale can be specified by the user in the makeup of the input data to the program (separate labor requirements can be specified for up to 10 logical units of the same type at the MRS facility).

LABREQ also calculates the labor requirements that are independent of the throughput of waste and the amount of waste stored. It does this by summing up the number of workers of each type that fall into this category (this information is specified by the user).

The number of workers required at the facility that are dependent on the number of workers of another labor type is calculated in the following way. The user specifies two things: 1) the labor type dependent on the number of workers of another labor type (called Labor Type A) and 2) the labor type on which the labor is dependent (Labor Type B). (If the user specifies no Labor Type B, the program defaults to using the number of workers of all the labor types that have been defined at the facility.) The program calculates the number of workers of Type A that are needed based on the number of workers of Type B that are employed at the facility. It does this by using a discrete step function that has up to five steps (which are user defined).

A single array is filled in LABREQ that contains the total number of workers of each type needed for each of the years of facility operation. This array is used in the subroutine LABCOS (Section 3.16) to calculate annual labor costs.

3.15 MATCOS SUBROUTINE

The MATCOS subroutine calculates all the material requirements and costs associated with each of the operating years.

It first calculates the material requirements associated with each of the 45 waste operations. The requirements associated with each operation are specified by the user in terms of the number of material units expended per bundle of waste operated on. The user can specify that the number of material units expended during each operation is dependent not only on the number of bundles being operated on, but on the type of bundles as well (e.g., it may require more water to wash down a rail cask than a truck cask). The user can also specify that several different types of materials are expended in the same operation. MATCOS takes all the material requirements associated with each of the different bundle types processed by each of the different waste operations

and sums them to yield the number of each type of material unit expended at the MRS facility in the current year.

The logical unit material requirements are calculated by multiplying the number of logical units in service (as calculated in LABREQ or STOCST) by the number of material units per logical unit expended in a year. By specifying that a different number of material units be expended by each additional logical unit at the facility, the user can model operational economies of scale. For instance, one hot cell may require 1 million kWh of electricity per year to run its HVAC system, but the addition of a second hot cell may require only an additional 500 thousand kWh per year because the second cell shares some of its HVAC system with the first cell.

The material requirements that are independent of waste throughput and the amount of waste stored are calculated by summing the number of material units (of each material type) specified by the user as independent of throughput or waste inventory.

The number of material units required at the facility that are dependent on the number of workers of a certain labor type is calculated in the same way that the number of workers dependent on the number of workers of another labor type is calculated; i.e., substituting "the number of material units dependent on labor" for "the number of workers dependent on the number of workers of another labor type" in Section 3.13, yields these material requirements.

All the material requirements calculated in MATCOS are summed into an array that contains the number of each type of material unit expended in the current year. The elements of this array are multiplied by a corresponding unit material cost to give a component material cost, and all the component material costs are summed to give a total material cost for the current year.

3.16 LABCOS SUBROUTINE

The LABCOS subroutine uses the annual labor requirements calculated in LABREQ to calculate annual labor costs at the MRS facility.

Rather than multiplying the labor requirements coming directly from LABREQ by a unit cost per worker, LABCOS employs logic that levels the labor requirements so that there are no years of unrealistically high or low employment at the facility. The user can specify a certain number of years to see what the future holds in terms of labor requirements and can have the program adjust the labor requirements in the current year based on this "forecast." The program also considers the labor requirement from the previous year in making its adjustments. The adjustments are made independently for each type of worker. The logic that LABCOS uses to make these adjustments is illustrated by Figure 3.3.

Figure 3.3 shows that if there is an unusually low labor requirement in a given year, the program will maintain the same number of workers as in the previous year, or at least as many as will be needed in the following year to avoid a year of layoffs followed by a year of hiring. Conversely, if the year has a high labor requirement, the program will not necessarily add more workers only to lay them off the following year, but will assume that some of the workers work overtime to handle the peak period.

After LABCOS has adjusted the annual labor requirements, the labor costs are calculated by multiplying the labor requirements by a cost per worker and the overtime labor requirements by an overtime cost per worker (these costs are specified by the user).

3.17 EQPCST AND REPLAS SUBROUTINES

The EQPCST and REPLAS subroutines are used to determine when storage area transporters and storage area cranes need to be purchased at the MRS facility and what the costs of these purchases are.

There are two possible circumstances under which transporters or storage area cranes are purchased: 1) the facility undergoes an expansion (or initial construction) and 2) a transporter or storage crane wears out and must be replaced.

FIGURE 3.3. Logic in LABCOS for Adjusting Labor Requirements

The number of transporters and storage cranes that need to be added each time there is an expansion is calculated in FACREQ. These numbers are multiplied in EQPCST by a user-specified unit cost to obtain the transporter and crane capital costs associated with each expansion. These costs are incurred in the years in which the expanded capacities go into effect. They are not spread over specified time periods preceding the expansions, as are most of the capital costs in the program. The rationale is that the transporters and storage cranes would most likely be purchased items (albeit in parts) that would not be "constructed" over an extended period in the same way that buildings are.

To calculate when transporters or storage cranes become worn out and need replacement, the EQPCST subroutine keeps track of the age of each transporter and crane. When the age of a given transporter or crane exceeds its user-specified life expectancy, the equipment is replaced. The life expectancy currently must be specified in years, but with a few minor changes to the program, it could be specified in terms of the total number of packs transported or lifted.

If the user decides that it is unrealistic to replace entire transporters or cranes, he or she can specify life expectancies that exceed the number of years the facility will operate, and no replacements will be made. In this case, the cost of replacement parts needed to keep the transporters and cranes operational can be accounted for (in the CALCS subroutine) by assuming that these costs are a percentage of facility capital costs.

The fairly complex logic used to keep track of the age of each transporter and crane and to determine when a replacement needs to be made is contained in the subroutine REPLAS. This logic was borrowed in part from RECON, a code used to evaluate repository economics (Clark et al. 1985). REPLAS is called from EQPCST once for each year of operations. It maintains a "stack" containing the age of each active transporter or crane. Whenever an item reaches its life expectancy, it is essentially discarded from the bottom of the stack and a new item with zero age is brought in on top of the stack. Entries on top of the stack are also made whenever a transporter or crane is added due to an expansion.

Like the costs of transporters and cranes added due to expansions, the costs of replacement transporters and cranes are incurred in the year in which they are purchased (costs are not spread over the years preceding the purchase).

3.18 DECOM SUBROUTINE

The DECOM subroutine is used to calculate all the decommissioning costs at the MRS facility. The decommissioning cost of each facility is calculated as a percentage of its capital cost. The user can define two different percentage rates to use, one for radioactive facilities and one for nonradioactive facilities. At the present time, all the logical units except hot cells are assumed to be nonradioactive. This assumption is hardwired into the program.

The facility decommissioning costs are spread over a user-specified decommissioning period in the same way that capital costs are spread over a construction period. The decommissioning period by default begins the year immediately following the last year that waste is shipped from the facility, although the user can specify that it begin prior to that time.

The decommissioning of packs is treated somewhat differently than the decommissioning of other facilities at the MRS facility. Pack decommissioning costs are calculated by multiplying the number of packs decommissioned by a decommissioning cost per pack rather than by taking a percentage of the total pack capital cost. Some of the packs may be decommissioned during the operating years of the facility, while others may be decommissioned only after all waste has been shipped from the facility. The cost associated with decommissioning a pack during a year of operation is incurred in that year. The cost associated with decommissioning all the packs that remain after operations have been completed is spread over the same decommissioning period used for all other facilities at the MRS facility.

3.19 DBOUT SUBROUTINE

The DBOUT subroutine can be used to print out the values of variables that may be of interest to the user for debugging or analysis. It is intended to be a scratch subroutine that is frequently modified. Because of its isolation

from the rest of the program, it can be modified without running the risk of inadvertently introducing errors in one of the computational algorithms of the model.

3.20 CALCS SUBROUTINE

The CALCS subroutine multiplies all the direct capital and operating costs calculated in the previous subroutines by factors to account for indirect costs, contingencies, owner's costs, maintenance costs, equipment replacement costs, consumables costs, and general and administrative (G&A) costs. It then prints out five tables that summarize all the costs associated with a given run.

The following formulas are used to calculate the above costs:

$$\text{Indirect Cost}(I) = \text{DIRCST}(I) * \text{Indirect Cost Factor} \quad (3.6)$$

where I = index for year

$\text{DIRCST}(I)$ = total direct capital cost in year I

$$\begin{aligned} \text{Contingency Cost}(I) &= (\text{DIRCST}(I) + \text{Indirect Cost}(I)) \\ &\quad * \text{Contingency Cost Factor} \end{aligned} \quad (3.7)$$

$$\begin{aligned} \text{Owner Cost}(I) &= (\text{DIRCST}(I) + \text{Indirect Cost}(I) \\ &\quad + \text{Contingency Cost}(I)) \\ &\quad * \text{Owner's Cost Factor} \end{aligned} \quad (3.8)$$

$$\text{Maintenance Cost}(I) = \text{CUMCOST} * \text{Maintenance Cost Factor} \quad (3.9)$$

where $\text{CUMCOST} = (\text{DIRCST}(I) + \text{Indirect Cost}(I) + \text{Contingency Cost}(I) + \text{Owner Cost}(I))$ summed over all years up to and including the current year (i.e., a cumulative cost)

Equipment

$$\text{Replacement Cost(I)} = \text{CUMCOST} * \text{Replacement Cost Factor} \quad (3.10)$$

$$\begin{aligned} \text{Consumables Cost(I)} = & \text{LABCST(I)} * \text{Consumables Cost} \\ & \text{Factor} \end{aligned} \quad (3.11)$$

where LABCST(I) = total labor cost in year I

$$\begin{aligned} \text{G\&A Cost(I)} = & (\text{LABCST(I)} + \text{Maintenance Cost(I)} \\ & + \text{Consumables Cost(I)}) * \text{G\&A Cost Factor} \end{aligned}$$

The cost factors in all of the above equations are user specified. The user can also specify that the indirect cost factor and owner's cost factor during the years of initial construction be different than the same cost factors during all other years of facility operation. This allows the user to specify that costs associated with repetitive construction are different than costs associated with initial construction. The user can also specify two different equipment replacement cost factors: one for years in which waste is being received at the facility, and one for all other years. The rationale here is that much more equipment will be used during years in which waste is arriving at the facility, so equipment replacement costs may be higher during those years.

The costs calculated in the above equations may be made to represent any costs that are reasonably predicted by the formulas. Contractor overhead and profit, for example, can be accounted for as an indirect cost. The program currently uses the maintenance cost equation to calculate the costs associated with maintenance, supplies, and contract labor.

When the CALCS subroutine has finished all its calculations and printed out the results of a run, execution of the MONITOR program is terminated.

4.0 INPUT REQUIREMENTS

Each time that it is executed, MONITOR reads five files containing input data:

- Design Throughput
- Facility Performance
- Waste Processing Facility
- Waste Storage Facility
- Waste Logistics.

This section describes the input requirements, the options that the user has relative to inputs, and the defaults associated with the inputs in each file. In most cases, the user will have to be concerned only with the first file, which is set up in a user friendly format. The second, third, and fourth files contain virtually all the cost and performance inputs to the program and should be accessible only to those who have a detailed knowledge of the MRS cost and performance database. The waste logistics file can be generated either by the user or by the WASTES model. In the former case, the user will be burdened with the task of providing detailed logistics data over the entire life of the facility.

In addition to the input files, the user must be concerned with 1) a set of PARAMETER statements used to define the dimensions of the key arrays in the program and 2) information that appears in the block data segment of the program. These items will also be discussed in this section.

4.1 DESIGN THROUGHPUT FILE

The design throughput file contains all the capacity information needed for sizing the initial construction and each expansion of the MRS facility. The subroutine that reads in the file is set up to read a string that contains alphanumeric "keywords" followed by numeric values that are assigned to the variables represented by the keywords. The user strings the keywords and numeric values together, using commas to separate them, and the program then takes the numeric values and assigns them to the proper variables. An example is:

KEYWRD1,500.,KEYWRD2,1000.,.....

In this case, the variable represented by the keyword KEYWRD1 is given a value of 500., and the variable represented by the keyword KEYWRD2 is given a value of 1000.

The following list describes each of the keywords and gives the default values of the variables that the keywords represent.

<u>Keyword</u>	<u>Description</u>
NYEAR	Represents the year in which the expansion (or initial) capacity goes into effect. Must be changed in conjunction with "Base Year" in the Facility Performance File and "Number of Construction Years" in the Waste Processing Facility File. (Base Year + Number Of Construction Years = NYEAR). Integer variable No defaults (a year must be specified for each expansion).
RRNOM	Represents the annual receipt capacity (in metric tons of spent fuel) associated with the expansion. Currently limited to three expansions (including the initial expansion) in the Parameter Statements. Real variable Default: 0.0
ORRNOM	Represents the annual shipping capacity (in metric tons of spent fuel) associated with the expansion. Real variable Default: 0.0
RTHRU	Represents the amount of waste (in metric tons) arriving at the facility that is to leave the facility within 1 year. It is assumed that this waste is not placed into the storage area. The value of RTHRU should not exceed the value of either RRNOM or ORRNOM. Real variable Default: 0.0
FCON	Represents the fraction (by weight) of spent fuel arriving at the facility that is already consolidated. It is assumed that the remainder consists of unconsolidated spent fuel assemblies. Real variable Default: 0.0
FPWR	Represents the PWR fuel fraction (by weight) of spent fuel arriving at the facility. It is assumed that the remainder is BWR fuel. Real variable Default: 0.6
TRKMAX	Represents the fraction (by weight) of waste that arrives at the facility by truck. It is assumed that the remainder is shipped by rail. Real variable Default: 0.5

NTCASK Represents the number of transportable casks (containing waste) that arrive at the facility annually. Although transportable casks are generally shipped by rail, they are not considered to be part of the fraction of waste that is shipped by rail, since they are separate entities that are not unloaded at the MRS facility. This keyword can only be used in conjunction with the user generated version of the Waste Logistics File. Appropriate data must be entered in the Waste Logistics File to represent the presence of transportable casks.

integer variable
Default: 0

NTCSKO Represents the number of transportable casks that are shipped from the MRS facility annually. This keyword can only be used in conjunction with the user-generated version of the Waste Logistics File. Appropriate data must be entered in the Waste Logistics File to represent the presence of transportable casks.

Integer variable
Default: 0

PWRH Represents the volume (in gallons) of PWR nonfuel bearing components that is to be shipped to the MRS facility but is not associated with consolidated PWR fuel arriving at the facility.

Real variable
Default: 0.0

BWR Represents the volume (in gallons) of BWR nonfuel bearing components that is to be shipped to the MRS facility but is not associated with consolidated BWR fuel arriving at the facility.

Real variable
Default: 0.0

NHLW Represents the number of high-level-waste (HLW) canisters that arrive at the MRS facility annually. It is assumed that all these canisters arrive by rail.

Integer variable
Default: 0

NHLWO Represents the number of HLW canisters that are shipped from the MRS facility annually.

integer variable
Default: 0

NHTHRU Represents the number of HLW canisters arriving at the MRS facility that are to leave the MRS facility within 1 year. It is assumed that these are not placed into the storage area. NHTHRU should not be greater than either NHLW or NHLWO.

Integer variable
Default: 0

DSNDST Represents the destination to which the MRS facility is designed to ship waste. The user must specify any integer from 1 to 5, which will tell the program that the waste is to be repackaged at the facility according to a scheme consistent with the final destination of the waste. For instance, if the waste is to go to a tuff repository, it will be repackaged into tuff repository packages. The integers from 1 to 5 represent any destination for which data exist. The repackaging scheme associated with a given integer (destination) is specified in the facility performance file. Currently the destinations are:

- 1 - At the MRS indefinitely (repackage into MRS packages)
- 2 - Basalt repository
- 3 - Salt repository
- 4 - Tuff repository
- 5 - No specification

Integer variable
Default: 1

DEST(1) where 1 = 1, 2, 3. Represent the destinations to which the waste is to be shipped. DEST(1), DEST(2), and DEST(3) correspond to destinations that the user (or the WASTES program) specifies in the waste logistics file (up to three destinations). The reason for specifying the different destinations is that the waste can then be repackaged at the MRS facility into packages corresponding to the destinations. The packages that the waste is repackaged into are specified in the facility performance file and can be changed at any time by the cognizant engineer, acting as the code custodian. The user can specify any integer from 1 to 5 to represent the destination for the waste. The destinations represented by 1 to 5 will correspond to the destinations represented by 1 to 5 for the DSNDST keyword.

Integer variable
Default: 0

PACKF Represents the storage concept at the MRS facility. Currently the user must specify either a 1 or a 2, where:
1 - Concrete casks
2 - Field drywells

When changing storage concepts, the "PADS," "PACKPAD," and "PACK INFO" subheadings in the Waste Storage Facility Data File must be changed to reflect the appropriate storage concept.

Integer variable
Default: 1

HRS Represents the number of hours per day that the MRS facility is designed to operate.

Real variable
Default: 24.0

DAYS Represents the number of days per year that the MRS facility is designed to operate.

Real variable
Default: 365.0

SHIFTS Represents the number of different shifts (crews) that are to work at the MRS facility.

Real variable
Default: 4.0

BREAK A keyword used to tell the program that it has finished reading in the data associated with a given expansion (or initial construction). BREAK separates the data for one expansion from the data for another expansion. Any data (keywords) coming after the BREAK keyword will be associated with the next expansion. BREAK does not have an associated numeric value.

Given below is an example of a simple design throughput file that specifies that a facility be built in 1998 to receive 3600 metric tons and ship 2000 metric tons of spent fuel (to a basalt repository), and then undergo an expansion in 2010, which allows it to simultaneously receive and ship (without storing) 5000 metric tons of spent fuel.

```
NYEAR,1998,RRNOM,3600.,ORRNOM,2000.,DSNDST,2,DEST(1),2,BREAK
NYEAR,2010,RRNOM,5000.,ORRNOM,5000.,RTHRU,5000.,BREAK
```

In this case default values will be used for the variables represented by keywords that do not appear in the file.

The following points should be kept in mind when setting up a design throughput file:

- NYEAR must be specified for each expansion (or initial construction).
- BREAK must be the last keyword associated with a given expansion.
- A line should not end with a comma.
- BREAK should only appear at the end of a line.
- Any value read in for a given expansion will remain the same for all subsequent expansions unless explicitly changed via the use of a keyword.
- The string of data for the last expansion need not end with the BREAK keyword.

Another example of a design throughput file is given in Table A.1.

4.2 FACILITY PERFORMANCE FILE

The facility performance file contains all the performance data associated with the MRS facility. These data include the following:

- times associated with each of the operations
- types of waste bundles that the operations are performed on
- processing station availabilities
- minimum number of stations at the facility
- number of stations of different types within a hot cell
- the repackaging scheme associated with each of the final waste destinations
- storage area information associated with each of the storage concepts.

The file is set up so that all the inputs to the program appear underneath or alongside headings or identifiers. The inputs are read from formatted fields, and the headings and identifiers appear in fields that are not read in by the program. The user is cued as to the format for a particular input by dashes that appear above the point at which input value should appear. If the field is for a real variable, a decimal point appears above the point at which where the decimal point should be. Like the headings, the dashes and decimal points used as cues are located in fields that are not read in by the program. Here is an example of how a section of the facility performance file that reads in two variables might look:

<u>First</u> <u>Year</u>	<u>Percentage</u>
1998	50.00

In this case, the first three lines are ignored by the program when it reads the file. Only the 1998 and the 50.00 are read in, and these are taken to be the values of the variables that represent "first year" and "percentage." When the user wishes to change the value of a variable, he or she can simply call up the file and replace the old value with the new value.

The different types of waste bundles at the MRS facility are identified in the facility performance file by alphanumeric strings. The strings should be limited to five characters, even though the cue indicates that eight characters are acceptable.

An example of a facility performance file is given in Table A.2. The following discussion is devoted to clarifying what each of the values appearing in the file represents. To do this effectively, the file is split into sections, with the beginning of each section identified by a one word line. The one word lines and the descriptions of the sections they precede are as follows.

<u>One</u> <u>Word Line</u>	<u>Description</u>
CASK	This section identifies the types of casks and their associated times for each of 27 cask operations at the MRS facility. Each cask is identified by an alphanumeric

string containing a maximum of five characters. The "type" of cask is designated as T (truck), R (rail), or P (transportable). The times (in hours) associated with each cask appear under the headings T01 to T27, which correspond to the cask operations, which are listed in Table 4.1. The capacities of each cask in terms of the number of canisters that can be transported are contained in the block data section of the program.

TABLE 4.1. Cask Operations

Cask Received

1. Receive and inspect cask at gate^(a)
2. Wash cask at R&H building^(a)
3. Prepare cask for offloading^(a)
4. Unload cask from transport onto port cart (or transporter in the case of transportable casks)^(a)
5. Inspect cask and take gas sample at inlet port
6. Cask dependent inlet port operations
7. Inspect and decontaminate cask at inlet port
8. Unload empty cask from port cart onto transport
9. Prepare empty cask for discharge

Casks Shipped

10. Prepare empty cask for offloading
11. Unload empty cask from transport onto port cart
12. Inspect cask, prepare for mating to cell
13. Cask dependent inlet port unloading operations
14. Prepare cask for shipping out (at inlet port)
15. Unload cask from port cart (transporter in the case of transportable casks) onto transport^(a)
16. Prepare cask for leaving^(a)
17. Send cask out gate^(a)

Transportable Casks Received

18. Prepare cask for storage
19. Move transporter to storage area
20. Place cask on cask pad
21. Secure cask on cask pad
22. Move transporter back to R&H building

Transportable Casks Shipped

23. Prepare cask for removal from pad
24. Move transporter to storage area
25. Load cask onto transporter
26. Move transporter to R&H building
27. Prepare cask for unloading

(a) Operations that also apply to transportable casks.

CANISTER^(a) This section identifies the types of canisters and their associated times (in hours) for each canister operation at the MRS facility. The seven operations are listed in Table 4.2. Each canister is identified by an alphanumeric string (which should be a maximum of five characters). The following canister designations currently must be followed for the program to execute properly:

- PWR - Must be the first canister type specified. It represents a PWR spent fuel assembly.
- BWR - Must be the second canister type specified. It represents a BWR spent fuel assembly.
- PWRC - Must be the third canister type specified. It represents a PWR assembly-sized canister containing the fuel rods from two PWR assemblies.
- BWRC - Must be the fourth canister type specified. It represents a BWR assembly-sized canister containing the fuel rods from two BWR assemblies.
- HLW - Must be the fifth canister type specified. It represents an HLW canister.
- PWRH - When it is specified that some of the spent fuel arrives at the facility consolidated, PWRH (PWR hulls) must be specified as the sixth canister type. PWRH represents a PWR assembly-sized canister filled with PWR nonfuel bearing components (PWR hulls) generated during the consolidation process.
- BWRH - When it is specified that some of the spent fuel arrives at the facility consolidated, BWRH (BWR hulls) must be specified as the seventh canister type. BWRH represents a BWR assembly-sized canister filled with BWR nonfuel bearing components (BWR hulls) generated during the consolidation process.

PACK This section identifies the types of packs and the times (in hours) associated with each of 17 pack operations at the MRS facility. The 17 operations are listed in Table 4.3. Each pack is identified by an alphanumeric string containing a maximum of five characters. The types of packs listed should include all the possible types for all the different storage concepts.

RECANISTERING This section identifies the possible repackaging combinations and the times (in hours) associated with each of six conversion operations at the MRS facility. The six operations are listed in Table 4.4. Alphanumeric identifiers for the type of canister being converted and the type of canister being generated are listed under the headings "old" and "new," respectively (the identifiers for the "old" and "new"

TABLE 4.2. Canister Operations

1. Unload assembly/canister from cask and place in lag storage (at inlet port)
2. Inspect and decontaminate canister if applicable (at decontamination station)
3. Put canister in lag storage (prior to shipping out or placing in storage yard)
4. Load canister to pack at outlet port
5. Unload canister from pack at outlet port
6. Prepare canister for shipment (at decontamination station)
7. Load canister to shipping cask (at inlet port)

(a) "Canister" as referred to in this section refers to the generic definition of "canister" as given in Section 3.4.

TABLE 4.3. Pack Operations

Packs Being Placed into Storage

1. Pack dependent outlet port operations
2. Prepare pack for storage
3. Move transporter (with pack on it) to storage area
4. Place pack on pad or in drywell
5. Secure pack on pad or in drywell
6. Move transporter back to R&H building (pick up another pack on the way if appropriate)

Packs Being Taken Out of Storage

7. Prepare pack for removal from pad or drywell
8. Load pack onto transporter
9. Move transporter (with pack on it) to R&H building
10. Prepare pack for unloading
11. Pack dependent outlet per unloading operations
12. Prepare pack for temporary storage
13. Move pack to temporary storage
14. Place pack in temporary storage
15. Move transporter back to R&H building

Pack Construction or Reactivation

16. Manufacture pack
17. Reactivate decommissioned pack if applicable

TABLE 4.4. Conversion Operations

1. Disassemble fuel assemblies
2. Consolidate fuel rods
3. Load received waste into canisters
4. Load nonfuel bearing components into drums (and then load drums into "cages")
5. Overpack canisters
6. Seal and weld canisters

RECANISTERING (contd)	canisters must be part of the list of identifiers for canisters). The number of canisters being converted that is required to generate one new canister is entered under the heading "C1-C2." The times associated with the operations are then listed under the remaining headings. Currently no more than 20 possible conversions can be specified.
AVAILABILITY	This section contains the estimated fractions of time that each of the processing stations will be available to actually process waste. This is intended to take into account lost production time due to maintenance, equipment changeover, decontamination, and lack of worker productivity. The file headings are clarified below:

Gate Line - Gate House Line
 Wash Down - Washdown Line
 Cran - Unloading Crane
 Rec Area - Receiving Area
 In Port - Inlet Port (part of Hot Cell)
 Skel Rem - Fuel Disassembly Station (part of Hot Cell)
 Re-Pack - Consolidation Station (part of Hot Cell)
 Over Pack - Overpacking Station (part of Hot Cell)
 Door - Shielded Door (part of Hot Cell)
 De-Con - Decontamination Station (part of Hot Cell)
 Out Port - Outlet Port (part of Hot Cell)
 Ship Port - Shipping Port (part of Hot Cell)

STATIONS This section characterizes the hot cell design in that it gives the number of each type of processing station that a hot cell contains (it is assumed that all the hot cells at the facility are identical). Different designs can be tested by altering these values. The headings have the same meanings as the headings for AVAILABILITY.

MINIMUM LOGICAL UNITS This section gives the minimum number of waste processing logical units that must be built at the facility. The headings are the same as the headings for AVAILABILITY except that "cell in," "cell out," and "cell" refer to the number of hot cells dedicated to waste being received, the number dedicated to waste being shipped, and the total number, respectively. This may prove useful in a situation in which the receipts dictate that three hot cells be built, but in which no shipments are being made. The designer may still want a hot cell at the facility to use to ship waste if necessary, so by specifying a minimum number of one "hot cell out," the program will build four hot cells at the facility instead of the three necessary for receiving the waste.

The headings "base year" and "MSHIP" also appear under MINIMUM LOGICAL UNITS. The "base year" is taken to be Year 1 at the facility (e.g., if the base year is 1990, Year 9 will be 1998). MSHIP is a flag used to indicate whether the waste that is shipped from the facility leaves the hot cells from the same ports through which it entered (the Inlet ports), or whether a separate "shipping port" is used. The options are:

MSHIP = 0, waste is shipped for the same port(s) through which it entered.

MSHIP = 1, waste is shipped from a separate shipping port.

CONFDATA This section identifies all the repackaging combinations associated with each of the possible final destinations of the waste. The repackaging combinations listed under CONFDATA pertain to repackaging of waste that is "on its way into" the facility. In other words, it refers to repackaging that is done before the waste is placed into the storage yard, as opposed to repackaging done after the waste is retrieved from storage.

The CONFDATA section is broken into subsections that describe the repackaging scheme for each of the possible waste destinations. The data associated with each destination appear under the heading "ConsolX," where X is the number associated with the destination. Up to five destinations can be specified. Identifiers for the canisters being converted and the canisters being generated appear under the subheadings "old" and "new," respectively. The fraction of "old" canisters being converted to "new" canisters is given under the subheading "Frac." If the user specifies a fraction less than 1.0, at least one other conversion should involve the "old" canister from that conversion that has a fraction of less than 1.0 (i.e., the sum of all the waste being converted should add up to the total amount of waste).

CONFODATA This section is analogous to the CONFDATA section except that it pertains to repackaging combinations for waste that is "on its way out" of the facility. The subheadings under CONFODATA are the same as they are for CONFDATA except that "CosolX" is used in place of "ConsolX." It should be noted that the X's appearing under CONFODATA must correspond exactly with the X's appearing under CONFDATA. In other words, if "Consol2" refers to a basalt repository destination, then "Cosol2" should also refer to a basalt repository destination.

PACKDATA

This section contains performance information related to the storage area of the MRS facility. The section is divided into subsections that contain information for each of the possible storage concepts (concrete casks and drywells are currently the two concepts for which information is entered into the file). The data associated with each storage concept currently appear under the headings "PackX," where X = 1 for concrete casks and X = 2 for drywells.

The information given under each of the "PackX" headings is as follows:

- Can, Pack,
and Cppk - Identifiers for all the possible canister types to be stored and the corresponding pack types that they are to be stored in appear under the Can and Pack subheadings. The number of canisters that can be stored in a pack appears under the Cppk subheading.
- MOREDATA - An identifier used to identify specifics of the above designated "PackX" heading.
- MSTOR - A flag indicating the storage concept chosen by the user. MSTOR should be 0 when the concrete cask concept is chosen and 1 when any other storage concept is chosen.
- MCASKT - A flag used to indicate whether the storage area transporters used for packs are of the same type as the ones used for transportable casks. The options are:

MCASKT = 0, same type of transporter is used for both.
MCASKT = 1, different transporters are required.
- MCASKC - A flag used to indicate whether the storage area cranes used to unload packs from transporters are of the same type as the ones used for transportable casks. The options are:

MCASKC = 0, same type of storage crane is used for both.
MCASKC = 1, different storage cranes are required.
- AVAILABILITY - The fraction of time that a storage area logical unit is actually available to perform operations.

A clarification of the subheadings is given below:

Pack Tran - Pack Transporter
Cask Tran - Cask Transporter
Pack Cran - Pack Storage Area Crane
Cask Cran - Cask Storage Area Crane
Pack Manuf - Pack Manufacturing Facility
Pad Manuf - Pad Manufacturing Labor
Cask Pad Manuf - Cask Pad Manufacturing Labor

- MINIMUM STATIONS - The minimum number of storage area logical units that are to be built (or are to be present) at the MRS facility. The subheadings have the same meanings as above except that "Pack Manuf" refers to the minimum number of packs that the pack manufacturing facility is to be designed to produce.

4.3 WASTE PROCESSING FACILITY FILE

The waste processing facility file contains all the cost information and the labor and material requirements associated with the waste processing facilities at the MRS facility.

The mechanics of the waste processing facility file are very similar to those of the facility performance file (the inputs to the program are read from formatted fields, and headings and identifiers for the inputs appear in fields that are not read in by the program). The second paragraph of Section 4.2 contains a discussion of mechanics.

An example of a waste processing facility file is given in Table A.3. The following discussion is devoted to clarifying what each value appearing in the file represents. To do this effectively, the file is split into sections, with the beginning of each section identified by a one word line. The one word lines and the descriptions of the sections they precede are as follows.

<u>One Word Line</u>	<u>Description</u>
LABOR	This section identifies the types of workers at the MRS facility, their annual labor rates, and their fractional increase in pay for working overtime. A list of identifiers for all the different labor types at the facility should be under the heading "type." The cost per year and an overtime factor appear under the headings "\$/yr" and "Ovtfac", respectively. These are associated with each of the labor types identified under the "type" heading. The identifiers for the labor types can be any alphanumeric string up to eight characters in length.
MATERIALS	This section identifies the types of materials at the MRS facility, their units, and their unit costs. A list of identifiers for all the different material types should be under the heading "type," and the units and unit costs should appear under the headings "units" and "\$/unit," respectively. The identifiers for the material types can be any alphanumeric string up to eight characters in length.
MORE	<p>This section contains the cost factors for the MRS facility, the capital costs for each of the waste processing logical units, the lengths of the construction and decommissioning periods, and the minimum number of shift stations to be operated for each of the waste processing stations. A clarification of the headings which are not self-explanatory is given below:</p> <p>Ind Cost1 - Indirect capital cost factor for years of initial construction.</p> <p>Ind Cost2 - Indirect capital cost factor for all years of facility operation.</p> <p>Contingency - Contingency factor for capital costs.</p> <p>Own Cost1 - Owner's capital cost factor for years of initial construction.</p> <p>Own Cost2 - Owner's capital cost factor for all years of facility operation.</p> <p>Cnsumables - Consumables cost factor.</p> <p>G&A Factor - General and administrative cost factor.</p> <p>MS&CL Cost - Maintenance, supplies, and contract labor.</p> <p>Eqpmt Cost1 - Equipment cost factor during years in which waste is arriving at the facility.</p> <p>Eqpmt Cost2 - Equipment cost factor during years in which no waste is arriving at the facility.</p>

Note: To see how the above factors are used, refer to Section 3.20.

Number of Construction Years - This file allows for a maximum of 10 years for the construction/decommissioning phase. Changes to this factor require changes being made in the subheading "Schedule" in this file.

Gate House Cost - The direct construction cost of a gate house that contains two lines for processing casks.

Washdown Area Cost - The direct construction cost of a washdown area that contains two lines for processing casks.

Overhead Crane Cost - The capital and construction cost of an overhead crane located in the receiving area.

Receiving Area Cost - The direct construction cost of the receiving area.

Hot Cell Cost - The direct construction cost of the following areas: the cask process area, the cask unloading cell, fuel-processing cells Numbers 1-3, the general fuel processing cell, and the storage cask loading cell.

Other Facilities that Scale with Receipt Rate - The direct construction cost of all the facilities that scale with spent fuel receipt rate in metric tons.

Other Facilities that Don't Scale (i.e., Fixed) - The direct construction cost of all the facilities that do not scale.

No. of Decm Yrs - The number of years that it takes to decommission the MRS facility.

Yrs Before Ops End - The number of years before the end of operations (including the last year of operations) to begin decommissioning the MRS facility.

Hot Decom Factor - Factor to multiply the capital cost of radioactive facilities by to get the decommissioning cost of the radioactive facilities. (Currently only the hot cells are considered "radioactive" facilities.)

Cold Decom Factor - Factor to multiply the capital cost of nonradioactive facilities by to get the decommissioning cost of the nonradioactive facilities.

Under "Minimum Shift Station Requirement", the subheadings are:

Gate House - Gate house lines.

Wash Down - Washdown lines.

Crane - Unloading cranes.

Recv Area - Receiving areas.

Iport In - Inlet ports for hot cells dedicated to processing waste that is arriving at the facility.

Iport Out - Inlet ports (or shipping ports) for hot cells dedicated to processing waste that is leaving the facility.

Skel R In - Fuel disassembly stations in hot cells dedicated to processing waste that is arriving at the facility.

Skel R Out - Fuel disassembly stations in hot cells dedicated to processing waste that is leaving the facility.

Consol In - Consolidation stations in hot cells dedicated to processing waste that is arriving at the facility.

Consol Out - Consolidation stations in hot cells dedicated to processing waste that is leaving the facility.

- Ovpak In - Overpacking stations in hot cells dedicated to processing waste that is arriving at the facility.
- Ovpak Out - Overpacking stations in hot cells dedicated to processing waste that is leaving the facility.
- Decon In - Decontamination stations in hot cells dedicated to processing waste that is arriving at the facility.
- Decon Out - Decontamination stations in hot cells dedicated to processing waste that is leaving the facility.
- Door In - Shielded doors at inlet ports of hot cells dedicated to processing waste that is arriving at the facility.
- Door Out - Shielded doors at inlet ports of hot cells dedicated to processing waste that is leaving the facility.
- Oport In - Outlet ports for hot cells dedicated to processing waste that is arriving at the facility.
- Oport Out - Outlet ports for hot cells dedicated to processing waste that is leaving the facility.

The final heading under MORE is:

Number of Years to Look Ahead for Labor Requirements - The number of years that the program looks ahead when doing calculations to adjust labor requirements. This is the N referred to in Figure 3.3.

SCHEDULE This section contains the construction schedules for all the waste processing logical units, as well as the decommissioning schedule for the MRS facility. The schedules essentially tell the program how to distribute the capital/decommissioning costs of the logical units over the construction/decommissioning period(s). The sum of the schedule factors over all the years of the construction/decommissioning period should be 1.0. The file allows a maximum construction/decommissioning period of 10 years, but if the period is shorter, the extra years should be specified as having schedule factors of 0.0.

The schedule factors appear under the "yearX" headings, where X specifies the year of the construction/decommissioning period (from 1 to 10). Identifiers for the facilities that the schedules refer to appear to the left of the schedules. The schedules are construction schedules except the one identified as "Decommission Sched." A clarification of the identifiers that are not self-explanatory follows:

LG10 Schedule - The construction schedule associated with facilities that scale with spent fuel receipt rate.

LG12 Schedule - The construction schedule associated with facilities that do not scale.

GATEHOUSE thru OUTPORT These sections contain the labor requirements associated with the waste processing stations. Identifiers for the labor types that work at a given station appear under the heading "Labor Type" for that station. The number of laborers of each labor type appear under the heading "Number of Laborers." The labor types that are identified at a given station must appear in the list of labor types provided in the LABOR section. It is acceptable to specify that no labor types are associated with a given station (this may be desirable when very little operating data are available for the facility). The one word lines identifying the processing stations are self-explanatory (and are consistent with the previous abbreviations for the processing stations).

LUGHOUSE thru LUHOTCELL These sections contain the labor requirements associated with waste processing logical units. Identifiers for the labor types that work at a given logical unit appear under the heading "Labor Type" for that logical unit. The number of laborers of each labor type can be specified as different for each additional logical unit that is in service at the facility. The number of laborers associated with the first logical unit in service appears under the heading "Number of Laborers 1," the number associated with the

second logical unit appears under "Number of Laborers 2," etc. Using this approach, operational economies of scale at the MRS facility can be modeled.

It is acceptable to specify that no labor types are associated with a given logical unit. The one word lines identifying the logical units are self-explanatory.

DEPEND This section contains the labor requirements for labor that is dependent on other labor. (Labor that is dependent on other labor is hereafter referred to as Type A labor and labor that dependent labor is dependent on is referred to as Type B labor.) Identifiers for Type A labor appear under the heading "Labor Type," and identifiers for Type B labor appear under the heading "Type Dependent On." If no labor type is specified for Type B labor, the program will automatically assume that Type A labor is dependent on the total number of laborers of all labor types at the facility. The relationship that defines the dependency of Type A labor on Type B labor must be specified as a step function, with a maximum of five steps. The number of steps is entered under the heading "# of Cutoffs" (this must be from 1 to 5). The cutoffs, or points at which the steps occur, are specified under the headings "Cutoff #X," where X ranges from 1 to 5. The number of Type A laborers that are needed at the facility for a given number of Type B laborers is entered under the heading "#Workers #X," where X corresponds to the cutoff number associated with the appropriate "step" of the user-defined step function. An example illustrates this best:

If two secretaries are required when there are 0 to 5 supervisors at the facility, 5 secretaries are required when there are 6 to 10 supervisors at the facility, and 8 secretaries are required when there are more than 10 supervisors at the facility, the values entered under the headings would be:

Labor Type	- SECRETARY
Type Dependent On	- SUPERVISOR
# of Cutoffs	- 3
Cutoff #1	- 5
Cutoff #2	- 10
Cutoff #3	- 1000
#Workers #1	- 2
#Workers #2	- 5
#Workers #3	- 8

Note that Cutoff #3 is intentionally set so high that it is never exceeded.

FIXED This section contains the labor requirements for the facility regardless of the amount of waste being processed or the number of other laborers. Identifiers for the labor types appear under the heading "Labor Type," and the number of laborers of each type appear under the heading "Number of Laborers."

CASKMATL This section contains the material requirements associated with each of the cask operations as a function of the cask type that is operated on. The identifiers for the different cask types that appear in the facility performance file (under CASK) must be entered as headings in this section. The identifiers do not have to be entered in the order in which they appear in the facility performance file, but they should all be there. Identifiers for the cask operations and the material types expended in each of the operations appear under the heading "Time Element/Material Type." This is illustrated by the following.

If water is expended in Operation 2 and gas and electricity are expended in Operation 5, then the column with heading "Time Element/Material Type" will look like this:

TIME ELEMENT/ MATL TYPE
ELEMENT 2
WATER
ELEMENT 5
GAS
ELECTRIC

The numbers 2 and 5 refer to Operations 2 and 5, which are listed in Table 4.1. Note that it is not necessary to specify a material type with each operation. Note also that each material identifier must also appear in the list of identifiers in the MATERIALS section.

The number of material units expended during each operation for each of the cask types operated on is entered under the appropriate cask heading.

- CANMATL This section is essentially the same as the CASKMATL section, except that the headings and operations refer to canisters rather than casks. The numbers associated with the canister operations are the same as those listed in Table 4.2.
- CONVMATL This section is essentially the same as the CASKMATL section, except that the headings and operations refer to conversions rather than casks. The conversion headings in this section consist of two canister identifiers. The first refers to the canister that is being converted, and the second refers to the canister that is being generated. These headings must appear one on top of the other in the file. The numbers associated with the conversion operations are the same as those listed in Table 4.4.
- LUGHMATL These sections contain the material requirements associated with the logical units.
thru The reader is referred to the discussion of the LUGHOUSE thru LUHOTCELL sections, which
LUHCMATL addresses labor requirements associated with the logical units. If the reader substitutes "material requirements" for "labor requirements" and "material units" for "number of laborers," the discussion of the LUGHOUSE thru LUHOTCELL sections applies here. The one word lines identifying the sections are clarified on the line directly below the line on which they appear.
- DEPMATL This section contains the material requirements that are dependent on the number of laborers of a given labor type. The reader is referred to the DEPEND section, which addresses labor requirements dependent on other labor types. The DEPMATL section is the same as the DEPEND section, except that it addresses material requirements.
- FIXMATL This section contains the material requirements at the MRS facility that are independent of the amount of waste processed and the number of logical units in service. The discussion of the FIXED section applies equally well here, except that material requirements are addressed instead of labor requirements.

4.4 WASTE STORAGE FACILITY FILE

The waste storage facility file contains all the cost information and labor and material requirements associated with the waste storage facilities for one storage concept (a different file is needed for each storage concept).

The mechanics of the waste storage facility file are essentially the same as those for the facility performance and waste processing files (the inputs to the program are read from formatted fields, and headings and identifiers for the inputs appear in fields that are not read in by the program). The reader is referred to the second paragraph of Section 4.2 for further discussion of mechanics.

An example of a waste storage facility file is given in Table A.4. The following discussion is devoted to clarifying what each of the values appearing in the file represent. To do this effectively, the file is split into sections, with the beginning of each section identified by a one word line. The one word lines and the descriptions of the sections they precede are provided below.

One Word Line	Description
PADS	<p>This section contains information that can be related to the different types of storage pads on which the packs are placed. Identifiers for the different types of storage pads appear under the heading "Pad Name." These can be any alphanumeric string of up to eight characters. Pad types for both concrete casks and drywells must not be listed simultaneously. Separate files are required for each cask. Entries associated with each pad identifier should be made under the following headings:</p> <p>Initial Mod Storage Areas - Refers to the number of modular storage areas containing a given storage pad type that are prepared during initial construction of the facility.</p> <p>Pads/Mod Area - Refers to the number of storage pads that the modular storage area is designed to hold.</p> <p>Pad Cost - Refers to the installed cost of a single storage pad.</p> <p>Mod Storage Area Cost - Refers to the capital cost of a modular storage area that contains a given storage pad type.</p> <p>Mod Areas/Big Area - Refers to the number of modular storage areas that a large storage area is designed to hold.</p> <p>Pad Manu Time - Refers to the time that it takes to manufacture a storage pad.</p> <p>Initial Pads - Refers to the number of storage pads that are built during initial facility construction.</p>
CASKPADS	<p>This section contains information that can be related to the different types of cask pads on which the transportable casks are placed. Identifiers for the different types of cask pads appear under the heading "Cask Pad Name." These identifiers can be any alphanumeric string of up to eight characters. Entries associated with each of the cask pad identifiers should be made under the following headings:</p> <p>Intl Mod Csk St Areas - Refers to the number of modular cask storage areas containing a given cask pad type that are to be prepared during initial facility construction.</p> <p>CPads/ModCArea - Refers to the number of cask pads that the modular cask storage area is designed to hold.</p> <p>CaskPad Cost - Refers to the installed cost of a single cask pad.</p> <p>Mod Cask Stor Area Cost - Refers to the capital cost of a modular cask storage area that contains a given cask pad type.</p> <p>Mod CAreas/Big CArea - Refers to the number of modular cask storage areas that a large cask storage area is designed to hold.</p> <p>CPad Manu Time - Refers to the time that it takes to manufacture a cask pad.</p> <p>Initial Cask Pads - Refers to the number of cask pads that are built during initial facility construction.</p>
PACKPAD	<p>This section contains information that tells the program which type of packs are to be placed onto which type of pads and how many of each pack type can be placed onto a given pad. Identifiers for each of the pack types appear under the heading "Pack Type." Identifiers for the storage pads associated with each of the packs appear under the heading "Pad Type." The number of packs that can be placed on a storage pad for a given pack/pad combination appears under the heading "Packs/Pad." It should be noted that several pack types may be specified as being stored on the same pad type.</p>
CSKCKPD	<p>This section is essentially the same as the PACKPAD section, except that it refers to transportable casks and cask pads instead of packs and storage pads.</p>

Note: Cask pads should not be confused with pads used to store concrete casks. Concrete casks are a type of pack and the pads that they are stored on are "storage pads." "Cask pads" are used to store transportable casks.

PACKINFO This section contains information relating to the packs and information relating to the construction and decommissioning schedules associated with the storage facilities. The identifiers for each pack type at the facility must be entered as headings in this section. The information that should appear under these headings is described briefly to the left of the point at which the information is entered. The following clarifications are provided for these descriptions:

- Initial Packs - The number of packs to manufacture during facility construction.
- Cost Per Pack - The unit capital cost per pack.
- Decom Cost/Pack - The unit decommissioning cost per pack.
- Max Avail Packs - The maximum number of empty packs to maintain and store for possible later use.
- Cost to Reinstate - The cost to reactivate a decommissioned pack so that it can be used to store waste.

The schedule information contained in the PACKINFO section includes:

- Pack Schedule - Schedule for the construction of the pack manufacturing facility.
- Pack Decom Sched - Schedule for the decommissioning of all packs that have not already been decommissioned when the last waste leaves the MRS facility.
- Storage Area Sched - Schedule for the construction of all the storage area logical units and all packs that are manufactured during the construction period.

The discussion of schedules given in Section 4.3 (pertaining to the SCHEDULES section of the waste processing facility file) applies here.

MORE This section contains miscellaneous information related to the storage facilities. A description of each heading appearing in the MORE section that is not self-explanatory is given here:

- Pack Cost Flag - A flag used to tell the program if the pack, storage pad, and cask pad costs are to be calculated by using unit costs or by summing the costs of all the labor and materials needed to build these items (in the latter case the labor and materials associated with building the packs, storage pads, and cask pads will have to be specified elsewhere in the file).

Pack Cost Flag = 0, use unit costs.

Pack Cost Flag = 1, sum all the labor and material costs.

- Pad Manu Flag - A flag used to tell the program if the labor crew that constructs the storage pads also constructs the cask pads.

Pad Manu Flag = 0, same crew.

Pad Manu Flag = 1, different crews.

- Pack Manufacturing Facility Cost - The cognizant engineer should be aware that the cost entered here pertains to a facility designed to produce the number of packs entered under the "Minimum Station-Pack Manuf" heading in the facility performance file.

- Initial Big Storage Areas/Initial Big Cask Storage Areas - The number of big/big cask storage areas that are built during the initial facility construction.

Big Stor Area Cost - Capital cost of one big storage area.

Big Cask Stor Area Cost - Capital cost of one big cask storage area.

Pack Trans Cost - Capital cost of one pack transporter.

Pack Trans Life - Pack transporter life in years.

Cask Trans Cost - Capital cost of one transportable cask transporter.

Cask Trans Life - Transportable cask transporter life in years.

Pack St Crane Cost - Capital cost of one pack storage crane.

Pack St Crane Life - Pack storage crane life in years.

Pack St Crane Cost - Capital cost of one transportable cask storage crane.

Cask St Crane Life - Transportable cask storage crane life in years.

The following subheadings are under the heading "Minimum Shift Station Requirements":

Pack Trans - Pack Transporters

Cask Trans - Transportable Cask Transporters

Pksto Crane - Pack Storage Crane

Casto Crane - Transportable Cask Storage Crane

Pack Manuf - Pack Manufacturing Facility

Pad Manuf - Pad Manufacturing Labor

Cpad Manuf - Cask Pad Manufacturing Labor

PKTRANS thru CKPMANU These sections contain the labor requirements associated with the storage area processing stations. These sections are analogous to the GATEHOUSE thru OUTPORT sections discussed in Section 4.3, which presents the mechanics of setting up the PKTRANS thru CKPMANU sections of this file. The one word lines in this section correspond to the processing stations listed above and appear in the same order.

LUPKTRANS thru LUBCKSTO These sections contain the labor requirements associated with the storage area logical units. They are analogous to the LUGHOUSE thru LUHOTCELL sections discussed in Section 4.3, which presents the mechanics of setting up the LUPKTRANS thru LUBCKSTO sections of this file. The one word lines used in this section are described below:

LUPKTRANS - Pack Transporter

LUBCKTRANS - Transportable Cask Transporter

LUPCRANE - Pack Storage Area Crane

LUBCKCRANE - Transportable Cask Storage Area Crane

LUPMANU - Pack Manufacturing Facility

LUBIGSTO - Large Storage Area

LUBCKSTO - Large Transportable Cask Storage Area

PACKMATL This section is the same as the CASKMATL section in the waste processing facility file, except that the headings and operations in PACKMATL refer to packs rather than casks (see Section 4.3). The numbers associated with the pack operations are the same as those listed in Table 4.3.

PADMATL This section is essentially the same as the CASKMATL section in the waste processing facility file, except that the headings in PADMATL refer to storage pads rather than casks. Also, only one operation (the manufacture of storage pads) is associated with storage pads, whereas 27 operations are associated with casks. Section 4.3 provides the mechanics of setting the PADMATL section of this file. Since only one operation is associated with storage pads, the number of the operation need not be specified in the file. All that should appear under the heading "Matl Type" is a list of identifiers for material types.

CKPDMATL This section is the same as the PADMATL section, except that it refers to cask pads rather than storage pads.

LUPTMATL These sections contain the material requirements associated with the storage area
thru logical units. They are analogous to the LUGHMATL thru LUHCMATL sections in the waste
LUCSMATL processing facility file (see Section 4.3). The one word lines identifying the
"LUPTMATL thru LUCSMATL" sections are clarified on the line directly below the line on
which they appear.

4.5 WASTE LOGISTICS FILE

The waste logistics file contains all the annual waste receipt and shipment data for the MRS facility. The file can either be generated by the user or by the WASTES program. An example of a file generated by the user is given in Table A.5, and an example of a file generated by the WASTES model is given in Table A.6.

4.5.1 User-Generated File

The first line in the user-generated file consists of headings for the columns of data. The second line consists of dashes and decimal points that serve to cue the user as to what the format of the input should be. The dashes indicate fields that are read in by the program, and the decimal points indicate where the decimal points are located in each of the real fields. The user fills in the remaining lines with annual receipt and shipment data tagged by year (the far left column). The user is free to specify years or any logistics information that is desired. The years should be sequential from top to bottom of the file. Years in which there are no waste receipts or shipments can be skipped.

The headings for the columns are described below.

<u>YEAR</u>	<u>Year</u>
MTUINx	where x = 1 to 3. Refers to the metric tons of spent fuel arriving at the MRS facility that will eventually be shipped to Destination X.
MTHRUx	where x = 1 to 3. Refers to the metric tons of spent fuel shipped to Destination X the same year that they arrive at the MRS facility.
MTOUTx	where x = 1 to 3. Refers to the metric tons of spent fuel shipped to Destination X from the MRS facility. MTHRUx must be less than or equal to the lesser of MTUINx and MTOUTx.
HLWx	where x = 1 to 3. Refers to the number of HLW canisters arriving at the MRS facility that will eventually be shipped to Destination X.
HTHx	where x = 1 to 3. Refers to the number of HLW canisters shipped to Destination X the same year that they arrived at the MRS facility.

<u>YEAR</u>	<u>Year</u>
HOUx	where x = 1 to 3. Refers to the number of HLW canisters shipped to Destination X from the MRS facility. HTHx must be less than or equal to the lesser of HLWx and HOUx.
TCSK	Refers to the number of transportable casks arriving at the MRS facility.
TCSKO	Refers to the number of transportable casks leaving the MRS facility.

4.5.2 File Generated by WASTES

The waste logistics file generated by the WASTES model contains the following headings (and corresponding information).

<u>YEAR</u>	<u>Year</u>
TRUKI	Refers to the number of truck casks arriving at the facility.
TRANI	Refers to the number of rail casks arriving at the facility.
PWRRx or BWRRx	Refers to the number of PWR or BWR assemblies arriving at the MRS facility that will eventually be shipped to Destination X.
PWRIx or BWRIx	Refers to the number of arriving PWR or BWR assemblies that will eventually be shipped to Destination X but that are placed into storage at the MRS facility and will remain there for at least 1 year.
PWRSx or BWRSx	Refers to the number of PWR or BWR assemblies that are shipped from the MRS facility to Destination X.

It should be noted that the program assumes that all shipments from the MRS facility are by rail.

4.6 PARAMETER STATEMENTS AND BLOCK DATA

In addition to all the input files, the user must be concerned with 1) a set of PARAMETER statements that are used to define the dimensions of the key arrays in the program and 2) information (primarily cask capacities) that appears in the block data segment of the program.

4.6.1 PARAMETER Statements

The PARAMETER statements appear in a PARAMETER block within the program. The key parameters that the user may wish to change are:

MAXOPT - Maximum number of different types of transportable cask pads.
Current value: 5

MAXPAD - Maximum number of different types of storage pads.
Current value: 5

MXFACID - Not in use.
Current value: 1

NWDT - Maximum number of different types of canisters.
Current value: 20

NPRM - Number of "primary" waste types (heat-generating waste types that arrive at the MRS facility).
Current value: 5 (PWR, BWR, PWRC, BWRC, HLW)^(a)

MAXPAK - Maximum number of different pack types.
Current value: 10

MAXCSK - Maximum number of different cask types.
Current value: 5

MC2C - Maximum number of different conversion types.
Current value: 20

MC2P - Maximum number of different canister/pack combinations for storage.
Current value: 20

NBRYR - Maximum number of years for facility life.
Current value: 100

NSTAT - Number of processing stations at the MRS facility.
Current value: 19

NTSTAT - Maximum number of different labor and different material types.
Current value: 20

NTYPE - Maximum number of labor or material types that can be associated with a processing station or logical unit.
Current value: 5

NFAC - Not in use.
Current value: 2

MCMTL - Number of cask operations at the MRS facility.
Current value: 27

MPMTL - Number of pack operations at the MRS facility.
Current value: 17

NCANTL - Number of canister operations at the MRS facility.
Current value: 7

NCONTL - Number of conversion operations at the MRS facility.
Current value: 6

MAXEXP - Maximum number of expansions that can take place at the MRS facility.
Current value: 3

MAXCUT - The maximum number of points at which dependent labor can make step-function increases.

NBLDGS - Number of hot cells.
Current value: 8

(a) C = consolidated.

NNOTHER - Maximum number of different types of nonfuel (nonheat generating) wastes arriving at the MRS facility.
Current value: 2

NOTHER - Actual number of different types of nonfuel wastes arriving at the facility. (This quantity is a variable set within the PARAMETER block, and not a parameter.)
Current value: 0

4.6.2 Block Data

The primary concerns of the user regarding the block data segment of the program are the values of the PCPCASK array. This array contains cask capacity information in terms of the number of each type of canister that can be contained in a cask. The data must be strung in such a way that the capacity of the first cask type is defined in terms of all the canister types before any data for the second cask are specified. Values must be specified not only for the cask and canister types identified in the facility performance file, but for the maximum number of types defined by parameters MAXCSK and NWDT (the PCPCSK array is dimensioned [NWDT, MAXCSK], and all locations, whether used or unused, must be accounted for).

5.0 SAMPLE PROBLEMS (VERSION 1)

Two sample problems were run to generate model output tables and to illustrate how the program is run. The costs in these problems came directly from the Ralph M. Parsons Company (1985a) 2A version of the cost estimate for the MRS facility. They represent the case for the primary storage concept (concrete cask) located at a warm-wet site. The two problems involved identical cases, but one was run using a waste logistics file generated by the user, and the other was run using a waste logistics file generated by the WASTES model. The first run used the data from the input files shown in Tables A.1 through A.5, and the second run used the data from the input files shown in Tables A.1 through A.4 and Table A.6.

The cases involve a MRS facility designed to start up in 1996 with a design rate of 1800 metric tons of spent-fuel receipts and 20 metric tons of high-level waste (HLW) receipts. It is capable of retrieval and shipment of 1800 MTU/yr or equivalent of the same spent fuel or waste. An expansion to a receipt rate of 3600 metric tons and a shipping rate of 3600 metric tons was specified for the year 2011. The storage concept at the facility was specified as concrete casks. One repository was specified as the destination for the waste. It is a salt repository that will open in 1996. The waste shipped to the repository was packaged at the MRS facility into appropriate disposal packages. The receipt rates at the MRS facility and at the repository (over all years of MRS operation) are shown in Table A.5.

An IBM-PC was used to execute the runs. The following procedure was followed:

1. Enter "MONITOR GOMONIT?.PCX" Either an N (for user-generated) or W (for WASTES-generated) is inserted at the "?" depending on how waste logistics are specified. The actual file to be used is called out in Step 2.f.
2. The program prompts the user to enter the names of the following files (in this order):

- a. Output File
 - b. Design Throughput Input File
 - c. Facility Performance Input File
 - d. Waste Processing Facility Input File
 - e. Waste Storage Facility Input File
 - f. The program then prompts the user, "Will you be using a file generated by WASTES? Enter 1 = Yes, 0 = No." The program then asks for the name of the Waste Logistics File in either case.
3. The program prompts the user to enter a title (80 characters or less) for the case. This title is shown on all the output tables.
 4. The program is then executed, leaving the output in the appropriate file.

The output tables generated by the two runs are shown in Tables B.1 and B.2. The differences between the two tables are essentially negligible. The small differences can be attributed mainly to slightly different pack requirements, which in turn can be attributed to the slightly different amounts of waste specified as arriving and leaving the facility. This difference arises because the user-specified receipts (in metric tons) and the WASTES-specified receipts (in assemblies) do not exactly correspond (there is a slight rounding difference).

It appears, then, that the logic for converting the waste receipt data from the two different (user-generated and WASTES-generated) waste logistics files into arrays manipulated by the program has been cross-verified. Of course, only a small fraction of all the possible options are demonstrated in these examples of the program.

It should be noted that the program inputs for these runs were considerably simpler than the program was capable of handling. One of the strengths of the MONITOR model is that it is capable of accepting inputs that vary widely in complexity. If little data are available on labor requirements, for instance, the inputs can be structured so that the labor requirements are essentially fixed or perhaps vary slightly with the number of hot cells in service. On the

other hand, labor requirements can also be made to vary with the number of processing shift stations required (if the data exist to support this), which would make them much more sensitive to processing throughput rates. With this kind of flexibility, MONITOR is ideally suited for supporting work in which the amount and complexity of the available data are continuously changing.

6.0 EXECUTION OF MONITOR FOR THE VERSION 2 DESIGN

MONITOR was originally developed using costs from the 2A version cost estimate for the MRS facility. Enough flexibility was built into the initial program to allow it to be run in a manner which simulates the integrated design with only minor changes being required. The changes are necessary because of the manner in which the 2B version cost estimate for the MRS facility, as developed by The Ralph M. Parsons Company of Delaware, was performed.

The Parsons estimate divides the integrated MRS facility conceptual design into seven areas. Area 1 contains the Receiving and Handling Building shielded process cells and overpack cells, their contained equipment, and utilities. Area 2 contains the Receiving and Handling Building canistered consolidated fuel vault storage area and its contained equipment and utilities. Area 3 contains the balance of the radioactive areas in the Receiving and Handling Building and its associated equipment and utilities. Area 4 contains the balance of the nonradioactive areas in the Receiving and Handling Building and its equipment and utilities. Area 5 contains all onsite improvements and support structures containing equipment and systems required for the Administration Building, Security Building, Main Gate/Badgehouse, Protected Area Gatehouse, Inspection Gatehouse, Storage Area Gate Station, Site Services Building, Warehouse, Vehicle Maintenance Building, Standby Generator Building, Sewage Treatment Facility, Water Treatment Facility, and Fire Station. Included in this are the improvements to land within the limited and protected areas, except to the areas designated for waste storage. Area 6 includes all onsite waste storage improvements. Included in this are all site improvements and fencing for 15,000-MTU storage of spent fuel, cask transportation and handling equipment, and storage installations for 5,000 MTU of spent fuel. Cost estimates are provided for both the concrete cask and field drywell storage concepts. Area 7 includes all offsite improvements required to interface the MRS Facility to existing infrastructures.

MONITOR was written to allow for different levels of detail--from very specific to very general. As a result of the way the Ralph M. Parsons Company cost estimate was written the very general level of details method is taken

advantage of. If detailed operating cost data by station becomes available it will be possible to run MONITOR as if it had not been modified. Areas 1 and 3 are the only two areas that throughput rate has any effect on. Areas 2 and 4-7 are independent of throughput rate.

The cost of Area 2 is added in the Facility Performance Input Data file and the Waste Processing Facility Input Data file. In the first of these two files the user specifies the number of Area 2 units to be costed. This is listed in the "Minimum Logical Units" heading under the subheading "Lag Stor." The cost per unit is defined in the latter of these two files. A schedule of what percentage of the cost of the unit(s) is to be costed in each year of construction is also found.

The costing of Areas 4, 5, and 7 are found in the Waste Processing Facility Input Data file. All three areas are grouped under a single heading entitled "Other Facilities That Don't Scale (i.e., fixed)." No other specifications are required. This is a direct addition to the construction cost.

The costing of Area 6 is found in the Waste Storage Facility Input Data file. The total cost is currently divided among three items: "Big Cask Stor Area Cost," "Pack Trans Cost" and "Pack St Crane Cost." The only additional specifications necessary are the initial quantity of each of the above listed items. The costs given are a unit cost and must be multiplied by a quantity to give the actual total cost.

Areas 1 and 3 make use of the same two previously mentioned files. The number of Area 1 and Area 3 units to be costed appear under the "Cell In" and "Cell Out" subheading in the "Minimum Logical Units" heading of the Facility Performance Input Data file. The unit cost and the costing schedule are listed in the Waste Processing Facility Input Data file.

Other options that exist in the input data files can be exercised when detailed costing data is made available. The options can be used or not on a case by case basis. At present, the costing is done on a general basis. Buildings are costed as entire units. The equipment contained within the buildings is not separated out. All of the more specific costing data does not need to become available simultaneously to take advantage of the detailed

options. For example, a crane can be costed separately from the building it is contained in. The cost of the crane would need to be added to the appropriate input data file and subtracted out of the cost for the overall building.

Attempts were made to keep MONITOR as close to its original form as possible. The only changes made in the source code were in the DBOUT, CAPCST and DSNRD files. A new listing of these three files is found in Appendix E. The changes in DBOUT and DSNRD have no effect on the numerical outcome of the program. They merely make changes to the titles of the output tables to more clearly reflect the general nature of the data for the Version 2 MONITOR model. The changes made in CAPCST are a result of the substitution of calculating input cells where gate lines had previously been costed, and put cells where washdown stations had previously been costed and lag storage where total hot cells had previously been costed. The additional gatehouse lines and washdown lines were originally costed at 30% and 45% of their respective building costs. Since this is not applicable to this MONITOR version, these factors have been replaced with 1.0. Input cells and output cells are costed as complete units. Each additional completed unit costs the same as the initial one. The change from the total hot cell cost to the lag storage cost required only a change in the title. They are costed in an identical manner with only a different base construction cost being required. In the event that data becomes available to fill the original entries, the program can be readily changed back.

7.0 SAMPLE PROBLEM (VERSION 2)

One sample problem was run to generate model output tables and to illustrate how the program is run. The input data files are shown in Appendix F and the output file is shown in Appendix G.

The hypothetical case involved an MRS facility designed to startup in 1996 with a design rate of 1,800 metric tons of spent fuel receipts and 20 metric tons of HLW receipts. It is capable of retrieval and shipment of 1,800 MTU/yr or equivalent of the same spent fuel or waste. An expansion to a receipt rate 3,600 metric tons and a shipping rate of 3,600 metric tons was specified for the year 2011. The storage concept at the facility was specified as concrete cask. One repository was specified as the destination for the waste. It is a salt repository, opening in 1996. The waste shipped to the repository was packaged at the MRS facility into appropriate disposal packages.

In this hypothetical case, costs for the base construction costs of the MRS facility came directly from the Ralph M. Parsons Company (1985b) 2B version cost estimate. It represents the case for the primary storage concept (concrete casks) located at the Clinch River site. As a result of the way MONITOR is capable of handling data, in order to get the same total construction cost as in the cost estimate, minor changes must be made to the total in MONITOR.

The Ralph M. Parsons Company came up with a total construction cost of only \$458,562,000 without contingencies. The MONITOR version came up with a total construction of \$458,848,200. The Parsons and MONITOR estimates both account for the cost of materials and labor during the actual construction period. The Parsons estimate also includes all costs associated with definitive engineering, design verification, A-E support during licensing, engineering support during construction, construction management and a contingency factor. The structure of MONITOR made it impossible or difficult to include these costs and come up with a cost estimate that was directly comparable to the Parsons estimate. These costs were therefore not taken into account in the MONITOR estimate. The MONITOR version includes in its construction cost estimate the cost of storage casks, storage pads, transportable cask pads and canister overpacks that occur during the construction period. The Parsons

Parsons estimate defines these as operating costs as opposed to construction costs and thus does not include the cost incurred for these items in its estimate. In the hypothetical case described above the two construction only costs can be made identical by subtracting the costs of the storage casks (\$12,600) and the storage pads (\$273,600) from the MONITOR construction cost estimate. These items are identified as separate costs in the MONITOR output tables. This hypothetical case can be found documented in the PNL project files.

REFERENCES

Clark, L. L., M. E. Schutz, and A. T. Luksic. 1985. RECON: A Computer Program for Analyzing Repository Economics--Documentation and Users Manual. PNL-4465 Rev. 1, Pacific Northwest Laboratory, Richland, Washington.

Ralph M. Parsons. 1985a. Integral Monitored Retrievable Storage (MRS) Facility. Conceptual Design Report. MRS-07, Ralph M. Parsons Company, Pasadena, California.

Ralph M. Parsons. 1985b. Integral Monitored Retrievable Storage (MRS) Facility. Conceptual Design Report. MRS-11, Ralph M. Parsons Company, Pasadena, California.

Shay, M. R. and M. E. Buxbaum. 1986. WASTES II: Waste System Transportation and Economic Simulation--Version II, User's Guide. PNL-5714, Pacific Northwest Laboratory, Richland, Washington.

DISTRIBUTION

No. of
Copies

OFFSITE

2 J. H. Carlson
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

C. W. Conner
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

K. A. Klein
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

P. J. Gross
Oak Ridge Operations Office
U.S. Department of Energy
Oak Ridge, TN 37830

L. Marks
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

M. L. Payton
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

E. L. Wilmot
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Cindy Boggs-Mayes
Chicago Operations Office
U.S. Department of Energy
Chicago, Illinois

No. of
Copies

M. A. Heiskell
Oak Ridge Operations Office
U.S. Department of Energy
Oak Ridge, TN 37830

L. Shappert
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

J. W. Cashwell
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

S. Gupta
Battelle-Columbus Laboratories
OSTP Department
505 King Ave.
Columbus, OH 43201

R. Peterson
Battelle-Columbus Laboratories
OSTP Department
505 King Avenue
Columbus, OH 43201

5 DOE Technical Information
Center

ONSITE

4 DOE Richland Operations Office

J. P. Collins
R. B. Goranson
R. D. Izatt
O. C. Langstaff

No. of
Copies

No. of
Copies

53 Pacific Northwest Laboratory

A. J. Boegel
J. L. Braitman
A. D. Chockie
L. L. Clark
C. A. Counts
P. M. Daling
R. L. Engel
J. F. Fletcher
R. M. Gale
R. E. Heineman
G. M. Holter
C. M. Imhoff
J. M. Latkovich
P. N. McDuffie

J. L. McElroy
R. W. McKee
G. W. McNair
D. F. Newman
D. R. Payson
P. W. Reimus (10)
M. E. Schutz
N. L. Sevigny (10)
M. R. Shay
R. I. Smith
M. B. Triplett
R. C. Walling
M. K. White
T. W. Wood
Publishing Coordination MH (2)
Technical Information (5)