SYSTEMS ANALYSIS OF ON-FARM IRRIGATION SYSTEMS

Research Technical Completion Report

Submitted to
New Zealand National Research Advisory Council

by

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and
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Resources Research Institute
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ACKNOWLEDGEMENTS

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ABSTRACT

An irrigation systems analysis procedure has been developed for the purpose of critically evaluating on-farm irrigation system plans and water management practices under New Zealand conditions. The procedure incorporates agronomic information along with irrigation system operating characteristics and costs. Management practices and water supply inputs are also considered. The entire procedure is a computerized model written in FORTRAN 77.

The entire procedure consists of (1) a preliminary analysis, (2) details of system component costs and operations and (3) a simulation of system operation. In the preliminary analysis, the statistical variation of peak irrigation water requirements is computed. This information is used to estimate system capacity along with irrigated area and/or cropping pattern while considering the level of risk involved. The system component information includes details of crop rotation, plant-soil-water relationships and irrigation priorities. Operating characteristics and costs including two separate loan terms are computed for all irrigation system components. Simulation of system operation determines how an irrigation system functions over a period of time in supplying irrigation water requirements and the costs involved.

Results produced by the procedure are designed to show the adequacy of irrigation for each crop in the rotation, irrigation system performance and the causes of any inadequacies in irrigation, and system cost. The results provide ample information for evaluating trade-offs between system cost and performance and for comparing alternative system plans.

The entire procedure is designed for use as a planning tool by predicting system operation based upon historic data. It is not intended for use as a management aid for the real time operation of a system.

CHAPTER 1
INTRODUCTION

1.1 Background

The production from much agricultural land in New Zealand is limited because of inadequate rainfall. Rickard and Fitzgerald (1970) have shown that there are on the average 42 days of drought occurring annually at Winchmore, and that there is a good correlation between days of drought and pasture production. Irrigation has been used in many parts of New Zealand to both overcome the effects of drought and to create opportunities for more diversified agriculture and intensive land use (Lobb, 1978). Such development is important to a country whose economy depends on agricultural exports.

New Zealand is a land with abundant water resources even in most of the drier areas of the country. Historically there has been enough water for all users. However, water resources are finite, and they must be used effectively to adequately provide for various competing uses. Huber (1973) has said that enough water exists for the development of more irrigated land on the Canterbury Plains by conjunctively using surface and groundwater resources. He also states that there is a need of a systems analysis approach to the problem of providing adequate water for intensive irrigated agriculture on the Plains.

Smart (1977) has developed a systems approach to compare water supply with demand for a portion of the Canterbury Plains to determine the potential of irrigation in the area by direct diversion of stream-flow. Simulation-based systems analysis has also been used to incorporate engineering, hydrologic, agronomic and engineering features

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in the design of water harvesting schemes in New Zealand (Heiler, 1981a and Heiler, 1981b). The availability of water for irrigation from surface and subsurface sources in different areas such as the Lower Rakaia has also been investigated (Mandel, 1974 and Maidment et al 1980). Busch et al (1975, 1978, 1978b) and Yoo et al (1982) have developed methods for obtaining least cost irrigation system plans while conjunctively considering water distribution and on-farm water application systems on a project wide basis.

On-farm irrigation systems design and analysis has also received much attention especially in the design aspects of individual system components. The design of border systems has been aided by complex mathematical models (Fangmeier and Strelkoff, 1979) and unique field investigation procedures to determine soil water intake and water advance functions (Taylor, 1980). Harrington (1977) has developed a procedure for estimating the earthwork required in a borderdyke system. The sizing and design of sprinkler system components has been studied quite thoroughly and is summarized quite well by Addink et al (1980). Keller and Watters (1980) have developed a method for minimizing the total cost of sprinkler systems by considering operating and capital costs. The effects of on-farm irrigation water management have been estimated and measured (Ritchie, 1976 and Jensen, 1978). Trickle irrigation design is presented by Jobling (1974) and Keller and Karmeli (1975).

The systems analysis approach has also been used at the on-farm level. Frengley (1979) has used mixed integer-linear programming to determine the maximum benefit resulting from various amounts of water applied to a "representative farm" on the Lower Rakaia Scheme. His was

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a determistic model used to consider both irrigation systems, crop water requirements and the estimated production. Lord (1979, 1981) has conducted an analysis comparing the operations and costs of using groundwater to supply a sprinkler system vs. a border strip system with temporary storage. The results obtained from such studies amplify the need for a systems approach in the planning and designing of on-farm irrigation systems. There is a definite need to integrate the design procedures for the various aspects to provide the best system design or a specific situation.

In the planning and design of effective on-farm irrigation systems it may be necessary to consider many alternative components that may be used to convey and apply water in a given situation. A systems analysis type of approach can be used to consider the myriad of physical, institutional and management factors that affect the design and operation of an irrigation system. Such an approach can provide the means of rapidly evaluating the effects of changing conditions and combining individual components so that the "best" system can be selected for a given set of conditions.

As each farm unit is unique in a physical sense as well as in its management, there is a need of matching the proper irrigation system and associated water management practices to the individual situation of a particular farm unit. To accomplish this goal, alternative irrigation systems must be critically evaluated to determine their operational characteristics as to how effectively they can be used to apply the proper amounts of water at the proper times in a given set of circumstances. In addition it is also necessary to consider both the capital and operating costs of a system. A suitable analysis procedure

should incorporate all pertinent inputs and produce output describing how well a given system functions along with associated costs.

1.2 Objectives

The overall objective of the work reported is to develop a procedure for critically evaluating on-farm irrigation system plans and water management practices for New Zealand conditions.

Specific objectives are:

1. To develop a means of determining the operating characteristics, pumping energy requirements and costs of alternative system components. The systems considered are surface, sprinkler and trickle systems, along with necessary on-farm water reticulation, operating under specific conditions as influenced by various factors including soil type, slope, water delivery, crop, climatic conditions and irrigation practices.

2. To develop a method for obtaining a detailed analysis of irrigation system operational characteristics and costs for a farm unit as influenced by physical, management and institutional constraints such as cultural practices and the availability and cost of water, energy and labour.

An analysis technique for irrigation systems would provide an extremely useful function in New Zealand. The country is relatively isolated from other irrigated areas of the world and has unique physical conditions and farming practices. Much of the farming is pastoral with the land in permanent pasture, and most of the soils in the drier parts of the South Island are quite shallow and stony. These factors are coupled with adequate irrigation water supplies in most areas. The

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development of border strip irrigation has provided an effective means of irrigating large areas of pasture and some crop land, and the practice is carried out with a minimum labour requirement (Taylor, et al, 1982).

Sprinkler and trickle irrigation has also been used effectively in New Zealand, and now supply water to a larger area than that supplied by surface systems. Converse to most parts of the world, sprinkler irrigation generally has a higher labour requirement than automated border systems. Also, a majority of the equipment or raw materials for manufacture are imported into the country at a cost that is greater than in countries where the equipment or materials originate.

Precipitation patterns in New Zealand impose unique conditions up-on irrigation system design and management. Long term precipitation data show most areas to receive moderate rainfall. However, the variation in precipitation varies considerably from year to year with some years requiring minimal supplemental irrigation, while at other times an irrigation system would have to supply nearly all crop water requirements. A farmer growing a high value horticultural crop would desire a system that would assure crop water-use demands be met in the most extreme conditions. However, for a pastoral situation a more desirable system design would be to irrigate a larger area with the water available and accept the risk of less than maximum production in an extreme dry condition.

The existence of unique climatic conditions, types of systems used and cost of importing system components makes it necessary to analyse irrigation systems and their operation under New Zealand conditions. System plans developed and successfully used in other parts of the

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world may not necessarily be the best for the unique conditions present. The planning of irrigation systems should be carried out to determine how well the system will function under local conditions.

CHAPTER 2

SYSTEMS ANALYSIS PROCEDURES

2.1 Irrigation System Planning

The effectiveness of an irrigation system to increase farm produc-
tion and income is influenced by many factors. These factors include
system design and configuration, crops irrigated, water availability
and cost, and system management in conjunction with other resources
such as labour and capital. A system must be designed to meet speci-
fied levels of crop water requirements, and these requirements are crop
dependent both in total requirement and in the level of risk involved
if the requirement is not met. The cost and availability of various
resources including water, energy, labour and capital affect system
design and performance. A well planned and designed system is one that
functions well with the resources available to produce beneficial re-
sults.

To ensure that irrigation systems function as they should requires
careful planning. The planning phase usually occurs before the final
design and is important in that the relative merits of alternative
plans and designs can be considered, compared and evaluated. Introduc-
ing an effective planning phase in the design process allows for the
critical evaluation of system design and operation, and systems analy-
sis procedures can be used effectively for this purpose.

2.2 Analysis Procedures

A systems analysis of on-farm irrigation systems should incorpor-
ate as many influencing factors as possible. As indicated by the dia-
gram in Figure 2-1, the major factors considered are those describing

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SYSTEMS ANALYSIS for ON-FARM IRRIGATION SYSTEMS

MAJOR FACTORS CONSIDERED

FARM
  Paddock layout
  Soils
  --Water-holding capacity
  --Intake rate
  --Slope
  Crops
  --Rotation
  --Water use

SYSTEMS ANALYSIS using
COMPUTER SIMULATION to
incorporate many factors

  Evaluate
  --System plans
  --System operation
  --Management

WATER SUPPLY
  How much & when
  Cost (scheme, pumping)

IRRIGATION SYSTEMS
  Operating characteristics
  --Efficiency
  --Capacity
  Labour requirements
  Cost

RESULTS obtained allow
a detailed analysis of

SYSTEM PERFORMANCE
and
SYSTEM COST

Figure 2-1 Major factors considered in

irrigation systems analysis

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the farm and water supply in addition to the irrigation system. The analysis procedures must incorporate the physical aspects of irrigation systems in conjunction with costs, various management aspects and institutional factors such as water rights.

To provide an accurate analysis, variations in the different inputs must be considered. Irrigation water requirements can vary quite markedly within an irrigation season and from season to season especially in an area where supplemental rainfall can be substantial. Other variations to be considered are the time value of money in the form of interest rates and rate of return, and the rate of inflation that can be expected to influence operation and maintenance costs.

The main purpose of the systems analysis is to incorporate site-specific input data, to perform necessary computations and to produce meaningful and understandable results. Results providing adequate information describing necessary details of system performance and cost can be used by farmers and/or advisers in determining what system would be best for a given situation. Systems analysis procedures can also be used by planners to determine the effects of the availability of resources such as water and energy as well as variations in costs, interest rates and inflation factors.

2.3 Farm Irrigation Systems Analysis (FISA)

Procedures for irrigation systems analysis are used to provide a thorough analysis of the cost and operation of on-farm irrigation systems for planning purposes. These procedures consist of digital computer routines designed to model on-farm irrigation systems incorporating the necessary ingredients to produce meaningful and accurate

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results. The routines are designed to provide meaningful information at each step of the analysis process to allow for intermediate analysis. Use of several seperate routines also provides more control and flexibility in the entire process.

The basic functions and interrelationships of the five separate computer routines are shown in Figure 2-2. The WATERUSE routine is used to first obtain the statistical variation of peak irrigation water requirements. Crop rotation, plant-soil-water relationships and irrigation priorities are input via the CROPADDOCK routine. The SUPPLY and SYSTEMS routines are then used to input and summarize the numerous data for the costs and operating characteristics of components in the water supply and irrigation application systems. All necessary information is combined in the SIMULATION routine which simulates how an irrigation system functions over a period of time to determine how well the system can supply irrigation water requirements and to compute the associated costs. The entire process is referred to as FISA (Farm Irrigation Systems Analysis).

2.3.1 Preliminary Analysis

The WATERUSE routine is a preliminary routine in the systems analysis process. Basic crop rotation and soils data are combined with historic evapotranspiration and rainfall data. From this information, daily net irrigation requirements are estimated for the crop rotation specified over the period of historical data. The irrigation requirements exceeded a given percent of time are then computed for different cumulative periods.

The results obtained allow net irrigation water requirements to be viewed in relation to the percent of time that they are equalled or

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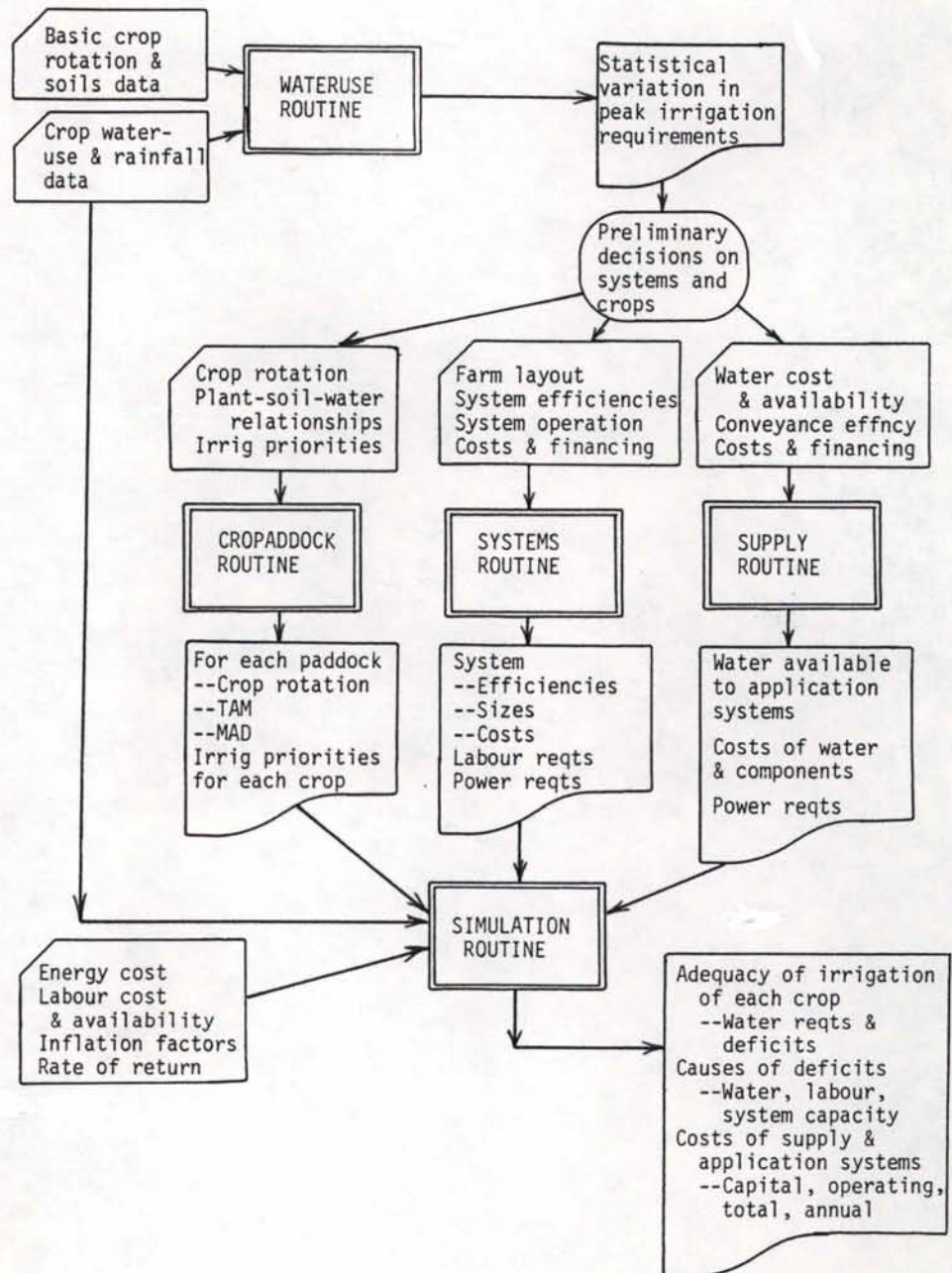
Figure 2-2 Computer routines of farm irrigation

systems analysis procedure (FISA)

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exceeded. Thus, preliminary decisions on system capacity can be made in light of the risk involved when system capacity is exceeded.

2.3.2 Irrigation System Components

Information on various irrigation system components is entered into the systems analysis process via the CROPADDOCK, SUPPLY and SYSTEMS routines. The CROPADDOCK routine is first used to enter site specific data on the number of paddocks to be irrigated along with the size of each paddock and crop rotation. For each crop in each paddock the following soil moisture characteristics are input:

1. Total Available Moisture (TAM)

   -- the <u>total</u> depth of water held in the root zone for plant use (mm).

2. Management Allowed Deficit (MAD)

   -- the allowable deficit when irrigation is required (mm).

3. Application Deficit (AD)

   -- the deficit following an irrigation if the soil is not filled to field capacity (mm).

In addition, irrigation priorities for all crops grown are entered for each half-monthly interval throughout the irrigation season.

The SUPPLY routine is employed to enter information about the irrigation water supply and all components in the supply system. For the purposes of the analysis procedures the supply system is that portion of the system used to supply all application systems used. Water supply information includes the flow rate delivered to the system, the number of days per week it is available and the conveyance efficiency of the system. It also includes water cost data for systems supplied by irrigation schemes.

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The expected life of the system is specified and the interest rate and length of loan for two separate finance terms are specified for attached and unattached components. Cost data entered for each item include total capital cost, amount subsidized, amount financed and type of loan (for attached or unattached components), salvage value, annual maintenance expense and miscellaneous expenses (for taxes, insurance, contingencies etc). Specific items for which data may be entered are supply races, structures, pipelines and pumps. If a pump or pumps are used, data are also entered to compute the flow rate pumped and the pump power requirements. In addition, provision is made to enter cost data for any additional items included in the system from shelter to fences to intermediate water storage facilities.

Irrigation application systems data are entered and computed using the SYSTEMS routine. Data can be entered for up to 20 separate systems each supplying one or more paddocks to a maximum of 20 paddocks. The types of systems for which data may be entered are border strip, furrow, sprinkler (hand-move, side-roll, traveller, self-propelled and solid set) and trickle. The application efficiency for each system on each paddock supplied is computed; it is computed for the surface systems and input directly for sprinkler and trickle systems. The labour requirement per irrigation is also computed for each paddock.

System life, finance and component cost data are entered in the same manner as in the SUPPLY routine. In addition, provision is made to enter cost data for land smoothing and preparation, and for subsurface drainage if required.

2.3.3 System Simulation

The SIMULATE routine is employed to determine how well the irrigation system(s) under consideration will function and the costs involved. Outputs from the CROPADDOCK, SUPPLY and SYSTEMS routines are all read into the routine along with rainfall and crop water use data. Other inputs are tariff data for pump energy use; labour availability; annual inflation factors for energy, labour and operation and maintenance; and a specified rate of return.

Using the input data, irrigation requirements for each paddock are computed for each half-monthly period throughout the irrigation season. Irrigation water is then allocated to each paddock in the simulation process considering the irrigation priority of the crop involved, the system capacity and efficiency, the total amount of water available, and the requirements and availability of labour. If the system involved is unable to supply the water requirements of any crop, the cause is flagged and displayed in the final output.

The output from the SIMULATE routine consists of three main components; the adequacy of irrigation for each crop, the cause(s) of any inadequacies and the costs of the supply and all application systems. Specific output data for each crop in the rotation for each half-monthly period include average irrigation requirement, percent of time irrigation is required, average requirement when irrigation is required, average irrigation application when water is required, percent of time when requirement exceeds application, average and maximum deficits, and the amount of water that must be applied before irrigation is actually needed to make full use of system capacity and water supply. The second component of the output designates the percent of

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time deficits occur in each half-monthly period due to water as limiting, labor as limiting or system capacity as limiting.

The irrigation system cost output contains information on both the capital and operating costs for the system. All costs are computed for each year of the expected life of the system. Capital cost data consist of repayment, interest and total capital costs. Operating costs are computed for average operating conditions as determined from irrigation of the crops under consideration. Specific operating costs computed for each application system are labour, energy, maintenance and miscellaneous costs. For the water supply system the operating costs consist of water, energy, maintenance and miscellaneous costs. The operating costs computed for each year reflect the effects of the various inflation factors. Capital and operating costs are also used to compute an overall annual system cost that reflects inflation rates and the specified rate of return. This annual cost is useful in comparing the overall costs of alternative systems.

CHAPTER 3

DESCRIPTIONS OF COMPUTER ROUTINES

Many details are incorporated in each of the computer routines of the FISA procedure. All routines are designed to accept and utilize input data that would be the most readily available for a given application. Consequently, they must be flexible enough to incorporate a wide variety of information as the layouts of on-farm irrigation systems can be extremely varied as well as the operational demands placed upon them.

The computational processes in each routine are many and varied and are designed to utilize the maximum amount of available data so that the operations and costs of a given irrigation system are represented as accurately as possible. The descriptions of the routines in this chapter that follow give an account of the processes involved. Details can be obtained from the computer program listings for each routine in Appendix A. All routines are written in FORTRAN 77 and are documented quite thoroughly.

3.1 WATERUSE Routine

The purpose of the WATERUSE routine is to provide information on the probability of peak irrigation requirements being exceeded for different cumulative periods. To accomplish this purpose, the routine requires daily rainfall and crop water use data along with crop rotation information, total available moisture (TAM) and management allowed deficit (MAD). A listing of the computer prompt statements for the required inputs is in Figure 3-1. The heading is a descriptive title that is assigned to the output file, and the beginning and ending seasons are those associated with the data in the rainfall and potential

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```
SEG WATERUSE
 ENTER ALL VALUES IN FREE FORMAT
 ENTER HEADING (<=20 CHARS)
WATERUSEEXMPL
 ENTER YEARS OF BEGINNING AND ENDING SEASONS
54  78
 ENTER NAME OF RAINFALL FILE
RAINDAT
 ENTER NAME OF PET FILE
AB703DAT
 ENTER TOTAL AVAILABLE MOISTURE - TAM (MM)
80
 ENTER MGT ALLOWED DEFICIT - MAD (MM)
60
 ENTER STARTING SOIL MOISTURE DEFICIT (MM)
0


  CROP MENU FOR 23 CROPS FROM CROPDATE FILE
  CROP ID NO. AND CROP NAME
       1 WINTER WHEAT1        2 SPRING WHEAT1
       3 SPRING WHEAT2        4 SPRING WHEAT3
       5 BARLEY1              6 BARLEY2
       7 BARLEY3              8 PEAS1
       9 PEAS2               10 PEAS3
      11 PEAS4               12 WHTCLOVER1
      13 WHTCLOVER2          14 WHTCLOVER3
      15 RYEGRASS 1          16 PASTURE1
      17 PASTURE2            18 PASTURE3
      19 PASTURE4            20 GREENFEED1
      21 GREENFEED2          22 GREENFEED3
      23 CULTIVATION



 ENTER NUMBER OF PADDOCKS IN ROTATION
8
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK        1
1 20
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK        2
8 17
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK        3
16 16
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK        4
16,16
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK        5
16 16
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK        6
16 16
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK        7
16 16

 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK        8
16 16
 ENTER THE NUMBER OF CUMULATIVE PERIODS
6
 ENTER THE CUMULATIVE PERIODS (DAYS)
7 10 14 21 28 36
 PRINTOUT OF WEEKLY WATER USE -- Y OR N
N
 PRINTOUT OF MAX ANNUAL WATER USE - Y OR N
Y


 I AM NOW THINKING AND TRYING TO DIGEST ALL THE DATA
 YOU HAVE FED ME.  I WILL TELL YOU WHEN I AM FINISHED.
 --- PROVIDED YOU HAVE NOT FED ME BAD DATA THAT WILL
 RESULT IN INDIGESTION!!!!!


 THE PROGRAM HAS SUCCESSFULLY EXECUTED
 AND THE OUTPUT IS IN FILE WATERUSEEXMPL
```

Figure 3.1   Computer prompt statements

for WATERUSE routine

evapotranspiration (PET) files. The dates for the beginning and ending seasons are those associated with the data in the rainfall and potential evapotranspiration (PET) files. The dates for the beginning and ending seasons must be between 1900 and 1999, and all four digits or only the last two for each date may be entered. Total available moisture, management allowed deficit and starting soil moisture deficit are then entered. These values should be representative averages for the soils and crops under consideration.

A menu of crops and identification numbers is printed to aid in entering crop rotation data. The number of paddocks in rotation is equal to the total number of years in the crop rotation considered and the soil moisture status for the crops is sequentially "rotated" from paddock to paddock at the beginning each year of the simulation. Two crop identification numbers are entered for each paddock to account for double cropping. (If a seasonal crop such as pasture, no. 16, is grown, the same number is entered twice.) The crops in the menu and their planting and harvest dates are shown as part of the printout in Figure 3-4a.

The last two inputs for the routine are for programme control. They are used to specify whether printouts of weekly water use and maximum annual water use are produced.

Four data files are required as input for the WATERUSE routine. Two files are the designated rainfall and potential evapotranspiration files. The rainfall file must contain daily rainfall values for a period greater than or equal to the desired period of study. The PET file consists of estimates of monthly potential evapotranspiration as computed using a modified Penman approach (Jensen, 1974) for a reference

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crop of lucerne over the period of study. Formats for rainfall and PET files must be compatible with FORMAT statements in the routine. The two additional files are required to provide agronomic data for crops grown. These files named CROPDATE and CROPFPOLY are listed in Appendix B. The CROPDATE file is a menu of crops with identification numbers; planting, cover and harvest dates; and polynomial references. This reference for each crop identifies a set of polynomial constants in the CROPFPOLY file. The polynomial constants are used to construct polynomial equations relating the evapotranspiration of individual crops to potential evapotranspiration. The constants are those developed by the U.S. Department of Agriculture (Harrington, 1981). All files are formatted to allow editing; however, it is essential that Crop No. 23 remain as cultivation (fallow) in the CROPDATE file and that line no. 12 in the CROPFPOLY file remain as the polynomial reference for fallow as these files are used as inputs to the WATERUSE and SIMULATION routines.

Figure 3-2 is a flowchart of the WATERUSE routine. Daily irrigation requirements for each crop of the crop rotation specified are computed using evapotranspiration estimates along with soil moisture and daily rainfall data. Irrigation is deemed necessary for a crop if the soil moisture deficit is greater than the MAD, and the irrigation requirement is that required to maintain a deficit no greater than MAD. If a rainfall event occurs the soil moisture deficit is adjusted accordingly, and evaporation from the soil is accelerated for three days following. Also included in the evapotranspiration calculations is the effect of increased soil moisture deficits on reduced evapotranspiration rates using a relationship developed by Minhas et al (1974).

20
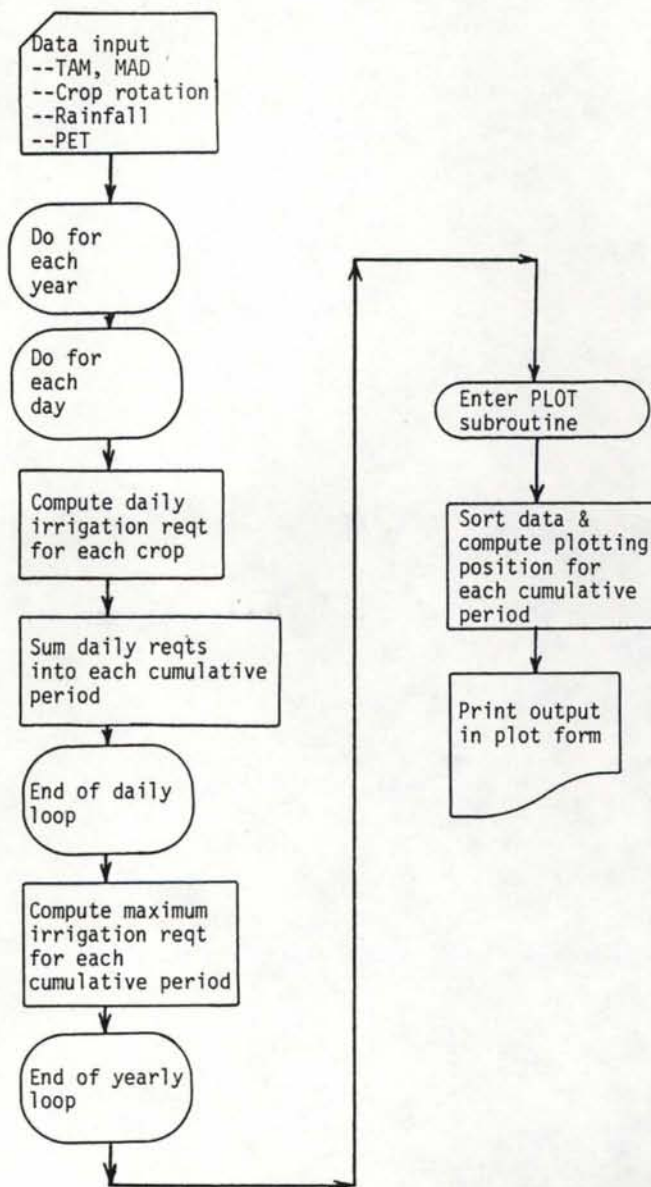
Figure 3-2 Flowchart of WATERUSE routine

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The daily irrigation requirements are summed into each of the cumulative periods specified in the input. For each crop year of record the maximum value for each cumulative period is selected and saved. After all years are processed, the maximum values for each period are sorted into descending order and their plotting positions computed using the Weibull Formula. The crop year is from 1 June through 31 May.

Final output from the routine consists of a plot showing the daily water requirement for each of the different cumulative periods that will be exceeded a given percent of time. In addition, all input data except files are printed as well as the total annual irrigation requirements for each year in the simulation. If desired, output can also be obtained showing weekly irrigation requirements for each paddock and/or the final ordered values for each cumulative period. An example output is shown in Figure 4-3 in section 4.3.

3.2 CROPADDOCK Routine

The CROPADDOCK routine is used to set up a crop-paddock file that contains data on each paddock irrigated and all crops in the rotation. A flowchart of the routine is shown in Figure 3-3. As shown in the figure, the main purpose of the programme is to accept user-supplied data to create an array that can be used as input to the SYSTEMS and SIMULATION routines.

A listing of the input prompt statements is shown in Figure 3-4. The title requested is used to name the output file. Data are then entered for the total number of paddocks and the size and number of years in the crop rotation for each paddock. It is necessary that each
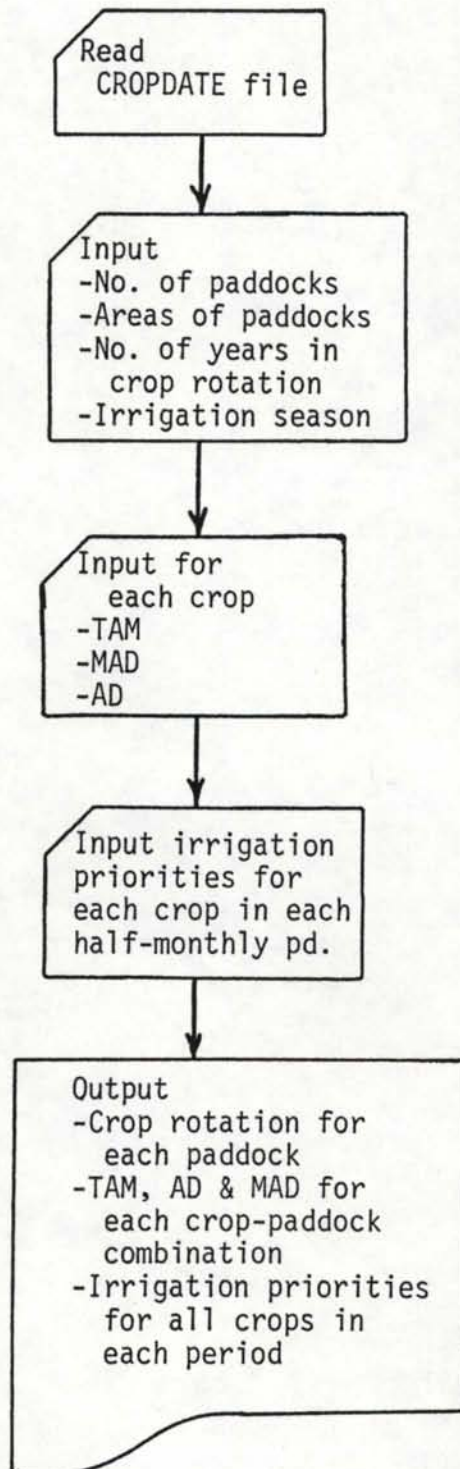
Figure 3-3   Flowchart of CROPADDOCK routine

```
SEG CROPADDOCK


>>> PROGRAM FOR SETTING UP CROP-PADDOCK FILE <<<

NOTE:   ALL NUMERIC DATA ARE FREE FORMAT (LIST-DIRECTED) INPUT
        NUMBERS MUST BE SEPARATED BY COMMAS OR SPACES


INPUT A DESCRIPTIVE TITLE TO BE USED IN NAMING
THE CROP PADDOCK FILE GENERATED
  -- <20 CHARACTERS AND NO BLANKS

CROPADDOCKEXAMPL

ENTER THE NUMBER OF PADDOCKS (MAX OF 20)
4

ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS
IN CROP ROTATION FOR PADDOCK NO.  1
16 4

ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS
IN CROP ROTATION FOR PADDOCK NO.  2
10 4

ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS
IN CROP ROTATION FOR PADDOCK NO.  3
16 1

ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS
IN CROP ROTATION FOR PADDOCK NO.  4
16 1

NAME THE FIRST MONTH OF THE IRRIGATION SEASON
SEPTEMBER
NAME THE LAST MONTH OF THE IRRIGATION SEASON
APRIL


CROP MENU FOR 23 CROPS FROM CROPDATE FILE
CROP NO. AND NAME WITH PLANTING AND HARVEST DATES

  1 WINTER WHEAT1   JUL  1   DEC 31      2 SPRING WHEAT1   AUG  1   DEC 31
  3 SPRING WHEAT2   SEP  1   DEC 31      4 SPRING WHEAT3   OCT  1   JAN 16
  5 BARLEY1         SEP  1   DEC 31      6 BARLEY2         OCT  1   JAN 16
  7 BARLEY3         NOV  1   JAN 31      8 PEAS1           AUG  1   DEC 31
  9 PEAS2           SEP  1   JAN  6     10 PEAS3           OCT  1   JAN 16
 11 PEAS4           NOV  1   JAN 31     12 WHTCLOVER1      JUN  1   DEC 31
 13 WHTCLOVER2      JUN  1   JAN 31     14 WHTCLOVER3      JUN  1   FEB 28
 15 RYEGRASS 1      JUN  1   DEC 31     16 PASTURE1        JUN  1   MAY 31

 17 PASTURE2        FEB  1   MAY 31     18 PASTURE3        MAR  2   MAY 31
 19 PASTURE4        APR  1   MAY 31     20 GREENFEED1      FEB  5   MAY 31
 21 GREENFEED2      MAR  2   MAY 31     22 GREENFEED3      APR  1   MAY 31
 23 CULTIVATION     JUN  1   MAY 31

ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR
THE  4 YEAR ROTATION IN PADDOCK  1
  NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR
          FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)
FOR ITEMS ARE ENTERED FOR EACH CROP:
  1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),
  3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)

DATA FOR YEAR NO.  1
CROP NO., TAM, MAD, AD
1 80 50 10
80 80 60 10

DATA FOR YEAR NO.  2
CROP NO., TAM, MAD, AD
8 75 50 10
17 60 40 0
```

Figure 3-4a   Computer prompt statements for CROPADDOCK routine

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```
                DATA FOR YEAR NO. 3
                 CROP NO., TAM, MAD, AD
                16 80 60 10
                16 80 60 10

                DATA FOR YEAR NO. 4
                 CROP NO., TAM, MAD, AD
                16 80 60 10
                16 80 60 10

                ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR
                THE  4 YEAR ROTATION IN PADDOCK  2
                  NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR
                          FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)
                FOUR ITEMS ARE ENTERED FOR EACH CROP:
                  1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),
                  3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)

                DATA FOR YEAR NO. 1
                 CROP NO., TAM, MAD, AD
                16 100 70 10
                16 100 70 10

                DATA FOR YEAR NO. 2
                 CROP NO., TAM, MAD, AD
                16 100 70 10
                16 100 70 10

                DATA FOR YEAR NO. 3
                 CROP NO., TAM, MAD, AD
                1 100 60 10
                20 90 60 10

                DATA FOR YEAR NO. 4
                 CROP NO., TAM, MAD, AD
                8 90 50 10
                17 80 50 0

                ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR
                THE  1 YEAR ROTATION IN PADDOCK  3
                  NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR
                          FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)
                FOUR ITEMS ARE ENTERED FOR EACH CROP:
                  1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),
                  3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)

                DATA FOR YEAR NO. 1
                 CROP NO., TAM, MAD, AD
                16 80 60 0
                16 80 60 0

                ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR
                THE  1 YEAR ROTATION IN PADDOCK  4
                  NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR
                          FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)
                FOUR ITEMS ARE ENTERED FOR EACH CROP:
                  1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),
                  3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)

                DATA FOR YEAR NO. 1
                 CROP NO., TAM, MAD, AD
                16 80 60 0
                16 80 60 0
```

Figure 3-4b Computer prompt statements for CROPADDOCK routine

```
THE FOLLOWING  6 CROPS ARE GROWN
     CROP NO. : NAME
          1   WINTER WHEAT1
          8   PEAS1
         16   PASTURE1
         17   PASTURE2
         20   GREENFEED1
         23   CULTIVATION

ENTER IRRIGATION PRIORITIES FOR CROPS FOR ALL
2-WEEK PERIODS THROUGHOUT THE YEAR WITH 1 BEING TOP
PRIORITY, 2 BEING SECOND ETC.


ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF SEP
  1  8 16 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF SEP
  1  8 16 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF OCT
  1  8 16 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF OCT
  1  8 16 23
2 1 3 4
```



```
ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF FEB
16 17 20 23
3 1 2 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF MAR
16 17 20 23
3 2 1 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF MAR
16 17 20 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF APR
16 17 20 23
2 1 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF APR
16 17 20 23
1 3 2 4
THE OUTPUT IS IN FILE CROPADDOCKEXAMPL
LIST THE FILE TO CHECK DATA
```

Figure 3-4c Computer prompt statements for

CROPADDOCK routine

26
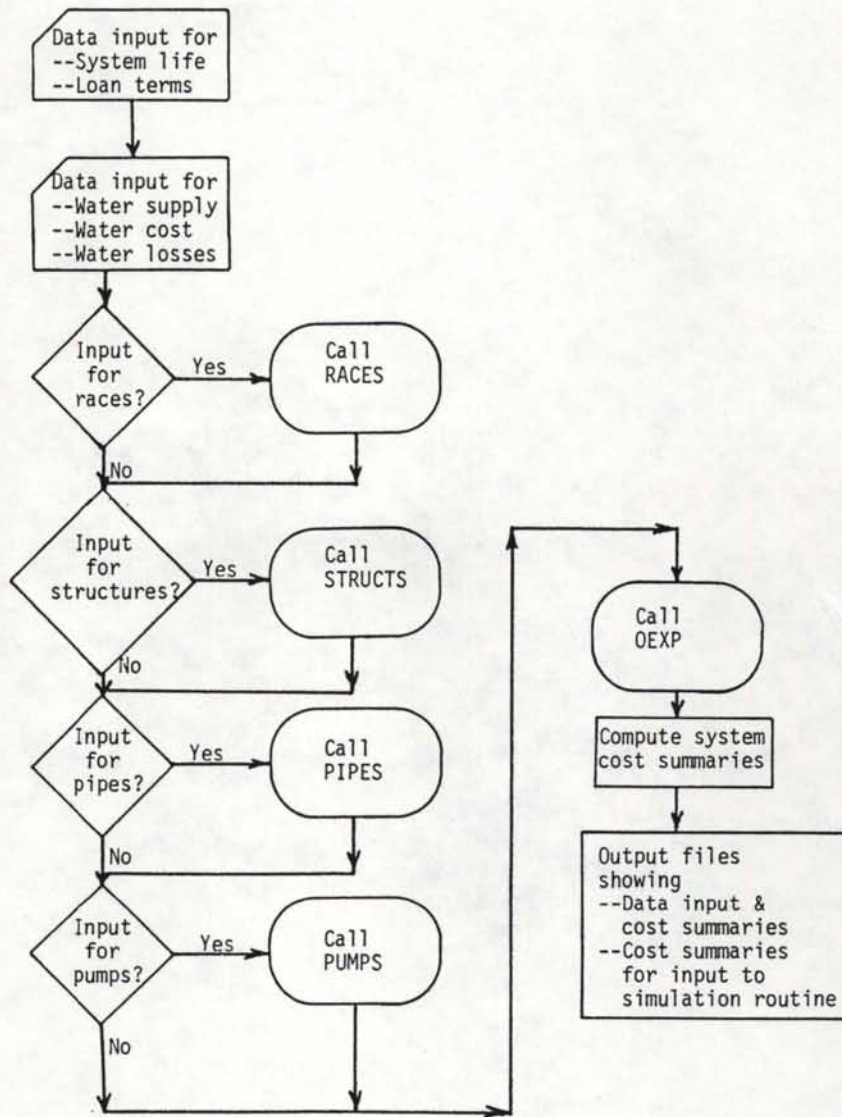
Figure 3-5   Flowchart of SUPPLY routine

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paddock be assigned an identification number that is used in this routine as well as in the SYSTEMS routine. The months marking the beginning and ending of the irrigation season are then entered.

The crop menu shown is obtained from the CROPDATE file (Appendix B) that is read into the programme. For each paddock, data are entered for two crops in each year of the crop rotation. This information consists of the crop identification number and the soil moisture parameters -- total available moisture, management allowed deficit and application deficit (TAM, MAD and AD) described in section 2.3.2.

After all crop rotation data are entered, the user is advised of all crops grown. Information is then requested on the irrigation priorities of the crops grown in each half-monthly period throughout the irrigation season. All compiled data are written into a file with the name of the title entered first in the programme. Output from the routine is shown in Figure 4-5 in section 4.4.1.

3.3 SUPPLY Routine

Operating characteristics and costs of the irrigation supply system are entered in the SUPPLY routine. The supply system is considered to be that portion of the system used to supply one or more application systems. Considerable flexibility is built into the supply routine so that many different types of components and water supplies can be considered for different systems and applications. The flow chart for the SUPPLY routine (Figure 3-5) shows the main elements of the routine. As shown, a portion of the routine deals with data input for a wide variety of system components via subroutines RACES, STRUCTS, PIPES, PUMPS and OEXP described in sections 3.3.1 - 3.3.5.

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Prompt statements for data input to the SUPPLY routine are shown in Figure 3-6. A descriptive title and system life are first entered followed by the interest rate and time of loan for each of two loans. Data for two loans, one for attached items and one for unattached items, are entered as lending institutions may have different loan rates for these two items. Water supply, water cost and water loss data are then entered. At this point, the user is asked whether or not data are to be entered for supply races, irrigation structures, pipelines and/or pumps. If data are to be entered for any of these items the proper subroutine is called for data entry. Data for miscellaneous items are the last entered via subroutine OEXP.

Once all data have been entered, summaries are computed for both attached and unattached items (Loans 1 and 2). The summaries include total capital cost, capital not financed or subsidized, subsidized capital, financed capital, interest rate, time of loan, salvage value, annual maintenance expense and annual miscellaneous expense. The system capacity, conveyance efficiency, and system life are also computed as well as pump capacity and power requirements.

Programme output is written into two files as shown by the last few lines in Figure 3-6. The file with LIST- as the first five characters contains a listing of the input data and computed results with appropriate documentation (Figure 4-7, section 4.4.2). The other file contains all computed results in a format for input to the SIMULATE routine (Figure 4-8, section 4.4.2).

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```
          SEG SUPPLY


          ENTER A DESCRIPTIVE NAME FOR THE OUTPUT FILE
          WITH <20 CHARACTERS AND NO EMBEDDED BLANKS
          SUPPLYEXMPL

          ENTER SYSTEM LIFE IN YEARS
          20

          SEPARATE LOAN TERMS ARE CONSIDERED FOR
          ATTACHED ITEMS -- LOAN NO. 1 AND
          UNATTACHED ITEMS -- LOAN NO. 2

          ENTER INTEREST RATE (PERCENT) AND
          TIME OF LOAN (YEARS) FOR LOAN NO. 1
          9 15

          ENTER INTEREST RATE (PERCENT) AND
          TIME OF LOAN (YEARS) FOR LOAN NO. 2
          14 7


          ENTER WATER SUPPLY DATA -- 2 ITEMS
           1 -- FLOW RATE ENTERING THE SYSTEM  (L/S)
           2 -- DAYS PER WEEK THIS FLOW RATE IS AVAILABLE
          30 7


          ENTER WATER COST DATA -- 3 ITEMS
           1 -- $ PER 1000 CUBIC M  (VOLUME)
           2 -- $ PER L/S  (FLOW RATE)
           3 -- $ LUMP SUM

           NOTE: ENTER 0 (ZERO) FOR THOSE ITEMS THAT DO NOT APPLY
                 DO NOT INCLUDE ANY POWER CHARGES
          0 0 0

          FOLLOWING ARE ESTIMATES OF SEEPAGE LOSS
          FOR THE FLOW RATE ENTERING THE SYSTEM
            SEEPAGE LOSS
           (L/S PER 100 M)
                 0.0  ..WELL MAINTAINED CONCRETE LINING
                 0.1  ..CEMENTED GRAVEL & HARDPAN WITH SANDY LOAM
                 0.1  ..CLAY AND CLAYEY LOAM
                 0.1  ..SANDY LOAM
                 0.1  ..VOLCANIC ASH
                 0.2  ..SAND OR VOLCANIC ASH AND CLAY
                 0.3  ..SANDY SOIL WITH ROCK
                 0.4  ..SANDY AND GRAVELLY SOIL
                 1.0  ..STONY GRAVELLY SOIL

           NOTE:  PIPELINES SHOULD HAVE NEGLIGIBLE LOSS

           FOR EVAPORATION FROM POND WATER SURFACES ----
           5 HA-MM/DAY   0.6 L/S

          ENTER THE TOTAL ESTIMATED LOSS (L/S) FOR SEEPAGE
          AND EVAPORATION IN THE SUPPLY SYSTEM
          0


          ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES? (Y OR N)
          N

          ARE DATA TO BE ENTERED FOR ANY STRUCTURES?  (Y OR N)
          N


          ARE DATA TO BE ENTERED FOR ANY PIPELINES?  (Y OR N)
          Y
```

Figure 3-6a   Computer prompt statements for SUPPLY routine

```
ARE DATA TO BE INPUT FOR ANY PUMPS?    (Y OR N)
Y

ENTER DATA FOR OTHER EXPENSES

ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

--MORE THAN ONE ITEM CAN BE ENTERED
  FOR BOTH LOANS 1 AND 2

--DATA FOR ALL ITEMS DIRECTLY ASSOCIATED WITH THE
  SYSTEM CAN BE ENTERED INCLUDING COSTS ASSOCIATED
  WITH FENCING, SHELTER BELTS, FARM ACCESS (BRIDGES & ROADS)
N
  ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N


>>>THE PROGRAM HAS SUCCESSFULLY EXECUTED!! <<

-- A LISTING OF INPUT DATA AND SUMMARY OUTPUT IS IN FILE LIST-SUPPLYEXMPL

-- DATA FOR THE SIMULATION PROGRAM IS IN FILE SUPPLYEXMPL
```

Figure 3-6b Computer prompt statements for SUPPLY routine

3.3.1 Subroutine RACES

Subroutine RACES is used to input cost data for irrigation races.
The prompt statements for data input are shown in Figure 3-7. The
routine has provisions to enter data for more than one section or type
of race for each of two different loans. Data for each loan rate (or
no loan if no financing is involved) are passed to the calling routine.
The user must estimate the sizes of races and costs as the subroutine
does not compute the sizes of races nor the earthwork required for
construction.

3.3.2 Subroutine STRUCTS

Cost data for different types of irrigation structures are input
via subroutine STRUCTS. As the prompt statements shown in Figure 3-8
indicate, data for several structures of the same type or for different
types can be entered for each of two different loan rates. Data for
all structures must be entered for a particular system including non
financed structures for which data are input as directed by the prompt
statements.

3.3.3 Subroutine PIPES

Input data for pipelines entered using subroutine PIPES are very
similar to those entered for races. Provision is made to input values
for associated fittings and laying if these items are not included in
the pipeline price (Figure 3-9). The subroutine does not compute pipe-
line sizes.

3.3.4 Subroutine PUMPS

If pumps are included in the system, subroutine PUMPS is called
for each pump for input of engineering and cost data. The prompt
statements are shown in Figure 3-10. Engineering data are used in the
subroutine to compute the input power required by the pump motor and

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```
ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)

NOTE:   IF NONE OF THE COST IS FINANCED ANSWER Y
        AND INDICATE 0 AMOUNT FINANCED WHEN ASKED

  -- DATA FOR MORE THAN ONE RACE OR DITCH CAN BE
     ENTERED FOR BOTH LOANS 1 AND 2
Y

DATA FOR RACE OR DITCH
(LOAN NO. 1)
ENTER THE FOLLOWING EIGHT ITEMS:
  1 -- LENGTH OF RACE (M)
  2 -- COST OF RACE ($/M)
  3 -- COST OF LINING ($/M) -- (ENTER 0 IF NOT APPLICABLE)
  4 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  5 -- PERCENT OF COST SUBSIDIZED
  6 -- PERCENT OF COST FINANCED
  7 -- TOTAL ANNUAL MAINTENANCE COST ($)
  8 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
       ( TAXES, INSURANCE, CONTINGENCIES ETC.)
200 2.5 0 0 50 50 150 0
  ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
N
  ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N
```

Figure 3-7   Computer prompt statements for subroutine RACES

```
ARE ANY STRUCTURES FINANCED BY LOAN NO. 1? (Y OR N)

NOTE:   IF NONE OF THE COST IS FINANCED ANSWER Y
        AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

--MORE THAN ONE TYPE OF STRUCTURE CAN BE ENTERED
  FOR BOTH LOANS 1 AND 2
Y

DATA FOR STRUCTURES
(LOAN NO. 1)
ENTER THE FOLLOWING SEVEN ITEMS:
  1 -- NUMBER OF STRUCTURES
  2 -- COST PER STRUCTURE ($)
  3 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  4 -- PERCENT OF COST SUBSIDIZED
  5 -- PERCENT OF COST FINANCED
  6 -- TOTAL ANNUAL MAINTENANCE COST ($)
  7 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
       ( TAXES, INSURANCE, CONTINGENCIES ETC.)
25 80 5 50 50 100 0
  ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
N
  ARE THE STRUCTURES FINANCED BY LOAN NO. 2? (Y OR N)
N
```

Figure 3-8   Computer prompt statements for subroutine STRUCTS

```
ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

  ---DATA FOR MORE THAN ONE PIPELINE CAN BE ENTERED FOR
     BOTH LOANS 1 AND 2
Y

DATA FOR PIPES -- (LOAN NO. 1)
ENTER THE FOLLOWING NINE ITEMS:
  1 -- LENGTH OF PIPE (M)
  2 -- COST OF PIPE ($/M)
  3 -- TOTAL COST OF FITTINGS ($)
  4 -- COST OF LAYING ($/M)
       (ENTER 0 (ZERO) FOR ITEMS 3 & 4 IF THE COST IS
        INCLUDED IN THE COST OF THE PIPE.)
  5 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  6 -- PERCENT OF COST SUBSIDIZED
  7 -- PERCENT OF COST FINANCED
  8 -- TOTAL ANNUAL MAINTENANCE COST ($)
  9 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
     ( TAXES, INSURANCE, CONTINGENCIES ETC.)
200 8.5 250 2.5 20 50 50 200 50
 ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
N
 ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N
```

Figure 3-9 Computer prompt statements for subroutine PIPES

```
ENTER THE NUMBER OF PUMPS AND THE ID NO. OF EACH PUMP
1 2

ENTER DATA FOR PUMP ID NO.  2

ENTER THE FOLLOWING SIX ITEMS
   1 -- FLOW RATE PUMPED (L/S)
   2 -- DISCHARGE PRESSURE (KPA)
   3 -- INLET PRESSURE (KPA)
        (ENTER 0 (ZERO) IF PUMPING FROM A SUMP OR WELL)
   4 -- VERTICAL PUMPING LIFT (M)
   5 -- PUMP EFFICIENCY (%)
        NOTE:  A CONSERVATIVE VALUE FOR PUMP EFFICIENCY SHOULD
               BE USED AS IT APPLES OVER THE LIFE OF THE SYSTEM
   6 -- MOTOR EFFICIENCY (%)
        NOTE:  THE EFFICIENCY OF MOST LARGE ELECTRIC MOTORS
               VARIES BETWEEN 90 AND 95 PERCENT
50 400 0 10 78 92

ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

--MORE THAN ONE ITEM CAN BE ENTERED
  FOR BOTH LOANS 1 AND 2

--DATA FOR ALL ITEMS ASSOCIATED WITH THE PUMP SHOULD BE
  ENTERED INCLUDING THE WELL OR SUMP, PIPE FITTINGS AND
  VALVES, PUMP HOUSE, ELECTRICAL CONTROLS, POWER
  RETICULATION, ETC.
Y

ENTER THE NAME OF THE ITEM FOR WHICH
DATA ARE BEING ENTERED  (<20 CHARACTERS)
PUMP&PANEL

DATA FOR ITEMS
(LOAN NO. 1)
ENTER THE FOLLOWING SIX ITEMS:
   1 -- COST ($)
   2 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
        AS A PERCENT OF THE ORIGINAL COST
   3 -- PERCENT OF COST SUBSIDIZED
   4 -- PERCENT OF COST FINANCED
   5 -- TOTAL ANNUAL MAINTENANCE COST ($)
        (SUGGESTED VALUE FOR PUMPS IS 3 TO 5 %
         OF THE ORIGINAL COST)
   6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
        ( TAXES, INSURANCE, CONTINGENCIES ETC.)
5200 15 0 60 250 50
  ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
N
  ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N
```

Figure 3-10 Computer prompt statements for subroutine PUMPS

the flow rate pumped. It is assumed that pumps are driven by electric motors as electricity is the energy source for essentially all irrigation pumping in New Zealand.

Cost data are input for each pump and all items associated with the pump including the well or sump, fittings, pump house, controls and necessary power reticulation. Provision is made to name each item for which cost data are being entered in order to identify the cost data in the summary printout.

Note: An identification number must be assigned to each pump in the irrigation distribution and application systems beginning with 1 and continuing consecutively.

3.3.5 Subroutine OEXP

Subroutine OEXP is called to prompt input cost data for any other expenses associated with supply system components and operations for which data are not entered in any other portion of the calling routine or subroutines. The name of the item or practice is entered along with the necessary cost data. As with other system components, data can be entered for either loan, and can include costs associated with detrimental effects of a system such as area lost from production and crop damage (Figure 3-11).

3.4 SYSTEMS Routine

The SYSTEMS routine is used to supply detailed information about application systems to the SIMULATE routine. An application system is that portion of the system used to apply irrigation water to one or more paddocks. The routine is used to input data of sufficient detail used to adequately compute the operational characteristics and costs of

```
ENTER DATA FOR OTHER EXPENSES
FOR SYSTEM NO.  1 -- BORDER
IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS

ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

--MORE THAN ONE ITEM CAN BE ENTERED
  FOR BOTH LOANS 1 AND 2

--DATA FOR ALL ITEMS DIRECTLY ASSOCIATED WITH THE
  SYSTEM CAN BE ENTERED INCLUDING COSTS ASSOCIATED
  WITH FENCING, SHELTER BELTS, FARM ACCESS (BRIDGES & ROADS)

--FOR ANNUAL VALUE OF CROP LOST DUE TO SYSTEM OPERATION
  SUCH AS NON-IRRIGATED AREAS OF PADDOCKS,
  DAMAGE FROM DRAG HOSE, TRACTORS, ETC., ENTER
  A COST ONLY FOR TOTAL MISCELLANEOUS ITEMS.

Y

ENTER THE NAME OF THE ITEM FOR WHICH
DATA ARE BEING ENTERED  (<20 CHARACTERS)
FENCING

DATA FOR ITEMS
(LOAN NO. 1)
ENTER THE FOLLOWING SIX ITEMS:
  1 -- COST ($)
  2 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  3 -- PERCENT OF COST SUBSIDIZED
  4 -- PERCENT OF COST FINANCED
  5 -- TOTAL ANNUAL MAINTENANCE COST ($)
  6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
       ( TAXES, INSURANCE, CONTINGENCIES ETC.)
1500 5 0 40 200 25
 ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
N

 ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N
```

Figure 3-11 Computer prompt statements for subroutine OEXP

different types of systems. A flow chart of the major elements and subroutines is shown in Figure 3-12.

The first step in the routine is to read agronomic data from the CROPADDOCK output file. These data are used to supply necessary information about the size of each paddock and the agronomic information required for system planning and design.

Prompt statements from the main SYSTEMS routine are in Figure 3-13. The identification numbers of all paddocks that have no systems are printed, and the type of application system is selected from the menu of 9 alternatives. The number of paddocks served by the system and their identification numbers are then entered. The number of paddocks served by a system can range from one to the total listed, and the identification numbers need not be entered in any specific order or sequence. The programme maintains an accounting of all paddocks served by a system and will not terminate until a system of one type or another is specified for all paddocks.

The system life and loan terms are then entered. Two different loan terms may be specified for attached and unattached items as in the SUPPLY routine. Programme control is then transferred to the proper subroutine depending upon the type of system selected; Systems 1 and 2 -- SURFACE, systems 3 through 8 -- SPNKLR, and system 9 -- TRICKLE. Each of these subroutines is described in subsequent sections.

Once programme control returns to the main SYSTEMS routine, the identification numbers of all paddocks for which a system has not been specified are displayed. A system is selected, paddocks specified and the process is repeated. When a system or systems are specified for all paddocks, output is written into two files and the user notified

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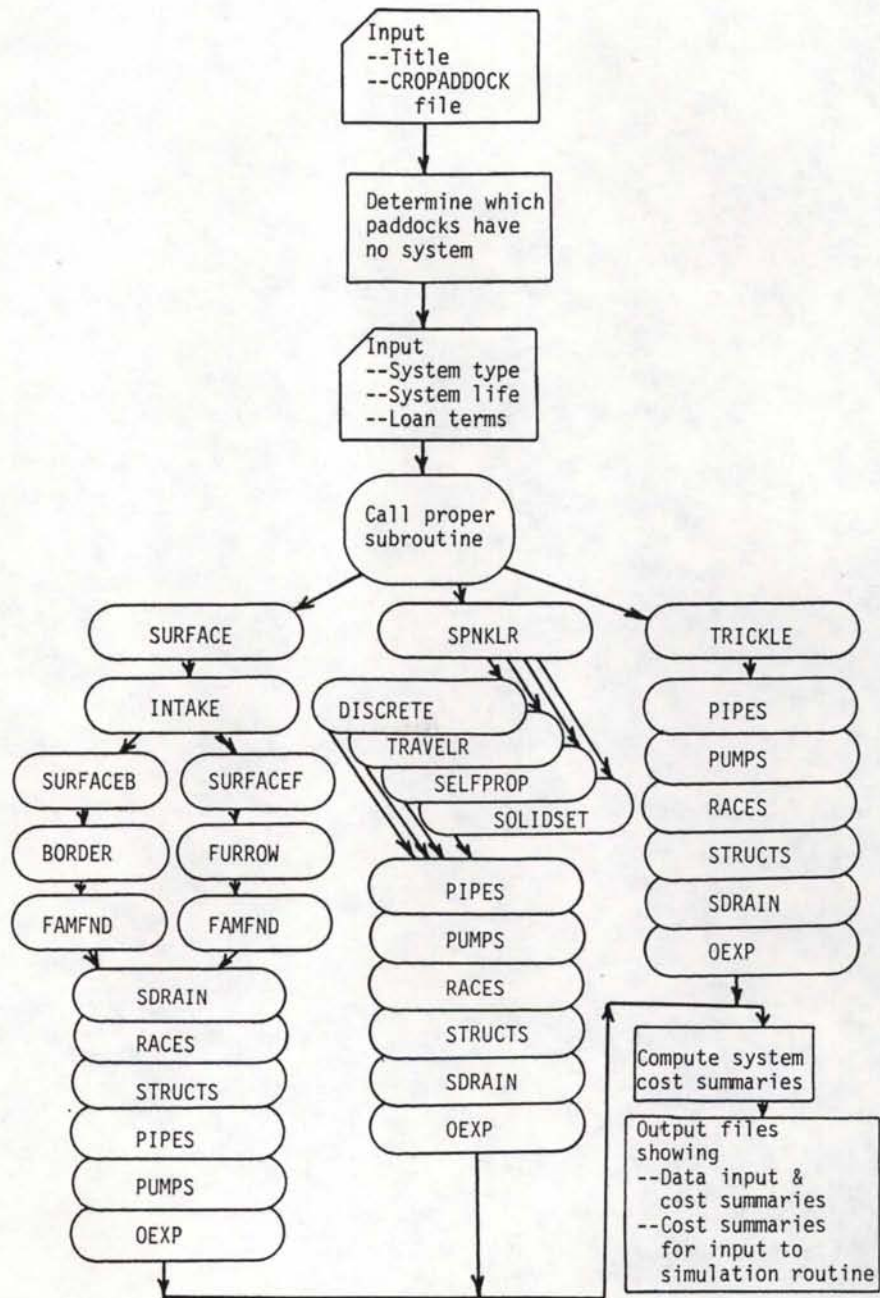
Figure 3-12   Flowchart of SYSTEMS routine

```
SEG SYSTEMS

ENTER A DESCRIPTIVE NAME FOR THE OUTPUT FILE
WITH <20 CHARACTERS AND NO EMBEDDED BLANKS
SYSTEMSINPUT


ENTER THE NAME OF THE CROPADDOCK FILE TO BE USED
CROPADDOCKEXMPL


THE FOLLOWING PADDOCKS HAVE NO SYSTEM
      1  2  3  4

ENTER THE TYPE OF IRRIGATION SYSTEM USING THE FOLLOWING CODE:

             1 -- BORDER
             2 -- FURROW OR CORRUGATE
             3 -- HAND-MOVE SPRINKLER
             4 -- END-TOW SPRINKLER
             5 -- SIDE-ROLL SPRINKLER
             6 -- TRAVELLING SPRINKLER (GUN OR BOOM)
             7 -- SELF-PROPELLED SPRINKLER (CENTER-PIVOT, LATERAL-MOVE ETC.)
             8 -- SOLID-SET SPRINKLER
             9 -- TRICKLE
1


ENTER THE NUMBER OF PADDOCKS SERVED BY THE SYSTEM
AND THE ID NOS. OF THE PADDOCKS
1 3

ENTER SYSTEM LIFE IN YEARS
20

SEPARATE LOAN TERMS ARE CONSIDERED FOR
ATTACHED ITEMS -- LOAN NO. 1 AND
UNATTACHED ITEMS -- LOAN NO. 2

ENTER INTEREST RATE (PERCENT) AND
TIME OF LOAN (YEARS) FOR LOAN NO. 1
9 15

ENTER INTEREST RATE (PERCENT) AND
TIME OF LOAN (YEARS) FOR LOAN NO. 2
14 7
```

DATA INPUT TO SUBROUTINES

```
>>>THE PROGRAM HAS SUCCESSFULLY EXECUTED!! <<

-- A LISTING OF INPUT DATA AND SUMMARY OUTPUT IS IN FILE LIST-SYSTEMSINPUT

-- DATA FOR THE SIMULATION PROGRAM IS IN FILE SYSTEMSINPUT
```

Figure 3-13   Computer prompt statements for the

main SYSTEMS routine

40

```
THE FOLLOWING INPUTS REFER TO SYSTEM NO.  1

ENTER THE FOLLOWING 2 ITEMS

1 --  FLOW RATE ENTERING THE SYSTEM (LITERS PER SECOND)
       NOTE:  THE FLOW RATE ENTERING THE SYSTEM MUST
              CORRESPOND TO THAT SUPPLIED BY THE
              WATER SUPPLY SYSTEM
2 -- HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE
230 24


FOLLOWING ARE ESTIMATES OF SEEPAGE LOSS
FOR THE FLOW RATE ENTERING THE SYSTEM
   SEEPAGE LOSS
   (L/S PER 100 M)
        0.1  ..WELL MAINTAINED CONCRETE LINING
        0.2  ..CEMENTED GRAVEL % HARDPAN WITH SANDY LOAM
        0.2  ..CLAY AND CLAYEY LOAM
        0.4  ..SANDY LOAM
        0.4  ..VOLCANIC ASH
        0.7  ..SAND OR VOLCANIC ASH AND CLAY
        0.9  ..SANDY SOIL WITH ROCK
        1.2  ..SANDY AND GRAVELLY SOIL
        2.8  ..STONY GRAVELLY SOIL
   NOTE:  PIPELINES SHOULD HAVE NEGLIGIBLE LOSS

ENTER THE TOTAL ESTIMATED LOSS (L/S) ONLY IN THIS APPLICATION
SYSTEM BEFORE WATER REACHES THE FIELD
7


ENTER INTAKE CHARACTERISTICS FOR THE SOIL IN PADDOCK  3
FOR SYSTEM NO.  1--BORDER

COEFFICIENTS MAY BE ENTERED FOR ONE OF THE FOLLOWING EQUATIONS
 A, B AND C ARE COEFFICIENTS
 Y = DEPTH INFILTRATED (MM)
 T = ELAPSED TIME IN MINUTES

EQN NO.
   1 --  Y = A*T**B + C*T              (KOSTIAKOV-LEWIS)
   2 --  Y = A*SQRT(T) + B*T           (PHILIP)
   3 --  Y = A*(1.0 - EXP(-B*T)) + C*T (JOBLING)
   4 --  Y = A*T**B + C                (USDA-SCS)
   5 --  SCS INTAKE FAMILY NO.         (USDA-SCS)
   6 --  MAX SPRINKLER INTAKE RATE (MM PER HOUR)
         NOTE:  EQN NO. 6 CAN BE SPECIFIED ONLY FOR
                SPRINKLER SYSTEMS

ENTER THE NUMBER OF THE EQUATION FOR WHICH
VALUES ARE TO BE ENTERED
3
 ENTER VALUES FOR A, B AND C IN EQN 3
40 .26 .567
```

Figure 3-14a   Computer prompt statements for subroutines SURFACE

41

DATA INPUT TO SUBROUTINE SURFACEB
or SUBROUTINE SURFACEF

```
ARE DATA TO BE ENTERED FOR HEAD RACES AND/OR
DRAINAGE DITCHES IN PADDOCK NO.  4  (Y OR N)
N

ARE DATA TO BE INPUT FOR IRRIGATION STRUCTURES
IN PADDOCK NO.  4  (Y OR N)
N

ARE DATA TO BE INPUT FOR PIPELINES
FOR PADDOCK NO.  4?  (Y OR N)
N

IS SUBSURFACE DRAINAGE REQUIRED FOR
PADDOCK NO.  4?  (Y OR N)
N

ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES
FOR SYSTEM NO.  4 -- BORDER
IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS?  (Y OR N)
N

ARE DATA TO BE ENTERED FOR ANY STRUCTURES
FOR SYSTEM NO.  4 -- BORDER
IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS?  (Y OR N)
N

ARE DATA TO BE ENTERED FOR ANY PIPELINES
FOR SYSTEM NO.  4 -- BORDER
IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS?  (Y OR N)
N

ARE DATA TO BE INPUT FOR ANY PUMPS
FOR SYSTEM NO.  4 -- BORDER
 NOTE: DO NOT INCLUDE ANY PUMPS SPECIFIED IN THE
       WATER SUPPLY ROUTINE!!
N

ENTER DATA FOR OTHER EXPENSES
FOR SYSTEM NO.  4 -- BORDER
IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS
```

Figure 3-14b   Computer prompt statements for subroutine SURFACE

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```
ENTER THE FOLLOWING DATA FOR SUBSURFACE DRAINAGE
---2 ITEMS
        1 -- ESTIMATED TIME BETWEEN IRRIGATIONS (DAYS)
        2 -- ROOT ZONE DEPTH IN MM
14 1000

ENTER THE FOLLOWING SUB SURFACE DRAINAGE DATA:
---5 ITEMS
1-DRAIN DEPTH, M
2-DISTANCE BETWEEN DRAIN AND LOWER BARRIER, M
3-PERMEABILITY BETWEEN ROOT ZONE AND BARRIER, M/DAY
4-MAX. PERMISSIBLE WATER TABLE HEIGHT ABOVE DRAIN, M
5-SLOPE OF LATERAL DRAIN, M/M
2.8 5 1.2 1.8 .01

ENTER VALUES FOR THE COST OF DRAIN PIPES, $/M
==> THIS VALUE INCLUDES THE COST OF LAYING
           ========
1-- 100-MM PIPE
2-- 150-MM PIPE
3-- 200-MM PIPE
5 7.5 8.7

ENTER THE FOLLOWING 4 ITEMS
1-UNIT COST OF EXCAVATION, $/CUBIC M
2-UNIT COST OF BACKFILL, $/CUBIC M
3-UNIT COST OF GRAVEL ENVELOP, $/M DRAIN LENGTH
4-CONTINGENCY COST, PERCENT

.60 .2 .10 10

ENTER THE FOLLOWING 6 ITEMS
 1 -- PERCENT OF COST SUBSIDIZED
 2 -- PERCENT OF COST FINANCED
 3 -- LOAN NO. (1 OR 2)
 4 -- COST OF MAINTENANCE AS A PERCENT OF INVESTMENT
      (2 - 3 % IS SUGGESTED)
 5 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
      AS A PERCENT OF THE ORIGINAL COST
 6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
      (TAXES, INSURANCE, ETC.)
30 50 1 2 50 200

 $    0.00   ..TOTAL COST FOR SUBSURFACE DRAINAGE IN PADDOCK NO.  3
```

Figure 3-15 Computer prompt statements for subroutine SDRAIN

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that the programme has successfully executed as shown by the last few lines in Figure 3-13. Examples of the output files are shown in Figures 4-10 and 4-11 in section 4.4.3.

Descriptions of the main subroutines of the SYSTEMS routine and all other subroutines are described in the following sections.

3.4.1 Subroutine SURFACE

If system type #1 -- Border or type #2 -- Furrow or Corrugate is specified in the SYSTEMS routine, subroutine SURFACE is called to process information for surface systems. Input data required by the subroutine are the flow rate entering the system, hours of operation per day and seepage losses as shown in Figure 3-14.

Soil intake rate characteristics for each paddock (Figure 3-14) are input via subroutine INTAKE that is called by subroutine SURFACE. The intake function for which data are available is specified and the user then enters the coefficient values for that equation.

After intake characteristics are input, control is transferred to either subroutine SURFACEB if the system is border or SURFACEF if it is a furrow system. These subroutines are described in sections 3.4.1.1 and 3.4.1.2. After control returns to subroutine SURFACE, data for the cost, life and type of loan are entered for system components for each paddock. The components are irrigation races, structures, pipelines and pumps. These data are entered via subroutines RACES, STRUCTS, PIPES and PUMPS described in sections 3.3.1 - 3.3.4.

If subsurface drainage is required subroutine SDRAIN is called to estimte draintile spacing and compute the cost for the paddock. Figure 3-15 is a listing of the prompt statements for SDRAIN. Drain spacing is computed using Donnan's Equations and the discharge by a U.S. Bureau

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of Reclamation estimate as described in the programme documentation (Appendix A).

Following data input for each paddock, the programme allows input for system components (races, structures, pipes and pumps) that was not entered for individual paddocks. In addition any other expenses are entered via subroutine OEXP (section 3.3.5). Control is then returned to the SYSTEMS routine.

3.4.1.1. Subroutine SURFACEB

Subroutine SURFACEB is used to input information for border systems. Detailed information for each paddock and crop are entered as shown by the prompt statements in Figure 3-16. The irrigation application efficiency and amounts of water last to deep percolation and surface runoff are computed in subroutine BORDER called by subroutine SURFACEB. If advance and recession data are available they are used to compute the efficiency and losses. If the data are not available, the method used for computing these values is based upon the zero-inertia model (Fangmeier and Strelkoff, 1978; Bassett et al, 1980), using a computer routine written by Allen et al (1978). Subroutine FAMFND (Figure 3-13) is called by BORDER to determine the proper intake family if soil intake characteristics are not specified as an intake family (Equation 5 in Figure 3-14).

Date for labour and landforming costs for border systems are input to subroutine SURFACEB as shown in Figure 3.17.

3.4.1.2 Subroutine SURFACEF

If the application system under consideration is a furrow or corrugation system, subroutine SURFACEF is called. Input data are similar to those for SURFACEB and include paddock slope and dimensions, furrow

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```
ENTER THE FOLLOWING INFORMATION FOR PADDOCK NO.  3
>> 4 PARAMETERS
 1 -- FIELD SLOPE (DECIMAL)
 2 -- BORDER STRIP LENGTH (M)
 3 -- BORDER STRIP WIDTH (M)
 4 -- NO. OF BORDERS IRRIGATED AT ONE TIME
.005 200 12 4

FOLLOWING ARE SOME SUGGESTED VALUES FOR MANNINGS
ROUGHNESS COEFFICIENT (N) FOR DIFFERENT CROPS
IRRIGATED IN BORDER STRIPS
        SMOOTH BARE SOIL SURFACES  . . . . . . . 0.04
        SMALL GRAIN DRILLED PARALLEL TO BORDERS  0.10
        SMALL GRAIN DRILLED ACROSS BORDERS . . . 0.25
        DENSE SOD CROPS  . . . . . . . . . . . . 0.25
        LUCERNE, MINT, BROADCAST SMALL GRAIN . . 0.15
        PASTURE -- SHORT (<50MM) TO TALL (100MM) 0.15 - 0.25
        VINING CROPS SUCH AS PEAS  . . . . . . . 0.3 OR GREATER

ENTER VALUES OF N FOR EACH OF THE FOLLOWING  1 CROPS
     PASTURE1
.16

ADDITIONAL INFORMATION ON BORDER IRRIGATION
 IN PADDOCK NO.  3 FOR CROP ==> PASTURE1

DO YOU HAVE ADVANCE AND RECESSION DATA \\\\\
( Y OR N)

N

TYPE:
    1--IF THE FLOW RATE AND SET TIME ARE TO BE ADJUSTED TO INCREASE EFFICIENCY
    2--IF ONLY THE SET TIME IS TO BE ADJUSTED
    3--IF NEITHER Q NOR SET TIME ARE TO BE ADJUSTED

  NOTE:  THE USUAL RESPONSE IS NO. 2
2

ENTER AN ESTIMATE OF SET TIME IN MINUTES
70


ENTER THE TOTAL LABOR REQUIREMENT -- HOURS PER IRRIGATION
FOR PADDOCK NO.  3 --  16 HECTARES
   NOTE:  ESTIMATED LABOR REQUIREMENTS WITH A STREAM SIZE OF
          230 L/S ARE 3 MIN PER HA PER IRRIGATION FOR AN
          AUTOMATED BORDER SYSTEM AND UP TO 90 MIN PER HA FOR
          A COMPLETELY MANUAL SYSTEM REQUIRING CONSTANT
          ATTENTION
1.2

ENTER THE FOLLOWING 5 ITEMS FOR LAND PREPARATION
FOR PADDOCK NO.  3
   1 -- TOTAL COST OF LAND GRADING AND BORDERING ($)
   2 -- PERCENT SUBSIDIZED
   3 -- PERCENT FINANCED
   4 -- LOAN NUMBER (1 OR 2)
   5 -- ANNUAL COST FOR LAND SMOOTHING AND BORDER MAINTENANCE
5000 50 50 1 150
```

Figure 3-16 Computer prompt statements for subroutine SURFACEB

spacing and flow rate and irrigation application time. If furrow flow rate and/or application time are unknown they are input as zero (0) and subroutine FURROW will adjust these values to obtain the maximum application efficiency. Application efficiency along with the percentages of applied water lost to deep percolation and surface runoff are computed using subroutine FURROW. The procedure used is that developed by the U.S. Dept. of Agriculture Soil Conservation Service (USDA, 1979; Hart et al, 1980). Data for labour and landforming costs are also input to subroutine SURFACEF.

3.4.2 Subroutine SPNKLR

Subroutine SPNKLR is called by SYSTEMS If any of the sprinkler system alternatives are specified. The purpose of this subroutine is to input data and perform calculations using proper subroutines in order to determine the operating characteristics and costs of sprinkler systems. A listing of prompt statements is contained in Figure 3-17.

The flow rate entering the system (system capacity) and time of operation are first entered. Control is then transferred to one of four subroutines depending upon the type of sprinkler system as follows:

Subroutine	Type of Sprinkler System
DISCRETE	Hand-Move, End-Tow or Side Roll
TRAVELR	Travelling Sprinkler (Gun or Boom)
SELFPROP	Self-Propelled (Centre-Pivot or Lateral Move)
SOLIDSET	Solid-Set

These subroutines provide the means to enter information specific to each type of system. Data for system efficiency and operating

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```
THE FOLLOWING INPUTS REFER TO SYSTEM NO. 3 -- HAND-MOVE SPRINKLER

ENTER THE FOLLOWING 4 ITEMS
    1 --  FLOW RATE ENTERING THE SYSTEM (LITERS PER SECOND)
           NOTE:  THE FLOW RATE ENTERING THE SYSTEM MUST
                  CORRESPOND TO THAT SUPPLIED BY THE
                  WATER SUPPLY SYSTEM
    2 -- HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE
    3 -- HOURS PER WEEK ADDITIONAL DOWN TIME WHEN WATER
          IS AVAILABLE TO THE SYSTEM ----> FOR MOVING FROM
          PADDOCK TO PADDOCK, MAINTENANCE ETC.
    4 -- DAYS PER WEEK WATER IS AVAILABLE
30 18 5 7


ENTER THE FOLLOWING 3 ITEMS FOR
SYSTEM NO.  3 -- HAND-MOVE SPRINKLER
  1 -- DISTANCE LATERAL LINE IS MOVED AT EACH SET (M)
  2 -- APPLICATION EFFICIENCY (%)
  3 -- PERCENTAGE OF WATER LOST TO EVAPORATION BEFORE
       COMING IN CONTACT WITH THE CROP CANOPY
18 70 8

INPUT THE FOLLOWING 3 ITEMS FOR PADDOCK NO.  2
  1 -- TOTAL DISTANCE THE SPRINKLER LATERAL IS MOVED (M)
       (PERPENDICULAR TO LATERAL)
  2 -- LABOR REQUIRED PER SET (HR)
  3 -- ADDITIONAL LABOR REQUIRED PER IRRIGATION (HR)
       (FOR TRANSPORTING LINES, SETTING UP ETC.)
250 .8 2


ENTER THE FOLLOWING COST INFORMATION FOR
SPRINKLER SYSTEM NO.  3 -- HAND-MOVE SPRINKLER
   NOTE:  DATA FOR MAINLINES, PUMPS, FITTINGS ETC. ARE
          ENTERED SEPARATELY
 ---- 8 ITEMS
  1 -- NUMBER OF LINES OR UNITS
  2 -- TOTAL CAPITAL COST PER UNIT ($)
  3 -- PERCENT OF COST SUBSIDIZED
  4 -- PERCENT OF COST FINANCED
  5 -- LOAN NO. (1 OR 2)
  6 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  7 -- TOTAL ANNUAL MAINTENANCE COST ($)
  8 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS
       (TAXES, INSURANCE, CONTINGENCIES ETC.)
1 15000 0 60 2 15 250 50


ARE DATA TO BE ENTERED FOR MAINLINES OR ANY OTHER
PIPELINES FOR SYSTEM NO.  3 -- HAND-MOVE SPRINKLER             (Y OR N)
N

ARE DATA TO BE INPUT FOR ANY PUMPS
FOR SYSTEM NO.  3 -- HAND-MOVE SPRINKLER          (Y OR N)
 NOTE: DO NOT INCLUDE ANY PUMPS SPECIFIED IN THE
       WATER SUPPLY ROUTINE!!
N


ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES
FOR SYSTEM NO.  3 -- HAND-MOVE SPRINKLER          (Y OR N)
N

ARE DATA TO BE ENTERED FOR ANY STRUCTURES
FOR SYSTEM NO.  3 -- HAND-MOVE SPRINKLER          (Y OR N)
N

IS LAND GRADING OR PREPARATION NECESSARY
FOR SYSTEM NO.  3 -- HAND-MOVE SPRINKLER          (Y OR N)
N

IS SUBSURFACE DRAINAGE REQUIRED FOR ANY PADDOCK?  (Y OR N)
N

ENTER DATA FOR OTHER EXPENSES
FOR SYSTEM NO.  3 -- HAND-MOVE SPRINKLER
```

Figure 3-17 Computer prompt statements for subroutine SPNKLR

characteristics along with site-specific data for each paddock are entered as shown by the prompt statements from subroutine DISCRETE in Figure 3-17. Similar system and paddock-specific information is required by each of the other three subroutines for the given types of sprinklers.

Once programme control returns to subroutine SPNKLR, cost data for the system are entered as shown in Figure 3-17. As indicated, these data are for the sprinkler lateral and appurtenances. Prompt statements ask the user if any data are to be entered for mainlines or other pipelines, pumps, races and/or structures. If entries are to be made for any of these items, the proper subroutine is called (PIPES, PUMPS, RACES or STRUCTS). Provision is made to enter data for land grading if required, and if subsurface drainage is needed, subroutine SDRAIN (section 3.4.1 and Figure 3-15) is called. Data for any other expenses are then entered and control returns to SYSTEMS.

3.4.3 Subroutine TRICKLE

If the system under consideration is a trickle system, subroutine TRICKLE is used. Input data requirements for TRICKLE are very similar to those for SPNKLR as shown by the prompt statements in Figure 3-18. In addition to operating and cost information for laterals and emitters, data can be entered for pipelines, pumps, races, structures, land grading, system appurtenances and other items directly associated with the system.

3.5 SIMULATE Routine

As implied, the purpose of the SIMULATE routine is to simulate the operation of an irrigation application system. Agronomic and

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```
THE FOLLOWING INPUTS REFER TO SYSTEM NO.  2 -- TRICKLE

ENTER THE FOLLOWING 3 ITEMS
    1 --  FLOW RATE ENTERING THE SYSTEM (LITERS PER SECOND)
           NOTE:  THE FLOW RATE ENTERING THE SYSTEM MUST
                  CORRESPOND TO THAT SUPPLIED BY THE
                  WATER SUPPLY SYSTEM
    2 -- HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE
    3 -- DAYS PER WEEK WATER IS AVAILABLE
15 20 3


ENTER THE FOLLOWING 2 ITEMS FOR
SYSTEM NO.  2 -- TRICKLE
 1 -- APPLICATION EFFICIENCY (%)
 2 -- LABOR REQUIREMENT (HR/DAY)
90 .8


ENTER THE FOLLOWING COST INFORMATION FOR
TRICKLE SYSTEM NO.  2 -- TRICKLE
  NOTE:  DATA FOR MAINLINES, SUBMAINS, PUMPS, FILTERS
          INJECTOR UNITS, ETC. ARE ENTERED SEPARATELY
ENTER THE FOLLOWING 10 ITEMS:
   1 -- LENGTH OF PIPE (M)
   2 -- COST OF PIPE ($/M)
   3 -- TOTAL COST OF EMITTERS & FITTINGS ($)
   4 -- COST OF LAYING ($/M)
        (ENTER 0 (ZERO) FOR ITEMS 3 & 4 IF THE COST IS
         INCLUDED IN THE COST OF THE PIPE.)
   5 -- SALVAGE VALUE AT THE END OF THE  15-YEAR SYSTEM LIFE
        AS A PERCENT OF THE ORIGINAL COST
   6 -- PERCENT OF COST SUBSIDIZED
   7 -- PERCENT OF COST FINANCED
   8 -- LOAN NO. (1 OR 2)
   9 -- TOTAL ANNUAL MAINTENANCE COST ($)
  10 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
        ( TAXES, INSURANCE, CONTINGENCIES ETC.)
16000 .45 2000 0 0 0 60 2 1500 250

ARE DATA TO BE ENTERED FOR MORE TRICKLE LATERALS?  (Y OR N)
N


ARE DATA TO BE ENTERED FOR MAINLINES, SUBMAINS
OR OTHER PIPELINES FOR SYSTEM NO.  2 -- TRICKLE                    (Y OR N)
N

ARE DATA TO BE INPUT FOR ANY PUMPS
FOR SYSTEM NO.  2 -- TRICKLE                      (Y OR N)
 NOTE: DO NOT INCLUDE ANY PUMPS SPECIFIED IN THE
       WATER SUPPLY ROUTINE!!
N


ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES
NFOR SYSTEM NO.  2 -- TRICKLE                     (Y OR N)


ARE DATA TO BE ENTERED FOR ANY STRUCTURES
FOR SYSTEM NO.  2 -- TRICKLE                      (Y OR N)
N

IS LAND GRADING OR PREPARATION NECESSARY
FOR SYSTEM NO.  2 -- TRICKLE                      (Y OR N)
N

IS SUBSURFACE DRAINAGE REQUIRED FOR ANY PADDOCK?  (Y OR N)
N

ENTER DATA FOR OTHER EXPENSES
FOR SYSTEM NO.  2 -- TRICKLE
FOR COMPONENTS SUCH AS FERTILIZER & CHEMICAL INJECTION
EQUIPMENT, FILTERS ETC. FOR WHICH DATA HAVE NOT YET
BEEN ENTERED
```

Figure 3-18 Computer prompt statements for subroutine TRICKLE

irrigation systems data are used to determine the total cost of a system and its ability to supply crop consumptive irrigation requirements.

The majority of input data used by SIMULATE are read from files generated by the CROPADDOCK, SUPPLY and SYSTEMS routines described in sections 3.2, 3.3 and 3.4 (Figure 3-19). Four additional files are required. The names of two are specified, the rainfall file containing daily rainfall data for the period of simulation and the potential evapotranspiration (PET) file containing average monthly values of potential evapotranspiration computed using the modified Penman approach (Jensen, 1974). Two files of agronomic data, CROPDATE and CROPFPOLY described in section 3.1, are read using subroutine AGRON.

Pump tariff data for electrically powered pumps are input if there are any pumps in the supply or application systems. If the tariff structure is not the same for all pumps, the proper response is given, and the tariff is entered for each pump as directed by the programme prompt statements. If the tariff is the same for all pumps, data are requested for only one pump. Provision is made to enter a wide variety of tariff structures including demand charges, block energy charges and nighttime rates. The program would require modification if the rate structure under consideration could not be entered properly or if the energy source were not electricity (e.g. fossil fuel).

The expected inflation rate for energy is input to more accurately compute system operating expenses throughout the life of the system. Data related to labour include the maximum allowable labour input, the labour wage rate and the expected inflation for the wage rate. A third inflation factor for operating and maintenance costs exclusive of

SEG SIMULATE

INPUT DATA FOR THE OPERATION SIMULATION MODULE

-THE MAXIMUM NUMBER OF CHARACTERS IN ANY TITLE IS 32
 WITH NO EMBEDDED BLANKS AND ONLY ALPHANUMERIC CHARACTERS

-ALL NUMERIC DATA ARE ENTERED IN FREE FORMAT (LIST DIRECTED)
 ENTER A DESCRIPTIVE TITLE
SIMULATEEXMPL
 ENTER NAME OF CROP-PADDOCK FILE
CROPADDOCKEXMPL
 ENTER NAME OF IRRIGATION SYSTEMS FILE
SYSTEMSEXMPL
 ENTER NAME OF WATER SUPPLY FILE
SUPPLYEXMPL
 ENTER NAME OF RAINFALL FILE
RAINDAT
 ENTER NAME OF PET FILE
AB703DAT
 IS THE TARIFF STRUCTURE THE SAME FOR ALL PUMPS-Y OR N
Y

ENTER THE FOLLOWING DATA FOR 1 PUMP(S)
THE DATA FOR EACH PUMP MUST BE ENTERED ON A SEPARATE LINE
ALL DATA MUST BE ENTERED IN THE ORDER INDICATED
--IF A PARTICULAR COEFFICIENT IS NOT APPLICABLE, ENTER 0 (ZERO)
--ALL DATA MUST BE SEPARATED BY COMMAS OR SPACES

DEMAND AND SERVICE CHARGES -- 5 ITEMS

INSTALLATION CHARGE	ANNUAL CHARGE		BILLING PD CHARGE	
LUMP SUM $	LUMP $	$/KW	LUMP $	$/KW
(ITEM 1)	(ITEM 2)	(ITEM 3)	(ITEM 4)	(ITEM 5)

0 0 24 0 0

ENERGY CHARGES FOR PUMPING IN DAYTIME

 --6 ITEMS

BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 1A	BLOCK 2A	BLOCK 3A
($/KWH)	($/KWH)	($/KWH)	($/KWH-KW)	($/KWH-KW)	($/KWH-KW)
(ITEM 1)	(ITEM 2)	(ITEM 3)	(ITEM 4)	(ITEM 5)	(ITEM 6)

.045 .032 0 0 0 0

ENTER THE TOTAL NUMBER OF UNITS (KWH OR KWH-KW) THAT
MUST BE USED BEFORE THE RATES IN BLOCKS 2, 3, 2A AND 3A
BECOME EFFECTIVE
 -- 4 ITEMS FOR EACH PUMP

BLOCK 2	BLOCK 3	BLOCK 2A	BLOCK 3A
(KWH)	(KWH)	(KWH-KW)	(KWH-KW)
(ITEM 1)	(ITEM 2)	(ITEM 3)	(ITEM 4)

16200 0 0 0

ENTER THE LENGTH OF PERIOD IN MONTHS USED IN COMPUTING
POWER CHARGES AND THE NUMBER OF MONTHS AFTER JUNE 1 THAT
THE PERIOD BEGINS
 -- 2 ITEMS FOR EACH PUMP
3 0

DOES A DIFFERENT TARIFF APPLY FOR A PERIOD OF TIME
EACH DAY (NIGHT RATE) -- Y OR N
N

ENTER EXPECTED ANNUAL INFLATION RATE FOR ENERGY (PERCENT)
16

Figure 3-19a Computer prompt statements for the

main SIMULATE routine

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```
 ENTER MAXIMUM LABOR INPUT IN HOURS PER WEEK
 25   .

 ENTER LABOR WAGE RATE ($/HR) AND
 EXPECTED  RATE OF INFLATION FOR LABOR (PERCENT)
 5.5 10

 INPUT INFLATION RATE FOR OTHER OPERATING
 AND MAINTENANCE COSTS (PERCENT)               .
 12
  ENTER THE RETURN ON INVESTMENT (PERCENT)
 18


 ENTER BEGINNING AND ENDING YEARS FOR SIMULATION RUN
 54 78


 I AM NOW THINKING, COMPUTING AND TRYING TO DIGEST ALL
 THE DATA YOU HAVE FED ME.  I WILL TELL YOU WHEN I HAVE
 SUCCESSFULLY COMPLETED ALL DETAILS ----- PROVIDED YOU
 HAVE NOT FED ME BAD DATA THAT WILL RESULT IN INDIGESTION!!



 THE JOB IS FINISHED AND OUTPUT IS IN FILE SIMULATEEXMPL
```

Figure 3-19b Computer prompt statements for the

main SIMULATE routine

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(discount rate) is used in computing the overall annual cost used to compare the relative annual costs of alternative systems amortised over the life of the system. After the beginning and ending years of the simulation run are input, a message is printed to show that the computer is processing the simulation. Once the job is finished, the user is notified along with the name of the output file generated by SIMULATE.

In the simulation process agronomic data are used to compute irrigation water requirements for the crops in each paddock at any given time. Crop rotation data are obtained from the CROPADDOCK file. Irrigation systems data read from the SUPPLY and SYSTEMS files are then used in computing the amount of water applied and determining the amount and cause of any deficit should it occur. This procedure is repeated for each half-monthly period within the specified simulation period, and the final output is a summary incorporating the information from individual time periods.

The flowchart in Figure 3-20 shows the major subroutines and functions in the simulation process. As shown, input data are first entered and read from files. After the beginning and ending years of simulation are entered, a crop rotation matrix is set up for each paddock for the entire simulation period. The crop rotation data are those furnished by the CROPADDOCK file. Subroutine AGRON is then called to read the CROPDATE and CROPFPOLY files. The proper beginning positions in the rainfall and potential evapotranspiration files are located via subroutine LOCATE.

The simulation begins on 1 June of the beginning year of simulation and continues through 31 May of the ending year. The time step

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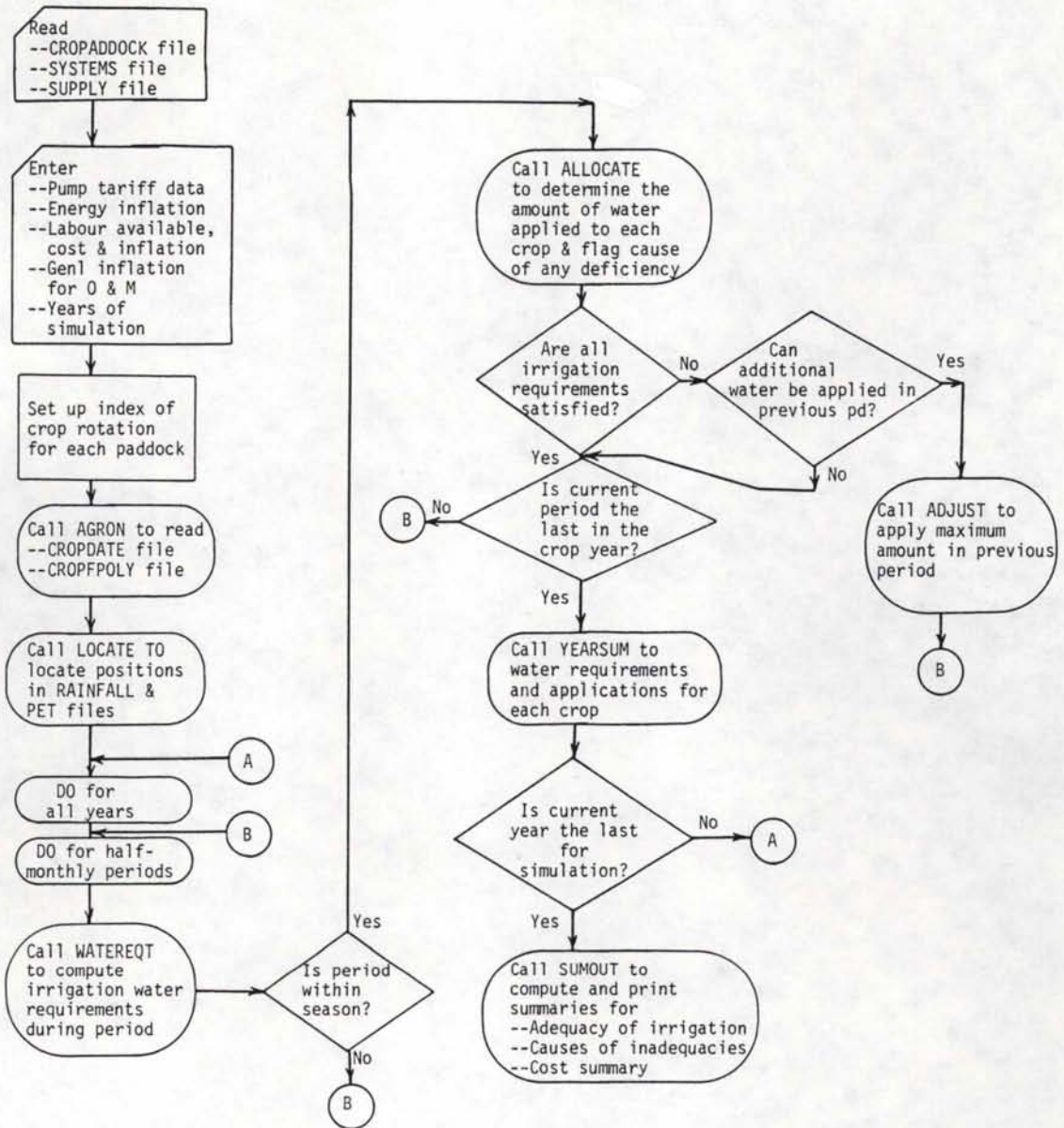
Figure 3-20 Flowchart of SIMULATE routine

used is a half-monthly step. For 31-day months the time steps are 15 and 16 days, and for leap year the 29 days in February are divided into 14 and 15-day periods. The first major subroutine in the simulation loop is the WATEREQT subroutine used to compute the consumptive irrigation requirements during each period and the soil moisture deficit at the end of the period for each paddock. A description of the WATEREQT routine follows in section 3.5.1.

When control returns from WATEREQT, the main programme checks the time step to determine if it is within the irrigation season as specified by CROPADDOCK data. If not, the soil moisture deficit for each paddock is increased by the amount of irrigation requirement for that paddock to a maximum of the total available moisture. If within the irrigation season, subroutine ALLOCATE (section 3.5.2) is called. The purpose of this subroutine is to compute the amount of water applied to each paddock by the proper irrigation application system(s). If a system is not capable of supplying all crop water requirements the cause is determined and flagged.

After subroutine ALLOCATE is called, the main programme checks for two conditions. First, is to check that all water requirements are satisfied for the period. If they are satisfied, simulation proceeds to the next time step. If they are NOT satisfied, the second condition is checked to determine if the system capacity, labour availability or the availability of water would allow additional water to be applied in the previous period contingent upon the soil moisture deficit in any paddock. If this condition is then satisfied subroutine ADJUST described in section 3.5.3 is called. This subroutine is used to compute the additional amount of water that could be applied to bring

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soil moisture levels in as many paddocks as possible to field capacity in the previous period. The purpose of reallocating water in the previous period using ADJUST is to simulate what an irrigator will usually do in irrigating before the normal management allowed deficit (MAD) is depleted to bring the soil to field capacity if dry conditions are expected.

After soil moisture levels are adjusted in subroutine ADJUST for the previous period, subroutine WATEREQT is again called for the present period to compute irrigation requirements and soil moisture deficits based upon the adjusted values. The program then proceeds to call subroutine ALLOCATE a second time for the present period. Subroutine ADJUST is not called a second time if crop water requirements are still not satisfied, and the programme continues to the next half-monthly time step.

After 24 time steps are completed for one year of simulation, subroutine YEARSUM is called to summarize the results for the year as described in section 3.5.4. Yearly results are obtained for all years in the simulation run, and subroutine SUMOUT is called to calculate and print out results. The output details the adequacy of irrigation for all crops in the rotation, the causes of any inadequacies and a cost summary detailing capital and operational costs.

3.5.1 Subroutine WATEREQT

The purpose of subroutine WATEREQT is to compute the irrigation water requirement during a half-monthly period and the resulting soil moisture deficit at the end of the period. Soil moisture deficits at the beginning of the simulation are supplied for all paddocks. The subroutine computes irrigation water requirements utilizing daily

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rainfall and daily evapotranspiration data along with soil moisture levels.

Daily rainfall data are read from the specified rainfall file using subroutine LOAD and are used in computing the daily water balance for each paddock. If daily rainfall exceeds 25 mm it is assumed that 10 percent is lost to surface runoff. If the user wishes to alter this estimate, the value of variable PCT in the subroutine must be changed.

Daily estimates for evapotranspiration are computed from monthly estimates of potential evapotranspiration read from the specified PET file and daily crop coefficients. The PET data are the same as required by the WATERUSE routine (section 3.1) and should be computed using a modified Penman equation (Jensen, 1974). Formats for PET and rainfall data are the same as required by the WATERUSE routine. Daily crop coefficients are computed using polynomials developed by the U.S. Department of Agriculture (Harrington, 1981). The rate of evapotranspiration is increased for a period of three days following a rainfall event (Harrington, 1981) and is decreased as the soil moisture level decreases using a relationship developed by Minhas et al (1974).

The irrigation water required for a paddock during a period is that amount needed to maintain a soil minimum moisture level midway between the beginning soil moisture deficit and the management allowed deficit (MAD) taking rainfall into account. The management allowed deficit is affected by the effective root zone depth that increases linearly from 50 percent to 100 percent of the root zone between planting and effective cover dates. If rainfall exceeds crop water use on a given day, the soil moisture level is adjusted accordingly and there is no irrigation requirement. There is also no irrigation requirement if

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the time is before the planting date or after the harvest date, or if the paddock is fallow. The irrigation water requirement computed for the period is the cumulative total of the daily requirements and the ending soil moisture deficit is that for the last day of the period.

The subroutine may be edited if required. Different methods of estimating daily evapotranspiration may be required depending upon the availability of data and the accuracy of a given method. The rules of water application, effective rainfall and the effects of soil moisture levels on evapotranspiration can also be changed for specific purposes. Any of these changes would require programme editing or writing another subroutine that would be compatible with the entire SIMULATE routine.

3.5.2 Subroutine ALLOCATE

In allocating water to each paddock, the amount of water required and the amount available must be considered in conjunction with irrigation priorities. Irrigation priorities for crops grown in each half-monthly period are read from the CROPADDOCK file. These data are used to establish irrigation priorities for all paddocks in a period.

The gross amount of water available during a period is obtained from the SUPPLY file. Efficiencies of the irrigation supply and application systems are then incorporated to compute the net amount available. System capacity is also checked to compute the net capacity for a period. The total net volume of water required by a paddock during a period is based upon the irrigation requirement computed by subroutine WATEREQT and the area of the paddock.

Water is allocated to each paddock in order of priority, and the subroutine maintains an accounting of all water applied. If the net

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water requirement for a paddock is supplied, the soil moisture level is adjusted to the specified application deficit (sections 2.3.2 and 3.2). If the net requirement exceeds the net amount available due to water availability, system capacity or labour availability, the cause is flagged and the partial amount supplied is computed.

The subroutine computes water allocations until all paddocks are supplied or until a deficiency occurs. At this point, proper values for the net requirement, net application, and gross requirement are added to the proper elements in an accounting array for each paddock in the period under consideration. The causes for any deficiencies are maintained in separate arrays.

3.5.3 Subroutine ADJUST

Subroutine ADJUST is called if all irrigation requirements for a period cannot be supplied and if they were all satisfied for the previous period. The purpose of the subroutine is to compute the amount of water that can be added to each paddock to bring the soil moisture level to field capacity, i.e. the amount of the application deficit specified for the paddock (section 3.2).

Irrigation water is allocated to paddocks in order of the priority established for the previous period. The allocation in the readjustment process continues until all paddocks are at field capacity or until a constraint is reached; system capacity, water availability or labour availability. Soil moisture levels are adjusted accordingly along with the net and gross amounts of water applied in the readjustment for the previous period. The cause of any constraint is also maintained.

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3.5.4 Subroutine YEARSUM

Subroutine YEARSUM is used to collate data for each crop grown. These data are obtained from the paddock-specific data generated by subroutines WATEREQT, ALLOCATE and ADJUST. The following parameters are stored for each half-monthly period:

       Net water requirement

       Net water application

       Net readjustment (from ADJUST)

       Maximum readjustment

       Net deficit

       Maximum deficit

       Number of times crop appears

       Number of times crop requires water

       Number of times water demands are not met

       Number of times water is added by readjustment

All water requirements, applications and deficits are calculated for each crop as an average volume per unit area or depth.

Period-specific data are saved for each system -- water supply and all application systems. These data include the following:

       Total volume entering the system

       Number of times system is required

       Number of times system size is limiting

The number of times that water supply or labour are limiting factors are maintained in a separate array.

3.5.5 Subroutine SUMOUT

After data have been processed for all years in the simulation process, subroutine SUMOUT is called to summarize and print out the

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results. Summaries are computed for (1) the adequacy of irrigation for each crop, (2) irrigation system performance and the causes of any inadequacies in irrigation and (3) system cost.

Detailed crop irrigation summaries are computed for each crop using the yearly results obtained from subroutine YEARSUM. Data are computed for each half-monthly period throughout the year for the following parameters (Units of the parameters are shown in parentheses.):

> Average irrigation requirement (mm)
>
> Percent of time irrigation is required (%)
>
> Average requirement when irrigation is required (mm)
>
> Average applied when required (mm)
>
> Percent of time requirement is greater than that applied (%)
>
> Average deficit when irrigation is required (mm)
>
> Maximum deficit (mm)
>
> Average readjustment (mm)
>
> Maximum readjustment (mm)

The values computed for each period are averages for all years in the simulation run. In addition, seasonal totals are computed for average irrigation requirement, average requirement when irrigation is required, average applied when required, average deficit when irrigation is required and average readjustment. Crop summaries generated by this portion of SUMOUT are shown in Figure 4-14, section 4.5. The discussion in that section focuses on interpretation of the results presented.

The causes of any deficits in supplying crop demands are gleaned from the various flags raised in the simulation process when the

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irrigation requirement could not be met in a given period. Deficits may be attributed to any of these factors; water supply, availability of labour and system capacity. The water supply and labour constraints pertain to the entire system while limitations in system capacity are identified for each application system under consideration. The results are presented in Figure 4-15, section 4.5 and show the percent of time deficits occur in any period when water is required due to any of the constraints.

The capital and operating costs for all systems are computed using the cost data input via the SUPPLY and SYSTEMS routines, and the SIMULATION routine in conjunction with the volumes of water supplied and applied through each system as determined in the simulation run. The average volumes of water for each period are used in determining costs. Therefore, the operational costs presented are those that could be expected for average conditions.

Costs for each system are computed and presented separately. A summary of all input costs is first printed (Figure 4-16, section 4.5) that summarizes input data including the total costs for attached and non-attached components and the appropriate loan terms along with the return on investment and inflation factors. If any pumps are included in the system, pumping costs are computed based upon the amount of water pumped, total dynamic pumping head, pump efficiency and the appropriate pump tariff.

An array of itemized costs for the system is then developed for each year in the specified system life as shown in Figure 4-16, section 4.5. Capital cost elements consist of repayment, interest and total capital costs, and operating costs are itemized for labour, energy,

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maintenance and miscellaneous items along with the total annual operating cost. The total overall cost as a sum of capital and operating costs is also computed for each year. All yearly costs take into account the various inflation factors and all subsidies.

In addition to yearly costs an overall annual cost is computed. This cost is the average annual cost that would exist over the specified life of the system considering both inflation factors and the rate of return. These annual costs provide a good basis for comparing the costs of two or more systems that have different capital and operating costs or different loan terms. Two overall annual costs are computed, one that includes subsidies and one that does not. An irrigator would use the value that includes subsidies for comparative purposes whereas a planner in a government agency concerned with the total system cost would consider the figure that excludes subsidies.

CHAPTER 4

MODEL APPLICATION

In applying the farm irrigation systems analysis (FISA) model, the user should have a basic understanding of the procedures involved. The overview of the individual procedures presented in Chapter 3 provides descriptions of the computational processes used. In addition it is important to realize the purpose for which the model is intended and to interpret the output results in a proper manner. An example application of the model is presented in this chapter to show how a problem can be formulated, data input and results interpreted.

4.1 Purpose of FISA

As a prelude to problem formulation and model application, the user should be aware of the overall purpose of the model. The FISA procedures are designed to be used as a planning tool and not as a management aid. As a planning tool it is used to determine the projected operation of an irrigation system on a given farm. The resulting overall operation and cost of the system should parallel the FISA results obtained. The advantage in using such an approach is that a planner, advisor and/or farmer can make objective comparisons between different systems and/or the effects of different cropping and management practices.

In contrast to a planning model, a management model is used to make real time (day-to-day or week-to-week) decisions. An example of a management model is an irrigation scheduling procedure used to provide information for management decisions regarding actual system operation.

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4.2 Problem Formulation

In formulating a problem for analysis it is first necessary to obtain plan and topographic data of the area under consideration. This information is necessary to determine the sizes and shapes of the paddocks involved along with their slopes. The location of the water supply should also be considered and its elevation if a surface source. Agronomic data are also required for each paddock that consist of the crop rotation and plant-soil-water parameters of TAM, MAD and AD (Section 2.3.2).

A plan of the example farm under consideration is shown in Figure 4-1. There are four paddocks with a total area of 52 ha. The crop rotation in paddocks #1 and #2 is such that there is one crop other than grass in cultivation each year. Paddocks #3 and #4 are in permanent pasture.

4.3 Estimated Irrigation Water Requirements

The first step in the systems analysis process should be an analysis of the estimated net irrigation water requirements for the area under consideration. The WATERUSE routine is used for this purpose. Input data for the example are shown in Figure 4-2 as responses to the prompt statements of the routine. The rainfall and potential evapotranspiration (PET) files used should be from data collected as close as possible to the site under consideration. Values for TAM and MAD should be approximate weighted averages for all crop paddock combinations; 80 mm and 60 mm for this example.

In entering the crop rotation data, 8 paddocks are specified to more accurately represent the crop mix at any time. Three-fourths of

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PADDOCK No. 1
16 HECTARES
4-YEAR CROP ROTATION

Year	Crop	TAM (mm)	AD (mm)	MAD (mm)
1	Wheat	80	10	50
	Greenfeed	80	10	60
2	Peas	75	10	50
	New grass	60	0	40
3	Pasture	80	10	60
4	Pasture	80	10	60

Side-roll sprinkler lateral used to irrigate all four paddocks

PADDOCK No. 3
16 HECTARES
CONTINUOUS PASTURE

Crop	TAM (mm)	AD (mm)	MAD (mm)
Pasture	80	0	60

Sprinkler mainline

PADDOCK No. 2
10 HECTARES
4-YEAR CROP ROTATION

Year	Crop	TAM (mm)	AD (mm)	MAD (mm)
1	Pasture	100	10	70
2	Pasture	100	10	70
3	Wheat	100	10	60
	Greenfeed	90	10	60
4	Peas	90	10	50
	New grass	80	0	50

PADDOCK No. 4
10 HECTARES
CONTINUOUS PASTURE

Crop	TAM (mm)	AD (mm)	MAD (mm)
Pasture	80	0	60

400 m

400 m

400 m

250 m

Well & pump

Supply pipe

160 m

Booster pump

Figure 4-1 Plan of example farm

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```
SEG WATERUSE
 ENTER ALL VALUES IN FREE FORMAT
 ENTER HEADING (<=20 CHARS)
WATERUSEEXMPL
 ENTER YEARS OF BEGINNING AND ENDING SEASONS
54  78
 ENTER NAME OF RAINFALL FILE
RAINDAT
 ENTER NAME OF PET FILE
AB703DAT
 ENTER TOTAL AVAILABLE MOISTURE - TAM (MM)
80
 ENTER MGT ALLOWED DEFICIT - MAD (MM)
60
 ENTER STARTING SOIL MOISTURE DEFICIT (MM)
0


 CROP MENU FOR 23 CROPS FROM CROPDATE FILE
 CROP ID NO. AND CROP NAME
     1 WINTER WHEAT1         2 SPRING WHEAT1
     3 SPRING WHEAT2         4 SPRING WHEAT3
     5 BARLEY1               6 BARLEY2
     7 BARLEY3               8 PEAS1
     9 PEAS2                10 PEAS3
    11 PEAS4                12 WHTCLOVER1
    13 WHTCLOVER2           14 WHTCLOVER3
    15 RYEGRASS 1           16 PASTURE1
    17 PASTURE2             18 PASTURE3
    19 PASTURE4             20 GREENFEED1
    21 GREENFEED2           22 GREENFEED3
    23 CULTIVATION


 ENTER NUMBER OF PADDOCKS IN ROTATION
8
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK          1
1 20
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK          2
8 17
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK          3
16 16
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK          4
16,16
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK          5
16 16
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK          6
16 16
 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK          7
16 16

 ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK          8
16 16
 ENTER THE NUMBER OF CUMULATIVE PERIODS
6
 ENTER THE CUMULATIVE PERIODS (DAYS)
7 10 14 21 28 36
 PRINTOUT OF WEEKLY WATER USE -- Y OR N
N
 PRINTOUT OF MAX ANNUAL WATER USE - Y OR N
Y


 I AM NOW THINKING AND TRYING TO DIGEST ALL THE DATA
 YOU HAVE FED ME.  I WILL TELL YOU WHEN I AM FINISHED.
 --- PROVIDED YOU HAVE NOT FED ME BAD DATA THAT WILL
 RESULT IN INDIGESTION!!!!!


 THE PROGRAM HAS SUCCESSFULLY EXECUTED
 AND THE OUTPUT IS IN FILE WATERUSEEXMPL
```

Figure 4-2   Example input data to WATERUSE routine

the paddocks are in grass at any given time, and the non-grass cropping sequence for paddocks #1 and #2 is a two-year cycle. Therefore, by specifying 8 paddocks, the crops in 6 of the paddocks can be designated as pasture (crop no. 16) with the other two being the winter wheat-greenfeed (crop nos. 1 and 20) and peas-new grass (crop nos. 8 and 17) sequence.

The cumulative periods specified should bracket the expected irrigation intervals. Enough periods should be used to provide an indication of the cumulative effects. If too many are used, the plotted output becomes "cluttered".

Figure 4-3 is output from the WATERUSE routine. Figure 4-3a is a summary of the input data along with the total annual irrigation requirements for each paddock. The annual irrigation requirements are printed only if requested. In the annual requirements printout crops remain in the same paddocks so that the requirements listed for paddock #1 are for the winter wheat greenfeed combination, paddock #2 for the peas-new grass and the rest for pasture. The soil moisture status is "rotated" as described in section 3.1. Weekly requirements can also be printed if desired, and the printout can be quite voluminous if the simulation period is long.

The plot in Figure 4-3b is a frequency distribution of the maximum net consumptive irrigation requirements for the different cumulative periods. The results for each period are represented by a letter as designated. For example, a cumulative period of 10 days is represented by the letter B. If a certain letter does not appear in a position, the same plotted value is shared with another period, designated by the next letter in the alphabet as in the case of the 5-percent

CUMULATIVE IRRIGATION REQUIREMENTS -- WATERUSEEXMPL

FIRST SEASON   1954
FINAL SEASON   1978
RAINFALL FILE   RAINDAT
PET FILE   AB703DAT
TOTAL AVAILABLE MOISTURE (MM)   80.0
MANAGEMENT ALLOWED DEFICIT (MM)   60.0
BEGINNING SOIL MOISTURE DEFICIT (MM)   0.0
NO. OF PADDOCKS -- 8
CROP ID NOS. -- 1 20   8 17   16 16   16 16   16 16   16 16   16 16   16 16

CROP MENU FOR 23 CROPS FROM CROPDATE FILE
CROP ID NO. AND CROP NAME
    1 WINTER WHEAT1   2 SPRING WHEAT1
    3 SPRING WHEAT2   4 SPRING WHEAT3
    5 BARLEY1   6 BARLEY2
    7 BARLEY3   8 PEAS1
    9 PEAS2   10 PEAS3
   11 PEAS4   12 WHTCLOVER1
   13 WHTCLOVER2   14 WHTCLOVER3
   15 RYEGRASS 1   16 PASTURE1
   17 PASTURE2   18 PASTURE3
   19 PASTURE4   20 GREENFEED1
   21 GREENFEED2   22 GREENFEED3
   23 CULTIVATION

TOTAL ANNUAL IRRIGATION REQUIREMENTS IN MM
==

YEAR AND PADDOCK

	1	2	3	4	5	6	7	8
54	162.1	133.0	311.3	311.3	311.3	311.3	311.3	311.3
55	157.4	157.6	404.0	404.0	404.0	404.0	404.0	404.0
56	15.6	26.0	197.6	197.6	197.6	197.6	197.6	197.6
57	70.2	33.4	138.8	138.8	138.8	138.8	138.8	138.8
58	83.3	75.8	240.5	240.5	240.5	240.5	240.5	240.5
59	94.5	134.0	322.2	322.2	322.2	322.2	322.2	322.2
60	28.9	0.0	83.7	83.7	83.7	83.7	83.7	83.7
61	215.2	168.2	366.3	366.3	366.3	366.3	366.3	366.3
62	147.1	114.6	294.3	294.3	294.3	294.3	294.3	294.3
63	147.8	161.2	364.7	364.7	364.7	364.7	364.7	364.7
64	183.8	130.5	286.6	286.6	286.6	286.6	286.6	286.6
65	67.9	40.8	145.4	145.4	145.4	145.4	145.4	145.4
66	63.4	71.2	232.4	232.4	232.4	232.4	232.4	232.4
67	57.3	75.3	179.9	179.9	179.9	179.9	179.9	179.9
68	124.1	129.4	331.5	331.5	331.5	331.5	331.5	331.5
69	119.1	88.6	218.3	218.3	218.3	218.3	218.3	218.3
70	113.2	157.5	308.9	308.9	308.9	308.9	308.9	308.9
71	132.7	156.9	335.1	335.1	335.1	335.1	335.1	335.1
72	126.3	184.7	365.6	365.6	365.6	365.6	365.6	365.6
73	140.5	101.8	267.4	267.4	267.4	267.4	267.4	267.4
74	88.9	73.5	194.5	194.5	194.5	194.5	194.5	194.5
75	103.4	116.1	244.2	244.2	244.2	244.2	244.2	244.2
76	93.1	118.3	211.1	211.1	211.1	211.1	211.1	211.1
77	214.7	245.4	407.5	407.5	407.5	407.5	407.5	407.5
78	67.6	71.5	248.9	248.9	248.9	248.9	248.9	248.9

RESULTS FOR ALL CUMULATIVE PERIODS

CUMULATIVE PERIODS IN DAYS

7	10	14	21	28	36
4.54	4.43	4.43	4.10	4.03	3.67
4.51	4.41	4.28	4.01	3.80	3.54
4.51	4.26	4.16	3.88	3.75	3.46
4.47	4.16	4.13	3.86	3.63	3.45
4.39	4.10	4.09	3.84	3.46	3.31
4.33	4.07	4.01	3.74	3.43	3.29
4.29	4.04	3.92	3.71	3.42	3.27
4.21	4.00	3.85	3.56	3.42	3.18
4.15	3.99	3.79	3.51	3.28	2.87
4.06	3.99	3.78	3.48	3.28	2.86
4.05	3.98	3.75	3.47	3.05	2.85
4.05	3.84	3.67	3.36	2.95	2.83
4.02	3.76	3.56	3.16	2.94	2.75
3.98	3.65	3.54	3.06	2.87	2.62
3.96	3.61	3.48	3.03	2.84	2.62
3.90	3.61	3.45	3.03	2.73	2.56
3.70	3.60	3.27	2.92	2.66	2.50
3.64	3.56	3.20	2.65	2.55	2.47
3.63	3.46	3.16	2.57	2.32	2.33
3.61	3.31	3.11	2.57	2.28	2.23
3.51	3.26	3.08	2.56	2.25	2.09
3.38	3.23	2.93	2.55	2.23	2.04
3.18	3.08	2.67	2.53	2.09	1.81
3.00	2.61	2.65	2.28	1.98	1.54
2.77	2.57	2.39	2.05	1.72	1.36

Figure 4-3a Example output from WATERUSE routine

Figure 4-3b Example output from WATERUSE routine

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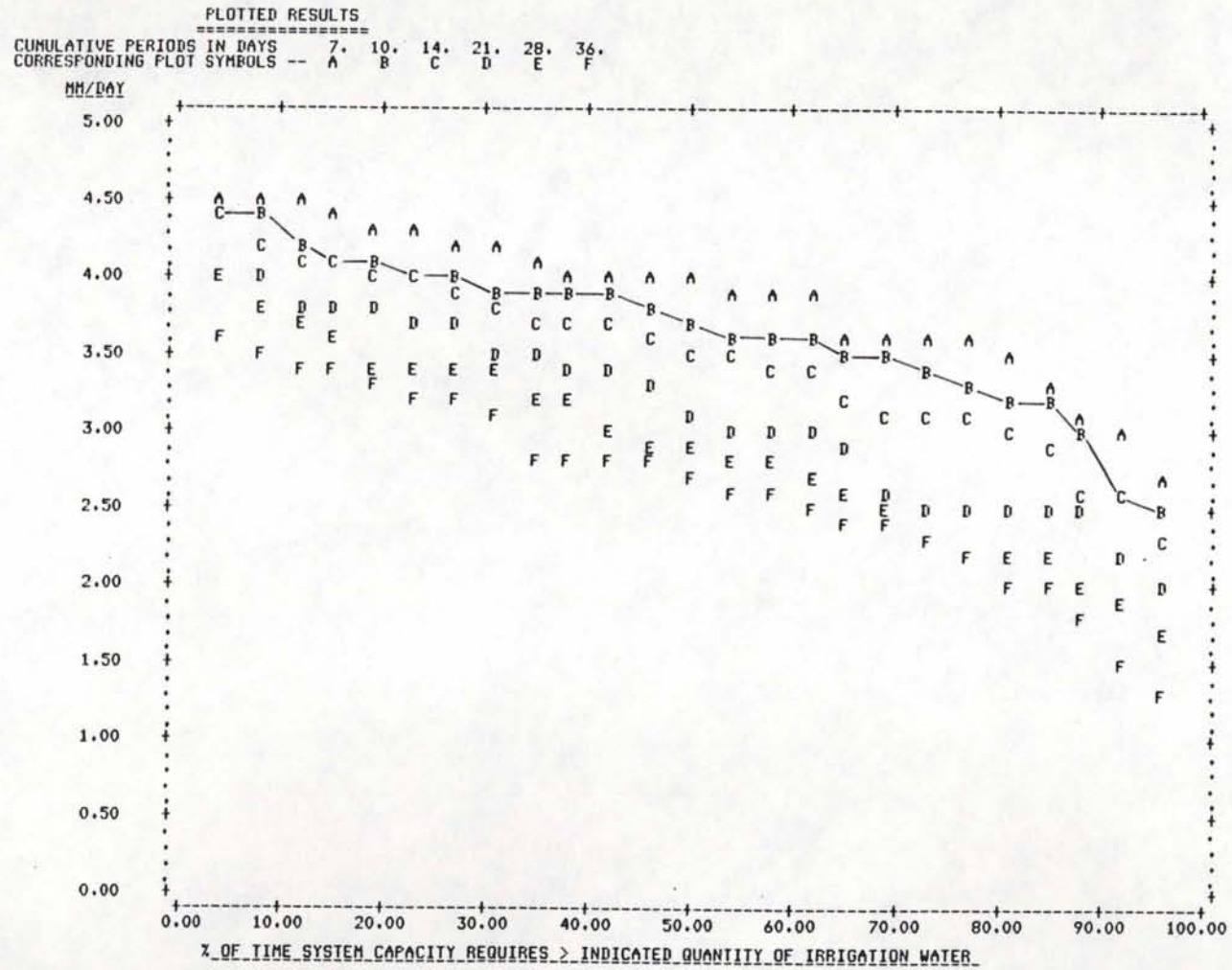
level for the 10-day period where the letter C represents both the 10 and 14-day periods. It is suggested that coloured lines be drawn for all periods as shown for the 10-day period.

Results from the plot show that for a 10-day cumulative period a net irrigation requirement of 4 mm/day will be exceeded 25 percent of the time, and a requirement of 3.5 mm per day would be exceeded 65 percent of the time. The 3.5 mm net requirement is equivalent to a flow rate of 21.1 L/s for the 52 ha farm. This information can be used to conjunctively consider the effects of crop rotation and distribution, system capacity and water availability, and the level of risk involved. In addition to the area served, system capacity is influenced by the irrigation interval (cumulative period) and the risk level.

The level of risk is an important factor especially in an area whose rainfall can contribute a significant portion of the crop water requirements, and it is influenced by the value of the crop(s) irrigated. For example, if a system were being considered for a high-value horticultural crop the system capacity should be great enough so that irrigation water requirements would be exceeded little if any. However if the irrigated crop were pasture, the cost of supplying water 100 percent of the time may well not be warranted. The plot of Figure 4-3b provides the means of quantitatively determining the risk levels of different system capacities.

The ranked values for different cumulative periods as plotted are also listed as shown in Figure 4-3a. These data may be used for further analysis if desired or for plotting on probability paper.

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It should be emphasized that the water use rates plotted are annual peak rates. These are useful in determining peak system capacity. However, a more detailed system analysis is required to evaluate how well a system will function throughout an irrigation season especially when considering irrigation priorities for different crops.

4.4 Irrigation Systems Components

Preliminary decisions can be made on the types and sizes of irrigation systems components based upon net water requirements, farm layout and irrigation desires. For the example in Figure 4-1 a side-roll sprinkler is to be considered with the water supply being a well as shown. The water supply system incorporates the well pump and 160 m of pipe supplying the booster pump. The application system then consists of the booster pump, mainline and sprinkler lateral. Before systems data are entered, site-specific information incorporating agronomic data is obtained using the CROPADDOCK routine.

4.4.1 CROPADDOCK Data and Output

Data for the example as input to the CROPADDOCK routine are shown in Figure 4-4. In addition to the information from Figure 4-1, the begining and ending months of the irrigation season are specified. Also input are the irrigation priorities for all half-monthly periods in the irrigation season.

The output from the routine (Figure 4-5) is a formatted file required as input for the SYSTEMS and SIMULATION routines.

```
SEG CROPADDOCK


>>> PROGRAM FOR SETTING UP CROP-PADDOCK FILE <<<

NOTE:   ALL NUMERIC DATA ARE FREE FORMAT (LIST-DIRECTED) INPUT
        NUMBERS MUST BE SEPARATED BY COMMAS OR SPACES


INPUT A DESCRIPTIVE TITLE TO BE USED IN NAMING
THE CROP PADDOCK FILE GENERATED
  -- <20 CHARACTERS AND NO BLANKS

CROPADDOCKEXAMPL

ENTER THE NUMBER OF PADDOCKS (MAX OF 20)
4

ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS
IN CROP ROTATION FOR PADDOCK NO.  1
16 4

ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS
IN CROP ROTATION FOR PADDOCK NO.  2
10 4

ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS
IN CROP ROTATION FOR PADDOCK NO.  3
16 1

ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS
IN CROP ROTATION FOR PADDOCK NO.  4
16 1

NAME THE FIRST MONTH OF THE IRRIGATION SEASON
SEPTEMBER
NAME THE LAST MONTH OF THE IRRIGATION SEASON
APRIL


CROP MENU FOR 23 CROPS FROM CROPDATE FILE
CROP NO. AND NAME WITH PLANTING AND HARVEST DATES

   1 WINTER WHEAT1    JUL  1   DEC 31      2 SPRING WHEAT1   AUG  1   DEC 31
   3 SPRING WHEAT2    SEP  1   DEC 31      4 SPRING WHEAT3   OCT  1   JAN 16
   5 BARLEY1          SEP  1   DEC 31      6 BARLEY2         OCT  1   JAN 16
   7 BARLEY3          NOV  1   JAN 31      8 PEAS1           AUG  1   DEC 31
   9 PEAS2            SEP  1   JAN  6     10 PEAS3           OCT  1   JAN 16
  11 PEAS4            NOV  1   JAN 31     12 WHTCLOVER1      JUN  1   DEC 31
  13 WHTCLOVER2       JUN  1   JAN 31     14 WHTCLOVER3      JUN  1   FEB 28
  15 RYEGRASS 1       JUN  1   DEC 31     16 PASTURE1        JUN  1   MAY 31

  17 PASTURE2         FEB  1   MAY 31     18 PASTURE3        MAR  2   MAY 31
  19 PASTURE4         APR  1   MAY 31     20 GREENFEED1      FEB  5   MAY 31
  21 GREENFEED2       MAR  2   MAY 31     22 GREENFEED3      APR  1   MAY 31
  23 CULTIVATION      JUN  1   MAY 31

ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR
THE  4 YEAR ROTATION IN PADDOCK  1
  NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR
          FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)
FOR ITEMS ARE ENTERED FOR EACH CROP:
  1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),
  3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)

DATA FOR YEAR NO.  1
CROP NO., TAM, MAD, AD
1 80 50 10
80 80 60 10

DATA FOR YEAR NO.  2
CROP NO., TAM, MAD, AD
8 75 50 10
17 60 40 0
```

Figure 4-4a   Example input data to

CROPADDOCK routine

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```
       DATA FOR YEAR NO.  3
       CROP NO., TAM, MAD, AD
       16 80 60 10
       16 80 60 10

       DATA FOR YEAR NO.  4
       CROP NO., TAM, MAD, AD
       16 80 60 10
       16 80 60 10

     ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR
     THE  4 YEAR ROTATION IN PADDOCK  2
        NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR
                FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)
     FOUR ITEMS ARE ENTERED FOR EACH CROP:
        1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),
        3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)

     DATA FOR YEAR NO.  1
     CROP NO., TAM, MAD, AD
     16 100 70 10
     16 100 70 10

     DATA FOR YEAR NO.  2
     CROP NO., TAM, MAD, AD
     16 100 70 10
     16 100 70 10

      DATA FOR YEAR NO.  3
      CROP NO., TAM, MAD, AD
      1 100 60 10
      20 90 60 10

     DATA FOR YEAR NO.  4
     CROP NO., TAM, MAD, AD
     8 90 50 10
     17 80 50 0

     ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR
     THE  1 YEAR ROTATION IN PADDOCK  3
        NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR
                FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)
     FOUR ITEMS ARE ENTERED FOR EACH CROP:
        1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),
        3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)

     DATA FOR YEAR NO.  1
     CROP NO., TAM, MAD, AD
     16 80 60 0
     16 80 60 0

     ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR
     THE  1 YEAR ROTATION IN PADDOCK  4
        NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR
                FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)
     FOUR ITEMS ARE ENTERED FOR EACH CROP:
        1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),
        3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)

     DATA FOR YEAR NO.  1
     CROP NO., TAM, MAD, AD
     16 80 60 0
     16 80 60 0
```

Figure 4-4b Example input data to

CROPADDOCK routine

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```
THE FOLLOWING  6 CROPS ARE GROWN
     CROP NO. & NAME
          1   WINTER WHEAT1
          8   PEAS1
         16   PASTURE1
         17   PASTURE2
         20   GREENFEED1
         23   CULTIVATION

ENTER IRRIGATION PRIORITIES FOR CROPS FOR ALL
2-WEEK PERIODS THROUGHOUT THE YEAR WITH 1 BEING TOP
PRIORITY, 2 BEING SECOND ETC.


ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF SEP
   1   8 16 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF SEP
   1   8 16 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF OCT
   1   8 16 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF OCT
   1   8 16 23
2 1 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF NOV
   1   8 16 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF NOV
   1   8 16 23
2 1 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF DEC
   1   8 16 23
3 2 1 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF DEC
   1   8 16 23
3 2 1 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  2 CROPS GROWING IN THE FIRST  HALF OF JAN
  16 23
1 2

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  2 CROPS GROWING IN THE SECOND HALF OF JAN
  16 23
1 2

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE

FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF FEB
  16 17 20 23
2 1 3 4
```

Figure 4-4c Example input data to

CROPADDOCK routine

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```
ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF FEB
16 17 20 23
3 1 2 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF MAR
16 17 20 23
3 2 1 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF MAR
16 17 20 23
1 2 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE FIRST  HALF OF APR
16 17 20 23
2 1 3 4

ENTER IRRIGATION PRIORITIES IN ORDER FOR THE
FOLLOWING  4 CROPS GROWING IN THE SECOND HALF OF APR
16 17 20 23
1 3 2 4
 THE OUTPUT IS IN FILE CROPADDOCKEXAMPL
 LIST THE FILE TO CHECK DATA
```

Figure 4-4d Example input data to

CROPADDOCK routine

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7-MONTH IRRIGATION SEASON
THE FIRST MONTH OF THE SEASON IS NO. 9 -- SEP
THE LAST MONTH OF THE SEASON IS NO. 4 -- APR

THE TOTAL NUMBER OF PADDOCKS IS 4

VALUES FOR PADDOCK NO. 1
    16.0 HECRTARES
    4-YEAR CROP ROTATION

| | - - - - FIRST CROP - - - - | | | | - - - - SECOND CROP - - - | | | |
ROTATION YEAR	CROP NO.	TAM (MM)	AD (MM)	MAD (MM)	CROP NO.	TAM (MM)	AD (MM)	MAD (MM)
1	1.	80.0	10.0	50.0	20.	80.0	10.0	60.0
2	8.	75.0	10.0	50.0	17.	60.0	0.0	40.0
3	16.	80.0	10.0	60.0	16.	80.0	10.0	60.0
4	16.	80.0	10.0	60.0	16.	80.0	10.0	60.0

VALUES FOR PADDOCK NO. 2
    10.0 HECRTARES
    4-YEAR CROP ROTATION

| | - - - - FIRST CROP - - - - | | | | - - - - SECOND CROP - - - | | | |
ROTATION YEAR	CROP NO.	TAM (MM)	AD (MM)	MAD (MM)	CROP NO.	TAM (MM)	AD (MM)	MAD (MM)
1	16.	100.0	10.0	70.0	16.	100.0	10.0	70.0
2	16.	100.0	10.0	70.0	16.	100.0	10.0	70.0
3	1.	100.0	10.0	60.0	20.	90.0	10.0	60.0
4	8.	90.0	10.0	50.0	17.	80.0	0.0	50.0

VALUES FOR PADDOCK NO. 3
    16.0 HECRTARES
    1-YEAR CROP ROTATION

| | - - - - FIRST CROP - - - - | | | | - - - - SECOND CROP - - - | | | |
ROTATION YEAR	CROP NO.	TAM (MM)	AD (MM)	MAD (MM)	CROP NO.	TAM (MM)	AD (MM)	MAD (MM)
1	16.	80.00	0.0	60.0	16.	80.0	0.0	60.0

VALUES FOR PADDOCK NO. 4
    10.0 HECRTARES
    1-YEAR CROP ROTATION

| | - - - - FIRST CROP - - - - | | | | - - - - SECOND CROP - - - | | | |
ROTATION YEAR	CROP NO.	TAM (MM)	AD (MM)	MAD (MM)	CROP NO.	TAM (MM)	AD (MM)	MAD (MM)
1	16.	80.0	0.0	60.0	16.	80.0	0.0	60.0

IRRIGATION PRIORITIES FOR THE 6 CROPS GROWN
AS INDICATED BY THE FOLLOWING CROP ID NOS.

MONTH	HALF	DECREASING IRRIGATION PRIORITY - - - - ->					
SEP	FIRST	1	8	16	23	0	0
SEP	SECOND	1	8	16	23	0	0
OCT	FIRST	1	8	16	23	0	0
OCT	SECOND	8	1	16	23	0	0
NOV	FIRST	1	8	16	23	0	0
NOV	SECOND	8	1	16	23	0	0
DEC	FIRST	16	8	1	23	0	0
DEC	SECOND	16	8	1	23	0	0
JAN	FIRST	16	23	0	0	0	0
JAN	SECOND	16	23	0	0	0	0
FEB	FIRST	17	16	20	23	0	0
FEB	SECOND	20	16	17	23	0	0
MAR	FIRST	20	17	16	23	0	0
MAR	SECOND	16	17	20	23	0	0
APR	FIRST	17	16	20	23	0	0
APR	SECOND	16	20	17	23	0	0

Figure 4-5   Example output from
CROPADDOCK routine

4.4.2 SUPPLY Data and Output

As the purpose of the SUPPLY routine is to develop a summary of the operating characteristics and costs of the supply system, data must be furnished for all components of the system. These inputs are shown in Figure 4-6. Following is a brief description of the input data for the example.

A title used in naming the output files is first entered followed by the expected life of the system. The loan terms entered are those used by the Rural Bank in July, 1982 for attached and non-attached components. A water supply of 30 L/s is available continuously. This gross flow rate compares to a net flow rate of 21 L/s (section 4.3) considering a system efficiency of 70 percent. There is no charge for the water as it is pumped from a well. If the water source were an irrigation scheme, the proper charge for water would be entered. As all water is conveyed in a pipeline there is no loss to seepage or evaporation, and no data are entered for races or structures.

Pipeline data are entered for the 160 m supply pipe. The pipeline is buried and is therefore financed under loan no. 1. The pipe has a cost of $9.50/m, the total cost of fittings is $150.00 and the cost of laying is $1.90/m. The salvage value is 15 percent of the original cost after 20 years. None of the cost is subsidized, but 100 percent is financed. Annual maintenance and miscellaneous costs are $100.00 and $25.00, respectively.

Data for the pump and well are entered next. The identification number for the pump is 1 and is entered first followed by flow, hydraulic head and efficiency data. The pump has a flow rate of 30 L/s (same as the supply), discharge and inlet pressures of 100 kPa and 0

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```
    SEG SUPPLY


 ENTER A DESCRIPTIVE NAME FOR THE OUTPUT FILE
 WITH <20 CHARACTERS AND NO EMBEDDED BLANKS
 SUPPLYEXMPL

 ENTER SYSTEM LIFE IN YEARS
 20

 SEPARATE LOAN TERMS ARE CONSIDERED FOR
 ATTACHED ITEMS -- LOAN NO. 1 AND
 UNATTACHED ITEMS -- LOAN NO. 2

 ENTER INTEREST RATE (PERCENT) AND
 TIME OF LOAN (YEARS) FOR LOAN NO. 1
 9 15

 ENTER INTEREST RATE (PERCENT) AND
 TIME OF LOAN (YEARS) FOR LOAN NO. 2
 14 7


 ENTER WATER SUPPLY DATA -- 2 ITEMS
   1 -- FLOW RATE ENTERING THE SYSTEM   (L/S)
   2 -- DAYS PER WEEK THIS FLOW RATE IS AVAILABLE
 30 7


 ENTER WATER COST DATA -- 3 ITEMS
   1 -- $ PER 1000 CUBIC M   (VOLUME)
   2 -- $ PER L/S   (FLOW RATE)
   3 -- $ LUMP SUM

   NOTE: ENTER 0 (ZERO) FOR THOSE ITEMS THAT DO NOT APPLY
         DO NOT INCLUDE ANY POWER CHARGES
 0 0 0

 FOLLOWING ARE ESTIMATES OF SEEPAGE LOSS
 FOR THE FLOW RATE ENTERING THE SYSTEM
    SEEPAGE LOSS
    (L/S PER 100 M)
          0.0  ..WELL MAINTAINED CONCRETE LINING
          0.1  ..CEMENTED GRAVEL & HARDPAN WITH SANDY LOAM
          0.1  ..CLAY AND CLAYEY LOAM
          0.1  ..SANDY LOAM
          0.1  ..VOLCANIC ASH
          0.2  ..SAND OR VOLCANIC ASH AND CLAY
          0.3  ..SANDY SOIL WITH ROCK
          0.4  ..SANDY AND GRAVELLY SOIL
          1.0  ..STONY GRAVELLY SOIL

   NOTE:  PIPELINES SHOULD HAVE NEGLIGIBLE LOSS

   FOR EVAPORATION FROM POND WATER SURFACES ----
   5 HA-MM/DAY  0.6 L/S

 ENTER THE TOTAL ESTIMATED LOSS (L/S) FOR SEEPAGE
 AND EVAPORATION IN THE SUPPLY SYSTEM
 0


 ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES?  (Y OR N)
 N

 ARE DATA TO BE ENTERED FOR ANY STRUCTURES?  (Y OR N)
 N


 ARE DATA TO BE ENTERED FOR ANY PIPELINES?  (Y OR N)
 Y
```

Figure 4-6a   Example input data to

SUPPLY routine

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```
ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE O (ZERO) AMOUNT FINANCED WHEN ASKED

  ---DATA FOR MORE THAN ONE PIPELINE CAN BE ENTERED FOR
     BOTH LOANS 1 AND 2
Y

DATA FOR PIPES -- (LOAN NO. 1)
ENTER THE FOLLOWING NINE ITEMS:
  1 -- LENGTH OF PIPE (M)
  2 -- COST OF PIPE ($/M)
  3 -- TOTAL COST OF FITTINGS ($)
  4 -- COST OF LAYING ($/M)
        (ENTER O (ZERO) FOR ITEMS 3 & 4 IF THE COST IS
         INCLUDED IN THE COST OF THE PIPE.)
  5 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  6 -- PERCENT OF COST SUBSIDIZED
  7 -- PERCENT OF COST FINANCED
  8 -- TOTAL ANNUAL MAINTENANCE COST ($)
  9 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
       ( TAXES, INSURANCE, CONTINGENCIES ETC.)
160 9.5 150 1.9 15 0 100 100 25
 ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
N
 ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N

 ARE DATA TO BE INPUT FOR ANY PUMPS?   (Y OR N)

Y

ENTER THE NUMBER OF PUMPS AND THE ID NO. OF EACH PUMP
1 1

ENTER DATA FOR PUMP ID NO.  1

ENTER THE FOLLOWING SIX ITEMS
  1 -- FLOW RATE PUMPED (L/S)
  2 -- DISCHARGE PRESSURE (KPA)
  3 -- INLET PRESSURE (KPA)
       (ENTER O (ZERO) IF PUMPING FROM A SUMP OR WELL)
  4 -- VERTICAL PUMPING LIFT (M)
  5 -- PUMP EFFICIENCY (%)
       NOTE:  A CONSERVATIVE VALUE FOR PUMP EFFICIENCY SHOULD
              BE USED AS IT APPLES OVER THE LIFE OF THE SYSTEM
  6 -- MOTOR EFFICIENCY (%)
       NOTE:  THE EFFICIENCY OF MOST LARGE ELECTRIC MOTORS
              VARIES BETWEEN 90 AND 95 PERCENT
30
100
0 45 82 90

ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE O (ZERO) AMOUNT FINANCED WHEN ASKED

--MORE THAN ONE ITEM CAN BE ENTERED
  FOR BOTH LOANS 1 AND 2

--DATA FOR ALL ITEMS ASSOCIATED WITH THE PUMP SHOULD BE
  ENTERED INCLUDING THE WELL OR SUMP, PIPE FITTINGS AND
  VALVES, PUMP HOUSE, ELECTRICAL CONTROLS, POWER
  RETICULATION, ETC.
Y
```

Figure 4-6b   Example input data to

SUPPLY routine

```
ENTER THE NAME OF THE ITEM FOR WHICH
 DATA ARE BEING ENTERED  (<20 CHARACTERS)
PUMP

DATA FOR ITEMS
(LOAN NO. 1)
ENTER THE FOLLOWING SIX ITEMS:
  1 -- COST ($)
  2 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  3 -- PERCENT OF COST SUBSIDIZED
  4 -- PERCENT OF COST FINANCED
  5 -- TOTAL ANNUAL MAINTENANCE COST ($)
       (SUGGESTED VALUE FOR PUMPS IS 3 TO 5 %

        OF THE ORIGINAL COST)
  6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
       ( TAXES, INSURANCE, CONTINGENCIES ETC.)
8700 20 0 100 300 100
 ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
Y

ENTER THE NAME OF THE ITEM FOR WHICH
 DATA ARE BEING ENTERED  (<20 CHARACTERS)
WELL

DATA FOR ITEMS
(LOAN NO. 1)
ENTER THE FOLLOWING SIX ITEMS:
  1 -- COST ($)
  2 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  3 -- PERCENT OF COST SUBSIDIZED
  4 -- PERCENT OF COST FINANCED
  5 -- TOTAL ANNUAL MAINTENANCE COST ($)
       (SUGGESTED VALUE FOR PUMPS IS 3 TO 5 %
        OF THE ORIGINAL COST)
  6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
       ( TAXES, INSURANCE, CONTINGENCIES ETC.)
14500 30 0 100 50 0
 ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
N
 ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N

ENTER THE NAME OF THE ITEM FOR WHICH
 DATA ARE BEING ENTERED  (<20 CHARACTERS)
PUMPHOUBEE

DATA FOR ITEMS
(LOAN NO. 2)
ENTER THE FOLLOWING SIX ITEMS:
  1 -- COST ($)
  2 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  3 -- PERCENT OF COST SUBSIDIZED
  4 -- PERCENT OF COST FINANCED
  5 -- TOTAL ANNUAL MAINTENANCE COST ($)
       (SUGGESTED VALUE FOR PUMPS IS 3 TO 5 %
        OF THE ORIGINAL COST)
  6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
       ( TAXES, INSURANCE, CONTINGENCIES ETC.)
500 0 0 0 20 0
 ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)
N
```

Figure 4-6c Example input data to

SUPPLY routine

```
ENTER DATA FOR OTHER EXPENSES

ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

--MORE THAN ONE ITEM CAN BE ENTERED
  FOR BOTH LOANS 1 AND 2

--DATA FOR ALL ITEMS DIRECTLY ASSOCIATED WITH THE
  SYSTEM CAN BE ENTERED INCLUDING COSTS ASSOCIATED
  WITH FENCING, SHELTER BELTS, FARM ACCESS (BRIDGES & ROADS)
N
  ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N


>>>THE PROGRAM HAS SUCCESSFULLY EXECUTED!! <<

-- A LISTING OF INPUT DATA AND SUMMARY OUTPUT IS IN FILE LIST-SUPPLYEXMPL

-- DATA FOR THE SIMULATION PROGRAM IS IN FILE SUPPLYEXMPL
```

Figure 4-6d   Example input data to

SUPPLY routine

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kPa, and a dynamic pumping lift of 45 m. The efficiencies of the pump and motor are 82 and 90 percent.

Cost data are entered for the pump, well and pumphouse. The pump has an initial cost of $8700.00 and a salvage value of 20 percent. None of the cost is subsidized, 100 percent is financed, and $300.00 and $100.00 are expended annually for maintenance and miscellaneous items, respectively. Similar data are entered for the well and pumphouse with the pump and well being financed by loan no. 1 and the pumphouse by loan no. 2. No data are entered for any other expenses in the supply system.

Figure 4-7 is a listing of the file LIST-SUPPLYEXMPL that contains a summary of the input data along with a summary. The file SUPPLYEXMPL, shown in Figure 4-8, is a formatted file of the summary data from SUPPLY that is read into the SIMULATE routine. In Figure 4-8, the first line contains the name of the file followed by a 22-element array with the water flow and cost information. The fifth line shows the number of pumps and their ID nos. followed by the power and flow rate for each pump. In the last line are data for the water charges specified.

4.4.3 SYSTEMS Data and Output

For the example system there is one application system consisting of a booster pump, mainline and sprinkler lateral. Input data for the application system components are contained with the prompt statements in Figure 4-9.

Following a title for the output file the name of the CROPADDOCK file is entered. The user is then informed that none of the four paddocks has a system assigned, and the menu of systems is listed. System

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```
RESULTS FOR SYSTEM -- SUPPLYEXMPL
THE LIFE OF THE SYSTEM IS  20 YEARS

TERMS FOR LOAN RATE NO. 1
      9.0    ..PERCENT INTEREST RATE
      15.    ..YEARS TIME OF LOAN

TERMS FOR LOAN RATE NO. 2
      14.0   ..PERCENT INTEREST RATE
      7.     ..YEARS TIME OF LOAN


WATER SUPPLY AND COST DATA
      30.0   ..L/S FLOW RATE ENTERING THE SYSTEM
      7.00   ..DAYS PER WEEK FLOW RATE IS AVAILABLE
    2592.00  ..CUBIC M PER DAY DELIVERED (AVERAGE)
$     0.00   ..PER 1000 CUBIC M WATER CHARGE
$     0.00   ..PER L/S WATER CHARGE
$     0.00   ..LUMP SUM WATER CHARGE


     100.0   ..PERCENT WATER CONVEYANCE EFFICIENCY


PIPELINES FOR SYSTEM -- SUPPLYEXMPL

DATA FOR A PIPE
LOAN NO. 1
     160.0   ..METERS LONG
$     9.50 PER METER COST OF PIPE
$   150.00   ..TOTAL COST OF FITTINGS
$     1.90 PER METER COST OF LAYING
      15.0   ..PERCENT SALVAGE VALUE
      0.0    ..PERCENT SUBSIDIZED
     100.0   ..PERCENT FINANCED
$   100.00   ..TOTAL ANNUAL MAINTENANCE COST
$    25.00   ..TOTAL ANNUAL MISC. COST


PUMPS FOR SYSTEM -- SUPPLYEXMPL
      1      ..NO. OF PUMPS

   PUMP ID NO.  1

      30.0   ..LITERS PER SECOND PUMPED
     100.0   ..KPA DISCHARGE PRESSURE
      0.0    ..KPA INLET PRESSURE
      45.00  ..METERS VERTICAL LIFT
      82.0   ..PERCENT PUMP EFFICIENCY
      90.0   ..PERCENT MOTOR EFFICIENCY
      22.00  ..KILOWATTS POWER INPUT

DATA FOR PUMP
LOAN NO. 1
$ 8700.00 COST
      20.0   ..PERCENT SALVAGE VALUE
      0.0    ..PERCENT SUBSIDIZED
     100.0   ..PERCENT FINANCED
$   300.00   ..TOTAL ANNUAL MAINTENANCE COST
$   100.00   ..TOTAL ANNUAL MISC. COST
DATA FOR WELL
LOAN NO. 1
$ 14500.00 COST
      30.0   ..PERCENT SALVAGE VALUE
      0.0    ..PERCENT SUBSIDIZED
     100.0   ..PERCENT FINANCED
$    50.00   ..TOTAL ANNUAL MAINTENANCE COST
$     0.00   ..TOTAL ANNUAL MISC. COST

DATA FOR PUMPHOUSE
LOAN NO. 2
$   500.00 COST
      0.0    ..PERCENT SALVAGE VALUE
      0.0    ..PERCENT SUBSIDIZED
      0.0    ..PERCENT FINANCED
$    20.00   ..TOTAL ANNUAL MAINTENANCE COST
$     0.00   ..TOTAL ANNUAL MISC. COST


OTHER EXPENSES FOR SYSTEM -- SUPPLYEXMPL
```

Figure 4-7a Example detailed output

from SUPPLY routine

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```
SUMMARY INFORMATION FOR WATER SUPPLY SYSTEM -- SUPPLYEXMPL

VOLUME OF WATER (CUBIC M/DAY) . . . . . . . . . . 2592.0

FLOW RATE ENTERING SYSTEM (L/S) . . . . . . . . .   30.0

CONVEYANCE EFFICIENCY (%) . . . . . . . . . . . . 100.0

SYSTEM LIFE (YEARS) . . . . . . . . . . . . . . .   20.


SUMMARY OF SYSTEM COSTS AND FINANCING -----------
                                        ATTACHED COMPONENTS   UNATTACHED COMPONENTS
                                           (LOAN NO. 1)          (LOAN NO.2)
  TOTAL CAPITAL COST ($) . . . . . .       25174.00               500.00
  CAPITAL NOT FINANCED
            OR SUBSIDIZED ($)  . . . .         0.00               500.00
  SUBSIDIZED CAPITAL ($) . . . . . . .         0.00                 0.00
  FINANCED CAPITAL ($) . . . . . . . .     25174.00                 0.00
  INTEREST RATE (%) . . . . . . . . .          9.00                14.00
  TIME OF LOAN (YEARS) . . . . . . . .         15.                  7.
  SALVAGE VALUE ($) . . . . . . . . .        6386.10                0.00
  ANNUAL MAINTENANCE EXPENSE ($) . .          450.00               20.00
  ANNUAL MISCELLANEOUS EXPENSE ($) .          125.00                0.00


SUMMARY INFORMATION FOR INCLUDED PUMPS
   PUMP ID NO.        FLOW RATE        INPUT POWER
                        (L/S)             (KW)
        1               30.0              22.0
```

Figure 4-7b Example detailed output

from SUPPLY routine

```
UPPLYEXMPL
  2592.00    30.00    100.00     20.00  25174.00      0.00      0.00  25174.00
     9.00    15.00   6386.10    450.00    125.00    500.00    500.00      0.00
     0.00    14.00      7.00      0.00     20.00      0.00
     1     1
    22.00    30.00
     0.00     0.00      0.00
```

Figure 4-8 Example output from SUPPLY routine

for SIMULATE routine

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no. 5 (side-roll sprinkler) is designated, and as there is only one system all four paddocks are specified as being served. The system life and loan terms are the same as for the supply system although they need not be.

System capacity and operations information are next requested. The flow rate entering the system is 30 L/s, the same as that supplied by the supply system. The system is to operate 18 hr/day, and an additional 5 hr downtime is required to move the lateral from paddock to paddock. As with the supply system water is available 7 days per week.

A sprinkler move distance of 18 m per set is specified. The application efficiency is input as 70 percent with 8 percent of the applied water lost to evaporation. Paddock-specific information for each paddock served is then entered as requested. The total distance over which the lateral must be moved in paddocks 1 and 3 is 400 m and for paddocks 2 and 4 is 250 m. Forty five minutes (0.75 hr) labour is required per set, and the additional labour required once per irrigation is either 1.5 or 2 hours depending upon the paddock.

Cost information for the lateral shows that the one side-roll lateral has a cost of $16,400.00 with none of the cost subsidized and 50 percent financed. The system is financed under loan no. 2 as it is portable and has a salvage value of 10 percent of the original cost. A $250.00 annual maintenance cost is specified along with $50.00 for miscellaneous expenditures.

Pipeline cost data are entered for the mainline as two sections both of which are financed under loan no. 1. The first section consists of 350 m of 150 mm diameter pipe costing $7.50/m. The total cost

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```
ENTER A DESCRIPTIVE NAME FOR THE OUTPUT FILE
WITH <20 CHARACTERS AND NO EMBEDDED BLANKS
SYSTEMSEXMPL


ENTER THE NAME OF THE CROPADDOCK FILE TO BE USED
CROPADDOCKEXMPL


THE FOLLOWING PADDOCKS HAVE NO SYSTEM
     1  2  3  4

ENTER THE TYPE OF IRRIGATION SYSTEM USING THE FOLLOWING CODE:

          1 -- BORDER
          2 -- FURROW OR CORRUGATE
          3 -- HAND-MOVE SPRINKLER
          4 -- END-TOW SPRINKLER
          5 -- SIDE-ROLL SPRINKLER
          6 -- TRAVELLING SPRINKLER (GUN OR BOOM)
          7 -- SELF-PROPELLED SPRINKLER (CENTER-PIVOT, LATERAL-MOVE ETC.)
          8 -- SOLID-SET SPRINKLER
          9 -- TRICKLE
5

ENTER THE NUMBER OF PADDOCKS SERVED BY THE SYSTEM
AND THE ID NOS. OF THE PADDOCKS
4 1 2 3 4

ENTER SYSTEM LIFE IN YEARS
20

SEPARATE LOAN TERMS ARE CONSIDERED FOR
ATTACHED ITEMS -- LOAN NO. 1 AND
UNATTACHED ITEMS -- LOAN NO. 2

ENTER INTEREST RATE (PERCENT) AND
TIME OF LOAN (YEARS) FOR LOAN NO. 1
9 15

ENTER INTEREST RATE (PERCENT) AND
TIME OF LOAN (YEARS) FOR LOAN NO. 2
14 7


THE FOLLOWING INPUTS REFER TO SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER


ENTER THE FOLLOWING 4 ITEMS
    1 --   FLOW RATE ENTERING THE SYSTEM (LITERS PER SECOND)
           NOTE:  THE FLOW RATE ENTERING THE SYSTEM MUST
                  CORRESPOND TO THAT SUPPLIED BY THE
                  WATER SUPPLY SYSTEM
    2 -- HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE
    3 -- HOURS PER WEEK ADDITIONAL DOWN TIME WHEN WATER
         IS AVAILABLE TO THE SYSTEM ----> FOR MOVING FROM
         PADDOCK TO PADDOCK, MAINTENACE ETC.
    4 -- DAYS PER WEEK WATER IS AVAILABLE
30 18 5 7
```

Figure 4-9a   Example input data to

SYSTEMS routine

```
ENTER THE FOLLOWING 3 ITEMS FOR
SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER
 1 -- DISTANCE LATERAL LINE IS MOVED AT EACH SET (M)
 2 -- APPLICATION EFFICIENCY (%)
 3 -- PERCENTAGE OF WATER LOST TO EVAPORATION BEFORE
      COMING IN CONTACT WITH THE CROP CANOPY
18 70 8

INPUT THE FOLLOWING 3 ITEMS FOR PADDOCK NO.  1
 1 -- TOTAL DISTANCE THE SPRINKLER LATERAL IS MOVED (M)
      (PERPENDICULAR TO LATERAL)
 2 -- LABOR REQUIRED PER SET (HR)
 3 -- ADDITIONAL LABOR REQUIRED PER IRRIGATION (HR)
      (FOR TRANSPORTING LINES, SETTING UP ETC.)
400 .75 1.5

INPUT THE FOLLOWING 3 ITEMS FOR PADDOCK NO.  2
 1 -- TOTAL DISTANCE THE SPRINKLER LATERAL IS MOVED (M)
      (PERPENDICULAR TO LATERAL)
 2 -- LABOR REQUIRED PER SET (HR)
 3 -- ADDITIONAL LABOR REQUIRED PER IRRIGATION (HR)
      (FOR TRANSPORTING LINES, SETTING UP ETC.)
250 .75 1.5

INPUT THE FOLLOWING 3 ITEMS FOR PADDOCK NO.  3
 1 -- TOTAL DISTANCE THE SPRINKLER LATERAL IS MOVED (M)
      (PERPENDICULAR TO LATERAL)
 2 -- LABOR REQUIRED PER SET (HR)
 3 -- ADDITIONAL LABOR REQUIRED PER IRRIGATION (HR)
      (FOR TRANSPORTING LINES, SETTING UP ETC.)
400 .75 2

INPUT THE FOLLOWING 3 ITEMS FOR PADDOCK NO.  4
 1 -- TOTAL DISTANCE THE SPRINKLER LATERAL IS MOVED (M)
      (PERPENDICULAR TO LATERAL)
 2 -- LABOR REQUIRED PER SET (HR)
 3 -- ADDITIONAL LABOR REQUIRED PER IRRIGATION (HR)

      (FOR TRANSPORTING LINES, SETTING UP ETC.)
250 1 1.5


ENTER THE FOLLOWING COST INFORMATION FOR
SPRINKLER SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER
  NOTE:  DATA FOR MAINLINES, PUMPS, FITTINGS ETC. ARE
         ENTERED SEPARATELY
 ---- 8 ITEMS
 1 -- NUMBER OF LINES OR UNITS
 2 -- TOTAL CAPITAL COST PER UNIT ($)
 3 -- PERCENT OF COST SUBSIDIZED
 4 -- PERCENT OF COST FINANCED
 5 -- LOAN NO. (1 OR 2)
 6 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
      AS A PERCENT OF THE ORIGINAL COST
 7 -- TOTAL ANNUAL MAINTENANCE COST ($)
 8 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS
      (TAXES, INSURANCE, CONTINGENCIES ETC.)
1 16400 0 50 2 10 250 50


ARE DATA TO BE ENTERED FOR MAINLINES OR ANY OTHER
PIPELINES FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER          (Y OR N)
Y
```

Figure 4-9b Example input data to

SYSTEMS routine

```
ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

  ---DATA FOR MORE THAN ONE PIPELINE CAN BE ENTERED FOR
     BOTH LOANS 1 AND 2
Y


DATA FOR PIPES -- (LOAN NO. 1)
ENTER THE FOLLOWING NINE ITEMS:
   1 -- LENGTH OF PIPE (M)
   2 -- COST OF PIPE ($/M)
   3 -- TOTAL COST OF FITTINGS ($)
   4 -- COST OF LAYING ($/M)
        (ENTER 0 (ZERO) FOR ITEMS 3 & 4 IF THE COST IS
         INCLUDED IN THE COST OF THE PIPE.)
   5 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
        AS A PERCENT OF THE ORIGINAL COST
   6 -- PERCENT OF COST SUBSIDIZED
   7 -- PERCENT OF COST FINANCED
   8 -- TOTAL ANNUAL MAINTENANCE COST ($)
   9 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
        ( TAXES, INSURANCE, CONTINGENCIES ETC.)
350 7.5 350 1.9 20 0 60 150 25

 ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
 Y


 DATA FOR PIPES -- (LOAN NO. 1)
 ENTER THE FOLLOWING NINE ITEMS:
   1 -- LENGTH OF PIPE (M)
   2 -- COST OF PIPE ($/M)
   3 -- TOTAL COST OF FITTINGS ($)
   4 -- COST OF LAYING ($/M)
        (ENTER 0 (ZERO) FOR ITEMS 3 & 4 IF THE COST IS
         INCLUDED IN THE COST OF THE PIPE.)
   5 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
        AS A PERCENT OF THE ORIGINAL COST
   6 -- PERCENT OF COST SUBSIDIZED
   7 -- PERCENT OF COST FINANCED
   8 -- TOTAL ANNUAL MAINTENANCE COST ($)
   9 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
        ( TAXES, INSURANCE, CONTINGENCIES ETC.)
300 9.5 300 1.9 20 0 60 125 25
 ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
N
 ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
N


 ARE DATA TO BE INPUT FOR ANY PUMPS
 FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER        (Y OR N)
  NOTE: DO NOT INCLUDE ANY PUMPS SPECIFIED IN THE
        WATER SUPPLY ROUTINE!!
Y

 ENTER THE NUMBER OF PUMPS AND THE ID NO. OF EACH PUMP
 1 2

 ENTER DATA FOR PUMP ID NO.  2

 ENTER THE FOLLOWING SIX ITEMS
   1 -- FLOW RATE PUMPED (L/S)
   2 -- DISCHARGE PRESSURE (KPA)
   3 -- INLET PRESSURE (KPA)
        (ENTER 0 (ZERO) IF PUMPING FROM A SUMP OR WELL)
   4 -- VERTICAL PUMPING LIFT (M)
   5 -- PUMP EFFICIENCY (%)
        NOTE:  A CONSERVATIVE VALUE FOR PUMP EFFICIENCY SHOULD
               BE USED AS IT APPLES OVER THE LIFE OF THE SYSTEM
   6 -- MOTOR EFFICIENCY (%)
        NOTE:  THE EFFICIENCY OF MOST LARGE ELECTRIC MOTORS
               VARIES BETWEEN 90 AND 95 PERCENT
30 400 70 0 78 90
```

Figure 4-9c   Example input data to

SYSTEMS routine

ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)

  NOTE: IF NONE OF THE COST IS FINANCED ANSWER Y
         AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

  --MORE THAN ONE ITEM CAN BE ENTERED
    FOR BOTH LOANS 1 AND 2

  --DATA FOR ALL ITEMS ASSOCIATED WITH THE PUMP SHOULD BE
    ENTERED INCLUDING THE WELL OR SUMP, PIPE FITTINGS AND
    VALVES, PUMP HOUSE, ELECTRICAL CONTROLS, POWER
    RETICULATION, ETC.
Y

  ENTER THE NAME OF THE ITEM FOR WHICH
  DATA ARE BEING ENTERED (<20 CHARACTERS)
PUMP&PANEL

  DATA FOR ITEMS
  (LOAN NO. 1)
  ENTER THE FOLLOWING SIX ITEMS:
    1 -- COST ($)
    2 -- SALVAGE VALUE AT THE END OF THE 20-YEAR SYSTEM LIFE
         AS A PERCENT OF THE ORIGINAL COST
    3 -- PERCENT OF COST SUBSIDIZED
    4 -- PERCENT OF COST FINANCED
    5 -- TOTAL ANNUAL MAINTENANCE COST ($)
         (SUGGESTED VALUE FOR PUMPS IS 3 TO 5 %
          OF THE ORIGINAL COST)
    6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
         (TAXES, INSURANCE, CONTINGENCIES ETC.)
5700 20 0 60 150 50
  ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
Y

  ENTER THE NAME OF THE ITEM FOR WHICH
  DATA ARE BEING ENTERED (<20 CHARACTERS)
RETUCULATION

  DATA FOR ITEMS
  (LOAN NO. 1)
  ENTER THE FOLLOWING SIX ITEMS:
    1 -- COST ($)
    2 -- SALVAGE VALUE AT THE END OF THE 20-YEAR SYSTEM LIFE
         AS A PERCENT OF THE ORIGINAL COST
    3 -- PERCENT OF COST SUBSIDIZED
    4 -- PERCENT OF COST FINANCED
    5 -- TOTAL ANNUAL MAINTENANCE COST ($)
         (SUGGESTED VALUE FOR PUMPS IS 3 TO 5 %
          OF THE ORIGINAL COST)
    6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
         (TAXES, INSURANCE, CONTINGENCIES ETC.)
2000 90 0 60 0 25

    ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)
  N
    ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
  N

Figure 4-9d Example input data to

SYSTEMS routine

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```
ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES
FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER          (Y OR N)
N

ARE DATA TO BE ENTERED FOR ANY STRUCTURES
FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER          (Y OR N)
N

IS LAND GRADING OR PREPARATION NECESSARY
FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER          (Y OR N)
N

IS SUBSURFACE DRAINAGE REQUIRED FOR ANY PADDOCK?  (Y OR N)
N


ENTER DATA FOR OTHER EXPENSES
FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER

ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)

NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y
       AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED

--MORE THAN ONE ITEM CAN BE ENTERED
  FOR BOTH LOANS 1 AND 2

--DATA FOR ALL ITEMS DIRECTLY ASSOCIATED WITH THE
  SYSTEM CAN BE ENTERED INCLUDING COSTS ASSOCIATED
  WITH FENCING, SHELTER BELTS, FARM ACCESS (BRIDGES & ROADS)

--FOR ANNUAL VALUE OF CROP LOST DUE TO SYSTEM OPERATION
  SUCH AS NON-IRRIGATED AREAS OF PADDOCKS,
  DAMAGE FROM DRAG HOSE, TRACTORS, ETC., ENTER
  A COST ONLY FOR TOTAL MISCELLANEOUS ITEMS.
N
  ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)
Y

ENTER THE NAME OF THE ITEM FOR WHICH
DATA ARE BEING ENTERED  (<20 CHARACTERS)
FENCING

DATA FOR ITEMS
(LOAN NO. 2)
ENTER THE FOLLOWING SIX ITEMS:

  1 -- COST ($)
  2 -- SALVAGE VALUE AT THE END OF THE  20-YEAR SYSTEM LIFE
       AS A PERCENT OF THE ORIGINAL COST
  3 -- PERCENT OF COST SUBSIDIZED
  4 -- PERCENT OF COST FINANCED
  5 -- TOTAL ANNUAL MAINTENANCE COST ($)
  6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)
     ( TAXES, INSURANCE, CONTINGENCIES ETC.)
3500 10 0 60 200 0
  ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)
N


>>>THE PROGRAM HAS SUCCESSFULLY EXECUTED!! <<

-- A LISTING OF INPUT DATA AND SUMMARY OUTPUT IS IN FILE LIST-SYSTEMSEXMPL

-- DATA FOR THE SIMULATION PROGRAM IS IN FILE SYSTEMSEXMPL
```

Figure 4-9e Example input data to

SYSTEMS routine

of fittings for that section is $350.00 and the cost of laying is $1.90/m. A salvage value of 20 percent is assumed. None of the cost is subsidized and 60 percent is financed. Annual maintenance and miscellaneous costs are $150.00 and $25.00, respectively. The second section is 300 m of 200 mm diameter pipeline costing $9.50/m. Other costs for the second section are quite similar to those for the first.

The booster pump as part of the application system is to pump 30 L/s with a discharge pressure of 400 kPa and an inlet pressure of 70 kPa. The efficiency for the pump is 78 percent and for the motor 90 percent. Cost data are then entered for the pump and panel and for power reticulation.

No data are entered for races or structures nor for land grading or subsurface drainage since none of these are required for the example system. The only item under other expense is $3500.00 worth of fencing required to complement the sprinkler system.

Output from the SYSTEMS routine is written in two files. The file for which the first five characters in the name are LIST- is a listing of all input data along with a summary of results. The file LIST-SYSTEMSEXMPL in Figure 4-10 is the summary file for the example problem. This detailed file allows the user to check all input data and output from the routine.

The file SYSTEMSEXMPL is the second file output in a format to be read by the SIMULATION routine (Figure 4-11). The first line is the number of application systems for which data are entered, and the second is the name of the system. The third line is the number of paddocks, and the fourth line contains the labour requirements per irrigation for each paddock. Lines 5 through 7 are a 21-element array

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```
RESULTS IN APPLICATION SYSTEMS FILE SYSTEMSEXMPL

CROPADDOCK INPUT FROM FILE CROPADDOCKEXMPL


RESULTS FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER
THE LIFE OF THE SYSTEM IS  20 YEARS
PADDOCKS SERVED BY THE SYSTEM ARE   1  2  3  4

TERMS FOR LOAN RATE NO. 1
      9.0    ..PERCENT INTEREST RATE
     15.     ..YEARS TIME OF LOAN

TERMS FOR LOAN RATE NO. 2
     14.0    ..PERCENT INTEREST RATE
      7.     ..YEARS TIME OF LOAN


INPUT DATA AND RESULTS FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER
     30.0    ..LITERS PER SECOND FLOW RATE ENTERING THE SYSTEM
     18.00   ..HOURS PER DAY SYSTEM OPERATION
      5.00   ..HOURS PER WEEK DOWN TIME
     72.8    ..PERCENT OF TIME SYSTEM OPERATES


     18.0    ..M MOVED PER SET
     70.0    ..PERCENT APPLICATION EFFICIENCY
      8.0    ..PERCENT LOSS TO EVAPORATION
     22.0    ..PERCENT LOSS TO DEEP PERCOLATION

LABOR FOR PADDOCK NO.  1
    400.0    ..M TOTAL DISTANCE SPRINKLER IS MOVED
      0.75   ..HR LABOR PER SET
      1.50   ..HR ADDITIONAL LABOR PER IRRIGATION
     18.00   ..HR TOTAL LABOR PER IRRIGATION

LABOR FOR PADDOCK NO.  2
    250.0    ..M TOTAL DISTANCE SPRINKLER IS MOVED
      0.75   ..HR LABOR PER SET
      1.50   ..HR ADDITIONAL LABOR PER IRRIGATION
     12.00   ..HR TOTAL LABOR PER IRRIGATION

LABOR FOR PADDOCK NO.  3
    400.0    ..M TOTAL DISTANCE SPRINKLER IS MOVED
      0.75   ..HR LABOR PER SET
      2.00   ..HR ADDITIONAL LABOR PER IRRIGATION
     18.50   ..HR TOTAL LABOR PER IRRIGATION

LABOR FOR PADDOCK NO.  4
    250.0    ..M TOTAL DISTANCE SPRINKLER IS MOVED
      1.00   ..HR LABOR PER SET
      1.50   ..HR ADDITIONAL LABOR PER IRRIGATION
     15.50   ..HR TOTAL LABOR PER IRRIGATION


COST DATA FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER
      1.     ..LINES OR UNITS
$ 16400.00   ..COST PER UNIT
      0.0    ..PERCENT SUBSIDIZED
     50.0    ..PERCENT FINANCED UNDER LOAN NO. 2
     10.0    ..PERCENT SALVAGE VALUE
$    250.00  ..ANNUAL MAINTENANCE COST
$     50.00  ..ANNUAL MISCELLANEOUS COST


PIPELINES FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER
```

Figure 4-10a Example detailed output from

SYSTEMS routine

```
$   200.00   ..TOTAL ANNUAL MAINTENANCE COST
$     0.00   ..TOTAL ANNUAL MISC. COST


DATA FOR A PIPE
LOAN NO. 1
      350.0    ..METERS LONG
$       7.50 PER METER COST OF PIPE
$     350.00   ..TOTAL COST OF FITTINGS
$       1.90 PER METER COST OF LAYING
       20.0    ..PERCENT SALVAGE VALUE
        0.0    ..PERCENT SUBSIDIZED
       60.0    ..PERCENT FINANCED
$     150.00   ..TOTAL ANNUAL MAINTENANCE COST
$      25.00   ..TOTAL ANNUAL MISC. COST

DATA FOR A PIPE
LOAN NO. 1
      300.0    ..METERS LONG
$       9.50 PER METER COST OF PIPE
$     300.00   ..TOTAL COST OF FITTINGS
$       1.90 PER METER COST OF LAYING
       20.0    ..PERCENT SALVAGE VALUE
        0.0    ..PERCENT SUBSIDIZED
       60.0    ..PERCENT FINANCED
$     125.00   ..TOTAL ANNUAL MAINTENANCE COST
$      25.00   ..TOTAL ANNUAL MISC. COST


PUMPS FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER
         1    ..NO. OF PUMPS

    PUMP ID NO.  2

       30.0    ..LITERS PER SECOND PUMPED
      400.0    ..KPA DISCHARGE PRESSURE
       70.0    ..KPA INLET PRESSURE
        0.00   ..METERS VERTICAL LIFT
       78.0    ..PERCENT PUMP EFFICIENCY
       90.0    ..PERCENT MOTOR EFFICIENCY
       14.09   ..KILOWATTS POWER INPUT

DATA FOR PUMP&PANEL
LOAN NO. 1
$ 5700.00 COST
       20.0    ..PERCENT SALVAGE VALUE
        0.0    ..PERCENT SUBSIDIZED
       60.0    ..PERCENT FINANCED
$     150.00   ..TOTAL ANNUAL MAINTENANCE COST
$      50.00   ..TOTAL ANNUAL MISC. COST

DATA FOR RETUCULATION
LOAN NO. 1
$ 2000.00 COST
       90.0    ..PERCENT SALVAGE VALUE
        0.0    ..PERCENT SUBSIDIZED
       60.0    ..PERCENT FINANCED
$       0.00   ..TOTAL ANNUAL MAINTENANCE COST
$      25.00   ..TOTAL ANNUAL MISC. COST


OTHER EXPENSES FOR SYSTEM NO.  1 -- SIDE-ROLL SPRINKLER

DATA FOR FENCING
LOAN NO. 2
$ 3500.00 COST.
       10.0    ..PERCENT SALVAGE VALUE
        0.0    ..PERCENT SUBSIDIZED
       60.0    ..PERCENT FINANCED
```

Figure 4-10b Example detailed output from

SYSTEMS routine

SUMMARY OF APPLICATION·SYSTEMS INFORMATION IN FILE LIST-SYSTEMSEXMPL
THE RESULTS FOR USE IN SIMULATION ARE IN FILE SYSTEMSEXMPL

SIDE-ROLL SPRINKLER   SERVING PADDOCKS   1 2 3 4

PADDOCKS SERVED AND LABOR REQUIREMENTS
    PADDOCK   LABOR REQUIREMENT
      NO.   (HR/IRRIG)
       1   18.0
       2   12.0
       3   18.5
       4   15.5

OVERALL SYSTEM EFFICIENCIES FOR CROPS IN EACH PADDOCK
PADDOCK   - CROP -   EFFICIENCY
  NO.   NO.   NAME   (%)

   1
          1   WINTER WHEAT1   70.0
          8   PEAS1   70.0
         16   PASTURE1   70.0
         17   PASTURE2   70.0
         20   GREENFEED1   70.0

   2
          1   WINTER WHEAT1   70.0
          8   PEAS1   70.0
         16   PASTURE1   70.0
         17   PASTURE2   70.0
         20   GREENFEED1   70.0

   3
         16   PASTURE1   70.0

   4
         16   PASTURE1   70.0

FLOW RATE ENTERING SYSTEM (L/S) 30.0

PERCENT OF TIME SYSTEM OPERATES 72.8

SYSTEM LIFE (YEARS) . . . .   20.

SUMMARY OF SYSTEM COSTS AND FINANCING -----------
                                     ATTACHED COMPONENTS   UNATTACHED COMPONENTS
                                        (LOAN NO. 1)   (LOAN NO.2)
    TOTAL CAPITAL COST ($) 15060.00   19900.00
    CAPITAL NOT FINANCED
           OR SUBSIDIZED ($) 6024.00   9600.00
    SUBSIDIZED CAPITAL ($) 0.00   0.00
    FINANCED CAPITAL ($) 9036.00   10300.00
    INTEREST RATE (%) 9.00   14.00
    TIME OF LOAN (YEARS) . . . .   15.   7.
    SALVAGE VALUE ($) 4412.00   1990.00
    ANNUAL MAINTENANCE EXPENSE ($) . .   425.00   450.00
    ANNUAL MISCELLANEOUS EXPENSE ($) .   125.00   50.00

SUMMARY INFORMATION FOR INCLUDED PUMPS
    PUMP ID NO.   FLOW RATE   INPUT POWER
                         (L/S)   (KW)
        2   30.0   14.1

Figure 4-10c Example detailed output from

SYSTEMS routine

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```
1
IDE-ROLL SPRINKLER
  4    1    2    3    4
   18.00    12.00    18.50    15.50
   30.00    72.77    20.00  15060.00    6024.00      0.00   9036.00      9.00
   15.00  4412.00   425.00    125.00   19900.00   9600.00      0.00  10300.00
   14.00     7.00  1990.00    450.00      50.00
  1    2
   14.09    30.00
   70.00     0.00     0.00     0.00     0.00     0.00     0.00    70.00
    0.00     0.00     0.00     0.00     0.00     0.00     0.00    70.00
   70.00     0.00     0.00    70.00     0.00     0.00     0.00    70.00
    0.00     0.00     0.00     0.00     0.00     0.00    70.00     0.00
    0.00     0.00     0.00     0.00     0.00     0.00    70.00    70.00
    0.00     0.00    70.00     0.00     0.00     0.00     0.00     0.00
    0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
    0.00     0.00     0.00     0.00     0.00    70.00     0.00     0.00
    0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
    0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
    0.00     0.00     0.00     0.00    70.00     0.00     0.00     0.00
    0.00     0.00     0.00     0.00
```

Figure 4-11   Example output from SYSTEMS routine

for SIMULATE routine

containing system flow rate, percent operating time, system life and summary cost data for each loan type. The format of lines 2 through 7 is repeated for each system if more than one system is included in the analysis. Lines 8 and 9 are pump data -- number of pumps, pump ID no., input power and flow rate. The last array of numbers is a 92-element array which contains the application efficiency for each crop irrigated in each paddock. The array length, AL is:

$$AL = (NCP)(No. \text{ of Paddocks})$$

where

NCP is the number of crops in the crop menu or 23

(Appendix B and Figure 4-4) and

No. of Paddocks is the total number of paddocks or 4.

The first 23 numbers refer to the crops grown in paddock no. 1, and an application efficiency of 70 percent is listed for crop nos. 1, 8, 16, 17, and 20. The next 23 numbers refer to efficiencies in paddock no. 2 and so forth. The same efficiency appears for all paddocks served by the same sprinkler system; however, it would vary for different crops in the same paddock if irrigated with a surface system as crop characteristics affect water distribution and therefore efficiency.

4.5 System Simulation

The simulation of system operation requires extensive data, much of which is generated by the CROPADDOCK, SYSTEMS and SUPPLY routines. As indicated in Figure 4-12 after the descriptive title, SIMULATEEXMPL, is given the names of the output files, CROPADDOCKEXMPL, SYSTEMSEXMPL and SUPPLYEXMPL are entered. A file of daily rainfall,

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SEG SIMULATE

INPUT DATA FOR THE OPERATION SIMULATION MODULE

-THE MAXIMUM NUMBER OF CHARACTERS IN ANY TITLE IS 32
 WITH NO EMBEDDED BLANKS AND ONLY ALPHANUMERIC CHARACTERS

-ALL NUMERIC DATA ARE ENTERED IN FREE FORMAT (LIST DIRECTED)
 ENTER A DESCRIPTIVE TITLE
SIMULATEEXMPL
 ENTER NAME OF CROP-PADDOCK FILE
CROPADDOCKEXMPL
 ENTER NAME OF IRRIGATION SYSTEMS FILE
SYSTEMSEXMPL
 ENTER NAME OF WATER SUPPLY FILE
SUPPLYEXMPL
 ENTER NAME OF RAINFALL FILE
RAINDAT
 ENTER NAME OF PET FILE
AB703DAT
 IS THE TARIFF STRUCTURE THE SAME FOR ALL PUMPS-Y OR N
Y

ENTER THE FOLLOWING DATA FOR 1 PUMP(S)
THE DATA FOR EACH PUMP MUST BE ENTERED ON A SEPARATE LINE
ALL DATA MUST BE ENTERED IN THE ORDER INDICATED
--IF A PARTICULAR COEFFICIENT IS NOT APPLICABLE, ENTER 0 (ZERO)
--ALL DATA MUST BE SEPARATED BY COMMAS OR SPACES

DEMAND AND SERVICE CHARGES -- 5 ITEMS
INSTALLATION CHARGE   ANNUAL CHARGE   BILLING PD CHARGE
    LUMP SUM $ LUMP $ $/KW   LUMP $ $/KW
      (ITEM 1)   (ITEM 2)(ITEM 3) (ITEM 4) (ITEM 5)

0 0 24 0 0

ENERGY CHARGES FOR PUMPING IN DAYTIME

 --6 ITEMS

BLOCK 1 BLOCK 2 BLOCK 3   BLOCK 1A   BLOCK 2A   BLOCK 3A
($/KWH) ($/KWH) ($/KWH)   ($/KWH-KW) ($/KWH-KW) ($/KWH-KW)
(ITEM 1) (ITEM 2) (ITEM 3)   (ITEM 4)   (ITEM 5)   (ITEM 6)

.045 .032 0 0 0 0

ENTER THE TOTAL NUMBER OF UNITS (KWH OR KWH-KW) THAT
MUST BE USED BEFORE THE RATES IN BLOCKS 2, 3, 2A AND 3A
BECOME EFFECTIVE
 -- 4 ITEMS FOR EACH PUMP

  BLOCK 2   BLOCK 3   BLOCK 2A   BLOCK 3A
   (KWH)   (KWH)   (KWH-KW)   (KWH-KW)
  (ITEM 1)   (ITEM 2)   (ITEM 3)   (ITEM 4)

16200 0 0 0

ENTER THE LENGTH OF PERIOD IN MONTHS USED IN COMPUTING
POWER CHARGES AND THE NUMBER OF MONTHS AFTER JUNE 1 THAT
THE PERIOD BEGINS
 -- 2 ITEMS FOR EACH PUMP
3 0

DOES A DIFFERENT TARIFF APPLY FOR A PERIOD OF TIME
EACH DAY (NIGHT RATE) -- Y OR N
N

ENTER EXPECTED ANNUAL INFLATION RATE FOR ENERGY (PERCENT)
16

Figure 4-12a   Example input to SIMULATE routine

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```
ENTER MAXIMUM LABOR INPUT IN HOURS PER WEEK
25   .

ENTER LABOR WAGE RATE ($/HR) AND
EXPECTED  RATE OF INFLATION FOR LABOR (PERCENT)
5.5 10

INPUT INFLATION RATE FOR OTHER OPERATING
AND MAINTENANCE COSTS (PERCENT)                    .
12
  ENTER THE RETURN ON INVESTMENT (PERCENT)
18


ENTER BEGINNING AND ENDING YEARS FOR SIMULATION RUN
54 78


I AM NOW THINKING, COMPUTING AND TRYING TO DIGEST ALL
THE DATA YOU HAVE FED ME.  I WILL TELL YOU WHEN I HAVE
SUCCESSFULLY COMPLETED ALL DETAILS ----- PROVIDED YOU
HAVE NOT FED ME BAD DATA THAT WILL RESULT IN INDIGESTION!!



THE JOB IS FINISHED AND OUTPUT IS IN FILE SIMULATEEXMPL
```

Figure 4-12b Example input to SIMULATE routine

RAINDAT, and monthly potential evapotranspiration, AB703DAT, are also required for simulation.

The pump tariff structure is the same for both pumps (well and booster) and consists of an annual demand charge coupled with a declining block rate. The demand charge is $24.00 per kW and is entered as item #3 in the demand charges. Note that zeros (0) are entered for all items that are not applicable. The energy charge is $0.045 per kWh for the first 16,200 kWh used in a billing period and then declines to $0.032 per kWh for all additional energy used. The length of billing period is 3 months and begins on June 1 as shown. There is no different tariff for nighttime pumping, and an annual inflation rate of 16 percent for energy is assumed.

For labour supply a maximum of 25 hr per week is available. The wage rate is $5.50 per hour and is estimated to increase at an annual rate of 10 percent per year. The inflation rate for all other operation and maintenance costs is 12 percent. The desired return on investment is 18 percent, and a 25-year simulation period from 1954 through 1978 is entered.

After all data are entered correctly, the user is informed that the computer is "thinking, computing and digesting" in the simulation process, a process that may require from several seconds to minutes depending upon the simulation problem and machine. The name of the output file is displayed when the job is completed.

Programme output for the example problem is shown in Figures 4-13 through 4-16. Figure 4-13 is merely a summary of the pump tariff data and provides a printed record of the input data. Simulation results

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```
PUMP TARIFF INPUT FOR SIMULATEEXMPL

INSTALLATION CHARGE      ANNUAL CHARGE      BILLING PD CHARGE
    LUMP SUM $           LUMP $   $/KW      LUMP $   $/KW
            0.00              0.00  24.00      0.00    0.00

ENERGY CHARGES FOR PUMPING IN DAYTIME

BLOCK 1   BLOCK 2   BLOCK 3     BLOCK 1A    BLOCK 2A    BLOCK 3A
($/KWH)   ($/KWH)   ($/KWH)   ($/KWH-KW) ($/KWH-KW) ($/KWH-KW)

0.0450   0.0320   0.0000       0.0000      0.0000      0.0000

THE TOTAL NUMBER OF UNITS (KWH OR KWH-KW) THAT
MUST BE USED BEFORE THE RATES IN BLOCKS 2, 3, 2A AND 3A
BECOME EFFECTIVE
-- 4 ITEMS FOR EACH PUMP
 BLOCK 2    BLOCK 3    BLOCK 2A    BLOCK 3A
  (KWH)      (KWH)     (KWH-KW)    (KWH-KW)

 16200.0        0.0        0.0         0.0
LENGTH OF BILLING PERIOD IN MONTHS
AND MONTHS AFTER JUNE 1 THAT BILLING PERIOD BEGINS
FOR ALL PUMPS
        3.0        0.0
```

Figure 4-13 Pump tariff summary from SIMULATE routine

contained in Figures 4-14, 4-15 and 4-16 provide information on the adequacy of irrigation, causes of inadequacies and system costs.

Figures 4-14a, b and c are irrigation summaries for all crops in the rotation. Discussion will centre on the results for PASTURE1 (crop no. 16) contained in Figure 4-14 as this crop appears most often in the rotation and has the longest growing season. Within the growing season the average irrigation requirement per period ranges from a negligible amount in April to a maximum of 50 mm in the second half of December with a average seasonal total of 432 mm. As expected, water is required 100 percent of the time during December and the first part of January with the percentage decreasing towards each end of the growing season. The third row of figures is the average requirement when water is required and is computed by dividing the average requirement by percent of time required (decimal). The average requirement when required is the average amount of irrigation water required to meet crop demands. The seasonal total of 567 mm is the average total irrigation demand.

The remainder of the data pertain to irrigation system performance in supplying crop water requirements. The fourth line is the average amount applied by the sprinkler system under consideration. The system is able to supply essently all requirements by pasture through October. The inability to meet requirements throughout the middle of the season is attributable to two factors -- increased water use and the irrigation priorities shown in Figure 4-5. The percentage of time that the requirement exceeds application is given for each period along with the average deficit in those periods when water is required and the maximum deficit occurring in the entire period of simulation.

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Figure 4-14a Irrigation summary output

from SIMULATE routine

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IRRIGATION SIMULATION OUTPUT FOR
SIMULATEEXMPL

SUMMARIES ARE GIVEN FOR:
1. ADEQUACY OF IRRIGATION FOR ALL CROPS
2. IRRIGATION SYSTEM PERFORMANCE AND COST
3. RESULTS ARE BASED ON 25 YEARS RECORDS FOR
   RAINFALL AND PET DATA

CROP SUMMARY RESULTS FOR WINTER WHEAT1
=======================================

| ---- MONTH ----> | JUN | | JUL | | AUG | | SEP | | OCT | | NOV | | DEC | | JAN | | FEB | | MAR | | APR | | MAY | | SEASONAL |
---- HALF ---->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	TOTAL
AVERAGE IRRIG REQUIREMENT - (MM)	0	0	0	0	0	0	4	7	15	27	40	37	14	17	4	0	1	0	0	0	0	0	0	0	166
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	15	38	77	92	92	92	69	77	38	8	15	0	0	0	0	0	0	0	
AVE REQUIREMENT WHEN REQUIRED (MM)	0	0	0	0	0	0	27	17	19	29	43	40	20	22	11	4	4	0	0	0	0	0	0	0	236
AVE APPLIED WHEN REQUIRED (MM)	0	0	0	0	0	0	27	17	19	29	43	40	5	4	11	4	4	0	0	0	0	0	0	0	203
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	0	0	0	0	56	50	0	0	0	0	0	0	0	0	0	0	
AVERAGE DEFICIT WHEN WTR REQD (MM)	0	0	0	0	0	0	0	0	0	0	0	0	15	17	0	0	0	0	0	0	0	0	0	0	32
MAXIMUM DEFICIT - - - (MM)	0	0	0	0	0	0	0	0	0	0	0	0	47	49	0	0	0	0	0	0	0	0	0	0	
AVERAGE READJUSTMENT (MM)	0	0	0	0	0	0	21	16	8	12	6	10	8	5	11	4	4	0	0	0	0	0	0	0	105
MAXIMUM READJUSTMENT (MM)	0	0	0	0	0	0	21	23	16	17	10	10	10	8	21	4	7	0	0	0	0	0	0	0	

Figure 4-14b   Irrigation summary output

from SIMULATE routine

CROP SUMMARY RESULTS FOR PEAS1
===

---- MONTH ------> ---- HALF ------>	JUN 1ST	2ND	JUL 1ST	2ND	AUG 1ST	2ND	SEP 1ST	2ND	OCT 1ST	2ND	NOV 1ST	2ND	DEC 1ST	2ND	JAN 1ST	2ND	FEB 1ST	2ND	MAR 1ST	2ND	APR 1ST	2ND	MAY 1ST	2ND	SEASONAL TOTAL
AVERAGE IRRIG REQUIREMENT - (MM)	0	0	0	0	0	0	2	4	9	17	30	41	40	28	0	1	0	0	0	0	0	0	0	0	172
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	8	50	58	67	92	100	100	75	17	17	0	0	0	0	0	0	0	0	
AVE REQUIREMENT WHEN REQUIRED (MM)	0	0	0	0	0	0	20	7	15	26	32	41	40	37	1	3	0	0	0	0	0	0	0	0	222
AVE APPLIED WHEN REQUIRED (MM)	0	0	0	0	0	0	20	7	15	26	32	41	2	4	1	3	0	0	0	0	0	0	0	0	151
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	0	0	0	0	83	78	0	0	0	0	0	0	0	0	0	0	
AVERAGE DEFICIT WHEN WTR REQD (MM)	0	0	0	0	0	0	0	0	0	0	0	0	38	33	0	0	0	0	0	0	0	0	0	0	71
MAXIMUM DEFICIT - - - (MM)	0	0	0	0	0	0	0	0	0	0	0	0	56	67	0	0	0	0	0	0	0	0	0	0	
AVERAGE READJUSTMENT (MM)	0	0	0	0	0	0	0	7	12	10	9	8	0	8	1	3	0	0	0	0	0	0	0	0	58
MAXIMUM READJUSTMENT (MM)	0	0	0	0	0	0	0	13	14	10	10	10	0	8	1	5	0	0	0	0	0	0	0	0	

CROP SUMMARY RESULTS FOR PASTURE1
===

---- MONTH ------> ---- HALF ------>	JUN 1ST	2ND	JUL 1ST	2ND	AUG 1ST	2ND	SEP 1ST	2ND	OCT 1ST	2ND	NOV 1ST	2ND	DEC 1ST	2ND	JAN 1ST	2ND	FEB 1ST	2ND	MAR 1ST	2ND	APR 1ST	2ND	MAY 1ST	2ND	SEASONAL TOTAL
AVERAGE IRRIG REQUIREMENT - (MM)	0	0	0	0	0	0	4	11	18	22	31	38	45	50	47	46	38	35	22	21	2	2	0	0	432
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	24	44	68	76	80	96	100	100	100	96	92	76	60	56	12	8	0	0	
AVE REQUIREMENT WHEN REQUIRED (MM)	0	0	0	0	0	0	18	25	27	29	38	40	45	50	47	48	41	46	37	37	15	24	0	0	567
AVE APPLIED WHEN REQUIRED (MM)	0	0	0	0	0	0	18	25	27	27	30	28	36	41	39	38	31	30	27	33	15	24	0	0	469
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	12	21	55	54	56	44	52	50	39	53	20	14	0	0	0	0	
AVERAGE DEFICIT WHEN WTR REQD (MM)	0	0	0	0	0	0	0	0	0	1	8	12	9	10	8	10	10	16	10	3	0	0	0	0	97
MAXIMUM DEFICIT - - - (MM)	0	0	0	0	0	0	0	0	2	16	47	42	48	73	47	39	44	70	68	34	0	0	0	0	
AVERAGE READJUSTMENT (MM)	0	0	0	0	0	0	29	26	22	10	16	19	16	12	9	15	21	29	18	23	0	0	0	0	265
MAXIMUM READJUSTMENT (MM)	0	0	0	0	0	0	29	37	30	28	34	36	18	26	24	27	28	29	39	23	0	0	0	0	

CROP SUMMARY RESULTS FOR PASTURE2
==

---- MONTH -----> ---- HALF ------>	JUN 1ST	2ND	JUL 1ST	2ND	AUG 1ST	2ND	SEP 1ST	2ND	OCT 1ST	2ND	NOV 1ST	2ND	DEC 1ST	2ND	JAN 1ST	2ND	FEB 1ST	2ND	MAR 1ST	2ND	APR 1ST	2ND	MAY 1ST	2ND	SEASONAL TOTAL
AVERAGE IRRIG REQUIREMENT - (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	30	16	20	2	6	0	0	98
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	83	75	58	8	17	0	0	
AVE REQUIREMENT WHEN REQUIRED (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	36	21	35	28	33	0	0	179
AVE APPLIED WHEN REQUIRED (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	36	21	29	28	33	0	0	173
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	
AVERAGE DEFICIT WHEN WTR REQD (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	6
MAXIMUM DEFICIT - - - (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	
AVERAGE READJUSTMENT (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	11
MAXIMUM READJUSTMENT (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	

CROP SUMMARY RESULTS FOR GREENFEED1
==

---- MONTH -----> ---- HALF ------>	JUN 1ST	2ND	JUL 1ST	2ND	AUG 1ST	2ND	SEP 1ST	2ND	OCT 1ST	2ND	NOV 1ST	2ND	DEC 1ST	2ND	JAN 1ST	2ND	FEB 1ST	2ND	MAR 1ST	2ND	APR 1ST	2ND	MAY 1ST	2ND	SEASONAL TOTAL
AVERAGE IRRIG REQUIREMENT - (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	10	12	0	3	0	0	31
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	46	46	0	8	0	0	
AVE REQUIREMENT WHEN REQUIRED (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	21	26	0	41	0	0	103
AVE APPLIED WHEN REQUIRED (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	21	26	0	41	0	0	103
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
AVERAGE DEFICIT WHEN WTR REQD (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAXIMUM DEFICIT - - - (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
AVERAGE READJUSTMENT (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	12	24	0	0	0	0	49
MAXIMUM READJUSTMENT (MM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	20	24	0	0	0	0	

==

Figure 4-14c Irrigation summary output from SIMULATE routine

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In the first period of October the average requirement when water is required is 27 mm and the average application is also 27 mm. However, the results show that system capacity is exceeded 12 percent of the time. When system capacity is exceeded, readjustment is used to fill the soil to field capacity during the previous period if possible (subroutine ADJUST, section 3.5.3). The average readjustment required in periods when water is required and the maximum readjustment in the simulation period are contained in the last two lines.

The results for each crop provide detailed information pertaining to water requirements and application. The half-monthly periods are short enough to provide sufficient detail relative to crop growth patterns and farm operations without excessive detail. An irrigator or planner can consider deficits in relation to a desired level of risk. The readjustment parameters give an indication of system management and operation necessary to maximize the effectiveness of the system(s) under consideration. Results for all crops should also be conjunctively evaluated to determine the effects of crop rotation and irrigation priorities.

Causes of irrigation deficits are shown in the printout of Figure 4-15. For the example, system capacity is the limiting factor causing all deficits. System capacity is limiting a high percentage of time during the peak of the season. These results also indicate that the system is used to capacity the majority of time. The printout would indicate if labour or water supply were limiting at any tme. Also, if more than one application system is used the percentage of time that capacity is limiting is listed separately for each.

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Figure 4-15 Constraining conditions output from SIMULATE routine

PERCENT OF TIME DEFICITS OCCUR WHEN WATER IS
REQUIRED DUE TO VARIOUS CONSTRAINTS

| ---- MONTH ------> | JUN | | JUL | | AUG | | SEP | | OCT | | NOV | | DEC | | JAN | | FEB | | MAR | | APR | | MAY | |
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
WATER AS																								
LIMITING - - - (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LABOR AS																								
LIMITING - - - (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SYSTEMS LIMITING (%)																								
SIDE-ROLL SPRINKLER	0	0	0	0	0	0	0	0	15	25	70	75	64	64	60	50	39	50	31	20	0	0	0	0

Cost information for the application system is shown in Figure 4-16 a and for the supply system in Figure 4-16 b. The printout in Figure 4-16 contains summary information for the application system similar to that in the LIST-SYSTEMSEXMPL file (Figure 4-10). Included in the summary information are data input to the SIMULATE routine; return on investment, labour wage rate and inflation factors.

System costs based upon cost inputs, loan terms and water use results from system simulation are shown in Figure 4-16a. The overall annual cost of $17,442.00 is the total annual cost over the life of the system taking into capital costs, interest rates, operating costs, inflation and the specified rate of return as described in section 3.5.5. This cost is a ficticious cost as far as actual annual cost to the irrigator is concerned, but it does provide a basis of comparison between two systems. For this example, the overall annual cost including subsidies is the same as that excluding subsidies as there are no subsidized costs. The total capital cost not subsidized or financed of $15,624.00 represents the cash required for system installation.

Detailed capital and operating costs are presented for each year of the system life. These figures accurately represent the expected costs taking into account the specified loan terms and inflation factors Capital cost items shown are the repayment and interest charges. for both loans along with the total. Repayment and interest are listed separately so that the information is available for accounting and tax purposes or for input into a farm budget model. Four categories of operating costs are listed; labour, energy, maintenance and

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```
IRRIGATION SYSTEM SUMMARY FOR SIDE-ROLL SPRINKLER
                 ====================

TOTAL AREA SERVED (HECTARES) - - - - - -     58.0
FLOW ENTERING SYSTEM (L/S) - - - - - - -     30
PERCENT OF TIME SYSTEM OPERATES (%)  - -     73
SYSTEM LIFE (YEARS)  - - - - - - - - - -     20

INPUT DATA FOR ATTACHED COMPONENTS
  TOTAL CAPITAL COST ($) - - - - - - - -     15060
  CAPITAL NOT FINANCED OR SUBSIDIZED ($)     6024
  SUBSIDIZED CAPITAL ($) - - - - - - - -        0
  FINANCED CAPITAL ($) - - - - - - - - -     9036
  FINANCE INTEREST RATE (%)  - - - - - -        9.0
  TIME OF LOAN (YEARS) - - - - - - - - -       15
  SALVAGE VALUE ($)  - - - - - - - - - -     4412
  ANNUAL MAINTENANCE EXPENSE ($) - - - -      425
  ANNUAL MISCELLANEOUS EXPENSE ($) - - -      125

INPUT DATA FOR NON-ATTACHED COMPONENTS
  TOTAL CAPITAL COST ($) - - - - - - - -     19900
  CAPITAL NOT FINANCED OR SUBSIDIZED ($)     9600
  SUBSIDIZED CAPITAL ($) - - - - - - - -        0
  FINANCED CAPITAL ($) - - - - - - - - -     10300
  FINANCE INTEREST RATE (%)  - - - - - -       14.0
  TIME OF LOAN (YEARS) - - - - - - - - -        7
  SALVAGE VALUE ($)  - - - - - - - - - -     1990
  ANNUAL MAINTENANCE EXPENSE ($) - - - -      450
  ANNUAL MISCELLANEOUS EXPENSE ($) - - -       50

RETURN ON INVESTMENT (%) - - - - - - - -     18.0
LABOR WAGE RATE ($/HR)   - - - - - - - -      5.50
INFLATION FOR LABOUR (%) - - - - - - - -     10.0
INFLATION FOR OPERATION AND MAINT. (%) -     12.0
INFLATION FOR ENERGY (%) - - - - - - - -     16.0


EXPECTED COSTS FOR IRRIGATION FOR SIDE-ROLL SPRINKLER
OVER THE LIFE OF THE SYSTEM

THE SYSTEM SUPPLIES   58.0 HECTARES

TOTAL OVERALL ANNUAL COST ($) - - - - - - - -    17442
OVERALL ANNUAL COST EXCLUDING SUBSIDIES ($) -    17442
  (NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)

TOTAL CAPITAL COST NOT SUBSIDIZED OR FINANCED ($) -    15624
```

| YEAR | - - - CAPITAL COSTS - - - | | | OPERATING COSTS FOR AVERAGE CONDITIONS | | | | | OVERALL |
	REPYMNT	INTRST	TOTAL	LABOR	ENERGY	MAINT	MISC	TOTAL	TOTAL
1	1268	2255	3523	1944	2001	875	175	4995	8518
2	1430	2093	3523	2138	2321	980	196	5635	9158
3	1613	1910	3523	2352	2692	1098	220	6362	9885
4	1821	1702	3523	2587	3123	1229	246	7185	10708
5	2056	1467	3523	2846	3622	1377	275	8120	11643
6	2322	1201	3523	3131	4202	1542	308	9183	12706
7	2623	900	3523	3444	4874	1727	345	10390	13913
8	563	558	1121	3788	5654	1934	387	11763	12884
9	613	508	1121	4167	6559	2166	433	13325	14446
10	668	453	1121	4584	7608	2426	485	15103	16224
11	729	392	1121	5042	8826	2718	544	17130	18251
12	794	327	1121	5546	10238	3044	609	19437	20558
13	866	255	1121	6101	11876	3409	682	22068	23189
14	944	177	1121	6711	13776	3818	764	25069	26190
15	1028	93	1121	7382	15980	4276	855	28493	29614
16	0	0	0	8120	18537	4789	958	32404	32404
17	0	0	0	8932	21502	5364	1073	36871	36871
18	0	0	0	9825	24943	6008	1202	41978	41978
19	0	0	0	10808	28934	6729	1346	47817	47817
20	0	0	0	11888	33563	7536	1507	54494	54494

Figure 4-16a   Cost summary output from

SIMULATE routine

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SUMMARY FOR WATER SUPPLY SYSTEM -- SUPPLYEXMPL

TOTAL AREA SERVED (HECTARES) - - - - - -   58.0
SYSTEM CAPACITY
    MAX VOLUME DELIVERED (CUBIC M/24 HR)   2592
    MAX FLOW RATE (L/S) - - - - - - - - - -   30
CONVEYANCE EFFICIENCY (%) - - - - - - -   100
SYSTEM LIFE (YEARS) - - - - - - - - - -   20

INPUT DATA FOR ATTACHED COMPONENTS
    TOTAL CAPITAL COST ($) - - - - - - - -   25174
    CAPITAL NOT FINANCED OR SUBSIDIZED ($)   0
    SUBSIDIZED CAPITAL ($) - - - - - - - -   0
    FINANCED CAPITAL ($) - - - - - - - - -   25174
    FINANCE INTEREST RATE (%) - - - - - -   9.0
    TIME OF LOAN (YEARS) - - - - - - - - -   15
    SALVAGE VALUE ($) - - - - - - - - - -   6386
    ANNUAL MAINTENANCE EXPENSE ($) - - - -   450
    ANNUAL MISCELLANEOUS EXPENSE ($) - - -   125

INPUT DATA FOR NON-ATTACHED COMPONENTS
    TOTAL CAPITAL COST ($) - - - - - - - -   500
    CAPITAL NOT FINANCED OR SUBSIDIZED ($)   500
    SUBSIDIZED CAPITAL ($) - - - - - - - -   0
    FINANCED CAPITAL ($) - - - - - - - - -   0
    FINANCE INTEREST RATE (%) - - - - - -   14.0
    TIME OF LOAN (YEARS) - - - - - - - - -   7
    SALVAGE VALUE ($) - - - - - - - - - -   0
    ANNUAL MAINTENANCE EXPENSE ($) - - - -   20
    ANNUAL MISCELLANEOUS EXPENSE ($) - - -   0

RETURN ON INVESTMENT (%) - - - - - - - -   18.0
INFLATION FOR OPERATION AND MAINT. (%) -   12.0
INFLATION FOR ENERGY (%) - - - - - - - -   16.0

EXPECTED COSTS FOR IRRIGATION FOR SUPPLYEXMPL
OVER THE LIFE OF THE SYSTEM

THE SYSTEM SUPPLIES   58.0 HECTARES

TOTAL OVERALL ANNUAL COST ($) - - - - - - - - -   13960
OVERALL ANNUAL COST EXCLUDING SUBSIDIES ($) -   13960
    (NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)

TOTAL CAPITAL COST NOT SUBSIDIZED OR FINANCED ($) -   500

| | - - - CAPITAL COSTS - - - | | | OPERATING COSTS FOR AVERAGE CONDITIONS | | | | | OVERALL |
YEAR	REPYMNT	INTRST	TOTAL	WATER	ENERGY	MAINT	MISC	TOTAL	TOTAL
1	857	2266	3123	0	2960	470	125	3555	6678
2	935	2188	3123	0	3434	526	140	4100	7223
3	1019	2104	3123	0	3983	590	157	4730	7853
4	1110	2013	3123	0	4620	660	176	5456	8579
5	1210	1913	3123	0	5360	740	197	6297	9420
6	1319	1804	3123	0	6217	828	220	7265	10388
7	1438	1685	3123	0	7212	928	247	8387	11510
8	1567	1556	3123	0	8366	1039	276	9681	12804
9	1708	1415	3123	0	9704	1164	309	11177	14300
10	1862	1261	3123	0	11257	1303	347	12907	16030
11	2030	1093	3123	0	13058	1460	388	14906	18029
12	2212	911	3123	0	15147	1635	435	17217	20340
13	2412	711	3123	0	17571	1831	487	19889	23012
14	2629	494	3123	0	20382	2051	545	22978	26101
15	2865	258	3123	0	23643	2297	611	26551	29674
16	0	0	0	0	27426	2573	684	30683	30683
17	0	0	0	0	31815	2881	766	35462	35462
18	0	0	0	0	36905	3227	858	40990	40990
19	0	0	0	0	42810	3614	961	47385	47385
20	0	0	0	0	49659	4048	1077	54784	54784

Figure 4-16b Cost summary output from

SIMULATE routine

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miscellaneous costs. The costs in each category increase annually by the amount of the respective inflation factor. Operating costs are based on the average irrigation application for each crop during each half-monthly period. The results, therefore, do not reflect the variability of operating costs between years due to varying water requirements. To present such detailed information would require voluminous output of questionable worth for irrigators and farm advisers as the exact sequence of water use requirements cannot be predicted. Also, if the system is operated at or near capacity, annual water application will not vary appreciably.

The overall total annual cost is comprised of the total capital and operating costs. The results for the example show that the overall cost increases rather uniformly at first and then levels out as the short-term loan is paid out. The rate of increase then becomes quite large at the end of the system life due to the effects of inflation. Such increases have been observed for systems operating over a number of years.

The results in Figure 4-16 b for the supply system are similar to those in Figure 4-16 a for the application system. One exception is that no annual cost for labour is shown, rather a cost for water if applicable. The total cost of owning and operating a system is the sum of the costs for the application system(s) and the supply system.

The results produced by the SIMULATE routine allow the user to evaluate system performance along with system cost. Labour and water constraints can also be considered. Planning decisions can be made considering multiple objectives that can easily vary from one farm to

another. Often the "best" choice is one involving trade-offs between cost, labour and the effectivenes of irrigation on a number of crops. Results from the systems analysis provide the necessary quantitative information upon which such decisions can be based.

CHAPTER 5

CONCLUSIONS

Systems analysis can be used effectively for planning irrigation systems. The analysis procedure developed provides a means of analysing the different aspects of an irrigation system along with the effects of many external factors that affect system performance. The farm irrigation systems analysis procedure (FISA) provides a means of critically evaluating on-farm irrigation system plans and water management practices under site-specific conditions. Computer routines are used in the procedure for determining operating characteristics and providing cost summaries for individual system components. A simulation model is then used to obtain a detailed analysis of system operational characteristics and costs.

The computer routines used provide a great deal of flexibility in the FISA procedure. This flexibility is necessary for the procedure to be useful for system planning purposes in New Zealand where site specific conditions vary quite markedly. The routines are designed to utilize available data to the fullest extent. If necessary, modules (routines and subroutines) in the FISA procedure can also be modified or new ones added to cope with unforeseen requirements.

Irrigation system operations can be accurately represented by simulation modeling. The simulation model developed is capable of estimating irrigation water requirements based upon crop water use, rainfall and soil moisture holding characteristics. Simulation of water application to individual paddocks based upon crop rotation schedules and irrigation priorities for each crop is accounted for each paddock. Management factors such as maintaining adequate soil moisture

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levels in anticipation of drought conditions are included in the simulation process. Results from the simulation process satisfactorily represent how a system would operate under conditions defined by input data.

As with the computer routines used to define component operating characteristics the simulation model is written in modular form. This form will allow modifications and/or expansions to be made if required.

The results obtained from the systems analysis procedure show the interactive effects of physical parameters, costs, loan terms, inflation and constraining conditions. This information can be used in making decisions in the planning phase considering multiple objectives and trade-offs that a planner or farm manager must consider. Data from the output are also sufficient to be used as inputs to cash flow and economic planning models.

An important feature of the FISA procedure is the ease with which alternative system plans can be evaluated. Plans involving different paddock layouts and cropping patterns can be considered along with alternative irrigation systems. Developing these plans can be accomplished quite rapidly, and the results also show how the effects of loan terms, inflation and rate of return on money. Developing and evaluating alternatives in the planning phase allows alternatives to be objectively evaluated and decisions to be made prior to detailed system design.

It can be concluded that the system analysis procedure developed is a technique suitable for New Zealand conditions as set forth in the project objectives stated in Chapter 1.

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CHAPTER 6

RECOMMENDATIONS

Although the irrigation systems analysis procedure developed is an effective planning tool, several recommendations are offered for effective use and possible extensions. An understanding of input data and computational processes used is necessary to understand and effectively interpret the results. The user should also be familiar with the computer system used.

A rather complete verification of all elements in the procedure should be an item of top priority before extensive use. Those subroutines which require thorough checking and verification are those used to estimate daily evapotranspiration in the WATERUSE routine and subroutine WATEREQT. It is recommended that daily data for potential evapotranspiration be used to estimate daily evapotranspiration if possible. Subroutines BORDER and FURROW should also be evaluated especially in regard to the effects soil intake rate parameters and roughness coefficients on estimated application efficiencies. Every effort was made to eliminate "BUGS" from the computer routines, but there are undoubtedly some remaining to be found by the unsuspecting users!

Extensions of the present procedure would provide added dimensions to the applications and results. The following extensions may prove effective:

1. Provide for a non-steady water supply that would closely resemble the supply from a run-of-the-river supply.

2. Include a more detailed analysis of the simulation results that might incorporate a probability distribution of

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irrigation requirements, water application and/or deficits for each crop, paddock, or system. Data of sufficient detail are passed to subroutine YEARSUM in the simulation process to compute numerous statistics.

3. Provide information pertaining to the expected variation in operating costs based upon variations in irrigation water applications obtained from the simulation process.

4. Reload all input data in a file that could be easily modified and read as input and thus alleviate reentering large amounts of data when only minor changes are being considered.

5. Additional programming may be incorporated into some of the subroutines such as PIPES and RACES to select the proper component size for specified conditions. Decision making and optimization routines could also be included, but their use would greatly magnify the complexity of the simulation and analysis procedures especially when considering multiple objectives and associated trade-offs.

6. Include crop production functions so that output could directly show the effects of water application on crop production.

7. Adapt the procedure for use on a micro computer.

It is hoped that the entire procedure will be improved, modified and expanded to be a useful tool for planning on farm irrigation systems in New Zealand.

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APPENDIX A
COMPUTER PROGRAMME LISTINGS

CONTENTS   Page

```
C   >>>> PROGRAM STORED IN FILE WATERUSE.F77 <<<<
C      PROGRAM FOR DETERMINING WATER USE FOR A
C      GIVEN CROP ROTATION AND SOIL
C      THIS PROGRAM USES POLYNOMIAL CROP COEFFICIENTS
C      BASED UPON USDA DATA
C   --
C   ---THIS PROGRAM IS BASED UPON ONE WRITTEN BY KEVIN ADAMSON
C      AGRICULTURAL ENGINEERING, LINCOLN COLLEGE UNDER THE
C      DIRECTION OF DR. TERRY HEILER, NZAEI AND WITH THE ASSISTANCE
C      OF JOHN BAIRD, NZAEI, 1981
C
C      THE PROGRAM WAS MODIFIED FOR ITS PRESENT USE BY J.R. BUSCH,
C      WINCHMORE, 1982
C
C

      INTEGER*2 LU8, LU9, PHDEV1
      INTEGER*2 ZERO, BUFSIZ
      PARAMETER PHDEV1 = 1
      PARAMETER LU8 = 5
      PARAMETER LU9 = 5
      PARAMETER ZERO = 0
      PARAMETER BUFSIZ = 80
      COMMON B(100,9)
      DIMENSION RAIN(366),PET(12),KKW(30),IDC(30),
     *MONLEN(12),CROPS(18,32),
     *NUM(32),RIRRID(366,10),SMFRAC(10),W(10),X1(10),
     *X3(10),X4(10),X5(10),X6(10),X7(10),EXS(10),AET(10),
     *AVE(365),TOT(365),CROPF(13,32),LSM(10),X2(10),
     *X8(10),SCRP(52,10),PERIOD(9),
     * KCROP1(10),KCROP2(10),FTOTAL(100,10)
      REAL K1,K2,LSM
      CHARACTER*1 CON,CON1,CNAME(30)*16
      CHARACTER*20 IRAIN,IPET,IOPLOT,CROP1,CROP2,HEAD
      INTEGER CROPS,X1,X2,X3,X4,X5,X6,X7,X8
      LOGICAL PROMPT
      DATA MONLEN/31,28,31,30,31,30,31,31,30,31,30,31/
      CALL ATTDEV (LU8, PHDEV1, ZERO, BUFSIZ)
      CALL ATTDEV (LU9, PHDEV1, ZERO, BUFSIZ)
      PROMPT=.TRUE.
C     CALL ASSIGN(9,'TT:')
      IF(PROMPT)WRITE(5,*)'ENTER ALL VALUES IN FREE FORMAT'
      IF(PROMPT)WRITE(5,*)'ENTER HEADING (<=20 CHARS)'
      READ(5,8) HEAD
      IF(PROMPT)WRITE(5,*)'ENTER YEARS OF BEGINNING AND ENDING SEASONS'
      READ(5,*)ISTART,ISTOP
      IF(ISTART.GT.100) ISTART = ISTART - 1900
      IF(ISTOP.GT.100) ISTOP = ISTOP - 1900
      IF(PROMPT)WRITE(5,*)'ENTER NAME OF RAINFALL FILE'
      READ(5,8)IRAIN
8     FORMAT(A)
      OPEN(10,FILE=IRAIN,STATUS='OLD',ERR=9009)
      IF(PROMPT)WRITE(5,*)'ENTER NAME OF PET FILE'
      READ(5,8)IPET
      OPEN(20,FILE=IPET,STATUS='OLD',ERR=9009)
```

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```fortran
      IF(PROMPT)WRITE(5,*)'ENTER TOTAL AVAILABLE MOISTURE - TAM (MM)'
      READ(5,*)TAM
      IF(PROMPT)WRITE(5,*)'ENTER MGT ALLOWED DEFICIT - MAD (MM)'
      READ(5,*) TMAD
      IF(PROMPT)WRITE(5,*)'ENTER STARTING SOIL MOISTURE DEFICIT (MM)'
      READ(5,*)STSM
      CROP1 = 'CROPDATE'
      OPEN(17,FILE=CROP1,STATUS='OLD',ERR=9009)
      CROP2 = 'CROPFPOLY'
      OPEN(18,FILE=CROP2,STATUS='OLD',ERR=9009)
C
C     READ AGRONOMIC DATA FILES
C
C    NCROPF = NO OF CROPS IN CROPF FILE
C    NCROPS = NO OF CROPS IN CROPS FILE
      NCROPF = 12
C
C     READ AGRONOMIC DATA FILES
C
      READ(17,220)NCROPS
220   FORMAT(I5,////)
      DO 230 J=1,NCROPS
230   READ(17,22)CNAME(J),IDC(J),(CROPS(I,J),I=1,4)
22    FORMAT(1X,A,5I10)
      READ(18,23)((CROPF(I, J),I=1,10),J=1,NCROPF)
23    FORMAT(22X,10E10.4)
C
      WRITE(5,221) NCROPS
221   FORMAT(//' CROP MENU FOR ',I2,' CROPS FROM CROPDATE FILE'/
     1' CROP ID NO. AND CROP NAME')
C
      WRITE(5,222) (IDC(J),CNAME(J),J=1,NCROPS)
222   FORMAT(3X,I2,1X,A,5X,I2,1X,A)
      WRITE(5,223)
223   FORMAT(//)
      IF(PROMPT)WRITE(5,*)'ENTER NUMBER OF PADDOCKS IN ROTATION'
      READ(5,*)ICROP
      DO 301 I=1, ICROP
      IF(PROMPT)WRITE(5,*)'ENTER 2 CROP NOS. FOR 2 CROPS IN PADDOCK',I
      KCROP1(I) = 0
      KCROP2(I) = 0
      KKW(I) = 4
      READ(5,*) KCROP1(I), KCROP2(I)
      IF (KCROP2(I).EQ.0) KCROP2(I)=23
301   CONTINUE
C
      IF(PROMPT)WRITE(5,*)'ENTER THE NUMBER OF CUMULATIVE PERIODS '
      READ(5,*)NRPD
      IF(PROMPT)WRITE(5,*)'ENTER THE CUMULATIVE PERIODS (DAYS)'
      READ(5,*)(PERIOD(I),I=1,NRPD)
      IF(PROMPT)WRITE(5,*)'PRINTOUT OF WEEKLY WATER USE -- Y OR N'
      READ(5,8)CON
      IF(PROMPT)WRITE(5,*)'PRINTOUT OF MAX ANNUAL WATER USE - Y OR N'
      READ(5,8)CON1
```
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```
C
      WRITE(5,4)
4     FORMAT(///' I AM NOW THINKING AND TRYING TO DIGEST ALL THE DATA'/
     1' YOU HAVE FED ME.  I WILL TELL YOU WHEN I AM FINISHED.'/
     2' --- PROVIDED YOU HAVE NOT FED ME BAD DATA THAT WILL'/
     3' RESULT IN INDIGESTION!!!!!'///)
C
C     PRINT INPUT SPECIFICATIONS
C
      OPEN(6,FILE=HEAD)
      WRITE(6,2)HEAD
2     FORMAT('1'///' CUMULATIVE IRRIGATION REQUIREMENTS -- ',A,//)
      WRITE(6,3)ISTART,ISTOP
3     FORMAT(' FIRST SEASON',8X,'19',I2,/,' FINAL SEASON',8X,'19',I2)
      WRITE(6,5)IRAIN,IPET
5     FORMAT(' RAINFALL FILE',7X,A,
     * /,' PET FILE',12X,A)
      WRITE(6,10)TAM,TMAD,STSM
10    FORMAT(' TOTAL AVAILABLE MOISTURE (MM)',T40,F5.1/
     1' MANAGEMENT ALLOWED DEFICIT (MM)',T40,F5.1/
     2' BEGINNING SOIL MOISTURE DEFICIT (MM)',T40,F5.1)
      WRITE(6,13)ICROP
13    FORMAT(' NO. OF PADDOCKS --',I2)
      WRITE(6,14)(KCROP1(I),KCROP2(I ),I=1,ICROP)
14    FORMAT(' CROP ID NOS. --',10(I3,I3,2X))
      WRITE(6,221)NCROPS
      WRITE(6,222)(IDC(J),CNAME(J),J=1,NCROPS)
      NYEAR=0
      A=30
C     CALCULATE AVAILABLE H2O
C
      AWC= TAM
      BGSM = TAM - STSM
      IF(BGSM.LT.0.) BGSM = 0.
      AWK = TAM - TMAD
      DO 16 I=1,ICROP
   16 LSM(I)=BGSM
C
C     LOCATE STARTING RECORDS IN FILES
C     FILE 10 = RAINFALL, 20 = PET
      NG=10
80    READ(10,82)LYEAR
82    FORMAT(13X,I2)
86    IF(LYEAR.LT.ISTART)GO TO 80
      IF(LYEAR.EQ.ISTART)BACKSPACE (NG)
      IF(LYEAR.EQ.ISTART)GO TO 81
19    WRITE(6,20)NG,LYEAR
20    FORMAT('0FILE ON UNIT',I2,'STARTS AT 19',I2,'RUN TERMINATED'/
     *,133('*'))
      STOP
81    NG=20
83    READ(20,85)LYEAR
85    FORMAT(3X,I2)
      IF(LYEAR.LT.ISTART)GO TO 83
```

```
          IF(LYEAR.EQ.ISTART)BACKSPACE (NG)
          IF(LYEAR.GT.ISTART)GO TO 19
C     READ FIRST YEARS DATA FROM FILES
C
          CALL LOAD(RAIN,10,ISTART)
          READ(20,21)PET
  21      FORMAT(5X,12F6.1)
C
C    PREPARE TO START FROM JUNE
C
          NDAY=152
          IF(MOD(ISTART,4).EQ.0)NDAY=153
C
C     LOOP FOR ASSIGNING IRRIGATION STRATAGIES
C
          DO 24 I=1,ICROP
          X1(I)=CROPS(1,KCROP1(I))
          X2(I)=CROPS(2,KCROP1(I))
          X3(I)=CROPS(3,KCROP1(I))
          X4(I)=CROPS(4,KCROP1(I))
          X5(I)=CROPS(1,KCROP2(I))
          X6(I)=CROPS(2,KCROP2(I))
          X7(I)=CROPS(3,KCROP2(I))
          X8(I)=CROPS(4,KCROP2(I))
  24      CONTINUE
C
C     ENTER YEARLY LOOP
C
          DO 200 IYR=ISTART,ISTOP
          NYEAR=NYEAR+1
          JDAY=0
C
C
          DO 109 I=1,10
  109     FTOTAL(NYEAR,I) = 0.
          DO 110 IWK = 1,52
          DO 110 I=1,5
  110     SCRP(IWK,I) = 0.
          IWK=1
          KDY = 0
          DO 201 MON=6,17
          IF(MON.GT.12)MONTH=MON-12
          IF(MON.LE.12)MONTH=MON
          IF(MONTH.NE.1)GO TO 50
C
C     READ IN DATA  FOR NEXT JAN - DEC PERIOD
C
          CALL LOAD(RAIN,10,IYR+1)
          READ(20,21)PET
          MONLEN(2)=28+(IYR+1)/4-IYR/4
          NDAY=0
  50      DAYPET=PET(MONTH)/MONLEN(MONTH)
C
C     ADJUST LSM VALUES AT START OF YEAR (JUNE)
```

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```
C
      IF(MON.NE.6)GO TO 28
      HOLD=LSM(1)
      DO 29 M = 2,ICROP
 29   LSM(M-1)=LSM(M)
      LSM(ICROP)=HOLD
 28   CONTINUE
C
C    DAILY LOOP
C
      DO 337 IDAY=1,MONLEN(MONTH)
      JDAY=JDAY+1
      KDY = KDY + 1
      NDAY = NDAY + 1
C
C    LOOP FOR ICROP ON SM BALANCES
C
      DO 99 I=1,ICROP
      W(I)=LSM(I)/AWC
      RIRRID(JDAY,I) = 0.
C
C    SELECTION OF SMFRAC(I)=I(CROP TYPE) AND COMPUTING CROP COEFFICIENTS
C
      IF(JDAY.GE.X1(I)) GO TO 30
 310  F1 = CROPF(1,12)
      F2 = CROPF(2,12)
      F3 = CROPF(3,12)
      F4 = CROPF(4,12)
      F5 = CROPF(9,12)
      F6 = CROPF(10,12)
      FDAY = FLOAT(JDAY)
      GO TO 38
C
 30   IF(JDAY.GE.X2(I)) GO TO 31
      F1 =  CROPF(1,X4(I))
      F2 = CROPF(2,X4(I))
      F3 = CROPF(3,X4(I))
      F4 = CROPF(4,X4(I))
      F5 = CROPF(9,X4(I))
      F6 = CROPF(10,X4(I))
      FDN = FLOAT (JDAY-X1(I))
      FDD = FLOAT(X2(I)-X1(I))
      FDAY = FDN/FDD
      GO TO 36
C
 31   IF(JDAY.GE.X3(I)) GO TO 32
      FDAY = FLOAT(JDAY - X2(I))
      F1 = CROPF(5,X4(I))
      F2 = CROPF(6,X4(I))
      F3 = CROPF(7,X4(I))
      F4 = CROPF(8,X4(I))
      F5 = CROPF(9,X4(I))
      F6 = CROPF(10,X4(I))
      GO TO 36
```

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```
32      IF(KCROP2(I).EQ.23) GO TO 310
        IF(JDAY.GE.X5(I)) GO TO 33
        GO TO 310
C
33      IF (JDAY.GE.X6(I)) GO TO 34
        F1 = CROPF(1,X8(I))
        F2 = CROPF(2,X8(I))
        F3 = CROPF(3,X8(I))
        F4 = CROPF(4,X8(I))
        F5 = CROPF (9,X8(I))
        F6 = CROPF(10,X8(I))
        FDAY = FLOAT(JDAY-X5(I))/FLOAT(X6(I)-X5(I))
        GO TO 36
C
34      IF (JDAY.GT.X7(I)) GO TO 310
        F1 = CROPF(5,X8(I))
        F2 = CROPF(6,X8(I))
        F3 = CROPF (7,X8(I))
        F4 = CROPF(8,X8(I))
        F5 = CROPF(9,X8(I))
        F6 = CROPF(10,X8(I))
        FDAY = FLOAT(JDAY - X6(I))
C
  36    SMFRAC(I)=(1.0-EXP(-A*W(I)))/(1.0-2.0*EXP(-A)+EXP(-A*W(I)))
        GO TO 39
  38    SMFRAC(I)=W(I)/(2.0-W(I))
  39    CONTINUE
C
C
        FCROP = F1*FDAY*FDAY*FDAY+
     *                          F2*FDAY*FDAY+
     *                          F3*FDAY + F4
        IF(FCROP.LT.F5) FCROP = F5
        IF (FCROP.GT.F6) FCROP = F6
C
C     FACTOR FOR ACCELERATED ET DUE TO PREVIOUS RAINFALL
C
        WKF = 1.1-0.3 * REAL(KKW(I))
        KKW(I) = KKW(I)+1
        IF(WKF.LE.0.0) WKF = 0.
        IF(KKW(I).GT.1.AND.WHC.LE.100.0) WKF = 0.0
        FKW = WKF*(0.9 - FCROP)
        IF(FKW.LT.0.0) FKW = 0.
C
C     DETERMINE AET(I)
C
        AET(I) = DAYPET * (FCROP*SMFRAC(I) + FKW)
C
C     WATER BALANCE
C
        IF (RAIN(NDAY).LT.10.0) GO TO 412
        DO 411 IXX=1,ICROP
411     KKW(IXX) = 1
412     LSM(I)=LSM(I)+RAIN(NDAY)-AET(I)
```

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```
          IF(LSM(I).GT.AWC) LSM(I) = AWC
          IF(LSM(I).GE.AWK) GO TO 42
          RIRRID(JDAY,I) = AWK - LSM(I)
          LSM(I) = AWK
42        CONTINUE
          FTOTAL(NYEAR,I) = FTOTAL(NYEAR,I) + RIRRID(JDAY,I)
          SCRP(IWK,I) = SCRP(IWK,I) + RIRRID(JDAY,I)
          IF(KDY.LT.7.OR.I.LT.ICROP) GO TO 99
          KDY = 0
          IWK = IWK + 1
 99       CONTINUE
337       CONTINUE
201       CONTINUE
C
C    SUM DAILY IRRIG DEPTHS
C
          K=0
          DO 113 IDAY = 1,365
          K=K+1
          SUM = 0.0
          DO 115 I = 1,ICROP
          SUM = SUM + RIRRID(IDAY,I)
 115      CONTINUE
          TOT(K) = SUM/REAL(ICROP)
 113      CONTINUE
C
C    WRITE OUT WEEKLY IRRIGATION REQUIREMENTS
C
          IF(CON.NE.'Y') GO TO 1115
          WRITE (6,122)IYR
122       FORMAT(//,' WEEKLY IRRIGATION REQUIREMENTS FOR 19',I2,//)
          DO 1222 IWK=1,52
          DO 1220 I=1,ICROP
1220      IF(SCRP(IWK,I).GT.0.0) GO TO 1221
          GO TO 1222
1221      WRITE(6,123) IWK,(SCRP(IWK,I),I=1,ICROP)
1222      CONTINUE
123       FORMAT(1X,I2,5X,10F7.1)
C
C    CALCULATE DAILY RUNNING MEANS FOR RETURN PERIODS
C
1115      DO 140 KPD = 1,NRPD
          PRD = PERIOD(KPD)
          KPRD = INT(PRD)
          BIG = 0.0
          NX = 1
          I = 365 - KPRD
          DO 116 N = 1,I
          K = N
          RUNTOT = 0.0
          DO 117 L = 1,KPRD
          RUNTOT = RUNTOT + TOT(K)
  117 K = K + 1
          AVE(NX) = RUNTOT/PRD
```
129

```
        BIG = MAX(BIG,AVE(NX))
        NX = NX + 1
 116    CONTINUE
C
        B(NYEAR,KPD) = BIG
140     CONTINUE
200     CONTINUE
C
C    WRITE OUT TOTAL ANNUAL IRRIG REQUIREMENTS
C
        WRITE(6,1241)(I,I=1,ICROP)
1241    FORMAT(1H1//' TOTAL ANNUAL IRRIGATION REQUIREMENTS IN MM'
     */1X,42('=')//1X,'YEAR AND PADDOCK'/8X,10(I5,2X)/)
        DO 210 IYR=ISTART,ISTOP
        IYX = IYR - ISTART + 1
210     WRITE(6,1242)IYR,(FTOTAL(IYX,I),I=1,ICROP)
1242    FORMAT(1X,I2,5X,10F7.1)
C
C    CALL PLOT ROUTINE
C
        CALL PLOT(NYEAR,NRPD,PERIOD,CON1)
C
        GO TO 9090
9009    WRITE(5,*)'THERE IS AN ERROR IN AN OPEN STATEMENT'
9090    WRITE(5,445) HEAD
445     FORMAT(' THE PROGRAM HAS SUCCESSFULLY EXECUTED'/
     1' AND THE OUTPUT IS IN FILE ',A//)
        STOP
        END
```

```
C
      SUBROUTINE LOAD(Q,NG,IY)
C     LOADS RAINFALL FOR 1 YEAR INTO ARRAY Q
C     NG = UNIT OF FILE TO BE READ
C     IY = NUMBER OF CURRENT YEAR
      DIMENSION Q(366),NDAY(12),ID(31)
      DATA NDAY/31,28,31,30,31,30,31,31,30,31,30,31/
      NADD=IY/4-(IY-1)/4
      NDAY(2)=28+NADD
      K=0.0
      DO 100 IM=1,12
      READ(NG,61)JY,MM,ID
 61   FORMAT(11X,I4,I2,14I4/1X,17I4)
      DO 150 J=1,NDAY(IM)
      K = K+1
      Q(K)=ID(J)
150   CONTINUE
100   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SORT(N,M)
C
C     SORTS Y VARIABLES INTO DESCENDING ORDER FOR PLOTTING
C     B = ARRAY TO BE SORTED
C     M = NUMBER OF COLUMNS WITHIN B
C     N = NUMBER OF VALUES/COLUMN
C
      COMMON B(100,9)
C
      DO 70 KLM = 1,M
      DO 66 I=1,N
      DO 67 J=I,N
      IF(B(I,KLM)-B(J,KLM))68,67,67
68    F=B(I,KLM)
      B(I,KLM)=B(J,KLM)
      B(J,KLM)=F
 67   CONTINUE
 66   CONTINUE
70    CONTINUE
      RETURN
      END
C
```

```
C
          SUBROUTINE PLOT(NN,NCL,PRD,CON1)
C
C
C
C     SUBROUTINE PLOT
C
C     PURPOSE
C       PLOT SEVERAL CROSS-VARIABLES VERSUS A BASE VARIABLE
C
C
C     USAGE
C       CALL PLOT(NN,NCL,PRD,CON1)
C
C     DESCRIPTION OF PARAMETERS
C     B   - MATRIX OF DATA TO BE PLOTTED
C     NN  - NUMBER OF ROWS USED IN MATRIX B
C     NCL - NUMBER OF COLUMNS IN MATRIX B
C           LINES ARE USED
C     PRD - MATRIX OF RETURN PERIODS
C     CON1 - CONTROL FOR PRINTOUT
C
C
          COMMON  B(100,9)
          DIMENSION OUT(101),YPR(11),ANG(9),L(9),POS(100),PRD(9),ULIN(90)
          CHARACTER*1 CON1
          DATA BLANK,ANG/' ','A','B','C','D','E','F','G','H','I'/
          DATA OUT/101*' '/
          DATA DOT,CEE,PLUS,UX/'.','C','+','='/ULIN/90*' '/
C
  91      FORMAT(/20X,'% OF TIME SYSTEM CAPACITY REQUIRES > '
         *'INDICATED'
         *,' QUANTITY OF IRRIGATION WATER',/'+',20X,75('_')//)
  110     FORMAT(1H1//20X,'PLOTTED RESULTS'/19X,17('='))
  111     FORMAT(/5X,' MM/DAY'/'+',5X,6('_'))
   2      FORMAT(1H ,15X,103A1)
   4      FORMAT(1H ,F11.2,4X,103A1)
   7      FORMAT(1H ,16X,1H+,10(9('-'),1H+))
   8      FORMAT(1H ,9X,11F10.2)
C
C
C
          NLL = 50
          N=NN
           CALL SORT(N,NCL)
C
C     COMPUTE PLOTTING POSITIONS
C
          ZN = NN + 1
          DO 18 I=1,N
          ZI = I
          POS(I) = 100.*ZI/ZN
  18      CONTINUE
C
```
133

```
C    WRITE OUT HEADINGS
C
      WRITE(6,110)
      WRITE(6,170)(PRD(I),I=1,NCL)
170   FORMAT(' CUMULATIVE PERIODS IN DAYS  ',9F5.0)
      WRITE(6,180)(ANG(I),I=1,NCL)
180   FORMAT(' CORRESPONDING PLOT SYMBOLS -- ',9A5)
 20   WRITE(6,111)
C
C    FIND SCALE FOR VARIABLES
C
      BIG = B(1,1)
      DO 24 KCL = 2,NCL
      BIG = MAX(BIG,B(1,KCL))
24    CONTINUE
      DO 30 AJX=5,100,5
      AJAX = AJX
30    IF(AJAX.GE.BIG) GO TO 32
32    IF(BIG.LE.2.5) AJAX = 2.5
      XSCAL=-AJAX/NLL
      YMAX=100
      YMIN=0
      YSCAL=(YMAX-YMIN)/100.0
C
C    FIND BASE VARIABLE PRINT POSITION
C    I=LINE COUNTER, L=ARRAY ELEMENT COUNTER
C
      WRITE(6,7)
      XB=AJAX
      DO 42 KCL=1,NCL
42    L(KCL)=1
      I=1
 45   F=I-1
      XPR=XB+F*XSCAL
49    DO 65 KCL = 1,NCL
      LCL = L(KCL)
 50   IF(B(LCL,KCL).LT.XPR.OR.LCL.GT.N)GO TO 65
56    JP = NINT((POS(LCL) - YMIN)/YSCAL) + 1
      OUT(JP) = ANG(KCL)
      L(KCL) = L(KCL) + 1
      LCL = L(KCL)
      IF(B(LCL,KCL).LT.XPR.OR.LCL.GT.N) GO TO 65
      GO TO 56
C
65    CONTINUE
C
C    FIND CROSS-VARIABLES
C
C
C    PRINT LINE AND CLEAR, OR SKIP
C
 70   IF(MOD(I,5).EQ.1)WRITE(6,4)XPR,PLUS,(OUT(IZ),IZ=1,101),PLUS
      IF(MOD(I,5).NE.1)WRITE(6,2)DOT,(OUT(IZ),IZ=1,101),DOT
      I=I+1
```

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```
      DO 55 IX=1,101
 55   OUT(IX)=BLANK
      IF(I.LT.NLL+1)GO TO 45
 84   XPR=0
      IF(I.EQ.NLL+1)GO TO 49
C
C   PRINT CROSS-VARIABLES NUMBERS
C
 86   WRITE(6,7)
      YPR(1)=YMIN
      DO 90 KN=1,10
 90   YPR(KN+1)=YPR(KN)+YSCAL*10.0
      WRITE(6,8)(YPR(IP),IP=1,11)
      WRITE(6,91)
      IF(CON1.NE.'Y') GO TO 95
      NNCL = NCL*8
      DO 93 I=1,NNCL
 93   ULIN(I) = UX
      WRITE(6,101)(PRD(I),I=1,NCL)
101   FORMAT(1H1//10X,'RESULTS FOR ALL CUMULATIVE PERIODS'//
     *' CUMULATIVE PERIODS IN DAYS',/10(I6,2X)/)
      WRITE(6,102)(ULIN(I),I=1,NNCL)
102   FORMAT(1X,90A1)
      DO 12 I=1,N
 12   WRITE(6,100)(B(I,J),J=1,NCL)
100   FORMAT(9F8.2)
 95   CONTINUE
      RETURN
      END
```

```
C  ROUTINE >>> CROPADDOCK <<< TO SET UP CROP-PADDOCK FILE
C  WITH DATA FOR CROP ROTATIONS, SOIL-PLANT-WATER RELATIONSHIPS
C  AND IRRIGATION PRIORITIES
C
C
      INTEGER*2 LUA, LUB, PHDEV1
      DIMENSION MONLEN(12),AREA(20),NCRP(30),CRPDK(20,30,8),IXC(5,30),
     1CDAY(2,30),KC(30),KC1(30),NDY(2),KON(30),MP(30),MPR(30),IDCP(30)
      CHARACTER*20  AMON(12)*3, TITLE, CMON(2,30)*3, PDN(2)*6
      CHARACTER*16 CNAME(30),BMON*3, EMON*3
      INTEGER CDAY
      DATA MONLEN/31,28,31,30,31,30,31,31,30,31,30,31/
     1AMON/'JAN','FEB','MAR','APR','MAY','JUN','JUL','AUG','SEP','OCT',
     2'NOV','DEC'/ PDN/'FIRST ','SECOND'/
C
      CALL LUNITS (7,8)
C
C  CLEAR CROP-PADDOCK ARRAY (CRPDK)
      DO 5 I=1,8
      DO 5 J=1,20
      DO 5 K=1,30
5     CRPDK(K,J,I) = 0.
C
C  READ CROPDATE FILE
      OPEN (12,FILE='CROPDATE')
C  TOTAL NO. OF CROPS -- NCP
      READ(12,501) NCP
501   FORMAT(I5,////)
C
      DO 10 I=1,NCP
10    READ(12,500) CNAME(I),(IXC(J,I),J=1,5)
500   FORMAT(1X,A,5I10)
C
C  SET UP ARRAY FOR PRINTING OUT THE MENU OF CROPS
      DO 16 I=1,NCP
      DO 14 K=2,4,2
      K1=K/2
      NDYY = 0
      NDYY1 = 0
      DO 12 J=6,17
      J1 = J
      IF(J.GT.12) J1 = J-12
      NDYY = NDYY + MONLEN(J1)
      IF(NDYY.GE.IXC(K,I)) GO TO 13
      NDYY1 = NDYY
12    CONTINUE
C
13    CMON(K1,I) = AMON(J1)
      CDAY(K1,I) = IXC(K,I) - NDYY1
14    CONTINUE
16    CONTINUE
C
      WRITE(8,599)
599   FORMAT(///' >>> PROGRAM FOR SETTING UP CROP-PADDOCK FILE <<<'//
```

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```
     1' NOTE:   ALL NUMERIC DATA ARE FREE FORMAT (LIST-DIRECTED) INPUT'/
     2'          NUMBERS MUST BE SEPARATED BY COMMAS OR SPACES')
       WRITE(8,600)
600    FORMAT(//' INPUT A DESCRIPTIVE TITLE TO BE USED IN NAMING'/
     1' THE CROP PADDOCK FILE GENERATED '/
     2'   -- <20 CHARACTERS AND NO BLANKS'/)
       READ(7,'(A)') TITLE
       OPEN(14, FILE=TITLE)
       WRITE(8,6001)
6001   FORMAT(// ENTER THE NUMBER OF PADDOCKS (MAX OF 20)')
       READ(7,*) NPDK
       DO 18 I=1,NPDK
       WRITE(8,601) I
601    FORMAT(//' ENTER THE IRRIGATED AREA IN HECTARES AND NO. OF YEARS'/
     1' IN CROP ROTATION FOR PADDOCK NO. ',I2)
18     READ(7,*) AREA(I), NCRP(I)
C

       WRITE (8,590)
590    FORMAT(//' NAME THE FIRST MONTH OF THE IRRIGATION SEASON')
       READ(7,'(A)') BMON
       WRITE(8,591)
591    FORMAT(' NAME THE LAST MONTH OF THE IRRIGATION SEASON')
       READ(7,'(A)') EMON
       DO 19 I=1,12
       IF (BMON.EQ.AMON(I)) IBM = I
       IF(EMON.EQ.AMON(I)) IEM = I
19     CONTINUE
       IF(IEM.LE.5) IEM = IEM + 12
       MTT = IEM - IBM + 1
C
C  WRITE CROP MENU ON SCREEN AND ON OUTPUT FILE
       DO 30 I=1,NPDK
       IF(I.GT.1) GO TO 24
       WRITE(8,602)NCP
       WRITE(14,602) NCP
602    FORMAT(//' CROP MENU FOR ',I2,' CROPS FROM CROPDATE FILE'/
     1' CROP NO. AND NAME WITH PLANTING AND HARVEST DATES'/)
       DO 20 J=1,NCP,2
       IF(J.EQ.NCP) GO TO 22
       J1 = J + 1
       WRITE(8,603) J,CNAME(J),CMON (1,J),CDAY(1,J),CMON(2,J),CDAY(2,J),
     1J1,CNAME(J1),CMON(1,J1),CDAY(1,J1),CMON(2,J1),CDAY(2,J1)
       WRITE(14,603) J,CNAME(J),CMON (1,J),CDAY(1,J),CMON(2,J),CDAY(2,J),
     1J1,CNAME(J1),CMON(1,J1),CDAY(1,J1),CMON(2,J1),CDAY(2,J1)
603    FORMAT(1X,I2,1X,A,A,I3,3X,A,I3,6X,I2,1X,A,A,I3,3X,A,I3)
       IF(J1.EQ.NCP) GO TO 24
20     CONTINUE
22     WRITE(8,603)J,CNAME(J),CMON(1,J),CDAY(1,J),CMON(2,J),CDAY(2,J)
       WRITE(14,603)J,CNAME(J),CMON(1,J),CDAY(1,J),CMON(2,J),CDAY(2,J)
C
24     WRITE(8,604) NCRP(I),I
604    FORMAT(/' ENTER THE FOLLOWING INFORMATION FOR EACH CROP FOR'/
     1' THE ',I2,' YEAR ROTATION IN PADDOCK ',I2/
     2'   NOTE -- DATA FOR TWO CROPS MUST BE ENTERED FOR EACH YEAR'/
```

```
      3'             FOR ONLY ONE CROP THE SECOND IS FALLOW (NO. 23)'/
      4' FOUR ITEMS ARE ENTERED FOR EACH CROP:'/
      5'   1--CROP NO., 2--TOTAL AVAILABLE MOISTURE (TAM),'/
      6'   3--MGT ALLOWED DEFICIT (MAD), 4--APPLICATION DEFICIT (AD)')
      DO 28 J=1,NCRP(I)
      WRITE(8,6040) J
6040  FORMAT(//' DATA FOR YEAR NO. ',I2/' CROP NO., TAM, MAD, AD')
      READ(7,*) CRPDK(I,J,1),CRPDK(I,J,2),CRPDK(I,J,4),CRPDK(I,J,3),
     1CRPDK(I,J,5),CRPDK(I,J,6),CRPDK(I,J,8),CRPDK(I,J,7)
28    CONTINUE
30    CONTINUE
C
C   WRITE OUTPUT ON LU 14
C
      IEMX = IEM
      IF(IEMX.GT.12) IEMX = IEMX - 12
      WRITE(14,710) TITLE,MTT,IBM,BMON,IEMX,EMON,NPDK
710   FORMAT(////' CROPADDOCK OUTPUT IN FILE -- ',A,//
     11XI2,'-MONTH IRRIGATION SEASON'/
     1' THE FIRST MONTH OF THE  SEASON IS NO. ',I2,' -- ',A,/
     2' THE LAST MONTH OF THE  SEASON IS NO. ',I2,' -- ',A,//
     3' THE TOTAL NUMBER OF PADDOCKS IS ',I2)
      DO 32 I=1,NPDK
      WRITE(14,711) I,AREA(I),NCRP(I)
711   FORMAT(///' VALUES FOR PADDOCK NO. ',I2,/5XF6.1,' HECTARES'/
     17XI2,'-YEAR CROP ROTATION'/
     214X'- - - - FIRST CROP - - - -',7X,'- - - - SECOND CROP - - - -'/
     3' ROTATION    CROP    TAM    AD    MAD',8X,'CROP    TAM    AD'
     4' MAD'/'    YEAR        ',2('NO.   (MM)   (MM)   (MM)',8X/))
      DO 32 J=1,NCRP(I)
      WRITE(14,712) J,(CRPDK(I,J,K),K=1,8)
712   FORMAT(5XI2,2X,2(F9.0,1X,3F7.1,2X))
32    CONTINUE
C
C   INPUT IRRIGATION PRIORITIES
C   --WRITE OUT CROPS GROWN
      DO 34 I=1,NCP
      KC(I) = 0
      DO 34 J=1,NPDK
      DO 34 K=1,NCRP(J)
      IF(CRPDK(J,K,1).EQ.I.OR.CRPDK(J,K,5).EQ.I) KC(I) = 1
34    CONTINUE
      KC(23) = 1
C   TOTAL NO OF CROPS GROWN
      KCTOT = 0
      DO 38 I=1,NCP
38    KCTOT = KCTOT + KC(I)
C
      WRITE(8,6041) KCTOT
6041  FORMAT(////' THE FOLLOWING ',I2,' CROPS ARE GROWN'/
     1'     CROP NO. & NAME')
      JT = 0
      DO 42 I=1,NCP
      IF(KC(I).LT.1) GO TO 42
```

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```
           JT = JT + 1
           KC1(JT) = I
           WRITE(8,605) I,CNAME(I)
605        FORMAT(8X,I2,2X,A)
42         CONTINUE
C
           WRITE(8,606)
606        FORMAT(/' ENTER IRRIGATION PRIORITIES FOR CROPS FOR ALL'/
          1' 2-WEEK PERIODS THROUGHOUT THE YEAR WITH 1 BEING TOP'/
          2' PRIORITY, 2 BEING SECOND ETC.')
C
           WRITE(14,713) KCTOT
713        FORMAT(///' IRRIGATION PRIORITIES FOR THE ',I2,' CROPS GROWN'/
          1' AS INDICATED BY THE FOLLOWING CROP ID NOS.'//
          25X'MONTH  HALF     DECREASING IRRIGATION PRIORITY'/21X'------->')
C
           KPD = 0
           JDAY = 0
           DO 60 IMO = 6,17
           IM = IMO
           IF(IM.GT.12) IM=IM-12
           NDY(1) = MONLEN(IM)/2
           NDY(2) = MONLEN(IM) - NDY(1)
           NCPD = 0
C
           DO 60 IPD=1,2
           JDY1 = JDAY + 1
           JDAY = JDAY + NDY(IPD)
           IF(IMO.LT.IBM.OR. IMO.GT.IEM) GO TO 60
C
           DO 48 I=1,30
           MP(I) = 0
           MPR(I) = 0
48         KON(I) = 0
           NOP = 0
C
           DO 50 I=1,JT
           IX = KC1(I)
           IF(IXC(2,IX).LT.JDAY) KON(IX)=1
           IF(IXC(4,IX).LT.JDY1) KON(IX)=0
           IF(KON(IX).EQ.0) GO TO 50
           NOP = NOP + 1
           IDCP(NOP) = IX
50         CONTINUE
C
52         WRITE(8,607) NOP, PDN(IPD),AMON(IM),(IDCP(N),N=1,NOP)
607        FORMAT(/' ENTER IRRIGATION PRIORITIES IN ORDER FOR THE'/
          2' FOLLOWING ',I2, ' CROPS GROWING IN THE ',A,' HALF OF ',A,/
          3 25I3)
           READ(7,*)(MP(N),N=1,NOP)
           DO 54 N=1,NOP
           IF(MP(N).EQ.0.OR.MP(N).GT.NOP)
          1    GO TO 56
54         CONTINUE
```
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```
      DO 53 N=1,30
53    MPR(N) = 0
      DO 55 N=1,NOP
55    MPR(MP(N)) = IDCP(N)
      WRITE(14,714) AMON(IM),PDN(IPD),(MPR(N),N=1,KCTOT)
714   FORMAT(6X,A,3X,A,3X,30I3)
      GO TO 60
56    WRITE(8,608)
608   FORMAT(/  '  >>>THERE IS AN ERROR IN THE LAST ENTRY <<<'/
     1  ' ---- PLEASE RE-ENTER AS DIRECTED:'/)
      GO TO 52
60    CONTINUE
C
      CLOSE(14)
      WRITE(8,*)' THE OUTPUT IS IN FILE ',TITLE
      WRITE(8,*)' LIST THE FILE TO CHECK DATA'
      STOP
      END
      SUBROUTINE LUNITS(II,JJ)
C  SUBROUTINE TO ASSIGN LOGICAL UNIT NOS. FOR INTERACTIVE USE
      INTEGER*2 LUA, LUB, PHDEV1
      INTEGER*2 ZERO, BUFSIZ
       PHDEV1 = 1
       LUA = II
       LUB = JJ
       ZERO = 0
       BUFSIZ = 80
      CALL ATTDEV (LUA, PHDEV1, ZERO, BUFSIZ)
      CALL ATTDEV (LUB, PHDEV1, ZERO, BUFSIZ)
      RETURN
      END
```

```fortran
      SUBROUTINE LUNITS(II,JJ)
C  SUBROUTINE TO ASSIGN LOGICAL UNIT NOS. FOR INTERACTIVE USE
      INTEGER*2 LUA, LUB, PHDEV1
      INTEGER*2 ZERO, BUFSIZ
       PHDEV1 = 1
       LUA = II
       LUB = JJ
       ZERO = 0
       BUFSIZ = 80
      CALL ATTDEV (LUA, PHDEV1, ZERO, BUFSIZ)
      CALL ATTDEV (LUB, PHDEV1, ZERO, BUFSIZ)
      RETURN
      END
```

```
C
C    >>>> PROGRAM FOR COMPUTING COSTS AND EFFICIENCIES OF <<<<
C    >>>>              IRRIGATION SUPPLY SYSTEMS              <<<<
C
C    PROGRAMS AND SUBROUTINES WRITTEN BY J.R. BUSCH, WINCHMORE, 1982
C
C
C    INPUT DATA ALONG WITH DESCRIPTIONS ARE WRITTEN ON LU 11
C    IN ADDITION TO A SUMMARY OF ALL COMPUTATIONS
C
C    PERTINENT RESULTS ARE WRITTEN ON LU 10 IN A SYSTEMS FILE
C    THAT IS SUBSEQUENTLY READ BY THE SIMULATION MODULE
C
C    LOGICAL UNIT ASSIGNMENTS ARE AS FOLLOWS:
C       7 -- READ FROM PROMPT
C       8 -- WRITE PROMPT
C      10 -- WRITE FILE FOR USE IN SIMULATION PROGRAM
C      11 -- WRITE DETAILED SUMMARY OF INPUT AND COMPUTATIONS
C
C
C    >> MAJOR ARRAYS AND VARIABLES ARE --------
C       WCOST(I) -- COST OF WATER ENTERING THE SYSTEM
C       SYST(J) -- ARRAY OF VALUES FOR SYSTEM AS FOLLOWS
C            J = 1 -- VOLUME ENTERING SYSTEM (CUBIC M/DAY)
C                 2 -- FLOW ENTERING SYSTEM (L/S)
C                 3 -- CONVEYANCE EFFICIENCY (%)
C                 4 -- SYSTEM LIFE (YR)
C                 5 -- TOTAL CAPITAL COST ($)--- (LOAN NO. 1)
C                 6 -- CAPITAL NOT FINANCED OR SUBSIDIZED ($)
C                 7 -- SUBSIDIZED CAPITAL ($)
C                 8 -- FINANCED CAPITAL ($)
C                 9 -- INTEREST RATE FOR LOAN NO. 1 (%) -- ATTACHED ITEMS
C                10 -- TIME OF LOAN NO. 1 (YR)
C                11 -- SALVAGE VALUE OF COMPONENTS ($)
C                12 -- ANNUAL MAINTENANCE EXPENSE ($)
C                13 -- ANNUAL MISCELLANEOUS EXPENSE ($)
C            PARAMETERS 14 -22 ARE THE SAME PARAMETERS AS 5 - 13 EXCEPT
C            UNATTACHED ITEMS (LOAN NO. 2)
C
C
C      NAPMP -- NO. OF PUMPS IN SYSTEM
C      IDXPMA(J) -- ID NOS. OF PUMPS IN SYSTEM
C      PWRPMP(K) -- ARRAY OF PUMP POWER REQTS (KW)
C      QPMP(K) -- ARRAY OF PUMP FLOW RATES (L/S)
C
       DIMENSION SYST(30),QPMP(30),PWRPMP(30),WCOST(3),VF(7,2),CX(9),
      1 SP(9),IDXPMA(30)
C
       CHARACTER*20 TITLE,TITLST*25,YIN*1,YS*1
C
       DATA CX/.1,.34,.41,.66,.68,1.2,1.68,2.2,5./
       YS = 'Y'
C
C    CALL LUNITS TO ASSIGN LU NOS. FOR TERMINAL -- 7-READ,  8-WRITE
```

```
C
      CALL LUNITS(7,8)
C
C  CLEAR ARRAYS
C
      DO 5 I=1,30
      SYST(I) = 0.
      IDXPMA(I) = 0
5     CONTINUE
C
C
C  ENTER A NAME FOR THE OUTPUT FILE
C
      WRITE(8,1000)
1000  FORMAT(//' ENTER A DESCRIPTIVE NAME FOR THE OUTPUT FILE'/
     1' WITH <20 CHARACTERS AND NO EMBEDDED BLANKS')
      READ(7,1100) TITLE
1100  FORMAT(A)
      OPEN (10,FILE=TITLE)
C
C  WRITE DETAILED SUMMARY OUTPUT ON LU 11
      TITLST = 'LIST-'//TITLE
      OPEN (11,FILE=TITLST)
C
C
C  ENTER SYSTEM LIFE IN YEARS -- SLIFE
C
      WRITE(8,1006)
1006  FORMAT(/' ENTER SYSTEM LIFE IN YEARS')
      READ(7,*) SLIFE
      SYST(4) = SLIFE
C
C  ENTER LENGTH AND TERMS FOR 2 POSSIBLE LOAN RATES
C  FOR ATTACHED AND UNATTACHED ITEMS
C
      WRITE(8,1007)
1007  FORMAT(/' SEPARATE LOAN TERMS ARE CONSIDERED FOR'/
     1' ATTACHED ITEMS -- LOAN NO. 1 AND'/
     2' UNATTACHED ITEMS -- LOAN NO. 2')
C
      DO 30 I=1,2
      WRITE(8,1008) I
1008  FORMAT(/' ENTER INTEREST RATE (PERCENT) AND'/
     1' TIME OF LOAN (YEARS) FOR LOAN NO. ',I1)
      NS = 9 + ((I-1)*9)
      NS1 = NS + 1
      READ(7,*) AX,BX
      SYST(NS) = AX
      SYST(NS1) = BX
30    CONTINUE
C
C  OUTPUT OF SYSTEM TYPE, PADDOCKS SERVED, SYSTEM LIFE
C  AND LOAN TERMS
C
```

```
       WRITE(11,1108) TITLE,SLIFE
1108   FORMAT('1'////' RESULTS FOR SYSTEM -- ',A/
      1' THE LIFE OF THE SYSTEM IS ',I3,' YEARS')
C
       DO 301 I=1,2
       NS = 9 + ((I-1)*9)
       NS1 = NS + 1
301    WRITE(11,1109) I,SYST(NS),SYST(NS1)
1109   FORMAT(/' TERMS FOR LOAN RATE NO. ',I1/
      1F10.1,T15,'..PERCENT INTEREST RATE'/
      2F9.0,T15,'..YEARS TIME OF LOAN')
C
C
C  INPUT DATA FOR THE AVAILABILITY OF WATER INTO THE SYSTEM
C
       WRITE(8,2200)
2200   FORMAT(//' ENTER WATER SUPPLY DATA -- 2 ITEMS'/
      1'  1 -- FLOW RATE ENTERING THE SYSTEM  (L/S)'/
      2'  2 -- DAYS PER WEEK THIS FLOW RATE IS AVAILABLE')
       READ(7,*) SYST(2),D
C  CUBIC M AVAILABLE PER DAY -- SYST(1)
       SYST(1) = (SYST(2)*86.4)*D/7.
C
C  ENTER WATER COST DATA
C
       WRITE(8,2201)
2201   FORMAT(//' ENTER WATER COST DATA -- 3 ITEMS'/
      1'  1 -- $ PER 1000 CUBIC M  (VOLUME)'/
      2'  2 -- $ PER L/S  (FLOW RATE)'/
      3'  3 -- $ LUMP SUM'//
      4'  NOTE: ENTER 0 (ZERO) FOR THOSE ITEMS THAT DO NOT APPLY'/
      5'         DO NOT INCLUDE ANY POWER CHARGES')
       READ(7,*) (WCOST(I),I=1,3)
C
C  WRITE SUMMARY OF INPUT DATA
C
       WRITE(11,2300) SYST(2),D,SYST(1),(WCOST(I),I=1,3)
2300   FORMAT(//' WATER SUPPLY AND COST DATA'/
      1F10.1,T15,'..L/S FLOW RATE ENTERING THE SYSTEM'/
      2F11.2,T15,'..DAYS PER WEEK FLOW RATE IS AVAILABLE'/
      3F11.2,T15,'..CUBIC M PER DAY DELIVERED (AVERAGE)'/
      4' $',F9.2,T15,'..PER 1000 CUBIC M WATER CHARGE'/
      5' $',F9.2,T15,'..PER L/S WATER CHARGE'/
      6' $',F9.2,T15,'..LUMP SUM WATER CHARGE')
C
C
C  COMPUTE ESTIMATED SEEPAGE LOSSES USING USBR MORITZ EQN
C
C          QLOSS = 0.0365 * CX * SQRT(Q)
C      WHERE  QLOSS = SEEPAGE LOSS IN L/S PER 100 M
C             CX = COEFFICIENT FOR TYPE OF MATERIAL
C                   (FOR VALUES REFER TO DATA STATEMENT)
C             Q = FLOW IN L/S
C                 NOTE: THIS RELATIONSHIP ASSUMES A VELOCITY
```

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```
C                              OF 1.0 M/S
C
      QINN = SYST(2)
      DO 517 I=1,9
517   SP(I) = (.0365 * CX(I) * SQRT(QINN))
C
      WRITE(8,1002)(SP(I),I=1,9)
1002  FORMAT(//' FOLLOWING ARE ESTIMATES OF SEEPAGE LOSS'/
     1' FOR THE FLOW RATE ENTERING THE SYSTEM'/
     2'      SEEPAGE LOSS'//    (L/S PER 100 M)'/
     3F12.1,T15,'..WELL MAINTAINED CONCRETE LINING'/
     4F12.1,T15,'..CEMENTED GRAVEL & HARDPAN WITH SANDY LOAM'/
     5F12.1,T15,'..CLAY AND CLAYEY LOAM'/
     6F12.1,T15,'..SANDY LOAM'/
     7F12.1,T15,'..VOLCANIC ASH'/
     8F12.1,T15,'..SAND OR VOLCANIC ASH AND CLAY'/
     9F12.1,T15,'..SANDY SOIL WITH ROCK'/
     AF12.1,T15,'..SANDY AND GRAVELLY SOIL'/
     BF12.1,T15,'..STONY GRAVELLY SOIL'/
     C'   NOTE:  PIPELINES SHOULD HAVE NEGLIGIBLE LOSS'//
     D'   FOR EVAPORATION FROM POND WATER SURFACES ----'/
     D'   5 HA-MM/DAY = 0.6 L/S'//
     D' ENTER THE TOTAL ESTIMATED LOSS (L/S) FOR SEEPAGE'/
     E' AND EVAPORATION IN THE SUPPLY SYSTEM')
      READ (7,*) QLOSS
C
      QIN = QINN - QLOSS
      SYST(3) = QIN/QINN * 100.
C
C
C  WRITE A RECORD OF INPUT DATA ON LU 11
      WRITE(11,1001)SYST(3)
1001  FORMAT(// F10.1,T15,'..PERCENT WATER CONVEYANCE EFFICIENCY')
C
C
C  DATA INPUT FOR SYSTEM COMPONENTS
C  --RACES
      WRITE(8,1016)
1016  FORMAT(//' ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES?'
     1' (Y OR N)')
      READ (7,1100) YIN
      IF(YIN.NE.YS) GO TO 48
      WRITE(11,1017) TITLE
1017  FORMAT(//' RACES AND DITCHES FOR SYSTEM -- ',A)
C
      CALL RACES(SLIFE,VF)
C
C
      DO 46 N=1,2
      J=5
      IF(N.GT.1) J=14
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
```

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```
          SYST(J+3) = SYST(J+3) + VF(4,N)
          SYST(J+6) = SYST(J+6) + VF(5,N)
          SYST(J+7) = SYST(J+7) + VF(6,N)
          SYST(J+8) = SYST(J+8) + VF(7,N)
46        CONTINUE
C
C   INPUT FOR STRUCTURES
C
48        WRITE(8,1018)
1018  FORMAT(/' ARE DATA TO BE ENTERED FOR ANY STRUCTURES?   (Y OR N)')
          READ(7,1100) YIN
          IF(YIN.NE.YS) GO TO 54
          WRITE(11,1019) TITLE
1019  FORMAT(//' STRUCTURES FOR SYSTEM -- ',A)
C
          CALL STRUCTS(SLIFE,VF)
C
C
          DO 52 N=1,2
          J=5
          IF(N.GT.1) J=14
          SYST(J) = SYST(J) + VF(1,N)
          SYST(J+1) = SYST(J+1) + VF(2,N)
          SYST(J+2) = SYST(J+2) + VF(3,N)
          SYST(J+3) = SYST(J+3) + VF(4,N)
          SYST(J+6) = SYST(J+6) + VF(5,N)
          SYST(J+7) = SYST(J+7) + VF(6,N)
          SYST(J+8) = SYST(J+8) + VF(7,N)
52        CONTINUE
C
C   INPUT FOR PIPELINES
C
54        WRITE(8,1020)
1020  FORMAT(//' ARE DATA TO BE ENTERED FOR ANY PIPELINES?   (Y OR N)')
          READ(7,1100) YIN
          IF(YIN.NE.YS) GO TO 60
          WRITE(11,1021) TITLE
1021  FORMAT(//' PIPELINES FOR SYSTEM -- ',A)
C
          CALL PIPES (SLIFE,VF)
C
C
          DO 58 N=1,2
          J=5
          IF(N.GT.1) J=14
          SYST(J) = SYST(J) + VF(1,N)
          SYST(J+1) = SYST(J+1) + VF(2,N)
          SYST(J+2) = SYST(J+2) + VF(3,N)
          SYST(J+3) = SYST(J+3) + VF(4,N)
          SYST(J+6) = SYST(J+6) + VF(5,N)
          SYST(J+7) = SYST(J+7) + VF(6,N)
          SYST(J+8) = SYST(J+8) + VF(7,N)
58        CONTINUE
C
```

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```fortran
C   INPUT FOR PUMPS
C
60    NAPMP = 0
      WRITE(8,1022)
1022  FORMAT(//' ARE DATA TO BE INPUT FOR ANY PUMPS?    (Y OR N)')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 71
      WRITE(8,1023)
1023  FORMAT(//' ENTER THE NUMBER OF PUMPS AND THE ID NO. OF EACH PUMP')
      READ(7,*) NAPMP,(IDXPMA(I),I=1,NAPMP)
      WRITE(11,1024)TITLE, NAPMP
1024  FORMAT(///' PUMPS FOR SYSTEM -- ',A/
     1I9,T15,'..NO. OF PUMPS')
      DO 70 I=1,NAPMP
      WRITE(11,1025) IDXPMA(I)
1025  FORMAT(//'    PUMP ID NO. ',I2)
      WRITE(8,1026) IDXPMA(I)
1026  FORMAT(//' ENTER DATA FOR PUMP ID NO. ',I2)
C
      CALL PUMPS(SLIFE,VF,PWR,QA)
C
      PWRPMP(IDXPMA(I)) = PWR
      QPMP(IDXPMA(I)) = QA
C
      DO 68 N=1,2
      J=5
      IF(N.GT.1) J=14
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
68    CONTINUE
70    CONTINUE
C
C   OTHER EXPENSES
C
71    WRITE(8,1027)
1027  FORMAT(//' ENTER DATA FOR OTHER EXPENSES')
      WRITE (11,1028) TITLE
1028  FORMAT(///' OTHER EXPENSES FOR SYSTEM -- ',A)
C
      CALL OEXP (SLIFE,VF)
C
C
      DO 72 N=1,2
      J=5
      IF(N.GT.1) J=14
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
```

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```
          SYST(J+6) = SYST(J+6) + VF(5,N)
          SYST(J+7) = SYST(J+7) + VF(6,N)
          SYST(J+8) = SYST(J+8) + VF(7,N)
72    CONTINUE
C
      WRITE(11,1122) TITLE
1122  FORMAT('1'////' SUMMARY INFORMATION FOR WATER SUPPLY SYSTEM -- ',A)
      WRITE(11,1125) (SYST(I),I=1,4)
1125  FORMAT(//' VOLUME OF WATER (CUBIC M/DAY) . . . . . . . . . . . '
     1,F6.1
     1//' FLOW RATE ENTERING SYSTEM (L/S) . . . . . . . . . ',F6.1//
     1' CONVEYANCE EFFICIENCY (%) . . . . . . . . . . . . . ',F6.1//
     2' SYSTEM LIFE (YEARS) . . . . . . . . . . . . . . . ',F5.0)
C
      WRITE(11,1126)(SYST(I),SYST(I+9),I=5,13)
1126  FORMAT(//' SUMMARY OF SYSTEM COSTS AND FINANCING ------------'/
     135X,'ATTACHED COMPONENTS   UNATTACHED COMPONENTS'/
     238X,'(LOAN NO. 1)',11X,'(LOAN NO.2)'/
     3'    TOTAL CAPITAL COST ($) . . . . . . .',F10.2,F23.2/
     4'    CAPITAL NOT FINANCED'/
     5'           OR SUBSIDIZED ($)  . . . .',F10.2,F23.2/
     6'    SUBSIDIZED CAPITAL ($) . . . . . .',F10.2,F23.2/
     7'    FINANCED CAPITAL ($) . . . . . . .',F10.2,F23.2/
     8'    INTEREST RATE (%) . . . . . . . .',F10.2,F23.2/
     9'    TIME OF LOAN (YEARS) . . . . . . .',F8.0,F23.0/
     A'    SALVAGE VALUE ($)  . . . . . . . .',F10.2,F23.2/
     B'    ANNUAL MAINTENANCE EXPENSE ($) . .',F10.2,F23.2/
     C'    ANNUAL MISCELLANEOUS EXPENSE ($) .',F10.2,F23.2)
C
      IF(NAPMP.EQ.0 )GO TO 80
      WRITE(11,1127) (IDXPMA(J),QPMP(IDXPMA(J)),
     1                  PWRPMP(IDXPMA(J)),J=1,NAPMP)
1127  FORMAT(//' SUMMARY INFORMATION FOR INCLUDED PUMPS'/
     1'     PUMP ID NO.         FLOW RATE          INPUT POWER'/
     225X,'(L/S)',13X,'(KW)'/ 30(I12,F18.1,F18.1,/))
C
80    CONTINUE
C
C  WRITE RESULTS ON LU 10 FOR USE IN SUMULATION PROGRAM
C
      WRITE(10,1131) TITLE
1131  FORMAT(A)
C
C
1132  FORMAT(16I5)
1133  FORMAT(8F10.2)
C
      WRITE(10,1133) (SYST(J),J=1,22)
      WRITE(10,1132) NAPMP,(IDXPMA(J),J=1,NAPMP)
      IF(NAPMP.EQ.0) GO TO 87
      WRITE(10,1133) (PWRPMP(IDXPMA(J)),QPMP(IDXPMA(J)),
     1                  J=1,NAPMP)
87    CONTINUE
C                        148
```

```
C   WRITE OUT ARRAY OF WATER COSTS
C
      WRITE(10,1133) (WCOST(I),I=1,3)
C
      WRITE(8,1140) TITLST,TITLE
1140 FORMAT(///' >>>THE PROGRAM HAS SUCCESSFULLY EXECUTED!! <<'//
     1' -- A LISTING OF INPUT DATA AND SUMMARY OUTPUT IS IN FILE ',A//
     2' -- DATA FOR THE SIMULATION PROGRAM IS IN FILE ',A)
99    STOP
      END
```

```
          SUBROUTINE RACES (SL,V)
C
C   SUBROUTINE RACES FOR INPUT OF INFORMATION FOR IRRIGATION RACES
C
C      VARIABLES PASSED
C      ---SL -- SYSTEM LIFE IN YEARS
C         V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C            V(I,J)
C            J = 1 OR 2 (LOAN NO.)
C            I = 1 -- TOTAL CAPITAL COST $
C                2 -- CAPITAL NOT FINANCED $
C                3 -- CAPITAL SUBSIDIZED $
C                4 -- CAPITAL FINANCED $
C                5 -- SALVAGE VALUE $
C                6 -- TOTAL ANNUAL MAINTENANCE COST $
C                7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                      --TAXES, INSURANCE, CONTINGENCIES, ETC.
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION V(7,2)
      CHARACTER*1 Y,YS
      YS = 'Y'
      IL = NINT(SL)
C
C   CLEAR V-ARRAY
      DO 10 J=1,2
      DO 10 I=1,7
10    V(I,J) = 0.
C
C   ENTER DATA FOR LOAN NO. 1
      I=1
      WRITE (8,99)
99    FORMAT(/' ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)'//
     1' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
     2'          AND INDICATE 0 AMOUNT FINANCED WHEN ASKED'//
     3'   -- DATA FOR MORE THAN ONE RACE OR DITCH CAN BE'/
     4'      ENTERED FOR BOTH LOANS 1 AND 2')
      READ (7,200)Y
      IF (Y.NE.YS) GO TO 40
200   FORMAT(A)
20    WRITE(8,100) I,IL
100   FORMAT(/' DATA FOR RACE OR DITCH'/
     1' (LOAN NO. ',I1,')'/
     1' ENTER THE FOLLOWING EIGHT ITEMS:'/
     2'   1 -- LENGTH OF RACE (M)'/
     3'   2 -- COST OF RACE ($/M)'/
     4'   3 -- COST OF LINING ($/M) -- (ENTER 0 IF NOT APPLICABLE)'/
     5'   4 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
     6'         AS A PERCENT OF THE ORIGINAL COST'/
```

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```
      7'   5 -- PERCENT OF COST SUBSIDIZED'/
      8'   6 -- PERCENT OF COST FINANCED'/
      9'   7 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
      A'   8 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
      B'        ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
      READ (7,*) A,B,C,D,E,F,G,H
C
C  LIST INPUT DATA
      WRITE(11,101)  I,A,B,C,D,E,F,G,H
101   FORMAT(/' DATA FOR A RACE OR DITCH'/
     1' LOAN NO. ',I1/
     2F10.1,T15,'..METERS LONG'//' $',F9.2,' PER METER COST OF RACE'/
     3' $',F9.2,' PER METER COST OF LINING'/F10.1,T15,'..PERCENT '
     4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
     5F10.1,T15,'..PERCENT FINANCED'//' $',F9.2,T15,'..TOTAL ANNUAL '
     6'MAINTENANCE COST'//' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
      E=E/100.
      D=D/100.
      F = F/100.
      T= A*B + A*C
      V(1,I) = V(1,I) + T
      V(2,I) = V(2,I) + T*(1.-(E+F))
      V(3,I) = V(3,I) + T*E
      V(4,I) = V(4,I) + T*F
      V(5,I) = V(5,I) + D*T
      V(6,I) = V(6,I) + G
      V(7,I) = V(7,I) + H
C
      IF(I.EQ.2) GO TO 45
C  CHECK IF ANY MORE FOR LOAN NO. 1
      WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
      READ(7,200) Y
      IF(Y.EQ.YS) GO TO 20
40    I = 2
      WRITE(8,*)' ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)'
      READ (7,200) Y
      IF (Y.EQ.YS) GO TO 20
      GO TO 50
45    WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
      READ(7,200) Y
      IF (Y.EQ.YS) GO TO 20
50    RETURN
      END
```

```
          SUBROUTINE STRUCTS (SL,V)
C
C  SUBROUTINE STRUCTS FOR INPUT OF INFORMATION FOR IRRIGATION STRUCTURES
C
C     VARIABLES PASSED
C     ---SL -- SYSTEM LIFE IN YEARS
C        V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C           V(I,J)
C             J = 1 OR 2 (LOAN NO.)
C             I = 1 -- TOTAL CAPITAL COST $
C                 2 -- CAPITAL NOT FINANCED $
C                 3 -- CAPITAL SUBSIDIZED $
C                 4 -- CAPITAL FINANCED $
C                 5 -- SALVAGE VALUE $
C                 6 -- TOTAL ANNUAL MAINTENANCE COST $
C                 7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                     --TAXES, INSURANCE, CONTINGENCIES, ETC.
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION V(7,2)
      CHARACTER*1 Y,YS
      YS = 'Y'
      IL = NINT(SL)
C
C  CLEAR V-ARRAY
      DO 10 J=1,2
      DO 10 I=1,7
10    V(I,J) = 0.
C
C  ENTER DATA FOR LOAN NO. 1
      I=1
      WRITE (8,99)
99    FORMAT(/' ARE ANY STRUCTURES FINANCED BY LOAN NO. 1? (Y OR N)'//
     1' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
     2'          AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED'//
     3' --MORE THAN ONE TYPE OF STRUCTURE CAN BE ENTERED'/
     4'   FOR BOTH LOANS 1 AND 2')
      READ (7,200)Y
      IF (Y.NE.YS) GO TO 40
200   FORMAT(A)
20    WRITE(8,100) I,IL
100   FORMAT(// DATA FOR STRUCTURES'/
     1' (LOAN NO. ',I1,')'/
     1' ENTER THE FOLLOWING SEVEN ITEMS:'/
     2'   1 -- NUMBER OF STRUCTURES'/
     3'   2 -- COST PER STRUCTURE ($)'/
     5'   3 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
     6'        AS A PERCENT OF THE ORIGINAL COST'/
     7'   4 -- PERCENT OF COST SUBSIDIZED'/
```

```
        8'   5 -- PERCENT OF COST FINANCED'/
        9'   6 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
        A'   7 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
        B'         ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
        READ (7,*) A,B,D,E,F,G,H
C
C   LIST INPUT DATA
        WRITE(11,101)  I,A,B,D,E,F,G,H
101     FORMAT(/' DATA FOR IRRIGATION STRUCTURES'/
        1' LOAN NO. ',I1/
        2F10.1,T15,'..NO. OF STRUCTURES'/' $',F9.2,' PER STRUCTURE'/
        3F10.1,T15,'..PERCENT '
        4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
        5F10.1,T15,'..PERCENT FINANCED'/' $',F9.2,T15,'..TOTAL ANNUAL '
        6'MAINTENANCE COST'/' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
        E=E/100.
        D=D/100.
        F = F/100.
        T= A*B
        V(1,I) = V(1,I) + T
        V(2,I) = V(2,I) + T*(1.-(E+F))
        V(3,I) = V(3,I) + T*E
        V(4,I) = V(4,I) + T*F
        V(5,I) = V(5,I) + D*T
        V(6,I) = V(6,I) + G
        V(7,I) = V(7,I) + H
C
        IF(I.EQ.2) GO TO 45
C   CHECK IF ANY MORE FOR LOAN NO. 1
        WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
        READ(7,200) Y
        IF(Y.EQ.YS) GO TO 20
40      I = 2
        WRITE(8,*)' ARE THE STRUCTURES FINANCED BY LOAN NO. 2? (Y OR N)'
        READ (7,200) Y
        IF (Y.EQ.YS) GO TO 20
        GO TO 50
45      WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
        READ(7,200) Y
        IF (Y.EQ.YS) GO TO 20
50      RETURN
        END
```

```
          SUBROUTINE PIPES(SL,V)
C
C  SUBROUTINE PIPES FOR INPUT OF INFORMATION FOR IRRIGATION PIPES
C
C     VARIABLES PASSED
C     ---SL -- SYSTEM LIFE IN YEARS
C        V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C           V(I,J)
C           J = 1 OR 2 (LOAN NO.)
C           I = 1 -- TOTAL CAPITAL COST $
C                 2 -- CAPITAL NOT FINANCED $
C                 3 -- CAPITAL SUBSIDIZED $
C                 4 -- CAPITAL FINANCED $
C                 5 -- SALVAGE VALUE $
C                 6 -- TOTAL ANNUAL MAINTENANCE COST $
C                 7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                       --TAXES, INSURANCE, CONTINGENCIES, ETC.
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION V(7,2)
      CHARACTER*1 Y,YS
      YS = 'Y'
      IL = NINT(SL)
C
C  CLEAR V-ARRAY
      DO 10 J=1,2
      DO 10 I=1,7
10    V(I,J) = 0.
C
C  ENTER DATA FOR LOAN NO. 1
      I=1
      WRITE (8,99)
99    FORMAT(/' ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)'//
     1' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
     2'           AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED'//
     3'    ---DATA FOR MORE THAN ONE PIPELINE CAN BE ENTERED FOR '/
     4'        BOTH LOANS 1 AND 2')
      READ (7,200)Y
      IF (Y.NE.YS) GO TO 40
200   FORMAT(A)
20    WRITE(8,100) I,IL
100   FORMAT(/' DATA FOR PIPES --'
     1' (LOAN NO. ',I1,')'/
     1' ENTER THE FOLLOWING NINE ITEMS:'/
     2'   1 -- LENGTH OF PIPE (M)'/
     3'   2 -- COST OF PIPE ($/M)'/
     3'   3 -- TOTAL COST OF FITTINGS ($)'/
     4'   4 -- COST OF LAYING ($/M)'/
     4'        (ENTER 0 (ZERO) FOR ITEMS 3 & 4 IF THE COST IS'/
```
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```
        4'           INCLUDED IN THE COST OF THE PIPE.)'/
        5'    5 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
        6'           AS A PERCENT OF THE ORIGINAL COST'/
        7'    6 -- PERCENT OF COST SUBSIDIZED'/
        8'    7 -- PERCENT OF COST FINANCED'/
        9'    8 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
        A'    9 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
        B'           ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
      READ (7,*) A,B,BB,C,D,E,F,G,H
C
C  LIST INPUT DATA
      WRITE(11,101)  I,A,B,BB,C,D,E,F,G,H
101    FORMAT(/' DATA FOR A PIPE'/
      1' LOAN NO. ',I1/
      2F10.1,T15,'..METERS LONG'/'  $',F9.2,' PER METER COST OF PIPE'/
      2' $',F9.2,T15,'..TOTAL COST OF FITTINGS'/
      3' $',F9.2,' PER METER COST OF LAYING'/F10.1,T15,'..PERCENT '
      4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
      5F10.1,T15,'..PERCENT FINANCED'/'  $',F9.2,T15,'..TOTAL ANNUAL '
      6'MAINTENANCE COST'/'  $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
      E=E/100.
      D=D/100.
      F = F/100.
      T= A*B + A*C + BB
      V(1,I) = V(1,I) + T
      V(2,I) = V(2,I) + T*(1.-(E+F))
      V(3,I) = V(3,I) + T*E
      V(4,I) = V(4,I) + T*F
      V(5,I) = V(5,I) + D*T
      V(6,I) = V(6,I) + G
      V(7,I) = V(7,I) + H
C
      IF(I.EQ.2) GO TO 45
C  CHECK IF ANY MORE FOR LOAN NO. 1
      WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
      READ(7,200) Y
      IF(Y.EQ.YS) GO TO 20
40     I = 2
      WRITE(8,*)' ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)'
      READ (7,200) Y
      IF (Y.EQ.YS) GO TO 20
      GO TO 50
45     WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
      READ(7,200) Y
      IF (Y.EQ.YS) GO TO 20
50     RETURN
      END
```

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```
      SUBROUTINE PUMPS (SL,V,PWR,QA)
C
C  SUBROUTINE PUMPS FOR INPUT OF INFORMATION FOR IRRIGATION PUMPS
C  NOTE:  THIS SUBROUTINE IS ONLY FOR ELECTRIC POWERED PUMPS
C
C    VARIABLES PASSED
C    ---SL -- SYSTEM LIFE IN YEARS
C       V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C          V(I,J)
C           J = 1 OR 2 (LOAN NO.)
C           I = 1 -- TOTAL CAPITAL COST $
C               2 -- CAPITAL NOT FINANCED $
C               3 -- CAPITAL SUBSIDIZED $
C               4 -- CAPITAL FINANCED $
C               5 -- SALVAGE VALUE $
C               6 -- TOTAL ANNUAL MAINTENANCE COST $
C               7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                     --TAXES, INSURANCE, CONTINGENCIES, ETC.
C      PWR -- POWER INPUT TO PUMP MOTOR (KW)
C        A -- FLOW RATE PUMPED (L/S)
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION V(7,2)
      CHARACTER*1 Y,YS,TT*20
      YS = 'Y'
      IL = NINT(SL)
C
C
      WRITE(8,105)
105   FORMAT(/' ENTER THE FOLLOWING SIX ITEMS'/
     1'   1 -- FLOW RATE PUMPED (L/S)'/
     2'   2 -- DISCHARGE PRESSURE (KPA)'/
     3'   3 -- INLET PRESSURE (KPA)'/
     4'        (ENTER 0 (ZERO) IF PUMPING FROM A SUMP OR WELL)'/
     5'   4 -- VERTICAL PUMPING LIFT (M)'/
     6'   5 -- PUMP EFFICIENCY (%)'/
     7'        NOTE:  A CONSERVATIVE VALUE FOR PUMP EFFICIENCY SHOULD '/
     8'               BE USED AS IT APPLES OVER THE LIFE OF THE SYSTEM'/
     9'   6 -- MOTOR EFFICIENCY (%)'/
     A'        NOTE:  THE EFFICIENCY OF MOST LARGE ELECTRIC MOTORS'/
     B'               VARIES BETWEEN 90 AND 95 PERCENT')
C
      READ (7,*) QA,B,C,D,E,F
C
C  LIST INPUT DATA
      WRITE (11,106) QA,B,C,D,E,F
106   FORMAT(/F10.1,T15,'..LITERS PER SECOND PUMPED'/
     1F10.1,T15,'..KPA DISCHARGE PRESSURE'/
     2F10.1,T15,'..KPA INLET PRESSURE'/
```

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```
          3F11.2,T15,'..METERS VERTICAL LIFT'/
          4F10.1,T15,'..PERCENT PUMP EFFICIENCY'/
          5F10.1,T15,'..PERCENT MOTOR EFFICIENCY')
C
          TDH = ((B-C)/9.81) + D
          PWR = TDH * QA/(102. * E * F/10000.)
C
          WRITE(11,107) PWR
107       FORMAT(F11.2,T15,'..KILOWATTS POWER INPUT')
C
C   CLEAR V-ARRAY
          DO 10 J=1,2
          DO 10 I=1,7
10        V(I,J) = 0.
C
C   ENTER DATA FOR LOAN NO. 1
          I=1
          WRITE (8,99)
99        FORMAT(/' ARE ANY ITEMS FINANCED BY LOAN NO. 1?   (Y OR N)'//
          1' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
          2'          AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED'//
          3' --MORE THAN ONE ITEM CAN BE ENTERED'/
          4'    FOR BOTH LOANS 1 AND 2'//
          5' --DATA FOR ALL ITEMS ASSOCIATED WITH THE PUMP SHOULD BE'/
          6'    ENTERED INCLUDING THE WELL OR SUMP, PIPE FITTINGS AND'/
          7'    VALVES, PUMP HOUSE, ELECTRICAL CONTROLS, POWER'/
          8'    RETICULATION, ETC.')
          READ (7,200)Y
          IF (Y.NE.YS) GO TO 40
200       FORMAT(A)
20        WRITE(8,108)
108       FORMAT(/' ENTER THE NAME OF THE ITEM FOR WHICH'/
          1' DATA ARE BEING ENTERED  (<20 CHARACTERS)')
          READ(7,200)TT
          WRITE(8,100) I,IL
100       FORMAT(/' DATA FOR ITEMS'/
          1' (LOAN NO. ',I1,')'/
          2' ENTER THE FOLLOWING SIX ITEMS:'/
          3'    1 -- COST ($)'/
          4'    2 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
          5'         AS A PERCENT OF THE ORIGINAL COST'/
          6'    3 -- PERCENT OF COST SUBSIDIZED'/
          7'    4 -- PERCENT OF COST FINANCED'/
          8'    5 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
          9'         (SUGGESTED VALUE FOR PUMPS IS 3 TO 5 %'/
          9'          OF THE ORIGINAL COST)'/
          A'    6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
          B'         ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
          READ (7,*) A,D,E,F,G,H
C
C   LIST INPUT DATA
          WRITE(11,101) TT,I,A,D,E,F,G,H
101       FORMAT(/' DATA FOR ',A/
```

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```
      1' LOAN NO. ',I1/
      2' $',F9.2,' COST'/
      3F10.1,T15,'..PERCENT '
      4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
      5F10.1,T15,'..PERCENT FINANCED'//' $',F9.2,T15,'..TOTAL ANNUAL '
      6'MAINTENANCE COST'//' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
      E=E/100.
      D=D/100.
      F = F/100.
      T= A
      V(1,I) = V(1,I) + T
      V(2,I) = V(2,I) + T*(1.-(E+F))
      V(3,I) = V(3,I) + T*E
      V(4,I) = V(4,I) + T*F
      V(5,I) = V(5,I) + D*T
      V(6,I) = V(6,I) + G
      V(7,I) = V(7,I) + H
C
      IF(I.EQ.2) GO TO 45
C CHECK IF ANY MORE FOR LOAN NO. 1
      WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
      READ(7,200) Y
      IF(Y.EQ.YS) GO TO 20
40    I = 2
      WRITE(8,*)' ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)'
      READ (7,200) Y
      IF (Y.EQ.YS) GO TO 20
      GO TO 50
45    WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
      READ(7,200) Y
      IF (Y.EQ.YS) GO TO 20
50    RETURN
      END
```

```
      SUBROUTINE OEXP (SL,V)
C
C   SUBROUTINE OEXP FOR INPUT OF INFORMATION FOR OTHER EXPENSES
C
C     VARIABLES PASSED
C     ---SL -- SYSTEM LIFE IN YEARS
C        V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C           V(I,J)
C             J = 1 OR 2 (LOAN NO.)
C             I = 1 -- TOTAL CAPITAL COST $
C                   2 -- CAPITAL NOT FINANCED $
C                   3 -- CAPITAL SUBSIDIZED $
C                   4 -- CAPITAL FINANCED $
C                   5 -- SALVAGE VALUE $
C                   6 -- TOTAL ANNUAL MAINTENANCE COST $
C                   7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                         --TAXES, INSURANCE, CONTINGENCIES, ETC.
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION V(7,2)
      CHARACTER*1 Y,YS,TT*20
      YS = 'Y'
      IL = NINT(SL)
C
C
C   CLEAR V-ARRAY
      DO 10 J=1,2
      DO 10 I=1,7
10    V(I,J) = 0.
C
C   ENTER DATA FOR LOAN NO. 1
      I=1
      WRITE (8,99)
99    FORMAT(/' ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)'/
     1/' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
     2'          AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED'///
     3' --MORE THAN ONE ITEM CAN BE ENTERED'/
     4'   FOR BOTH LOANS 1 AND 2'//
     5' --DATA FOR ALL ITEMS DIRECTLY ASSOCIATED WITH THE'/
     6'   SYSTEM CAN BE ENTERED INCLUDING COSTS ASSOCIATED'/
     7'   WITH FENCING, SHELTER BELTS, FARM ACCESS (BRIDGES & ROADS)'/
     8/' --FOR ANNUAL VALUE OF CROP LOST DUE TO SYSTEM OPERATION'/
     9'   SUCH AS NON-IRRIGATED AREAS OF PADDOCKS, '/
     9'   DAMAGE FROM DRAG HOSE, TRACTORS, ETC., ENTER'/
     A'   A COST ONLY FOR TOTAL MISCELLANEOUS ITEMS.')
      READ (7,200)Y
      IF (Y.NE.YS) GO TO 40
200   FORMAT(A)
20    WRITE(8,108)
108   FORMAT(/' ENTER THE NAME OF THE ITEM FOR WHICH'/
```

```
      1' DATA ARE BEING ENTERED   (<20 CHARACTERS)')
       READ(7,200)TT
       WRITE(8,100) I,IL
100    FORMAT(// ' DATA FOR ITEMS'/
      1' (LOAN NO. ',I1,')'/
      2' ENTER THE FOLLOWING SIX ITEMS:'/
      3'    1 -- COST ($)'/
      4'    2 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
      5'         AS A PERCENT OF THE ORIGINAL COST'/
      6'    3 -- PERCENT OF COST SUBSIDIZED'/
      7'    4 -- PERCENT OF COST FINANCED'/
      8'    5 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
      A'    6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
      B'         ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
       READ (7,*) A,D,E,F,G,H
C
C  LIST INPUT DATA
       WRITE(11,101)  TT,I,A,D,E,F,G,H
101    FORMAT(/' DATA FOR ',A/
      1' LOAN NO. ',I1/
      2' $',F9.2,' COST'/
      3F10.1,T15,'..PERCENT '
      4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
      5F10.1,T15,'..PERCENT FINANCED'// ' $',F9.2,T15,'..TOTAL ANNUAL '
      6'MAINTENANCE COST'// ' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
       E=E/100.
       D=D/100.
       F = F/100.
       T= A
       V(1,I) = V(1,I) + T
       V(2,I) = V(2,I) + T*(1.-(E+F))
       V(3,I) = V(3,I) + T*E
       V(4,I) = V(4,I) + T*F
       V(5,I) = V(5,I) + D*T
       V(6,I) = V(6,I) + G
       V(7,I) = V(7,I) + H
C
       IF(I.EQ.2) GO TO 45
C  CHECK IF ANY MORE FOR LOAN NO. 1
       WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
       READ(7,200) Y
       IF(Y.EQ.YS) GO TO 20
40     I = 2
       WRITE(8,*)' ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)'
       READ (7,200) Y
       IF (Y.EQ.YS) GO TO 20
       GO TO 50
45     WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
       READ(7,200) Y
       IF (Y.EQ.YS) GO TO 20
50     RETURN
       END                          160
```

```
      SUBROUTINE LUNITS(II,JJ)
C  SUBROUTINE TO ASSIGN LOGICAL UNIT NOS. FOR INTERACTIVE USE
      INTEGER*2 LUA, LUB, PHDEV1
      INTEGER*2 ZERO, BUFSIZ
       PHDEV1 = 1
       LUA = II
       LUB = JJ
       ZERO = 0
       BUFSIZ = 80
      CALL ATTDEV (LUA, PHDEV1, ZERO, BUFSIZ)
      CALL ATTDEV (LUB, PHDEV1, ZERO, BUFSIZ)
      RETURN
      END
```

```
C
C   >>>> PROGRAM FOR COMPUTING COSTS AND EFFICIENCIES OF <<<<
C   >>>>      ON-FARM IRRIGATION APPLICATION SYSTEMS        <<<<
C
C   PROGRAMS AND SUBROUTINES WRITTEN BY J.R. BUSCH, WINCHMORE, 1982
C   EXCEPT WHERE NOTED ON FURROW AND BORDER EFFICIENCY ROUTINES
C
C   PROVISION IS MADE TO ENTER DATA FOR ONE OR MORE SYSTEMS
C   SUPPLIED BY THE SAME WATER SOURCE ON A FARM
C
C   DATA FOR CROP ROTATION AND PLANT-SOIL-WATER RELATIONSHIPS
C   ARE READ FROM THE APPROPRIATE CROPADDOCK FILE
C
C   INPUT DATA ALONG WITH DESCRIPTIONS ARE WRITTEN ON LU 11
C   IN ADDITION TO A SUMMARY OF ALL COMPUTATIONS
C
C   PERTINENT RESULTS ARE WRITTEN ON LU 10 IN A SYSTEMS FILE
C   THAT IS SUBSEQUENTLY READ BY THE SIMULATION MODULE
C
C   LOGICAL UNIT ASSIGNMENTS ARE AS FOLLOWS:
C    7 -- READ FROM PROMPT
C    8 -- WRITE PROMPT
C    10 -- WRITE FILE FOR USE IN SIMULATION PROGRAM
C    11 -- WRITE DETAILED SUMMARY OF INPUT AND COMPUTATIONS
C    12 -- READ CROPADDOCK FILE
C
C
C   >> MAJOR ARRAYS AND VARIABLES ARE --------
C      NSYS -- NO. OF SYSTEMS
C      NPKSYS(I) -- NO. OF PADDOCKS IRRIGATED BY SYSTEM I
C      IPSYS(J,I) -- ARRAY OF PADDOCK ID NOS. IRRIGATED BY SYSTEM I
C      TLAB(J) -- LABOR REQT FOR PADDOCK J (HR/IRRIGATION)
C      EAPP(CROP,PADDOCK) -- ARRAY OF OVERALL APPLICATION EFFICIENCIES (%)
C      SYSVAL(J,I) -- ARRAY OF VALUES FOR SYSTEM I AS FOLLOWS
C            J = 1 -- FLOW ENTERING SYSTEM (L/S)
C                2 -- PERCENT OF TIME SYSTEM OPERATES
C                3 -- SYSTEM LIFE (YR)
C                4 -- TOTAL CAPITAL COST ($)--- (LOAN NO. 1)
C                5 -- CAPITAL NOT FINANCED OR SUBSIDIZED ($)
C                6 -- SUBSIDIZED CAPITAL ($)
C                7 -- FINANCED CAPITAL ($)
C                8 -- INTEREST RATE FOR LOAN NO. 1 (%) -- ATTACHED ITEMS
C                9 -- TIME OF LOAN NO. 1 (YR)
C                10 -- SALVAGE VALUE OF COMPONENTS ($)
C                11 -- ANNUAL MAINTENANCE EXPENSE ($)
C                12 -- ANNUAL MISCELLANEOUS EXPENSE ($)
C            PARAMETERS 13 -21 ARE THE SAME PARAMETERS AS 4 - 12 EXCEPT
C            UNATTACHED ITEMS (LOAN NO. 2)
C
C      SYST(J) -- A WORKING ARRAY WITH J EQUAL TO J OF SYSVAL ARRAY
C
C      NAPMP(I) -- NO. OF PUMPS IN SYSTEM I
C      IDXPMA(J,I) -- ID NOS. OF PUMPS IN SYSTEM I
C      PWRPMP(K) -- ARRAY OF PUMP POWER REQTS (KW)
```

```
C      QPMP(K) -- ARRAY OF PUMP FLOW RATES (L/S)
C
C
C

       COMMON   IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
      1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
      2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
      3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
       DIMENSION NT(30,20),N(20),J1(20)
C
       CHARACTER*20 TITLE,CPKTIT,CNAME(30)*16, SYSNAM(20)*30, SID(9)*30,
      1 TITLST*25
C
       DATA SID/'BORDER','FURROW','HAND-MOVE SPRINKLER',
      1'END-TOW SPRINKLER','SIDE-ROLL SPRINKLER','TRAVELLING SPRINKLER',
      2'SELF-PROPELLED SPRINKLER','SOLID-SET SPRINKLER','TRICKLE'/
C
C  CALL LUNITS TO ASSIGN LU NOS. FOR TERMINAL -- 7-READ,  8-WRITE
C
       CALL LUNITS(7,8)
C
C  CLEAR ARRAYS
C
       DO 5 I=1,20
       TLAB(I) = 0.
       DO 5 J = 1,30
5      EAPP(J,I) = 0.
C
C
C  ENTER A NAME FOR THE OUTPUT FILE
C
       WRITE(8,1000)
1000   FORMAT(//' ENTER A DESCRIPTIVE NAME FOR THE OUTPUT FILE'/
      1' WITH <20 CHARACTERS AND NO EMBEDDED BLANKS')
       READ(7,1100) TITLE
1100   FORMAT(A)
       OPEN (10,FILE=TITLE)
C
C  WRITE DETAILED SUMMARY OUTPUT ON LU 11
       TITLST = 'LIST-'//TITLE
       OPEN (11,FILE=TITLST)
C
C  ENTER NAME OF CROPADDOCK FILE
       WRITE(8,1001)
1001   FORMAT(//' ENTER THE NAME OF THE CROPADDOCK FILE TO BE USED')
       READ(7,1100) CPKTIT
       OPEN(12,FILE=CPKTIT,ERR=990)
       WRITE(11,1050) TITLE, CPKTIT
1050   FORMAT(//' RESULTS IN APPLICATION SYSTEMS FILE ',A/
      1/' CROPADDOCK INPUT FROM FILE ',A)
C
C  READ CROPADDOCK FILE
C  --NO OF CROPS IN MENU
```

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```
          READ(12,1101) NCP
1101  FORMAT(//14X,I3//)
C
C   --CROP ID NOS. & NAMES
          READ(12,1102)(IDCP(I),CNAME(I),I=1,NCP)
1102  FORMAT(1X,I2,1X,A,21X,I2,1X,A)
C
C   --NO OF PADDOCKS AND INFORMATION FOR EACH PADDOCK
          READ(12,1103) NPDK
1103  FORMAT(//////////33XI2)
C
          DO 10 I=1,NPDK
          READ(12,1104) AREA(I),NCRP(I)
1104  FORMAT(///5XF6.1/7XI2////)
          DO 10 J=1,NCRP(I)
          READ(12,1105)(CRPDK(I,J,K),K=1,8)
1105  FORMAT(9X,2(F9.0,1X,3F7.1,2X))
10      CONTINUE
C
C   CLEAR ARRAY FOR PADDOCK USE ID
C
          DO 12,I=1,20
12      KSEL(I) = 0
C
C   ENTER SYSTEM TYPE AND CALL APPROPRIATE SUBROUTINE
          NSYS = 0
C
C   CLEAR SYSTEM SUMMARY ARRAY
15      DO 16 I=1,30
16      SYST(I) = 0.
C
C   --CHECK PADDOCKS THAT HAVE NO SYSTEM
          J=0
          DO 18 I=1,NPDK
          IF(KSEL(I).GT.0) GO TO 18
          J= J+1
          N(J)= I
18      CONTINUE
C
          IF(J.EQ.0) GO TO 80
20      WRITE(8,1002) (N(I),I=1,J)
1002  FORMAT(//' THE FOLLOWING PADDOCKS HAVE NO SYSTEM'/5X,20I3)
C
C   --ENTER TYPE OF SYSTEM
          WRITE(8,1003)
1003  FORMAT(/' ENTER THE TYPE OF IRRIGATION SYSTEM USING THE FOLLOWING
     1CODE:'//T10,'1 -- BORDER'/T10,'2 -- FURROW OR CORRUGATE'/
     2T10,'3 -- HAND-MOVE SPRINKLER'/T10,'4 -- END-TOW SPRINKLER'/T10,
     3'5 -- SIDE-ROLL SPRINKLER'/T10,'6 -- TRAVELLING SPRINKLER (GUN '
     4'OR BOOM)'/T10,'7 -- SELF-PROPELLED SPRINKLER (CENTER-PIVOT, '
     4'LATERAL-MOVE ETC.)'/T10,'8 -- SOLID-SET '
     5'SPRINKLER'/T10,'9 -- TRICKLE')
          NSYS = NSYS + 1
          READ(7,*) IDS(NSYS)
```

```
          SYSNAM(NSYS) = SID(IDS(NSYS))
C
C  --ENTER PADDOCKS SERVED
C
       WRITE(8,1004)
1004  FORMAT(/' ENTER THE NUMBER OF PADDOCKS SERVED BY THE SYSTEM'/
      1' AND THE ID NOS. OF THE PADDOCKS')
       READ(7,*) NPKSYS(NSYS),(IPSYS(J,NSYS),J=1,NPKSYS(NSYS))
C
C  --CHECK IF A PADDOCK HAS BEEN PREVIOUSLY SPECIFIED
       DO 22 I=1,NPKSYS(NSYS)
       IF(KSEL(IPSYS(I,NSYS)).NE.0) GO TO 23
C
22     CONTINUE
       GO TO 25
C  --NOTIFICATION OF ERROR
23     WRITE(8,1005)  IPSYS(I,NSYS)
1005  FORMAT(/' >>> PADDOCK ',I2,' IS IRRIGATED BY ANOTHER SYSTEM <<<'/
      1' --> PLEASE RE-ENTER DATA AS DIRECTED ----->'/)
       NSYS = NSYS - 1
       GO TO 20
C
C  --UPGRADE PADDOCK USE ID
25     DO 27 I=1,NPKSYS(NSYS)
       KSEL(IPSYS(I,NSYS)) = 1
27     CONTINUE
C
C  ENTER SYSTEM LIFE IN YEARS -- SLIFE
C
       WRITE(8,1006)
1006  FORMAT(/' ENTER SYSTEM LIFE IN YEARS')
       READ(7,*) SLIFE
       SYST(3) = SLIFE
C
C  ENTER LENGTH AND TERMS FOR 2 POSSIBLE LOAN RATES
C  FOR ATTACHED AND UNATTACHED ITEMS
C
       WRITE(8,1007)
1007  FORMAT(/' SEPARATE LOAN TERMS ARE CONSIDERED FOR'/
      1' ATTACHED ITEMS -- LOAN NO. 1 AND'/
      2' UNATTACHED ITEMS -- LOAN NO. 2')
C
       DO 30 I=1,2
       WRITE(8,1008) I
1008  FORMAT(/' ENTER INTEREST RATE (PERCENT) AND'/
      1' TIME OF LOAN (YEARS) FOR LOAN NO. ',I1)
       NS = 8 + ((I-1)*9)
       NS1 = NS + 1
       READ(7,*) AX,BX
       SYST(NS) = AX
       SYST(NS1) = BX
30     CONTINUE
C
C  OUTPUT OF SYSTEM TYPE, PADDOCKS SERVED, SYSTEM LIFE
```

```
C   AND LOAN TERMS
C
      WRITE(11,1108) NSYS,SYSNAM(NSYS),SLIFE,
     1 (IPSYS(J,NSYS),J=1,NPKSYS(NSYS))
1108  FORMAT('1'/////' RESULTS FOR SYSTEM NO. ',I2,' -- ',A/
     1' THE LIFE OF THE SYSTEM IS ',I3,' YEARS'/
     2' PADDOCKS SERVED BY THE SYSTEM ARE ',20I3//)
C
      DO 301 I=1,2
      NS = 8 + ((I-1)*9)
      NS1 = NS + 1
301   WRITE(11,1109) I,SYST(NS),SYST(NS1)
1109  FORMAT(/' TERMS FOR LOAN RATE NO. ',I1/
     1F10.1,T15,'..PERCENT INTEREST RATE'/
     2F9.0,T15,'..YEARS TIME OF LOAN')
C
C   CALL PROPER SUBROUTINE FOR SYSTEM TYPE
C
      GO TO (32,32,34,34,34,34,34,34,35),IDS(NSYS)
32    CALL SURFACE(SLIFE,SYSNAM(NSYS),NSYS,IDS(NSYS),J1,NT,CNAME)
      GO TO 40
34    CALL SPNKLR(SLIFE,SYSNAM(NSYS),NSYS,IDS(NSYS),J1,NT)
      GO TO 40
35    CALL TRICKLE(SLIFE,SYSNAM(NSYS),NSYS,IDS(NSYS),J1,NT)
C
C   WRITE SUMMARY ON LU 11
C
40    WRITE(11,1120) TITLST,TITLE,SYSNAM(NSYS),
     1(IPSYS(J,NSYS),J=1,NPKSYS(NSYS))
1120  FORMAT('1',//' SUMMARY OF APPLICATION SYSTEMS INFORMATION '
     1'IN FILE ',A/' THE RESULTS FOR USE IN SIMULATION ARE IN FILE ',A//
     25X,A,' SERVING PADDOCKS ',20I3)
C
      WRITE(11,1121)(IPSYS(J,NSYS),TLAB(IPSYS(J,NSYS)),
     1                J=1,NPKSYS(NSYS))
1121  FORMAT(//' PADDOCKS SERVED AND LABOR REQUIREMENTS'/
     1'   PADDOCK       LABOR REQUIREMENT'/
     2'    NO.             (HR/IRRIG)'/20(I7,F19.1/))
C
      WRITE(11,1122)
1122  FORMAT(//' OVERALL SYSTEM EFFICIENCIES FOR CROPS IN EACH PADDOCK'/
     1' PADDOCK    - CROP -           EFFICIENCY'/
     2'   NO.      NO.    NAME            (%)')
C
      DO 50 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
      WRITE(11,1123) IPK
1123  FORMAT(/I5)
      WRITE(11,1124) (NT(J,IPK),CNAME(NT(J,IPK)),EAPP(NT(J,IPK),
     1                IPK),J=1,J1(IPK))
1124  FORMAT(I14,2X,A,F6.1)
50    CONTINUE
C
      WRITE(11,1125) (SYST(I),I=1,3)
```

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```
1125  FORMAT(
     1//' FLOW RATE ENTERING SYSTEM (L/S) . . . . . . . . ',F6.1//
     1' PERCENT OF TIME SYSTEM OPERATES . . . . . . . . ',F6.1//
     2' SYSTEM LIFE (YEARS) . . . . . . . . . . . . . . ',F5.0)
C
      WRITE(11,1126)(SYST(I),SYST(I+9),I=4,12)
1126  FORMAT(//' SUMMARY OF SYSTEM COSTS AND FINANCING ------------'/
     135X,'ATTACHED COMPONENTS   UNATTACHED COMPONENTS'/
     238X,'(LOAN NO. 1)',11X,'(LOAN NO.2)'/
     3'   TOTAL CAPITAL COST ($) . . . . . .',F10.2,F23.2/
     4'   CAPITAL NOT FINANCED'/
     5'           OR SUBSIDIZED ($) . . . .',F10.2,F23.2/
     6'   SUBSIDIZED CAPITAL ($) . . . . . ',F10.2,F23.2/
     7'   FINANCED CAPITAL ($) . . . . . . .',F10.2,F23.2/
     8'   INTEREST RATE (%) . . . . . . . .',F10.2,F23.2/
     9'   TIME OF LOAN (YEARS) . . . . . . .',F8.0,F23.0/
     A'   SALVAGE VALUE ($) . . . . . . . .',F10.2,F23.2/
     B'   ANNUAL MAINTENANCE EXPENSE ($) . .',F10.2,F23.2/
     C'   ANNUAL MISCELLANEOUS EXPENSE ($) .',F10.2,F23.2)
C
      IF(NAPMP(NSYS).EQ.0 )GO TO 60
      WRITE(11,1127) (IDXPMA(J,NSYS),QPMP(IDXPMA(J,NSYS)),
     1                PWRPMP(IDXPMA(J,NSYS)),J=1,NAPMP(NSYS))
1127  FORMAT(//' SUMMARY INFORMATION FOR INCLUDED PUMPS'/
     1'     PUMP ID NO.        FLOW RATE          INPUT POWER'/
     225X,'(L/S)',13X,'(KW)'/ 30(I12,F18.1,F18.1,/))
C
60    DO 65 I=1,21
65    SYSVAL(I,NSYS) = SYST(I)
C
C  RETURN TO STATEMENT 15 FOR DATA FOR ANOTHER SYSTEM
C
      GO TO 15
C
C  WRITE RESULTS ON LU 10 FOR USE IN SUMULATION PROGRAM
C
80    WRITE(10,1130) NSYS
1130  FORMAT(I5)
      DO 87 I=1,NSYS
      WRITE(10,1131) SYSNAM(I)
1131  FORMAT(A)
C
      WRITE(10,1132) NPKSYS(I), (IPSYS(J,I),J=1,NPKSYS(I))
1132  FORMAT(16I5)
C
      WRITE(10,1133) (TLAB(IPSYS(J,I)),J=1,NPKSYS(I))
1133  FORMAT(8F10.2)
C
      WRITE(10,1133) (SYSVAL(J,I),J=1,21)
      WRITE(10,1132) NAPMP(I),(IDXPMA(J,I),J=1,NAPMP(I))
      IF(NAPMP(I).EQ.0) GO TO 87
      WRITE(10,1133) (PWRPMP(IDXPMA(J,I)),QPMP(IDXPMA(J,I)),
     1                J=1,NAPMP(I))
87    CONTINUE
```

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```
C
C  WRITE OUT EFFICIENCY ARRAY
C
      WRITE(10,1133) ((EAPP(I,J),I=1,NCP),J=1,NPDK)
C
      WRITE(8,1140) TITLST,TITLE
1140  FORMAT(///' >>>THE PROGRAM HAS SUCCESSFULLY EXECUTED!! <<'//
     1' -- A LISTING OF INPUT DATA AND SUMMARY OUTPUT IS IN FILE ',A//
     2' -- DATA FOR THE SIMULATION PROGRAM IS IN FILE ',A)
      GO TO 99
990   WRITE(8,*)' THE CROPADDOCK FILE SPECIFIED DOES NOT EXIST!!'
99    STOP
      END
```

```
            SUBROUTINE SURFACE(SLIFE,SNM,NSYS,ID,J1,NT,CNAME)
C
C  SUBROUTINE SURFACE FOR COMPUTING COSTS AND EFFICIENCIES OF
C  BORDER AND FURROW IRRIGATION SYSTEMS
C
C  VARIABLES PASSED
C    SLIFE -- SYSTEM LIFE IN YEARS
C    SNM -- SYSTEM NAME
C    NSYS -- SYSTEM ID NO.
C    ID -- SYSTEM TYPE ID NO.
C    J1 -- ARRAY OF NO. OF CROPS IN EACH PADDOCK
C    NT -- ARRAY OF CROP ID NOS. FOR EACH PADDOCK
C
C
       COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
      1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
      2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
      3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
C
       DIMENSION NT(30,20),RN(30),VF(7,2), MAD(30),CX(9),SP(9),J1(20)
       REAL MAD
C
       CHARACTER*30 SNM,YIN*1,YS*1,CNAME(30)*16
C
       DATA CX/.1,.34,.41,.66,.68,1.2,1.68,2.2,5./
       YS = 'Y'
C
C  ENTER FLOW RATE ENTERING SYSTEM -- QIN
       WRITE(8,1000) NSYS,SNM
1000  FORMAT(//' THE FOLLOWING INPUTS REFER TO SYSTEM NO. ',I2,' -- '
      1 A//' ENTER THE FOLLOWING 2 ITEMS'/
      1'  1 --  FLOW RATE ENTERING THE SYSTEM (LITERS PER SECOND)'/
      2'         NOTE: THE FLOW RATE ENTERING THE SYSTEM MUST'/
      3'               CORRESPOND TO THAT SUPPLIED BY THE'/
      4'               WATER SUPPLY SYSTEM'/
      5'  2 -- HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE')
       READ(7,*) QINN,HRD
       SYST(1) = QINN
       SYST(2) = 100. * HRD/24.
C
C  COMPUTE ESTIMATED SEEPAGE LOSSES USING USBR MORITZ EQN
C
C         QLOSS = 0.0365 * CX * SQRT(Q)
C     WHERE  QLOSS = SEEPAGE LOSS IN L/S PER 100 M
C            CX = COEFFICIENT FOR TYPE OF MATERIAL
C                 (FOR VALUES REFER TO DATA STATEMENT)
C            Q = FLOW IN L/S
C                NOTE: THIS RELATIONSHIP ASSUMES A VELOCITY
C                      OF 1.0 M/S
       DO 5 I=1,9
5      SP(I) = (.0365 * CX(I) * SQRT(QINN))
C
       WRITE(8,1002)(SP(I),I=1,9)
```

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```fortran
1002  FORMAT(//' FOLLOWING ARE ESTIMATES OF SEEPAGE LOSS'/
     1' FOR THE FLOW RATE ENTERING THE SYSTEM'/
     2'    SEEPAGE LOSS'//'   (L/S PER 100 M)'/
     3F12.1,T15,'..WELL MAINTAINED CONCRETE LINING'/
     4F12.1,T15,'..CEMENTED GRAVEL & HARDPAN WITH SANDY LOAM'/
     5F12.1,T15,'..CLAY AND CLAYEY LOAM'/
     6F12.1,T15,'..SANDY LOAM'/
     7F12.1,T15,'..VOLCANIC ASH'/
     8F12.1,T15,'..SAND OR VOLCANIC ASH AND CLAY'/
     9F12.1,T15,'..SANDY SOIL WITH ROCK'/
     AF12.1,T15,'..SANDY AND GRAVELLY SOIL'/
     BF12.1,T15,'..STONY GRAVELLY SOIL'/
     C'   NOTE:  PIPELINES SHOULD HAVE NEGLIGIBLE LOSS'//
     D' ENTER THE TOTAL ESTIMATED LOSS (L/S) ONLY IN THIS APPLICATION'/
     E' SYSTEM BEFORE WATER REACHES THE FIELD')
      READ (7,*) QLOSS
C
      QIN = QINN - QLOSS
      ECONV = QIN/QINN
C
C
C  WRITE A RECORD OF INPUT DATA ON LU 11
      WRITE(11,1001)NSYS,SNM,HRD,QINN,QLOSS,QIN
1001  FORMAT(///' INPUT DATA AND RESULTS FOR SYSTEM NO. ',I2,' -- ',A/
     1/F11.2,T15,'..HOURS PER DAY SYSTEM OPERATION'/
     1F10.1,T15,'..LITERS PER SECOND FLOW RATE ENTERING THE SYSTEM'/
     2F10.1,T15,'..LITERS PER SECOND LOSS'/
     3F10.1,T15,'..LITERS PER SECOND REACHING THE FIELD')
C
C  LOOP FOR EACH PADDOCK
      DO 40 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
C
C  CALL SUBROUTINE INTAKE TO OBTAIN COEFFICIENTS FOR INTAKE RATE EQN
C
      CALL INTAKE(NOEQN,FAMI,SNM,NSYS,IPK)
C
C  SORT OUT WHICH CROPS ARE IRRIGATED IN THE PADDOCK
C
C  -- TMAD = AVERAGE MAD FOR DRAINAGE COMPUTATIONS
      TMAD = 0.
      J1(IPK) = 0
      DO 10 J=1,NCP
      IF(J.EQ.23) GO TO 10
      DO 7 JK = 1,NCRP(IPK)
      JJ = JK
      IF(NINT(CRPDK(IPK,JJ,1)).EQ.J) GO TO 8
      IF (NINT(CRPDK(IPK,JJ,5)).EQ.J) GO TO 9
7     CONTINUE
      GO TO 10
8     J1(IPK) = J1(IPK) + 1
      NT(J1(IPK),IPK) = J
      MAD(J1(IPK)) = CRPDK(IPK,JJ,4) - CRPDK(IPK,JJ,3)
      GO TO 6
```

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```
9      J1(IPK) = J1(IPK) +  1
       NT(J1(IPK),IPK) = J
       MAD(J1(IPK)) = CRPDK(IPK,JJ,8) - CRPDK(IPK,JJ,7)
6      TMAD = TMAD + MAD(J1(IPK))
10     CONTINUE
       TMAD = TMAD/J1(IPK)
C
C  CALL PROPER SUBROUTINE -- SURFACEB FOR BORDER OR
C                                    SURFACEF FOR FURROW IRRIGATION SYSTEM
C
       GO TO (12,14),ID
C
12     CALL SURFACEB(IPK,J1,NT,MAD,NSYS,SNM,SLIFE,NOEQN,FLEN,QIN,ECONV
      1 ,DVOL,EFFAVE,CNAME)
       GO TO 15
14     CALL SURFACEF(IPK,J1,NT,MAD,NSYS,SNM,SLIFE,NOEQN,FLEN,FAMI,QIN,
      1 ECONV,DVOL,EFFAVE,CNAME)
C
C  ADD DATA TO APPROPRIATE ARRAY ELEMENTS FOR SYSTEM SUMMARY FILE
C
C
C  INPUT DATA FOR HEAD RACES AND DITCHES
C
15     WRITE(8,1009) IPK
1009   FORMAT(// ' ARE DATA TO BE ENTERED FOR HEAD RACES AND/OR'/
      1' DRAINAGE DITCHES IN PADDOCK NO. ',I2,'  (Y OR N)')
       READ(7,1100) YIN
1100   FORMAT (A)
       IF(YIN.NE.YS) GO TO 24
       WRITE(11,1008) IPK
1008   FORMAT(// ' HEADRACES AND DITCHES FOR PADDOCK NO. ',I2)
C
       CALL RACES(SLIFE,VF)
C
       DO 22 N=1,2
       J=4
       IF(N.GT.1) J=13
       SYST(J) = SYST(J) + VF(1,N)
       SYST(J+1) = SYST(J+1) + VF(2,N)
       SYST(J+2) = SYST(J+2) + VF(3,N)
       SYST(J+3) = SYST(J+3) + VF(4,N)
       SYST(J+6) = SYST(J+6) + VF(5,N)
       SYST(J+7) = SYST(J+7) + VF(6,N)
       SYST(J+8) = SYST(J+8) + VF(7,N)
22     CONTINUE
C
C  INPUT DATA FOR IRRIGATION STRUCTURES
C
24     WRITE(8,1010) IPK
1010   FORMAT(/ ' ARE DATA TO BE INPUT FOR IRRIGATION STRUCTURES '/
      1' IN PADDOCK NO. ',I2,'  (Y OR N)')
       READ(7,1100) YIN
       IF(YIN.NE.YS) GO TO 30
       WRITE(11,1011) IPK
```

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```
1011   FORMAT(///' IRRIGATION STRUCTURES FOR PADDOCK NO. ',I2)
C
       CALL STRUCTS(SLIFE,VF)
C
C
       DO 28 N=1,2
       J=4
       IF(N.GT.1) J=13
       SYST(J) = SYST(J) + VF(1,N)
       SYST(J+1) = SYST(J+1) + VF(2,N)
       SYST(J+2) = SYST(J+2) + VF(3,N)
       SYST(J+3) = SYST(J+3) + VF(4,N)
       SYST(J+6) = SYST(J+6) + VF(5,N)
       SYST(J+7) = SYST(J+7) + VF(6,N)
       SYST(J+8) = SYST(J+8) + VF(7,N)
28     CONTINUE
C
C  INPUT DATA FOR PIPELINES
C
30     WRITE(8,1012) IPK
1012   FORMAT(/' ARE DATA TO BE INPUT FOR PIPELINES'/
      1' FOR PADDOCK NO. ',I2,'?  (Y OR N)')
       READ(7,1100) YIN
       IF(YIN.NE.YS) GO TO 36
       WRITE(11,1013) IPK
1013   FORMAT(///' PIPELINES FOR PADDOCK NO. ',I2)
C
       CALL PIPES(SLIFE,VF)
C
C
       DO 34 N=1,2
       J=4
       IF(N.GT.1) J=13
       SYST(J) = SYST(J) + VF(1,N)
       SYST(J+1) = SYST(J+1) + VF(2,N)
       SYST(J+2) = SYST(J+2) + VF(3,N)
       SYST(J+3) = SYST(J+3) + VF(4,N)
       SYST(J+6) = SYST(J+6) + VF(5,N)
       SYST(J+7) = SYST(J+7) + VF(6,N)
       SYST(J+8) = SYST(J+8) + VF(7,N)
34     CONTINUE
C
C  INPUT DATA FOR SUBSURFACE DRAINAGE
C
36     WRITE(8,1014) IPK
1014   FORMAT(/' IS SUBSURFACE DRAINAGE REQUIRED FOR'/
      1' PADDOCK NO. ',I2,'?  (Y OR N)')
       READ(7,1100) YIN
       IF(YIN.NE.YS) GO TO 40
       WRITE(11,1015) IPK
1015   FORMAT(///' SUBSURFACE DRAINAGE FOR PADDOCK NO. ',I2)
C
       CALL SDRAIN(FLEN, SLIFE,V,IPK,DVOL,EFFAVE,TMAD)
C
```

```
C
        DO 38 N=1,2
        J=4
        IF(N.GT.1) J=13
        SYST(J) = SYST(J) + VF(1,N)
        SYST(J+1) = SYST(J+1) + VF(2,N)
        SYST(J+2) = SYST(J+2) + VF(3,N)
        SYST(J+3) = SYST(J+3) + VF(4,N)
        SYST(J+6) = SYST(J+6) + VF(5,N)
        SYST(J+7) = SYST(J+7) + VF(6,N)
        SYST(J+8) = SYST(J+8) + VF(7,N)
38      CONTINUE
C
40      CONTINUE
C
C  DATA INPUT FOR SYSTEM COMPONENTS AND COSTS NOT ENTERED FOR
C  INDIVIDUAL PADDOCKS
C  --RACES
        WRITE(8,1016) NSYS,SNM
1016 FORMAT(///' ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES'/
      1' FOR SYSTEM NO. ',I2,' -- ',A/
      2' IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS?  (Y OR N)')
        READ (7,1100) YIN
        IF(YIN.NE.YS) GO TO 48
        WRITE(11,1017) NSYS,SNM
1017 FORMAT(///' RACES AND DITCHES FOR SYSTEM NO. ',I2,' -- ',A)
C
        CALL RACES(SLIFE,VF)
C
C
        DO 46 N=1,2
        J=4
        IF(N.GT.1) J=13
        SYST(J) = SYST(J) + VF(1,N)
        SYST(J+1) = SYST(J+1) + VF(2,N)
        SYST(J+2) = SYST(J+2) + VF(3,N)
        SYST(J+3) = SYST(J+3) + VF(4,N)
        SYST(J+6) = SYST(J+6) + VF(5,N)
        SYST(J+7) = SYST(J+7) + VF(6,N)
        SYST(J+8) = SYST(J+8) + VF(7,N)
46      CONTINUE
C
C  INPUT FOR STRUCTURES
C
48      WRITE(8,1018) NSYS,SNM
1018 FORMAT(/' ARE DATA TO BE ENTERED FOR ANY STRUCTURES'/
      1' FOR SYSTEM NO. ',I2,' -- ',A/
      2' IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS?  (Y OR N)')
        READ(7,1100) YIN
        IF(YIN.NE.YS) GO TO 54
        WRITE(11,1019) NSYS,SNM
1019 FORMAT(///' STRUCTURES FOR SYSTEM NO. ', I2,' -- ',A)
C
        CALL STRUCTS(SLIFE,VF)
```

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```
C
C
      DO 52 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
52    CONTINUE
C
C  INPUT FOR PIPELINES
C
54    WRITE(8,1020) NSYS,SNM
1020  FORMAT(//' ARE DATA TO BE ENTERED FOR ANY PIPELINES'/
     1' FOR SYSTEM NO. ',I2,' -- ',A/
     2' IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS?  (Y OR N)')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 60
      WRITE(11,1021) NSYS,SNM
1021  FORMAT(//' PIPELINES FOR SYSTEM NO. ',I2,' -- ',A)
C
      CALL PIPES (SLIFE,VF)
C
C
      DO 58 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
58    CONTINUE
C
C  INPUT FOR PUMPS
C
60    NAPMP(NSYS) = 0
      WRITE(8,1022) NSYS,SNM
1022  FORMAT(/' ARE DATA TO BE INPUT FOR ANY PUMPS'/
     1' FOR SYSTEM NO. ',I2,' -- ',A/
     2'  NOTE: DO NOT INCLUDE ANY PUMPS SPECIFIED IN THE'/
     3'         WATER SUPPLY ROUTINE!!')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 71
      WRITE(8,1023)
1023  FORMAT(//' ENTER THE NUMBER OF PUMPS AND THE ID NO. OF EACH PUMP')
      READ(7,*) NAPMP(NSYS),(IDXPMA(I,NSYS),I=1,NAPMP(NSYS))
      WRITE(11,1024)NSYS,SNM,NAPMP(NSYS)
```

```
1024  FORMAT(///' PUMPS FOR SYSTEM NO. ',I2,' -- ',A/
     1I9,T15,'..NO. OF PUMPS')
      DO 70 I=1,NAPMP(NSYS)
      WRITE(11,1025) IDXPMA(I,NSYS)
1025  FORMAT(//'    PUMP ID NO. ',I2)
      WRITE(8,1026) IDXPMA(I,NSYS)
1026  FORMAT(/' ENTER DATA FOR PUMP ID NO. ',I2)
C
      CALL PUMPS(SLIFE,VF,PWR,QA)
C
      PWRPMP(IDXPMA(I,NSYS)) = PWR
      QPMP(IDXPMA(I,NSYS)) = QA
C
      DO 68 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
68    CONTINUE
70    CONTINUE
C
C  OTHER EXPENSES
C
71    WRITE(8,1027) NSYS,SNM
1027  FORMAT(/' ENTER DATA FOR OTHER EXPENSES'/
     1' FOR SYSTEM NO. ',I2,' -- ',A/
     2' IN ADDITION TO THOSE INPUT FOR INDIVIDUAL PADDOCKS')
      WRITE (11,1028) NSYS,SNM
1028  FORMAT(///' OTHER EXPENSES FOR SYSTEM NO. ',I2,' -- ',A)
C
      CALL OEXP (SLIFE,VF)
C
C
      DO 72 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
72    CONTINUE
      RETURN
      END
```

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```
              SUBROUTINE SURFACEB (IPK,J1,NT,MAD,NSYS,SNM,SLIFE,NOEQN,BLEN,
           1 QIN,ECONV,DVOL,EFFAVE,CNAME)
C
C   SUBROUTINE SURFACEB FOR COMPUTING COSTS AND EFFICIENCIES OF
C   BORDER IRRIGATION SYSTEMS
C
C   VARIABLES PASSED
C     IPK -- PADDOCK ID NO.
C     J1 -- NO. OF CROPS IN PADDOCK IPK
C     NT -- ARRAY OF J1 CROP ID NOS.
C     MAD -- NET IRRIGATION APPLICATION (MM)
C     NSYS -- SYSTEM ID NO.
C     SNM -- SYSTEM NAME
C     SLIFE -- SYSTEM LIFE (YEARS)
C     NOEQN -- INTAKE EQN ID NO. (SUBROUTINE INTAKE)
C     BLEN -- BORDER STRIP LENGTH (M)
C     QIN -- FLOW REACHING FIELD (L/S)
C     ECONV -- CONVEYANCE EFFICIENCY (DECIMAL)
C     DVOL -- PERCENT LOST TO DEEP PERCOLATION
C     EFFAVE -- AVERAGE APPLICATION EFFICIENCY
C
      COMMON   IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
C
      DIMENSION NT(30,20),RN(30),VF(7,2), MAD(30),J1(20)
      REAL MAD
C
      CHARACTER*30 SNM,YIN*1,YS*1,CNAME(30)*16
C
      YS = 'Y'
C
C   ENTER PADDOCK PARAMETERS
C   -- SLP = SLOPE (DECIMAL)
C   -- BLEN = LENGTH OF BORDER STRIPS (M)
C   -- BWID = WIDTH OF BORDER STRIPS (M)
C   -- NTM = NO. OF BORDERS IRRIGATED AT ONE TIME
C
      WRITE(8,1002) IPK
1002  FORMAT(/' ENTER THE FOLLOWING INFORMATION FOR PADDOCK NO. ',I2/
     1' >> 4 PARAMETERS'/
     2' 1 -- FIELD SLOPE (DECIMAL)'/
     3' 2 -- BORDER STRIP LENGTH (M)'/
     4' 3 -- BORDER STRIP WIDTH (M)'/
     5' 4 -- NO. OF BORDERS IRRIGATED AT ONE TIME')
      READ(7,*) SLP,BLEN,BWID,NTM
C
      WRITE(11,1003) IPK,SLP,BLEN,BWID,NTM
1003  FORMAT(/' INFORMATION FOR PADDOCK NO. ',I2/F13.4,T15,
     1'..FIELD SLOPE (DECIMAL)'/F10.1,T15,'..METERS BORDER STRIP'
     2' LENGTH'/F10.1,T15,'..METERS BORDER STRIP WIDTH'/
     3I8,T15,'..BORDERS IRRIGATED AT THE SAME TIME')
```

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```
C
C
C   INPUT MANNINGS ROUGHNESS COEFFICIENTS
C
        WRITE(8,1004) J1(IPK)
1004  FORMAT(//' FOLLOWING ARE SOME SUGGESTED VALUES FOR MANNINGS '/
     1' ROUGHNESS COEFFICIENT (N) FOR DIFFERENT CROPS'/
     2' IRRIGATED IN BORDER STRIPS'/
     3T10,'SMOOTH BARE SOIL SURFACES . . . . . . . . 0.04'/
     4T10,'SMALL GRAIN DRILLED PARALLEL TO BORDERS  0.10'/
     5T10,'SMALL GRAIN DRILLED ACROSS BORDERS . . . 0.25'/
     6T10,'DENSE SOD CROPS . . . . . . . . . . . . . 0.25'/
     7T10,'LUCERNE, MINT, BROADCAST SMALL GRAIN . . 0.15'/
     8T10,'PASTURE -- SHORT (<50MM) TO TALL (100MM) 0.15 - 0.25'/
     9T10,'VINING CROPS SUCH AS PEAS . . . . . . . . 0.3 OR GREATER'//
     A' ENTER VALUES OF N FOR EACH OF THE FOLLOWING ',I2,' CROPS')
        WRITE(8,10041)(CNAME(NT(J,IPK)),J=1,J1(IPK))
10041 FORMAT(5X,A)
        READ(7,*)(RN(J),J=1,J1(IPK))
C
C   CALL SUBROUTINE BORDER TO COMPUTE ESTIMATED IRRIGATION EFFICIENCY
C   FOR EACH CROP
C
        QBRD = QIN/REAL(NTM)
        DO 18 LL = 1,J1(IPK)
C
        CALL BORDER(IPK,CNAME(NT(LL,IPK)),MAD(LL),QBRD,BWID,BLEN,SLP,
     1RN(LL),EFFA,DVOL,RVOL,QU,DH,DE,NOEQN)
C
C   ARRAY OF APPLICATION EFFICIENCIES -- EAPP(CROP,PADDOCK)
        EAPP(NT(LL,IPK),IPK) = EFFA * ECONV
C
C   VOLUME OF WATER STORED IN ROOT ZONE (CUBIC M/DAY)
        EFFAVE = EFFAVE + EFFA
C
C
        WRITE(11,1005) IPK,CNAME(NT(LL,IPK)),MAD(LL),QBRD,QU,RN(LL),
     1 EFFA,RVOL,DVOL,DH,DE,EAPP(NT(LL,IPK),IPK)
1005  FORMAT(//' RESULTS FOR PADDOCK NO. ',I2,' WITH CROP ... ',A/
     1F10.1,T15,'..MM NET DEPTH REQUIRED'/
     2F11.2,T15,'..L/S STREAM SIZE PER BORDER'/
     3F11.2,T15,'..L/S PER METER OF WIDTH UNIT STREAM SIZE'/
     4F12.3,T15,'..MANNINGS ROUGHNESS COEFFICIENT'/
     5F10.1,T15,'..PERCENT APPLICATION EFFICIENCY'/
     6F10.1,T15,'..PERCENT LOST TO RUNOFF'/
     7F10.1,T15,'..PERCENT LOST TO DEEP PERCOLATION'/
     8F10.1,T15,'..MM DEPTH APPLIED AT HEAD OF STRIP'/
     9F10.1,T15,'..MM DEPTH APPLIED AT END OF STRIP'//
     AF10.1,T15,'..PERCENT OVERALL APPLICATION SYSTEM EFFICIENCY')
18    CONTINUE
C
C   INPUT DATA FOR LABOR AND VARIOUS COSTS FOR EACH PADDOCK
C
        WRITE(8,1006) IPK,AREA(IPK)
```

```
1006  FORMAT(///' ENTER THE TOTAL LABOR REQUIREMENT'
      1' -- HOURS PER IRRIGATION'/
      1' FOR PADDOCK NO. ',I2,' -- ',I3,' HECTARES'/
      2'   NOTE:  ESTIMATED LABOR REQUIREMENTS WITH A STREAM SIZE OF'/
      3'          230 L/S ARE 3 MIN PER HA PER IRRIGATION FOR AN'/
      4'          AUTOMATED BORDER SYSTEM AND UP TO 90 MIN PER HA FOR'/
      5'          A COMPLETELY MANUAL SYSTEM REQUIRING CONSTANT '/
      6'          ATTENTION')
       READ (7,*) TLAB(IPK)
       WRITE(11,10061) TLAB(IPK)
10061  FORMAT(/F11.2,T15,'..HOURS PER HA PER IRRIGATION LABOR REQT')
C
C  DATA FOR LAND PREPARATION
C
       WRITE(8,10062) IPK
10062 FORMAT(/' ENTER THE FOLLOWING 5 ITEMS FOR LAND PREPARATION'/
      1' FOR PADDOCK NO. ',I2/
      2'  1 -- TOTAL COST OF LAND GRADING AND BORDERING ($)'/
      3'  2 -- PERCENT SUBSIDIZED'/
      4'  3 -- PERCENT FINANCED'/
      5'  4 -- LOAN NUMBER (1 OR 2)'/
      6'  5 -- ANNUAL COST FOR LAND SMOOTHING AND BORDER MAINTENANCE')
       READ(7,*) CLEV,SUB,FIN,LNO,ALEV
C
       WRITE(11,1007) CLEV,SUB,FIN,LNO,ALEV
1007  FORMAT(/' $',F9.2,T15,'..TOTAL COST OF LAND GRADING & BORDERING'/
      1F10.1,T15,'..PERCENT SUBSIDIZED'/
      2F10.1,T15,'..PERCENT FINANCED UNDER LOAN NO. ',I1/
      3' $',F9.2,T15,'..ANNUAL MAINTENANCE COST FOR LAND PREPARATION')
C
C  ADD DATA TO APPROPRIATE ARRAY ELEMENTS FOR SYSTEM SUMMARY FILE
C
       SUB = SUB/100.
       FIN = FIN/100.
       J=4
       IF(LNO.GT.1) J=13
       SYST(J) = SYST(J) + CLEV
       SYST(J+1) = SYST(J+1) + CLEV*(1. - (SUB+FIN))
       SYST(J+2) = SYST(J+2) + CLEV * SUB
       SYST(J+3) = SYST(J+3) + CLEV*FIN
       SYST(J+7) = SYST(J+7) + ALEV
       EFFAVE = EFFAVE/J1(IPK)
       RETURN
       END
```

```
C---THIS SUBROUTINE COMPUTES APPLICATION EFFICIENCIES OF
C    BORDER IRRIGATION SYSTEMS....R.G.ALLEN...G.D.GALINATO....
C    UNIVERSITY OF IDAHO, MOSCOW, IDAHO USA
C      MODIFIED BY J.R. BUSCH WINCHMORE  10 JUNE 1982
C
       SUBROUTINE BORDER (KSOIL,HEAD,MAD,QBRD,BWID,BLEN,SL,RN,
      1 EFFA,DVOL,RVOL,QUM,DH,DE,NOEQN)
C
C   VARIABLES PASSED
C     KSOIL -- PADDOCK NO.
C     HEAD -- CROP NAME
C     MAD DEFICIT REPLACED IN IRRIGATION (MM)
C     QBRD -- FLOW RATE PER BORDER (L/S)
C     BWID -- BORDER WIDTH (M)
C     BLEN -- BORDER LENGTH (M)
C     SL -- SLOPE (DECIMAL)
C     RN -- MANNINGS ROUGHNESS COEFFICIENT
C     EFFA -- APPLICATION EFFICIENCY (%)
C     RVOL -- PERCENT TO RUNOFF
C     DVOL -- PERCENT TO DEEP PERCOLATION
C     DH -- DEPTH APPLIED AT HEAD (MM)
C     DE -- DEPTH APPLIED AT END (MM)
C     NOEQN -- ID NO. OF INTAKE RATE EQN (SUBROUTINE INTAKE)
C
C   NOTE:   THE VARIABLES PASSED ARE IN SI UNITS
C   ====    HOWEVER, ALL COMPUTATIONS ARE DONE IN ENGLISH UNITS WITH
C           APPROPRIATE CONVERSIONS AT THE BEGINNING AND END OF THE
C           SUBROUTINE FOR ALL VARIABLES PASSED
C
C
       COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
      1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
      2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
      3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
C
       DIMENSION TA(100),TTR(100),DPPH(100),DPTH(100)
       DIMENSION LAL(2),LG(2),CF(4,5),COEF(5,9,4),COEF1(90),COEF2(90)
       DIMENSION XI(10),XDS(10),TDS(4,10),TRS(10),TIN(10)
       EQUIVALENCE (COEF1(1),COEF(1,1,1)), (COEF2(1),COEF(1,1,3))
       CHARACTER*16 HEAD, YS*1,ADV*1
       REAL MAD
       DATA YS/1HY/
       DATA COEF1/
      & -0.4150, 2.3160, 0.0924,-0.0455,-0.0079,
      & -0.2994, 2.1981, 0.1181,-0.0494,-0.0148,
      & -0.1468, 2.0824, 0.1333,-0.0090,-0.0006,
      &  0.0407, 1.9526, 0.1403,-0.0103,-0.0041,
      &  0.2987, 1.7926, 0.1221, 0.0004,-0.0019,
      &  0.5293, 1.6122, 0.1013, 0.0084,-0.0002,
      &  0.5849, 1.4689, 0.1509, 0.0419, 0.0043,
      &  0.5818, 1.4445, 0.1806, 0.0430, 0.0037,
      &  0.5825, 1.4489, 0.1794, 0.0388, 0.0033,
      & -0.4824, 2.9732, 0.3149,-0.1295,-0.0414,
```

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          & -0.3600,  2.7319,  0.3469,-0.0548,-0.0225,
          & -0.2239,  2.5006,  0.4359,  0.0363,-0.0062,
          & -0.0068,  2.2471,  0.4526,  0.1211,  0.0153,
          &  0.2474,  2.1225,  0.4042,  0.0571,-0.0012,
          &  0.5693,  1.9495,  0.2585,  0.0054,-0.0058,
          &  0.5726,  1.7614,  0.4251,  0.1288,  0.0135,
          &  0.5847,  1.7385,  0.4384,  0.1193,  0.0111,
          &  0.5823,  1.7349,  0.4484,  0.1193,  0.0110/
           DATA COEF2/
          & -0.6769,  3.9867,  1.1193,-0.1685,-0.1404,
          & -0.5245,  3.4924,  1.2310,  0.2436,  0.0035,
          & -0.2962,  3.1432,  1.2328,  0.4197,  0.0608,
          & -0.0400,  2.9050,  1.2328,  0.4439,  0.0608,
          &  0.2539,  2.6001,  1.0028,  0.3401,  0.0424,
          &  0.4791,  2.3461,  0.9260,  0.3266,  0.0400,
          &  0.5835,  2.3119,  0.9534,  0.3031,  0.0325,
          &  0.6093,  2.2950,  0.9449,  0.2758,  0.0271,
          &  0.6482,  2.2491,  0.8792,  0.2468,  0.0236,
          & -0.6234,  6.7411,  5.6423,  2.1934,  0.2117,
          & -0.5195,  6.0496,  6.2052,  3.5753,  0.7379,
          & -0.2863,  5.5300,  5.4534,  2.8355,  0.5053,
          &  0.0297,  4.8251,  4.2143,  1.9799,  0.3144,
          &  0.4247,  4.0387,  3.0400,  1.3074,  0.1874,
          &  0.6862,  3.5188,  2.1300,  0.7616,  0.0916,
          &  0.8811,  3.4234,  1.9788,  0.6451,  0.0701,
          &  0.9393,  3.2551,  1.7330,  0.5178,  0.0517,
          &  0.9496,  3.2288,  1.6451,  0.4667,  0.0446/
C
C----DEFINITION OF VARIABLES
C     QCFS - BORDER STREAM SIZE
C     SL - FIELD SLOPE, PERCENT
C     XLNT - LENGTH OF EIIRGATION RUN, FEET
C     BWIDE - BORDER WIDTH
C     TM - TIME OF APPLICATION
C     FAM - INTAKE FAMILY ACCORDING TO SCS CLASSIFICATION
C     RN - MANNINGS ROUGHNESS COEFFICIENT FOR BORDER
C
C  --REM = LENGTH AT END OF BORDER WHERE PONDING OCCURS (M)
      REM = 15.
C
C  CONVERT ENGLISH UNITS TO SI UNITS
      TRAMC = MAD/25.4
      QCFS = QBRD/28.317
      BWIDE = BWID * 3.281
      XLNT = (BLEN - REM) * 3.281
      TOTLEN = REM * 3.281
C
C
   110 FORMAT(/,' ADDITIONAL INFORMATION ON BORDER IRRIGATION'/
         '' IN PADDOCK NO. ',I2,' FOR CROP ==> ',A//
         '' DO YOU HAVE ADVANCE AND RECESSION DATA \\\\\'/
         '' ( Y OR N)'/)
   130 FORMAT(/,' TYPE MULTIPLIER AND EXPONENT OF ADVANCE CURVE'/
       1'    ADV = M * TIME ** E    WHERE ADV IS ADVANCE IN M')
                                180
```

```
    132 FORMAT(/,' TYPE MULTIPLIER AND EXPONENT OF RECESSION CURVE'/
       1'   RECESSION = M * TIME ** E    WHERE REC IS RECESSION IN M')
    117 FORMAT(/,' TYPE:                                          '/
       '            5X,'1--IF THE FLOW RATE AND SET TIME ARE TO BE ',
       '              'ADJUSTED TO INCREASE EFFICIENCY'/
       '            5X,'2--IF ONLY THE SET TIME IS TO BE ADJUSTED'/
       '            5X,'3--IF NEITHER Q NOR SET TIME ARE TO BE ADJUSTED'//
       ''    NOTE:  THE USUAL RESPONSE IS NO. 2')
C
C
      WRITE(8,110)  KSOIL,HEAD
      READ(7,112)ADV
      IF(ADV.EQ.YS)GO TO 114
C
    112 FORMAT(A)
C
C  FOR THE ZERO-INERTIAL MODEL, THE INTAKE EQN  MUST BE THE SCS EQN
C      Y = A * T ** B + C
C  IF INTAKE DATA WERE ENTERED FOR ANOTHER EQN CALL FAMFND TO
C  FIND THE PROPER SCS COEFFICIENTS
C
      IF(NOEQN.LE.3) CALL FAMFND(MAD,FAM)
      AC = Q3/25.4
      BC = Q4
      C = 0.275
      WRITE(8,117)
      READ(7,*) NIMP
      WRITE (8,118)
    118    FORMAT(//' ENTER AN ESTIMATE OF SET TIME IN MINUTES')
      READ(7,*) TM
      TLAG = 12.
      QU =QCFS/BWIDE
      TTA = TM
C
C---COMPUTE ADVANCE USING GENERALIZED DIMENSIONLESS SOLUTION
C     DEVELOPED BY N.D. KATOPODES AND THEODOR STRELKOFF, UCD.
C
C----COMPUTE NORMAL DEPTH USING MANNINGS EQUATION FOR OPEN CHANNEL FLOW
C
    120 Q0 = QU
      CU = 1.486
      IF(SL.LE.0.) SL=0.00001
      YN = (Q0*RN/(CU*SL**.5))**.600
C
C----CALCULATE DIMENSIONAL PARAMETERS USED IN COMPUTATION OF ADVANCE
      TS = (YN/(AC/(60.**BC*12.)))**(1./BC)
      XS = Q0/YN*TS
      P = SL*Q0*TS/YN**2
C
C----CALCULATE THE SQUARE OF THE FROUDE NUMBER AND TEST FOR ZERO INERTIA
      FN2 = Q0**2/(32.17*YN**3)
      IF(FN2.GT..05) WRITE(11,330) FN2
      IF(FN2.GT..05) WRITE(8,330) FN2
C----DETERMINE COEFFICIENTS OF THE 4TH DEGREE POLYNOMIAL REGRESSION
```

```
C     EQUATIONS DESCRIBING T* VS X* FOR THE FOUR CURVES
C     OF ALPHA AND NPL WHICH ENVELOPE BC AND P.
C
      LAL(1) = INT(BC*10.)
      LAL(2) = LAL(1)+1
      PLG = ALOG10(P*10.**6)
      LG(1) = INT(PLG)
      LG(2) = LG(1)+1
      JC = 0
      DO 210 I=1,2
      LALPHA = LAL(I)-5
      DO 210 J=1,2
      NPL = LG(J)
      IF(NPL.GT.9) NPL=9
      IF(NPL.LT.1) NPL=1
      JC = JC+1
      DO 205 JP=1,5
  205 CF(JC,JP) = COEF(JP,NPL,LALPHA)
  210 CONTINUE
C
C----DIVIDE FIELD INTO 10 STATIONS AND CALCULATE DIMINSIONLESS DISTANCES
      XL = XLNT/10.
      XJ = 0.
      DO 220 I=1,10
      XJ = XJ+XL
      XI(I) = XJ
  220 XDS(I) = XJ/XS
C
C----COMPUTE DIMENSIONLESS ADVANCE TIMES OF EACH STATION FOR
C     EACH OF 4 SETS OF REGRESSED CURVES
      DO 250 JC=1,4
      DO 250 I=1,10
      TJ = CF(JC,1)
      DO 240 JP=2,5
  240 TJ = TJ+CF(JC,JP)*(ALOG(XDS(I)))**(JP-1)
  250 TDS(JC,I) = EXP(TJ)
C
C----DETERMINE INTERPOLATED VALUE OF TDS BETWEEN THE FOUR CURVES
      P1 = 10.**(LG(1)-6)
      P2 = 10.**(LG(2)-6)
      IF(LG(1).LT.1.OR.LG(2).GT.9) GO TO 260
      DP = (P-P1)/(P2-P1)
      GO TO 264
  260 DP = 0.
  264 DO 270 J=1,3,2
      DO 270 I=1,10
  270 TDS(J,I) = TDS(J,I)+DP*(TDS(J+1,I)-TDS(J,I))
      DP = (BC*10.-LAL(1))/(LAL(2)-LAL(1))
      DO 280 I=1,10
  280 TDS(1,I) = TDS(1,I)+DP*(TDS(3,I)-TDS(1,I))
C
C----TRANSFORM DIMENSIONLESS TIME INTO ACTUAL TIME IN MINUTES
      DO 290 I=1,10
      TA(I) = TDS(1,I)*TS/60.
```
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```
    290 CONTINUE
C
C------COMPUTATION OF VOLUMES OF INFILTRATION FOR THE STATIONS,
C       AND RUNOFF FROM THE FIELD USING AN ALGEBRAIC COMPUTATION DERIVED
C       BY T. STRELKOFF,(UNIV. CALIF.,DAVIS), IN PROC. ASCE IR3 SEPT,1977
C
C----COMPUTE THE RECESSION CURVE
C----FIND THE AVERAGE INFILTRATION RATE IN THE FIELD AT BEGINNING OF
C    RECESSION
        TR = TTA+TLAG
        AIN = (AC*BC*TR**(BC-1))/20.
        DO 300 I=1,9
        IF((TR-TA(I)).LE.0.) GO TO 435
    300 AIN = AIN+(AC*BC*(TR-TA(I))**(BC-1))/10.
        IF((TR-TA(10)).LE.0.) GO TO 435
        AIN = AIN+(AC*BC*(TR-TA(10))**(BC-1))/20.
C
C----COMPUTE THE FLOW RATE OFF END OF FIELD AT BEGINNING
C    OF RECESSION
        Q1 = Q0-(AIN*XLNT/(60.*12.))
C----DETERMINE NORMAL DEPTH AT END OF FIELD
        YN = (Q1*RN/(CU*SL**.5))**.600
C
C----CALCULATE SY, THE RATE OF CHANGE OF DEPTH WITH DISTANCE
        SY = YN/XLNT
        IF((SL-SY).LE.0.) GO TO 400
        IF(SY.LE.0.) GO TO 400
        AIN = AIN/(60.*12.)
C----CALCULATE COEFFICIENT FOR SOLUTION OF A NONLINEAR ORDINARY
C    DIFFERENTIAL EQUATION
        CD = CU*SL**.5*SY**(5./3.)/(RN*AIN)
        CP = CD**1.5
C----DETERMINE TIME WATER FRONT RECEDES PAST STATIONS
        IF((CP*XLNT).LE.0.) GO TO 420
        RECL=0.
        IF((CP*XLNT).LE.1.) GO TO 310
        DO 305 K=1,15
        J=K-1
    305 RECL = RECL+(-1.)**J*(CP*XLNT)**((1.-2.*J)/3.)/((1.-2.*J)/3.)
        RECL = RECL-4.71238
        GO TO 315
    310 DO 312 K=1,15
        J=K-1
    312 RECL = RECL+(-1.)**J*(CP*XLNT)**((2.*J+3.)/3.)/((2.*J+3.)/3.)
    315 DO 320 II = 1,9
        RECD = 0.
        I=10-II
        IF((CP*XI(I)).LE.0.) GO TO 420
        IF((CP*XI(I)).LE.1.) GO TO 317
        DO 316 K=1,15
        J=K-1
    316 RECD = RECD+(-1.)**J*(CP*XI(I))**((1.-2.*J)/3.)/((1.-2.*J)/3.)
        RECD = RECD-4.71238
        TRS(II) = TR+SY/(AIN*CP)*(RECL-RECD)/60.
```

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```
      GO TO 320
  317 DO 318 K=1,15
      J=K-1
  318 RECD = RECD+(-1.)**J*(CP*XI(I))**((2.*J+3.)/3.)/((2.*J+3.)/3.)
      TRS(II) = TR+SY/(AIN*CP)*(RECL-RECD)/60.
  320 CONTINUE
      TRS(10) = TR+SY/(AIN*CP)*RECL/60.
C----CALCULATE TOTAL INFILTRATION OF THE STATIONS AND FIND AVERAGE
  340 TINH = AC*TR**BC+C
      TAIN = TINH/20.
      DO 350 I=1,9
      TIN(I) = AC*(TRS(I)-TA(I))**BC+C
      TAIN = TAIN+TIN(I)/10.
  350 CONTINUE
      TIN(10) = AC*(TRS(10)-TA(10))**BC+C
      VIN = TAIN + TIN(10)/20.
C----DETERMINE THE TOTAL VOLUME OF WATER TO FLOW ONTO THE FIELD
      VON = TTA*QO*60./XLNT*12.
C----DETERMINE TOTAL RUNOFF
C        --ACCOUNT FOR PONDAGE IN WIPE-OFF STRIP AT END
      VINN = VIN*((XLNT + TOTLEN)/XLNT)
      VSR = VON-VINN
C----CALCULATE DEEP PERCOLATION
      IF(TINH.LE.TRAMC.AND.TIN(10).LE.TRAMC) GO TO 380
      TN = TRAMC
      VDP = AMAX1((TINH-TN),0.)/18.
      DO 360 I=1,9
      VDP = VDP+AMAX1((TIN(I)-TN),0.)/9.
  360 CONTINUE
      VDP = VDP+AMAX1((TIN(10)-TN),0.)/18.
      GO TO 385
  380 VDP = 0.
C
C----CALCULATE APPLICATION EFFICIENCY AND DISTRIBUTION EFFICIENCY
  385 EFFA = (VINN-VDP)/VON*100.
      EFFD = AMIN1(TIN(10),TINH)/VIN*100.
C----CALCULATE SEASON LOSSES
      RVOL = VSR/VON * 100.
      DVOL = VDP/VON * 100.
C
      IF(NIMP.EQ.3) GO TO 200
      DIFIN = TIN(10)/TRAMC
      TMQ1 = QU * 28.317 * 3.281
      XXLNTM = XLNT/3.281
      TEMPA1 = TINH * 25.4
      TEMPA2 = TIN(10) * 25.4
      IF(DIFIN.LT..85) GO TO 390
      IF(DIFIN.LT.1.1) GO TO 200
      IF(NQT.EQ.2) GO TO 200
C
C
      WRITE(11,512) KSOIL
      WRITE(8,512) KSOIL
  512 FORMAT(T21,'PADDOCK NO. -- ',I2)
```

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```
      WRITE(11,514) HEAD
      WRITE(8,514) HEAD
  514 FORMAT(T21,A,/)
C
C
      WRITE(11,518) XXLNTM
      WRITE(8,518) XXLNTM
  518 FORMAT(T21,'RUN LENGTH (M) ',F5.0)
      WRITE(11,441) TTA,EFFD,EFFA,TMQ1,TEMPA1,TEMPA2
      WRITE(8,441) TTA,EFFD,EFFA,TMQ1,TEMPA1,TEMPA2
  441 FORMAT(/5X,'THE SET TIME OF ',F10.3,' MINUTES IS TOO LONG.'/
     &5X,'DEEP PERCOLATION AT THE FIELD END IS OCCURRING. '/
     &5X,'   TIME WILL BE DECEASED BY 5. PERCENT.'/
     &5X,'DISTRIBUTION EFFICIENCY =',F5.1,' PERCENT'/
     &5X,'APPLICATION EFFICIENCY  =',F5.1,' PERCENT'/
     &5X,'UNIT FLOW RATE =',F6.4,' L/S.'//
     &5X,'INFILTRATION AT FIELD HEAD IS ',F8.4,' MM'/
     &5X,'INFILTRATION AT FIELD END  IS ',F8.4,' MM.'//)
      TTA = TTA/1.05
      TM = TTA
      NQT=1
      GO TO 120
  390 CONTINUE
C
      WRITE(11,512) KSOIL
      WRITE(8,512) KSOIL
      WRITE(11,514) HEAD
      WRITE(8,514) HEAD
C
      WRITE(11,518) XXLNTM
      WRITE(8,518) XXLNTM
      WRITE(11,443) EFFD,EFFA,TMQ1,TTA,TEMPA1,TEMPA2
      WRITE(8,443) EFFD,EFFA,TMQ1,TTA,TEMPA1,TEMPA2
C
  443 FORMAT(/5X,'   THE END OF THE FIELD IS BEING UNDERIRRIGATED.'/
     &5X,'DISTRIBUTION EFFICIENCY =',F5.1,' PERCENT.'/
     &5X,'APPLICATION EFFICIENCY  =',F5.1,' PERCENT'/
     &5X,'UNIT FLOW RATE =',F8.4,' L/S'/
     &5X,'SET TIME = ',F10.2,' MINUTES.'/
     &5X,'INFILTRATION AT FIELD HEAD IS ',F8.4,' MM '//
     &5X,'INFILTRATION AT FIELD  END IS ',F8.4,' MM.'//
     &5X,'   Q AND TIME WILL BE INCREASED BY 10. PERCENT.'//)
      TTA = TTA*1.1
      TM = TTA
      IF(NIMP.EQ.1) QU=QU*1.1
      GO TO 120
  330 FORMAT(5X,'THE VALUE OF THE FROUDE NUMBER DESCRIBING THE FLOW OF'/
     &5X,'WATER ALONG THE FIELD IS HIGHER THAN ALLOWED FOR ACCURATE'/
     &5X,'ADVANCE PREDICTIONS USING THE ASSUMPTION OF ZERO INERTIA. '/
     &5X,'THE VALUE OF THE FROUDE NO.**2 IS',F6.2,' ,WHICH IS GREATER'/
     &5X,'THAN THE SUGGESTED VALUE OF .05'/)
  400 WRITE(11,410)
      WRITE(8,410)
  410 FORMAT(5X,'THE RATE OF CHANGE OF NORMAL DEPTH AT THE END OF THE',
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      &/5X,'FIELD AT T=TR IS GREATER THAN THE SLOPE OF THE FIELD,'/
      &5X,'OR SY IS LESS THAN OR EQUAL TO ZERO'/
      &5X,'EFFICIENCY IS SET AT 0.'/)
      GO TO 440
  420 WRITE(11,430)
      WRITE(8,430)
  430 FORMAT(5X,'THE VALUE OF CP*XLNT OR CP*XDS(I) APPEARING IN THE',
      &/5X,' FORMULA DESCRIBING THE DIFFERENTIAL EQUATION'/
      &5X,' RECL IS LESS THAN OR EQUAL TO 0.'/
      &5X,'EFFICIENCY IS SET AT 0.'/)
      GO TO 440
  435 IF(NQT.EQ.0) GO TO 436
      NQT=2
      TTA=TTA*1.05
      TM=TTA
      GO TO 120
C
  436    WRITE(11,512) KSOIL
         WRITE(8,512) KSOIL
         WRITE(11 ,514) HEAD
         WRITE(8 ,514) HEAD
C
         XXLNTM = XLNT /3.281
         WRITE(11 ,518) XXLNTM
         WRITE(8 ,518) XXLNTM
         X1TMP = XI(I)/3.281
         WRITE(11 ,442) TR,X1TMP,TA(I)
         WRITE(8 ,442) TR,X1TMP,TA(I)
  442 FORMAT(/5X,'RECESSION OF THE BORDER STREAM HAS BEEN DETERMINED'/
      '5X,'TO BEGIN BEFORE THE STREAM HAS ADVANCED ACROSS THE FIELD.'/
      '5X,'RECESSION TIME IS AT',F8.2,' MINUTES'/
      '5X,'THE STREAM HAS ADVANCED TO ',F7.1,' M AT',F8.2,' MINUTES')
  444 FORMAT(5X,
      '     'A LARGER FLOW RATE AND LONGER SET TIME WILL BE TRIED.'/)
  445 FORMAT(5X,'A LONGER SET TIME WIL BE TRIED.'/)
      IF(NIMP.EQ.1) WRITE(11 ,444)
      IF(NIMP.EQ.1) WRITE(8 ,444)
      IF(NIMP.GT.1) WRITE(11 ,445)
      IF(NIMP.GT.1) WRITE(8 ,445)
      IF(NIMP.EQ.1) QU=QU*1.2
      TTA = TTA*1.2
      TM = TTA
      GO TO 120
  440 EFFA=0.
      EFFD=0.
      RVOL=0.
      DVOL=0.
      GO TO 200
C
C----IF ADVANCE AND RECESSION DATA ARE AVAILABLE--ENTER DATA
C
  114 IF(LL.NE.1)GO TO 152
      WRITE(8,130)
      READ(7,*) AKK,AN
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```
        AK = AKK * 3.281
        WRITE(8,132)
        READ(7,*) RKK,RNR
        RK = RKK * 3.281
C----ASSUME 50 FEET BETWEEN STATION
        DIST = 50.
        STA = XLNT/DIST
        NSTA = STA
        STA = NSTA
        DREM = XLNT-STA*DIST
        DO 131 KX=1,100
        X= KX
        NEND =KX
        DSTA = DIST*(X-1.)
        IF(DSTA.GE.XLNT)GO TO 133
        TA(KX) = (DSTA/AK)**(1./AN)
        TTR(KX) = (DSTA/RK)**(1./RNR)
  131 CONTINUE
  133 TA(NEND) = (XLNT/AK)**(1./AN)
        TTR(NEND) =(XLNT/RK)**(1./RNR)
  152 CONTINUE
C
        IF(TM.NE.0.)GO TO 138
C----COMPUTE SET TIME AND EFFICIENCY
C  ----CALL ENTRY POINT TIMEDPTH IN SUBROUTINE FAMFND
C      TO DETERMINE TIME REQUIRED TO INFILTER MAD
        CALL TIMEDPTH (MAD,TIMEX)
C
        TM = TA(NEND)-TTR(NEND)+TIMEX
C
  138 DO 134 KN = 1,NEND
        DPPH(KN) = DK*((TM-TA(KN)+TTR(KN))**TD)
        DPTH(KN) = DPPH(KN)-TRAMC
  134 IF(DPTH(KN).LT.0.)DPTH(KN) =0.
C----COMPUTE VOLUME OF WATER LOST OF DP AND SR
        NEND1 = NEND-1
        VPP = 0.
        VDP = 0.
        DO 136 KN = 2,NEND1
        VPP = VPP+((DPPH(KN-1)+DPPH(KN))/24.)*DIST
  136 VDP = VDP+((DPTH(KN-1)+DPTH(KN))/24.)*DIST
        VPP = VPP+((DPPH(NEND1)+DPPH(NEND))/24.) * DREM
        VDP = VDP+((DPTH(NEND1)+DPTH(NEND))/24.)* DREM
        UST = QCFS/BWIDE
        QU = UST
        VSR = ((UST*TM*60.)-VPP)*BWIDE/43560.
       1    -(TOTLEN*TRAMC*BWIDE/12.)/43560.
        VDP = VDP * BWIDE/43560.
        VAPP = UST * BWIDE * TM * 60./43560.
C----COMPUTE EFFICIENCY
        EFFA = 100. * (VAPP - VSR - VDP)/VAPP
C----PERCENT LOST OF DP
        DVOL = VDP / VAPP * 100.
C----PERCENT LOST SR
                              187
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      RVOL = VSR / VAPP * 100.
      TINH=DPPH(1)
      TIN(10)=DPPH(NEND)
C
  200 CONTINUE
      DH=TINH   * 25.4
      DE=TIN(10) * 25.4
      QUM = QU * 28.317*3.281
      RETURN
      END
```

```
       SUBROUTINE SURFACEF (IPK,J1,NT,MAD,NSYS,SNM,SLIFE,NOEQN,PLEN,
      1 FAMI,QIN,ECONV,DVOL,EFFAVE,CNAME)
C
C   SUBROUTINE SURFACEB FOR COMPUTING COSTS AND EFFICIENCIES OF
C   BORDER IRRIGATION SYSTEMS
C
C   VARIABLES PASSED
C     IPK -- PADDOCK ID NO.
C     J1 -- NO. OF CROPS IN PADDOCK IPK
C     NT -- ARRAY OF J1 CROP ID NOS.
C     MAD -- NET IRRIGATION APPLICATION (MM)
C     NSYS -- SYSTEM ID NO.
C     SNM -- SYSTEM NAME
C     SLIFE -- SYSTEM LIFE (YEARS)
C     NOEQN -- INTAKE EQN ID NO. (SUBROUTINE INTAKE)
C     PLEN -- PADDOCK LENGTH (M)
C     FAMI -- INTAKE FAMILY (FOR SCS INTAKE EQN)
C     QIN -- FLOW RATE REACHING THE FIELD (L/S)
C     ECONV -- CONVEYANCE EFFICIENCY (DECIMAL)
C     DVOL -- PERCENT LOST TO DEEP PERCOLATION
C     EFFAVE -- AVERAGE APPLICATION EFFICIENCY FOR ALL CROPS
C
       COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
      1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
      2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
      3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
C
       DIMENSION NT(30,20),RN(30),VF(7,2), MAD(30),J1(20)
       REAL MAD
C
       CHARACTER*30 SNM,YIN*1,YS*1,CNAME(30)*16
C
       YS = 'Y'
       EFFAVE = 0.
C
C   ENTER PADDOCK PARAMETERS
C   -- SLP = SLOPE (DECIMAL)
C   -- PWID = PADDOCK WIDTH (M)
C   -- PLEN = PADDOCK LENGTH (M)
C   -- FLEN = FURROW LENGTH (M)
C
       WRITE(8,1002) IPK
 1002  FORMAT(/' ENTER THE FOLLOWING INFORMATION FOR PADDOCK NO. ',I2/
      1' >> 4 PARAMETERS'/
      2'  1 -- FIELD SLOPE (DECIMAL)'/
      3'  2 -- PADDOCK WIDTH (M)'/
      4'  3 -- PADDOCK LENGTH (M)'/
      5'  4 -- FURROW LENGTH (M)')
       READ(7,*) SLP,PWID,PLEN,FLEN
C
C   ENTER FURROW FLOW AND SET TIME PARAMETERS
C   -- QFUR = FURROW FLOW RATE (L/S)
C   -- TIME = APPLICATION TIME IN MINUTES
```

```
C
      WRITE (8,10021)
10021 FORMAT(/' ENTER THE FOLLOWING 2 ITEMS'/
     1'  1 -- FURROW STREAM SIZE (L/S)'/
     2'  2 -- TOTAL APPLICATION TIME IN MINUTES'/
     2' NOTE:'/
     3'    >>>> 0 (ZERO) MAY BE ENTERED FOR BOTH OF THESE VALUES'/
     4'         IF UNKNOWN.'/
     5'    >>>> IF 0 (ZERO) IS ENTERED FOR BOTH VALUES, THE STREAM'/
     6'         SIZE AND TIME OF APPLICATION WILL BE ADJUSTED TO'/
     7'         OBTAIN MAXIMUM APPLICATION EFFICIENCY')
      READ(7,*) QFUR,TIME
C
C  WRITE INPUTS ON LU 11
      WRITE(11,1003) IPK,SLP,PWID,PLEN,FLEN,QFUR,TIME
1003  FORMAT(/' INFORMATION FOR PADDOCK NO. ',I2/F13.4,T15,
     1'..FIELD SLOPE (DECIMAL)'/F10.1,T15,'..METERS PADDOCK '
     2'WIDTH'/F10.1,T15,'..METERS PADDOCK LENGTH'/
     3F10.1,T15,'..METERS FURROW LENGTH'/
     4F10.1,T15,'..L/S FURROW STREAM SIZE INPUT'/
     5F10.1,T15,'..MINUTES APPLICATION TIME INPUT')
C
C
C  INPUT FURROW SPACINGS FOR DIFFERENT CROPS
C
      WRITE(8,1004) J1(IPK)
1004  FORMAT(/
     9' ENTER FURROW SPACING IN MM'/
     A' FOR EACH OF THE FOLLOWING ',I2,' CROPS')
      WRITE(8,10041)(CNAME(NT(J,IPK)),J=1,J1(IPK))
10041 FORMAT(5X,A)
      READ(7,*)(RN(J),J=1,J1(IPK))
C
C  CALL SUBROUTINE FURROW TO COMPUTE ESTIMATED IRRIGATION EFFICIENCY
C  FOR EACH CROP
C
      QT = 0.
      RNT = 0.
      DO 18 LL = 1,J1(IPK)
C
      CALL FURROW(IPK,CNAME(NT(LL,IPK)),MAD(LL),QFUR,RN(LL),FLEN,SLP,
     1NOEQN,F1M,F1IM,FXLM,TT,EFFA,DVOL,RVOL,TIME)
C
C  ARRAY OF APPLICATION EFFICIENCIES -- EAPP(CROP,PADDOCK)
      EAPP(NT(LL,IPK),IPK) = EFFA * ECONV
C  VOLUME OF WATER STORED IN ROOT ZONE (CUBIC M/D)
      EFFAVE = EFFAVE + EFFA
C
      WRITE(11,1005) IPK,CNAME(NT(LL,IPK)),MAD(LL),QFUR,RN(LL),TIME,TT,
     1EFFA,RVOL,DVOL,F1M,F1IM,FXLM,EAPP(NT(LL,IPK),IPK)
1005  FORMAT(//' RESULTS FOR PADDOCK NO. ',I2,' WITH CROP ... ',A/
     1F10.1,T15,'..MM NET DEPTH REQUIRED'/
     2F11.2,T15,'..L/S STREAM SIZE PER FURROW'/
     3F10.1,T15,'..MM FURROW SPACING'/
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      4F10.1,T15,'..MINUTES TOTAL TIME OF APPLICATION'/
      4F10.1,T15,'..MINUTES ADVANCE TIME'/
      5F10.1,T15,'..PERCENT APPLICATION EFFICIENCY'/
      6F10.1,T15,'..PERCENT LOST TO RUNOFF'/
      7F10.1,T15,'..PERCENT LOST TO DEEP PERCOLATION'/
      7F10.1,T15,'..MM TOTAL DEPTH DELIVERED TO PADDOCK'/
      8F10.1,T15,'..MM DEPTH APPLIED AT HEAD OF STRIP'/
      9F10.1,T15,'..MM DEPTH APPLIED AT END OF STRIP'///
      AF10.1,T15,'..PERCENT OVERALL APPLICATION SYSTEM EFFICIENCY')
       QT = QT + QFUR
       RNT = RNT + RN(LL)
18     CONTINUE
C
C  COMPUTE NO. OF SETS PER IRRIGATION
C  BASED ON AVERAGE FLOW AND FURROW SPACING
C
       RNT = RNT/J1(IPK)
       QT = QT/J1(IPK)
       NSET = NINT(((PWID*PLEN/FLEN)/(QIN/QT*RNT/1000.)) + .35)
C
C  INPUT DATA FOR LABOR AND VARIOUS COSTS FOR EACH PADDOCK
C
       WRITE(8,1006) IPK,AREA(IPK),NSET
1006  FORMAT(/// ENTER THE TOTAL LABOR REQUIREMENTS'/
      1' FOR PADDOCK NO. ',I2,' -- ',I3,' HECTARES'/
      21X,I3,' SETS ARE REQUIRED PER IRRIGATION'//
      3' ENTER THE FOLLOWING 2 ITEMS'/
      4'   1 -- HOURS LABOR REQUIRED PER SET'/
      5'   2 -- HOURS ADDITIONAL LABOR REQUIRED PER IRRIGATION'/
      6' NOTE:  IF THE TOTAL TIME REQUIRED FOR THE PADDOCK PER '/
      7'         IRRIGATION IS KNOWN, ENTER 0 (ZERO) FOR ITEM 1'/
      8'         AND THE PROPER VALUE FOR ITEM 2')
      READ (7,*) HRS,HRI
      TLAB(IPK) = (HRS*REAL(NSET)) + HRI
      WRITE(11,10061) TLAB(IPK)
10061  FORMAT(/F11.2,T15,'..HOURS PER IRRIGATION LABOR REQT')
C
C  DATA FOR LAND PREPARATION
C
       WRITE(8,10062) IPK
10062 FORMAT(/' ENTER THE FOLLOWING 5 ITEMS FOR LAND PREPARATION'/
      1' FOR PADDOCK NO. ',I2/
      2'   1 -- TOTAL COST OF LAND GRADING   ($)'/
      3'   2 -- PERCENT SUBSIDIZED'/
      4'   3 -- PERCENT FINANCED'/
      5'   4 -- LOAN NUMBER (1 OR 2)'/
      6'   5 -- ANNUAL COST FOR LAND SMOOTHING')
      READ(7,*) CLEV,SUB,FIN,LNO,ALEV
C
       WRITE(11,1007) CLEV,SUB,FIN,LNO,ALEV
1007  FORMAT(/' $',F9.2,T15,'..TOTAL COST OF LAND GRADING & BORDERING'/
      1F10.1,T15,'..PERCENT SUBSIDIZED'/
      2F10.1,T15,'..PERCENT FINANCED UNDER LOAN NO. ',I1/
      3' $',F9.2,T15,'..ANNUAL MAINTENANCE COST FOR LAND PREPARATION')
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C
C   ADD DATA TO APPROPRIATE ARRAY ELEMENTS FOR SYSTEM SUMMARY FILE
C
      SUB = SUB/100.
      FIN = FIN/100.
      J=4
      IF(LNO.GT.1) J=13
      SYST(J) = SYST(J) + CLEV
      SYST(J+1) = SYST(J+1) + CLEV*(1. - (SUB+FIN))
      SYST(J+2) = SYST(J+2) + CLEV * SUB
      SYST(J+3) = SYST(J+3) + CLEV*FIN
      SYST(J+7) = SYST(J+7) + ALEV
      EFFAVE = EFFAVE/J1(IPK)
      RETURN
      END
```

```
C
C
C     FURROW IRRIGATION EVALUATION PROGRAM
C     PRESENT AND ELEVATION DESIGN
C     SCS-STSC-IRRI-NO  2 AND NO. 3
C     PROGRAMMED FOR TEXAS INSTRUMENT MODEL 59 BY H. G. COLLINS AND
C     PAUL KLUVEK
C     REVISED FOR FORTRAN IV BY KYUNG HAK YOO, UNIVERSITY OF IDAHO
C     REVISED FOR SIMULATION PROGRAM BY J.R. BUSCH, WINCHMORE,  JUNE,1982
C
C     THE COMPUTATIONAL PROCEDURES ARE SUMMARIZED IN A DRAFT COPY OF THE
C     SCS NATIONAL ENGINEERING HANDBOOK              ==========
C            SECTION 15, CHAPTER 5 -- FURROW IRRIGATION
C
C        NOTE:  ALL COMPUTATIONS ARE DONE IN ENGLISH UNITS
C               ALL VARIABLES PASSED FROM THE CALLING PROGRAM ARE CONVERTED
C               TO SI UNITS FOR COMPUTATIONS
C
C
C
      SUBROUTINE FURROW(KSOIL,HEAD,MAD,QGDM,FWD,FLEN,SL,NOEQN,
     1 F1M,F1IM,FXLM,TT,EFFA,DVOL,RVOL,TM)
C
C     VARIABLES PASSED ----------------------
C       KSOIL -- PADDOCK NO.
C       HEAD -- NAME OF CROP
C       MAD -- NET IRRIGATION APPLICATION (MM)
C       QGDM -- FURROW STREAM SIZE (L/S)
C       FWD -- FURROW SPACING (MM)
C       FLEN -- FURROW LENGTH (M)
C       SL -- SLOPE (M/M)
C       NOEQN -- ID NO. OF INTAKE RATE EQN (SUBROUTINE INTAKE)
C       F1M -- TOTAL DEPTH APPLIED (MM)
C       F1IM -- DEPTH APPLIED AT HEAD OF FIELD (MM)
C       FXLM -- DEPTH APPLIED AT FIELD END (MM)
C       TT -- ADVANCE TIME
C       EFFA -- APPLICATION EFFICIENCY (%)
C       DVOL -- % TO DEEP PERC
C       RVOL -- % TO RUNOFF
C       TM -- MINUTES INFLOW TIME
C
C
C     THIS PROGRAM EVALUATES  IMPROVED AND UNIMPROVED GRAVITY IRRIGATION
C     SYSTEM -- THE OUTPUT INCLUDES INFLOW RATE (GPM), INFLOW TIME (MIN),
C     APPLICATION DEPTH (IN), APPLICATION DEPTH AT THE FIELD END (IN),
C     RUNOFF (IN), DEEP PERCOLATION (IN) AND APPLICATION EFFICIENCY (%)
C
C     FOR IMPROVED SYSTEM
C     THIS EVALUATE A FURROW DESIGN TO DETERMINE FLOW RATE  AND INFLOW
C     TIME WHICH PROVEDES MAXIMUM EFFICIENCY. THE INFLOW TIME INCREMENT
C     IS SELECTED AS 15 MINUTES.
C     THE PROGRAM COMPUTES THE INFLOW RATE; INFLOW TIME; INTAKE DEPTH;
C     THE RUNOFF; THE DEEP PERCOLATION; AND MAXIMUM EFFICIENCY. ADDITIONAL
C     INFORMATION MAY BE OBTAINED BY RECALLING SEPCIFIC VARIABLES SUCH AS
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C    ADVANCE TIME AND AVERAGE INTAKE.
C
C    FOR IMPROVED SYSTEM INPUT '0' FOR INFLOW RATE AND APPLICATION
C    (OR INFLOW) TIME.
C
C    FOR UNIMPROVED SYSTEM
C    THIS EVALUATES AN EXISTING (PRESENT) IRRIGATION FURROW OR
C    CORRUGATION, OR AN ASSUMED DESIGN.
C    THE PROGRAM COMPUTES THE DEPTH OF APPLICATION AT THE END OF THE
C    FURROW, THE RUNOFF, THE DEEP PERCOLATION, AND THE EFFICIENCY
C    IF THE INFLOW TIME IS UNKNOWN, THE TIME IS COMPUTED TO APPLY THE
C    DESIGN APPLICATION AT THE LOWER END OF THE FURROW.
C
C    FOR UNKNOWN APPLICATION TIME INPUT '0' FOR THE APPLICATION TIME.
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      CHARACTER*16 HEAD
      REAL IRTOTC, MAD
      FWIDE = FWD/304.8
      XMAD=MAD/25.4
      T1=TM
      XLNTF = FLEN * 3.281
      QGPM=QGDM * 15.856
      C=0.275
      IFLAG=0
      DELT=1.0
      FX=0.0
C
C    COMPUTE AC, BC, CC, DC, TOP
C    AC AND BC F COEFFICIENTS OF INTAKE RATE EQUATION
C    TOP WETTED PERIMETER
C    FWIDE ; FURROW WIDTH INCHES
C    SL ; SLOPE STEEPNESS
C    QGDM ; INFLOW
C    TM ; INFLOW TIME MINUTES
C    QGDM ; INFLOW GPM
C    XLNTF FIELD LENGTH FEET
C    XMAD ; DESIGN APPLICATION INCHES
C    TN ; ADVANCE TIME AT XMAD=FAVE, MINUTES
C    TT ; ADVANCE TIME AT FIELD END,MINUTES
C    T1 ; TOTAL INFLOW TIME, MINUTES
C    F1 ; TOTAL WATER APPLIED, INCHES
C    FAVEX ; AVERAGE INFILTRATION BEHIND XMAD=FAVE
C    TOX ; TIME AT XMAD=FAVE
C    FAVE : AVERAGE INTAKE IN INCHES
C    DP ; DEEP PERCOLATION
C    RO ; RUNOFF
   50 CONTINUE
C
C  IF INFILTRATION DATA WERE NOT ENTERED IN SCS FORM, CALL FAMFND TO
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C   OBTAIN INTAKE FAMILY AND SCS COEFFICIENTS
C
      IF(NOEQN.NE.4) CALL FAMFND(MAD,FAM)
      AC = Q3/25.4
      BC = Q4
   20 CC=23.211+5.8653*FAM
      DC=0.00044685+0.0015764*FAM
C
C   IF APPLICATION TIME AND INFLOW RATE ARE '0' EVALUATE IMPROVED
C   SYSTEM
C
      IF(TM.EQ.0.0.AND.QGPM.EQ.0.0) GO TO 500
  730 CONTINUE
      TOP=0.2686*((QGPM*0.04)/(SL**0.5))**0.4247+0.7462
      DUM1=DC/(QGPM*SL**0.5)
      DUM2=TOP/FWIDE
      TN=(((XMAD/DUM2)-0.275)/AC)**(1.0/BC)
      TT=(XLNTF/CC)*EXP(DUM1*XLNTF)
      IF(T1.NE.0.0) GO TO 30
C
C   IF APPLICATION TIME IS NOT GIVEN EVALUATE IT
C
      IFLAG=0
      T1=TN+TT
   30 F1=(1.6041*QGPM*T1)/(FWIDE*XLNTF)
      TO=T1-(1.0/((CC*XLNTF)*(DUM1**2))*(((DUM1*XLNTF)-1.0)*EXP(DUM1*
     &XLNTF)+1.0))
      IF(TO.LT.0.0) GO TO 990
      TX=T1-TT
      IF(TX.LT.0.0) GO TO 990
      FAVE=(AC*TO**BC+0.275)*DUM2
      FAVEX=(AC*TX**BC+0.275)*DUM2
      FX=FAVEX
      IF(F1.LT.FAVE) GO TO 990
      FX=FAVEX
      IF(IFLAG.EQ.0) GO TO 800
      IF(FAVEX.GE.XMAD) GO TO 850
      TTX=T1-TN
      ATTX=TTX
      IF(TTX.LE.0.0) GO TO 990
C
C   ESTIMATE COEFFICIENTS OF LINEAR REGRESSION
C
      XT=0.0
      DIF=XLNTF/4.0
      SXT=0.0
      YT=0.0
      SYT=0.0
      XYT=0.0
      N=0
      DO 40 I=1,4
      X=DIF*I
      XT=XT+X
      SXT=SXT+X**2                195
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        TTX=X/CC*EXP(DUM1*X)
        AYT=ALOG(TTX)
        YT=YT+AYT
        SYT=SYT+AYT**2
        XYT=X*AYT+XYT
        N=N+1
   40 CONTINUE
        AN=N
        SSXT=SXT-(XT*XT/AN)
        SSYT=SYT-(YT*YT/AN)
        SXYT=XYT-(XT*YT/AN)
        AMB=SXYT/SSXT
        BB=(YT-AMB*XT)/AN
        XO=(ALOG(ATTX)-BB)/AMB
        TOX=T1-(1.0/((CC*XO)*(DUM1**2)))*(((DUM1*XO)-1.0)*
     &EXP(DUM1*XO)+1.0))
        FAVEX=(AC*TOX**BC+0.275)*DUM2
        DP=(FAVEX-XMAD)*XO/XLNTF
        AEFF=100.0*(FAVE-DP)/F1
        GO TO 900
  800 IF(F1.LE.XMAD) GO TO 990
  850 DP=FAVE-XMAD
        AEFF=100.0*(FAVE-DP)/F1
        TTX=0.0
  900 RO=F1-FAVE
        F1I=(AC*T1**BC+0.275)*DUM2
        FXL=FX
        TM=T1
C
C  CALCULATE PERCENT OF APPLIED WATER LOST TO DEEP PERC & RUNOFF
C
        QGDM=QGPM
        DVOL = (DP/F1) * 100.
        RVOL = (RO/F1) * 100.
        EFFA=AEFF
        FWIDE=FWIDE*12.0
        GO TO 980
  500 TEFF=0.0
C
C    IMPROVED GRAVITY IRRIGATION SYSTEM
C
        QGPM=5.0
  550 TOP=0.2686*((QGPM*0.04)/(SL**0.5))**0.4247+0.7462
        DUM2=TOP/FWIDE
        DUM1=DC*XLNTF/(QGPM*SL**0.5)
        TT=(XLNTF/CC)*EXP(DUM1)
        TN=(((XMAD/DUM2)-0.275)/AC)**(1.0/BC)
        T1=TN+TT
        I=T1/DELT+0.5
        T1I=I*DELT
        F1=1.6041*QGPM*T1I/(FWIDE*XLNTF)
        AEFF=100.0*XMAD/F1
        IF(TEFF.GE.AEFF) GO TO 605
  555 CONTINUE
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        IF(IFLAG.GE.1) GO TO 510
        QGPM=QGPM+5.0
        SDUM1=DUM1
        SDUM2=DUM2
        STT=TT
        STN=TN
        ST1=T1
        ST1I=T1I
        TEFF=AEFF
        GO TO 550
  605 IF(TEFF.NE.AEFF) GO TO 600
        GO TO 555
  600 IF(IFLAG.EQ.2) GO TO 560
        IFLAG=1
        GO TO 650
  510 F1=1.6041*QGPM*T1I/(FWIDE*XLNTF)
        TO=T1I-(1.0/((CC*XLNTF)*((DUM1/XLNTF)**2)))*
      &((DUM1-1.0)*EXP(DUM1)+1.0))
        FAVE=(AC*TO**BC+0.275)*DUM2
        IF (F1.LT.FAVE) GO TO 560
C
C   IF IFLAG=2, MAXIMUM EFFICIENCY WAS FOUND
C
        IFLAG=2
  650 QGPM=QGPM-1.0
        SDUM1=DUM1
        SDUM2=DUM2
        STT=TT
        STN=TN
        ST1=T1
        ST1I=T1I
        TEFF=AEFF
        GO TO 550
C
C   LIMIT THE EVALUATED INFLOW RATE AND APPLICATION TIME
C   MIXIMUM INFLOW RATE IS LESS THAN 41 GPM OR 0.15/SLOPE STEEPNESS
C   MAXIMUM APPLICATION IS LESS THAN 2881 MINUTES
C
  560 QGPM=QGPM+1.0
        QMAX2=(FWIDE-0.345)/0.022
        IF(QGPM.GE.41.0) GO TO 700
        IF(QGPM.GE.QMAX2) GO TO  700
        QMAX1=0.15/SL+1.0
        IF(QGPM.GE.QMAX1) GO TO 700
        IF(T1I.GE.2881.0) GO TO 700
        DUM1=SDUM1
        DUM2=SDUM2
        T1=ST1
        T1I=ST1I
        TT=STT
        TN=STN
        AEFF=TEFF
        TO=T1I-(1.0/((CC*XLNTF)*((DUM1/XLNTF)**2)))*((DUM1-1.0)*
      &EXP(DUM1)+1.0))
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      FAVE=(AC*TO**BC+0.275)*DUM2
      DP=FAVE-XMAD
      TX=T1I-TT
      FX=(AC*TX**BC+0.275)*DUM2
      F1=1.6041*QGPM*T1I/(FWIDE*XLNTF)
      AEFF=100.0*XMAD/F1
      T1=T1I
      GO TO 900
  700 CONTINUE
      WRITE(11,810)
      WRITE(8,810)
  810 FORMAT(/////T21,'FURROW IRRIGATION')
      WRITE(11,812) KSOIL
      WRITE(8,812) KSOIL
  812 FORMAT(T21,'PADDOCK NO. -- ',I2)
      WRITE(11 ,814)HEAD
      WRITE(8 ,814)HEAD
  814 FORMAT(T21,A,/)
      XLNTFM = XLNTF
      WRITE(11 ,818) XLNTFM
      WRITE(8 ,818) XLNTFM
  818 FORMAT(T21,'RUN LENGTH, M  ',F5.0)
      IF(QGPM.GE.41.0) GO TO 711
      IF(QGPM.GE.QMAX2) GO TO 710
      IF(QGPM.GE.QMAX1) GO TO 712
      IF(T1I.GE.2881.0) GO TO 713
  710 WRITE(11 ,720)
      WRITE(8 ,720)
      GO TO 995
  711 WRITE(11 ,721)
      WRITE(8 ,721)
      GO TO 995
  712 WRITE(11 ,722)
      WRITE(8 ,722)
      GO TO 995
  713 WRITE(11 ,723)
      WRITE(8 ,723)
      GO TO 995
  720 FORMAT(/////,
     &1X,'INFLOW RATE (QGPM) EXCEEDS FURROW CAPACITY',/,
     &1X,'INCREASE FURROW SPACING (FWIDE)',//////)
  721 FORMAT(/////,
     &1X,'INFLOW RATE (QGPM) EXCEED MAXIMUM FLOW (40GPM OR 2.517 L/S)'/
     &1X,'REDUCE THE RUN LENGTH',//////)
  722 FORMAT(/////,
     &1X,'INFLOW RATE (QGPM) EXCEEDS MAXIMUM RATE OF NON-ERODIBLE',/,
     &1X,'FLOW RATE, 0.15/SLOPE IN M/M',/,
     &1X,'REDUCE THE RUN LENGTH',//////)
  723 FORMAT(/////,
     &1X,'INFLOW TIME EXCEEDS THE MAXIMUM 2880 MINUTES',/,
     &1X,'REDUCE THE RUN LENGTH',//////)
  990 CONTINUE
      F1I=(AC*T1**BC+0.275)*DUM2
C
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C  CONVERT TO SI UNITS FOR PRINTOUT
C
      QGPMM = 0.063 * QGPM
      F1M = F1 * 25.4
      F1IM = F1I * 25.4
      FXM = FX * 25.4
C
      WRITE(11 ,120) QGPMM,T1,F1M,F1IM,FXM
      WRITE(8 ,120) QGPMM,T1,F1M,F1IM,FXM
  120 FORMAT(/////,
     &//,5X,'THE COMBINATION OF INFLOW RATE (QGDM) AND',/,
     &5X,'INFLOW TIME (TM) ARE NOT LARGE ENOUGH FOR',/,
     &5X,'THE LENGTH (XLNTF) AND INTAKE FAMILY (FAM)',/,
     &/,5X,'INFLOW RATE, L/S',T45,F8.2,/,
     &5X,'INFLOW TIME, MINUTES',T45,F8.2,/,
     @5X,'TOTAL DEPTH OF WATER APPLIED, MM',T45,F8.2,/,
     %5X,'DEPTH OF WATER APPLIED AT FIELD HEAD, MM',T45,F8.2,/,
     &5X,'DEPTH OF WATER APPLIED AT FIELD END, MM',T45,F8.2,/,
     @5X,'INFLOW RATE AND APPLICATION TIME WILL BE INCREASED BY 10 %',//
     &///)
      QGPM=QGPM*1.1
      T1=T1*1.1
      GO TO 730
  995 CONTINUE
C
C  CONVERT DEPTHS TO SI UNITS FOR PASSING TO CALLING PROGRAM
C
980   F1M = F1 * 25.4
      F1IM = F1I * 25.4
      FXLM = FXL * 25.4
      QGDM = QGPM * 0.0631
      TM = T1
C
      RETURN
      END
```

```
          SUBROUTINE INTAKE(NO,F,SNM,NSYS,IPK)
C
C  SUBROUTINE INTAKE FOR INPUT OF COEFFICIENTS FOR INFILTRATION EQN.
C     SNM -- SYSTEM NAME
C     NSYS -- ID NO. OF THE PRESENT SYSTEM
C     IPD -- ID NO OF THE PRESENT PADDOCK
C     NO -- ID NO OF THE INFILTRATION EQUATION FOR WHICH DATA ARE INPUT
C           1 -- KOSTIAKOV-LEWIS
C           2 -- PHILIP
C           3 -- JOBLING
C           4 -- USDA-SCS
C           5 -- USDA-SCS INTAKE FAMILY
C           6 -- MAX SPRINKLER INTAKE RATE (FOR SPRINKLER SYSTEMS ONLY)
C
C  Q1 - Q7 ARE COEFFICIENTS FOR THE FOLLOWING EQN
C
C    Y = Q1*SQRT(T) + Q2*T + Q3*T**Q4 + Q5 + Q6*(1-EXP(-Q7*T))
C        WHERE
C                 Y = DEPTH INFILTRATED (MM)
C                 T = TIME IN MINUTES
C
C
       COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
      1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
      2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
      3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
       CHARACTER*30 SNM, EQNM(6)
       DIMENSION FI(19),AA(19),BB(19)
       DATA EQNM/'KOSTIAKOV-LEWIS','PHILIP','JOBLING','USDA-SCS',
      1'USDA-SCS INTAKE FAMILY','MAX SPRINKLER RATE (MM/HR)'/
       DATA
      1FI/.05,.1,.15,.2,.25,.3,.35,.4,.45,.5,.6,.7,.8,.9,1.,1.5,2.,3.,4./
      2AA/.021,.0244,.0276,.0306,.0336,.0364,.0392,.0419,.0445,.0471,.052
      3,.0568,.0614,.0659,.0703,.0899,.1084,.1437,.175/
      4BB/.618,.661,.6834,.6988,.7107,.7204,.7285,.7356,.7419,.7475,
      5.7572,.7656,.7728,.7792,.785,.799,.808,.816,.823/
C
       Q1=0.
       Q2=0.
       Q3 = 0.
       Q4 = 0.
       Q5 = 0.
       Q6 = 0.
       Q7 = 0.
C
C
       F = 0.
       WRITE(8,100)IPK,NSYS,SNM
100    FORMAT(//' ENTER INTAKE CHARACTERISTICS FOR THE SOIL IN PADDOCK ',
      1I2,/' FOR SYSTEM NO. ',I2,'--',A//
      2' COEFFICIENTS MAY BE ENTERED FOR ONE OF THE FOLLOWING EQUATIONS'
      3/'  A, B AND C ARE COEFFICIENTS'//'  Y = DEPTH INFILTRATED (MM)'/
      4'  T = ELAPSED TIME IN MINUTES'///'  EQN NO.'/
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      5'      1 -- Y = A*T**B + C*T              (KOSTIAKOV-LEWIS)'/
      6'      2 -- Y = A*SQRT(T) + B*T              (PHILIP)'/
      7'      3 -- Y = A*(1.0 - EXP(-B*T)) + C*T  (JOBLING)'/
      8'      4 -- Y = A*T**B + C                  (USDA-SCS)'/
      9'      5 -- SCS INTAKE FAMILY NO.           (USDA-SCS)'/
      A'      6 -- MAX SPRINKLER INTAKE RATE (MM PER HOUR)'/
      B'         NOTE: EQN NO. 6 CAN BE SPECIFIED ONLY FOR'/
      B'              SPRINKLER SYSTEMS'//
      C' ENTER THE NUMBER OF THE EQUATION FOR WHICH'/
      D' VALUES ARE TO BE ENTERED')
C
      READ(7,*) NO
      GO TO (11,12,13,14,15,16), NO
C  KOSTIAKOV-LEWIS EQN
11    WRITE(8,*)' ENTER VALUES FOR A, B AND C IN EQN 1'
      READ(7,*) Q3,Q4,Q2
      WRITE(11,150) IPK, EQNM(NO),Q3,Q4,Q2
150   FORMAT(/' INTAKE CHARACTERISTICS FOR PADDOCK NO. ',I2/
     1' AS INPUT FOR THE FOLLOWING EQUATION.......',A/5X,3F9.4)
      GO TO 40
C  PHILIP EQN
12    WRITE(8,*)' ENTER VALUES FOR A AND B IN EQN 2'
      READ(7,*) Q1,Q2
      WRITE(11,150) IPK,EQNM(NO),Q1,Q2
      GO TO 40
C  JOBLING EQN
13    WRITE(8,*)' ENTER VALUES FOR A, B AND C IN EQN 3'
      READ(7,*) Q6,Q7,Q2
      WRITE(11,150) IPK,EQNM(NO),Q6,Q7,Q2
      GO TO 40
C  USDA-SCS EQN
14    WRITE(8,101)
101   FORMAT(' ENTER VALUES FOR A, B AND C IN EQN 4'/
     1' NOTE:  USDA-SCS ASSUME C = 6.985 (FOR SI UNITS)')
      READ(7,*) Q3,Q4,Q5
      WRITE(11,150) IPK,EQNM(NO), Q3,Q4,Q5
      GO TO 40
C  USDA-SCS INTAKE FAMILY
15    WRITE(8,*)' ENTER USDA-SCS INTAKE FAMILY NO.'
      READ(7,*) F
      WRITE(11,150) IPK,EQNM(NO),F
      GO TO 20
C  MAX SPRINKLER INTAKE RATE
16    WRITE(8,*)' ENTER MAX SPRINKLER INTAKE RATE (MM PER HOUR)'
      READ (7,*) Q2
      Q2 = Q2/60.
      GO TO 40
C
C  ASSIGN PROPER COEFFICIENTS FOR SCS INTAKE FAMILY
20    J = 1
21    IF(F.LE.FI(J)) GO TO 25
      IF (J.EQ.19) GO TO 23
      J= J + 1
      GO TO 21
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23      WRITE(8,102)
102     FORMAT(/' >>> THE MAXIMUM INTAKE FAMILY NO. IS 4 <<<'/
       1'      THEREFORE A VALUE OF 4 IS ASSUMED'/)
        WRITE(11,102)
25      Q3 = AA(J)*25.4
        Q4 = BB(J)
        Q5 = 6.985
C
40      CONTINUE
        RETURN
        END
```

```
      SUBROUTINE FAMFND (DEPTH,FAM)
C
C  SUBROUTINE FAMFND TO FIND THE SCS INTAKE FAMILY AND ASSOCIATED
C  COEFFICIENTS FOR A GIVEN DEPTH INFILTRATED
C      (EQN NO. 4 IN INTAKE SUBROUTINE)
C
C  VARIABLES PASSED
C    DEPTH -- DEPTH INFILTRATED IN MM
C    FAM -- SCS INTAKE FAMILY
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION FI(19),AA(19),BB(19)
      DATA
     1FI/.05,.1,.15,.2,.25,.3,.35,.4,.45,.5,.6,.7,.8,.9,1.,1.5,2.,3.,4./
     2AA/.021,.0244,.0276,.0306,.0336,.0364,.0392,.0419,.0445,.0471,.052
     3,.0568,.0614,.0659,.0703,.0899,.1084,.1437,.175/
     4BB/.618,.661,.6834,.6988,.7107,.7204,.7285,.7356,.7419,.7475,
     5.7572,.7656,.7728,.7792,.785,.799,.808,.816,.823/
C
C
C
      KONT = 0
      GO TO 50
C
C  ENTRY TIMEDPTH TO DETERMINE THE TIME REQUIRED TO INFILTER A GIVEN
C  DEPTH IN MM FOR ANY OF THE EQUATIONS IN SUBROUTINE INTAKE
C
      ENTRY TIMEDPTH (DEPTH,T)
C  VARIABLES PASSED
C  DEPTH -- DEPTH INFILTRATED IN MM
C  T -- TIME IN MINUTES
      KONT = 1
C
C  COMPUTE TIME REQUIRED TO INFILTER THE GIVEN DEPTH
50    YD = DEPTH
      DELT = 20.
      KT = 1
      KON = 0
      DF1 = 1.
      T = 0.
52    KON = KON + 1
      Y = Q1*SQRT(T) + Q2*T + Q5
      IF(Q3.EQ.0.) GO TO 44
      Y = Y + Q3*T**Q4
44    IF(Q6.EQ.0.) GO TO 46
      Y = Y + Q6*(1. - EXP(-Q7*T))
46    DF = Y - YD
      IF (ABS(DF).LE.2.) GO TO 65
      IF(KON.GT.1) GO TO 54
      DF1 = DF
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      IF(DF) 59,65,65
54    PRD = DF * DF1
      DF1 = DF
C
      IF(KON.GT.1000) GO TO 65
      IF(PRD.GT.0.) GO TO 58
      DELT = DELT/2.
56    GO TO (59,60), KZ
58    GO TO (60,59),KZ
C
59    T = T + DELT
      KZ = 2
      GO TO 52
C
60    T = T- DELT
      KZ = 1
      GO TO 52
C
65    IF(T.GT.0.) GO TO 68
      WRITE(8,500)
      WRITE(11,500)
500   FORMAT(//' >>> A NEGATIVE TIME HAS BEEN OBTAINED IN DETERMINING'/
     1'     THE SCS COEFFICIENTS FOR INTAKE RATE'/
     2' >>> THE PROGRAM HAS ABORTED!! <<<'/8X,33('='))
      STOP
68    IF(KONT.GT.0) GO TO 80
C
C   DETERMINE THE PROPER SCS COEFFICIENTS
      Y1 = 1.
      N = 0
      DO 70 I=1,19
      J = I
      Y = 25.4*AA(I)*T**BB(I) + 6.985
      IF(Y.GT.YD) GO TO 72
      Y1 = Y
70    CONTINUE
72    IF(J.EQ.1) GO TO 74
      DIF1 = YD - Y1
      DIF2 = Y - YD
      IF (DIF1.LT.DIF2) J=J-1
74    CONTINUE
      Q1 = 0.
      Q2 = 0.
      Q6 = 0.
      Q7 = 0.
      Q3 = AA(J)*25.4
      Q4 = BB(J)
      Q5 = 6.985
      FAM = FI(J)
80    RETURN
      END
```

```
          SUBROUTINE SPNKLR(SLIFE,SNM,NSYS,ID,J1,NT)
C
C  SUBROUTINE SURFACE FOR COMPUTING COSTS AND EFFICIENCIES OF
C  BORDER AND FURROW IRRIGATION SYSTEMS
C
C  VARIABLES PASSED
C    SLIFE -- SYSTEM LIFE IN YEARS
C    SNM -- SYSTEM NAME
C    NSYS -- SYSTEM ID NO.
C    ID -- SYSTEM TYPE ID NO.
C    J1 -- ARRAY OF NO. OF CROPS IN EACH PADDOCK
C    NT -- ARRAY OF CROP ID NOS. FOR EACH PADDOCK
C
C
       COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
      1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
      2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
      3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
C
       DIMENSION NT(30,20),RN(30),VF(7,2), MAD(30),J1(20)
      1,TMAD(20)
       REAL MAD
C
       CHARACTER*30 SNM,YIN*1,YS*1
C
       YS = 'Y'
C
C  ENTER FLOW RATE ENTERING SYSTEM -- QINN
       WRITE(8,1000) NSYS,SNM
1000   FORMAT(//' THE FOLLOWING INPUTS REFER TO SYSTEM NO. ',I2,' -- '
      1 A//' ENTER THE FOLLOWING 4 ITEMS'/
      1'  1 --  FLOW RATE ENTERING THE SYSTEM (LITERS PER SECOND)'/
      2'         NOTE:  THE FLOW RATE ENTERING THE SYSTEM MUST'/
      3'                CORRESPOND TO THAT SUPPLIED BY THE'/
      4'                WATER SUPPLY SYSTEM'/
      5'  2 -- HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE'
      6//'  3 -- HOURS PER WEEK ADDITIONAL DOWN TIME WHEN WATER'/
      7'         IS AVAILABLE TO THE SYSTEM ----> FOR MOVING FROM'/
      8'         PADDOCK TO PADDOCK, MAINTENANCE ETC.'/
      9'  4 -- DAYS PER WEEK WATER IS AVAILABLE')
       READ(7,*) QINN,HRD,HRW,DWK
       SYST(1) = QINN
       SYST(2) = 100. * (HRD/24.) * (1. - HRW/(DWK*24)) * (DWK/7.)
C
C  WRITE A RECORD OF INPUT DATA ON LU 11
       WRITE(11,1001)NSYS,SNM,QINN,HRD,HRW,SYST(2)
1001   FORMAT(//' INPUT DATA AND RESULTS FOR SYSTEM NO. ',I2,' -- ',A/
      1F10.1,T15,'..LITERS PER SECOND FLOW RATE ENTERING THE SYSTEM'/
      1F11.2,T15,'..HOURS PER DAY SYSTEM OPERATION'/
      3F11.2,T15,'..HOURS PER WEEK DOWN TIME'/
      4F10.1,T15,'..PERCENT OF TIME SYSTEM OPERATES')
C
C  LOOP FOR EACH PADDOCK
                          205
```

```
          DO 20 I=1,NPKSYS(NSYS)
          IPK = IPSYS(I,NSYS)
C
C
C  SORT OUT WHICH CROPS ARE IRRIGATED IN THE PADDOCK
C
C  -- TMAD(IPK) = AVERAGE MAD FOR DRAINAGE COMPUTATIONS
          TMAD(IPK) = 0.
          J1(IPK) = 0
          DO 10 J=1,NCP
          IF(J.EQ.23) GO TO 10
          DO 7 JK = 1,NCRP(IPK)
          JJ = JK
          IF(NINT(CRPDK(IPK,JJ,1)).EQ.J) GO TO 8
          IF (NINT(CRPDK(IPK,JJ,5)).EQ.J) GO TO 9
7         CONTINUE
          GO TO 10
8         J1(IPK) = J1(IPK) + 1
          NT(J1(IPK),IPK) = J
          MAD(J1(IPK)) = CRPDK(IPK,JJ,4) - CRPDK(IPK,JJ,3)
          GO TO 6
9         J1(IPK) = J1(IPK) + 1
          NT(J1(IPK),IPK) = J
          MAD(J1(IPK)) = CRPDK(IPK,JJ,8) - CRPDK(IPK,JJ,7)
6         TMAD(IPK) = TMAD(IPK) + MAD(J1(IPK))
10        CONTINUE
          TMAD(IPK) = TMAD(IPK)/J1(IPK)
20        CONTINUE
C
C
C  CALL PROPER SUBROUTINE TO INPUT SYSTEM SPECIFIC DATA
C
          IDT = ID-2
          GO TO(30,30,30,32,34,36),IDT
30        CALL DISCRETE(SLIFE,SNM,NSYS,J1,NT,DVOL,EFFAVE)
          GO TO 40
32        CALL TRAVELR(SLIFE,SNM,NSYS,J1,NT,DVOL,EFFAVE)
          GO TO 40
34        CALL SELFPROP(SLIFE,SNM,NSYS,J1,NT,DVOL,EFFAVE)
          GO TO 40
36        CALL SOLIDSET(SLIFE,SNM,NSYS,J1,NT,DVOL,EFFAVE)
C
C  ENTER SYSTEM COST DATA
C
40        WRITE(8,104) NSYS,SNM,SLIFE
104       FORMAT(///' ENTER THE FOLLOWING COST INFORMATION FOR '/
         1' SPRINKLER SYSTEM NO. ',I2,' -- ',A/
         2'   NOTE:  DATA FOR MAINLINES, PUMPS, FITTINGS ETC. ARE'/
         3'          ENTERED SEPARATELY'/' ---- 8 ITEMS'/
         4'  1 -- NUMBER OF LINES OR UNITS'/
         5'  2 -- TOTAL CAPITAL COST PER UNIT ($)'/
         6'  3 -- PERCENT OF COST SUBSIDIZED'/
         7'  4 -- PERCENT OF COST FINANCED'/
         8'  5 -- LOAN NO. (1 OR 2)'/
```

```
       9'  6 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
       A'       AS A PERCENT OF THE ORIGINAL COST'/
       B'  7 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
       C'  8 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS'/
       D'        (TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
       READ(7,*) A,B,C,D,E,F,G,H
       IE = NINT(E)
C
       WRITE(11,105) NSYS,SNM,A,B,C,D,IE,F,G,H
105    FORMAT(///' COST DATA FOR SYSTEM NO. ',I2,' -- ',A/
      1F9.0,T15,'..LINES OR UNITS'/
      2' $',F9.2,T15,'..COST PER UNIT'/
      3F10.1,T15,'..PERCENT SUBSIDIZED'/
      4F10.1,T15,'..PERCENT FINANCED UNDER LOAN NO. ',I1/
      5F10.1,T15,'..PERCENT SALVAGE VALUE'/
      6' $',F9.2,T15,'..ANNUAL MAINTENANCE COST'/
      7' $',F9.2,T15,'..ANNUAL MISCELLANEOUS COST')
C
       C = C/100.
       D = D/100.
       F = F/100.
       Z = A*B
       J = 4
       IF(IE.GT.1) J = 13
C
       SYST(J) = SYST(J) + Z
       SYST(J+1) = SYST(J+1) + Z*(1.-(C+D))
       SYST(J+2) = SYST(J+2) + Z * C
       SYST(J+3) = SYST(J+3) + Z * D
       SYST(J+6) = SYST(J+6) + Z * F
       SYST(J+7) = SYST(J+7) + G
       SYST(J+8) = SYST(J+8) + H
C
C
C  INPUT FOR PIPELINES
C
54     WRITE(8,1020) NSYS,SNM
1020   FORMAT(///' ARE DATA TO BE ENTERED FOR MAINLINES OR ANY OTHER'/
      1' PIPELINES FOR SYSTEM NO. ',I2,' -- ',A,' (Y OR N)')
       READ(7,1100) YIN
1100   FORMAT(A)
       IF(YIN.NE.YS) GO TO 60
       WRITE(11,1021) NSYS,SNM
1021   FORMAT(///' PIPELINES FOR SYSTEM NO. ',I2,' -- ',A)
C
       CALL PIPES (SLIFE,VF)
C
C
       DO 58 N=1,2
       J=4
       IF(N.GT.1) J=13
       SYST(J) = SYST(J) + VF(1,N)
       SYST(J+1) = SYST(J+1) + VF(2,N)
```

```
              SYST(J+2) = SYST(J+2) + VF(3,N)
              SYST(J+3) = SYST(J+3) + VF(4,N)
              SYST(J+6) = SYST(J+6) + VF(5,N)
              SYST(J+7) = SYST(J+7) + VF(6,N)
              SYST(J+8) = SYST(J+8) + VF(7,N)
58    CONTINUE
C
C  INPUT FOR PUMPS
C
60    NAPMP(NSYS) = 0
      WRITE(8,1022) NSYS,SNM
1022  FORMAT(/' ARE DATA TO BE INPUT FOR ANY PUMPS'/
     1' FOR SYSTEM NO. ',I2,' -- ',A,'(Y OR N)'/
     2'  NOTE: DO NOT INCLUDE ANY PUMPS SPECIFIED IN THE'/
     3'         WATER SUPPLY ROUTINE!!')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 72
      WRITE(8,1023)
1023  FORMAT(/' ENTER THE NUMBER OF PUMPS AND THE ID NO. OF EACH PUMP')
      READ(7,*) NAPMP(NSYS),(IDXPMA(I,NSYS),I=1,NAPMP(NSYS))
      WRITE(11,1024)NSYS,SNM,NAPMP(NSYS)
1024  FORMAT(//' PUMPS FOR SYSTEM NO. ',I2,' -- ',A/
     1I9,T15,'..NO. OF PUMPS')
      DO 70 I=1,NAPMP(NSYS)
      WRITE(11,1025) IDXPMA(I,NSYS)
1025  FORMAT(/'    PUMP ID NO. ',I2)
      WRITE(8,1026) IDXPMA(I,NSYS)
1026  FORMAT(/' ENTER DATA FOR PUMP ID NO. ',I2)
C
      CALL PUMPS(SLIFE,VF,PWR,QA)
C
      PWRPMP(IDXPMA(I,NSYS)) = PWR
      QPMP(IDXPMA(I,NSYS)) = QA
C
      DO 68 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
68    CONTINUE
70    CONTINUE
C
C  INPUT FOR RACES
C
72    WRITE(8,1016) NSYS,SNM
1016  FORMAT(//' ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES'/
     1' FOR SYSTEM NO. ',I2,' -- ',A,' (Y OR N)')
      READ (7,1100) YIN
      IF(YIN.NE.YS) GO TO 78
```

```
      WRITE(11,1017) NSYS,SNM
1017  FORMAT(///' RACES AND DITCHES FOR SYSTEM NO. ',I2,' -- ',A)
C
      CALL RACES(SLIFE,VF)
C
C
      DO 76 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
76    CONTINUE
C
C  INPUT FOR STRUCTURES
C
78    WRITE(8,1018) NSYS,SNM
1018  FORMAT(/' ARE DATA TO BE ENTERED FOR ANY STRUCTURES'/
     1' FOR SYSTEM NO. ',I2,' -- ',A,' (Y OR N)')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 84
      WRITE(11,1019) NSYS,SNM
1019  FORMAT(///' STRUCTURES FOR SYSTEM NO. ', I2,' -- ',A)
C
      CALL STRUCTS(SLIFE,VF)
C
C
      DO 82 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
82    CONTINUE
C  INPUT FOR LAND PREPARATION
C
84    WRITE(8,10061) NSYS,SNM
10061 FORMAT(/' IS LAND GRADING OR PREPARATION NECESSARY'/
     1' FOR SYSTEM NO. ',I2,' -- ',A,' (Y OR N)')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 86
C
      WRITE(8,10062)
10062 FORMAT(/' ENTER THE FOLLOWING 5 ITEMS FOR LAND PREPARATION'
     2/'   1 -- TOTAL COST OF LAND GRADING   ($)'/
     3'   2 -- PERCENT SUBSIDIZED'/
```

209

```
          4'   3 -- PERCENT FINANCED'/
          5'   4 -- LOAN NUMBER (1 OR 2)'/
          6'   5 -- ANNUAL COST FOR LAND SMOOTHING')
           READ(7,*) CLEV,SUB,FIN,LNO,ALEV
C
           WRITE(11,1007) NSYS,SNM,CLEV,SUB,FIN,LNO,ALEV
1007  FORMAT(///' LAND GRADING FOR SYSTEM NO. ',I2,' -- ',A,
      1// $',F9.2,T15,'..TOTAL COST OF LAND GRADING & BORDERING'/
      1F10.1,T15,'..PERCENT SUBSIDIZED'/
      2F10.1,T15,'..PERCENT FINANCED UNDER LOAN NO. ',I1/
      3' $',F9.2,T15,'..ANNUAL MAINTENANCE COST FOR LAND PREPARATION')
C
C   ADD DATA TO APPROPRIATE ARRAY ELEMENTS FOR SYSTEM SUMMARY FILE
C
           SUB = SUB/100.
           FIN = FIN/100.
           J=4
           IF(LNO.GT.1) J=13
           SYST(J) = SYST(J) + CLEV
           SYST(J+1) = SYST(J+1) + CLEV*(1. - (SUB+FIN))
           SYST(J+2) = SYST(J+2) + CLEV * SUB
           SYST(J+3) = SYST(J+3) + CLEV*FIN
           SYST(J+7) = SYST(J+7) + ALEV
C
C   INPUT DATA FOR SUBSURFACE DRAINAGE
C
86    WRITE(8,1014)
1014  FORMAT(/' IS SUBSURFACE DRAINAGE REQUIRED FOR ANY PADDOCK'
      1'?  (Y OR N)')
           READ(7,1100) YIN
           IF(YIN.NE.YS) GO TO 90
C
87    WRITE(8,*)' ENTER THE PADDOCK ID NO. AND LENGTH OF PADDOCK (M)'
           READ (7,*) IPK,FLEN
           WRITE(11,1015) IPK
1015  FORMAT(///' SUBSURFACE DRAINAGE FOR PADDOCK NO. ',I2)
C
           CALL SDRAIN(FLEN, SLIFE,VF,IPK,DVOL,EFFAVE,TMAD(IPK))
C
C
           DO 88 N=1,2
           J=4
           IF(N.GT.1) J=13
           SYST(J) = SYST(J) + VF(1,N)
           SYST(J+1) = SYST(J+1) + VF(2,N)
           SYST(J+2) = SYST(J+2) + VF(3,N)
           SYST(J+3) = SYST(J+3) + VF(4,N)
           SYST(J+6) = SYST(J+6) + VF(5,N)
           SYST(J+7) = SYST(J+7) + VF(6,N)
           SYST(J+8) = SYST(J+8) + VF(7,N)
88    CONTINUE
           WRITE(8,10151)
10151 FORMAT(// ' ARE DRAINAGE DATA TO BE ENTERED '
      1'FOR ANY MORE PADDOCKS?  (Y OR N)')
```
210

```
          READ (7,1100) YIN
          IF (YIN.EQ.YS) GO TO 87
C
C
C   OTHER EXPENSES
C
90        WRITE(8,1027) NSYS,SNM
1027      FORMAT(//' ENTER DATA FOR OTHER EXPENSES'/
         1' FOR SYSTEM NO. ',I2,' -- ',A)
          WRITE (11,1028) NSYS,SNM
1028      FORMAT(///' OTHER EXPENSES FOR SYSTEM NO. ',I2,' -- ',A)
C
          CALL OEXP (SLIFE,VF)
C
C
          DO 92 N=1,2
          J=4
          IF(N.GT.1) J=13
          SYST(J) = SYST(J) + VF(1,N)
          SYST(J+1) = SYST(J+1) + VF(2,N)
          SYST(J+2) = SYST(J+2) + VF(3,N)
          SYST(J+3) = SYST(J+3) + VF(4,N)
          SYST(J+6) = SYST(J+6) + VF(5,N)
          SYST(J+7) = SYST(J+7) + VF(6,N)
          SYST(J+8) = SYST(J+8) + VF(7,N)
92        CONTINUE
          RETURN
          END
```

```
          SUBROUTINE DISCRETE (SLIFE,SNM,NSYS,J1,NT,DVOL,EFFA)
C
C   SUBROUTINE FOR DISCRETE SET SPRINKLER SYSTEMS ----------
C      HAND-MOVE, SIDE-ROLL, END-TOW
C
C   VARIABLES PASSED--------------------
C      SLIFE -- SYSTEM LIFE (YR)
C
C      SNM -- SYSTEM NAME
C      NSYS -- SYSTEM NO.
C      J1 -- ARRAY OF THE NO OF CROPS IN EACH PADDOCK
C      NT -- ARRAY OF CROP ID NOS. IN EACH PADDOCK
C      DVOL -- PERCENT LOSS TO DEEP PERCOLATION
C      EFFA -- APPLICATION EFFICIENCY
C
          COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
         1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
         2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
         3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
          DIMENSION J1(20),NT(30,20)
          CHARACTER*30 SNM
C
C   INPUT VARIABLES FOR SYSTEM
C
          WRITE(8,100) NSYS,SNM
100   FORMAT(//' ENTER THE FOLLOWING 3 ITEMS FOR'/
         1' SYSTEM NO. ',I2,' -- ',A/
         2'   1 -- DISTANCE LATERAL LINE IS MOVED AT EACH SET (M)'/
         3'   2 -- APPLICATION EFFICIENCY (%)'/
         4'   3 -- PERCENTAGE OF WATER LOST TO EVAPORATION BEFORE'/
         5'        COMING IN CONTACT WITH THE CROP CANOPY')
          READ(7,*) DSET,EFFA,EVAP
C
C   COMPUTE PERCENT LOSS TO DEEP PERCOLATION
          DVOL =  ((1. - EFFA/100.) - EVAP/100.) * 100.
C
          WRITE(11,101) DSET,EFFA,EVAP,DVOL
101   FORMAT(//F10.1,T15,'..M MOVED PER SET'/
         1F10.1,T15,'..PERCENT APPLICATION EFFICIENCY'/
         2F10.1,T15,'..PERCENT LOSS TO EVAPORATION'/
         3F10.1,T15,'..PERCENT LOSS TO DEEP PERCOLATION')
C
C   LABOR INPUTS FOR EACH PADDOCK
C
          DO 20 I=1,NPKSYS(NSYS)
          IPK = IPSYS(I,NSYS)
          WRITE(8,102) IPK
102   FORMAT(/' INPUT THE FOLLOWING 3 ITEMS FOR PADDOCK NO. ',I2/
         1'   1 -- TOTAL DISTANCE THE SPRINKLER LATERAL IS MOVED (M)'/
         1'        (PERPENDICULAR TO LATERAL)'/
         2'   2 -- LABOR REQUIRED PER SET (HR)'/
         3'   3 -- ADDITIONAL LABOR REQUIRED PER IRRIGATION (HR)'/
         4'        (FOR TRANSPORTING LINES, SETTING UP ETC.)')
```

212

```
       READ(7,*) PLEN,STLB,TTLB
C
C    TOTAL LABOR PER IRRIG
C
       TLAB(IPK) = TTLB + STLB * REAL(NINT(PLEN/DSET) )
C
       WRITE(11,103) IPK,PLEN,STLB,TTLB,TLAB(IPK)
103    FORMAT(/' LABOR FOR PADDOCK NO. ',I2/
      1F10.1,T15,'..M TOTAL DISTANCE SPRINKLER IS MOVED'/
      2F11.2,T15,'..HR LABOR PER SET'/
      3F11.2,T15,'..HR ADDITIONAL LABOR PER IRRIGATION'/
      4F11.2,T15,'..HR TOTAL LABOR PER IRRIGATION')
C
C  ASSIGN EFFICIENCY VALUES TO ALL CROPS IN PADDOCK IPK
       DO 15 J=1,J1(IPK)
15     EAPP(NT(J,IPK),IPK) = EFFA
C
20     CONTINUE
C
       RETURN
       END
```

```
          SUBROUTINE TRAVELR (SLIFE,SNM,NSYS,J1,NT,DVOL,EFFA)
C
C  SUBROUTINE FOR TRAVELLING SPRINKLER SYSTEMS ----------
C    HAND-MOVE, SIDE-ROLL, END-TOW
C
C  VARIABLES PASSED--------------------
C    SLIFE -- SYSTEM LIFE (YR)
C
C    SNM -- SYSTEM NAME
C    NSYS -- SYSTEM NO.
C    J1 -- ARRAY OF THE NO OF CROPS IN EACH PADDOCK
C    NT -- ARRAY OF CROP ID NOS. IN EACH PADDOCK
C    DVOL -- PERCENT LOSS TO DEEP PERCOLATION
C    EFFA -- APPLICATION EFFICIENCY
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION J1(20),NT(30,20)
      CHARACTER*30 SNM
C
C  INPUT VARIABLES FOR SYSTEM
C
      WRITE(8,100) NSYS,SNM
100   FORMAT(//' ENTER THE FOLLOWING 3 ITEMS FOR'/
     1' SYSTEM NO. ',I2,' -- ',A/
     2'  1 -- LANE SPACING FOR TRAVELLING SPRINKLER (M)'/
     3'  2 -- APPLICATION EFFICIENCY (%)'/
     4'  3 -- PERCENTAGE OF WATER LOST TO EVAPORATION BEFORE'/
     5'        COMING IN CONTACT WITH THE CROP CANOPY')
      READ(7,*) DSET,EFFA,EVAP
C
C  COMPUTE PERCENT LOSS TO DEEP PERCOLATION
      DVOL =  ((1. - EFFA/100.) - EVAP/100.) * 100.
C
      WRITE(11,101) DSET,EFFA,EVAP,DVOL
101   FORMAT(//F10.1,T15,'..M MOVED PER SET'/
     1F10.1,T15,'..PERCENT APPLICATION EFFICIENCY'/
     2F10.1,T15,'..PERCENT LOSS TO EVAPORATION'/
     3F10.1,T15,'..PERCENT LOSS TO DEEP PERCOLATION')
C
C  LABOR INPUTS FOR EACH PADDOCK
C
      DO 20 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
      WRITE(8,102) IPK
102   FORMAT(/' INPUT THE FOLLOWING 3 ITEMS FOR PADDOCK NO. ',I2/
     1'  1 -- TOTAL DISTANCE ACROSS THE PADDOCK (M)'/
     1'        (PERPENDICULAR TO LANES)'/
     2'  2 -- LABOR REQUIRED PER SET (HR)'/
     3'  3 -- ADDITIONAL LABOR REQUIRED PER IRRIGATION (HR)'/
     4'        (FOR TRANSPORTING LINES, SETTING UP ETC.)')
```

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```
      READ(7,*) PLEN,STLB,TTLB
C
C    TOTAL LABOR PER IRRIG
C
      TLAB(IPK) = TTLB + STLB * REAL(NINT(PLEN/DSET) )
C
      WRITE(11,103) IPK,PLEN,STLB,TTLB,TLAB(IPK)
103   FORMAT(// ' LABOR FOR PADDOCK NO. ',I2/
     1F10.1,T15,'..M TOTAL DISTANCE SPRINKLER IS MOVED'/
     2F11.2,T15,'..HR LABOR PER SET'/
     3F11.2,T15,'..HR ADDITIONAL LABOR PER IRRIGATION'/
     4F11.2,T15,'..HR TOTAL LABOR PER IRRIGATION')
C
C  ASSIGN EFFICIENCY VALUES TO ALL CROPS IN PADDOCK IPK
      DO 15 J=1,J1(IPK)
15    EAPP(NT(J,IPK),IPK) = EFFA
C
20    CONTINUE
C
      RETURN
      END
```

```fortran
      SUBROUTINE SELFPROP (SLIFE,SNM,NSYS,J1,NT,DVOL,EFFA)
C
C   SUBROUTINE FOR SELF PROPELLED SPRINKLER SYSTEMS ----------
C     HAND-MOVE, SIDE-ROLL, END-TOW
C
C   VARIABLES PASSED--------------------
C     SLIFE -- SYSTEM LIFE (YR)
C
C     SNM -- SYSTEM NAME
C     NSYS -- SYSTEM NO.
C     J1 -- ARRAY OF THE NO OF CROPS IN EACH PADDOCK
C     NT -- ARRAY OF CROP ID NOS. IN EACH PADDOCK
C     DVOL -- PERCENT LOSS TO DEEP PERCOLATION
C     EFFA -- APPLICATION EFFICIENCY
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION J1(20),NT(30,20)
      CHARACTER*30 SNM
C
C   INPUT VARIABLES FOR SYSTEM
C
      WRITE(8,100) NSYS,SNM
100   FORMAT(//' ENTER THE FOLLOWING 2 ITEMS FOR'/
     1' SYSTEM NO. ',I2,' -- ',A/
     3'   1 -- APPLICATION EFFICIENCY (%)'/
     4'   2 -- PERCENTAGE OF WATER LOST TO EVAPORATION BEFORE'/
     5'        COMING IN CONTACT WITH THE CROP CANOPY')
      READ(7,*) EFFA,EVAP
C
C   COMPUTE PERCENT LOSS TO DEEP PERCOLATION
      DVOL =  ((1. - EFFA/100.) - EVAP/100.) * 100.
C
      WRITE(11,101) EFFA,EVAP,DVOL
101   FORMAT(//
     1F10.1,T15,'..PERCENT APPLICATION EFFICIENCY'/
     2F10.1,T15,'..PERCENT LOSS TO EVAPORATION'/
     3F10.1,T15,'..PERCENT LOSS TO DEEP PERCOLATION')
C
C   LABOR INPUTS FOR EACH PADDOCK
C
      DO 20 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
      WRITE(8,102) IPK
102   FORMAT(/' INPUT THE FOLLOWING ITEM FOR PADDOCK NO. ',I2/
     3'   ----- LABOR REQUIRED PER IRRIGATION (HR)'/
     4'         (FOR TRANSPORTING LINES, SETTING UP ETC.)')
      READ(7,*) TTLB
C
C     TOTAL LABOR PER IRRIG
C                          216
```

```
         TLAB(IPK) = TTLB
C
         WRITE(11,103) IPK,TLAB(IPK)
103      FORMAT(//' LABOR FOR PADDOCK NO. ',I2/
     4F11.2,T15,'..HR TOTAL LABOR PER IRRIGATION')
C
C  ASSIGN EFFICIENCY VALUES TO ALL CROPS IN PADDOCK IPK
         DO 15 J=1,J1(IPK)
15       EAPP(NT(J,IPK),IPK) = EFFA
C
20       CONTINUE
C
         RETURN
         END
```

```fortran
      SUBROUTINE SOLIDSET (SLIFE,SNM,NSYS,J1,NT,DVOL,EFFA)
C
C  SUBROUTINE FOR SOLID SET SPRINKLER SYSTEMS ----------
C    HAND-MOVE, SIDE-ROLL, END-TOW
C
C  VARIABLES PASSED--------------------
C    SLIFE -- SYSTEM LIFE (YR)
C
C    SNM -- SYSTEM NAME
C    NSYS -- SYSTEM NO.
C    J1 -- ARRAY OF THE NO OF CROPS IN EACH PADDOCK
C    NT -- ARRAY OF CROP ID NOS. IN EACH PADDOCK
C    DVOL -- PERCENT LOSS TO DEEP PERCOLATION
C    EFFA -- APPLICATION EFFICIENCY
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION J1(20),NT(30,20)
      CHARACTER*30 SNM
C
C  INPUT VARIABLES FOR SYSTEM
C
      WRITE(8,100) NSYS,SNM
100   FORMAT(//' ENTER THE FOLLOWING 2 ITEMS FOR'/
     1' SYSTEM NO. ',I2,' -- ',A/
     3'  1 -- APPLICATION EFFICIENCY (%)'/
     4'  2 -- PERCENTAGE OF WATER LOST TO EVAPORATION BEFORE'/
     5'       COMING IN CONTACT WITH THE CROP CANOPY')
      READ(7,*) EFFA,EVAP
C
C  COMPUTE PERCENT LOSS TO DEEP PERCOLATION
      DVOL =  ((1. - EFFA/100.) - EVAP/100.) * 100.
C
      WRITE(11,101) EFFA,EVAP,DVOL
101   FORMAT(//
     1F10.1,T15,'..PERCENT APPLICATION EFFICIENCY'/
     2F10.1,T15,'..PERCENT LOSS TO EVAPORATION'/
     3F10.1,T15,'..PERCENT LOSS TO DEEP PERCOLATION')
C
C  LABOR INPUTS FOR EACH PADDOCK
C
      DO 20 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
      WRITE(8,102) IPK
102   FORMAT(/' INPUT THE FOLLOWING 3 ITEMS FOR PADDOCK NO. ',I2/
     3'  1 -- LABOR REQUIRED PER IRRIGATION (HR)'/
     4'  2 -- LABOR REQUIRED BEFORE & AFTER IRRIGATION SEASON'/
     5'       FOR LAYING OUT AND PICKING UP LINES  (TOTAL HOURS)'/
     6'  3 -- HOURLY RATE FOR THE LABOR OF ITEM NO. 2')
      READ(7,*) TTLB,ANLB,RATE
C
```

```
C     TOTAL LABOR PER IRRIG
C

      TLAB(IPK) = TTLB
C
C  ANNUAL LABOR  --- CONSIDERED AS PART OF MISCELLANEOUS EXPENSE
      SYST(12) = SYST(12) + ANLB*RATE
C

      WRITE(11,103) IPK,TLAB(IPK),ANLB,RATE
103   FORMAT(// ' LABOR FOR PADDOCK NO. ',I2/
     4F11.2,T15,'..HR TOTAL LABOR PER IRRIGATION'/
     5F11.2,T15,'..HR LABOR REQUIRED FOR LAYING PIPES'/
     6' $',F9.2,T15,'..PER HOUR CHARGE FOR PIPE-LAYING LABOR')
C
C  ASSIGN EFFICIENCY VALUES TO ALL CROPS IN PADDOCK IPK
      DO 15 J=1,J1(IPK)
15    EAPP(NT(J,IPK),IPK) = EFFA
C
20    CONTINUE
C
      RETURN
      END
```

```
          SUBROUTINE TRICKLE(SLIFE,SNM,NSYS,ID,J1,NT)
C
C  SUBROUTINE SURFACE FOR COMPUTING COSTS AND EFFICIENCIES OF
C  BORDER AND FURROW IRRIGATION SYSTEMS
C
C  VARIABLES PASSED
C     SLIFE -- SYSTEM LIFE IN YEARS
C     SNM -- SYSTEM NAME
C     NSYS -- SYSTEM ID NO.
C     ID -- SYSTEM TYPE ID NO.
C     J1 -- ARRAY OF NO. OF CROPS IN EACH PADDOCK
C     NT -- ARRAY OF CROP ID NOS. FOR EACH PADDOCK
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
C
      DIMENSION NT(30,20),VF(7,2), MAD(30),J1(20)
     1,TMAD(20)
      REAL MAD
C
      CHARACTER*30 SNM,YIN*1,YS*1
C
      YS = 'Y'
C
C  ENTER FLOW RATE ENTERING SYSTEM -- QINN
      WRITE(8,1000) NSYS,SNM
1000  FORMAT(//' THE FOLLOWING INPUTS REFER TO SYSTEM NO. ',I2,' -- '
     1 A//' ENTER THE FOLLOWING 3 ITEMS'/
     1'   1 --   FLOW RATE ENTERING THE SYSTEM (LITERS PER SECOND)'/
     2'          NOTE:  THE FLOW RATE ENTERING THE SYSTEM MUST'/
     3'                 CORRESPOND TO THAT SUPPLIED BY THE'/
     4'                 WATER SUPPLY SYSTEM'/
     5'   2 -- HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE'/
     6'   3 -- DAYS PER WEEK WATER IS AVAILABLE')
      READ(7,*) QINN,HRD,DWK
      SYST(1) = QINN
      SYST(2) = 100. * (HRD/24.) * (DWK/7.)
C
C  WRITE A RECORD OF INPUT DATA ON LU 11
      WRITE(11,1001)NSYS,SNM,QINN,HRD,HRW,SYST(2)
1001  FORMAT(//' INPUT DATA AND RESULTS FOR SYSTEM NO. ',I2,' -- ',A/
     1F10.1,T15,'..LITERS PER SECOND FLOW RATE ENTERING THE SYSTEM'/
     1F11.2,T15,'..HOURS PER DAY SYSTEM OPERATION'/
     4F10.1,T15,'..PERCENT OF TIME SYSTEM OPERATES')
C
C
C  INPUT VARIABLES FOR SYSTEM
C
      WRITE(8,100) NSYS,SNM
100   FORMAT(//' ENTER THE FOLLOWING 2 ITEMS FOR'/
```

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```
      1' SYSTEM NO. ',I2,' -- ',A/
      3'   1 -- APPLICATION EFFICIENCY (%)'/
      4'   2 -- LABOR REQUIREMENT (HR/DAY)')
      READ(7,*) EFFA,TTLB
C
C  COMPUTE PERCENT LOSS TO DEEP PERCOLATION
C    ASSUME 5% EVAPORATION FROM SOIL SURFACE
      EVAP = 5.
      DVOL =  ((1. - EFFA/100.) - EVAP/100.) * 100.
C
      WRITE(11,101) EFFA,EVAP,DVOL,TTLB
101   FORMAT(//
      1F10.1,T15,'..PERCENT APPLICATION EFFICIENCY'/
      2F10.1,T15,'..PERCENT LOSS TO EVAPORATION  (5% ASSUMED)'/
      3F10.1,T15,'..PERCENT LOSS TO DEEP PERCOLATION'/
      4F11.2,T15,'..HOURS PER DAY LABOR REQUIREMENT')
C
C
C  LOOP FOR EACH PADDOCK
      DO 20 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
C
C
C  SORT OUT WHICH CROPS ARE IRRIGATED IN THE PADDOCK
C
C  -- TMAD(IPK) = AVERAGE MAD FOR DRAINAGE COMPUTATIONS
      TMAD(IPK) = 0.
      J1(IPK) = 0
      DO 10 J=1,NCP
      IF(J.EQ.23) GO TO 10
      DO 7 JK = 1,NCRP(IPK)
      JJ = JK
      IF(NINT(CRPDK(IPK,JJ,1)).EQ.J) GO TO 8
      IF (NINT(CRPDK(IPK,JJ,5)).EQ.J) GO TO 9
7     CONTINUE
      GO TO 10
8     J1(IPK) = J1(IPK) + 1
      NT(J1(IPK),IPK) = J
      MAD(J1(IPK)) = CRPDK(IPK,JJ,4) - CRPDK(IPK,JJ,3)
      GO TO 6
9     J1(IPK) = J1(IPK) +  1
      NT(J1(IPK),IPK) = J
      MAD(J1(IPK)) = CRPDK(IPK,JJ,8) - CRPDK(IPK,JJ,7)
6     TMAD(IPK) = TMAD(IPK) + MAD(J1(IPK))
10    CONTINUE
      TMAD(IPK) = TMAD(IPK) / J1(IPK)
C
C  COMPUTE LABOR REQUIREMENT ON AVERAGE MAD -- TMAD(IPK)
C
      TLAB(IPK) = TTLB*(TMAD(IPK)*AREA(IPK)*10./(QINN*EFFA*86.4))
     1                 *100./SYST(2)
      WRITE(11,1070) TLAB(IPK)
1070  FORMAT(F11.2,T15,'..HOURS PER IRRIGATION LABOR FOR PADDOCK ',I2)
C
                         221
```

```
C
C  ASSIGN EFFICIENCY VALUES TO ALL CROPS IN PADDOCK IPK
       DO 15 J=1,J1(IPK)
15     EAPP(NT(J,IPK),IPK) = EFFA
C
20     CONTINUE
C
C
C
C  ENTER SYSTEM COST DATA
C
40     WRITE(8,104) NSYS,SNM,SLIFE
104    FORMAT(///' ENTER THE FOLLOWING COST INFORMATION FOR '/
      1' TRICKLE SYSTEM NO. ',I2,' -- ',A/
      A'   NOTE: DATA FOR MAINLINES, SUBMAINS, PUMPS, FILTERS'/
      B'            INJECTOR UNITS, ETC. ARE ENTERED SEPARATELY'/
      1' ENTER THE FOLLOWING 10 ITEMS:'/
      2'   1 -- LENGTH OF PIPE (M)'/
      3'   2 -- COST OF PIPE ($/M)'/
      3'   3 -- TOTAL COST OF EMITTERS & FITTINGS ($)'/
      4'   4 -- COST OF LAYING ($/M)'/
      4'        (ENTER 0 (ZERO) FOR ITEMS 3 & 4 IF THE COST IS'/
      4'         INCLUDED IN THE COST OF THE PIPE.)'/
      5'   5 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
      6'        AS A PERCENT OF THE ORIGINAL COST'/
      7'   6 -- PERCENT OF COST SUBSIDIZED'/
      8'   7 -- PERCENT OF COST FINANCED'/
      8'   8 -- LOAN NO. (1 OR 2)'/
      9'   9 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
      A'  10 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
      B'        ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
       READ (7,*) A,B,BB,C,D,E,F,L,G,H
C
C  LIST INPUT DATA
       WRITE(11,1011)  L,A,B,BB,C,D,E,F,G,H
1011   FORMAT(/' DATA FOR TRICKLE LATERALS'/
      1' LOAN NO. ',I1/
      2F10.1,T15,'..METERS LONG'/' $',F9.2,' PER METER COST OF PIPE'/
      2' $',F9.2,T15,'..TOTAL COST OF EMITTERS & FITTINGS'/
      3' $',F9.2,' PER METER COST OF LAYING'/F10.1,T15,'..PERCENT '
      4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
      5F10.1,T15,'..PERCENT FINANCED'/' $',F9.2,T15,'..TOTAL ANNUAL '
      6'MAINTENANCE COST'/' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
       E=E/100.
       D=D/100.
       F = F/100.
       T= A*B + A*C + BB
       J = 4
       IF(L.GT.1) J = 13
C
       SYST(J) = SYST(J) + T
       SYST(J+1) = SYST(J+1) + T*(1.-(E+F))
```

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```
        SYST(J+2) = SYST(J+2) + T*E
        SYST(J+3) = SYST(J+3) + T*F
        SYST(J+6) = SYST(J+6) + T*D
        SYST(J+7) = SYST(J+7) + G
           SYST(J+8) = SYST(J+8) + H
C
      WRITE(8,106)
106   FORMAT(//' ARE DATA TO BE ENTERED FOR MORE'
     1' TRICKLE LATERALS?  (Y OR N)')
      READ(7,1100)YIN
      IF(YIN.EQ.YS) GO TO 40
C
C  INPUT FOR PIPELINES
C
54    WRITE(8,1020) NSYS,SNM
1020  FORMAT(//' ARE DATA TO BE ENTERED FOR MAINLINES, SUBMAINS'/
     1' OR OTHER PIPELINES FOR SYSTEM NO. ',I2,' -- ',A,' (Y OR N)')
      READ(7,1100) YIN
1100  FORMAT(A)
      IF(YIN.NE.YS) GO TO 60
      WRITE(11,1021) NSYS,SNM
1021  FORMAT(//' PIPELINES FOR SYSTEM NO. ',I2,' -- ',A)
C
      CALL PIPES (SLIFE,VF)
C
C
      DO 58 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
58    CONTINUE
C
C  INPUT FOR PUMPS
C
60    NAPMP(NSYS) = 0
      WRITE(8,1022) NSYS,SNM
1022  FORMAT(/' ARE DATA TO BE INPUT FOR ANY PUMPS'/
     1' FOR SYSTEM NO. ',I2,' -- ',A,'(Y OR N)'/
     2'  NOTE: DO NOT INCLUDE ANY PUMPS SPECIFIED IN THE'/
     3'          WATER SUPPLY ROUTINE!!')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 72
      WRITE(8,1023)
1023  FORMAT(/' ENTER THE NUMBER OF PUMPS AND THE ID NO. OF EACH PUMP')
      READ(7,*) NAPMP(NSYS),(IDXPMA(I,NSYS),I=1,NAPMP(NSYS))
      WRITE(11,1024)NSYS,SNM,NAPMP(NSYS)
1024  FORMAT(//' PUMPS FOR SYSTEM NO. ',I2,' -- ',A/
     1I9,T15,'..NO. OF PUMPS')
```

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```
        DO 70 I=1,NAPMP(NSYS)
        WRITE(11,1025) IDXPMA(I,NSYS)
1025    FORMAT(/'    PUMP ID NO. ',I2)
        WRITE(8,1026) IDXPMA(I,NSYS)
1026    FORMAT(/' ENTER DATA FOR PUMP ID NO. ',I2)
C
        CALL PUMPS(SLIFE,VF,PWR,QA)
C
        PWRPMP(IDXPMA(I,NSYS)) = PWR
        QPMP(IDXPMA(I,NSYS)) = QA
C
        DO 68 N=1,2
        J=4
        IF(N.GT.1) J=13
        SYST(J) = SYST(J) + VF(1,N)
        SYST(J+1) = SYST(J+1) + VF(2,N)
        SYST(J+2) = SYST(J+2) + VF(3,N)
        SYST(J+3) = SYST(J+3) + VF(4,N)
        SYST(J+6) = SYST(J+6) + VF(5,N)
        SYST(J+7) = SYST(J+7) + VF(6,N)
        SYST(J+8) = SYST(J+8) + VF(7,N)
68      CONTINUE
70      CONTINUE
C
C   INPUT FOR RACES
C
72      WRITE(8,1016) NSYS,SNM
1016    FORMAT(//' ARE DATA TO BE INPUT FOR ANY RACES OR DITCHES'/
       1' FOR SYSTEM NO. ',I2,' -- ',A,' (Y OR N)')
        READ (7,1100) YIN
        IF(YIN.NE.YS) GO TO 78
        WRITE(11,1017) NSYS,SNM
1017    FORMAT(//' RACES AND DITCHES FOR SYSTEM NO. ',I2,' -- ',A)
C
        CALL RACES(SLIFE,VF)
C
C
        DO 76 N=1,2
        J=4
        IF(N.GT.1) J=13
        SYST(J) = SYST(J) + VF(1,N)
        SYST(J+1) = SYST(J+1) + VF(2,N)
        SYST(J+2) = SYST(J+2) + VF(3,N)
        SYST(J+3) = SYST(J+3) + VF(4,N)
        SYST(J+6) = SYST(J+6) + VF(5,N)
        SYST(J+7) = SYST(J+7) + VF(6,N)
        SYST(J+8) = SYST(J+8) + VF(7,N)
76      CONTINUE
C
C   INPUT FOR STRUCTURES
C
78      WRITE(8,1018) NSYS,SNM
1018    FORMAT(/' ARE DATA TO BE ENTERED FOR ANY STRUCTURES'/
       1' FOR SYSTEM NO. ',I2,' -- ',A,' (Y OR N)')
```

```
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 84
      WRITE(11,1019) NSYS,SNM
1019  FORMAT(//' STRUCTURES FOR SYSTEM NO. ', I2,' -- ',A)
C
      CALL STRUCTS(SLIFE,VF)
C
C
      DO 82 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
82    CONTINUE
C INPUT FOR LAND PREPARATION
C
84    WRITE(8,10061) NSYS,SNM
10061 FORMAT(/' IS LAND GRADING OR PREPARATION NECESSARY'/
     1' FOR SYSTEM NO. ',I2,' -- ',A,' (Y OR N)')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 86
C
      WRITE(8,10062)
10062 FORMAT(/' ENTER THE FOLLOWING 5 ITEMS FOR LAND PREPARATION'
     2/'  1 -- TOTAL COST OF LAND GRADING  ($)'/
     3'  2 -- PERCENT SUBSIDIZED'/
     4'  3 -- PERCENT FINANCED'/
     5'  4 -- LOAN NUMBER (1 OR 2)'/
     6'  5 -- ANNUAL COST FOR LAND SMOOTHING')
      READ(7,*) CLEV,SUB,FIN,LNO,ALEV
C
      WRITE(11,1007) CLEV,SUB,FIN,LNO,ALEV
1007  FORMAT(//' LAND GRADING FOR SYSTEM NO. ',I2,' -- ',A,
     1/' $',F9.2,T15,'..TOTAL COST OF LAND GRADING & BORDERING'/
     1F10.1,T15,'..PERCENT SUBSIDIZED'/
     2F10.1,T15,'..PERCENT FINANCED UNDER LOAN NO. ',I1/
     3' $',F9.2,T15,'..ANNUAL MAINTENANCE COST FOR LAND PREPARATION')
C
C ADD DATA TO APPROPRIATE ARRAY ELEMENTS FOR SYSTEM SUMMARY FILE
C
      SUB = SUB/100.
      FIN = FIN/100.
      J=4
      IF(LNO.GT.1) J=13
      SYST(J) = SYST(J) + CLEV
      SYST(J+1) = SYST(J+1) + CLEV*(1. - (SUB+FIN))
      SYST(J+2) = SYST(J+2) + CLEV * SUB
      SYST(J+3) = SYST(J+3) + CLEV*FIN
      SYST(J+7) = SYST(J+7) + ALEV
```

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```
C
C   INPUT DATA FOR SUBSURFACE DRAINAGE
C
86    WRITE(8,1014)
1014  FORMAT(//' IS SUBSURFACE DRAINAGE REQUIRED FOR ANY PADDOCK'
     1'?   (Y OR N)')
      READ(7,1100) YIN
      IF(YIN.NE.YS) GO TO 90
C
87    WRITE(8,*)' ENTER THE PADDOCK ID NO. AND LENGTH OF PADDOCK (M)'
      READ (7,*) IPK,FLEN
      WRITE(11,1015) IPK
1015  FORMAT(///' SUBSURFACE DRAINAGE FOR PADDOCK NO. ',I2)
C
      CALL SDRAIN(FLEN, SLIFE,VF,IPK,DVOL,EFFA,TMAD(IPK))
C
C
      DO 88 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
88    CONTINUE
      WRITE(8,10151)
10151 FORMAT(/' ARE DRAINAGE DATA TO BE ENTERED '
     1'FOR ANY MORE PADDOCKS?   (Y OR N)')
      READ (7,1100) YIN
      IF (YIN.EQ.YS) GO TO 87
C
C
C   OTHER EXPENSES
C
90    WRITE(8,1027) NSYS,SNM
1027  FORMAT(/' ENTER DATA FOR OTHER EXPENSES'/
     1' FOR SYSTEM NO. ',I2,' -- ',A/
     2' FOR COMPONENTS SUCH AS FERTILIZER & CHEMICAL INJECTION'/
     3' EQUIPMENT, FILTERS ETC. FOR WHICH DATA HAVE NOT YET'/
     4' BEEN ENTERED')
      WRITE (11,1028) NSYS,SNM
1028  FORMAT(//' OTHER EXPENSES FOR SYSTEM NO. ',I2,' -- ',A)
C
      CALL OEXP (SLIFE,VF)
C
C
      DO 92 N=1,2
      J=4
      IF(N.GT.1) J=13
      SYST(J) = SYST(J) + VF(1,N)
      SYST(J+1) = SYST(J+1) + VF(2,N)
```

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      SYST(J+2) = SYST(J+2) + VF(3,N)
      SYST(J+3) = SYST(J+3) + VF(4,N)
      SYST(J+6) = SYST(J+6) + VF(5,N)
      SYST(J+7) = SYST(J+7) + VF(6,N)
      SYST(J+8) = SYST(J+8) + VF(7,N)
   92 CONTINUE
      RETURN
      END
```

```
          SUBROUTINE RACES (SL,V)
C
C  SUBROUTINE RACES FOR INPUT OF INFORMATION FOR IRRIGATION RACES
C
C     VARIABLES PASSED
C     ---SL -- SYSTEM LIFE IN YEARS
C        V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C           V(I,J)
C           J = 1 OR 2 (LOAN NO.)
C           I = 1 -- TOTAL CAPITAL COST $
C               2 -- CAPITAL NOT FINANCED $
C               3 -- CAPITAL SUBSIDIZED $
C               4 -- CAPITAL FINANCED $
C               5 -- SALVAGE VALUE $
C               6 -- TOTAL ANNUAL MAINTENANCE COST $
C               7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                      --TAXES, INSURANCE, CONTINGENCIES, ETC.
C
C
       COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
      1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
      2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
      3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
       DIMENSION V(7,2)
       CHARACTER*1 Y,YS
       YS = 'Y'
       IL = NINT(SL)
C
C  CLEAR V-ARRAY
       DO 10 J=1,2
       DO 10 I=1,7
10     V(I,J) = 0.
C
C  ENTER DATA FOR LOAN NO. 1
       I=1
       WRITE (8,99)
99     FORMAT(/' ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)'//
      1' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
      2'          AND INDICATE 0 AMOUNT FINANCED WHEN ASKED'//
      3'  -- DATA FOR MORE THAN ONE RACE OR DITCH CAN BE'/
      4'     ENTERED FOR BOTH LOANS 1 AND 2')
       READ (7,200)Y
       IF (Y.NE.YS) GO TO 40
200    FORMAT(A)
20     WRITE(8,100) I,IL
100    FORMAT(/' DATA FOR RACE OR DITCH'/
      1' (LOAN NO. ',I1,')'/
      1' ENTER THE FOLLOWING EIGHT ITEMS:'/
      2'   1 -- LENGTH OF RACE (M)'/
      3'   2 -- COST OF RACE ($/M)'/
      4'   3 -- COST OF LINING ($/M) -- (ENTER 0 IF NOT APPLICABLE)'/
      5'   4 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
      6'        AS A PERCENT OF THE ORIGINAL COST'/
```

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```
       7'   5 -- PERCENT OF COST SUBSIDIZED'/
       8'   6 -- PERCENT OF COST FINANCED'/
       9'   7 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
       A'   8 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
       B'        ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
       READ (7,*) A,B,C,D,E,F,G,H
C
C  LIST INPUT DATA
       WRITE(11,101)  I,A,B,C,D,E,F,G,H
101    FORMAT(/' DATA FOR A RACE OR DITCH'/
      1' LOAN NO. ',I1/
      2F10.1,T15,'..METERS LONG'/' $',F9.2,' PER METER COST OF RACE'/
      3' $',F9.2,' PER METER COST OF LINING'/F10.1,T15,'..PERCENT '
      4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
      5F10.1,T15,'..PERCENT FINANCED'/' $',F9.2,T15,'..TOTAL ANNUAL '
      6'MAINTENANCE COST'/' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
       E=E/100.
       D=D/100.
       F = F/100.
       T= A*B + A*C
       V(1,I) = V(1,I) + T
       V(2,I) = V(2,I) + T*(1.-(E+F))
       V(3,I) = V(3,I) + T*E
       V(4,I) = V(4,I) + T*F
       V(5,I) = V(5,I) + D*T
       V(6,I) = V(6,I) + G
       V(7,I) = V(7,I) + H
C
       IF(I.EQ.2) GO TO 45
C  CHECK IF ANY MORE FOR LOAN NO. 1
       WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
       READ(7,200) Y
       IF(Y.EQ.YS) GO TO 20
40     I = 2
       WRITE(8,*)' ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)'
       READ (7,200) Y
       IF (Y.EQ.YS) GO TO 20
       GO TO 50
45     WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
       READ(7,200) Y
       IF (Y.EQ.YS) GO TO 20
50     RETURN
       END
```

```
          SUBROUTINE STRUCTS (SL,V)
C
C  SUBROUTINE STRUCTS FOR INPUT OF INFORMATION FOR IRRIGATION STRUCTURES
C
C     VARIABLES PASSED
C     ---SL -- SYSTEM LIFE IN YEARS
C        V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C            V(I,J)
C            J = 1 OR 2 (LOAN NO.)
C            I = 1 -- TOTAL CAPITAL COST $
C                2 -- CAPITAL NOT FINANCED $
C                3 -- CAPITAL SUBSIDIZED $
C                4 -- CAPITAL FINANCED $
C                5 -- SALVAGE VALUE $
C                6 -- TOTAL ANNUAL MAINTENANCE COST $
C                7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                     --TAXES, INSURANCE, CONTINGENCIES, ETC.
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION V(7,2)
      CHARACTER*1 Y,YS
      YS = 'Y'
      IL = NINT(SL)
C
C  CLEAR V-ARRAY
      DO 10 J=1,2
      DO 10 I=1,7
10    V(I,J) = 0.
C
C  ENTER DATA FOR LOAN NO. 1
      I=1
      WRITE (8,99)
99    FORMAT(/' ARE ANY STRUCTURES FINANCED BY LOAN NO. 1? (Y OR N)'//
     1' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
     2'          AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED'///
     3' --MORE THAN ONE TYPE OF STRUCTURE CAN BE ENTERED'/
     4'    FOR BOTH LOANS 1 AND 2')
      READ (7,200)Y
      IF (Y.NE.YS) GO TO 40
200   FORMAT(A)
20    WRITE(8,100) I,IL
100   FORMAT(/' DATA FOR STRUCTURES'/
     1' (LOAN NO. ',I1,')'/
     1' ENTER THE FOLLOWING SEVEN ITEMS:'/
     2'   1 -- NUMBER OF STRUCTURES'/
     3'   2 -- COST PER STRUCTURE ($)'/
     5'   3 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
     6'        AS A PERCENT OF THE ORIGINAL COST'/
     7'   4 -- PERCENT OF COST SUBSIDIZED'/
```

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        8'   5 -- PERCENT OF COST FINANCED'/
        9'   6 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
        A'   7 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
        B'        ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
       READ (7,*) A,B,D,E,F,G,H
C
C  LIST INPUT DATA
       WRITE(11,101)  I,A,B,D,E,F,G,H
101    FORMAT(/' DATA FOR IRRIGATION STRUCTURES'/
      1' LOAN NO. ',I1/
      2F10.1,T15,'..NO. OF STRUCTURES'/' $',F9.2,' PER STRUCTURE'/
      3F10.1,T15,'..PERCENT '
      4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
      5F10.1,T15,'..PERCENT FINANCED'/' $',F9.2,T15,'..TOTAL ANNUAL '
      6'MAINTENANCE COST'/' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
       E=E/100.
       D=D/100.
       F = F/100.
       T= A*B
       V(1,I) = V(1,I) + T
       V(2,I) = V(2,I) + T*(1.-(E+F))
       V(3,I) = V(3,I) + T*E
       V(4,I) = V(4,I) + T*F
       V(5,I) = V(5,I) + D*T
       V(6,I) = V(6,I) + G
       V(7,I) = V(7,I) + H
C
       IF(I.EQ.2) GO TO 45
C  CHECK IF ANY MORE FOR LOAN NO. 1
       WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
       READ(7,200) Y
       IF(Y.EQ.YS) GO TO 20
40     I = 2
       WRITE(8,*)' ARE THE STRUCTURES FINANCED BY LOAN NO. 2? (Y OR N)'
       READ (7,200) Y
       IF (Y.EQ.YS) GO TO 20
       GO TO 50
45     WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
       READ(7,200) Y
       IF (Y.EQ.YS) GO TO 20
50     RETURN
       END
```

```
      SUBROUTINE PIPES(SL,V)
C
C  SUBROUTINE PIPES FOR INPUT OF INFORMATION FOR IRRIGATION PIPES
C
C     VARIABLES PASSED
C     ---SL -- SYSTEM LIFE IN YEARS
C        V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C           V(I,J)
C           J = 1 OR 2 (LOAN NO.)
C           I = 1 -- TOTAL CAPITAL COST $
C               2 -- CAPITAL NOT FINANCED $
C               3 -- CAPITAL SUBSIDIZED $
C               4 -- CAPITAL FINANCED $
C               5 -- SALVAGE VALUE $
C               6 -- TOTAL ANNUAL MAINTENANCE COST $
C               7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                     --TAXES, INSURANCE, CONTINGENCIES, ETC.
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION V(7,2)
      CHARACTER*1 Y,YS
      YS = 'Y'
      IL = NINT(SL)
C
C  CLEAR V-ARRAY
      DO 10 J=1,2
      DO 10 I=1,7
10    V(I,J) = 0.
C
C  ENTER DATA FOR LOAN NO. 1
      I=1
      WRITE (8,99)
99    FORMAT(/' ARE ANY ITEMS FINANCED BY LOAN NO. 1? (Y OR N)'//
     1' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
     2'         AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED'//
     3'   ---DATA FOR MORE THAN ONE PIPELINE CAN BE ENTERED FOR '/
     4'       BOTH LOANS 1 AND 2')
      READ (7,200)Y
      IF (Y.NE.YS) GO TO 40
200   FORMAT(A)
20    WRITE(8,100) I,IL
100   FORMAT(/' DATA FOR PIPES --'
     1' (LOAN NO. ',I1,')'/
     1' ENTER THE FOLLOWING NINE ITEMS:'/
     2'   1 -- LENGTH OF PIPE (M)'/
     3'   2 -- COST OF PIPE ($/M)'/
     3'   3 -- TOTAL COST OF FITTINGS ($)'/
     4'   4 -- COST OF LAYING ($/M)'/
     4'       (ENTER 0 (ZERO) FOR ITEMS 3 & 4 IF THE COST IS'/
```

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```
      4'         INCLUDED IN THE COST OF THE PIPE.)'/
      5'    5 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
      6'         AS A PERCENT OF THE ORIGINAL COST'/
      7'    6 -- PERCENT OF COST SUBSIDIZED'/
      8'    7 -- PERCENT OF COST FINANCED'/
      9'    8 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
      A'    9 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
      B'         ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
      READ (7,*) A,B,BB,C,D,E,F,G,H
C
C  LIST INPUT DATA
      WRITE(11,101)  I,A,B,BB,C,D,E,F,G,H
101   FORMAT(//' DATA FOR A PIPE'/
      1' LOAN NO. ',I1/
      2F10.1,T15,'..METERS LONG'/' $',F9.2,' PER METER COST OF PIPE'/
      2' $',F9.2,T15,'..TOTAL COST OF FITTINGS'/
      3' $',F9.2,' PER METER COST OF LAYING'/F10.1,T15,'..PERCENT '
      4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
      5F10.1,T15,'..PERCENT FINANCED'/' $',F9.2,T15,'..TOTAL ANNUAL '
      6'MAINTENANCE COST'/' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
      E=E/100.
      D=D/100.
      F = F/100.
      T= A*B + A*C + BB
      V(1,I) = V(1,I) + T
      V(2,I) = V(2,I) + T*(1.-(E+F))
      V(3,I) = V(3,I) + T*E
      V(4,I) = V(4,I) + T*F
      V(5,I) = V(5,I) + D*T
      V(6,I) = V(6,I) + G
      V(7,I) = V(7,I) + H
C
      IF(I.EQ.2) GO TO 45
C  CHECK IF ANY MORE FOR LOAN NO. 1
      WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
      READ(7,200) Y
      IF(Y.EQ.YS) GO TO 20
40    I = 2
      WRITE(8,*)' ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)'
      READ (7,200) Y
      IF (Y.EQ.YS) GO TO 20
      GO TO 50
45    WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
      READ(7,200) Y
      IF (Y.EQ.YS) GO TO 20
50    RETURN
      END
```

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```
          SUBROUTINE PUMPS (SL,V,PWR,QA)
C
C   SUBROUTINE PUMPS FOR INPUT OF INFORMATION FOR IRRIGATION PUMPS
C   NOTE:   THIS SUBROUTINE IS ONLY FOR ELECTRIC POWERED PUMPS
C
C      VARIABLES PASSED
C      ---SL -- SYSTEM LIFE IN YEARS
C         V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C             V(I,J)
C             J = 1 OR 2 (LOAN NO.)
C             I = 1 -- TOTAL CAPITAL COST $
C                   2 -- CAPITAL NOT FINANCED $
C                   3 -- CAPITAL SUBSIDIZED $
C                   4 -- CAPITAL FINANCED $
C                   5 -- SALVAGE VALUE $
C                   6 -- TOTAL ANNUAL MAINTENANCE COST $
C                   7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                         --TAXES, INSURANCE, CONTINGENCIES, ETC.
C         PWR -- POWER INPUT TO PUMP MOTOR (KW)
C         A -- FLOW RATE PUMPED (L/S)
C
C
          COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
         1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
         2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
         3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
          DIMENSION V(7,2)
          CHARACTER*1 Y,YS,TT*20
          YS = 'Y'
          IL = NINT(SL)
C
C
          WRITE(8,105)
105       FORMAT(//' ENTER THE FOLLOWING SIX ITEMS'/
         1'   1 -- FLOW RATE PUMPED (L/S)'/
         2'   2 -- DISCHARGE PRESSURE (KPA)'/
         3'   3 -- INLET PRESSURE (KPA)'/
         4'        (ENTER 0 (ZERO) IF PUMPING FROM A SUMP OR WELL)'/
         5'   4 -- VERTICAL PUMPING LIFT (M)'/
         6'   5 -- PUMP EFFICIENCY (%)'/
         7'        NOTE:  A CONSERVATIVE VALUE FOR PUMP EFFICIENCY SHOULD '/
         8'               BE USED AS IT APPLES OVER THE LIFE OF THE SYSTEM'/
         9'   6 -- MOTOR EFFICIENCY (%)'/
         A'        NOTE:  THE EFFICIENCY OF MOST LARGE ELECTRIC MOTORS'/
         B'               VARIES BETWEEN 90 AND 95 PERCENT')
C
          READ (7,*) QA,B,C,D,E,F
C
C   LIST INPUT DATA
          WRITE (11,106) QA,B,C,D,E,F
106       FORMAT(/F10.1,T15,'..LITERS PER SECOND PUMPED'/
         1F10.1,T15,'..KPA DISCHARGE PRESSURE'/
         2F10.1,T15,'..KPA INLET PRESSURE'/
```

```
        3F11.2,T15,'..METERS VERTICAL LIFT'/
        4F10.1,T15,'..PERCENT PUMP EFFICIENCY'/
        5F10.1,T15,'..PERCENT MOTOR EFFICIENCY')
C
        TDH = ((B-C)/9.81) + D
        PWR = TDH * QA/(102. * E * F/10000.)
C
        WRITE(11,107) PWR
107     FORMAT(F11.2,T15,'..KILOWATTS POWER INPUT')
C
C  CLEAR V-ARRAY
        DO 10 J=1,2
        DO 10 I=1,7
10      V(I,J) = 0.
C
C  ENTER DATA FOR LOAN NO. 1
        I=1
        WRITE (8,99)
99      FORMAT(/' ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)'//
       1' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
       2'         AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED'///
       3' --MORE THAN ONE ITEM CAN BE ENTERED'/
       4'    FOR BOTH LOANS 1 AND 2'//
       5' --DATA FOR ALL ITEMS ASSOCIATED WITH THE PUMP SHOULD BE'/
       6'    ENTERED INCLUDING THE WELL OR SUMP, PIPE FITTINGS AND'/
       7'    VALVES, PUMP HOUSE, ELECTRICAL CONTROLS, POWER'/
       8'    RETICULATION, ETC.')
        READ (7,200)Y
        IF (Y.NE.YS) GO TO 40
200     FORMAT(A)
20      WRITE(8,108)
108     FORMAT(/' ENTER THE NAME OF THE ITEM FOR WHICH'/
       1' DATA ARE BEING ENTERED  (<20 CHARACTERS)')
        READ(7,200)TT
        WRITE(8,100) I,IL
100     FORMAT(/' DATA FOR ITEMS'/
       1' (LOAN NO. ',I1,')'/
       2' ENTER THE FOLLOWING SIX ITEMS:'/
       3'   1 -- COST ($)'/
       4'   2 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
       5'        AS A PERCENT OF THE ORIGINAL COST'/
       6'   3 -- PERCENT OF COST SUBSIDIZED'/
       7'   4 -- PERCENT OF COST FINANCED'/
       8'   5 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
       9'        (SUGGESTED VALUE FOR PUMPS IS 3 TO 5 %'/
       9'         OF THE ORIGINAL COST)'/
       A'   6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
       B'        ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
        READ (7,*) A,D,E,F,G,H
C
C  LIST INPUT DATA
        WRITE(11,101)  TT,I,A,D,E,F,G,H
101     FORMAT(/' DATA FOR ',A/
```

```
      1' LOAN NO. ',I1/
      2' $',F9.2,' COST'/
      3F10.1,T15,'..PERCENT '
      4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
      5F10.1,T15,'..PERCENT FINANCED'//' $',F9.2,T15,'..TOTAL ANNUAL '
      6'MAINTENANCE COST'//' $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C

      E=E/100.
      D=D/100.
      F = F/100.
      T= A
      V(1,I) = V(1,I) + T
      V(2,I) = V(2,I) + T*(1.-(E+F))
      V(3,I) = V(3,I) + T*E
      V(4,I) = V(4,I) + T*F
      V(5,I) = V(5,I) + D*T
      V(6,I) = V(6,I) + G
      V(7,I) = V(7,I) + H
C

      IF(I.EQ.2) GO TO 45
C  CHECK IF ANY MORE FOR LOAN NO. 1
      WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
      READ(7,200) Y
      IF(Y.EQ.YS) GO TO 20
40    I = 2
      WRITE(8,*)' ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)'
      READ (7,200) Y
      IF (Y.EQ.YS) GO TO 20
      GO TO 50
45    WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
      READ(7,200) Y
      IF (Y.EQ.YS) GO TO 20
50    RETURN
      END
```

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```
          SUBROUTINE OEXP (SL,V)
C
C   SUBROUTINE OEXP FOR INPUT OF INFORMATION FOR OTHER EXPENSES
C
C      VARIABLES PASSED
C      ---SL -- SYSTEM LIFE IN YEARS
C         V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C             V(I,J)
C             J = 1 OR 2 (LOAN NO.)
C             I = 1 -- TOTAL CAPITAL COST $
C                   2 -- CAPITAL NOT FINANCED $
C                   3 -- CAPITAL SUBSIDIZED $
C                   4 -- CAPITAL FINANCED $
C                   5 -- SALVAGE VALUE $
C                   6 -- TOTAL ANNUAL MAINTENANCE COST $
C                   7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                       --TAXES, INSURANCE, CONTINGENCIES, ETC.
C
C
          COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
      1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
      2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
      3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
          DIMENSION V(7,2)
          CHARACTER*1 Y,YS,TT*20
          YS = 'Y'
          IL = NINT(SL)
C
C
C  CLEAR V-ARRAY
          DO 10 J=1,2
          DO 10 I=1,7
10        V(I,J) = 0.
C
C  ENTER DATA FOR LOAN NO. 1
          I=1
          WRITE (8,99)
99        FORMAT(/' ARE ANY ITEMS FINANCED BY LOAN NO. 1?  (Y OR N)'/
      1/' NOTE:  IF NONE OF THE COST IS FINANCED ANSWER Y'/
      2'          AND INDICATE 0 (ZERO) AMOUNT FINANCED WHEN ASKED'///
      3' --MORE THAN ONE ITEM CAN BE ENTERED'/
      4'    FOR BOTH LOANS 1 AND 2'//
      5' --DATA FOR ALL ITEMS DIRECTLY ASSOCIATED WITH THE'/
      6'    SYSTEM CAN BE ENTERED INCLUDING COSTS ASSOCIATED'/
      7'    WITH FENCING, SHELTER BELTS, FARM ACCESS (BRIDGES & ROADS)'/
      8/' --FOR ANNUAL VALUE OF CROP LOST DUE TO SYSTEM OPERATION'/
      9'    SUCH AS NON-IRRIGATED AREAS OF PADDOCKS, '/
      9'    DAMAGE FROM DRAG HOSE, TRACTORS, ETC., ENTER'/
      A'    A COST ONLY FOR TOTAL MISCELLANEOUS ITEMS.')
          READ (7,200)Y
          IF (Y.NE.YS) GO TO 40
200       FORMAT(A)
20        WRITE(8,108)
108       FORMAT(//' ENTER THE NAME OF THE ITEM FOR WHICH'/
```

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```
      1' DATA ARE BEING ENTERED  (<20 CHARACTERS)')
      READ(7,200)TT
      WRITE(8,100) I,IL
100   FORMAT(//' DATA FOR ITEMS'/
     1' (LOAN NO. ',I1,')'/
     2' ENTER THE FOLLOWING SIX ITEMS!'/
     3'   1 -- COST ($)'/
     4'   2 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
     5'         AS A PERCENT OF THE ORIGINAL COST'/
     6'   3 -- PERCENT OF COST SUBSIDIZED'/
     7'   4 -- PERCENT OF COST FINANCED'/
     8'   5 -- TOTAL ANNUAL MAINTENANCE COST ($)'/
     A'   6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
     B'         ( TAXES, INSURANCE, CONTINGENCIES ETC.)')
C
      READ (7,*) A,D,E,F,G,H
C
C  LIST INPUT DATA
      WRITE(11,101)  TT,I,A,D,E,F,G,H
101   FORMAT(//' DATA FOR ',A/
     1' LOAN NO. ',I1/
     2' $',F9.2,' COST'/
     3F10.1,T15,'..PERCENT '
     4'SALVAGE VALUE'/F10.1,T15,'..PERCENT SUBSIDIZED'/
     5F10.1,T15,'..PERCENT FINANCED'// $',F9.2,T15,'..TOTAL ANNUAL '
     6'MAINTENANCE COST'// $',F9.2,T15,'..TOTAL ANNUAL MISC. COST')
C
      E=E/100.
      D=D/100.
      F = F/100.
      T= A
      V(1,I) = V(1,I) + T
      V(2,I) = V(2,I) + T*(1.-(E+F))
      V(3,I) = V(3,I) + T*E
      V(4,I) = V(4,I) + T*F
      V(5,I) = V(5,I) + D*T
      V(6,I) = V(6,I) + G
      V(7,I) = V(7,I) + H
C
      IF(I.EQ.2) GO TO 45
C  CHECK IF ANY MORE FOR LOAN NO. 1
      WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 1? (Y OR N)'
      READ(7,200) Y
      IF(Y.EQ.YS) GO TO 20
40    I = 2
      WRITE(8,*)' ARE ANY ITEMS FINANCED BY LOAN NO. 2? (Y OR N)'
      READ (7,200) Y
      IF (Y.EQ.YS) GO TO 20
      GO TO 50
45    WRITE(8,*)' ARE THERE ANY MORE DATA FOR LOAN NO 2? (Y OR N)'
      READ(7,200) Y
      IF (Y.EQ.YS) GO TO 20
50    RETURN
      END
```

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```
              SUBROUTINE SDRAIN (FLEN,SLIFE,V,IPK,DVOL,EFFA,MAD)
C
C     SUBROUTINE SDRAIN FOR ESTIMATING COSTS OF SUBSURFACE DRAINAGE
C     WRITTEN BY G.D. GALINATO, UNIV OF IDAHO, MOSCOW, IDAHO  USA
C     MODIFIED BY J.R. BUSCH, WINCHMORE   JUNE,1982
C
C     ALL COMPUTATIONS IN THE ORIGINAL ROUTINE ARE IN ENGLISH UNITS
C     THEREFORE, ALL PASSED VARIABLES AND INPUTS IN SI UNITS ARE
C     CONVERTED BEFORE AND AFTER MAIN COMPUTATIONS
C
C
C     VARIABLES PASSED-----------
C       FLEN -- FIELD LENGTH (M)
C       SLIFE -- SYSTEM LIFE IN YEARS
C       V -- 2-D ARRAY OF VARIABLES PASSED FOR 2 POSSIBLE LOAN RATES
C             V(I,J)
C                 J = 1 OR 2 (LOAN NO.)
C                 I = 1 -- TOTAL CAPITAL COST $
C                     2 -- CAPITAL NOT FINANCED $
C                     3 -- CAPITAL SUBSIDIZED $
C                     4 -- CAPITAL FINANCED $
C                     5 -- SALVAGE VALUE $
C                     6 -- TOTAL ANNUAL MAINTENANCE COST $
C                     7 -- TOTAL ANNUAL MISCELLANEOUS EXPENSE $
C                          --TAXES, INSURANCE, CONTINGENCIES, ETC.
C       IPK -- PADDOCK ID NO.
C       DVOL -- PERCENT LOSS TO DEEP PERCOLATION
C       EFFA -- PERCENT APPLICATION EFFICIENCY
C       MAD -- NET IRRIGATION APPLICATION
C
C
      COMMON  IDCP(30),AREA(20),NCRP(20),CRPDK(20,30,8),KSEL(20),
     1NPKSYS(20),IDS(20),IPSYS(20,20),NCP,TLAB(20),
     2SYST(30),SYSVAL(21,20),NAPMP(30),IDXPMA(30,20),PWRPMP(30),
     3EAPP(30,20),Q1,Q2,Q3,Q4,Q5,Q6,Q7,QPMP(30)
C
      DIMENSION V(7,2), QP(10)
      REAL MAD
46    FORMAT(/' ENTER THE FOLLOWING DATA FOR SUBSURFACE DRAINAGE'/
     1' ---2 ITEMS'/
     2'          1 -- ESTIMATED TIME BETWEEN IRRIGATIONS (DAYS)'/
     3'          2 -- ROOT ZONE DEPTH IN MM')
48 FORMAT(/,' ENTER THE FOLLOWING SUB SURFACE DRAINAGE DATA:'/
     '' ---5 ITEMS'/
     '' 1-DRAIN DEPTH, M'/
     '' 2-DISTANCE BETWEEN DRAIN AND LOWER BARRIER, M'/
     '' 3-PERMEABILITY BETWEEN ROOT ZONE AND BARRIER, M/DAY'/
     '' 4-MAX. PERMISSIBLE WATER TABLE HEIGHT ABOVE DRAIN, M'/
     '' 5-SLOPE OF LATERAL DRAIN, M/M')
50 FORMAT(/,' ENTER VALUES FOR THE COST OF DRAIN PIPES, $/M'/
     '' ==> THIS VALUE INCLUDES THE COST OF LAYING'/16X,8('=')/
     '' 1-- 100-MM PIPE'/
     '' 2-- 150-MM PIPE'/
     '' 3-- 200-MM PIPE')
```

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   52 FORMAT(/,' ENTER THE FOLLOWING 4 ITEMS'/
     '' 1-UNIT COST OF EXCAVATION, $/CUBIC M'/
     '' 2-UNIT COST OF BACKFILL, $/CUBIC M'/
     '' 3-UNIT COST OF GRAVEL ENVELOP, $/M DRAIN LENGTH'/
     '' 4-CONTINGENCY COST, PERCENT'/)
   54    FORMAT (/' ENTER THE FOLLOWING 6 ITEMS'/
     1'  1 -- PERCENT OF COST SUBSIDIZED'/
     2'  2 -- PERCENT OF COST FINANCED'/
     3'  3 -- LOAN NO. (1 OR 2)'/
     4'  4 -- COST OF MAINTENANCE AS A PERCENT OF INVESTMENT'/
     4'        (2 - 3 % IS SUGGESTED)'/
     5'  5 -- SALVAGE VALUE AT THE END OF THE ',I3,'-YEAR SYSTEM LIFE'/
     5'        AS A PERCENT OF THE ORIGINAL COST'/
     6'  6 -- TOTAL ANNUAL COST FOR MISCELLANEOUS ITEMS ($)'/
     7'        (TAXES, INSURANCE, ETC.)')
C
C  CLEAR V-ARRAY
C
      DO 8 I=1,2
      DO 8 J=1,7
    8 V(J,I) = 0.
C
C  INPUT OF NECESSARY DATA
C
      WRITE(8,46)
      READ(7,*) FREQC,RZD
      WRITE(8,48)
      READ(7,*) DEPDDM,DBFM,PERMM,XMAXM,SLOP
      WRITE(8,50)
      READ(7,*) C4,C6,C8
      WRITE(8,52)
      READ(7,*) UEXDM,UBKDM,UGRAVM,CONTG
      WRITE(8,54)SLIFE
      READ(7,*)PCS,PCF,LNO,XMAINT,SVAL,CMISC
C
C
C  WRITE OUT INPUTS ON LU 11
      WRITE (11,56)IPK,FLEN,DVOL,FREQC,RZD,DEPDDM,DBFM,PERMM,XMAXM,SLOP,
     1 C4,C6,C8,UEXDM,UBKDM,UGRAVM,CONTG,PCS,PCF,LNO,XMAINT,SVAL,CMISC
   56    FORMAT(///' SUBSURFACE DRAINAGE DATA FOR PADDOCK NO. ',I2/
     1F10.1,T15,'..METER FIELD LENGTH'/
     2F10.1,T15,'..PERCENT APPLIED WATER TO DEEP PERCOLATION'/
     3F10.1,T15,'..DAYS IRRIGATION FREQUENCY'/
     4F10.1,T15,'..MM ROOT ZONE DEPTH'/
     5F11.2,T15,'..M DRAIN DEPTH'/
     6F11.2,T15,'..M DISTANCE BETWEEN DRAIN AND LOWER BARRIER'/
     7F14.5,T15,'..M/DAY PERMEABILITY'/
     8F11.2,T15,'..M MAXIMUM WATER TABLE HEIGHT ABOVE DRAIN'/
     9F14.5,T15,'..SLOPE OF LATERAL DRAIN'/
     AF11.2,T15,'..$/M COST OF 100-MM DRAIN PIPE'/
     BF11.2,T15,'..$/M COST OF 150-MM DRAIN PIPE'/
     CF11.2,T15,'..$/M COST OF 200-MM DRAIN PIPE'/
     DF11.2,T15,'..$/CM COST OF EXCAVATION'/
     EF11.2,T15,'..$/CM COST OF BACKFILL'/
```

```
          FF11.2,T15,'..$/CM COST OF GRAVEL ENVELOP'/
          GF10.1,T15,'..PERCENT CONTINGENCY COST'/
          HF10.1,T15,'..PERCENT OF COST SUBSIDIZED'/
          IF10.1,T15,'..PERCENT OF COST FINANCED UNDER LOAN NO. ',I1/
          KF10.1,T15,'..PERCENT OF COST FOR ANNUAL MAINTENANCE'/
          LF10.1,T15,'..PERCENT SALVAGE VALUE'/
          M' $',F9.2,T15,'..ANNUAL MISCELLANEOUS COST')
C
C   CONVERT SI TO ENGLISH UNITS FOR COMPUTATIONS IN THE PROGRAM
C
          RZDR = RZD/304.8
          DEPD = DEPDDM*3.281
          DBF = DBFM*3.281
          PERM = PERMM*3.281
          XMAX = XMAXM*3.281
          FL = FLEN*3.281
          UEXD = UEXDM/1.308
          UBKD = UBKDM/1.308
          UGRAV = UGRAVM/3.281
          CROPA = AREA(IPK)*2.471
          CONTG = CONTG/100.
          C4 = C4/3.281
          C6 = C6/3.281
          C8 = C8/3.281
C
C
C---CONVERT D.P. TO CU FT PER SQ FT PER IRRIGATION
          QD = ((MAD/EFFA)*DVOL/3.048)/FREQC
          DBF1 = DBF + DEPD - RZDR
C---COMPUTE SPACING USING DONNAN*S EQUATION--FT
          DSPAC = (4.*PERM*(DBF1**2.-DBF**2.)/QD)**(1./2.)
C---FIND DRAIN DISCHARGE USING  USBR EQUATION
          DDB1 = DBF + XMAX/2.
          QLF = (2.*3.1416*PERM*XMAX*DDB1)/DSPAC
          QLF = QLF/ 86400.
C
C---ASSUMPTION* LENGTH OF LATERAL DRAIN = FIELD WIDTH
C                     MANNINGS N=.015
C
          NN = 0
          DO 20 LZ=4,8,2
          NN=NN+1
          XLD=LZ/12.
          AREP=(3.1416*XLD**2.)/4.
          HR=XLD/4.
          VL=(1.49*HR**(2./3.)*SLOP**(1./2.))/.015
          QP(NN) = AREP*VL
      20 CONTINUE
C
C---COMPUTE COST OF PIPES
          FWIDT = CROPA*43560./FL
          XL1=QP(1)/QLF
          IF(XL1.GE.FWIDT)GO TO 68
          XL2=FWIDT-XL1
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      XL3=QP(2)/QLF
      IF(XL3.GE.FWIDT)GO TO 82
      XL4=FWIDT-XL3
      XL3 = FWIDT - XL4 - XL1
      CPP=XL1*C4+XL3*C6+XL4*C8
      VOLP=(3.1416/(144.*4.*27.))*(4.**2.*XL1+6.**2.*XL3+8.**2.
     _*XL4)
      GO TO 80
   68 CPP = FWIDT*C4
      VOLP = 3.1416*4.**2.*FWIDT/(144.*4.*27.)
      GO TO 80
   82 CPP = XL1*C4 + XL2*C6
      VOLP = (3.1416/(144.*4.*27.))*(4.**2.*XL1+6.**2.*XL2)
   80 CONTINUE
C---COMPUTE COST OF EXCVA. AND BACKFILL
C   ASSUME 8-FT DEPTH, 12 INCHES MIN WIDTH
C   USE FACTOR .889 CU YD/LF--USBR
      VODEX = FWIDT * .889
      VODBF = VODEX - VOLP
      ERCD = VODEX * UEXD + VODBF * UBKD
      DNCST = CPP + ERCD + FWIDT*UGRAV
      DNCST = (DNCST + DNCST*CONTG) * REAL(NINT((FL/DSPAC)+.3))
      WRITE(8,58) DNCST,IPK
      WRITE(11,58)DNCST,IPK
   58    FORMAT(/' $',F9.2,T15,'..TOTAL COST FOR SUBSURFACE DRAINAGE '
     1'IN PADDOCK NO. ',I2)
C
C   ADD PROPER VALUES TO ELEMENTS IN THE V-ARRAY FOR PASSING TO
C   THE CALLING PROGRAM
C
      V(1,LNO) = DNCST
      V(2,LNO) = DNCST*(1.-(PCS*PCF/10000.))
      V(3,LNO) = DNCST * PCS/100.
      V(4,LNO) = DNCST * PCF/100.
      V(5,LNO) = DNCST * SVAL/100.
      V(6,LNO) = DNCST * XMAINT/100.
      V(7,LNO) = CMISC
C
      RETURN
      END
```

```
      SUBROUTINE LUNITS(II,JJ)
C  SUBROUTINE TO ASSIGN LOGICAL UNIT NOS. FOR INTERACTIVE USE
      INTEGER*2 LUA, LUB, PHDEV1
      INTEGER*2 ZERO, BUFSIZ
       PHDEV1 = 1
       LUA = II
       LUB = JJ
       ZERO = 0
       BUFSIZ = 80
      CALL ATTDEV (LUA, PHDEV1, ZERO, BUFSIZ)
      CALL ATTDEV (LUB, PHDEV1, ZERO, BUFSIZ)
      RETURN
      END
```

```fortran
C >>> PROGRAM FOR SIMULATING THE OPERATION OF AN IRRIGATION SYSTEM <<<
C
C       THIS PROGRAM INCORPORATES AGRONOMIC, IRRIGATION SYSTEMS AND
C       WATER SUPPLY DATA IN ESTIMATING IRRIGATION SYSTEM PERFORMANCE
C       AND COSTS
C
C       WRITTEN BY J.R. BUSCH, WINCHMORE, 1982
C
C       PROGRAM LOGIC AND OPERATION ARE DESCRIBED IN A REPORT
C
C
        DIMENSION TRUMP(30,10),NCRP(20),NDAY(2)
C
C
        COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
       1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
       2,IPDKPR(20,2),KCP(20,2)    ,IDXSYS(20),JFLG(0:24,50),
       3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
       4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
       5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
       6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
       7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
C
        CHARACTER*32 TITLE,RESTFIL,CRPROT,IRRSYS,WTRSUP,RAINFL,PETFIL,
       1TSPEC1,TSPEC2
        CHARACTER*20 SYSNAM(20), CNAME(30)*16,SUPTIT
        CHARACTER*1,Y,Y1
        DATA Y,TSPEC1,TSPEC2/'Y','DAYTIME','NIGHT TIME'/
C
        DATA MONLEN/31,28,31,30,31,30,31,31,30,31,30,31/
C
C -- ASSIGN LU NOS.  #8 WRITE        #7 READ
        CALL LUNITS(7,8)
C
        WRITE(8,1001)
 1001   FORMAT(//' INPUT DATA FOR THE OPERATION SIMULATION MODULE'//
       1' -THE MAXIMUM NUMBER OF CHARACTERS IN ANY TITLE IS 32'/
       2'  WITH NO EMBEDDED BLANKS AND ONLY ALPHANUMERIC CHARACTERS'//
       3' -ALL NUMERIC DATA ARE ENTERED IN FREE FORMAT (LIST DIRECTED)')
C
C   ENTER INPUT DATA
C
        WRITE(8,*)' ENTER A DESCRIPTIVE TITLE'
        READ(7,1101)  TITLE
C  OUTPUT FILE HAS THE SAME NAME AS THE TITLE
        OPEN(10,FILE=TITLE)
        WRITE(8,*)' ENTER NAME OF CROP-PADDOCK FILE'
        READ(7,1101) CRPROT
 1101   FORMAT(A)
        OPEN(11,FILE=CRPROT)
        WRITE(8,*)' ENTER NAME OF IRRIGATION SYSTEMS FILE'
        READ(7,1101) IRRSYS
        OPEN(12,FILE=IRRSYS)
        WRITE(8,*)' ENTER NAME OF WATER SUPPLY FILE'
```

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```
            READ(7,1101) WTRSUP
            OPEN(13,FILE=WTRSUP)
            WRITE(8,*)' ENTER NAME OF RAINFALL FILE'
            READ(7,1101) RAINFL
            OPEN(14,FILE=RAINFL)
            WRITE(8,*)' ENTER NAME OF PET FILE'
            READ(7,1101) PETFIL
            OPEN (15,FILE=PETFIL)
C  OPEN FILES FOR AGRONOMIC DATA
            OPEN(16,FILE='CROPFPOLY')
            OPEN(17,FILE='CROPDATE')
C
C
C >>>>>>>>>> READ CROP-PADDOCK FILE
C >>>>>>>>>> GENERATED BY 'CROPADDOCK' ROUTINE
C >>>>>>>> ARRAYS AND VARIABLES ARE --------------
C    NCP -- TOTAL NO OF CROPS IN MENU
C    IDCP -- CROP ID NO.
C    CNAME -- CROP NAME   (CHARACTER*16)
C    MBEG & MFIN -- NOS. OF MONTHS MARKING BEGINNING & ENDING OF SEASON
C    NPDK -- NO. OF PADDOCKS
C    AREA -- AREA OF PADDOCK
C    NCRP -- NO. OF CROPS IN PADDOCK
C    CRPDK(I,J,K) -- CROP-PADDOCK ARRAY
C           I -- PADDOCK NO.
C           J -- CROP ROTATION POSITION
C           K -- VARIABLE POSITION (1-8)
C    NTCP -- TOTAL NO OF CROPS IN CRPDK ARRAY
C    MPRIOR -- IRRIGATION PRIORITIES OF CROPS
C
C  --NO OF CROPS IN MENU
            READ(11,7101) NCP
7101  FORMAT(//14X,I3//)
C
C  --CROP ID NOS. & NAMES
            READ(11,7102)(IDCP(I),CNAME(I),I=1,NCP)
7102  FORMAT(1X,I2,1X,A,21X,I2,1X,A)
C
C  BEGINNING AND ENDING MONTHS OF IRRIGATION SEASON
            READ(11,7106) MBEG,MFIN
7106  FORMAT(///////39XI2,/,38XI2)
C
C  --NO OF PADDOCKS AND INFORMATION FOR EACH PADDOCK
            READ(11,7103) NPDK
7103  FORMAT(/33XI2)
C
            DO 10 I=1,NPDK
            READ(11,7104) AREA(I),NCRP(I)
7104  FORMAT(///5XF6.1/7XI2////)
            DO 10 J=1,NCRP(I)
            READ(11,7105)(CRPDK(I,J,K),K=1,8)
7105  FORMAT(9X,2(F9.0,1X,3F7.1,2X))
10    CONTINUE
            MFX = MFIN
```
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```
          IF(MFX.LE.5) MFX = MFX + 12
          J1 = ((MBEG-5)*2) - 1
          J2 = (MFX - 5)*2
          READ(11,7107) NTCP
7107   FORMAT(//31XI2,////)
          DO 5 N=J1,J2
5         READ(11,7108) (MPRIOR(I,N),I=1,NTCP)
7108   FORMAT(21X,30I3)
C
C   >>>INPUTS FOR IRRIGATION SYSTEMS
C    >>>>>>> GENERATED FROM 'SYSTEMS' ROUTINE
C   >> MAJOR ARRAYS AND VARIABLES ARE --------
C      NSYS -- NO. OF SYSTEMS
C      NPKSYS(I) -- NO. OF PADDOCKS IRRIGATED BY SYSTEM I
C      IPSYS(J,I) -- ARRAY OF PADDOCK ID NOS. IRRIGATED BY SYSTEM I
C      TLAB(J) -- LABOR REQT FOR PADDOCK J (HR/IRRIGATION)
C      EAPP(CROP,PADDOCK) -- ARRAY OF OVERALL APPLICATION EFFICIENCIES (%)
C      SYSVAL(J,I) -- ARRAY OF VALUES FOR SYSTEM I AS FOLLOWS
C            J = 1 -- FLOW ENTERING SYSTEM (L/S)
C                2 -- PERCENT OF TIME SYSTEM OPERATES
C                3 -- SYSTEM LIFE (YR)
C                4 -- TOTAL CAPITAL COST ($)--- (LOAN NO. 1)
C                5 -- CAPITAL NOT FINANCED OR SUBSIDIZED ($)
C                6 -- SUBSIDIZED CAPITAL ($)
C                7 -- FINANCED CAPITAL ($)
C                8 -- INTEREST RATE FOR LOAN NO. 1 (%) -- ATTACHED ITEMS
C                9 -- TIME OF LOAN NO. 1 (YR)
C               10 -- SALVAGE VALUE OF COMPONENTS ($)
C               11 -- ANNUAL MAINTENANCE EXPENSE ($)
C               12 -- ANNUAL MISCELLANEOUS EXPENSE ($)
C            PARAMETERS 13 -21 ARE THE SAME PARAMETERS AS 4 - 12 EXCEPT
C            UNATTACHED ITEMS (LOAN NO. 2)
C
C      NAPMP(I) -- NO. OF PUMPS IN SYSTEM I
C      IDXPMA(J,I) -- ID NOS. OF PUMPS IN SYSTEM I
C      PWRPMP(K) -- ARRAY OF PUMP POWER REQTS (KW)
C      QPMP(K) -- ARRAY OF PUMP FLOW RATES (L/S)
C
          READ(12,7130) NSYS
7130   FORMAT(I5)
          DO 7 I=1,NSYS
          READ(12,7131) SYSNAM(I)
7131   FORMAT(A)
C
          READ(12,7132) NPKSYS(I), (IPSYS(J,I),J=1,NPKSYS(I))
7132   FORMAT(16I5)
C
          READ(12,7133) (TLAB(IPSYS(J,I)),J=1,NPKSYS(I))
7133   FORMAT(8F10.2)
C
          READ(12,7133) (SYSVAL(J,I),J=1,21)
          READ(12,7132) NAPMP(I),(IDXPMA(J,I),J=1,NAPMP(I))
          IF(NAPMP(I).EQ.0) GO TO 7
          READ(12,7133) (PWRPMP(IDXPMA(J,I)),QPMP(IDXPMA(J,I)),
```

```
      1                   J=1,NAPMP(I))
7     CONTINUE
C
C  READ EFFICIENCY ARRAY
C
      READ(12,7133) ((EAPP(I,J),I=1,NCP),J=1,NPDK)
C
C  SET UP SYSTEM-PADDOCK INDEX ARRAY
      DO 8 I=1,NSYS
      DO 8 J=1,NPKSYS(I)
8     IDXSYS(IPSYS(J,I)) = I
C
C >>>> INPUT DATA FOR WATER SUPPLY SYSTEMS
C >>>>>>>>> GENERATED FROM 'SUPPLY' ROUTINE
C >> MAJOR ARRAYS AND VARIABLES ARE --------
C    WCOST(I) -- COST OF WATER ENTERING THE SYSTEM
C    SUPRAM(J) -- ARRAY OF VALUES FOR SYSTEM AS FOLLOWS
C          J = 1 -- VOLUME ENTERING SYSTEM (CUBIC M/DAY)
C              2 -- FLOW ENTERING SYSTEM (L/S)
C              3 -- CONVEYANCE EFFICIENCY (%)
C              4 -- SYSTEM LIFE (YR)
C              5 -- TOTAL CAPITAL COST ($)--- (LOAN NO. 1)
C              6 -- CAPITAL NOT FINANCED OR SUBSIDIZED ($)
C              7 -- SUBSIDIZED CAPITAL ($)
C              8 -- FINANCED CAPITAL ($)
C              9 -- INTEREST RATE FOR LOAN NO. 1 (%) -- ATTACHED ITEMS
C             10 -- TIME OF LOAN NO. 1 (YR)
C             11 -- SALVAGE VALUE OF COMPONENTS ($)
C             12 -- ANNUAL MAINTENANCE EXPENSE ($)
C             13 -- ANNUAL MISCELLANEOUS EXPENSE ($)
C          PARAMETERS 14 -22 ARE THE SAME PARAMETERS AS 5 - 13 EXCEPT
C          UNATTACHED ITEMS (LOAN NO. 2)
C
C
C    NAPMP -- NO. OF PUMPS IN SYSTEM
C    IDXPMA(J) -- ID NOS. OF PUMPS IN SYSTEM
C    PWRPMP(K) -- ARRAY OF PUMP POWER REQTS (KW)
C    QPMP(K) -- ARRAY OF PUMP FLOW RATES (L/S)
C
      READ(13,7131) SUPTIT
C
      READ(13,7133) (SUPRAM(J),J=1,22)
      READ(13,7132) NAPMP(0),(IDXPMA(J,0),J=1,NAPMP(0))
      IF(NAPMP(0).EQ.0) GO TO 9
      READ(13,7133) (PWRPMP(IDXPMA(J,0)),QPMP(IDXPMA(J,0)),
      1                   J=1,NAPMP(0))
C
C  READ WATER COST ARRAY
9     READ(13,7133) (WCOST(I),I=1,3)
C
C
C  DETERMINE IF A PUMP OR PUMPS
C  ARE USED AND INPUT POWER RATE STRUCTURE
      NPUMP = 0
```

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```
         DO 18 I=0,20
         NPUMP = NPUMP + NAPMP(I)
18       CONTINUE
         IF(NPUMP) 45,45,19
C
19       WRITE(8,*)' IS THE TARIFF STRUCTURE THE SAME FOR ALL PUMPS-Y OR N'
         READ(7,1101)Y1
         NP = 1
         IF(Y1.NE.Y) NP = NPUMP
         WRITE(8,1002) NP
1002     FORMAT(/' ENTER THE FOLLOWING DATA FOR ',I2, ' PUMP(S)'/
        1' THE DATA FOR EACH PUMP MUST BE ENTERED ON A SEPARATE LINE'/
        2' ALL DATA MUST BE ENTERED IN THE ORDER INDICATED'/
        3' --IF A PARTICULAR COEFFICIENT IS NOT APPLICABLE, ENTER 0 (ZERO)'
        4/' --ALL DATA MUST BE SEPARATED BY COMMAS OR SPACES'//
        5' DEMAND AND SERVICE CHARGES -- 5 ITEMS'/
        6' INSTALLATION CHARGE    ANNUAL CHARGE     BILLING PD CHARGE'/
        7'      LUMP SUM $          LUMP $  $/KW      LUMP $   $/KW'/
        8'      (ITEM 1)          (ITEM 2)(ITEM 3)  (ITEM 4) (ITEM 5)'/)
         DO 20 I=1,NP
20       READ(7,*) (TPUMP(K,I),K=1,5)
C
         WRITE(8,1003) TSPEC1
1003     FORMAT(/' ENERGY CHARGES FOR PUMPING IN ',A//' --6 ITEMS'//
        1' BLOCK 1  BLOCK 2  BLOCK 3    BLOCK 1A   BLOCK 2A   BLOCK 3A'/
        2' ($/KWH)  ($/KWH)  ($/KWH)   ($/KWH-KW) ($/KWH-KW) ($/KWH-KW)'/
        3' (ITEM 1) (ITEM 2) (ITEM 3)   (ITEM 4)   (ITEM 5)   (ITEM 6)'/)
         KON = 0
         DO 22 I=1,NP
         DO 21 K=6,29
21       TPUMP(K,I)=0.
         READ(7,*) (TPUMP(K,I),K=6,11)
         IF(TPUMP(7,I).NE.0.0.OR.TPUMP(8,I).NE.0.0
        1   .OR.TPUMP(10,I).NE.0.0.OR.TPUMP(11,I).NE.0.0) KON =1
22       CONTINUE
C
C  ENTER NO OF UNITS AT WHICH DIFFERENT BLOCKS TAKE EFFECT
C
         IF(KON.EQ.0) GO TO 28
         WRITE(8,1004)
1004     FORMAT(/' ENTER THE TOTAL NUMBER OF UNITS (KWH OR KWH-KW) THAT'/
        1' MUST BE USED BEFORE THE RATES IN BLOCKS 2, 3, 2A AND 3A'/
        2' BECOME EFFECTIVE'//   -- 4 ITEMS FOR EACH PUMP'/
        3'   BLOCK 2    BLOCK 3    BLOCK 2A    BLOCK 3A'/
        4'   (KWH)      (KWH)      (KWH-KW)    (KWH-KW)'/
        5'   (ITEM 1)   (ITEM 2)   (ITEM 3)    (ITEM 4)'/)
C
24       READ(7,*)((TPUMP(K,I),K=12,15),I=1,NP)
C
C  ENTER LENGTH OF BILLING PERIOD FOR CHANGING BLOCK STRUCTURE
28       CONTINUE
         WRITE(8,1005)
1005     FORMAT(/' ENTER THE LENGTH OF PERIOD IN MONTHS USED IN COMPUTING'/
        1' POWER CHARGES AND THE NUMBER OF MONTHS AFTER JUNE 1 THAT'/
```

```
          2' THE PERIOD BEGINS'/'   -- 2 ITEMS FOR EACH PUMP')
26      READ(7,*)((TPUMP(K,I), K=16,17),I=1,NP)
        WRITE(8,1006)
1006   FORMAT(/' DOES A DIFFERENT TARIFF APPLY FOR A PERIOD OF TIME'/
       1' EACH DAY (NIGHT RATE) -- Y OR N')
        READ(7,1101) Y1
        IF(Y1 .NE.Y) GO TO 40
        KON = 0
        WRITE(8,1003) TSPEC2
        DO 32 I=1,NP
        READ(7,*)(TPUMP(K,I),K=18,23)
        IF(TPUMP(19,I).NE.0.0.OR.TPUMP(20,I).NE.0.0
       1    .OR.TPUMP(22,I).NE.0.0.OR.TPUMP(23,I).NE.0.0) KON = 1
32      CONTINUE
C
        IF(KON.EQ.0) GO TO 38
        WRITE(8,1007)
1007   FORMAT(/' ENTER THE FOLLOWING FOR NIGHT RATES')
        WRITE (8,1004)
        READ(7,*)((TPUMP(K,I),K=24,27),I=1,NP)
C
38      WRITE(8,1008)
1008   FORMAT(/' ENTER THE NUMBER OF HOURS PER DAY THAT'/
       1' THE NIGHT RATES APPLY FOR EACH PUMP')
        READ(7,*)(TPUMP(28,I),I=1,NP)
C
        WRITE(8,1009)
1009   FORMAT(/' ENTER,THE FOLLOWING CODE FOR OPERATIONAL PRIORITY'/
       1' FOR EACH PUMP'/
       2'   1 -- NO PRIORITY'/'   2 -- DAYTIME OPERATION HAS PRIORITY'/
       3'   3 -- NIGHT TIME OPERATION HAS PRIORITY')
        READ(7,*)(TPUMP(29,I),I=1,NP)
C ENTER INFLATION RATE
40      WRITE(8,1010)
1010   FORMAT(/' ENTER EXPECTED ANNUAL INFLATION RATE FOR ENERGY'
       1' (PERCENT)')
        READ(7,*) FLATP
C  END OF PUMP TARIFF INPUT
C
C  WRITE PUMP TARIFF STRUCTURE TO OUTPUT FILE
C
        WRITE(10,1050) TITLE
1050   FORMAT('1'//' PUMP TARIFF INPUT FOR ',A/)
        WRITE(10,1051)
1051   FORMAT(' INSTALLATION CHARGE    ANNUAL CHARGE     BILLING PD CHARGE
       1'//      LUMP SUM $         LUMP $  $/KW     LUMP $  $/KW')
        WRITE(10,1052)((TPUMP(K,I),K=1,5),I=1,NP)
1052   FORMAT(F14.2,F16.2,3F8.2)
        WRITE(10,1053) TSPEC1
1053   FORMAT(/' ENERGY CHARGES FOR PUMPING IN ',A//
       1' BLOCK 1  BLOCK 2  BLOCK 3    BLOCK 1A   BLOCK 2A   BLOCK 3A'/
       2' ($/KWH)  ($/KWH)  ($/KWH)   ($/KWH-KW) ($/KWH-KW) ($/KWH-KW)'/)
        WRITE(10,1054)((TPUMP(K,I),K=6,11),I=1,NP)
1054   FORMAT(3F8.4,2X,3F11.4)
```

```
      WRITE(10,1055)
1055  FORMAT(//'  THE TOTAL NUMBER OF UNITS (KWH OR KWH-KW) THAT'/
     1' MUST BE USED BEFORE THE RATES IN BLOCKS 2, 3, 2A AND 3A'/
     2' BECOME EFFECTIVE'//'  -- 4 ITEMS FOR EACH PUMP'/
     3'   BLOCK 2    BLOCK 3    BLOCK 2A    BLOCK 3A'/
     4'   (KWH)      (KWH)     (KWH-KW)   (KWH-KW)'/)
      WRITE(10,1056)((TPUMP(K,I),K=12,15),I=1,NP)
1056  FORMAT(3F10.1,F11.1)
      IF(Y1.NE.Y) GO TO 42
      WRITE(10,1053) TSPEC2
      WRITE(10,1054)((TPUMP(K,I),K=18,23),I=1,NP)
      WRITE(10,1055)
      WRITE(10,1056)((TPUMP(K,I),K=24,27),I=1,NP)
      WRITE(10,1059)
1059  FORMAT(///' HOURS PER DAY THAT NIGHT RATES APPLY'/
     1' AND OPERATIONAL PRIORITY ACCORDENG TO THE'/
     2' FOLLOWING CODE:'//'  1 -- NO PRIORITY'//'  2 -- DAYTIME '
     3'PRIORITY'//'  3 -- NIGHT TIME PRIORITY')
      WRITE(10,1060)((TPUMP(K,I),K=28,29),I=1,NP)
1060  FORMAT(2F10.1)
42    WRITE(10,1057)
1057  FORMAT(' LENGTH OF BILLING PERIOD IN MONTHS'//' AND MONTHS '
     1'AFTER JUNE 1 THAT BILLING PERIOD BEGINS'//' FOR ALL PUMPS')
      WRITE(10,1058)((TPUMP(K,I),K=16,17),I=1,NP)
1058  FORMAT(2F10.1)
C
C  ENTER LABOR DATA
C
45    CONTINUE
      WRITE(8,10110)
10110 FORMAT(/' ENTER MAXIMUM LABOR INPUT IN HOURS PER WEEK')
      READ(7,*) XLAB
C
      WRITE(8,1011)
1011  FORMAT(/' ENTER LABOR WAGE RATE ($/HR) AND'//' EXPECTED '
     1' RATE OF INFLATION FOR LABOR (PERCENT)')
      READ(7,*) RLABC,RLABI
C
      WRITE(8,1012)
1012  FORMAT(/' INPUT INFLATION RATE FOR OTHER OPERATING'/
     1' AND MAINTENANCE COSTS (PERCENT)')
      READ(7,*) OMI
      WRITE(8,*)' ENTER THE RETURN ON INVESTMENT (PERCENT)'
      READ(7,*) RINV
C
      WRITE(8,1013)
1013  FORMAT(//' ENTER BEGINNING AND ENDING YEARS FOR SIMULATION RUN')
      READ(7,*) ISTART,ISTOP
      IF(ISTART.GT.100)ISTART=ISTART-1900
      IF(ISTOP.GT.100)ISTOP=ISTOP-1900
        NYEAR=ISTOP-ISTART+1
C
      WRITE(8,10131)
10131 FORMAT(//' I AM NOW THINKING, COMPUTING AND TRYING TO DIGEST ALL'//
```
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                  1' THE DATA YOU HAVE FED ME.   I WILL TELL YOU WHEN I HAVE'/
                  2' SUCCESSFULLY COMPLETED ALL DETAILS ----- PROVIDED YOU '/
                  3' HAVE NOT FED ME BAD DATA THAT WILL RESULT IN INDIGESTION!!'//)
      C
      C
      C  SET UP INDEX ARRAY OF CROP ROTATION FOR SIMULATION PERIOD
      C  --IDXCRP(PADDOCK,YEAR) DENOTES CROP IN PADDOCK FOR THAT YEAR
             DO 65 IPDK=1,NPDK
             I = 0
             DO 65 IYR =1,NYEAR
             I = I + 1
             IDXCRP(IPDK,IYR) = I
             IF(I.GE.NCRP(IPDK)) I = 0
      65     CONTINUE
      C
      C      INITIALIZE PRIORITIES
      C
             DO 68 I=1,NPDK
      68     IPDKPR(I,1) = 0
      C
      C  READ AGRONOMIC FILES FOR CROP DATES AND ET COEFFICIENTS
      C  VIA SUBROUTINE AGRON -- ARGUMENTS ARE LU NO. FOR CROPS & CROPF FILES
      C     --CROPS FILE IS CROP-DATE FILE WITH PLANTING, COVER & HARVEST DATES
      C       AND REFERENCE FOR PROPER POLYNOMIAL FOR ESTIMATING ET
      C     --CROPF FILE IS FILE OF COEFFICIENTS FOR RELATING AET/PET
      C
             CALL AGRON (17,16)
      C
      C  LOCATE STARTING RECORDS IN RAINFALL AND PET FILES AND READ
      C  FIRST YEAR'S DATA
      C  --LOGICAL UNITS AND STARTING YEAR ARE ARGUMENTS
      C
             CALL LOCATE (14,15,ISTART)
      C
      C  ENTER SIMULATION LOOP
      C  -- INITIALIZE SOIL MOISTURE LEVELS (SMD) AT FIELD CAPACITY AND
      C     IRRIGATION REQUIREMENTS (RQI) AT ZERO
             DO 70 IPDK=1,NPDK
             SMD(IPDK,1)= 0.0
             DO 70 I=1,2
             ISF(IPDK,I) = 0
      70     RQI(IPDK,I) = 0.0
      C
             DO 71 J=1,50
             DO 71 I=0,24
      71     JFLG(I,J)=0
             TOTWTR=0
             TOTLBR=0
      C
      C  INITIALIZE EFFECT OF RAINFALL
      C
             KRAIN = 4
      C
      C  ENTER YEARLY LOOP
```

```
            NXX = 0
            DO 120 IYR=1,NYEAR
            LYEAR = ISTART + IYR - 1
            JDAY = 0
            LPDY = 1
            KTPD = 0
            MONLEN(2)=28
            IF (MOD(LYEAR+1,4).EQ.0) MONLEN(2) = 29
C
C
C
C
C   ENTER LOOP FOR 2-WEEK PERIODS
C
            DO 90 IMNTH = 6,17
            MONTH = IMNTH
            IF(MONTH.GT.12) MONTH = MONTH - 12
            NDAY(1) = MONLEN(MONTH)/2
            NDAY(2) = MONLEN(MONTH) - NDAY(1)
C
            DO  90 KPD = 1,2
            NXX = NXX + 1
            KTPD = KTPD + 1
            TLBR = TOTLBR
            JUST = 1
            TWTR = TOTWTR
            LD1 = LPDY
            JDAY = JDAY + LPDY
            LPDY = NDAY(KPD)
C
C   SAVE NECESSARY DATA FOR POSSIBLE USE IN REALLOCATION LOOP
C
            DO 72 I=1,NPDK
            KCP(I,2) = KCP(I,1)
            IPDKPR(I,2) = IPDKPR(I,1)
            RQI(I,2) = RQI(I,1)
            SMD(I,2) = SMD(I,1)
72          CONTINUE
C
            DO 74 I = 1,NSYS
            SYSV(I,2) = SYSV(I,1)
74          ISF(I,2) = ISF(I,1)
C
C   CALL SUBROUTINE WATEREQT TO OBTAIN IRRIGATION REQUIREMENTS
C
76          CALL WATEREQT(KPD,JDAY,LPDY,IYR,LYEAR,MONTH,NPDK,KRAIN,JUST)
C
C   CHECK IF CURRENT PERIOD IS WITHIN IRRIGATION SEASON
            IF(MONTH.GE.6.AND.MONTH.GE.MBEG)GO TO 80
            IF(MONTH.LT.6.AND.MONTH.LE.MFIN)GO TO 80
            DO 78 I = 1,NPDK
            SMD(I,1) = SMD(I,1) + CRPDK(I,IDXCRP(I,IYR),KCP(I,1)+2)
        1    + RQI(I,1)
            IF (SMD(I,1).GT.CRPDK(I,IDXCRP(I,IYR),KCP(I,1)+1))
        1        SMD(I,1)= CRPDK(I,IDXCRP(I,IYR),KCP(I,1)+1)
```

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```
78      CONTINUE
        GO TO  90
C
C   ENTER ALLOCATION LOOP
C    CALL SUBROUTINE ALLOCATE TO COMPUTE THE IRRIGATION APPLICATIONS
C    IN THE PERIOD UNDER CONSIDERATION
C
80      CALL ALLOCATE(NDAY(KPD),KTPD,IYR,XLAB,NSYS,NPDK,NTCP,TOTLBR,
      1 TOTWTR,JUST)
C
C   NO REALLOCATION ON FIRST PERIOD
C
        IF(NXX.LE.1) GO TO 90
C
C   CHECK IF REALLOCATION IS NECESSARY OR ALLOWABLE
C
C     ----CHECK SYSTEM CAPACITY
        II = 0
        DO 83 I=1,NSYS
83      II = II + ISF(I,1)
        IF(II.GT.0.AND.JUST.EQ.1) GO TO 84
C
C
C
C     -- CHECK WATER & LABOR AVAILABILITY OR PREVIOUS REALLOCATION
        IF(JFLG(KTPD,IYR).LT.1.OR.JUST.GT.1) GO TO 90
C
C     -- CHECK SYSTEM CAPACITY IN PREVIOUS PERIOD
84        II = 0
        DO 85 I=1,NSYS
85        II = II + ISF(I,2)
        IF(II.EQ.NSYS) GO TO 90
C
C     -- CHECK WATER AND LABOR AVAILABILITY IN PREVIOUS PERIOD
        I = KTPD - 1
        IF(JFLG(I,IYR).GT.0) GO TO 90
C
C   ENTER REALLOCATION LOOP VIA SUBROUTINE ADJUST
C
        CALL ADJUST(LD1,KTPD,XLAB,NPDK,TLBR,  NSYS,IYR,TWTR)
        JUST = 2
        GO TO 76
90      CONTINUE
C
C   SUMMARIZE PERTINENT DATA FOR EACH YEAR VIA SUBROUTINE YEARSUM
C
        CALL YEARSUM(IYR,NYEAR,NCP,NSYS,NPDK,J1,J2)
120     CONTINUE
C
C   END OF SUMULATION LOOP
C
C   CALL SUBROUTINE SUMOUT TO COMPUTE AND PRINT OUT FINAL SUMMARY
C
        CALL SUMOUT (NYEAR,TITLE,NCP,SYSNAM,NP,NPUMP,RINV,RLABC,
```

```
      1 RLABI,OMI,FLATP,NPDK,NSYS,CNAME,SUPTIT)
C
      WRITE(8,1020) TITLE
1020  FORMAT(//' THE JOB IS FINISHED AND OUTPUT IS IN FILE ',A)
      STOP
      END
```

```
          SUBROUTINE WATEREQT(KPD,JDAY,NDAY,IYR,LYEAR,MTH,NPDK,KRN,JUST)
C
C  SUBROUTINE WATEREQT COMPUTES THE NET IRRIGATION REQUIREMENT
C  FOR A GIVEN PERIOD
C     KPD -- NUMBER OF PERIOD WITHIN A MONTH
C     JDAY -- DAY NUMBER OF PERIOD START (JUNE 1 = JDAY 1)
C  NDAY -- NUMBER OF DAYS IN PERIOD
C     IYR -- YEAR NUMBER
C     MTH -- NUMBER OF MONTH WITHIN A YEAR
C     NPDK -- NUMBER OF PADDOCKS
C     KRN -- NUMBER OF DAYS SINCE A RAINFALL > 10 MM
       COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
      1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
      2,IPDKPR(20,2),KCP(20,2)    ,IDXSYS(20),JFLG(0:24,50),
      3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
      4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
      5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
      6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
      7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
C  CRPDK -- CROP-PADDOCK ARRAY
C  IDXCRP -- INDEX ARRAY
C  SMD -- SOIL MOISTURE DEFICIT ARRAY
C
       INTEGER X1,X2,X3,X4,X5,X6,X7,X8
       DIMENSION X1(20),X2(20),X3(20),X4(20),X5(20),X6(20),X7(20),X8(20),
      1W(20)
C
C  READ IN DATA FOR NEXT JAN - DEC PERIOD
C
       IF(MTH.NE.1.OR.KPD.NE.1) GO TO 20
       IF(JUST.GT.1) GO TO 20
       CALL LOAD (14,LYEAR+1)
       READ(15,1104) PET
1104   FORMAT(5X,12F6.1)
20     DAYPET = PET(MTH)/MONLEN(MTH)
C
C  ASSIGN IRRIGATION STRATEGIES
C
       DO 24 I=1,NPDK
       IX1 = NINT(CRPDK(I,IDXCRP(I,IYR),1))
       IX2 = NINT(CRPDK(I,IDXCRP(I,IYR),5))
       X1(I)=ICROPS(1,IX1)
       X2(I)=ICROPS(2,IX1)
       X3(I)=ICROPS(3,IX1)
       X4(I)=ICROPS(4,IX1)
       X5(I)=ICROPS(1,IX2)
       X6(I)=ICROPS(2,IX2)
       X7(I)=ICROPS(3,IX2)
       X8(I)=ICROPS(4,IX2)
24     CONTINUE
C
C  INITIALIZE PARAMETERS FOR SOIL MOISTURE DEPLETION
C  -- SHAPE FACTOR FOR ET REDUCTION FACTOR (SMFRAC)
C     REF: MINHAS ET AL -- WTR RES RESEARCH 10(3):383-393
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```
        A = 30.
C    -- PERCENT OF RAINFALL LOST TO RUNOFF FOR RAINFALL > 25 MM/DAY
        PCT = 10.
        PCT = PCT/100.
C
C   KDAY = JULIAN DAY WITHIN A YEAR
        KDAY = 0
        DO 25 I=1,MTH-1
        KDAY = KDAY + MONLEN(I)
25      CONTINUE
        IF(KPD.EQ.2) KDAY=KDAY+MONLEN(MTH) - NDAY
C
C   ENTER DAILY LOOP FOR EACH PADDOCK
C
        DO 60 I=1,NPDK
        DEF = SMD(I,1)
        RQX = 0.
        K = 1
        IF(JDAY.LT.X5(I)) GO TO 26
        K = 5
26      KKW = KRN
        KCP(I,1) = K
C
C   ACCOUNT FOR EXPANDING ROOT ZONE DEPTH (RZD) IN
C    VEGETATIVE STATE
C    RZD VARIES BETWEEN 0.5 AND 1.0 OF THE ROOT ZONE
        RZD = 1.
        IF(X2(I).EQ.X1(I).OR.X5(I).EQ.X6(I)) GO TO 29
        IF(X4(I).GE.12.AND.X4(I).LE.16) GO TO 29
        IF(X8(I).GE.12.AND.X8(I).LE.16) GO TO 29
        IF(JDAY.LT.X1(I).OR.JDAY.GT.X2(I)) GO TO 27
        RZD = 0.5 + 0.5 * REAL(JDAY-X1(I))/REAL(X2(I)-X1(I))
        GO TO 29
27      IF(JDAY.LT.X5(I).OR.JDAY.GT.X6(I)) GO TO 29
        RZD = 0.5 + 0.5 * REAL(JDAY - X5(I))/ REAL(X6(I)-X5(I))
29      TAM = CRPDK(I,IDXCRP(I,IYR),K+1) * RZD
        BLIM = ((CRPDK(I,IDXCRP(I,IYR),K+3) * RZD) + DEF)/2.
        W(I) = (TAM-BLIM)/TAM
C
        KKDAY = KDAY
        DO 55 IDY=JDAY,JDAY+NDAY-1
        KKDAY = KKDAY + 1
        RIRRID = 0.
        RNOFF = 0.
C
C
C    SELECTION OF SMFRAC(I)=I(CROP TYPE) AND COMPUTING CROP COEFFICIENTS
C
        IF(IDY.GE.X1(I)) GO TO 30
310     F1 = CROPF(1,12)
        F2 = CROPF(2,12)
        F3 = CROPF(3,12)
        F4 = CROPF(4,12)
        F5 = CROPF(9,12)
                         256
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              F6 = CROPF(10,12)
              FDAY = FLOAT(IDY)
              GO TO 38
       C
       30     IF(IDY.GE.X2(I)) GO TO 31
              F1 =  CROPF(1,X4(I))
              F2 = CROPF(2,X4(I))
              F3 = CROPF(3,X4(I))
              F4 = CROPF(4,X4(I))
              F5 = CROPF(9,X4(I))
              F6 = CROPF(10,X4(I))
              FDN = FLOAT (IDY-X1(I))
              FDD = FLOAT(X2(I)-X1(I))
              FDAY = FDN/FDD
              GO TO 36
       C
       31     IF(IDY.GE.X3(I)) GO TO 32
              FDAY = FLOAT(IDY - X2(I))
              F1 = CROPF(5,X4(I))
              F2 = CROPF(6,X4(I))
              F3 = CROPF(7,X4(I))
              F4 = CROPF(8,X4(I))
              F5 = CROPF(9,X4(I))
              F6 = CROPF(10,X4(I))
              GO TO 36
       32     IF(X8(I).EQ.12) GO TO 310
              IF(IDY.GE.X5(I)) GO TO 33
              GO TO 310
       C
       33     IF (IDY.GE.X6(I)) GO TO 34
              F1 = CROPF(1,X8(I))
              F2 = CROPF(2,X8(I))
              F3 = CROPF(3,X8(I))
              F4 = CROPF(4,X8(I))
              F5 = CROPF (9,X8(I))
              F6 = CROPF(10,X8(I))
              FDAY = FLOAT(IDY-X5(I))/FLOAT(X6(I)-X5(I))
              GO TO 36
       C
       34     IF (IDY.GT.X7(I)) GO TO 310
              F1 = CROPF(5,X8(I))
              F2 = CROPF(6,X8(I))
              F3 = CROPF (7,X8(I))
              F4 = CROPF(8,X8(I))
              F5 = CROPF(9,X8(I))
              F6 = CROPF(10,X8(I))
              FDAY = FLOAT(IDY - X6(I))
       C
        36    SMFRAC=(1.0-EXP(-A*W(I)))/(1.0-2.0*EXP(-A)+EXP(-A*W(I)))
              GO TO 39
        38    SMFRAC=W(I)/(2.0-W(I))
        39    CONTINUE
       C
       C
```

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```fortran
      FCROP = F1*FDAY*FDAY*FDAY+
     *                         F2*FDAY*FDAY+
     *                         F3*FDAY + F4
      IF(FCROP.LT.F5) FCROP = F5
      IF (FCROP.GT.F6) FCROP = F6
C
C     FACTOR FOR ACCELERATED ET DUE TO PREVIOUS RAINFALL
C
      WKF = 1.1-0.3 * REAL(KKW)
      KKW = KKW+1
      IF(WKF.LE.0.0) WKF = 0.
      IF(KKW.GT.1.AND.TAM.LE.50.0) WKF = 0.0
      FKW = WKF*(0.9 - FCROP)
      IF(FKW.LT.0.0) FKW = 0.
C
C     DETERMINE AET
C
      AET = DAYPET * (FCROP*SMFRAC + FKW)
C
C
C   WATER BALANCE
C
      IF(RAIN(KKDAY).GT.10.0) KKW=1
      IF(RAIN(KKDAY).GT.25.0) RNOFF = PCT
      DEF = DEF + AET - (1.0-RNOFF)*RAIN(KKDAY)
      IF(DEF.LT.0.0) DEF = 0.
      IF(DEF.LT.BLIM) GO TO 45
      IF(IDY.LT.X1(I))GO TO 45
      IF(IDY.GT.X3(I).AND.IDY.LT.X5(I))GO TO 45
      IF(IDY.GT.X7(I)) GO TO 45
      RQX     =RQX     + (DEF - BLIM)
      DEF = BLIM
45    IF(DEF.GT.TAM) DEF = TAM
55    CONTINUE
      IF(RQX.LE.0.0) GO TO 57
      IF(DEF.LT.CRPDK(I,IDXCRP(I,IYR),K+2)) GO TO 56
      RQI(I,1) = RQX + DEF - CRPDK(I,IDXCRP(I,IYR),K+2)
      SMD(I,1) = CRPDK(I,IDXCRP(I,IYR),K+2)
      GO TO 60
56    RQI(I,1) = RQX
      SMD(I,1) = DEF
      GO TO 60
57    RQI(I,1) = 0.
      SMD(I,1) = DEF
60    CONTINUE
      KRN = KKW
C
      RETURN
      END
```

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```
          SUBROUTINE ALLOCATE (NDY,KTD,IYR,XLAB,NSYS,NPDK,NTCP,TOTLBR,
      1   TOTWTR,JUST)
C         SUBROUTINE ALLOCATE FOR COMPUTING THE EFFECTIVE APPLICATION
C         OF WATER TO EACH PADDOCK IN A 2-WEEK TIME PERIOD
C           NDY -- NO. OF DAYS IN THE PERIOD
C           KTD -- 2-WEEK PERIOD WITHIN A YEAR
C           IYR -- YEAR NO.
C           XLAB -- LABOR CONSTRAINT (HRS/WEEK)
C           NSYS -- NO. OF DIFFERENT APPLICATION SYSTEMS
C           NPDK -- NO. OF PADDOCKS
C           NTCP -- TOTAL NO. OF CROPS (USED FOR ESTABLISHING IRRIG PRIORITIES)
C
         COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
      1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
      2,IPDKPR(20,2),KCP(20,2)    ,IDXSYS(20),JFLG(0:24,50),
      3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
      4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
      5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
      6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
      7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
         DIMENSION VRQD(20),APPN(20), GRQD(20) ,SYSVOL(20),ISFLG(20),
      1TCAP(20),K(20),KPR(20)
C
C         SET OP INDEX OF IRRIGATION PRIORITIES FOR EACH PADDOCK
C
         IF(JUST.GT.1) GO TO 97
        DO 2 I = 1,NPDK
      2  KPR(I) = 0
        LL = 1
        LU = NPDK
        LI = 1
        IF(MOD(KTD,2).EQ.0) GO TO 4
        LL = NPDK
        LU = 1
        LI = -1
      4   IPRR=1
         DO 8 I=1,NTCP
        IF(MPRIOR(I,KTD).EQ.0) GO TO 9
         DO 6 J=LL,LU,LI
         K(J)  = KCP(J,1)
         IF ( NINT(CRPDK(J,IDXCRP(J,IYR),K(J))).NE.MPRIOR(I,KTD))
      1            GO TO 6
        IPDKPR(IPRR,1) = J
        KPR(J) = 1
         IPRR = IPRR + 1
      6   CONTINUE
      8   CONTINUE
      9   IF (IPRR.GT.NPDK) GO TO 97
        DO 95 J=LL,LU,LI
        IF(KPR(J).GT.0) GO TO 95
        IPDKPR(IPRR,1) = J
        IPRR = IPRR + 1
     95   CONTINUE
     97     TOTWTR =0.
```

```fortran
      TOTLBR =0.
      LFLAG  =0
      AV = SUPRAM(1) * REAL(NDY)
      ALB = (XLAB/7.) * REAL(NDY)
C     INITIALIZE FOR SYSTEMS
      DO 5 I=1,NSYS
      SYSVOL(I) = 0.
5     ISFLG(I) = 0
C
C     COMPUTE VOLUME REQUIREMENTS AND INITIALIZE APPLICATION ARRAY
C     -- VRQD = VOLUME REQUIRED IN CUBIC METERS (NET APPLCATION)
10    DO 15 I=1,NPDK
      VRQD(I) = RQI(I,1) * AREA (I) * 10.
      APPN(I) = 0.
      GRQD(I) = 0.
15    CONTINUE
C
C
C     ENTER ALLOCATION LOOP IN ORDER OF PRIORITY FOR ALL PADDOCKS
C
C
      DO 40 I=1,NPDK
      II = IPDKPR(I,1)
      IDXT = IDXCRP(II,IYR)            /* IDXT -- CROP NO. */
      IXS = IDXSYS(II)                 /* IXS -- SYSTEM INDEX */
      ICPXT = NINT(CRPDK(II,IDXT,K(II)))
      OAE = EAPP(ICPXT,II) * SUPRAM(3)/10000.
      TCAP(IXS)=(SYSVAL(1,IXS) * EAPP(ICPXT,II) * SYSVAL(2,IXS)/10000.)
     1           * 86.4 * REAL(NDY)
C
C     CHECK IF PADDOCK HAS NO CROP
      IF(ICPXT.EQ.23) GO TO 40
C
C     COMPUTE GROSS REQUIREMENT
C
      GRQD(II) = VRQD(II) / OAE
      GTEMP = GRQD(II)
      IF(GRQD(II).EQ.0.0) GO TO 40
C
C     CHECK SYSTEM, WATER AND LABOR CONSTRAINTS
      IF(ISFLG(IXS).GT.0) GO TO 40
      SYSVOL(IXS) = SYSVOL(IXS) + VRQD(II)
      IF(SYSVOL(IXS).LE.TCAP(IXS)) GO TO 20
      GRQD(II) = (TCAP(IXS) - (SYSVOL(IXS)-VRQD(II)))/OAE
      ISFLG(IXS) = 1
C     CHECK WATER AVAILABILITY
20    TOTWTR = TOTWTR + GRQD(II)
      IF(TOTWTR.LE.AV) GO TO 25
      GTEMP = AV - (TOTWTR - GRQD(II))
      ATEMP = GTEMP * OAE/ ( AREA(II) * 10.)
      LFLAG = 1
C     CHECK LABOR AVAILABILITY
25    RXL=TLAB(II)/(CRPDK(II,IDXT,K(II)+3)-CRPDK(II,IDXT,K(II)+2))
      TLBB = RXL * GRQD(II)*OAE/(AREA(II)*10.)
```

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```
         TOTLBR = TOTLBR + TLBB
         IF(TOTLBR.LE.ALB) GO TO 30
         APPN(II) = ((ALB-(TOTLBR - TLBB))/RXL)
        GRQD(II) = APPN(II)*AREA(II)*10. /OAE
         IF(GRQD(II).GT.GTEMP) GO TO 32
         LFLAG  = 2
         GO TO 60
30       IF(LFLAG.LT.1) GO TO 35
32       GRQD(II) = GTEMP
         APPN(II) = ATEMP
         GO TO 60
35       APPN(II) = GRQD(II) * OAE/ ( AREA(II) * 10.)
40       CONTINUE
C
C        COMPUTE SOIL MOISTURE DEFICITS AND SET UP SUMMARY ARRAY
C
60       DO 80 I=1,NPDK
         SMD(I,1) = SMD(I,1) + RQI(I,1) - APPN(I)
         D = CRPDK(I,IDXCRP(I,IYR),KCP(I,1)+1)
         IF (SMD(I,1).GT.D) SMD(I,1) = D
         PDSUM(1,I,KTD) = I
         PDSUM(2,I,KTD) = CRPDK(I,IDXCRP(I,IYR),K(I))
         PDSUM(3,I,KTD) = RQI(I,1)
         PDSUM(4,I,KTD) = APPN(I)
         PDSUM(5,I,KTD) = GRQD(I)
         PDSUM(6,I,KTD) = 0.
80       CONTINUE
C        FLAG CONSTRAINTS
         JFLG(KTD,IYR) = LFLAG
C
C        FLAG SYSTEM CHARACTERISTICS
C
         DO 90 I=1,NSYS
         SYSV(I,1) = SYSVOL(I)
         ISF(I,1) = ISFLG (I)
90       ISFLAG(I,KTD) = ISFLG(I)
         RETURN
         END
```

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```
              SUBROUTINE ADJUST (LD1,KTD, XLAB,NPDK,TLBR,NSYS,IYR,TWTR)
C
C   SUBROUTINE ADJUST FOR COMPUTING A REALLOCATION OF WATER
C   IN PREVIOUS PERIOD IF THERE ARE BINDING CONSTRAINTS IN THE
C   PRESENT PERIOD AND NONE IN THE PREVIOUS PERIOD
C
C     LD1 -- NO. OF DAYS IN PREVIOUS PERIOD
C     KTD  -- PRESENT 2-WEEK PERIOD WITHIN A YEAR
C     XLAB -- LABOR CONSTRAINT (MAX HRS PER WEEK)
C     NPDK -- NO. OF PADDOCKS
C     TLBR -- TOTAL LABOR ALREADY USED IN PERIOD LD1
C     NSYS -- TOTAL NUMBER OF IRRIGATION SYSTEMS
C     IYR -- YEAR OF PERIOD LD1
C     TWTR -- TOTAL WATER ALREADY USED IN PERIOD LD1
C
        COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
       1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
       2,IPDKPR(20,2),KCP(20,2)     ,IDXSYS(20),JFLG(0:24,50),
       3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
       4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
       5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
       6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
       7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
        DIMENSION SYSVOL(20),APPN(20),GRQD(20),VRQD(20)
C  DETERMINE TOTAL AMT OF WATER AVAILABLE
        AV = SUPRAM(1) * REAL(LD1)
        KPD = KTD - 1
        IF(KPD.EQ.0) KPD=24
C  DETERMINE TOTAL AMOUNT OF LABOR AVAILABLE
        ALB =((XLAB/7.) * REAL(LD1))
C
C  INITIALIZE NECESSARY VARIABLES
        LFLAG = 0
        IF(KTD.EQ.1) IYR = IYR -1
        DO 5 I = 1,NPDK
        VRQD(I) =0.
        GRQD(I) = 0.
5       APPN(I) = 0.
C
C  ENTER REALLOCATION LOOP IN ORDER OF PRIORITY
C
        DO 50 I=1,NPDK
        II = IPDKPR(I,2)
        IDXT = IDXCRP(II,IYR)
        K = KCP(II,2)
        IXS = IDXSYS(II)
        ICPXT = NINT(CRPDK(II,IDXT,K))
        OAE = EAPP(ICPXT,II) * SUPRAM(3)/10000.
        TCAP = (SYSVAL(1,IXS) * EAPP(ICPXT,II) * SYSVAL(2,IXS)/10000.)
       1        * 86.4 * REAL(LD1)
C  CHECK IF PADDOCK HAS NO CROP
        IF(CRPDK(II,IDXT,K).NE.23.0.AND.CRPDK(II,IDXT,KCP(II,1)).NE.23.0)
       1  GO TO 10
        IF(CRPDK(II,IDXT,K).EQ.23.0.AND.CRPDK(II,IDXT,KCP(II,1)).NE.23.0)
       1  GO TO 10
```

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```
      GO TO 50
C  CHECK SYSTEM VOLUME IN PERIOD LD1
10    IF(ISF(IXS,2).EQ.1)GO TO 50
C
C  COMPUTE AMOUNT OF WATER TO BE ADDED TO PADDOCK
C
      VRQD(II) = SMD(II,2) * AREA(II) * 10.
      IF(VRQD(II).EQ.0.0) GO TO 50
      GRQD(II) = VRQD(II) / OAE
      GTEMP = GRQD(II)
C
C  CHECK SYSTEM, WATER AND LABOR CONSTRAINTS
C
C  CHECK SYSTEM CAPACITY
      SYSV(IXS,2) = SYSV(IXS,2) + VRQD(II)
      IF(SYSV(IXS,2).LE.TCAP) GO TO 20
      GRQD(II) =(TCAP - (SYSV(IXS,2) - VRQD(II)))/OAE
      ISF(IXS,2) = 1
C  CHECK WATER AVAILABILITY
20    TWTR = TWTR + GRQD(II)
      IF(TWTR.LE.AV) GO TO 25
      GTEMP = AV - (TWTR-GRQD(II))
      ATEMP = GTEMP * OAE / ( AREA(II) * 10.)
      LFLAG = 1
C  CHECK LABOR AVAILABILITY
25    RXL = TLAB(II)/((CRPDK(II,IDXT,K+3) - CRPDK(II,IDXT,K+2))
      TLBB = RXL * GRQD(II)*OAE/(AREA(II) * 10.)
      TLBR = TLBR + TLBB
      IF(TLBR.LT.ALB) GO TO 30
      APPN(II) = ((ALB - (TLBR - TLBB))/RXL)
      GRQD(II) = APPN(II) * AREA(II) *10. / OAE
      IF(GRQD(II).GT.GTEMP) GO TO 32
      LFLAG = 2
      GO TO 60
30    IF(LFLAG.LT.1) GO TO 35
32    GRQD(II) = GTEMP
      APPN(II) = ATEMP
      GO TO 60
35    APPN(II) = GRQD(II) * OAE/ (AREA(II) *10.)
50    CONTINUE
C
C  COMPUTE SOIL MOISTURE DEFICITS AND MODIFY THE SUMMARY ARRAY
C
60    DO 80 I=1,NPDK
      SMD(I,1) = SMD(I,2) - APPN(I)
      PDSUM(4,I,KPD) = PDSUM(4,I,KPD) + APPN(I)
      PDSUM(5,I,KPD) = PDSUM(5,I,KPD) + GRQD(I)
      PDSUM(6,I,KPD) = APPN(I)
80    CONTINUE
      JFLG (KPD,IYR) = LFLAG
      DO 90 I =1,NSYS
90    ISFLAG(I,KPD) = ISF(I,2)
      IF(KTD.EQ.1.) IYR = IYR + 1
      RETURN
      END
```

```fortran
      SUBROUTINE LOCATE (LUA,LUB,ISTART)
C
C  SUBROUTINE TO LOCATE STARTING RECORDS IN RAINFALL AND PET FILES
C  --LVA = LU OF RAINFALL FILE
C  --LUB = LU OF PET FILE
C  -- ISTART =STARTING YEAR
C
      COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
     1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
     2,IPDKPR(20,2),KCP(20,2)    ,IDXSYS(20),JFLG(0:24,50),
     3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
     4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
     5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
     6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
     7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
C
20    READ(LUA,101,END=80) LYEAR
101   FORMAT(13X,I2)
      IDIF = ISTART - LYEAR
      IF(IDIF)30,40,20
30    WRITE(8,150) LUA,NYEAR
      WRITE(10,150) LUA,NYEAR
150   FORMAT(' FILE ON UNIT ',I2,' BEGINS AT 19',I2,'.  >RUN TERMINATED'
     1'<'/1X,80('X'))
      STOP
40    BACKSPACE (LUA)
C
50    READ(LUB,102,END=85) LYEAR
102   FORMAT(3X,I2)
      IDIF = ISTART - LYEAR
      IF(IDIF) 70,60,50
60    BACKSPACE (LUB)
      GO TO 90
C
70    WRITE(8,150) LUB,LYEAR
      WRITE(10,150) LUB,LYEAR
      STOP
80    WRITE(8,151) LUA,LYEAR
      WRITE(10,151) LUA,LYEAR
151   FORMAT(' FILE ON UNIT ',I2,'ENDS AT 19',I2,'.  >RUN TERMINATED<'/
     11X,80('*'))
      STOP
85    WRITE(8,151) LUB,LYEAR
      WRITE(10,151)LUB,LYEAR
      STOP
C
C  READ FIRST YEAR'S DATA
C
90    CALL LOAD(LUA,ISTART)
      READ(LUB,105)PET
105   FORMAT(5X,12F6.1)
      RETURN
      END
```

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```fortran
      SUBROUTINE LOAD(NG,IY)
C     LOADS RAINFALL FOR 1 YEAR INTO ARRAY RAIN
C     NG = UNIT OF FILE TO BE READ
C     IY = NUMBER OF CURRENT YEAR
      COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
     1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
     2,IPDKPR(20,2),KCP(20,2)    ,IDXSYS(20),JFLG(0:24,50),
     3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
     4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
     5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
     6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
     7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
      DIMENSION NDAY(12),ID(31)
      DATA NDAY/31,28,31,30,31,30,31,31,30,31,30,31/
      NADD=IY/4-(IY-1)/4
      NDAY(2)=28+NADD
      K=0
      DO 100 IM=1,12
      READ(NG,61)JY,MM,ID
 61   FORMAT(11X,I4,I2,14I4/1X,17I4)
      DO 150 J=1,NDAY(IM)
      K = K+1
      RAIN(K)=ID(J)
 150  CONTINUE
 100  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE AGRON(LUA,LUB)
C
C  SUBROUTINE AGRON FOR READING AGRONOMIC DATA FOR CROP DATES
C  AND POLYNOMIAL COEFFICIENTS FOR CROP ET CURVES
C  --COEFFICIENTS ARE FOR MODIFIED PENMAN EQUATION AS
C    USED BY THE USDA (1981)
C
C
C  NCP = NUMBER OF CROPS IN CROPS FILE
C  NCROPF = NUMBER OF CROPS IN CROPF FILE
      COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
     1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
     2,IPDKPR(20,2),KCP(20,2)    ,IDXSYS(20),JFLG(0:24,50),
     3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
     4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
     5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
     6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
     7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
      NCROPF = 12
C
C
C  READ CROPDATE FILE
C  TOTAL NO. OF CROPS -- NCP
      READ(LUA,501) NCP
501   FORMAT(I5,////)
C
      DO 10 I=1,NCP
10    READ(LUA,101) (ICROPS(J,I),J=1,4)
101   FORMAT(27X,4I10)
      READ(LUB,102)((CROPF(I,J),I=1,10),J=1,NCROPF)
102   FORMAT(22X,10E10.4)
C
      RETURN
      END
```

```
            SUBROUTINE YEARSUM (IYR,NYEAR,NTCP,NSYS,NPDK,J1,J2)
C
C   SUBROUTINE YEARSUM IS USED TO SUMMARIZE PERTINENT DATA FOR
C   EACH 2-WEEK PERIOD FOR EACH YEAR
C
C     IYR -- COUNTER NUMBER OF CURRENT YEAR
C     NYEAR -- TOTAL NUMBER OF YEARS
C     NTCP -- TOTAL NUMBER OF CROPS
C     NSYS -- TOTAL NUMBER OF SYSTEMS
C     NPDK -- TOTAL NUMBER OF PADDOCKS


        COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
       1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
       2,IPDKPR(20,2),KCP(20,2)    ,IDXSYS(20),JFLG(0:24,50),
       3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
       4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
       5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
       6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
       7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
        DIMENSION  WCA(8),ISCNT(20)
C
C   SUMMARY DATA ARE STORED IN ARRAY ANNSUM
C
C   --CLEAR ARRAY ON FIRST ACCESS
C
        IF(IYR.GT.1) GO TO 10
        DO 8 I=1,24
        DO 5 J=1,30
        DO 5 K=1,10
5       ANNSUM(K,J,I) = 0.
        DO 8 J=1,20
        DO 8 K=1,3
8       SYSUM(K,J,I) = 0.
        DO 9 I =1,20
9       TOTIRG(I) = 0.
C
C   SUMMARIZE DATA BY PERIOD
C
10      DO 70 ID =0,24
        IF(ID.LT.J1.OR.ID.GT.J2) GO TO 70
        I = ID
        IC = 0
        IF(IYR.EQ.1.AND.ID.EQ.0) GO TO 70
        IF(ID.EQ.0) I= 24
        IF(ID.EQ.24.AND.IYR.NE.NYEAR) GO TO 80
        IRRR = IYR
        IF(ID.EQ.0) IRRR = IYR - 1
        DO 14 IK = 1,20
14      ISCNT(IK) = 0
C
C   ENTER LOOP TO COLLATE DATA FROM EACH PADDOCK FOR EACH CROP
C
        DO 40 IC = 1,NTCP
```

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```fortran
      IX = IDCP(IC)
      J = 0
C CLEAR WORKING ARRAY
      DO 12 IK=1,8
12    WCA(IK)=0.
C LOOP FOR EACH PADDOCK
      DO 30 IP=1,NPDK
      IF(NINT(PDSUM(2,IP,ID)).NE.IX) GO TO 30
      IXXX = IDXCRP(IP,IRRR)
      J = 2
      K = KCP(IP,1)
      TOTIRG(IP) = TOTIRG(IP) + PDSUM(4,IP,ID)/(CRPDK(IP,IXXX,K+3)
     1           -CRPDK(IP,IXXX,K+2))
      WCA(1) = WCA(1) + (PDSUM(3,IP,ID)+PDSUM(6,IP,ID))* AREA(IP)
      WCA(2) = WCA(2) + AREA(IP)
      WCA(3) = WCA(3) + PDSUM(4,IP,ID)* AREA(IP)
      IF(WCA(1).GT.0.1) WCA(4)=1.
      IF(WCA(1).GT.0.1) ISCNT(IDXSYS(IP)) = 1
      WCA(7) = 1.
      TMP = PDSUM(3,IP,ID) - (PDSUM(4,IP,ID) + 0.5)
      IF(TMP.LE.0.0) GO TO 29
      WCA(5) = 1.
29    WCA(6) = WCA(6) + PDSUM(6,IP,ID)* AREA(IP)
30    CONTINUE
C
      IF (J.LT.1) GO TO 40
C --NET REQUIREMENT
      ANNSUM(1,IC,I) = ANNSUM(1,IC,I) + WCA(1)/WCA(2)
C --NET APPLICATION
      ANNSUM(2,IC,I) = ANNSUM(2,IC,I) + WCA(3)/WCA(2)
C --NET SUPPLEMENTAL APPLICATION
      SUPP = WCA(6)/WCA(2)
      ANNSUM(3,IC,I) = ANNSUM(3,IC,I) + SUPP
C --MAXIMUM DEFICIT
      DEF =(WCA(1) - WCA(3))/ WCA(2)
      IF(ANNSUM(4,IC,I).LT.DEF) ANNSUM(4,IC,I) = DEF
C --NET DEFICIT
      ANNSUM(10,IC,I) = ANNSUM(10,IC,I) + DEF
C --MAX SUPPLEMENTAL APPLICATION
      IF(ANNSUM(5,IC,I).LT.SUPP) ANNSUM(5,IC,I) = SUPP
C --NO. OF TIMES CROP APPEARS
      ANNSUM(6,IC,I) = ANNSUM(6,IC,I) + WCA(7)
C --NO. OF TIMES CROP REQUIRES WATER
      ANNSUM(7,IC,I) = ANNSUM(7,IC,I) + WCA(4)
C --NO. OF TIMES WATER DEMANDS ARE NOT MET
      ANNSUM(8,IC,I) = ANNSUM(8,IC,I) + WCA(5)
C --NO. OF TIMES REALLOCATED WATER IS ADDED
      IF(WCA(6).GT.0.1) ANNSUM(9,IC,I) = ANNSUM(9,IC,I) + 1.
C
40    CONTINUE
C
C SUMMARIES FOR EACH SYSTEM IN SUMMARY ARRAY
C
      DO 60 IS = 1,NSYS
```

```
C
C   CLEAR WORKING ARRAY
      DO 45 IK=1,8
45    WCA(IK) = 0.
C
      DO 50 IP =1,NPDK
      IF(IDXSYS(IP).NE.IS) GO TO 50
      WCA(1) = WCA(1) + PDSUM(5,IP,ID) * SUPRAM(3)/100.
      IF(ISFLAG(IS,ID).GT.0) WCA(2)=1.
50    CONTINUE
C
C   SUMMARIZE DATA FOR EACH SYSTEM
C   --TOTAL VOLUME ENTERING SYSTEM
      SYSUM(1,IS,I) = SYSUM(1,IS,I) + WCA(1)
C   --NUMBER OF TIMES SYSTEM IS REQUIRED
      SYSUM(2,IS,I) = SYSUM(2,IS,I) + REAL(ISCNT(IS))
C   --NUMBER OF TIMES SYSTEM SIZE IS LIMITING
      SYSUM(3,IS,I) = SYSUM(3,IS,I) + WCA(2)
60    CONTINUE
70    CONTINUE
      GO TO 95
C
C   TRANSFER DATA FOR PD 24 INTO PD 0 EXCEPT FOR LAST YEAR
C
80    DO 85 I = 1,20
      DO 85 J = 1,6
85    PDSUM(J,I,0) = PDSUM(J,I,24)
      DO 88 I=1,NSYS
88    ISFLAG(I,0) = ISFLAG(I,24)
      JFLG(0,IYR+1) = JFLG(24,IYR)
C
95    RETURN
      END
```

```
              SUBROUTINE SUMOUT(NYEAR,TITLE,NTCP,SYSNAM,NP,NPUMP,RINV,RLABC,
             1RLABI   ,OMI,FLATP,NPK,NSYS,CNAME,SUPTIT)

C
C   SUBROUTINE SUMOUT IS USED TO GENERATE AND PRINT OUTPUT SUMMARIES
C   FOR EACH SYSTEM AND EACH CROP
C
C     NYEAR -- NUMBER OF YEARS IN THE SIMULATION
C     NPK -- NUMBER OF PADDOCKS
C
C
C
        COMMON ICROPS(4,30),CROPF(10,15),RAIN(366),PET(12),CRPDK(20,30,8),
       1IDXCRP(20,50),MONLEN(12),RQI(20,2 ),AREA(20),MPRIOR(30,24)
       2,IPDKPR(20,2),KCP(20,2)     ,IDXSYS(20),JFLG(0:24,50),
       3ISFLAG(20,0:24),PDSUM(6,20,0:24),SYSV(20,2),ISF(20,2),SMD(20,2),
       4ANNSUM(10,30,24),SYSUM(3,20,24),SYSVAL(21,20),
       5NAPMP(0:20),IDXPMA(10,0:20),PWRPMP(20),QPMP(20),WCOST(10),
       6SUPRAM(22),TPUMP(29,20),EAPP(30,20),IDCP(30)
       7,NPKSYS(20),IPSYS(20,20),TLAB(20),TOTIRG(20)
C
        DIMENSION ITOT(10),IOUT(20,30),TREQ(24),TTW(24),TTL(24),PCP(40),
       1HRTOT(24),EL(12)
        CHARACTER*3 MNAME(12)
        CHARACTER*20 CNAME(30)*16,SYSNAM(21),SUPTIT
C
        CHARACTER*32 TITLE

        DATA MNAME/'JUN','JUL','AUG','SEP','OCT','NOV','DEC','JAN','FEB',
       1'MAR','APR','MAY'/,HRTOT/15,15,15,16,15,16,15,15,16,15,15,15,15,
       216,15,16,14,14.25,15,16,15,15,15,16/
C
C     WRITE A DESCRIPTIVE TITLE IN THE OUTPUT FILE
C
        WRITE(10,1000) TITLE,NYEAR
1000   FORMAT('1'///' IRRIGATION SIMULATION OUTPUT FOR'/1X,A//
       1' SUMMARIES ARE GIVEN FOR: '/
       2'    1. ADEQUACY OF IRRIGATION FOR ALL CROPS'/
       3'    2. IRRIGATION SYSTEM PERFORMANCE AND COST'/
       4'    3. RESULTS ARE BASED ON ',I2,' YEARS RECORDS FOR'/
       5'       RAINFALL AND PET DATA')
        NL =7
C
        RRINV = RINV
        RINV = RINV/100.
C
C   CLEAR NECESSARY ARRAYS
        DO 5 I=1,24
        TREQ(I) = 0.
        TTW(I) = 0.
5       TTL(I) = 0.
C
C   OUTPUT SUMMARIES FOR EACH CROP IRRIGATED
C
```

```
          DO 40 I = 1,NTCP
          I  = IDCP(I)
          DO 12 IPX=1,24
          IF(ANNSUM(6,I,IPX).GT.0.01) GO TO 14
12        CONTINUE
          GO TO 40
C
14        IF(NL.LT. 35) GO TO 18
          NL = 0
          WRITE (10,'(1H1)')
C
18        WRITE (10,1001) CNAME(I)
1001      FORMAT (////' CROP SUMMARY RESULTS FOR ',A,/
      1 1X,38('=')/)
          WRITE (10,1002) MNAME
1002      FORMAT(' ---- MONTH ------>',12(5X,A),3X,'SEASONAL'/
      1' ---- HALF ------->  ',12(' 1ST 2ND'),'  TOTAL'/
      2 1X,125('-'))
C
C  COMPUTE AND SET UP SUMMARY ARRAY
C  --OUTPUT IS IN INTEGER FORM
C
C  ---CLEAR ARRAY FOR SEASONAL TOTALS
C
          DO 20 J=1,8
20        ITOT(J) = 0
C
          DO 30 J = 1,24
C  --AVE WATER REQT
          IOUT(1,J) = 0
          IOUT(9,J) = 0
          IF(ANNSUM(6,I,J).LT.0.1) GO TO 21
          IOUT(1,J) = NINT(ANNSUM(1,I,J)/ANNSUM(6,I,J))
          IOUT(9,J) = NINT(100.*(ANNSUM(7,I,J)/ANNSUM(6,I,J)))
C  --AVE WATER REQT WHEN IRRIGATION IS REQUIRED
21        IOUT(2,J) = 0
          IOUT(3,J) = 0
          IOUT(4,J) = 0
          IOUT(5,J) = 0
          IF(ANNSUM(7,I,J).LT.0.1) GO TO 23
          IOUT(2,J) = NINT(ANNSUM(1,I,J)/ANNSUM(7,I,J))
C  --AVE IRRIG APPLICATION WHEN IRRIG IS REQD
          IOUT(3,J) = NINT(ANNSUM(2,I,J)/ANNSUM(7,I,J))
C  --% OF TIME REQT > APPLIED
          IOUT(4,J) = NINT(100.*(ANNSUM(8,I,J)/ANNSUM(7,I,J)))
C  --AVE DEFICIT WHEN IRRIG IS REQD
          IOUT(5,J) = NINT(ANNSUM(10,I,J)/ANNSUM(7,I,J))
C  --MAX DEFICIT
23        IOUT(6,J) = NINT(ANNSUM(4,I,J))
C  --AVE READJUSTMENT
          IOUT(7,J) = 0
          IF(ANNSUM(9,I,J).LT.0.1) GO TO 25
          IOUT(7,J) = NINT(ANNSUM(3,I,J)/ANNSUM(9,I,J))
C  --MAX READJUSTMENT
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```
25      IOUT(8,J) = NINT(ANNSUM(5,I,J))
C   --SUM SEASONAL TOTALS
        ITOT(1) = ITOT(1) + IOUT(1,J)
        ITOT(2) = ITOT(2) + IOUT(2,J)
        ITOT(3) = ITOT(3) + IOUT(3,J)
        ITOT(5) = ITOT(5) + IOUT(5,J)
        ITOT(7) = ITOT(7) + IOUT(7,J)
        TREQ(J) = MAX(TREQ(J),ANNSUM(7,I,J))
30      CONTINUE
C
C   PRINT OUT RESULTS
C
        WRITE(10,1004) (IOUT(1,J),J=1,24),ITOT(1)
1004    FORMAT(' AVERAGE IRRIG'//'   REQUIREMENT - (MM)',24I4,I6)
C
        WRITE(10,10041) (IOUT(9,J),J=1,24)
10041   FORMAT(' PERCENT OF TIME'//'   IRRIG IS REQD  (%)',24I4)
C
        WRITE(10,1005) (IOUT(2,J),J=1,24),ITOT(2)
1005    FORMAT(' AVE REQUIREMENT'//'   WHEN REQUIRED (MM)',24I4,I6)
C
        WRITE(10,1006) (IOUT(3,J),J=1,24),ITOT(3)
1006    FORMAT(' AVE APPLIED'//'   WHEN REQUIRED (MM)',24I4,I6)
        WRITE(10,1007) (IOUT(4,J),J=1,24)
1007    FORMAT(' PERCENT OF TIME'//'   REQT > APPLIED (%)',24I4)
C
        WRITE(10,1008) (IOUT(5,J),J=1,24),ITOT(5)
1008    FORMAT(' AVERAGE DEFICIT'//'   WHEN WTR REQD (MM)',24I4,I6)
C
        WRITE(10,1009) (IOUT(6,J),J=1,24)
1009    FORMAT(' MAXIMUM'//'   DEFICIT - - - (MM)' 24I4)
C
        WRITE(10,1010) (IOUT(7,J),J=1,24),ITOT(7)
1010    FORMAT(' AVERAGE'//'   READJUSTMENT  (MM)',24I4,I6)
C
        WRITE(10,1011) (IOUT(8,J),J=1,24)
1011    FORMAT(' MAXIMUM'//'   READJUSTMENT  (MM)',24I4)
C
        NL = NL + 27
40      CONTINUE
C
C   WRITE OUT SUMMARY OF CAUSES OF DECIFITS
C
        IF(NL.LT. 45) GO TO 45
        WRITE(10,'(1H1)')
        NL = 0
45      WRITE(10,1012)
1012    FORMAT(/81('=')//' PERCENT OF TIME DEFICITS OCCUR WHEN WATER IS'/
     1' REQUIRED DUE TO VARIOUS CONSTRAINTS'/)
C
        WRITE(10,1013) MNAME
1013    FORMAT(' ---- MONTH ------>',12(5X,A)/
     1' ---- HALF ------->  ',12(' 1ST 2ND')/1X,117('-'))
C                               272
```

```
C   --WATER AND LABOR CONSTRAINTS
      DO 48 I=1,NYEAR
      DO 48 J=1,24
      IF(JFLG(J,I).EQ.2) TTL(J)=TTL(J)+1
      IF(JFLG(J,I).EQ.1) TTW(J)=TTW(J)+1
48    CONTINUE
C
      DO 50 I = 1,24
      IOUT(1,I) = 0
      IOUT(2,I) = 0
      IF(TREQ(I).LT.0.1) GO TO 50
      IOUT(1,I) = NINT(100.*TTW(I)/TREQ(I))
      IOUT(2,I) = NINT(100.*TTL(I)/TREQ(I))
50    CONTINUE
      WRITE(10,1014) (IOUT(1,I),I=1,24)
1014  FORMAT(' WATER AS'/'   LIMITING - - - (%)',24I4)
      WRITE(10,1015) (IOUT(2,I),I=1,24)
1015  FORMAT(' LABOR AS'/'   LIMITING - - - (%)',24I4)
C
C   --SYSTEM CONSTRAINTS
      DO 55 I=1,NSYS
      DO 55 J=1,24
      IOUT(I,J) = 0
      IF(SYSUM(2,I,J).LT.0.1) GO TO 55
      IOUT(I,J) = NINT(100.*SYSUM(3,I,J)/SYSUM(2,I,J))
55    CONTINUE
      WRITE(10,1016)
1016  FORMAT(' SYSTEMS LIMITING (%)')
      DO 60 I=1,NSYS
60    WRITE(10,1017) SYSNAM(I),(IOUT(I,J),J=1,24)
1017  FORMAT(3X,A,I2,23I4)
C
C
C  COMPUTE AND PRINT OUT SUMMARY AND COST INFORMATION FOR SYSTEMS
C   -SUMMARY INFORMATION
C
      DO 120 I=1,NSYS
      WRITE(10,1020) SYSNAM(I)
1020  FORMAT('1',//' IRRIGATION SYSTEM SUMMARY FOR ',A/31X,20('=')//)
      TA = 0.
      DO 64 J=1,NPKSYS(I)
64    TA = TA + AREA(IPSYS(J,I))
C
      ITOT(1) = NINT(SYSVAL(1,I))
      ITOT(2) = NINT(SYSVAL(2,I))
      ITOT(3)  = NINT(SYSVAL(3,I))
      WRITE(10,1021) TA,ITOT(1),ITOT(2),ITOT(3)
C
C   --CHECK IF ATTACHED COMPONENTS ARE PRESENT
      IF(SYSVAL(4,I).LT.0.1.AND.SYSVAL(12,I).LT.0.01) GO TO 68
      WRITE(10,1022)
C
      DO 66 J=1,9
66    ITOT(J) = NINT(SYSVAL(J+3,I))
```
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```
      WRITE (10,1023) (ITOT(J),J=1,4),SYSVAL(8,I),(ITOT(J),J=6,9)
C
C  --CHECK IF UNATTACHED COMPONENTS ARE PRESENT
68    IF(SYSVAL(13,I).LT.0.1.AND.SYSVAL(21,I).LT.0.01) GO TO 72
      WRITE(10,1024)
      DO 70 J=1,9
70    ITOT(J) = NINT(SYSVAL(J+12,I))
      WRITE(10,1023) (ITOT(J),J=1,4),SYSVAL(17,I),(ITOT(J),J=6,9)
C
C  --INFLATION RATES, RATE OF RETURN, ETC.
72    WRITE(10,1025) RRINV,RLABC,RLABI,OMI,FLATP
C
C   COMPUTE ANNUAL COSTS FOR THE LIFE OF THE SYSTEM
C    --COMPUTE ENERGY COST FOR AVERAGE CONDITIONS
C    ----VOLUME IN EACH BILLING PERIOD FOR EACH PUMP
75    XT = 0.
      DO 76 J=1,NAPMP(I)
76    XT = XT +  QPMP(IDXPMA(J,I))
C   ----% OF WATER PUMPED BY ANY ONE PUMP
      DO 78 J = 1,NAPMP(I)
78    PCP(J) =  QPMP(IDXPMA(J,I))/XT
      PLUMP = 0.
      ANNRG = 0.
C
C  CALCULATE ENERGY COST FOR EACH PUMP
      DO 99 J=1,NAPMP(I)
      ID = IDXPMA(J,I)
C   --INDEXES OF 2-WK PDS IN BILLING PDS
      IDT = ID
      IF(NP.EQ.1) IDT = 1
      NBPD =NINT(12/(TPUMP(16,IDT)))
      IXPD = 2*NINT(TPUMP(17,IDT))
      LBPD = (NINT(TPUMP(16,IDT)))*2
C
C  COMPUTE POWER CHARGES FOR EACH BILLING PD.  .
      PWRCHG = 0.
      DO 98 II=1,NBPD
      WVOL = 0.
      HRS = 0.
C
C  COMPUTE WATER PUMPED IN EACH BILLING PD. (CUBIC M)
      DO 80 IJ=1,LBPD
      IXPD = IXPD +1
      IF(IXPD.GT.24) IXPD=IXPD-24
C
      IF(I.NE.0) GO TO 792
      DO 79 JJ=1,NSYS
79    WVOL = WVOL +(SYSUM(1,JJ,IXPD)/REAL(NYEAR))
      GO TO 794
792    WVOL = WVOL +(SYSUM(1,I,IXPD)/REAL(NYEAR))
794   HRS =HRS + HRTOT(IXPD)
80    CONTINUE
C
C  --HOURS OF OPERATION AND KWH
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```
          HROP =(WVOL *PCP(J)/QPMP(ID))/3.6
          WH  = HROP * PWRPMP(ID)
          DO 82 I1=1,12
82        EL(I1) = 0.
C
          IF( WH .LT.TPUMP(12,IDT).OR.TPUMP(12,IDT).LT.0.1) GO TO 85
          IF( WH .LT.TPUMP(13,IDT).OR.TPUMP(13,IDT).LT.0.1) GO TO 84
          EL(1) = TPUMP(12,IDT)
          EL(2) = TPUMP(13,IDT)
          EL(3) = WH - TPUMP(13,IDT)
          GO TO 86
C
84        EL(1) = TPUMP(12,IDT)
          EL(2) = WH - TPUMP(12,IDT)
          GO TO 86
C
85        EL(1) = WH
C
86        WHKW = WH * PWRPMP(ID)
          IF(WHKW.LT.TPUMP(14,IDT).OR.TPUMP(14,IDT).LT.0.1) GO TO 88
          IF(WHKW.LT.TPUMP(15,IDT).OR.TPUMP(15,IDT).LT.0.1) GO TO 87
          EL(4) = TPUMP(14,IDT)
          EL(5) = TPUMP(15,IDT)
          EL(6) = WHKW  - TPUMP(15,IDT)
          GO TO 89
C
87        EL(4) = TPUMP(14,IDT)
          EL(5) = WHKW - TPUMP(14,IDT)
          GO TO 89
C
88        EL(4) = WHKW
C
C   --SET UP FACTORS FOR NIGHT RATES
C
89        IF(TPUMP(18,IDT).EQ.0.0.AND.TPUMP(21,IDT).EQ.0.0) GO TO 95
          IF(WH.LT.TPUMP(24,IDT).OR.TPUMP(24,IDT).LT.0.1)GO TO 91
          IF(WH.LT.TPUMP(25,IDT).OR.TPUMP(25,IDT).LT.0.1)GO TO 90
          EL(7) = TPUMP(18,IDT)
          EL(8) = TPUMP(19,IDT)
          EL(9) = WH - TPUMP(19,IDT)
          GO TO 92
C
90        EL(7) = TPUMP(18,IDT)
          EL(8) = WH - TPUMP(18,IDT)
          GO TO 92
91        EL(7) = WH
C
92        IF(WHKW.LT.TPUMP(26,IDT).OR.TPUMP(26,IDT).LT.0.1) GO TO 94
          IF(WHKW.LT.TPUMP(27,IDT).OR.TPUMP(27,IDT).LT.0.1) GO TO 93
          EL(10) = TPUMP(26,IDT)
          EL(11) = TPUMP(27,IDT)
          EL(12) = WHKW - TPUMP(27,IDT)
          GO TO 95
C
```
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```
93      EL(10) = TPUMP(26,IDT)
        EL(11) = WHKW - TPUMP(26,IDT)
        GO TO 95
C
94      EL(10) = WHKW
C   --HOURS OF NIGHT PUMPING
95      PCT1 = 1.0
        PCT2 = 0.
        IF(TPUMP(29,IDT).LT.0.9) GO TO 98
        PCT1 = (24.0 - TPUMP(28,IDT))/24.
        PCT2 = 1 - PCT1
        IF(TPUMP(29,IDT).LT.1.5) GO TO 98
C
        HRS = HRS*24.
        IF(HRS.GT.HROP) GO TO 96
        WRITE(10,1026) HRS,HROP
        WRITE(8,1026) HRS,HROP
1026    FORMAT('CHECK ERROR IN VARIABLES HROP AND HRS IN SUMOUT',2F10.2)
C
        GO TO 98
96      IF(TPUMP(29,IDT).GT.2.5) GO TO 97
        PCT2 = (HROP -(PCT1*HRS))/HROP
        PCT1 = 1 - PCT2
        GO TO 98
C
97      PCT1 = (HROP -(PCT2*HRS))/HROP
        PCT2 = 1 - PCT1
C   --EQUATION FOR POWER COST FOR A BILLING PERIOD
98      PWRCHG = PWRCHG + TPUMP(4,IDT) + TPUMP(5,IDT)*PWRPMP(ID)
     1          +PCT1*(EL(1)*TPUMP(6,IDT) + EL(2)*TPUMP(7,IDT)
     2             +EL(3)*TPUMP(8,IDT) + PWRPMP(ID)*(EL(4)*TPUMP(9,IDT)
     3                +EL(5)*TPUMP(10,IDT)+ EL(6)*TPUMP(11,IDT)))
     4          +PCT2*(EL(7)*TPUMP(18,IDT) + EL(8)*TPUMP(19,IDT)
     5             +EL(9)*TPUMP(20,IDT) + PWRPMP(ID)*(EL(10)*TPUMP(21,IDT)
     6                +EL(11)*TPUMP(22,IDT) + EL(12)*TPUMP(23,IDT)))
C
C    TOTAL ANNUAL ENERGY COST
        ANNRG = ANNRG + PWRCHG + TPUMP(2,IDT) + TPUMP(3,IDT)*PWRPMP(ID)
        PLUMP = PLUMP + TPUMP(1,IDT)
99      CONTINUE
         IF(I.EQ.0) GO TO 150
C   --TOTAL ANNUAL LABOR COST
        TRLB = 0.
        DO 102 J=1,NPKSYS(I)
        TRLB = TRLB + TLAB(IPSYS(J,I))*TOTIRG(IPSYS(J,I))
102     CONTINUE
        CTLAB = (TRLB/REAL(NYEAR) ) * RLABC
C
C   --SET UP ARRAY OF ITEMIZED ANNUAL COSTS FOR THE LIFE OF THE SYSTEM
        DO 104 J=1,30
        DO 104 J1=1,20
104     IOUT(J1,J) = 0
C
        CATT = SYSVAL(7,I)
```

```
        CNA = SYSVAL(16,I) + PLUMP
        X1 = SYSVAL(8,I)/100.
        X2 = SYSVAL(9,I)
        X3 = SYSVAL(17,I)/100.
        X4 = SYSVAL(18,I)
C
        CRFATT =((X1*((1.+X1)**X2))/(((1.+X1)**X2)-1.)) * CATT
        CRFNA =((X3*((1.+X3)**X4))/(((1.+X3)**X4)-1.)) * CNA
        PW = 0.
        JL = NINT(SYSVAL(3,I))
        DO 110 J=1,JL
        IOUT(1,J) = J
C
C   --CAPITAL COSTS
        DO 105 J1=1,12
105     EL(J1) = 0.
        IF(J.GT.NINT(X2)) GO TO 106
        EL(3)   = CRFATT
        EL(2)   = X1 * CATT
        EL(1)   = EL(3) - EL(2)
        CATT = CATT - EL(1)

106     IF(J.GT.NINT(X4)) GO TO 107
C
        EL(6) = CRFNA
        EL(5) = CNA * X3
        EL(4) = EL(6) - EL(5)
        CNA = CNA - EL(4)
107     IOUT(2,J) = NINT(EL(1) +EL(4))
        IOUT(3,J) = NINT(EL(2) + EL(5))
        IOUT(4,J) = NINT(EL(3) + EL(6))
C
C   --OPERATING COSTS AS FF --> LABOR, ENERGY,MAINT,MISC,TOTAL
C   --LABOR
        IOUT(5,J) = NINT(CTLAB *((1.+RLABI/100.)**REAL(J-1)))
C   --ENERGY
        IOUT(6,J) = NINT(ANNRG *((1.+FLATP/100.)**REAL(J-1)))
C   --MAINTENANCE
        IOUT(7,J) = NINT((SYSVAL(11,I)+SYSVAL(20,I))*
     1                  ((1.+OMI/100.)**REAL(J-1)))
C   --MISCELLANEOUS
        IOUT(8,J) = NINT((SYSVAL(12,I)+SYSVAL(21,I))*
     1                  ((1.+OMI/100.)**REAL(J-1)))
        IOUT(9,J) = IOUT(6,J)+IOUT(7,J) + IOUT(8,J) + IOUT(5,J)
        IOUT(10,J) = IOUT(9,J) + IOUT(4,J)
C
C   COMPUTE PRESENT WORTH OF OPERATING EXPENSES
        PW = PW+((REAL(IOUT(9,J)))/((1.+RINV)**REAL(J)))
C
110     CONTINUE
C
C   COMPUTE ANNUAL COST
C   --WITH SUBSIDY
        CRF=(RINV*((1.+RINV)**SYSVAL(3,I)))/(((1.+RINV)**SYSVAL(3,I))-1.)
```

```
          SFDF = RINV/(((1.+RINV)**SYSVAL(3,I))-1.)
          DT1 = SYSVAL(4,I) + SYSVAL(13,I)+ PW
          DT2 = SYSVAL(10,I) + SYSVAL(19,I)
          DT3 = SYSVAL(6,I) + SYSVAL(15,I)
          DT4 = SYSVAL(5,I) + SYSVAL(14,I)
          AC1 = (DT1 * CRF) - (DT2 * SFDF)
C
C   ---WITHOUT SUBSIDY
          AC2= AC1 - (DT3)*CRF
          IC1 = NINT(AC1)
          IC2 = NINT(AC2)
          IC3 = NINT(DT4)
          WRITE(10,1027) SYSNAM(I),TA
          WRITE(10,1028) IC1,IC2,IC3
          WRITE(10,1029)
          WRITE(10,1030)((IOUT(J,J1),J=1,10),J1=1,JL)
120   CONTINUE
C
C  COSTS FOR WATER SUPPLY SYSTEM
C
          TA = 0.
          DO 132 I=1,NPK
132   TA = TA + AREA(I)
C
          WRITE(10,1031)SUPTIT
1031  FORMAT('1',// ' SUMMARY FOR WATER SUPPLY SYSTEM -- ',A/)
          ITOT(1) = NINT(SUPRAM(1))
          ITOT(2) = NINT(SUPRAM(2))
          ITOT(3) = NINT(SUPRAM(3))
          ITOT(4) = NINT(SUPRAM(4))
          WRITE(10,1032) TA, (ITOT(I),I=1,4)
C
C --CHECK IF ATTACHED COMPONENTS ARE PRESENT
          IF(SUPRAM(5).LT.0.1.AND.SUPRAM(13).LT.0.1) GO TO 140
          DO 136 I=1,9
136   ITOT(I) = NINT(SUPRAM(I+4))
          WRITE(10,1022)
          WRITE(10,1023)(ITOT(I),I=1,4),SUPRAM(9),(ITOT(I),I=6,9)
C
C  --CHECK IF UNATTACHED COMPONENTS ARE PRESENT
140   IF(SUPRAM(14).LT.0.1.AND.SUPRAM(22).LT.0.1) GO TO 144
          DO 142 I=1,9
142   ITOT(I) = NINT(SUPRAM(I+13))
          WRITE(10,1024)
          WRITE(10,1023)(ITOT(I),I=1,4),SUPRAM(18),(ITOT(I),I=6,9)
144   WRITE(10,1033) RRINV,OMI,FLATP
C
C  COMPUTE ANNUAL COSTS FOR THE LIFE OF THE SYSTEM
C  --ENERGY FOR PUMPING
          I = 0
          GO TO 75
150   CONTINUE
C  WATER COST
          WCST = 0.
```
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```
      IF(WCOST(1).EQ.0.0) GO TO 156
      DO 155 I = 1,24
      DO 155 J = 1,NSYS
155   WCST = WCST + SYSUM(1,J,I)
      WCST = WCST/REAL(NYEAR)* WCOST(1)
      GO TO 165
156   IF(WCOST(2).EQ.0.0) GO TO 160
      WCST = SUPRAM(2)* WCOST(2)
      GO TO 165
C
160   WCST = WCST + WCOST(3)
C
165   DO 167 J =1,30
      DO 167 J1=1,20
167   IOUT(J1,J) = 0
      CATT = SUPRAM(8)
      CNA = SUPRAM(17) + PLUMP
      X1 = SUPRAM(9)/100.
      X2 = SUPRAM(10)
      X3 = SUPRAM(18)/100.
      X4 = SUPRAM(19)
C
      CRFATT = ((X1*((1.+X1)**X2))/(((1.+X1)**X2)-1.)) * CATT
      CRFNA = ((X3*((1.+X3)**X4))/(((1.+X3)**X4)-1.)) * CNA
      PW = 0.
      JL = NINT(SUPRAM(4))
C
      DO 180 J=1,JL
      IOUT(1,J) = J
      DO 172 J1=1,12
172   EL(J1) = 0.
C
      IF(J.GT.NINT(X2)) GO TO 174
      EL(3) = CRFATT
      EL(2) = X1 * CATT
      EL(1) = EL(3) - EL(2)
      CATT = CATT - EL(1)
C
174   IF(J.GT.NINT(X4)) GO TO 176
      EL(6) = CRFNA
      EL(5) = X3 * CNA
      EL(4) = EL(6) - EL(5)
      CNA = CNA - EL(4)
C
176   IOUT(2,J) = NINT(EL(1) + EL(4))
      IOUT(3,J) = NINT(EL(2) + EL(5))
      IOUT(4,J) =  NINT(EL(3) + EL(6))
C
C  --OPERATING COSTS AS FF --> WATER, ENERGY, MAINT, MISC, TOTAL
C  --WATER
      IOUT(5,J) = NINT(WCST *((1.+OMI/100.)**REAL(J-1)))
C  --ENERGY
      IOUT(6,J) = NINT(ANNRG *((1.+FLATP/100.)**REAL(J-1)))
C  --MAINTENANCE
```

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```
         IOUT(7,J) = NINT((SUPRAM(12)+SUPRAM(21)) *
       1                ((1.+OMI/100.)**REAL(J-1)))
C  --MISCELLANEOUS
         IOUT(8,J) = NINT((SUPRAM(13) + SUPRAM(22)) *
       1                ((1.+OMI/100.)**REAL(J-1)))
C
         IOUT(9,J) = IOUT(5,J)+IOUT(6,J)+IOUT(7,J)+IOUT(8,J)
         IOUT(10,J) =IOUT(9,J)+IOUT(4,J)
C
C  PRESENT WORTH OF OPERATING EXPENSES
C
         PW = PW +((REAL(IOUT(9,J)))/((1.+RINV)**REAL(J)))
180      CONTINUE
C
C  COMPUTE ANNUAL COST
C  --WITH SUBSIDY
       AC1 = (SUPRAM(5)+SUPRAM(14) + PW) * CRF
       1     -(SUPRAM(11) + SUPRAM(20)) * SFDF
C
C  --WITHOUT SUBSIDY
       AC2 = (SUPRAM(5)-SUPRAM(7)+SUPRAM(14)-SUPRAM(16) + PW) * CRF
       1     -(SUPRAM(11)+SUPRAM(20))* SFDF
       IC1 = NINT(AC1)
       IC2 = NINT(AC2)
       IC3 = NINT(SUPRAM(6)+SUPRAM(15))
       WRITE(10,1027) SUPTIT,TA
       WRITE(10,1028) IC1,IC2,IC3
       WRITE(10,1034)
       WRITE(10,1030)((IOUT(J,J1),J=1,10),J1=1,JL)
1021  FORMAT(' TOTAL AREA SERVED (HECTARES) - - - - - -      ',F6.1/
      1   ' FLOW ENTERING SYSTEM (L/S) - - - - - - -     ',I4/
      2   ' PERCENT OF TIME SYSTEM OPERATES (%)  - -     ',I4/
      3   ' SYSTEM LIFE (YEARS)  - - - - - - - - - -     ',I4/)
C
1022  FORMAT(' INPUT DATA FOR ATTACHED COMPONENTS')
C
1023  FORMAT('    TOTAL CAPITAL COST ($) - - - - - - - - -',I8/
      1    '     CAPITAL NOT FINANCED OR SUBSIDIZED ($)',I8/
      2    '     SUBSIDIZED CAPITAL ($) - - - - - - - -',I8/
      3    '     FINANCED CAPITAL ($) - - - - - - - - -',I8/
      4    '     FINANCE INTEREST RATE (%)  - - - - - -',F10.1/
      5    '     TIME OF LOAN (YEARS) - - - - - - - - -',I8/
      6    '     SALVAGE VALUE ($)  - - - - - - - - - -',I8/
      7    '     ANNUAL MAINTENANCE EXPENSE ($) - - - -',I8/
      8    '     ANNUAL MISCELLANEOUS EXPENSE ($) - - -',I8/)
C
1024  FORMAT(' INPUT DATA FOR NON-ATTACHED COMPONENTS')
C
1025  FORMAT(' RETURN ON INVESTMENT (%) - - - - - - - - -',F10.1/
      1   ' LABOR WAGE RATE ($/HR)   - - - - - - - -',F11.2/
      2   ' INFLATION FOR LABOUR (%) - - - - - - - -',F10.1/
      3   ' INFLATION FOR OPERATION AND MAINT. (%) -',F10.1/
      4   ' INFLATION FOR ENERGY (%) - - - - - - - -',F10.1/'1')
C
```

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```fortran
1027  FORMAT(///' EXPECTED COSTS FOR IRRIGATION FOR ',A/
     1' OVER THE LIFE OF THE SYSTEM'
     2//' THE SYSTEM SUPPLIES ',F6.1,' HECTARES')
C
1028  FORMAT(/' TOTAL OVERALL ANNUAL COST ($) - - - - - - - -',I8/
     1   ' OVERALL ANNUAL COST EXCLUDING SUBSIDIES ($) -',I8/
     2   '  (NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)'//
     3   ' TOTAL CAPITAL COST NOT SUBSIDIZED OR FINANCED ($) -',I8)
C
1029  FORMAT(//8X,'- - - CAPITAL COSTS - - -      OPERATING '
     1'COSTS FOR AVERAGE CONDITIONS ',7X,'OVERALL'//' YEAR '
     2'REPYMNT   INTRST    TOTAL     LABOR    ENERGY    MAINT    '
     3'MISC    TOTAL',8X,'TOTAL'/2X,91('-'))
C
1030  FORMAT(3X,I2,1XI8,1XI8,1XI8,2X,I9,I9,I9,I9,I9,I13)
C
1032  FORMAT(' TOTAL AREA SERVED (HECTARES) - - - - - -     ',F5.1/
     1   ' SYSTEM CAPACITY'/
     2   '    MAX VOLUME DELIVERED (CUBIC M/24 HR) ',I8/
     3   '    MAX FLOW RATE (L/S) - - - - - - - - -',I8/
     4   ' CONVEYANCE EFFICIENCY (%) - - - - - - - -',I8/
     5   ' SYSTEM LIFE (YEARS) - - - - - - - - - - -',I8/)
C
1033  FORMAT(' RETURN ON INVESTMENT (%) - - - - - - - - -',F10.1/
     1   ' INFLATION FOR OPERATION AND MAINT. (%) -',F10.1/
     2   ' INFLATION FOR ENERGY (%) - - - - - - - - -',F10.1/'1')
C
1034  FORMAT(//8X,'- - - CAPITAL COSTS - - -      OPERATING C'
     1'OSTS FOR AVERAGE CONDITIONS ',5X,'OVERALL'//' YEAR '
     2' REPYMNT   INTRST    TOTAL     WATER    ENERGY    MAINT    '
     3'MISC    TOTAL',8X,'TOTAL'/2X,91('-'))
C
      RETURN
      END
```

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```
      SUBROUTINE LUNITS(II,JJ)
C  SUBROUTINE TO ASSIGN LOGICAL UNIT NOS. FOR INTERACTIVE USE
      INTEGER*2 LUA, LUB, PHDEV1
      INTEGER*2 ZERO, BUFSIZ
       PHDEV1 = 1
       LUA = II
       LUB = JJ
       ZERO = 0
       BUFSIZ = 80
      CALL ATTDEV (LUA, PHDEV1, ZERO, BUFSIZ)
      CALL ATTDEV (LUB, PHDEV1, ZERO, BUFSIZ)
      RETURN
      END
```

APPENDIX B
AGRONOMIC DATA FILE LISTINGS

CONTENTS   Page

23 CROPS -- DATES REFER TO NO. OF DAYS WITH JUNE 1 AS DAY NO.1
THE FORMAT IS 1X,16A1,5I10
CROP NO.23 MUST REMAIN CULTIVATION FOR USE IN SIMULATION MODEL

CROP NAME	CROP NO.	PLANTING DATE	EFFECTIVE COVER DATE	HARVEST DATE	POLYNOMIAL CURVE NO.
WINTER WHEAT1	1	31	160	214	5
SPRING WHEAT1	2	62	160	214	5
SPRING WHEAT2	3	93	175	214	5
SPRING WHEAT3	4	123	190	230	5
BARLEY1	5	93	175	214	5
BARLEY2	6	123	190	230	5
BARLEY3	7	154	205	245	5
PEAS1	8	62	183	214	6
PEAS2	9	93	190	220	6
PEAS3	10	123	200	230	6
PEAS4	11	154	214	245	6
WHTCLOVER1	12	1	122	214	11
WHTCLOVER2	13	1	122	245	11
WHTCLOVER3	14	1	122	273	11
RYEGRASS 1	15	1	122	214	11
PASTURE1	16	1	30	365	8
PASTURE2	17	246	275	365	8
PASTURE3	18	275	305	365	8
PASTURE4	19	305	334	365	8
GREENFEED1	20	250	295	365	2
GREENFEED2	21	275	310	365	2
GREENFEED3	22	305	334	365	2
CULTIVATION	23	1	1	365	12

```
CORN                1-.1583E+010.2756E+01-.4276E+000.2130E+000.2750E-05-.4688E-030.1195E-010.9150E+000.1000E+000.1100E+01
SUGAR BEETS         2-.1435E+010.2382E+01-.2259E+000.2000E+00-.1670E-050.5000E-040.0000E+000.8990E+000.1000E+000.1100E+01
BEANS               3-.1353E+010.2562E+01-.3532E+000.2120E+000.1650E-05-.2644E-03-.1120E-030.1050E+010.1000E+000.1100E+01
ALFALFA             40.0000E+000.0000E+000.1087E+010.2500E+000.0000E+000.0000E+000.2500E+000.5000E+000.1000E+000.1000E+01
SMALL GRAIN         5-.2893E+010.4843E+01-.1140E+010.2330E+000.4440E-05-.7261E-030.8532E-020.1022E+010.1000E+000.1100E+01
PEAS                6-.1321E+010.2470E+01-.3067E+000.2110E+00-.2110E-04-.9865E-03-.1010E-010.1005E+010.1000E+000.1100E+01
POTATOES            7-.1381E+010.2456E+01-.3710E+000.2130E+000.0000E+000.0000E+000.0000E+000.9000E+000.1000E+000.7800E+00
PASTURE             80.0000E+000.0000E+000.1508E+010.2500E+000.0000E+000.0000E+000.0000E+000.8700E+000.1000E+000.8700E+00
ONIONS              9-.1381E+010.2456E+01-.3710E+000.2130E+000.0000E+000.0000E+000.0000E+000.9000E+000.1500E+000.1100E+01
GRAIN SORGHUM       10-.1583E+010.2756E+01-.4276E+000.2130E+000.2750E-05-.4588E-030.1195E-010.9150E+000.1000E+000.1100E+01
GRASS-CLOVER SEED   110.0000E+000.0000E+000.1508E+010.2500E+000.4440E-05-.7261E-030.8532E-020.1022E+010.1000E+000.8700E+00
CULTIVATION         120.0000E+000.0000E+000.0000E+000.2000E+000.0000E+000.0000E+000.0000E+000.2000E+000.2000E+000.2000E+00
```