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USER'S GUIDE
AGRICULTURAL FIELD SCALE IRRIGATION REQUIREMENTS SIMULATION (AFSIRS) MODEL

VERSION 5.5

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

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by

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TABLE OF CONTENTS

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INTRODUCTION

The Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) Model is a numerical simulation model which allows the user to estimate irrigation requirements (IRR) for Florida crops, soils, irrigation systems, growing seasons, and climate conditions. The irrigation requirement for crop production is the amount of water, exclusive of precipitation, that must be applied to meet a crop's evapotranspiration (ET) requirement without significant reduction in yield. IRR, as defined in this model, does not include leaching, freeze protection, or crop cooling requirements, even though water for these purposes may be applied through an irrigation system.

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Although the AFSIRS model is believed to be complete and accurate, no explicit or implicit warranties are made with regard to its use. The responsibility for the use of this model for any specific purpose lies solely with the user.

This Users Guide contains instructions for the use of the AFSIRS model. Details of the mechanisms of operation of the model, assumptions made in its development, and its applications and limitations are given in the AFSIRS model Technical Manual. The user is urged to consult the Technical Manual to determine whether the assumptions made in the model development limit its application for any specific purpose.

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The AFSIRS model is based on a water budget of the crop root zone and the concept that crop ET can be estimated from potential evapotranspiration (ETp) and crop water use coefficients. The water budget includes inputs to the crop root zone from rain and irrigation, and losses from the root zone by drainage and ET. The water storage capacity in the crop root zone is defined as the multiple of the water-holding capacity of the soil and the depth of the effective root zone for the crop being grown.

Irrigations are scheduled based on an allowable level (depth or volume) of soil water depletion from the crop root zone. Irrigation amounts are optionally calculated to restore the soil water content to field capacity, to apply a fixed amount of water per irrigation, or to restore the soil water content to a given fraction of field capacity (deficit irrigation). Either net irrigation requirements, which consider only the crop water needs, or gross irrigation requirements, which also considers the water application efficiency of the irrigation system being used, can be calculated.

The AFSIRS model uses historical climate data. Long-term (18-25 year) records of daily rainfall and potential ET for nine Florida locations are provided as a part of the model data base. These data are used to simulate daily irrigation requirements for each crop season. This long-term record of IRR is then used to calculate statistical parameters including the probabilities of occurrence of IRR for fractions of the crop growing season.

LOADING THE AFSIRS MODEL

The AFSIRS model was developed for IBM-compatible (MS/DOS) microcomputers. The model and required data bases are provided on 5.25-inch, double-sided, double-density floppy diskettes containing the following files:

Computer Code Files (Program Listings)

AFSIRS.FOR = FORTRAN source code, interactive model version
AFSIRS-B.FOR = FORTRAN source code, batch model version

Computer Machine Code (Executable Files)

AFSIRS.EXE = computer machine code, interactive model version
AFSIRS-B.EXE = computer machine code, batch model version

Data Files

Crop Data File

CROP.DAT = crop coefficient data base

Irrigation System Data File

IR.DAT = irrigation systems and coefficients data base

Soil Characteristic Data Files

SOIL-776.DAT = soil water-holding characteristic data base (complete SCS mapped soil series list)
SOIL-GEN.DAT = generic soil water-holding characteristic data base
SOIL.DAT = soils data base read during model execution

Batch Model Data File

INPUT.DAT = data file read by the AFSIRS batch model (AFSIRS-B). The INPUT.DAT file provided contains data for the example simulation of citrus irrigation requirements in Appendix B.

Climate Data Files

CLIM.APL = climate data base for Apalachicola
CLIM.DTB = climate data base for Daytona Beach
CLIM.JAX = climate data base for Jacksonville
CLIM.MIA = climate data base for Miami
CLIM.MOB = climate data base for Mobile, Alabama
CLIM.ORL = climate data base for Orlando
CLIM.TAL = climate data base for Tallahassee
CLIM.TAM = climate data base for Tampa
CLIM.WPB = climate data base for West Palm Beach

The AFSIRS model computer program reads four data bases during execution: CROP.DAT, IR.DAT, SOIL.DAT, and one of the climate data files. The CROP.DAT, IR.DAT, and climate data files will be read without modification of the files provided.

SOIL.DAT is the soils data base that will be used by the AFSIRS model. Therefore, first copy one of the SOIL----.DAT data bases to a file titled SOIL.DAT. For future simulations, the soils data base accessed by the model can be changed by copying the appropriate data base to the SOIL.DAT file.

Model Versions

Two versions of the AFSIRS model were developed. An interactive version (AFSIRS.EXE) was developed to allow the user to make the required data inputs to the model from the computer keyboard in response to prompts from the model as they are displayed on the computer screen. This version will be the most easily used by the average user because all data needs are prompted as they are needed, default values are provided for most inputs required, range checking is performed on most inputs, and error checking is performed on all data inputs to ensure that the correct data form is entered.

A second version of the AFSIRS model was developed to permit model use in a batch mode. This version requires that the user create a data input file, INPUT.DAT, from which data inputs are read as they are needed during execution of the model. This version allows the user to make successive simulations without needing to interact with the computer.

Both the interactive and batch mode models were compiled using the Microsoft FORTRAN emulator math library. This approach allows the compiled versions of the model to be used with microcomputers equipped with math co-processors as well as those without math co-processors. Because the math co-processor speeds mathematical computations, the model execution time will be much improved with this capability. Because the FORTRAN source code is also distributed, users can compile the model for other system configurations if required.

Computer Hardware Requirements

The use of the AFSIRS model requires a microcomputer equipped with a minimum of 640K RAM and a minimum of two floppy disk drives. The recommended hardware configuration is a microcomputer equipped with a math co-processor and a hard disk drive. These features will speed the handling of the large data bases and the overall operation of the model.

Hard Disk Microcomputer Systems

For a microcomputer equipped with a hard disk with sufficient storage capacity, the interactive AFSIRS model is loaded in the following steps:

1. Copy the AFSIRS.EXE file and at least the four data files (CROP.DAT, IR.DAT, SOIL.DAT, and one of the CLIM.--- files) to the same hard disk directory or sub-directory. If space permits, other files may also be copied to the hard disk for convenience in later use.

2. Make the hard disk directory where the AFSIRS model files are located the default directory. Type AFSIRS to begin execution.

3. The output file name and disk drive location will be specified by interactions with the model. If the output file is to be written to a floppy disk drive, place a formatted, blank disk (or a disk with sufficient space available for the output file size anticipated) in that drive. The computer will create the output file as the model is executed. If the disk drive is not specified when the output file name is prompted, the file will be created on the default (hard) disk.

Floppy Disk Microcomputer Systems

For microcomputers equipped only with two floppy disks, the AFSIRS model is loaded in the following steps:

1. Boot the computer using your system disk. The AFSIRS model is not self-booting.

2. Copy the AFSIRS.EXE, CROP.DAT, IR.DAT, and SOIL.DAT files to a single floppy disk. Place this disk into disk drive A. This will be the default drive during model execution.

3. Copy the desired climate data file(s) to a second floppy disk. Place the climate data disk in computer disk drive B. Output files will also be written to this disk. Because of the size of the climate data files, limit the number of climate data files on this disk to one or two, in order to leave room for output files.

4. Be sure that drive A is the default drive. Type AFSIRS. The model will be loaded and execution will begin. When prompted to name the output file, identify it as being located on drive B: by using the form B:filename.

In both cases the procedure for the use of the AFSIRS batch mode model is identical to that for the interactive model except that the user-created INPUT.DAT file must also be located on the default drive with the AFSIRS model machine code, and the batch model is run by typing its file name, AFSIRS-B. Because of data storage requirements, it is strongly recommended that the batch mode model only be used on computer systems equipped with hard disk drives.

RUNNING THE AFSIRS MODEL: INTERACTIVE VERSION

The interactive version of the AFSIRS model questions the user for inputs for each entry. Most entries are selected from the model data bases. Other data are input by the users from their knowledge of the crop production system being simulated. For most data required, users may elect either to accept the AFSIRS Model default values, or to enter data from the keyboard while the model is executing.

Data Entries

Entries to the AFSIRS model are made by typing them from the computer keyboard. Numerical entries are prompted for most responses. Entries must be made by typing an appropriate response, followed by <carriage return>, <return>, or <enter>, depending on the specific keyboard used. For brevity, entries will be specified as numerical values or text entries only throughout this manual. It is implicit that each specific entry is followed by <carriage return>, <return>, or <enter>, as appropriate.

Errors in Data Entry

If entries are incorrectly made, such that they cannot be read by the computer, a data input error will result. This will cause the computer to repeat the prompt for the same data entry. This will occur, for example, if alphabetic or punctuation characters are entered when the computer expects to read numeric characters. If this occurs, merely make an acceptable response at the second prompt.

If numeric entries are made, but they are out of the range of acceptable responses, the computer will again prompt for that data entry. If a response must be chosen from a list, the list will be given, or a code will be given to allow the user to request the list of acceptable responses. Prompts will be repeated until an acceptable entry is made.

If an error is made in data entry, such that the response is acceptable to the computer, but it is not the desired entry, enter <u>-99 for the next data entry</u> requested. In most cases, this will cause the computer to backspace and again prompt for the previous data entry.

If an error is made in data entry, but it is not discovered until more than 1 additional entry is made, in some cases it is possible to "backspace" to the incorrect entry by entering -99 for each intermediate data entry. All of the intermediate entries will be lost when you backspace past them. They will then need to be re-entered in sequence after the error is corrected. All entries should be made only when prompted by the computer.

In some cases, because of the structure of the computer code, it will not be possible to backspace to the previous entry. If that occurs, continue to the end of all data entries. At that point, the computer will prompt:

ENTER 1 TO COMPUTE
ENTER 0 TO RETURN TO DATA ENTRY MODE:

Enter 0 to re-initialize data entry. This feature will allow you to avoid computations made with erroneous entries. However, all interactive data entries will again need to be made.

Interactive Use

After loading the AFSIRS model, the model title and a brief description, disclaimer, and operating instructions as shown in Figure 1 will be displayed. This includes the model version number. The version for use with this User's Guide is Version 5.5. If the text shown in Figure 1 is displayed, the model was successfully loaded and is now ready for interactive use.

In the following paragraphs, each interaction with the AFSIRS model is described. In Appendix A, an example of the user interactions with the AFSIRS model for the simulation of irrigation requirements for micro irrigated citrus grown on Astatula fine sand near Tampa are given. Reference to this example may help clarify the requests for the several data entries required by the AFSIRS model.

A. Output File Name and Location:

After displaying the header information, the computer will pause so that the header can be read. The computer will then prompt:

PRESS <RETURN> TO CONTINUE :

Press <return> to begin interactive data entry. The computer will then prompt for the name and location of the output file:

ENTER OUTPUT FILE NAME:

This option allows the user to specify the disk drive and file name where the output file will be located. If, for example, the user's response is B:OUT.AFS, the outputs will be written to a file titled OUT.AFS that the model will create on disk drive B:. If the user merely responds OUT, an output file titled OUT will be created in the current (default) directory.

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AGRICULTURAL
FIELD
SCALE
IRRIGATION
REQUIREMENTS
SIMULATION

MODEL

AFSIRS MODEL: INTERACTIVE VERSION 5.5

THIS MODEL SIMULATES IRRIGATION REQUIREMENTS
FOR FLORIDA CROPS, SOILS, AND CLIMATE CONDITIONS.

PROBABILITIES OF OCCURRENCE OF IRRIGATION REQUIREMENTS
ARE CALCULATED USING HISTORICAL WEATHER DATA BASES
FOR NINE FLORIDA LOCATIONS.

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ALTHOUGH THIS MODEL IS BELIEVED TO BE COMPLETE AND ACCURATE, NO EXPLICIT OR IMPLICIT WARRANTIES ARE MADE WITH REGARD TO ITS USE.

THE RESPONSIBILITY FOR THE USE OF THIS MODEL FOR ANY SPECIFIC PURPOSE LIES SOLELY WITH THE USER.

INSTRUCTIONS FOR THE USE OF THIS MODEL ARE GIVEN IN THE AFSIRS MODEL OPERATOR'S MANUAL.

DETAILS OF THE OPERATION OF THIS MODEL, ITS APPLICATIONS AND LIMITATIONS ARE GIVEN IN THE AFSIRS MODEL TECHNICAL MANUAL.

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Figure 1. Model title, description, disclaimer, and operating instructions given when the AFSIRS model is initiated.

The length of the output file name can be up to 20 characters to permit the designation of disk drive, file directories, and sub-directories in addition to the standard eight-character file name with its extension.

If the output file specified interactively already exists, or if an illegal file name is entered, the following statement will be displayed:

FILE ALREADY EXISTS OR ILLEGAL FILE NAME

ENTER 1 TO OVER-WRITE:
ENTER 0 TO SPECIFY NEW OUTPUT FILE NAME:

If the user enters 1, the existing file with the specified file name will be over-written. The user should enter 0 to correct an illegal file name or to protect an existing file from being over-written. If 0 is entered, the computer will again prompt for interactive entry of the output file name.

B. Simulation Date:

The date that the AFSIRS model simulation was run is requested and printed on each output. The computer will prompt:

ENTER TODAY'S DATE (MONTH, DAY, YEAR):

A numerical value must be entered for each variable, such as 8, 31, 1989 for August 31, 1989. This date is printed as 8 - 31 - 1989 on the outputs produced.

When multiple entries are requested, such as the three entries required for the date, all entries can be made on one line, separated by commas. Alternatively, each entry can be made separately, with each followed by <carriage return>, <return>, or <enter>.

C. Location or Site Description:

Terms which describe the field site or location for which irrigation requirements are being calculated are requested by the next computer prompt:

ENTER LOCATION / SITE DESCRIPTION:

This may be the field, farm, or grower identifier. A total of 36 characters are allocated to this description. After the identifier or description is entered, it is reiterated by the computer for verification.

D. Style of Output:

The user is requested to select a style of output as follows:

ENTER ICODE TO DEFINE STYLE OF OUTPUT:

ICODE = -1 FOR BASIC (MINIMAL) OUTPUT
ICODE = 0 FOR BASIC PLUS BIWEEKLY AND WEEKLY SUMMARIES
ICODE = 1 FOR OUTPUT OF INTERMEDIATE PARAMETERS
ICODE = 2 FOR EXTENSIVE OUTPUT (NORMALLY USED FOR DEBUGGING ONLY)

If ICODE = -1 is entered, the output will be very brief. It will summarize all inputs, and a table of the seasonal and monthly irrigation requirements and probabilities of occurrence will be printed. This is the output style that will probably be most often used.

If ICODE = 0, 1, or 2 are entered, increasingly greater data summaries will be output. The entry of 0 will result in the addition of bi-weekly and weekly summaries of IRR to the previous monthly and seasonal summaries. This style will be useful if irrigation requirements for shorter than monthly periods are required.

The entry of 1 will result in the output of seasonal, monthly, bi-weekly, and weekly IRR, as well as all of the soil, crop, and irrigation system parameters used in the current simulation. This output style will allow the user to observe the causes of differences in irrigation requirements simulated for the various input parameters.

The entry of 2 will result in the printing of all of the previously described outputs plus all components of the daily water budget for each day simulated. This will be a very large output. Thus, this style should only be used for checking the mechanisms of operation of the model, and it is advisable that only short growing seasons (rather than 365 days per year) be specified when this output style is selected.

After ICODE is selected and entered, the computer will respond "ICODE ENTERED WAS = __". This reiteration of the ICODE entered will allow verification that it was correctly entered. If it was not correctly entered, backspace to this data entry by entering -99 for the next requested data entry.

If ICODE was entered as 0, 1, or 2, additional information will be requested to describe the style of output. The computer will prompt:

ENTER CODE TO SUPPRESS PRINTING OF DATA SUMMARIES
WHEN IRRIGATION REQUIREMENTS = 0.0

PRINT CODE = 1 TO SUPPRESS PRINTING
PRINT CODE = 0 TO PRINT ALL ZEROS

Enter 0 to print data for all summary periods, even if the data are all zeros, as would be the case for those times of the year when this crop is not grown or when irrigation is not practiced. Enter 1 to only print those summary periods when the irrigation requirements data are non-zero. This option will reduce the length of output file generated.

E. Graphics Option:

The AFSIRS model has the capability of producing graphs of annual distributions of IRR for monthly, biweekly, and weekly periods. This option is prompted as follows:

ENTER 1 TO GRAPH OUTPUTS:
ENTER 0 FOR NO GRAPHS:

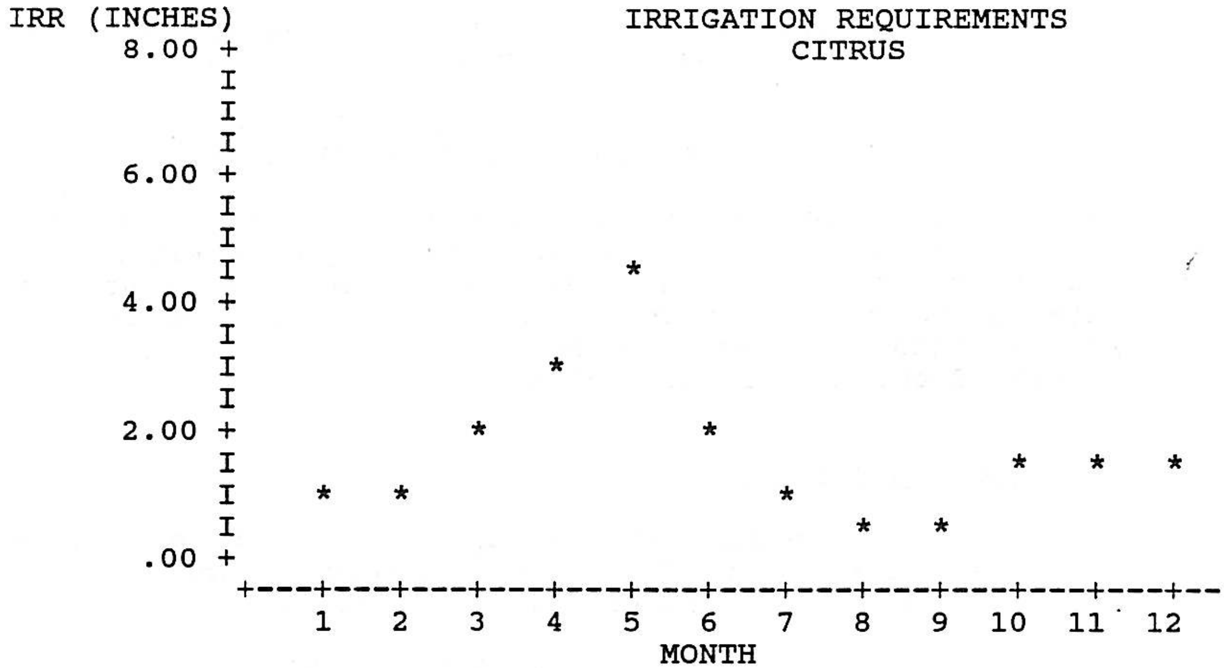
Computations and tabular outputs will proceed quicker if graphs are not produced. If 1 is entered, graphs such as those shown in Figures 2- 4 will be produced for the data summaries previously requested.

F. Style of Input:

Sensitivity analyses performed during the development of the AFSIRS model revealed that simulated irrigation requirements are very sensitive to data entries made for the crop root depth, the fraction of the soil surface irrigated (for micro irrigation systems), and the irrigation efficiency. Results indicated that site-specific conditions which restrict root growth, affect the amount of soil surface irrigated with a micro irrigation system, or affect irrigation efficiency, would also affect IRR for that site. For this reason, the AFSIRS model prompts:

IRRIGATION REQUIREMENTS CALCULATED USING THE AFSIRS MODEL
ARE VERY SENSITIVE TO THE CROP ROOT DEPTH, FRACTION
OF THE ROOT ZONE IRRIGATED AND IRRIGATION EFFICIENCY.

ENTER 0 TO USE THE MODEL DEFAULT VALUES FOR THESE DATA.
ENTER 1 IF THESE DATA WILL BE ENTERED FROM THE KEYBOARD.



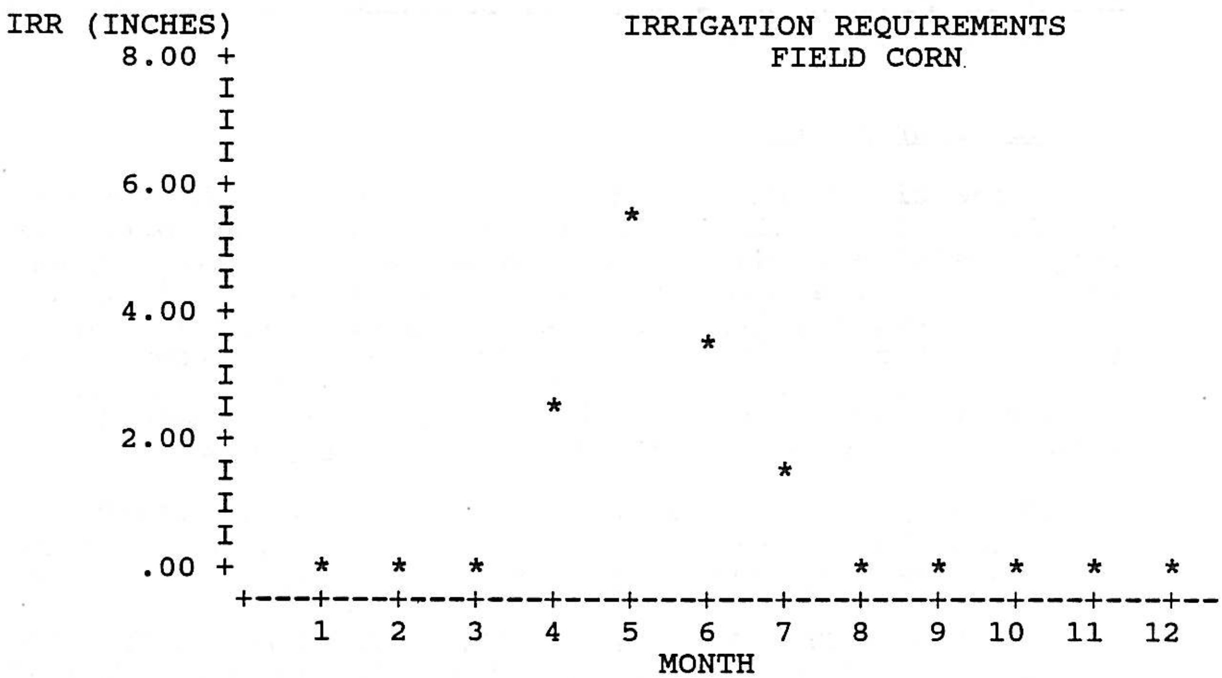
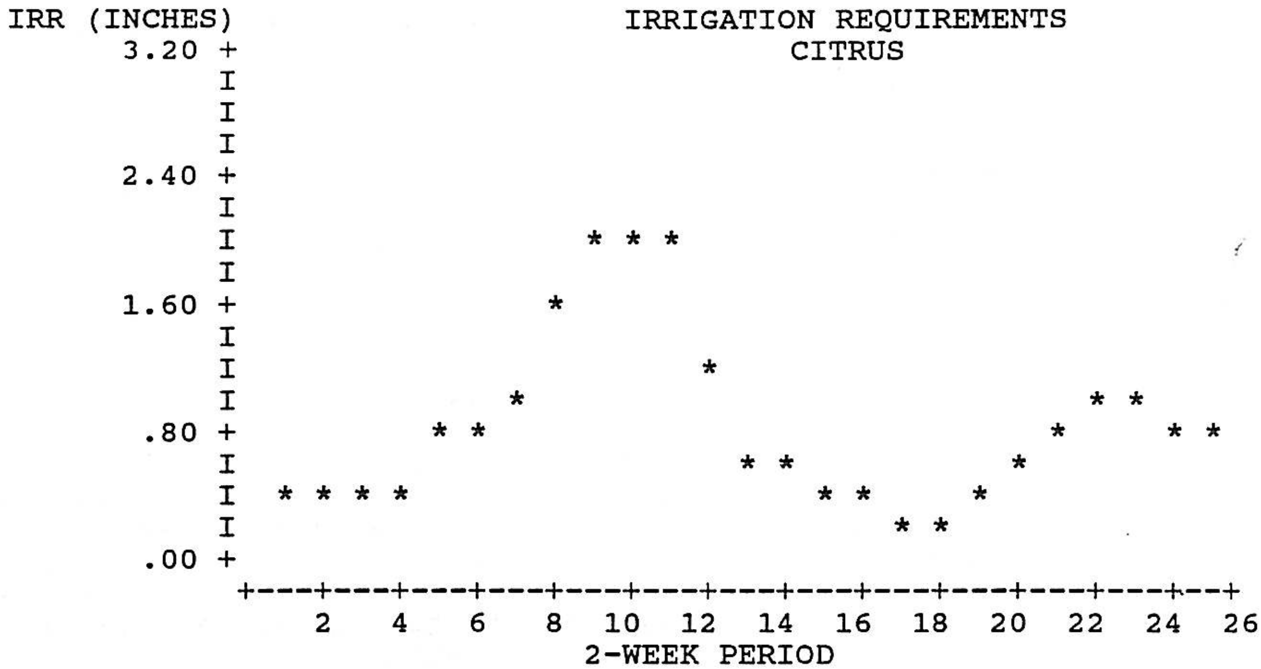


Figure 2. Typical graphs of monthly distribution of simulated irrigation requirements for citrus and field corn.



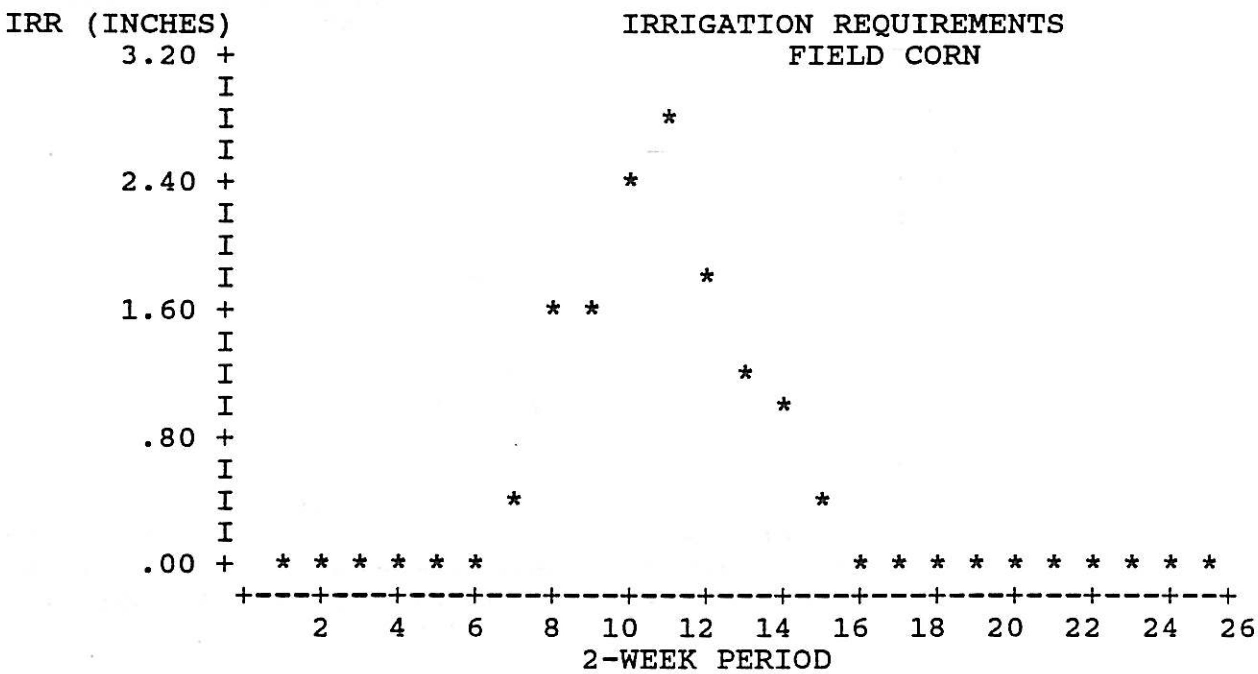
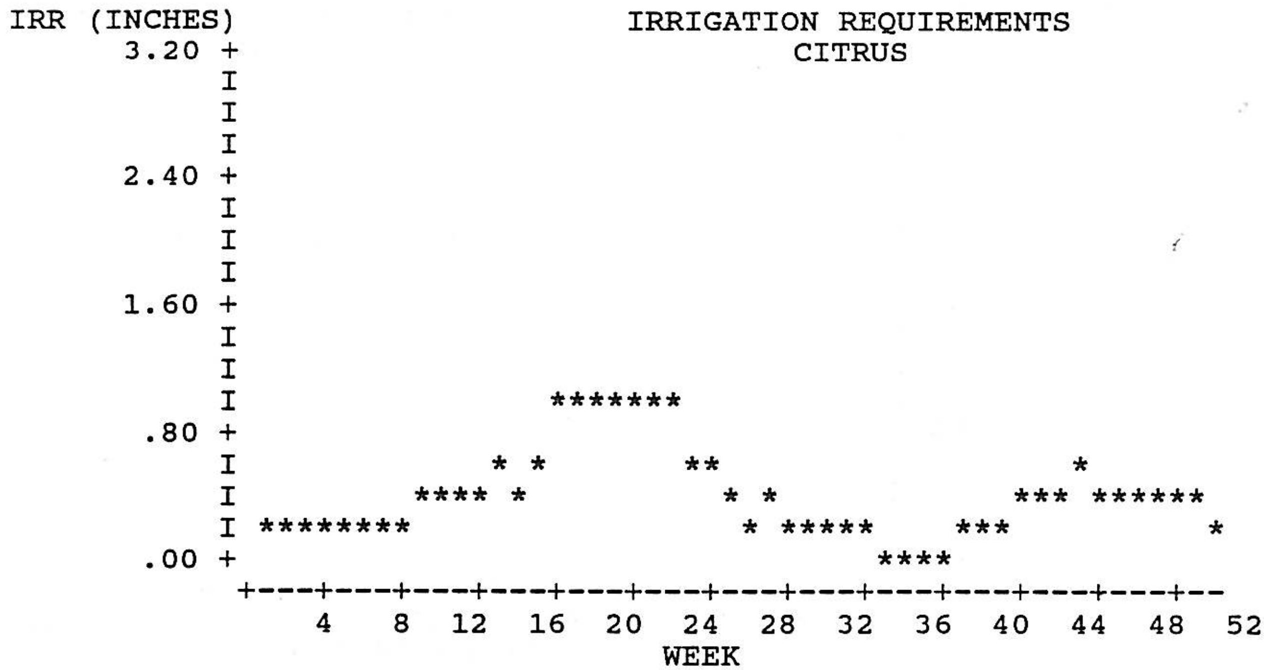


Figure 3. Typical graphs of bi-weekly distribution of simulated irrigation requirements for citrus and field corn.



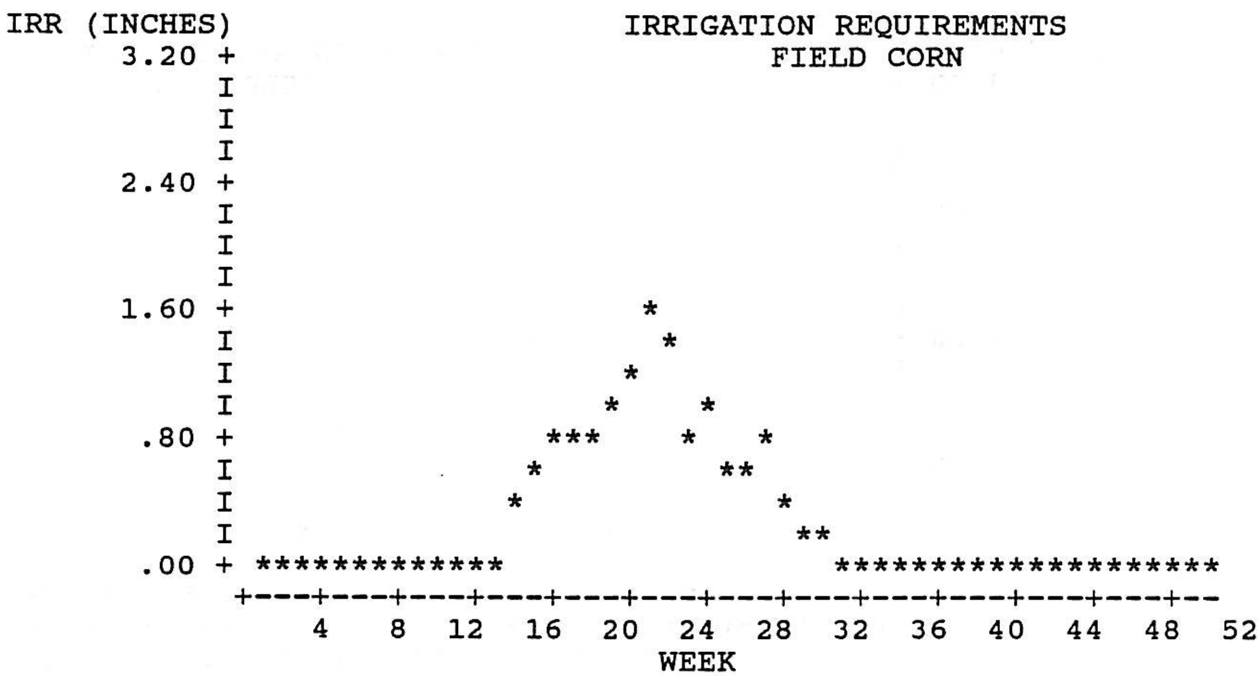


Figure 4. Typical graphs of weekly distribution of simulated irrigation requirements for citrus and field corn.

The entry of 0 for the input code will cause the model default values to be used to define total crop root depths, the depths of the crop root zone irrigated, the fraction of the soil surface irrigated with micro irrigation systems, and the irrigation efficiency. The entry of 1 for the input code will cause the computer to prompt the user for these entries for the specific crop production system being simulated. The prompts will occur later in the simulation when crop and irrigation system characteristic data are being read.

The input code will be reiterated by the computer for verification. If the code was incorrectly entered, or to backspace to the previous entry, enter -99 at the next prompt.

G. Crop Type:

The crop type (species) for which irrigation requirements are to be calculated is specified by selection from a list contained in the CROP.DAT file or by entry from the keyboard. The computer will display the list of crops shown in Figure 5. In Figure 5, crop types are listed alphabetically in annual and perennial crop categories. A number or crop code is given for each crop type. This code must be entered to specify the crop type desired. After the list of crops and codes is displayed, the computer will prompt:

ENTER CROP CODE:

Enter the numerical code corresponding to the crop type for which irrigation requirements are to be calculated. Entering the crop code will cause the computer to read the crop water use, growth, and root development coefficients contained in the CROP.DAT file. Irrigation requirements can be simulated for the crop types and characteristics contained in the model data base as well as other crops whose characteristics are input by the user.

If the crop code entered is not within the acceptable range, its re-entry will be prompted. After an acceptable crop code is entered, it will be repeated by the computer, and the crop type will be listed for verification. If the crop code was incorrectly entered, but was accepted by the computer, backspace to correct this entry by entering -99 at the next data entry prompt.

In Figure 5, crops are classified as annual or perennial. Annual crops are those normally replanted each year. They complete their life cycles in one growing season, then must be replanted for the next season. As an example, soybeans must be planted from seed. The crop develops, reproduces, senesces, is harvested, and dies. Seed must be replanted the next year.

CROP LIST : TOTAL NUMBER = 60

NUMBER OF PERENNIAL CROPS = 16

1 ALFALFA	2 AVOCADO	3 BLUEBERRY
4 CITRUS	5 FERNS	6 GENERIC CROP
7 GRAPES	8 NURSERY,CNTR	9 NURSERY,FLD.
10 PASTURE	11 PEACHES	12 PECANS
13 SOD	14 SUGARCANE	15 TURF,GOLF
16 TURF,LNDSCP.		

NUMBER OF ANNUAL CROPS = 44

17 BARLEY	18 BEANS,GRN.	19 BEANS,DRY
20 BEETS	21 BROCCOLI	22 BRUSSEL SPTS
23 CABBAGE	24 CARROTS	25 CAULIFLOWER
26 CELERY	27 CLOVER	28 CORN,FIELD
29 CORN,SWEET	30 COTTON	31 CUCUMBER
32 EGGPLANT	33 FIELD CROPS	34 GENERIC CROP
35 GREENS,HERBS	36 LETTUCE	37 MELONS
38 MILLET,FORGE	39 MILLET,GRAIN	40 OATS
41 ONION,DRY	42 ONION,GRN.	43 PEANUTS
44 PEAS	45 PEPPERS,GRN.	46 POTATOES
47 RADISH	48 RICE	49 SMALL GRAINS
50 SMALL VEGETS	51 SORGHUM	52 SOYBEAN
53 SPINACH	54 SQUASH	55 STRAWBERRY
56 SUNFLOWERS	57 SWEET POTATO	58 TOBACCO
59 TOMATO	60 WHEAT	

Figure 5. List of crops and crop codes included in the AFSIRS model.

In general, most field and vegetable crops, and many ornamental crops are annual crops. It is not implied that all annual crops are grown from seeds. Some may be transplanted as seedlings or young plants. If they complete their life cycles within a 1-year period and must be replanted, they are classified as annual crops by the AFSIRS model.

It is not implied that annual crops must be grown within one calendar year. Thus, for example, an annual crop may be planted in November and harvested in March. This crop would then be replanted the following November.

Perennial crops are those which are not replanted each year, and thus do not undergo the rapid changes from seedling stages to maturity in one year. Citrus is an example of a perennial crop. Young trees are transplanted to a grove site, develop to maturity over several years, and then remain productive for many years. Likewise, many grass, fruit, and other tree crops are perennial crops.

When a selection of a perennial crop is made in the AFSIRS model, it is implied that <u>irrigation requirements will be calculated for a mature crop.</u> Data were not found to permit the calculation of IRR for immature perennial crops. This primarily is a concern only for tree crops, such as citrus, for example. Other perennial crops, such as grasses, develop quickly and use water at mature crop rates during the first few months of growth.

Figure 5 contains listings of general crop categories as well as individual species. For example, these listings include small vegetables, field crops, and small grains. These categories contain typical (average) crop coefficients for these crop classes. They should be used to estimate irrigation requirements for production systems where the specific crop type might vary from year-to-year in response, for example to marketing conditions. Greater accuracy would, however, be expected if the irrigation requirements of the specific crops and growing seasons were individually simulated.

Figure 5 contains listings for "Generic Crops" under both the perennial and annual crop categories. These categories contain typical (average) data for all crops in these major categories. These data may be useful in general simulation studies of the effects of different factors affecting irrigation requirements, but these data should not be expected to represent any specific crop well.

If the AFSIRS model user selects either of the generic crop categories, the model will prompt:

```
ENTER 0 TO USE GENERIC CROP DATA FROM DATA FILE:
ENTER 1 TO INPUT CROP DATA FROM KEYBOARD:
```

If the user enters 0, the data contained in the CROP.DAT data file will be used in the simulation. If the user enters 1, the computer will prompt for the entry of all crop data from the keyboard. This includes crop type (name or variety), irrigated and total root zone depths for perennial crops and initial and final root zone depths for annual crops, crop water use coefficients, and allowable soil water depletions before irrigations are scheduled. This feature of the AFSIRS model allows the user to readily enter data for crops which are not included in the CROP.DAT file or to study the effects of changes in any of the above factors on IRR.

H. Irrigation Season:

To allow the user to specify the irrigation season, the AFSIRS model prompts:

ENTER BEGINNING DATE OF CROP IRRIGATION SEASON, (MONTH, DAY):

The month and day on which the irrigation season begins should be entered, separated by a comma, or as two separate entries. Acceptable entries are 1 through 12 for the month, and 1 through 31 for the day.

Following acceptable entries for the beginning of the irrigation season, the computer will prompt for the end of the irrigation season:

ENTER ENDING DATE OF CROP IRRIGATION SEASON, (MONTH, DAY):

Acceptable entries are the same as those for the beginning of the irrigation season. Errors in data entries will cause these prompts to be repeated.

The relative magnitudes of beginning and ending dates are not critical to the AFSIRS model. If, for example, the dates 3,1 and 8,1 are entered for the beginning and ending dates of the irrigation season, respectively, then IRR would be calculated beginning on March 1 and ending on August 1 of each year in the climate data base. If the above dates are reversed and given as 8,1 followed by 3,1, then this would be interpreted as an irrigation season beginning on August 1 and ending on March 1 of the next calendar year. When entered in this manner, all irrigation seasons will have a duration of 365 days or less. The AFSIRS model cannot accept crop growing seasons of durations greater than 365 days.

The irrigation season may be the entire growing season (planting to harvest) for many annual crops, or it may be only a portion of the growing season, depending on the crop and production practices.

The irrigation season may be all year (1,1 to 12,31) for some perennial crops, such as citrus, which may bear fruit continuously. It may be only a portion of the year for deciduous trees (dormant in the winter) such as pecans or peaches. For those trees, the irrigation season would normally be limited to that portion of the year when the crop is not dormant.

The length of the irrigation season will not be constant for a given crop type. Rather, in the case of annual crops it will depend on when the crop was planted. For all crops it will depend on geographic location (climate conditions) and variety. Other factors such as management, marketing strategies, etc. will affect the irrigation season, thus greatest accuracy can be expected if the user supplies these data for a specific production system or region.

The AFSIRS model user should enter the beginning and ending dates for the average year to simulate long-term irrigation requirements. Also, the model can be used to study the expected effects of scheduling earlier or later crop growing seasons.

Although the AFSIRS model may primarily be used to simulate IRR for the entire crop growing season, for perennial crops it may be used to simulate IRR for only a portion of the irrigation season. For example, to simulate IRR for the month of March, the irrigation season would be specified as 3,1 to 3,31. This feature can be used only for perennial crops because of the way the crop growth data are analyzed.

Caution should be applied when using the AFSIRS model to simulate IRR for only a portion of a crop growing season because the soil water-holding capacity is initialized as 90% of field capacity at the beginning of the simulation period. This assumption will affect the accuracy of the simulated IRR for short time periods (periods of less than 1 month) or time periods in which IRR is small with respect to the soil water-holding capacity, such as for "heavy" soils or during low ET months.

After the beginning and ending dates of the irrigation season have been specified, the computer repeats the values read for verification. It also outputs the length of the irrigation season in days, and J1 and Jn, which are the calendar days for the beginning and end of the irrigation season, respectively.

As an example, if the month,day at the beginning of the irrigation season are given as 1,1 and the ending month,day as 12,31, the length of the irrigation season will be calculated as 365 days (leap years are not considered by the AFSIRS model). J1 will be equal to 1, Jn will be equal to 365. As another example, if the beginning of the irrigation season is given as 3,1 and the ending as 8,31, then the length of the growing season will be calculated as 184 days, J1 will be = 60, and Jn will be = 243.

If the irrigation season extends beyond the end of the calendar year, it is still specified as before. For example, for a crop irrigated from November 1 to February 1, specify 11,1 as the beginning of the irrigation season, and 2,1 as the end of the irrigation season. J1 will be = 305 and Jn will be = 32. The length of the irrigation season will correctly be calculated as 93 days. However, because the irrigation season extends from one calendar year to the next, the length of the climate data base will be reduced by one year. That is, only 24 rather than the typical 25 years of weather record will be available to the simulation model.

If more than one crop is produced on a farm per year, each must be analyzed separately and then summed to obtain the annual farm IRR or to obtain IRR for data reporting periods (such as monthly periods) which overlap. The AFSIRS model can accept only one irrigation season definition per simulation.

I. Climate Data Base Location:

The climate data base required for the AFSIRS model is large. It consists of from 18 to 25 years of daily values of potential ET and rainfall for each climate data base location. These occupy approximately 100 kilobytes of storage each.

Climate data bases are provided with the AFSIRS model for nine locations in and near Florida. The data base locations, titles, and lengths of record are:

	Location	Title	Years of Record
1.	Apalachicola	CLIM.APL	18
2.	Daytona Beach	CLIM.DTB	25
3.	Jacksonville	CLIM.JAX	25
4.	Miami	CLIM.MIA	24
5.	Mobile,Alabama	CLIM.MOB	25
6.	Orlando	CLIM.ORL	22
7.	Tallahassee	CLIM.TAL	25
8.	Tampa	CLIM.TAM	25
9.	West Palm Beach	CLIM.WPB	25

The total computer data storage requirement for only the climate data bases is about 800 kilobytes. Many microcomputer systems do not have the storage capability to accommodate the entire climate data base in random access memory (RAM) at once. For this reason, the AFSIRS model was structured to read and retain in RAM only a single data base at once. To identify the data base, the computer prompts:

ENTER CLIMATE DATA BASE FILE NAME:

The climate data file name is limited to a total of 20 characters, including the disk drive and directory designation. The user may enter the disk drive designation, and a file directory with the file name if required. For example, if the user entered B:CLIM.TAM, the computer would read the climate data from the file CLIM.TAM located on disk drive B:. If the user entered C:\CLIMATE\CLIM.DTB, the computer would read the CLIM.DTB file located on disk drive C: under directory CLIMATE. If the user merely entered the file name CLIM.ORL, the computer would read the CLIM.ORL file located in the current (default) directory.

After it is read, the climate data file name is printed to the computer screen for verification. The designated disk drive and directory are searched for the data file. If the requested data file is not found, the statement:

FILE NAME DOES NOT EXIST!

is printed, and the user is again prompted to enter the file name.

Because a relatively long period of time is required to read the large data bases, the following message is displayed:

```
*****   READING DATA FILES   *****
        ETP,   YEAR = 19--
        RAIN,  YEAR = 19--
```

This message remains displayed for the 1 to 3 minutes required to read the data base. The year and type of data (potential ET or rain) being read are incremented as the data are read.

The first line of each climate data base contains the location and number of years of record contained in the data base. After the climate data are read, the following information is displayed to the computer screen:

THE CLIMATE DATA BASE LOCATION IS : ________

LENGTH OF CLIMATE DATA RECORD = _____ YEARS

For some consecutive simulations using the same climate data base, the data base remains undisturbed in the computer memory, and it is not necessary to re-read it. In those cases, the data base location and length of record are displayed as before, but the computer then moves immediately to the prompt for the next input parameter.

It is necessary to read the climate data base for (a) the first simulation using that data base, and for (b) each successive simulation which follows an irrigation season which extended beyond one calendar year, and which has different beginning or ending dates than the previous irrigation season simulated.

It is not necessary to read the climate data base for (a) successive simulations where the irrigation season does not extend beyond the end of the calendar year, and (b) irrigation seasons which extend beyond the end of the calendar year, but the beginning or ending date of the irrigation season is identical to that of the previous simulation. Thus, to save computer operator time, when several simulations are to be run, they should be grouped with respect to climate data base location, and beginning and ending dates of the growing season.

When a different climate data base is to be used in order to simulate IRR for another location, the model must be re-initiated, and the new data base name must be entered when prompted.

J. Irrigation System Type:

Many different types of irrigation systems are used in Florida. In the AFSIRS model, all of the major types have been classified into eight type categories. In addition, a ninth, "User-Specified System" category is included to allow the model user to directly enter the irrigation system characteristics from the keyboard. The major irrigation system types, their application efficiencies, and other required system operating characteristics are contained in the AFSIRS model data base.

Irrigation application efficiency (EFFa) refers to the effectiveness of the irrigation system in applying water to the crop root zone where it can be utilized in production. EFFa is expressed as a percentage, with 100% meaning that all water distributed is effectively applied to the crop root zone. In practice, application efficiencies are always less than 100% because of nonuniformity in water application and losses due to wind drift, evaporation, and drainage from the root zone during application.

Some irrigation systems, such as micro types, can have very high application efficiencies when they are properly designed and well-managed. All systems can have very poor application efficiencies if they are improperly designed or improperly managed. Application efficiencies as contained in the AFSIRS model data base are average efficiencies of properly managed irrigation systems that are well-designed and installed according to standard practice in Florida.

To request the required information on irrigation system types, the computer prompts:

SELECT THE TYPE OF IRRIGATION SYSTEM TO BE USED:

1 = USER-SPECIFIED SYSTEM
2 = MICRO, DRIP
3 = MICRO, SPRAY
4 = MULTIPLE SPRINKLER
5 = SPRINKLER, CONTAINER NURSERY
6 = SPRINKLER, LARGE GUNS
7 = SEEPAGE
8 = CROWN FLOOD (CITRUS)
9 = FLOOD (RICE)

After displaying the list of available irrigation system types, the computer will again prompt:

ENTER THE IRRIGATION SYSTEM CODE:

The user should respond by entering the appropriate number from 1 through 9. The computer will read the irrigation system code, reiterate it, and display the irrigation system type, efficiency, and fraction of the soil surface assumed to be irrigated with this system. These outputs will allow the user to verify that the correct irrigation system selection has been made.

Each of the nine irrigation system types listed above is defined and discussed in the following paragraphs:

1. User-Specified System: This is a generic irrigation system category which enables the user to enter all of the data required to specify the irrigation system characteristics. If this category is selected, the user will be prompted for each data entry. Data entry requirements include the (a) irrigation system efficiency, (b) fraction of the soil surface irrigated, and (c) fraction of crop water use extracted from the irrigated as opposed to the non-irrigated portion of the root zone.

2. Micro, Drip: Drip irrigation systems are those which use an extensive plastic pipe network and drip irrigation emitters to apply water near or directly into the plant root zone. Because water is dripped near the soil surface rather than being sprayed through the air, efficiency of water application can be very high. The default value of the application efficiency used in the AFSIRS model is 85%, primarily because pressure loss in a drip irrigation system causes nonuniform water application and prohibits greater water application efficiency.

Simulated irrigation requirements were found to be sensitive to the fraction of the crop root zone irrigated when using micro (drip and spray) irrigation systems. Micro systems irrigate less than 100% of the soil surface, typically making frequent applications, concentrating water near the plants and in the upper part of the crop root zone. This changes the water budget of the irrigated crop (and IRR) as compared to a sprinkler irrigation system which irrigates the entire soil surface.

Because of the sensitivity of the simulated irrigation requirements to the fraction of the soil surface irrigated, the AFSIRS model user may enter this fraction as an option in the model. If the user earlier specified the model version which would permit entry of this parameter (INPUT CODE ENTERED = 1, in the "Style of Input" section [Section C under subheading "Interactive Use"]), the model will now prompt: "ENTER FRACTION OF THE SOIL SURFACE IRRIGATED:". The user should respond by entering the proportion of the soil surface that is irrigated with the specific micro,drip irrigation system being used. This entry must range from 0.1 to 1.0 to be acceptable to the model.

The AFSIRS model default value for the fraction of the soil surface irrigated with micro,drip irrigation is 0.50. This value is used in the calculation of IRR when the INPUT CODE ENTERED = 0, in section C of the "Style of Input" section of this manual.

<u>3. Micro, Spray:</u> Micro,spray irrigation systems use an extensive plastic pipe network to deliver water near the crop root zone. However, as opposed to drip systems, water is sprayed through the air to irrigate larger fractions of the crop root system. Spray distances are relatively short (normally 3 to 10 ft) as compared to sprinkler irrigation systems. Spray micro irrigation systems are very common in Florida citrus production. Because of spray losses due to evaporation and wind drift of small water droplets, as well as nonuniformity of application due to system pressure variation and other causes, spray systems have a lower water application efficiency than drip systems. The default value of the micro,spray application efficiency used in the AFSIRS model is 80%.

Like drip irrigation systems, spray systems are sensitive to the fraction of the soil surface irrigated as compared to the entire soil surface. As with drip systems, the default value for this entry is 0.50 (50% of the soil surface assumed to be irrigated), and the model user may specify this parameter from the keyboard by entering INPUT CODE = 1 in the "Style of Input" section (Section C under subheading "Interactive Use") of this manual.

4. Multiple Sprinkler: Multiple sprinkler irrigation systems include various types of systems which use large numbers of impact, spray, or gear-driven sprinklers. These are used in many permanent solid-set irrigation systems in Florida. Examples are the "permanent overhead" irrigation systems used on citrus, "pop-up" sprinklers used in lawns and golf courses, and the permanent sprinkler systems used for strawberry, nursery, and fern irrigation and freeze protection. This category also includes sprinklers and spray nozzles mounted on self-propelled center pivot irrigation systems. In general, this category includes sprinklers with flow rates in the range of tens of gallons per minute or less, and pressures in the range of up to about 70 psi.

A characteristic of multiple sprinkler systems is that they spray water at high velocities greater distances through the air (up to as much as 50 - 60 ft from the sprinkler) as compared to micro spray systems, and thus, they are subject to greater wind drift and evaporation losses. They often apply water above the crop, wetting the crop canopy, and causing further losses in efficiency. All of the water used to wet the canopy is not lost, however, as some is effective in reducing transpiration losses from crops while the foliage is wet.

The default application efficiency of multiple sprinkler irrigation systems used in the AFSIRS model is 75%. This value is believed to be typical for Florida conditions. In practice, it can be much less during system operation on hot, dry, windy days, but it can also be greater than 75% when sprinkler systems are operated at night or on calm, overcast, high humidity days.

5. Sprinkler, container nursery: Container nurseries are nurseries where crops are grown in pots, small confined beds, or other containers rather than in the soil under field conditions. Because the plant root systems are contained and thus unable to extract water from throughout larger soil areas, frequent irrigations are required.

Because of the relatively small proportion of the surface area occupied by the containers (15 - 30% is typical), much of the rainfall and irrigation applied by sprinklers is ineffective in meeting crop water requirements. These factors, coupled with inefficiencies in uniformity of water application, wind drift, and evaporation losses characteristic of small sprinklers, result in an estimated water application efficiency of 20% for container nurseries irrigated with sprinkler systems. This is the default value used in the AFSIRS model. In practice, this factor may vary widely depending on actual plant spacing, effectiveness of irrigation interception on foliage, time of irrigation, etc. For container nurseries that use micro irrigation, select the appropriate micro irrigation category.

6. <u>Sprinkler, large guns:</u> Large guns are large, high flow rate sprinklers which operate at very high pressures. These include large hand or tractor-moved portable guns as well as cable-tow and hose-reel traveling (or self-propelled) guns. Flow rates are typically in the range of 300 to 1000 gallons per minute, pressures may range from 80 to 120 psi, and water may be sprayed 300 ft or more from the gun.

With large guns, high pressure is required to create the high velocity necessary to distribute water over large areas. The high velocities also cause the breakup of water streams into greater fractions of small particles which are more easily lost to wind drift and evaporation as compared to small sprinklers. For this reason, in addition to all of the considerations given for multiple sprinkler systems, the default application efficiency used for large guns is 70%.

7. <u>Seepage or subirrigation:</u> Seepage or subirrigation systems are those in which crops are irrigated by raising and maintaining a water table in the crop root zone. Upward movement of water from the water table occurs due to capillary action and root extraction. The water table is maintained relatively constant, although it may undergo some diurnal fluctuations, and it may be maintained at different levels as the crop growing season progresses, in anticipation of rainfall, or for other management reasons.

Seepage irrigation system efficiencies depend heavily on site-specific considerations. For seepage irrigation to be efficient, a soil restrictive layer or a normally high water table must exist. If the restrictive layer is not entirely impermeable (which most are not), irrigation efficiency will be reduced as water is lost to the underlying areas. If the immediately adjacent land areas are also seepage irrigated, with water tables maintained at about the same heights in all fields, then lateral flow of water will be small. If, however, adjacent land areas are not being irrigated, then water will be lost to lateral flow and efficiency of water application will be reduced.

Seepage irrigation efficiencies may range widely. Magnitudes ranging from less than 20% to more than 75% have been reported from various research studies. For the purposes of the AFSIRS model, a default value of the seepage irrigation application efficiency of 50% has been used. It is recognized that site specific efficiencies may range widely from this value.

8. <u>Crown flood (citrus):</u> Crown flood irrigation systems are flood irrigation systems with specific applications to the bedded citrus production systems of Florida flatwoods soils. In this

type of system, soil is irrigated by raising water tables in ditches between raised beds. Water is allowed to stand in the ditches for 1 to 3 days, saturating the beds to a short distance below the crowns of the tree trunks. Water is then drained from the ditches, and the saturated soil slowly drains due to gravity. This process is repeated approximately every 10 to 21 days, depending on climate conditions and management practices. The irrigation ditches function as drainage ditches also.

Crown flood systems differ from seepage irrigation systems in that water tables are not constantly maintained at static levels. Soil water fluctuates over a wider range with crown flood, and thus rainfall may be more effective. In the AFSIRS model, the default irrigation application efficiency is 50% for crown flood systems.

The simulated IRR for a crown flood irrigation system is very sensitive to the height of the crown flood soil bed and the assumed crop root zone associated with the bed height. For this reason, when the crown flood irrigation method is selected, the AFSIRS model prompts:

ENTER HEIGHT OF CROWN FLOOD SYSTEM BEDS (FT):

The model user should respond by entering the average bed height in feet. Permissible entries range from 1.0 to 5.0 ft, with 2.5-3.0 ft being very common. After an acceptable crown flood bed height is entered, the computer will repeat this as:

HEIGHT OF CROWN FLOOD IRRIGATION SYSTEM BEDS = ____ FT

This value will be used to define the effective root zone and to calculate IRR for the crown flood irrigation method.

<u>9. Flood (rice):</u> This category is used to simulate IRR of rice produced in flooded paddies. Paddies are flooded for weed control, and (specifically in Florida) for control of oxidation of organic soils. Flood waters are maintained at approximately fixed levels to optimize production. Irrigation efficiencies of rice production systems may be expected to vary widely for the same reasons as discussed for seepage systems. A default application efficiency of 50% is used for FLOOD (RICE) systems in the AFSIRS model.

Rice flood irrigation requirements are very sensitive to the allowable change in flood water level in the paddies before drainage occurs following rainfall. If little water level change is permitted, much of the rainfall will be ineffective because it will be lost to drainage. IRR will be large in this case. If greater water level changes are permitted, more rain will be stored in the paddies and used in crop ET, reducing IRR.

When AFSIRS model users select FLOOD (RICE) as the irrigation and crop production system, they will be prompted:

ENTER THE RICE FLOOD STORAGE DEPTH (INCHES):

Acceptable values of flood storage depth are 0.0 to 3.0 inches. The narrow range reflects the sensitivity of the production system to accurate water table control. Most growers strive to keep the flood water level within 1.0 inch of the design level.

After entry of an acceptable depth, the value read will be repeated as:

RICE FLOOD STORAGE DEPTH ENTERED = ____ INCHES

This depth will then be used in the calculation of effective rainfall and IRR for rice production systems.

K. Gross versus Net Irrigation Requirements:

The AFSIRS model permits the user to calculate either gross or net irrigation requirements. The gross irrigation requirement includes the effects of losses due to inefficiencies in water application. It is calculated by dividing the net irrigation requirement by the irrigation application efficiency as a decimal number.

The net irrigation requirement is the amount of water required for crop ET for the given production system and climate conditions, assuming that the water can be delivered to the crop root zone without losses. Although it is not possible to irrigate without losses, this option was included in the AFSIRS model to permit the net crop water requirements to be calculated separately from the total irrigation requirements (IRR), which includes application efficiency losses.

The user is prompted to specify whether net or gross irrigation requirements are to be calculated as follows:

ENTER 0 TO CALCULATE NET IRRIGATION REQUIREMENTS:
ENTER 1 TO CALCULATE GROSS IRRIGATION REQUIREMENTS:

After the user's response, the input will be verified by one of the following statements:

NET IRRIGATION REQUIREMENTS WILL BE CALCULATED

GROSS IRRIGATION REQUIREMENTS WILL BE CALCULATED

L. Irrigation System Management:

Irrigation requirements depend heavily on the management of the irrigation system. Three of the most common irrigation management strategies can be simulated by the AFSIRS model. The user is prompted to select the appropriate management strategy as follows:

ENTER 0 TO IRRIGATE TO FIELD CAPACITY (NORMAL PRACTICE):
ENTER 1 TO APPLY A FIXED DEPTH PER IRRIGATION:
ENTER 2 FOR DEFICIT IRRIGATION:

If the user's response is 0, the model will calculate the exact amount of water required to restore the irrigated soil zone to field capacity at each irrigation. This is defined as the net irrigation amount. This entry will be verified by the statement:

NORMAL IRRIGATION: SOIL WILL BE IRRIGATED TO FIELD CAPACITY AT EACH IRRIGATION

If the user's response is 1, a constant (fixed) depth of water will be applied at each irrigation. The model will further prompt the user to enter the depth in inches to be applied at each irrigation. These entries will be verified by the following statements:

FIXED DEPTH IRRIGATION: A FIXED (CONSTANT) DEPTH OF WATER WILL BE APPLIED AT EACH IRRIGATION

DEPTH OF WATER TO APPLY PER IRRIGATION = ____ INCHES

If the user's response is 2, deficit irrigation will be simulated. At each irrigation, the irrigated soil zone will be restored to only a fraction of field capacity, allowing some storage capacity to remain in anticipation of rainfall. The model will further prompt the user to enter the percent of field capacity to be restored at each irrigation. The permissible range for this factor is 50% to 100%, because depletions below 50% would cause yield-reducing water stress in most crops. These entries will be verified by the following statements:

DEFICIT IRRIGATION: THE SOIL WILL BE IRRIGATED TO A FRACTION OF FIELD CAPACITY AT EACH IRRIGATION

PERCENT OF FIELD CAPACITY ENTERED FOR DEFICIT IRRIGATION = ___ %

Following the entry of all irrigation system and irrigation management data, the irrigation system design efficiency, the fraction of the soil surface irrigated, and the fraction of ET extracted from the irrigated soil zone will be displayed for verification.

M. Crop Root Zones (optional):

If, in Section C above, the INPUT CODE entered was 1, crop root zone depths must be entered from the keyboard rather than using values supplied in the AFSIRS model data base. To permit that data entry, one of the following prompts will appear:

ENTER IRRIGATED AND TOTAL ROOT ZONE DEPTHS (INCHES)
FOR PERENNIAL CROPS:

ENTER INITIAL AND MAXIMUM IRRIGATED ROOT ZONE DEPTHS (INCHES)
FOR ANNUAL CROPS:

For perennial crops, the model user should make two entries. The first entry is the depth of the crop root zone that will be irrigated. The second entry is the total crop root zone depth into which any crop roots penetrate, or which in any way supplies water (such as by capillarity) for crop ET. Both entries are soil depths in inches.

The total root zone depth entered must always be greater than the depth irrigated. If these data are not entered in this manner, the prompts for data entry will be repeated.

Typically, the total root zone depth is significantly greater than the depth irrigated. For example, in citrus produced on deep sandy soils, irrigations are often concentrated in the upper 24 to 36 inches of the root zone where most of the tree roots are located and where most of the water extraction for ET occurs. However, some water extraction also occurs from the nonirrigated root zone when water is available in this zone from rainfall. This non-irrigated root extraction is important because, although it is typically smaller than the extraction from the irrigated zone, it will reduce IRR by contributing to the crop ET requirements. Also, in Florida's humid climate, water is often available in this zone because of rainfall.

In Florida, citrus root have been observed to penetrate to depths of 60 to 96 inches (or more) from the soil surface. This is the total root zone depth that should be entered in the model. Both the total root zone depth and the irrigated root zone depth are measured from the soil surface.

In some cases, the total root zone depth and the irrigated root zone depth may be equal. An example of this is a container nursery production system. In this case, plant root penetration is limited to the container, and, because of the small container sizes as compared to the soil volumes that would be penetrated by roots if the same plants were grown in the field, the water-holding capacity of the container is small, and the entire plant root zone is irrigated at each application. Thus, for the irrigation of a container nursery with 8-inch deep containers, both the irrigated and total root zone depths would be entered as 8 inches. This will increase IRR as compared to the same crop grown in the field where some of the crop roots would extract water from a nonirrigated soil zone.

For annual crops, the AFSIRS model user should make two entries when prompted as follows:

ENTER INITIAL AND MAXIMUM IRRIGATED ROOT ZONE DEPTHS
(INCHES) FOR ANNUAL CROPS

The first entry should be the depth of soil that will be irrigated early in the crop growing season, at planting or transplanting. Because annual crops progress through a complete growth cycle within one year, normally plants are small and have limited root systems at the beginning of the growing season. For greatest efficiency, irrigation depths should be limited to this zone during this growth stage.

As annual crops grow and develop, their root systems expand, and irrigation depths per application are typically increased proportionally. The maximum irrigated root zone depth to be entered in the AFSIRS model should be that where most of the crop roots are located during peak and late season crop growth stages. For acceptance by the AFSIRS model, the maximum irrigated root zone depth must be greater than or equal to the initial depth. If depths are not entered in this manner, the prompt for their entry will be repeated.

As an example of the entry of crop root zone depth data for an annual crop, field corn might be irrigated with a center pivot irrigation system with 0.5-inch water applications early in the growing season, thus limiting irrigation to approximately the upper 8 to 12 inches of the soil surface, depending on the soil water-holding capacity. As the crop reaches peak growth stages, the upper 18 to 24 inches of the root zone might be irrigated, with applications of 1.0 to 1.5 inches of water per irrigation.

Depending on the irrigation strategy selected, the AFSIRS model calculates irrigation amounts (depths) that will be sufficient to restore the water content in the irrigated zone to field capacity, to a fraction of field capacity, or with a fixed irrigation amount. Thus, when the model user specifies the root zone depth to be irrigated and the soil type, the irrigation amount and frequency will also be indirectly specified. For seepage and rice flood irrigation systems, irrigation is simulated as a continuous occurrence, and crop root depth has only small effect on IRR.

After all crop root depth data have been entered, or alternatively, after these data have been read from the CROP.DAT file, both the irrigated and total crop root zone depths will be displayed for verification. Monthly values of crop water use coefficients and monthly values of allowable soil water depletions will be displayed for perennial crops. For annual crops, crop water use coefficients for growth stages 3 and 4, fractions of the growing season in each of the four crop growth stages, and allowable soil water depletions in each of the four crop growth stages will be displayed.

N. Soil Type:

Soil types (and associated textures, water-holding capacities and depth characteristics) are selected from a list of the mapped soil series of Florida. Two soils data bases are included with the AFSIRS model (a) a complete data base of the 765 soil types currently being mapped in county soil surveys by the Soil Conservation Service in Florida plus a description of potting media used in container nursery production systems for a total of 766 selections, and (b) a generic soils data base containing average soils data as a function of soil texture. The generic soils data base has only 8 entries to describe the major soil textural classifications. To select a soils data base for simulation use, copy one of the data bases to a file titled SOIL.DAT. This is the file that will be read by the AFSIRS model during execution.

The computer reads and displays the number of soils in the data base. The user is then prompted:

ENTER CODE FOR SOIL TYPE DESIRED:
ENTER 0 IF YOU WANT A LIST OF SOILS:
ENTER -1 TO INPUT SOILS DATA FROM THE KEYBOARD:

If a list of soil types is needed, enter 0. The computer will then prompt:

ENTER SOIL CODE TO BEGIN LIST:

The computer can display only 40 soil series on the monitor at once. This soil code allows the user to move immediately to that portion of the soils data base where the desired soil series is located. The 40 soils beginning with the soil code entered will be displayed alphabetically in the format shown in Figure 6. Following each listed page, the computer will prompt:

ENTER 0 TO STOP. ENTER 1 TO CONTINUE LIST.

If 1 is entered, the computer will again prompt for the soil code to begin the next 40-soil list. If 0 is entered, the computer will prompt for the soil code as follows:

ENTER CODE FOR SOIL TYPE:

The user should respond by typing the numerical code associated with the soil series that is to be used. The computer will read the soil code, repeat it, read the soils data base, and then display the name and textural classification(s) of the soil series selected. Next the soil depth and water-holding characteristic data will be displayed as shown at the bottom of Figure 6.

In Figure 6, soil depths are given in inches, and volumetric water-holding capacities of soil layers are given as decimal fractions. Depths listed are measured to the bottoms of the soil layers. The example shown is for Astatula sand (S) or fine sand (FS). Depths are given for 2 distinct soil layers in the profile. These are 0-3 and 3-86 inches. The layers are respectively, 3 and 83 inches thick, for a total of 86 inches, the depth to the bottom of the deepest layer.

Soil water-holding capacities for each of the (I) previously described layers are given as the minimum (MIN.WCON) and maximum (MAX.WCON) values expected for each of the layers. This is the available water for each layer as a volumetric fraction. For the Astatula sand or fine sand, the volumetric water content in the surface 3-inch layer would be expected to range from a minimum of 0.04 (4%) to a maximum of 0.10 (10%). Likewise, the volumetric water content of the 3 to 86-inch soil layer of Florida soils classified as Astatula sand or fine sand would be expected to range from 0.02 (2%) to 0.05 (5%).

Soil water content data given in this data base are available soil water contents on a volumetric basis. The term available soil water content means that all of this water is available for plant use. It is the water content between field capacity and the level at which water can no longer be extracted from the soil by the plant (permanent wilting point).

Soil water content data are given on a volumetric basis because these data can readily be translated to depths (inches) of water applied for comparisons with rainfall, irrigation applied, or ET. For example, the volumetric soil water content ranges from 0.04 to 0.10 for the upper 3-inch layer of Astatula sand or fine sand shown in Figure 6. The depth of water stored in this soil layer is calculated to range from (0.04)(3 inches) = 0.12 inches to (0.10)(3 inches) = 0.30 inches. Likewise, the volume of water stored in the 3- to 86-inch layer (a soil layer depth of 83 inches) ranges from (0.02)(83 inches) = 1.66 inches to (0.05)(83 inches) = 4.15 inches.

```
               ENTER CODE FOR SOIL TYPE DESIRED :
              ENTER 0 IF YOU WANT A LIST OF SOILS:
        ENTER -1 TO INPUT SOILS DATA FROM THE KEYBOARD :
0
                 ENTER SOIL CODE TO BEGIN LIST:
20
20 ANCLOTE,DP.        S    FS          21 ANCLOTE,DP.       LS   LFS
22 ANCLOTE,FREQ.FL.   S    FS          23 ANCLOTE VAR.      MK
24 ANGIE              FSL  SL          25 ANGIE             VFSL SIL
26 ANGIE VAR.         L    FSL SL      27 ANKONA            S    FS
28 ANKONA,DP.         S    FS          29 APALACHEE         C
30 APOPKA             S    FS          31 APOPKA VAR.       FS
32 ARCHBOLD           S    FS          33 ARCHER            LS   LFS
34 ARCHER             S    FS          35 ARDILLA           SL   FSL
36 ARDILLA            LS   LFS COS     37 ARENTS            S    FS
38 ARENTS,MOD.WET     S    FS  S       39 ARENTS,MOD.WET    LS   SL
40 ARENTS,ORG.SUBS.   S    FS  S       41 ARENTS,V.ST.      VAR
42 ARENTS,SAN.LNDF.   S    FS          43 ARIPEKA           FS   LFS
44 ARREDONDO          FS   S           45 ARREDONDO         LS   LFS
46 ARREDONDO,BD.      FS   S           47 ASTATULA          S    FS
48 ASTOR              S    FS  LS      49 ASTOR             S    FS   LS
50 ASTOR,FL.          S    FS  LS      51 ASTOR,FL.         S    FS   LS
52 BAKERSVILLE        MK               53 BASINGER          S    FS
54 BASINGER,DP.       S    FS          55 BASINGER,DP.      MK
56 BASINGER,FL.       S    FS          57 BAYBORO           FSL
58 BAYBORO            L    CL          59 BAYBORO           FSL  L

           ENTER 0 TO STOP.  ENTER 1 TO CONTINUE LIST.
0
                   ENTER CODE FOR SOIL TYPE :
47
              THE SOIL TYPE CODE ENTERED WAS :  47

            THE SOIL SERIES SPECIFIED WAS : ASTATULA
                 THE SOIL TEXTURE IS :  S    FS

         SOIL LAYER DEPTHS (INCHES) AND WATER CONTENTS
                 DEPTH(I)=     3.    86.
              MIN.WCON(I)=    .04    .02
              MAX.WCON(I)=    .10    .05

        DO YOU WANT TO USE MINIMUM, AVERAGE, OR MAXIMUM
         WATER-HOLDING CAPACITY FOR THIS SOIL SERIES ?
     MINIMUM = 0           AVERAGE = 1           MAXIMUM = 2
     ENTER THE SOIL CODE FOR THE APPROPRIATE CONDITION :
2
                 DEPTH(I)=     3.    86.
         WCON(I) ENTERED=     .10    .05
```

Figure 6. AFSIRS model interactions required to obtain the alphabetical list of soils and to specify a soil type.

After displaying the soil characteristics as shown in Figure 6, the computer questions:

DO YOU WANT TO USE MINIMUM, AVERAGE, OR MAXIMUM WATER-HOLDING CAPACITY FOR THIS SOIL SERIES?

MINIMUM = 0, AVERAGE = 1, MAXIMUM = 2.

ENTER THE SOIL CODE FOR THE APPROPRIATE CONDITION:

The user should respond by entering 0, 1, or 2, depending on the action requested. The results of these entries can be interpreted as yielding, respectively, the minimum, average, and maximum IRR that would be expected for this soil type. After one of the above codes is entered, the computer will display the soil water contents that will be used in the following simulation of irrigation requirements. The values displayed will be either the minimum or maximum values for soil codes 0 and 2, respectively, or the arithmetic average of the minimum and maximum values for soil code = 1.

Continuing the previous example for Astatula sand or fine sand in Figure 6, an entry of 2 was made, indicating that the average soil water content was to be used. The last lines in Figure 6 show the computer response to that entry: the water content used for the 0-3 inch soil layer was 0.10, and that used for the 3-86 inch layer was 0.05. If an entry of 1 had been made, the arithmetic average of the maximum and minimum water contents would have been used.

The AFSIRS model permits user-entry of soil characteristics from the keyboard. If, following the first prompt for soils data entry, a user responds with -1 to input soils data from the keyboard, all soils data will be required to be entered from the keyboard. The computer will prompt the user for each entry, including (a) the soil series name, (b) the soil texture, (c) the number of soil layers with different water-holding characteristics, and (d) the depth and volumetric water content of each soil layer. This capability will enable the user to specify any desired set of soil characteristics for any given field condition.

O. Depth to Water Table:

Because many Florida crops are produced on soils with water tables sufficiently near the soil surface to restrict the crop root zone or to contribute to crop water use by capillarity, the depth to water table must be entered. The computer prompts for this information as follows:

ENTER DEPTH TO WATER TABLE (FEET):

After this information is entered, it is repeated for verification as:

DEPTH TO WATER TABLE ENTERED = ____ FEET

This information is used to determine whether crop root zones are restricted by high water tables and whether the root zone water capacity and the amount of water crop water contribution from the water table are affected by the depth to the water table. In the AFSIRS model, water tables deeper than the total crop root zone have no effect on IRR.

P. Data Re-entry Option:

At this point, all required data entries have been made, and computations can proceed. The user is prompted to allow the computations to proceed as follows:

THIS COMPLETES DATA ENTRY

ENTER 1 TO COMPUTE:
ENTER 0 TO RETURN TO DATA ENTRY MODE:

If the user enters 1, computations will proceed. The statement "***** COMPUTING *****" will appear on the display for the few minutes while computations are being made. Then the simulation results will be scrolled onto the screen.

If the user enters 0 in response to the above prompt, all data entries will be re-initiated. The user will be prompted to begin with Section B, "Location or Site Description". This action will enable the user to correct errors in data entries before computations are made and without the need to abort the program or re-read the climate data files.

Q. Computing:

The computer will display the message "***** COMPUTING *****" to signal the end of the user inputs and that computations are being made. Computations should require from approximately 1 to 3 or 4 minutes per analysis. This will depend on conflicts with other users on multi-user systems, the speed of the microcomputer used, the length of growing season, and other options specified. When computations are complete, the simulation outputs will be scrolled onto the computer screen.

R. Printing Outputs:

After the last output data are printed, the model then questions the user:

PRINT SIMULATION RESULTS?

1 = YES, PRINT AND SAVE TO DISK FILE
0 = NO, SAVE TO DISK FILE ONLY

This option permits the model user to print the latest simulation output without exiting the model. If the response is 1, the just-completed simulation results will be sent to the printer. These results will also be saved to the designated disk output file. If the user's response is 0, the simulation results will be saved to the disk file only.

S. Exiting the Model:

After the print option, the user will be prompted to exit the model or to run another simulation as follows:

DO YOU WANT TO RUN ANOTHER SIMULATION?
1 = YES, 0 = NO

A response of 0 will terminate the execution of the model and will exit to the operating system. This action will close all data files and the output file. A response of 0 will allow the simulation model to continue to run.

T. Successive Simulations:

A response of 1 to the question: "DO YOU WANT TO RUN ANOTHER SIMULATION?" will result in a new simulation being initiated. The screen will display the model title and heading, and all previously discussed interactions with the model user will be required for each succeeding simulation. Succeeding simulations will execute much quicker than the first simulation if the climate data base does not need to be read.

The outputs from each succeeding simulation will be stacked behind the previous one in the output file. The output file will not be closed until execution of the AFSIRS model is terminated.

RUNNING THE AFSIRS MODEL: BATCH VERSION

The batch version of the AFSIRS model permits the user to run successive simulations without needing to be present to provide interactive inputs. As with the interactive model, most entries can be selected from the AFSIRS model data bases, while other data which describe the specific production system are input by the user. For most data required, model default values may be used. Alternatively, other crop, irrigation system, and soil data may be specified by the user.

Data Entries

Upon startup, the batch model prompts the user for the output file name and the simulation date. The remaining data required are read from the user-created file INPUT.DAT and from the climate, crop, irrigation system, and soil data bases provided with the model.

Output File Name

The output file name allows the user to specify the disk drive and the output file name where the output file will be located. The computer will prompt:

ENTER OUTPUT FILE NAME:

If, for example, the user's response is B:OUT.AFS, outputs will be written to a file that the model will create, titled OUT.AFS, and located on disk drive B:. If the user merely responds OUT, an output file titled OUT will be created in the current (default) directory. The file name is limited by standard MS/DOS file naming conventions, including a limit of eight characters, plus up to a three character extension.

The name entered by the model user may be up to 20 characters in length. This length allows file directories and sub-directories to be specified with the output file name.

Upon entry, the file name will be read and written to the computer screen for verification. If the output file name entered already exists, or if file name does not follow MS/DOS file naming conventions, the following message will appear:

FILE ALREADY EXISTS OR ILLEGAL FILE NAME

ENTER 1 TO OVER-WRITE:
ENTER 0 TO SPECIFY NEW OUTPUT FILE NAME:

If 1 is entered and the previously entered file name was a legal file name, the existing data file with that name will be over-written. If 0 is entered, or if the previously entered file name was illegal, the following message will be displayed:

ENTER OUTPUT FILE NAME:

The user should then either correct the illegal file name or enter a new file name, as appropriate.

Simulation Date

The model user will be prompted for the simulation date as follows:

ENTER TODAY'S DATE (MONTH, DAY, YEAR):

The month, day, and year, separated by commas (or entered as three separate numbers, each followed by <carriage return>) is being requested. A numerical value must be entered for each variable, such as 8, 30, 1989 for August 31, 1989. This date is printed as 8 - 30 - 1989 on the outputs produced.

Creating INPUT.DAT Files

Interactive entries are made by typing an appropriate response, followed by <carriage return>, <return>, or <enter>, depending on the specific keyboard used. The remaining entries require that data be arranged in specific formats in data files that the model reads. This requirement is already met with the CLIM.DAT, CROP.DAT, IR.DAT, and SOIL.DAT files provided with the model. The INPUT.DAT file is, however, created by the model user, and care must be take to ensure that the proper formats are used.

INPUT.DAT files can be created using word processing software or the computer operating system editor. Normally, word processing software will be used because of the ease of data entry and modification. The word processor should be used in the non-document mode to create files in ASKII code that can be read by the AFSIRS model.

The structure of each line of the INPUT.DAT file is discussed in the following sections of this manual. Some data lines are optional, depending on the model options chosen. For each simulation, a range of from 7 to 14 data lines is required, depending on the options chosen.

It is assumed that AFSIRS batch model users are familiar with the interactive version of the model. Because the interactive model version prompts for all data entries, it should be the version used by the novice. This User's Manual contains more detailed discussions of each of the required data entries in those sections where the interactive version of the model is discussed. For more information on any of the data entries, the user is referred to those sections of this manual. Also, Appendix B contains an example INPUT.DAT file. This file contains data entries which will produce the same results as the previously-discussed interactive simulation of citrus irrigation requirements.

<u>Line 1</u>: SITE
Format: A36

SITE is the site description or identifier for which irrigation requirements are being calculated. A total of 36 characters are allocated to this description, beginning with the first character of the first line of the INPUT.DAT file.

<u>Line 2</u>: ICODE, IPRT, IPLOT, IVERS
Format: I2, 3(1X,I1)

ICODE is a code which specifies the style of output from the model. ICODE = -1 for basic (minimal) output. ICODE = 0 for basic plus biweekly and weekly summaries, ICODE = 1 for output of all previous plus intermediate parameters, and ICODE = 2 for extensive output (normally used only for debugging or determining how the model works). ICODE = -1 would be used for most purposes because it provides monthly and irrigation season data summaries.

IPRT is a code to further specify style of output. IPRT = 0 to print all data summaries, even though some are zeros because the crop is not grown or irrigated during that time of year. IPRT = 1 to suppress printing of zeros to reduce the length of output.

IPLOT is a code to specify whether outputs will be graphed. IPLOT = 1 to graph outputs. IPLOT = 0 for no graphs.

IVERS is a code to specify style of inputs. Irrigation requirements simulated with the AFSIRS model were found to be very sensitive to the crop root zone depth, fraction of the root zone irrigated (for micro irrigation systems) and irrigation application efficiency. Enter IVERS = 0 to use model default values for inputs. Enter IVERS = 1 for optional (later) user entries of these values.

<u>Line 3</u>: ICROP, MO1, DAY1, MON, DAYN
Format: I2, 4(1X,I2)

ICROP is the crop code for the crop type to be used in the simulation model. See Figure 5. For crops other than those listed in the AFSIRS model data base, enter ICROP = 6 or ICROP = 34 for generic annual or perennial crops, respectively. Either of these entries (6 or 34) require that the crop name and all other crop data be specified later in this data file. Entries of other codes cause crop data to be read from the model data bases.

The remaining data entries on Line 3 specify the irrigation season to be simulated. MO1 and DAY1 are the month and day that begin the irrigation season. MON and DAYN are the month and day that end the irrigation season. Acceptable values are 1 - 12 for months and 1 - 31 for days.

<u>Line 4</u>: FNAME
Format: A20

FNAME is the climate data base file name to be read. Normally, this is one of the nine climate data bases provided with the AFSIRS model, such as CLIM.TAM for Tampa, CLIM.ORL for Orlando, etc. However, this entry may also be used to specify a climate data base created by the model user, if the formats of the given climate data bases are used.

FNAME may be used to specify both the climate data file name and the disk drive on which the file is located. For example, specifying B:CLIM.WPB will cause the West Palm Beach climate data to be used, and the computer will expect to find that data file located on disk drive B:.

The FNAME format permits a total of 20 characters. This allows the file name as well as disk directories and sub-directories to be specified. Specifying B:\WPB\CLIM.WPB will cause the West Palm Beach data file, located in file directory WPB on disk drive B: to be used.

<u>Line 5</u>: IR, INET, IDCODE, FIX, PIR, EFF, AREA, EXIN, SYS
Format: I2, 2(1X,I1), 5F5.1, 1X, A28

IR is the irrigation system code. See Section J in the "Interactive Use" section of this manual for a list of irrigation system types and descriptions of the irrigation systems supported by the model. IR = 2 through 9 define specific types of irrigation systems and their associated data bases. IR = 1 identifies a user-specified irrigation system. For IR = 1, the irrigation system will be defined by the last four entries on this data line (Line 5).

INET is a code used to specify whether net (irrigation application efficiency not included) or gross (including losses due to inefficiencies in water application) irrigation requirements will be calculated. INET = 0 to specify net irrigation requirements. INET = 1 to specify gross irrigation requirements.

IDCODE is a code used to define the irrigation management practice used. IDCODE = 0 to specify that the soil will be irrigated to field capacity at each irrigation. This is the most common irrigation management practice. IDCODE = 1 specifies that a fixed depth of water will be applied at each irrigation. IDCODE = 2 specifies that deficit irrigation will be practiced. With deficit irrigation, the soil will be irrigated to only a percentage of field capacity (between 50% and 100%) in order to reduce irrigation requirements by permitting storage for rainfall.

FIX is the fixed depth of water to apply at each irrigation (in inches) if fixed depth irrigation management is practiced. This value is only read if IDCODE = 1 was previously specified.

PIR is the fraction (entered as a percent between 50% and 100%) of field capacity to be used if deficit irrigation is practiced. This value is only read if IDCODE = 2 was previously specified.

The remaining four entries on Line 5 are only read if a user-specified irrigation system was defined (IR = 1 as the first entry on Line 5). EFF is the irrigation system application efficiency (entered as decimal fraction) which may range up to 1.00 (100%). Note that 0 is not a valid entry because the net irrigation requirement must be divided by the efficiency to calculate the gross irrigation requirement.

AREA is the fraction of the soil surface (entered as a decimal fraction) that will be irrigated with the irrigation system specified. For sprinkler, seepage, and flood systems this value is typically 1.00 (100%), whereas for micro systems, typically less than 100% of the soil surface is irrigated.

EXIN is the fraction (entered as a decimal fraction) of evapotranspiration (ET) that is extracted from the irrigated (versus the non-irrigated) portion of the crop root zone. For containerized and flood-irrigated systems, most or all of the ET may be extracted from the irrigated root zone. For many crops grown under field conditions, the entire crop root zone is not irrigated, or water moves to the irrigated root zone by capillarity from water tables or other moist soil zones, thus less than 100% of ET is extracted from the irrigated root zone. EXIN = 0.70 (70% of ET extracted from irrigated zones) is typically used in the AFSIRS model irrigation data base.

SYS is the irrigation system type or name for a user-specified system. Its length is limited to 28 characters.

Line 6: DWT, HGT, DRINC
Format: 3F5.1

DWT is the depth to the water table (in feet) at the irrigation site. This value is required because shallow water tables limit root zones and contribute water to the irrigated soil zone by capillarity.

HGT is the height of the soil beds (in feet) in citrus crown flood irrigation systems. This value is only read if the irrigation system type was previously specified as a crown flood (citrus) irrigation system on Line 5.

DRINC is the flood storage depth (in inches) for flooded rice paddies. This value is only read if the irrigation system type was previously specified as a flood (rice) irrigation system on Line 5.

Optional Lines 7-9: Lines 7-9 are used only when ICROP = 6 (generic perennial crop) in Line 3. These lines must otherwise be omitted.

Line 7 (Optional): CTYPE, DRZIRR, DRZTOT
Format: A12, 2F5.0

CTYPE is the type of generic perennial crop specified. DRZIRR and DRZTOT are, respectively the irrigated and total crop root zone depths (in inches).

Line 8 (Optional): KC(1)...KC(12)
Format: 12F5.2

KC(i) is the monthly crop water use coefficient (dimensionless) for month i. Twelve monthly crop coefficients must be specified for January through December, even if the irrigation season is less than 12 months. Zeros are valid entries for non-irrigation months.

Line 9 (Optional): ALDP(1)...ALDP(12)
Format: 12F5.2

ALDP is the monthly allowable soil water depletion level (given as a decimal fraction) used for irrigation management. Twelve monthly allowable water depletions must be specified for

January through December, even if the irrigation season is less than 12 months. Values from 0.00 to 1.00 are valid entries. Values ranging from 1/3 (0.333) to 2/3 (0.667) are very common, with 1/2 (0.500) being most common.

Optional Line 10: Line 10 is used only when a perennial crop other than a generic perennial crop (other than ICROP = 6) is specified, and when IVERS = 1, indicating that the user will enter crop root zone data (default crop root zone data will not be used). This line must otherwise be omitted.

Line 10 (Optional): DRZIRR, DRZTOT
Format: 2F5.0

DRZIRR and DRZTOT are, respectively the irrigated and total crop root depths (in inches).

Optional Line 11: Line 11 is used only when ICROP = 34 (generic annual crop) in Line 3. This line must otherwise be omitted.

Line 11 (Optional): CTYPE, DZN, DZX, KC3, KC4, F(1)...F(4), ALD(1)...ALD(4)
Format: A12, 2F5.0, 10F5.2

CTYPE is the type of generic annual crop specified. DZN and DZX are, respectively the initial (early season) and final irrigated root depths (in inches). KC3 and KC4 are the crop water use coefficients (dimensionless) for annual crop growth stages 3 and 4, respectively. F(1) through F(4) are the fractions of the crop growing season in each of the four crop growth stages for annual crops (entered as decimal fractions). ALD(1) through ALD(4) are the allowable soil water depletion levels for the four annual crop growth stages (entered as decimal fractions).

Optional Line 12: Line 12 is used only when an annual crop other than a generic annual crop (other than ICROP = 34) is specified, and when IVERS = 1, indicating that default crop root zone data will not be used. Otherwise, this line must be omitted.

Line 12 (Optional): DZN, DZX
Format: 2F6.2

DZN and DZX are, respectively the initial (early season) and final irrigated root depths (in inches).

Line 13: ISOIL, ISCODE, SNAME, TXT, NL
Format: I3, 1X, I1, A20, A4, 1X, I1

ISOIL is a code to specify the soil type to be used in the AFSIRS model. A list of soil types is contained in the AFSIRS Technical Manual. A list is also obtainable by running the Interactive Version of the AFSIRS model or by printing the computerized soils data bases that are provided with the model. The range of permissible values depends on the soils data base being used.

ISCODE is a code to specify whether minimum (ISCODE = 0), average (ISCODE = 1), or maximum (ISCODE = 2) soil water capacity data are to be used from the range of data that are provided for each soil series.

Generic soils data can be specified by the model user by entering ISOIL = 0. In that case, the generic soil series name should be entered as SNAME, its textural classification as TXT, and the number of soil layers with different water-holding characteristics should be entered as NL (permissible range from 1 through 6).

Optional Line 14: Line 14 is used only when a generic soil type was specified on Line 13 (ISOIL = 0). Otherwise, this line must be omitted.

Line 14 (Optional): DU(1),WC(1)...DU(NL),WC(NL)
Format: 6(F5.0,F5.2)

DU(I) and WC(I) are, respectively, the depth from the soil surface to the bottom of the ith soil layer and the volumetric water content of the Ith soil layer. Up to 6 soil layers may be specified. Data are required for the number of soil layers (NL) specified on Line 13.

Successive Simulations

Multiple simulations which execute successively can be executed by "stacking" input data lines in the INPUT.DAT file. There is no specific limit to the number of successive simulations that can be run because the model will execute until the end of the INPUT.DAT file is encountered. Blank lines should not be placed between successive sets of input data. Rather, the last line of each data set (Line 13 or optionally, Line 14) should immediately be followed by Line 1, giving the site description for the next data set.

To allow the model user to view progress toward multiple simulations, the computer screen will display the site description as each simulation is initiated. Succeeding simulations will execute quicker than the first simulation if the climate data base does not need to be read.

The outputs from each successive simulation will be stacked behind the pervious one in the output file. The output file will not be closed until execution of the model is terminated.

SIMULATION OUTPUTS

Outputs from the interactive version of the AFSIRS model will be displayed on the video screen and will also be written to the output file (and disk drive and directory) designated by the user. Only a limited number of outputs from the batch model version will be written to the computer screen. These include interactions to define the simulation date and output file name and location.

Each version of the model will re-initiate and require re-naming the output file each time that it is executed, and it will sequentially print into one output file the outputs from all simulations run during one computing session. Therefore, at the end of a computing session, the output file may contain the outputs from several separate simulations.

Outputs will consist of a listing of all data inputs made by the model user, tabular summaries of seasonal and monthly IRR simulated, and bi-weekly and weekly summaries of IRR if that option was elected by the user. If graphic outputs were elected during the model data entry, graphs as shown in Figures 2-4 will follow the tabular outputs.

Basic Output

A sample output is shown as Appendix C. This is the basic or minimal output that results from the entry of -1 as the Output Style control character in the AFSIRS model. For brevity, this is the only output shown, although the other styles are discussed in the following paragraphs.

The output format reiterates each of the inputs made, then presents selected crop, soil, irrigation system, and climate data read from the model data bases. These data include the length of climate record, irrigation system efficiency, fraction of soil surface irrigated, fraction of ET extracted from the irrigated soil zone, irrigated soil depth, crop root depth, crop water use coefficients, allowable soil water depletions, and soil water-holding characteristics.

The output file then presents tabulations of the irrigation requirements (IRR) calculated, selected statistical characteristics of IRR, and probabilities of occurrence of extreme values of IRR estimated by the AFSIRS model. The output also summarizes rainfall (RAIN), potential ET (ETP), actual crop ET (ET), and drainage (DR) for each of the periods that IRR was analyzed.

The first part of the tabulated output is of seasonal or annual IRR. Either gross or net irrigation requirements are presented, depending on interactive user entries. This is the total IRR calculated from the beginning to the end of the irrigation season defined by the model user.

Outputs under this and each following category include the mean (MEAN), median (MED.), coefficient of variation (CV), maximum (XMAX), and minimum (XMIN) irrigation requirements calculated from the period of record available for the climate data base used. The next columns report the fraction of years with no irrigation (ZERO) and the coefficient of determination (RSQ) for the least squares curve fit to the extreme value distribution used to represent the statistical distribution of the irrigation requirements data. The next columns are the probabilities of occurrence of the extreme events calculated. The 50%, 80%, 90%, and 95% probabilities of occurrence of IRR are given. The final columns are the rainfall (RAIN), potential ET (ETP), actual crop ET (ET), and drainage (DR) summaries for the same time periods as the irrigation requirements summaries.

The second portion of the output lists the same parameters summarized monthly. Monthly summaries are calendar months in this analysis. Also, if the graphics option was chosen, a graph of the monthly distribution of IRR will be printed following the tabulated data.

Basic Output Plus Biweekly and Weekly Summaries

If the user elects to enter ICODE = 0 in selecting the AFSIRS model output style, all of the previously discussed basic output parameters are printed. However, in addition to the seasonal and monthly summaries, biweekly (14-day) and weekly summaries are also listed. In these summaries the same statistical parameters that were calculated for the seasonal and monthly IRR are also calculated for the biweekly and weekly IRR. Again, if the graphics option was also chosen, graphs of the biweekly and weekly distributions of IRR are also printed following the tabulated data.

Biweekly periods are consecutive 14-day periods beginning January 1. Weekly periods are consecutive 7-day periods beginning January 1. The last biweekly period contains 15 days, and the last weekly period contains 8 days, for a total of 365. Leap years are not considered in the AFSIRS model.

Output of Intermediate Parameters

If the AFSIRS model user enters ICODE = 1 to specify the output style, a large output will result. This choice will cause the previously discussed seasonal, monthly, biweekly, and weekly outputs to occur, and in addition, it will output all crop, soil, and irrigation system coefficients for each day of the irrigation season.

Extensive Output

If the AFSIRS model user enters ICODE = 2 to select the output style, an extremely large output will result. This will result in the printing of all of the previously discussed parameters plus the daily water budgets for each day of the irrigation season and for all years of record. This output option may be used to study how the model functions. It is recommended that it be used only with short irrigation seasons and an abbreviated climate data base to minimize the amount of output.

INTERPRETING SIMULATION RESULTS

The output of the AFSIRS model consists of the simulated irrigation requirements (IRR) for seasonal, monthly, biweekly, and weekly time periods, depending on the output option chosen. For each time period, the following IRR statistical parameters are printed or graphed: mean (MEAN), median (MED.), coefficient of variation (CV), maximum observed value (XMAX), minimum observed value (XMIN), fraction of years with no IRR (ZERO), coefficient of determination for least squares curve fitting of the IRR data to the extreme value distribution used (RSQ), and the 50%, 80%, 90%, and 95% probability of occurrence values. Rainfall (RAIN), potential ET (ETP), actual crop evapotranspiration (ET), and drainage (DR) summaries are also printed.

The mean IRR reported is the arithmetic average value observed for the number of years of climate record simulated. The median (MED.) value is the centermost value for the period of record. It is calculated by ordering the IRR values calculated for the period of record from smallest to largest, and then choosing the value nearest the center of the ordered values. In Appendix C, for example, IRR values are reported for 25 years of record. The seasonal or annual median IRR reported is 21.3 inches. This was the 13th (or centermost) of IRR values calculated for the 25 years of record.

Close agreement between the mean and median IRR values is one indication of a normal data distribution. A large discrepancy between the mean and median values is evidence of a skewed (non-normal) data distribution.

The coefficient of variation of the IRR data set for the period of record is a measure of the expected year-to-year variation in the simulated IRR. If the CV is large, the IRR would be expected to vary greatly from year-to-year. If the standard deviation is small, this indicates that the IRR would be expected to vary little from year-to-year.

The maximum (XMAX) and minimum (XMIN) observed values are the largest and smallest simulated values of IRR for the period of record. The maximum observed seasonal or annual IRR was 34.2 inches from Appendix C. The minimum observed IRR was 8.9 inches. These values are the largest and smallest that occurred for the 25 years of record. Obviously, the 34.2 inches was required during a drought year, while only 8.9 inches was required during a high rainfall year.

ZERO is the fraction of years with no irrigation requirement for the period of record simulated. If, for example, ZERO = 0.0, then some irrigation was required each year. If ZERO = 0.20, then 20% of the years during the simulation period required no irrigation.

The coefficient of determination, RSQ, is a measure of how well the simulated IRR fit the extreme value distribution used to estimate the probabilities of occurrence of extreme IRR values. RSQ can range from 0.0 to 1.0, with values near 1.0 indicating a perfect fit of the extreme value distribution. RSQ values above 0.70 should be interpreted as good fits of the extreme value function. RSQ values above 0.90 indicate excellent fits of the extreme value function.

The AFSIRS model outputs RSQ values of -1.00 if the computed coefficient of determination is low, indicating that a poor trend exists in the data distribution, and that extreme values of IRR cannot be estimated with a high degree of certainty. The model outputs RSQ values of -9.99 if there are not sufficient non-zero IRR values to fit the extreme value distribution.

The next output columns are the 50% through 95% IRR values, calculated based on the extreme value distribution. These probability values should be interpreted as the proportion of future irrigation seasons during which the given IRR would be expected to meet the needs of the crop being irrigated based on long-term averages. For example, the 80% seasonal or annual IRR for citrus in Appendix C was calculated to be 27.1 inches. This is the amount that would provide adequate irrigation for crop production in 80% of future years, on the average for a long-term period of record. That is, on the average, 27.1 inches of irrigation would be adequate to prevent water stress in 8 of every 10 years of production. Conversely, in only 2 years of every 10 or 20% of the time, on the average, would the calculated IRR not be adequate to prevent water stress.

For the 80% probability example, the return period (expected period of time between exceedence events) of stress years would be 1 / 0.20 = 5 years. As with the probability values, this return period only has meaning when interpreted for long-term periods of record. There is no certainty implied that one and only one water stress year will occur in the next 5, nor in each succeeding group of 5 years. Likewise, no statement is being made concerning the magnitude of water stress that will occur during a water stress year.

The 50% probability value is the expected IRR for a 2-year return period. When the IRR data base is normally distributed, the 50% IRR value will be approximately equal to the MEAN value. This is the case for most seasonal and many of the monthly periods analyzed. For example, in Appendix C, the mean, median, and 50% probability values were 21.1, 21.3, and 21.0 inches, respectively, indicating that it is very likely that these data are normally distributed.

When the data base is skewed, the 50% IRR value will be different from the MEAN value. This is typically caused by the occurrence of a large number of zero or very small values, thus it obviously occurs more often for the shorter (see the monthly data in Appendix C for examples of this) time periods analyzed. If a data base contains a large number of zero values, there is a high probability that it is not normally distributed. If, however, XMIN is nonzero, the mean and median values are approximately equal, and the MEAN and 50% IRR values are approximately equal, these are good indications that the data are normally distributed.

For Florida irrigated crops, the assumption of a normal distribution for seasonal or annual IRR approximates the simulated distributions well. For monthly IRR, the simulated data are normally distributed for months with large IRR. For months with small irrigation requirements and for shorter (weekly and bi-weekly) time periods, where there are a high proportion of zero (no irrigation) data, the simulated data do not fit a normal distribution. Therefore, the extreme value distribution was used to calculate probabilities of occurrence, and the adequacy of data fit to this distribution is indicated by the coefficient of determination (RSQ) printed with each data summary.

The Type I extreme value distribution used in this model is bounded by zero at the lower end, but it is unbounded at the upper end. Therefore, this distribution may estimate extreme values of IRR that are unrealistically large if there is sufficient scatter in the data, the soil water storage is large with respect to ET for the period analyzed, and there are a sufficient number of years with no rainfall so that all of the crop water use is supplied by irrigation. These conditions would be most likely to occur for the shorter (weekly and bi-weekly) periods analyzed. Under these conditions, net irrigation requirements which exceed ET values may be predicted by the extreme value distribution. If that occurs, the AFSIRS model limits the net irrigation requirement extreme value to the magnitude of crop ET and it limits the gross irrigation requirement to ET divided by the irrigation efficiency.

Summaries of RAIN, ETP, ET, and DR calculated by the AFSIRS model are provided as the final part of the tabulated model output. These summaries permit the effects of rainfall and climatic demand on IRR to be directly observed. The average crop water use coefficient can be determined as the ratio of ET to ETP for each period of analysis. Ratios greater than 1.0 indicate crop water use coefficients that are greater than 1.0 for those analysis periods. Drainage is calculated as the difference between rainfall and available soil water storage at the time that rain occurs. Thus, drainage depends on both the amounts and time distributions of rainfall as well as the type of irrigation system used and the irrigation management strategies.

APPENDIX A

Example of Interactive Use of the AFSIRS Model

****

AGRICULTURAL
FIELD
SCALE
IRRIGATION
REQUIREMENTS
SIMULATION

MODEL

AFSIRS MODEL: INTERACTIVE VERSION 5.5

THIS MODEL SIMULATES IRRIGATION REQUIREMENTS
FOR FLORIDA CROPS, SOILS, AND CLIMATE CONDITIONS.

PROBABILITIES OF OCCURRENCE OF IRRIGATION REQUIREMENTS
ARE CALCULATED USING HISTORICAL WEATHER DATA BASES
FOR NINE FLORIDA LOCATIONS.

****

PRESS <RETURN> TO CONTINUE :

<cr>

****

ALTHOUGH THIS MODEL IS BELIEVED TO BE COMPLETE AND ACCURATE,
NO EXPLICIT OR IMPLICIT WARRANTIES ARE MADE WITH REGARD TO ITS USE.

THE RESPONSIBILITY FOR THE USE OF THIS MODEL FOR ANY
SPECIFIC PURPOSE LIES SOLELY WITH THE USER.

INSTRUCTIONS FOR THE USE OF THIS MODEL ARE GIVEN
IN THE AFSIRS MODEL USER'S GUIDE.

DETAILS OF THE OPERATION OF THIS MODEL, ITS APPLICATIONS
AND LIMITATIONS ARE GIVEN IN THE AFSIRS MODEL TECHNICAL MANUAL.

****

```
                     ENTER OUTPUT FILE NAME:
CITRUS.OUT

                OUTPUT FILE NAME ENTERED = CITRUS.OUT


******************************************************************

              AFSIRS MODEL: INTERACTIVE VERSION 5.5

           THIS MODEL SIMULATES IRRIGATION REQUIREMENTS
         FOR FLORIDA CROPS, SOILS, AND CLIMATE CONDITIONS.

******************************************************************


                ENTER TODAY'S DATE (MONTH, DAY, YEAR) :
8,31,1989
                                       DATE:  8 - 31 - 1989


                   ENTER LOCATION / SITE DESCRIPTION :
EXAMPLE: J.H. DOE, BLOCK 22

                   LOCATION : EXAMPLE: J.H. DOE, BLOCK 22


                  ENTER ICODE TO DEFINE STYLE OF OUTPUT:

                 ICODE = -1  FOR BASIC (MINIMAL) OUTPUT
        ICODE =  0  FOR BASIC PLUS BIWEEKLY & WEEKLY SUMMARIES
          ICODE =  1  FOR OUTPUT OF INTERMEDIATE PARAMETERS
  ICODE =  2  FOR EXTENSIVE OUTPUT (NORMALLY FOR DEBUGGING ONLY)
-1
                     ICODE ENTERED WAS = -1


                    ENTER  1  TO GRAPH OUTPUTS:
                    ENTER  0  FOR NO GRAPHS:
1
                    RESULTS WILL BE GRAPHED
```

IRRIGATION REQUIREMENTS CALCULATED USING THE AFSIRS MODEL
ARE VERY SENSITIVE TO THE CROP ROOT DEPTH, FRACTION
OF THE ROOT ZONE IRRIGATED, AND IRRIGATION EFFICIENCY.

ENTER 0 TO USE THE MODEL DEFAULT VALUES FOR THESE DATA.
ENTER 1 IF THESE DATA WILL BE ENTERED FROM THE KEYBOARD.

0

INPUT CODE ENTERED = 0

******* PERENNIAL CROPS *******

1 ALFALFA	2 AVOCADO	3 BLUEBERRY
4 CITRUS	5 FERNS	6 GENERIC CROP
7 GRAPES	8 NURSERY,CNTR	9 NURSERY,FLD.
10 PASTURE	11 PEACHES	12 PECANS
13 SOD	14 SUGARCANE	15 TURF,GOLF
16 TURF,LNDSCP.		

******* ANNUAL CROPS *******

17 BARLEY	18 BEANS,GRN.	19 BEANS,DRY
20 BEETS	21 BROCCOLI	22 BRUSSEL SPTS
23 CABBAGE	24 CARROTS	25 CAULIFLOWER
26 CELERY	27 CLOVER	28 CORN,FIELD
29 CORN,SWEET	30 COTTON	31 CUCUMBER
32 EGGPLANT	33 FIELD CROPS	34 GENERIC CROP
35 GREENS,HERBS	36 LETTUCE	37 MELONS
38 MILLET,FORGE	39 MILLET,GRAIN	40 OATS
41 ONION,DRY	42 ONION,GRN.	43 PEANUTS
44 PEAS	45 PEPPERS,GRN.	46 POTATOES
47 RADISH	48 RICE	49 SMALL GRAINS
50 SMALL VEGETS	51 SORGHUM	52 SOYBEAN
53 SPINACH	54 SQUASH	55 STRAWBERRY
56 SUNFLOWERS	57 SWEET POTATO	58 TOBACCO
59 TOMATO	60 WHEAT	

ENTER CROP CODE:

4

THE CROP CODE SELECTED = 4
THE CROP TYPE SELECTED IS : CITRUS

ENTER BEGINNING DATE OF CROP IRRIGATION SEASON (MONTH, DAY):
1,1
ENTER ENDING DATE OF CROP IRRIGATION SEASON (MONTH, DAY):
12,31

THE IRRIGATION SEASON SPECIFIED WAS 1- 1 TO 12-31

LENGTH OF IRRIGATION SEASON = 365 DAYS
J1= 1 JN= 365

ENTER CLIMATE DATA BASE FILE NAME:

CLIM.TAM

CLIMATE DATA BASE FILE NAME ENTERED = CLIM.TAM

***** READING DATA FILES *****

THE CLIMATE DATA BASE LOCATION IS : TAMPA

LENGTH OF CLIMATE DATA RECORD = 25 YEARS

IRRIGATION SYSTEM DATA

SELECT THE TYPE OF IRRIGATION SYSTEM TO BE USED :

1 = USER-SPECIFIED SYSTEM
2 = MICRO, DRIP
3 = MICRO, SPRAY
4 = MULTIPLE SPRINKLER
5 = SPRINKLER, CONTAINER NURSERY
6 = SPRINKLER, LARGE GUNS
7 = SEEPAGE, SUBIRRIGATION
8 = CROWN FLOOD (CITRUS)
9 = FLOOD (RICE)

ENTER THE IRRIGATION SYSTEM CODE :

3

THE IRRIGATION SYSTEM CODE ENTERED = 3
THE IRRIGATION SYSTEM TYPE IS : MICRO, SPRAY

ENTER 0 TO CALCULATE NET IRRIGATION REQUIREMENTS:
ENTER 1 TO CALCULATE GROSS IRRIGATION REQUIREMENTS:

1

GROSS IRRIGATION REQUIREMENTS WILL BE CALCULATED

ENTER 0 TO IRRIGATE TO FIELD CAPACITY (NORMAL PRACTICE):
ENTER 1 TO APPLY A FIXED DEPTH PER IRRIGATION:
ENTER 2 FOR DEFICIT IRRIGATION:

0

NORMAL IRRIGATION: SOIL WILL BE IRRIGATED TO FIELD CAPACITY AT EACH IRRIGATION

THE IRRIGATION SYSTEM DESIGN EFFICIENCY = .80
FRACTION OF SOIL SURFACE IRRIGATED = .50
FRACTION EXTRACTED FROM IRRIGATED ZONE = .40

CROP TYPE = CITRUS

ROOT ZONE DEPTH IRRIGATED (INCHES) = 30.0
TOTAL CROP ROOT ZONE DEPTH (INCHES)= 60.0

	MONTH											
	1	2	3	4	5	6	7	8	9	10	11	12
KC=	.90	.90	.90	.90	.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ALDP=	.67	.67	.33	.33	.33	.33	.67	.67	.67	.67	.67	.67

SOILS DATA ENTRY

NUMBER OF SOILS = 766

ENTER CODE FOR SOIL TYPE DESIRED :
ENTER 0 IF YOU WANT A LIST OF SOILS:
ENTER -1 TO INPUT SOILS DATA FROM THE KEYBOARD :

47

THE SOIL TYPE CODE ENTERED WAS : 47

THE SOIL SERIES SPECIFIED WAS : ASTATULA

THE SOIL TEXTURE IS : S FS

SOIL LAYER DEPTHS (INCHES) AND WATER CONTENTS

DEPTH(I)=	3.	86.
MIN.WCON(I)=	.04	.02
MAX.WCON(I)=	.10	.05

DO YOU WANT TO USE MINIMUM, AVERAGE, OR MAXIMUM
WATER-HOLDING CAPACITY FOR THIS SOIL SERIES ?
MINIMUM = 0 AVERAGE = 1 MAXIMUM = 2

ENTER THE SOIL CODE FOR THE APPROPRIATE CONDITION :

2

DEPTH(I)= 3. 86.
WCON(I) ENTERED= .10 .05

ENTER DEPTH TO WATER TABLE (FEET):

50

DEPTH TO WATER TABLE ENTERED = 50.0 FEET

THIS COMPLETES DATA ENTRY

ENTER 1 TO COMPUTE
ENTER 0 TO RETURN TO DATA ENTRY MODE:

1

***** COMPUTING *****

SEASONAL OR ANNUAL GROSS IRRIGATION REQUIREMENT (INCHES)

MEAN	MED.	CV	XMAX	XMIN	ZERO	RSQ	50%	80%	90%	95%	RAIN	ETP	ET	DR
21.1	21.3	.30	34.2	8.9	.00	.98	21.0	27.1	30.1	32.6	47.4	54.1	52.4	11.9

MONTHLY GROSS IRRIGATION REQUIREMENT (INCHES)

MO	MEAN	MED.	CV	XMAX	XMIN	ZERO	RSQ	50%	80%	90%	95%	RAIN	ETP	ET	DR
1	1.0	.8	.75	2.2	.0	.24	.88	.7	1.5	1.9	2.3	2.1	2.7	2.5	.5
2	.8	.7	1.05	3.1	.0	.40	.91	.2	1.1	1.7	2.3	3.1	3.3	3.0	.5
3	1.9	1.8	.64	4.5	.0	.04	.97	1.6	3.1	4.1	5.0	3.7	4.5	4.1	1.3
4	3.3	3.3	.47	6.2	.4	.00	.95	3.1	5.0	6.2	6.3	1.7	5.6	5.1	.2
5	4.6	5.1	.36	6.8	1.3	.00	.91	4.5	6.3	7.4	7.5	2.9	6.3	6.0	.3
6	2.2	2.4	.57	5.0	.4	.00	.96	2.0	3.5	4.4	5.2	5.9	5.9	5.8	1.0
7	1.0	.8	1.04	3.9	.0	.36	.93	.3	1.3	2.0	2.7	7.7	5.7	5.7	2.3
8	.5	.0	1.35	1.6	.0	.60	.76	.0	.6	1.0	1.4	7.6	5.3	5.3	2.6
9	.7	.7	1.06	2.3	.0	.44	.85	.2	.9	1.4	1.8	6.1	4.8	4.8	2.1
10	1.8	1.5	.73	5.5	.0	.08	.93	1.5	2.7	3.5	4.2	2.6	4.3	4.3	.4
11	1.9	1.5	.55	4.6	.7	.00	.89	1.8	2.6	3.1	3.5	1.9	3.2	3.2	.3
12	1.3	1.5	.63	3.0	.0	.16	.90	1.1	1.9	2.3	2.7	2.2	2.6	2.6	.3

```
IRR (INCHES)                  IRRIGATION REQUIREMENTS
                                     CITRUS
      5.00 +
           I
           I                    *
           I
      4.00 +
           I
           I
           I                *
      3.00 +
           I
           I
           I                        *
      2.00 +            *                               *
           I                                        *
           I
           I                                                *
      1.00 +    *                       *
           I        *                           *
           I                                *
           I
       .00 +
            +---+---+---+---+---+---+---+---+---+---+---+---+---+
                1   2   3   4   5   6   7   8   9  10  11  12
                                   MONTH
```

PRINT SIMULATION RESULTS?

1 = YES, PRINT AND SAVE TO DISK FILE
0 = NO,   SAVE TO DISK FILE ONLY

0

DO YOU WANT TO RUN ANOTHER SIMULATION?

1 = YES
0 = NO

0

APPENDIX B

Example of INPUT.DAT File for the AFSIRS Model: Batch Version

The INPUT.DAT file will contain a range of 7 to 14 lines depending on the options selected. The following example data file contains the data required to produce the same simulation results as the interactive inputs shown in Appendix A. The resulting output file from both simulations is listed in Appendix C.

In the following INPUT.DAT file, each data line is presented in the required format. Each line is followed by an indented line (in parenthesis) which describes the data entries. The explanatory lines are for instructional purposes only. They must be omitted in the file that the computer will read.

<u>FILE INPUT.DAT</u>

```
EXAMPLE: J.H.DOE, BLOCK 22
     (Description of the simulation site; Format A36)

-1 1 1 0
     (Codes to describe simulation style: IDBUG, ISUP, IPLOT, and
      IVERS; Format I2,3(1X,I1))

 4  1  1 12 31
     (Crop code and month and day beginning and ending the
irrigation season: ICROP, MO1, DAY1, MON, DAYN;  Format
I2,4(1X,I2))

CLIM.TAM
     (Climate data base file name; Format A20)

 3 1 0
     (Irrigation codes IR,INET, and IDCODE to define type of
irrigation system, net or gross irrigation requirements,     and
irrigation management practices to be simulated, Format
3(1X,I1))

 50.0
     (Depth to the water table, DWT (ft);  Format F5.1)

 47 2
     (Soil codes, ISOIL to identify soil series and ISCODE to
define whether max, min, or average soil water data will be
used;  Format I3,1X,I1)
```

With the descriptive text and line spaces omitted, the INPUT.DAT file should appear as follows to be read by the computer:

```
EXAMPLE: J.H.DOE, BLOCK 22
-1 1 1 0
 4  1  1 12 31
CLIM.TAM
 3 1 0
 50.0
 47 2
```

For successive simulations, the site description of the next simulation site should immediately follow the last line of the previous data set.

APPENDIX C

Example of AFSIRS Model Basic Output

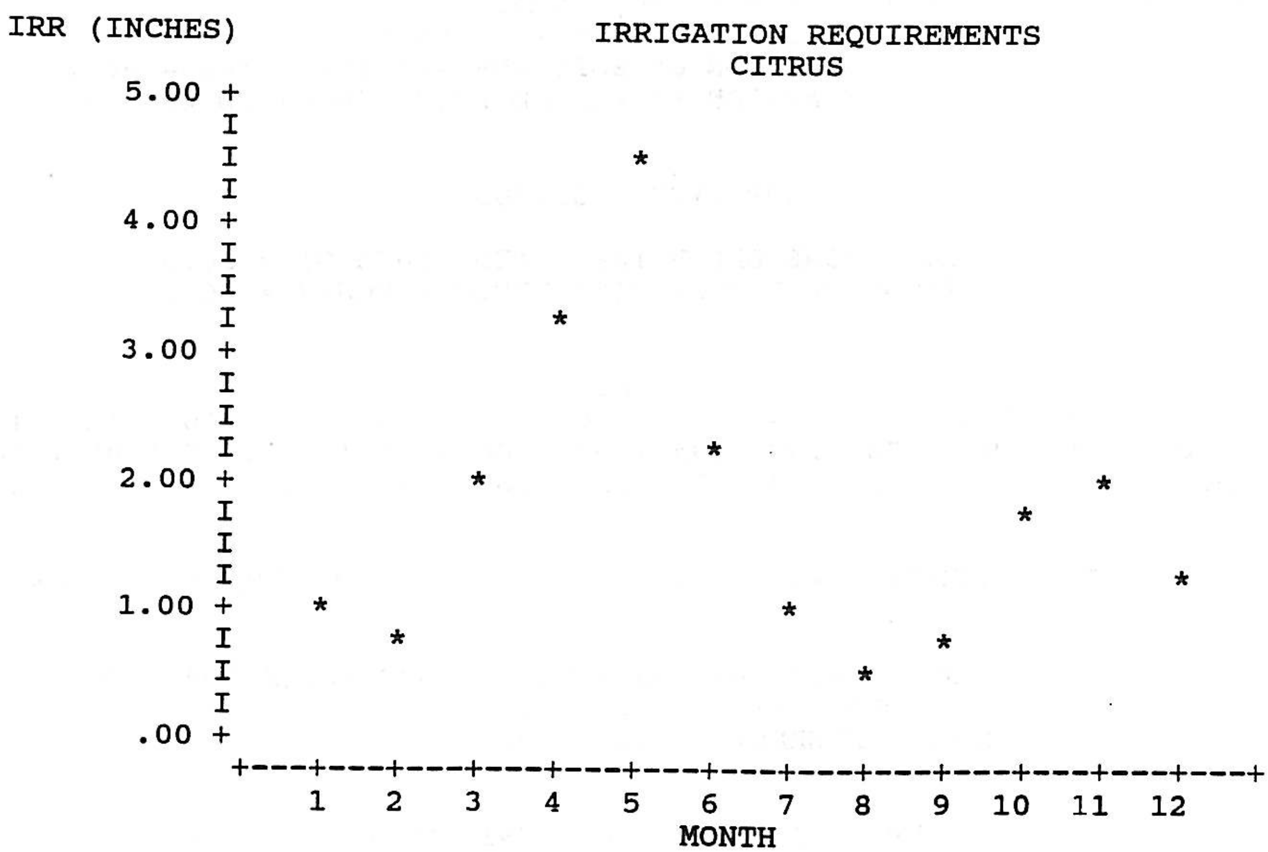
```
*****************************************************************

            AFSIRS MODEL: INTERACTIVE VERSION 5.5

         THIS MODEL SIMULATES IRRIGATION REQUIREMENTS
       FOR FLORIDA CROPS, SOILS, AND CLIMATE CONDITIONS.

*****************************************************************

 LOCATION = TEST 1                             DATE =  8-31-1989

                    CROP TYPE = CITRUS

IRRIGATION SEASON =  1- 1 TO 12-31            LENGTH = 365 DAYS

CLIMATE DATA BASE: LOCATION = TAMPA           LENGTH = 25 YEARS

   NORMAL IRRIGATION: SOIL WILL BE IRRIGATED TO FIELD CAPACITY
                      AT EACH IRRIGATION

IRRIGATION SYSTEM : TYPE = MICRO, SPRAY
                    DESIGN EFFICIENCY =  80 %
                    FRACTION OF SOIL SURFACE IRRIGATED = 50 %
                    FRACTION EXTRACTED FROM IRRIGATED ZONE = .40


                  CROP TYPE = CITRUS

             ROOT ZONE DEPTH IRRIGATED (INCHES) = 30.0
             TOTAL CROP ROOT ZONE DEPTH (INCHES)= 60.0


                              MONTH
        1    2    3    4    5    6    7    8    9   10   11   12
  KC = .90  .90  .90  .90  .95 1.00 1.00 1.00 1.00 1.00 1.00 1.00
 ALDP= .67  .67  .33  .33  .33  .33  .67  .67  .67  .67  .67  .67


    SOIL :  SERIES = ASTATULA                 TEXTURE = S    FS


             SOIL LAYER DEPTHS (INCHES) AND WATER CONTENTS
                DEPTH(I)=     3.   86.
          WCON(I) ENTERED=    .10   .05


              DEPTH TO WATER TABLE ENTERED = 50.0 FEET
```

SEASONAL OR ANNUAL GROSS IRRIGATION REQUIREMENT (INCHES)

MEAN	MED.	CV	XMAX	XMIN	ZERO	RSQ	50%	80%	90%	95%	RAIN	ETP	ET	D
21.1	21.3	.30	34.2	8.9	.00	.98	21.0	27.1	30.1	32.6	47.4	54.1	52.4	11 9

MONTHLY GROSS IRRIGATION REQUIREMENT (INCHES)

MO	MEAN	MED.	CV	XMAX	XMIN	ZERO	RSQ	50%	80%	90%	95%	RAIN	ETP	ET	D
1	1.0	.8	.75	2.2	.0	.24	.88	.7	1.5	1.9	2.3	2.1	2.7	2.5	.[illegible]
2	.8	.7	1.05	3.1	.0	.40	.91	.2	1.1	1.7	2.3	3.1	3.3	3.0	.5
3	1.9	1.8	.64	4.5	.0	.04	.97	1.6	3.1	4.1	5.0	3.7	4.5	4.1	1.
4	3.3	3.3	.47	6.2	.4	.00	.95	3.1	5.0	6.2	6.3	1.7	5.6	5.1	.
5	4.6	5.1	.36	6.8	1.3	.00	.91	4.5	6.3	7.4	7.5	2.9	6.3	6.0	.3
6	2.2	2.4	.57	5.0	.4	.00	.96	2.0	3.5	4.4	5.2	5.9	5.9	5.8	1.[illegible]
7	1.0	.8	1.04	3.9	.0	.36	.93	.3	1.3	2.0	2.7	7.7	5.7	5.7	2.
8	.5	.0	1.35	1.6	.0	.60	.76	.0	.6	1.0	1.4	7.6	5.3	5.3	2.[illegible]
9	.7	.7	1.06	2.3	.0	.44	.85	.2	.9	1.4	1.8	6.1	4.8	4.8	2.1
10	1.8	1.5	.73	5.5	.0	.08	.93	1.5	2.7	3.5	4.2	2.6	4.3	4.3	.[illegible]
11	1.9	1.5	.55	4.6	.7	.00	.89	1.8	2.6	3.1	3.5	1.9	3.2	3.2	.[illegible]
12	1.3	1.5	.63	3.0	.0	.16	.90	1.1	1.9	2.3	2.7	2.2	2.6	2.6	.3



APPENDIX D

Abbreviations Used in the AFSIRS Model and Technical Manuals

ALD(i) = allowable depletion of available soil water between irrigations during the ith growth stage for annual crops (decimal fraction).

ALDP = allowable depletion of available soil water between irrigations for perennial crops (decimal fraction).

APL = Apalachicola, Florida.

AREA = fraction of the soil surface irrigated with the irrigation system specified (decimal fraction).

ARZI = area of the soil surface (crop root zone) irrigated with the irrigation system used (decimal fraction).

AWD = fraction of allowable water depletion in the crop root zone between irrigations (decimal fraction).

BAL = subroutine which calculates the daily soil water balance and schedules irrigations.

C = clay.

cb = centibars.

CL = clay loam.

CLIMAT = subroutine which reads the climate (ETp and RAIN) data bases for the simulation location.

COS = coarse sand.

<cr> = carriage return.

CROP.DAT = crop coefficient, root depth, and allowable water depletion data base.

CTYPE = user-specified crop type.

CV = coefficient of variation.

.DAT = file name extension which indicates a data file.

DAY1 = day of month on which irrigation season begins.

DAYN = day of month on which irrigation season ends.

DCOEF = subroutine which reads crop characteristics and calculates daily values of coefficients and root depths.

DR = drainage depth (inches).

DRINC = flood storage depth for flood-irrigated rice paddies (inches).

DRZIRR = depth of root zone irrigated for perennial crops (inches).

DRZTOT = total root zone depth for perennial crops (inches).

DTB = Daytona Beach, Florida.

DU(i) = depth from the soil surface to the bottom of the ith soil layer (inches).

DWT = depth to the water table, measured from the soil surface (ft).

DZN = initial (beginning of growing season) irrigated root depth for annual crops (inches).

DZX = final (end of growing season) irrigated root depth for annual crops (inches).

EFFa = irrigation system application efficiency (decimal fraction or %)

ET = evapotranspiration (inches) or daily evapotranspiration rate (inches/day).

ETp = potential ET (inches) or potential ET rate (inches/day).

.EXE = file name extension which indicates an executable file.

EXIN = fraction of ET that is extracted from the nonirrigated portion of the crop root zone (decimal fraction).

EXIR = fraction of ET extracted from the irrigated portion of the crop root zone (decimal fraction).

F(i) = fraction of the crop growing season that occurs in the ith growth stage (decimal fraction).

FIS = Florida Irrigation Society.

FIX = fixed depth of water to be applied at each irrigation (inches).

FNAME = climate data base file name.

.FOR = file name extension which indicates a FORTRAN source code file.

FS = fine sand.

FSL = fine sandy loam.

ft = feet.

gpm = gallons per minute.

HGT = height of the soil beds in citrus crown flood irrigation systems (ft).

ICODE = code to designate style of model output, from minimum through extensive.

ICROP = crop type code.

IDCODE = code which specifies the irrigation management practice to be used.

INET = code which specifies whether net or gross irrigation requirements will be calculated.

INPUT = subroutine which allows the model user to specify styles of input and output, crop type, and irrigation season.

INPUT.DAT = input data file for the batch-mode model.

IPLOT = code to specify whether outputs will be graphed.

IPRT = code to specify output print style.

IR = irrigation system type code.

IR.DAT = irrigation system characteristics data file.

IRR = gross irrigation requirement (inches).
= NIR / EFFa.

IRRI = subroutine which reads irrigation system characteristics data and identifies the irrigation system type to be simulated.

ISCODE = soil code which specifies whether maximum, minimum or average soil water capacity data are used when a soil series is specified.

ISOIL = soil type code.

IVERS = code to specify style of inputs, either default or user-specified.

JAX = Jacksonville, Florida.

J1 = first day of the irrigation season (normally also first day of the crop growing season).

Jn = last day of the irrigation season (normally also last day of the crop growing season).

KC = crop water use coefficient.

L = loam.

LFS = loamy fine sand.

LS = loamy sand.

LSQ = subroutine which calculates the least squares curve fit of IRR data to a straight line.

MEAN = arithmetic average.

MED. = median (centermost) data point.

MIA = Miami, Florida.

MOB = Mobile, Alabama.

MK = muck.

MO = month.

MO1 = month during which irrigation season begins.

MON = month during which irrigation season ends.

NIR = net irrigation requirement (inches).

NL = number of layers or horizons in the soil profile.

NRR = number of days required for redistribution of soil water to field capacity following rainfall.

ORL = Orlando, Florida.

P = plotting formula probability that a given value will not be exceeded (%).

PIR = fraction of field capacity used for deficit irrigation.

PLOT = subroutine which graphs IRR data for monthly, 2-week, and weekly periods of analysis.

PROBX = subroutine which calculates IRR 50%, 80%, 90%, and 95% probability values based on the extreme value distribution.
psi = water pressure, pounds per square inch.

PWP = permanent wilting point (-15 bars soil water potential).

RAIN = rainfall depth (inches).

RAM = computer random access memory.

RSQ = statistical coefficient of determination for the least squares curve fit to the extreme value distribution.

S = sand.

Si = silt.

SITE = site or location description.

SL = sandy loam.

SCS = Soil Conservation Service.

SNAME = name of user-specified soil type.

SOIL.DAT = soil profile description and water-holding capacity data base.

STATX = subroutine that calculates statistical properties of the IRR data, including mean, median, standard deviation, maximum value, minimum value, and probability of zero IRR.

SUMX = subroutine that sums and outputs IRR data for seasonal, monthly, bi-weekly, and weekly totals.

SW = subroutine which reads the soil characteristics data base and calculates the daily available soil water content and the water content at which irrigations will be scheduled.

SWCI = soil water content in the irrigated portion of the crop root zone (inches).

SWCIX = maximum soil water content (at field capacity) in the irrigated portion of the crop root zone (inches).

SWCIRR = soil water content in the irrigated root zone at which irrigations are scheduled (inches).

SWCMAX = maximum soil water content in the total (irrigated plus nonirrigated) crop root zone (inches).

SWCN = soil water content in the nonirrigated portion of the crop root zone (inches).

SWCNX = maximum soil water content (at field capacity) in the nonirrigated portion of the crop root zone (inches).

T = transpiration (inches) or transpiration rate (inches/day).

TAL = Tallahassee, Florida.

TAM = Tampa, Florida.

TXT = soil textural classification.

VAR = variant.

VFSL = very fine sandy loam.

W = Weibull transform of P.

WC(i) = available volumetric soil water content of the ith soil layer (decimal fraction).

WCON = volumetric soil water content available for crop use (% or decimal fraction).

WPB = West Palm Beach, Florida.

XMAX = maximum IRR value observed for all simulated years of record (inches).

XMIN = minimum IRR value observed for all simulated years of record (inches).

ZERO = fraction of simulated years of record for which IRR = 0.0 (decimal fraction).