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**TECHNICAL MANUAL
AGRICULTURAL FIELD SCALE IRRIGATION
REQUIREMENTS SIMULATION (AFSIRS) MODEL**

VERSION 5.5



TECHNICAL MANUAL

AGRICULTURAL FIELD SCALE IRRIGATION REQUIREMENTS SIMULATION
(AFSIRS) MODEL

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by

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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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A.G. Smajstrla

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, climate conditions and irrigation management practices. IRR for crop production is the amount of water, exclusive of precipitation, that must be applied to meet a crop's evapotranspiration (ET) requirements 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.

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.

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The AFSIRS model uses historical climate data. Long-term (18-25 year) records of daily rainfall and potential evapotranspiration (ETp) for nine Florida locations are provided as a part of the model data base. These data are used to simulate daily IRR for crop seasons for the number of years of climate record. This long-term record of IRR is then used to calculate statistical parameters including the probabilities of occurrence of IRR for various portions of the crop growing season. These extreme values may be required for irrigation system design or irrigation water use permitting.

Both user-interactive and batch versions of the AFSIRS model were developed. Both versions were written for MS/DOS (IBM compatible) microcomputer systems, and both were written using the Microsoft FORTRAN Version 4.1 computer language. Both the FORTRAN and machine (executable) code are distributed with the model.

This manual presents the technical basis for the AFSIRS model. It documents the computational techniques and sources of data used in the model. It presents the assumptions used in the model development and discusses why these assumptions were required. Finally, this manual contains listings of the computer program code and the crop and soil coefficient data bases.

THE WATER BUDGET

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 (ET_p) and crop water use coefficients. A water budget is a mass balance for water in the crop production system.

The water budget approach to modeling of IRR requires that all water inputs to and outputs from the crop root zone be known. Then IRR is calculated as the amount of water required to maintain the required soil water content in the crop root zone. Each of the water budget components, and how they are handled in the model are presented in the following subsections of this manual. Components of the water budget used in this work include soil water storage in the crop root zone, inputs to the crop root zone from rain and irrigation, and losses by drainage and ET. These components are illustrated in Figure 1.

The daily water budget used in the AFSIRS model simulates the complex dynamic processes of soil water infiltration, redistribution, and extraction by evapotranspiration (ET) as steady state processes on a daily basis. This level of simulation model development was required to produce a functional model that could address the wide variety of crops, soils, and irrigation systems typical of Florida, and to estimate IRR in a reasonable amount of computer time. This simulation time scale is adequate to permit the interactions of distributions of rainfall and ET on IRR to be calculated.

Numerical simulation models exist which address the details of the interactions of water in soil-plant-atmosphere systems, and which function on a real-time basis, but such models require large amounts of computation time and data storage.

Most importantly, however, data required for such detailed models are not available for all of the production systems desired to be simulated by the AFSIRS model, and the use of a real-time simulation model to increase accuracy is not justified because of the levels of accuracy implicit in assumptions of irrigation efficiency, crop growth, and water use coefficients. Thus, the AFSIRS model was developed as a soil water budget model which functions on a daily basis.

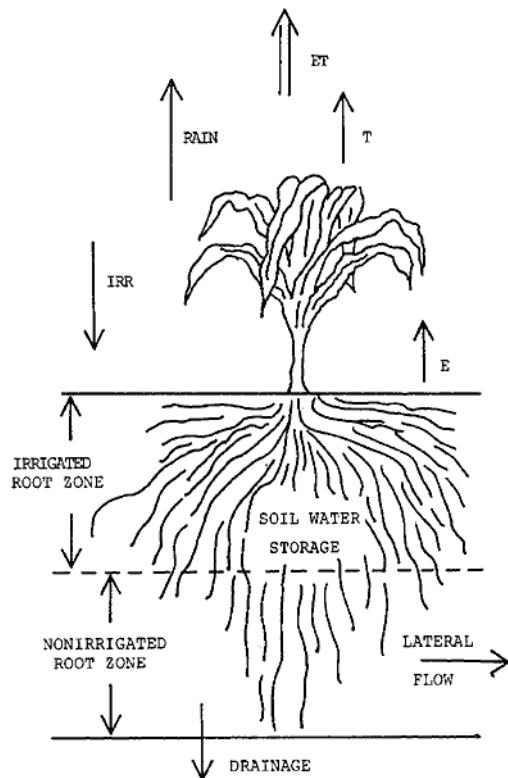


Figure 1: Components of the water budget of a crop root zone.

The water budget approach has been successfully used for many applications. Melaika and Bottcher (1988) applied this approach to modeling nutrient movement from a south Florida watershed in the Everglades Agricultural Area. Villalobos and Fereres (1989) developed a water budget model based on long-term average potential ET and actual rainfall data. In their model, potential ET was assumed to be constant each year because long-term data were not available. Samani et al. (1987) used a water budget approach to develop a crop yield model. They simulated weather data because long-term climate data were not available.

A team of IFAS Agricultural Engineers recommended the water budget approach for the development of a basic irrigation scheduling model for Florida conditions (Smajstrla et al., 1988a). This approach was also used to develop a Florida citrus micro irrigation

scheduling model (Smajstrla et al., 1987). Smajstrla and Zazueta (1987, 1988) demonstrated the data requirements and sensitivity of the water budget approach to determining irrigation requirements of Florida nursery and agronomic crops.

Techniques other than a daily water budget exist for the estimation of IRR for crop production systems. The most widely used is the empirical Soil Conservation Service (SCS, 1970) method which estimates monthly IRR based on monthly average rainfall and ET, and on soil water-holding capacity. The AFSIRS model integrates the effects of day-to-day distributions of rainfall, ET, and soil water-holding capacity to calculate IRR, rather than using monthly averages only. Considering actual distributions of these parameters obtained from historical climate records allows the short-term climate variations which affect IRR in a given geographical location to be considered.

The AFSIRS model allows IRR to be estimated for time periods of less than a month, because calculations are made on a daily basis. This allows bi-weekly and weekly IRR to be reported.

Soil Water Storage

The water storage capacity in the crop root zone was defined as the multiple of the available water-holding capacity of the soil, and the depth of the effective root zone for the crop being grown. Available water-holding capacity was expressed as a volumetric decimal fraction, and depth in units of inches. Thus, the water storage capacity also had units of inches. Additions to and deletions from soil water storage were also expressed as depths, and the soil water storage at any time had the same units.

Soil Water-Holding Capacity

The water-holding capacities of Florida soils were obtained from a data base of soil series mapped by the Soil Conservation Service (SCS) in a cooperative program with IFAS. This data base contains a complete list (as of 1984) of the soil series mapped in county soil surveys in Florida and soil water-holding capacity data. It was amended to include data for container-grown nursery plants (Dr. Dewayne Ingram, IFAS Ornamental Horticulture Department, personal communication). Most of these soil types were described in the SCS Florida Irrigation Guide (1982) and by Smajstrla (1985).

Appendix A contains the soil water-holding capacity data base used in the AFSIRS model. Soil series, textures, and water-holding capacities are listed. Water-holding capacities are given as volumetric fractions. Model users can determine soil series names for specific locations from county soil surveys for their locations, or by consultation with the SCS or IFAS extension personnel.

The water-holding capacity data were obtained from laboratory analyses of field samples. Field capacity was defined as the volumetric water content retained in the soil at a soil water potential of -10 centibars (cb). Available soil water was water stored between field capacity and the permanent wilting point (PWP). PWP is the soil water potential beyond which a crop cannot extract water, and dies. PWP was defined as the volumetric water content retained in the soil at a water potential of -15 bars.

Because of the naturally-occurring range in soil water-holding capacities within a soil series, the soils data base lists both maximum and minimum expected values. The AFSIRS model allows the user to select the maximum, minimum, or average (arithmetic average of the maximum and minimum) values during each simulation.

Crop Root Zone

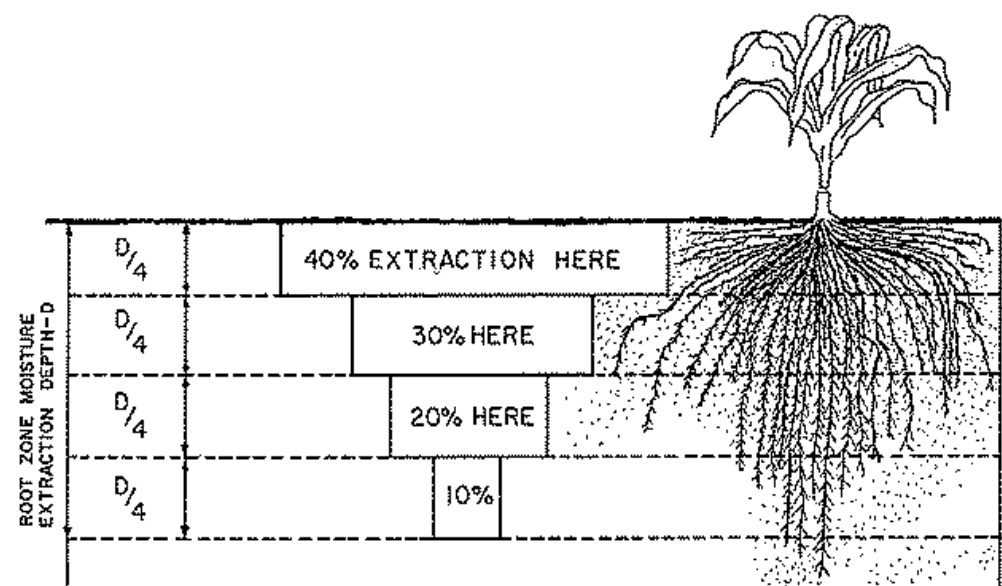
The water budget approach to the simulation of IRR requires that the extent

of the crop root zone be defined for each crop to be simulated. This information was obtained from the literature, including research reports, irrigation texts, and specific crop irrigation and production guides. See the crop growth and water use characteristics data sections in Appendix B of this report for specific references.

Irrigated versus nonirrigated crop root zones: In the AFSIRS model, the crop root zone was subdivided into irrigated and nonirrigated zones and separate water budgets were maintained for each zone. This was required because, depending upon the method of irrigation, it is common practice to irrigate only the upper portions of the crop root zone where most of the roots are located, rather than to irrigate the maximum depth to which any few individual roots penetrate. This practice saves both water and energy as compared to the practice of irrigating the entire crop root zone. Also, for micro irrigation systems, only a portion of the crop root zone is irrigated because only a fraction of the soil surface is normally irrigated with these systems. For other production systems such as those which use seepage irrigation, the entire crop root zone is irrigated because of the manner in which water is applied.

The Florida Soil Conservation Service (SCS, 1982) presented the irrigated crop water extraction pattern typically illustrated in irrigation texts as that shown in Fig. 2. They showed that 70% of the water use by a well-irrigated crop can be expected to occur from the upper 50% of the crop root depth, while only 30% is normally extracted from the lower 50% of the root zone.

The water extraction pattern shown in Fig. 2 occurs primarily because of the distribution of roots in the soil, with most roots being concentrated near the soil surface.



It also occurs, however, because of the movement of soil water due to differences in soil water potential as water is extracted in greater amounts near the soil surface. Water moves from the wetter to the drier soil zones due to this soil water potential difference.

Figure 2 Water extraction pattern assumed in the AFSIRS model (from SCS, 1982)

Separate water budgets were maintained for the irrigated and nonirrigated crop root zones in the AFSIRS model (Fig. 3). The irrigated root zone was assumed to be the upper 50% of the maximum

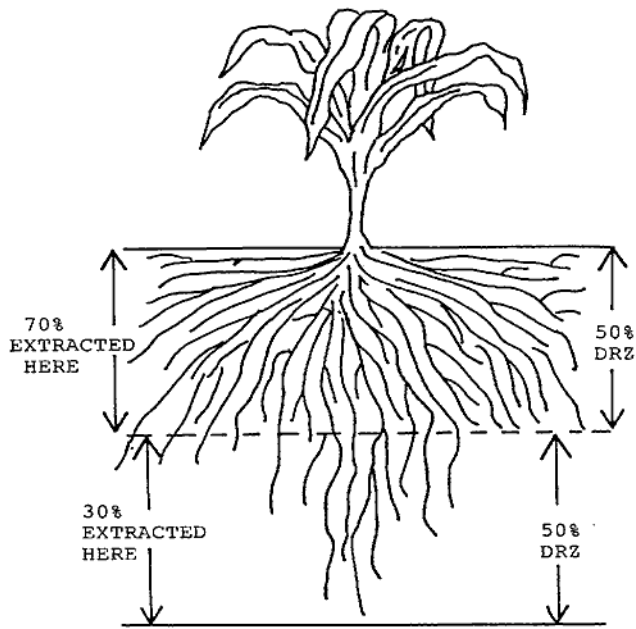


Figure 3: Water extraction pattern used for sprinkler irrigated crops on deep soils.

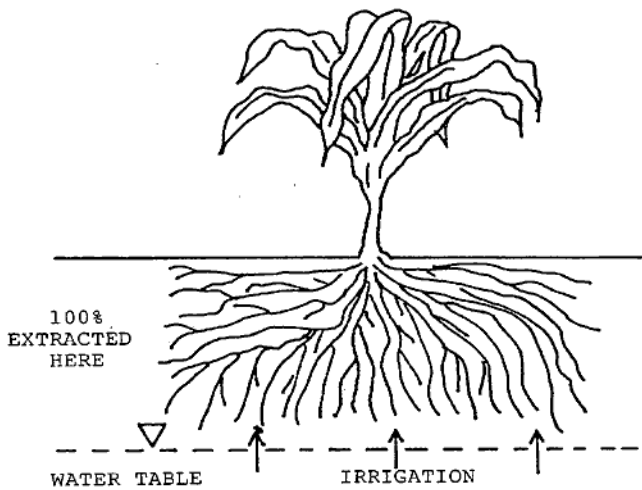


Figure 4: Water extraction patterns for seepage irrigated crops.

expected root depth, and 70% of the crop ET was assumed to be extracted from this zone when water was equally available in both the irrigated and nonirrigated portions of the root zone. The nonirrigated root zone was assumed to be the lower 50% of the maximum root depth, and the remaining 30% of the crop ET was assumed to be extracted from this zone when water was available.

As the nonirrigated root zone dries during drought periods, water becomes less available in this zone, and a greater proportion is then extracted from the irrigated zone in order to meet the total crop ET. In the AFSIRS model, the water extracted from the nonirrigated root zone is calculated as a function of the available water in that zone. When the available water is entirely depleted from the nonirrigated root zone, all extractions are simulated to occur from the irrigated root zone.

For some Florida irrigated crop production systems, the nonirrigated root zone does not exist. Specifically, for seepage irrigation systems the entire crop root zone is irrigated because water is applied from below (Fig. 4), while for flood irrigation systems the entire root zone is flooded. Also, in container nursery production systems, the crop root zone is physically restricted to the containers. In these systems, all crop transpiration is extracted from the irrigated zone and thus NIR is higher than that of the same crops produced on soils with some root penetration into nonirrigated soil zones. IRR is also much greater than NIR because of the low application efficiencies typical of the above irrigation system types.

For micro irrigation systems (drip and spray), the entire soil surface is not irrigated, and the nonirrigated root zone is therefore greater

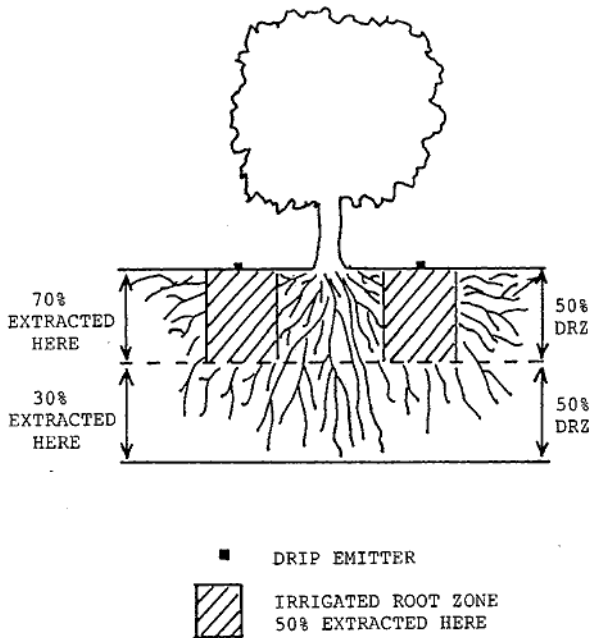


Figure 5: Water extraction pattern for micro-irrigated crops with about 50% of the surface area irrigated.

irrigation season.

For alfalfa, the root zone data indicate that water extraction would be expected to occur from a soil depth of 72 inches, but that normally only the upper 36 inches would be irrigated. Also, most of the water use would be expected to occur from the upper root zone, both because of irrigation being confined to this zone and because of the greater root density in this zone.

than 50% of the total root zone. Fig. 5 illustrates this irrigation pattern.

Crop root zones are reduced to less than normal depths by soil restrictions. In the AFSIRS model, when the soil selected is shallower than the maximum crop root depth, the crop root depth is limited to the soil depth. Also, if the water table is maintained near the soil surface, the irrigated root zone is restricted by the depth to the water table.

Perennial Crop Root Zone Depths:

Average crop root zone depths were obtained from the literature as referenced in Appendix B. Table 1 lists these data for perennial crops included in the AFSIRS model. Table 1 contains 16 perennial crops. The irrigated and total crop root depths in inches are given for each crop under the column labelled DEPTH(IN). For example, the irrigated root zone depth for alfalfa is 36 inches. The total root zone depth is 72 inches. In the AFSIRS model these depths are treated as constants throughout the

Table 1. Perennial crop data used in the AFSIRS model.

16 PERENNIAL CROPS : ROOT ZONE AND WATER USE COEFFICIENT DATA

CROP	DEPTH(IN)	KC / AWD											
ALFALFA		0.60	0.75	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.80	0.70
	36 72	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
AVOCADO		0.90	0.90	0.90	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	30 60	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
BLUEBERRY		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	12 24	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
CITRUS		0.90	0.90	0.90	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	30 60	0.67	0.67	0.33	0.33	0.33	0.33	0.67	0.67	0.67	0.67	0.67	0.67
FERNS		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	10 20	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
GENERIC CROP		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	24 48	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
GRAPES		0.40	0.40	0.55	0.75	0.80	0.80	0.80	0.80	0.80	0.80	0.70	0.50
	30 60	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
NURSERY,CNTR.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	8 8	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
NURSERY,FLD.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	8 16	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
PASTURE		0.65	0.70	0.75	0.90	0.90	0.95	0.95	0.95	0.90	0.80	0.70	0.65
	36 72	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
PEACHES		0.70	0.75	0.80	0.85	0.90	1.00	1.00	1.00	0.95	0.80	0.80	0.70
	30 60	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
PECANS		0.70	0.75	0.80	0.85	0.90	1.00	1.00	1.00	0.95	0.80	0.80	0.70
	30 60	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
SOD		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	8 24	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
SUGARCANE		0.80	0.60	0.55	0.80	0.95	1.00	1.05	1.05	1.05	1.00	0.95	0.90
	18 36	0.65	0.65	0.35	0.35	0.35	0.50	0.65	0.65	0.65	0.65	0.65	0.65
TURF,GOLF		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	9 24	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
TURF,LNDSCP.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	12 24	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

The root depth data given in Table 1 are believed to be average data for Florida conditions when soil conditions do not restrict root depth. However, site-specific depths may vary. For this reason, the AFISRS model permits user inputs of crop root depth data interactively from the computer keyboard. The model will then simulate IRR based on these site-specific root depths.

Annual Crop Root Zone Depths: Average crop root zone depths for annual crops are given in Table 2. This table lists the 44 annual crops included in the AFSIRS model data base. Root zone depths (inches) are given as the first two numerical columns labelled DEPTH(IN). The first of these columns lists the minimum annual

crop irrigated root zone depth. This is the root zone depth that would be irrigated at the beginning of the crop growing season.

The second numerical entry in each row of Table 2 is the maximum irrigated crop root zone depth. This is the maximum root zone depth that would be obtained by the crop during peak growth stages, and which would then be expected to be maintained for the remainder of the crop growing season.

From Table 2, the minimum irrigated crop root depth at the beginning of the growing season for barley is 12 inches. This is the zone in which irrigations should be concentrated at the beginning of the crop growing season. The maximum root zone depth to be irrigated is 24 inches for barley. This should be the zone irrigated after the crop reaches peak growth.

Figure 6 shows the pattern of crop root zone development used in the AFSIRS model for annual crops. The root zone is assumed to be constant at the minimum depth throughout crop Growth Stage 1 (establishment of the crop). The root zone is then assumed to increase linearly towards the maximum depth throughout Growth Stage 2 (vegetative growth and development). Finally, the maximum root zone is achieved at the beginning of crop Growth Stage 3 (peak growth), and it is assumed to be maintained at that depth throughout Growth Stages 3 and 4.

Average lengths of annual crop growth stages are given in Table 2 as fractions of the crop growing season. These are the 4 columns of data under the heading ...FRACTION... For barley, the relative duration of each crop growth stage is 0.15, 0.19, 0.44, and 0.22. These data represent an expected duration of crop Growth Stage 1 of 15% of the crop season specified by the AFSIRS model user. Stages 2-4 would be expected to have durations of 19%, 44% and 22% of the growing season, respectively.

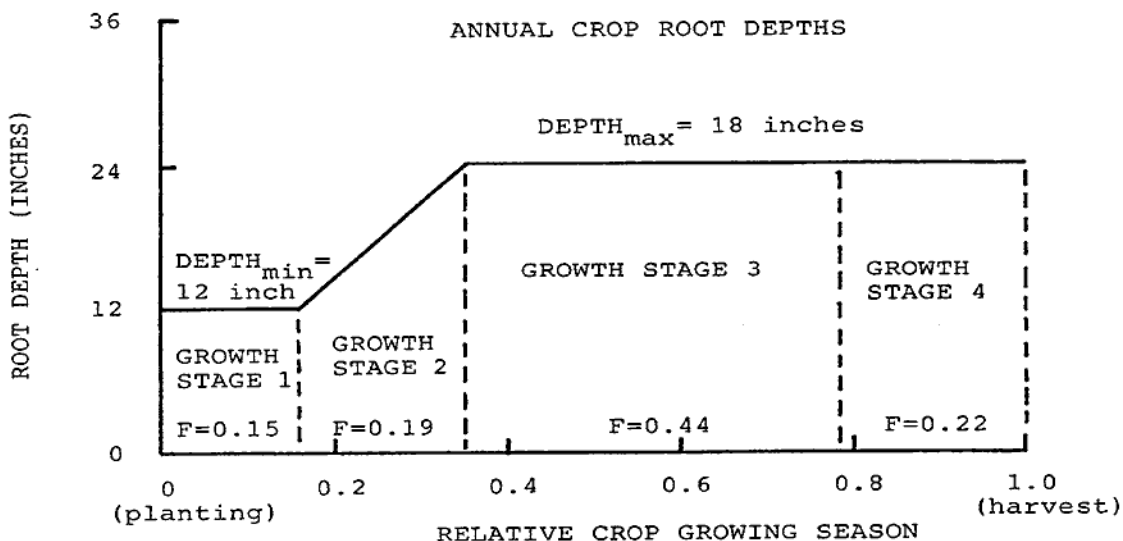


Figure 6: Annual crop root development function. The example shown here is for barley.

Table 2. Annual crop data file used in the AFSIRS model.

44 ANNUAL CROPS : ROOT ZONE AND WATER USE COEFFICIENT DATA												
CROP	DEPTH(IN)	...	KC...	FRACTION	...	ALLOWABLE	DEPLETION				
BARLEY	12 18	1.05	0.25	0.15	0.19	0.44	0.22	0.60	0.60	0.60	0.90	
BEANS,GRN.	8 12	0.95	0.85	0.20	0.33	0.33	0.14	0.45	0.45	0.45	0.45	
BEANS,DRY	8 12	1.05	0.30	0.18	0.28	0.36	0.18	0.45	0.45	0.45	0.67	
BEETS	8 12	1.00	0.90	0.21	0.36	0.29	0.14	0.50	0.50	0.50	0.50	
BROCCOLI	8 12	1.00	0.85	0.25	0.38	0.25	0.12	0.50	0.50	0.50	0.50	
BRUSSEL SPTS	8 12	1.00	0.85	0.25	0.38	0.25	0.12	0.50	0.50	0.50	0.50	
CABBAGE	8 12	1.00	0.85	0.25	0.38	0.25	0.12	0.45	0.45	0.45	0.45	
CARROTS	8 12	1.00	0.70	0.20	0.30	0.30	0.20	0.35	0.35	0.35	0.35	
CAULIFLOWER	8 12	1.00	0.85	0.25	0.38	0.25	0.12	0.50	0.50	0.50	0.50	
CELERY	8 12	1.00	0.90	0.20	0.32	0.36	0.12	0.20	0.20	0.20	0.20	
CLOVER	12 18	1.00	0.90	0.15	0.20	0.55	0.10	0.35	0.35	0.35	0.35	
CORN,FIELD	12 18	1.05	0.55	0.16	0.28	0.32	0.24	0.60	0.60	0.60	0.80	
CORN,SWEET	12 18	1.05	0.95	0.25	0.25	0.38	0.12	0.35	0.35	0.35	0.35	
COTTON	12 24	1.05	0.65	0.17	0.28	0.30	0.25	0.60	0.70	0.60	0.80	
CUCUMBER	8 12	0.90	0.80	0.19	0.29	0.38	0.14	0.50	0.50	0.50	0.50	
EGGPLANT	8 12	0.95	0.80	0.23	0.31	0.31	0.15	0.40	0.40	0.40	0.40	
FIELD CROPS	12 18	1.05	0.60	0.20	0.30	0.30	0.20	0.50	0.50	0.50	0.67	
GENERIC CROP	8 12	1.00	0.90	0.25	0.33	0.25	0.17	0.50	0.50	0.50	0.50	
GREENS,HERBS	8 12	0.95	0.90	0.33	0.33	0.25	0.09	0.20	0.20	0.20	0.20	
LETTUCE	8 12	0.95	0.90	0.27	0.40	0.20	0.13	0.30	0.30	0.30	0.30	
MELONS	8 18	0.95	0.65	0.21	0.29	0.33	0.17	0.35	0.35	0.35	0.35	
MILLET,FORGE	12 18	1.00	0.30	0.15	0.21	0.39	0.25	0.60	0.60	0.60	0.60	
MILLET,GRAIN	12 18	1.00	0.30	0.15	0.21	0.39	0.25	0.60	0.60	0.60	0.90	
OATS	12 18	1.05	0.25	0.15	0.19	0.44	0.22	0.60	0.60	0.60	0.90	
ONION,DRY	8 12	0.95	0.75	0.10	0.17	0.47	0.26	0.25	0.25	0.25	0.90	
ONION,GRN.	8 12	0.95	0.95	0.36	0.43	0.14	0.07	0.25	0.25	0.25	0.25	
PEANUTS	12 18	1.00	0.55	0.25	0.32	0.25	0.18	0.50	0.40	0.50	0.50	
PEAS	8 12	1.05	0.95	0.25	0.30	0.30	0.15	0.40	0.40	0.40	0.40	
PEPPERS,GRN.	8 12	0.95	0.80	0.24	0.28	0.32	0.16	0.35	0.35	0.35	0.35	
POTATOES	12 18	1.05	0.70	0.23	0.29	0.29	0.19	0.25	0.25	0.25	0.40	
RADISH	6 8	0.80	0.75	0.14	0.29	0.43	0.14	0.33	0.33	0.33	0.33	
RICE	12 18	1.20	1.05	0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00	
SMALL GRAINS	12 18	1.05	0.30	0.15	0.21	0.41	0.23	0.58	0.58	0.58	0.90	
SMALL VEGETS	8 12	1.00	0.85	0.24	0.33	0.29	0.14	0.37	0.37	0.37	0.40	
SORGHUM	12 24	1.00	0.50	0.17	0.25	0.33	0.25	0.55	0.55	0.55	0.80	
SOYBEAN	12 18	1.05	0.45	0.14	0.25	0.43	0.18	0.50	0.50	0.50	0.67	
SPINACH	8 12	0.95	0.90	0.33	0.33	0.25	0.09	0.20	0.20	0.20	0.20	
SQUASH	8 12	0.90	0.70	0.25	0.35	0.25	0.15	0.33	0.33	0.33	0.33	
STRAWBERRY	8 10	1.00	0.90	0.25	0.35	0.25	0.15	0.33	0.33	0.33	0.33	
SUNFLOWERS	12 18	1.05	0.40	0.16	0.28	0.36	0.20	0.45	0.45	0.45	0.67	
SWEET POTATO	12 18	1.05	0.70	0.23	0.29	0.29	0.19	0.65	0.65	0.65	0.65	
TOBACCO	12 18	1.05	0.60	0.22	0.30	0.30	0.18	0.35	0.35	0.35	0.65	
TOMATO	9 12	1.05	0.75	0.22	0.30	0.30	0.18	0.40	0.40	0.40	0.65	
WHEAT	12 18	1.05	0.25	0.15	0.19	0.44	0.22	0.55	0.55	0.55	0.90	

Inputs to the Crop Root Zone

Inputs to the water budget of a crop root zone occur only by rainfall and irrigation in the AFSIRS model. These inputs are discussed in the following sections of this report.

Rainfall

Historical rainfall records were used as inputs to the AFSIRS model. Daily rainfall depths in inches for nine locations in and near Florida are provided as part of the model data base. Where potential ET data were available, 25 years

of record were used. For other locations, the length of the data base was 18-24 years. The rainfall data source was the HISARS weather data base.

Rainfall was input to the water budget by adding it to the soil water storage. For small rainfall depths, runoff was assumed to be negligible for Florida's sandy soils, while for large rainfalls runoff was combined with drainage. Effective rainfall was calculated as the rainfall depth that was stored in the crop root zone and available for crop use. Effective rainfall was defined as rainfall minus drainage. Drainage is discussed in a following section of this report titled "Losses from the Crop Root Zone".

Irrigation

The purpose of the AFSIRS model is to calculate irrigation requirements (IRR), where IRR is the amount of supplemental water which must be applied to a crop to prevent yield-reducing water stress. Irrigations were calculated to occur when the available soil water storage decreased to a predetermined minimum allowable level. The minimum allowable level was calculated as the multiple of the available soil water storage capacity in the crop root zone times the allowable soil water depletion.

Allowable soil water depletions (AWD) were included in the AFSIRS model data base. AWD values were determined from the literature. They are fractions of the available soil water storage capacity in the crop root zone which can be allowed to be depleted without significant reduction of crop yield. AWD values for the crops in the AFSIRS model data base are given in Tables 1 and 2.

In Table 1 monthly values of AWD are listed for each perennial crop. They are listed sequentially by month on the same line as the crop root depths. For alfalfa, for example, AWD = 0.50 for all 12 months. This means that 50% of the available water in the irrigated crop root zone can be allowed to be depleted between irrigations without significant yield reduction.

In Table 2 AWD values are given for each of the 4 crop growth stages for annual crops. They are located in the last 4 data columns for each crop. For barley, for example, the AWD values are 0.60, 0.60, 0.60, and 0.90. These data mean that 60% of the available soil water storage in the irrigated zone can be allowed to be depleted between irrigations during the first three crop growth stages without significant yield reduction. Also, 90% of the soil water can be allowed to be depleted without significant yield reduction during Growth Stage 4.

At each irrigation the net irrigation requirement (NIR) was calculated as the depth of water required to restore the soil water to field capacity (maximum soil water storage capacity) in the irrigated crop root zone. The gross irrigation requirement (IRR) was calculated as NIR divided by the irrigation system application efficiency (EFF), where EFF was expressed as a decimal fraction. Thus IRR is always greater than NIR, and IRR is the irrigation requirement of the production system, including the effectiveness of water application with the irrigation system used. EFF values are given in Table 3 for each of the types of irrigation systems included in the AFSIRS model.

Table 3. Irrigation systems data used in the AFSIRS model.

9 IRRIGATION SYSTEM DATA				
CODE	EFF	ARZI	EXIR	SYSTEM TYPE
---	---	---	---	-----
1	1.00	1.00	1.00	USER-SPECIFIED SYSTEM
2	0.85	0.50	0.40	MICRO, DRIP
3	0.80	0.50	0.40	MICRO, SPRAY
4	0.75	1.00	0.70	MULTIPLE SPRINKLER
5	0.20	0.30	0.70	SPRINKLER, CONTAINER NURSERY
6	0.70	1.00	0.70	SPRINKLER, LARGE GUNS
7	0.50	1.00	1.00	SEEPAGE, SUBIRRIGATION
8	0.50	1.00	0.70	CROWN FLOOD (CITRUS)
9	0.50	1.00	1.00	FLOOD (RICE)

Outputs from the Crop Root Zone

Outputs from a crop root zone occur by runoff, lateral flow, drainage, and evapotranspiration (ET). In the development of the AFSIRS model, runoff was not separated from drainage. Runoff was assumed to be negligible for small rainfalls, while for large rainfalls it was assumed that sufficient rain would infiltrate to restore the crop root zone to field capacity and the excess would be lost to either drainage or runoff. Since both runoff and drainage are losses from the crop root zone, it was not necessary to separate the two processes. This is believed to be an adequate assumption for Florida typical sandy soil conditions since the water budget is being maintained for the crop root zone only.

Lateral Flow

Lateral flow is the lateral movement of water from an irrigated area to surrounding nonirrigated areas (or vice-versa) due to a difference in water table heights or soil water contents. In the AFSIRS model unsaturated lateral flows were assumed to be small, and were therefore neglected.

Saturated lateral flows were also not directly considered, but for different reasons. Saturated lateral flows from an area of high water table, such as an irrigated field, to an area of low water table, such as surrounding nonirrigated fields, may be quite large or very small. It is impossible to determine the amounts of these exchanges with surrounding areas without extensive site-specific measurements. Thus, this factor was included indirectly in the 50% irrigation application efficiency assigned to flood and seepage irrigation systems.

The water management districts that funded the initiation of the development of the AFSIRS model requested that seepage and flood irrigation systems be assigned application efficiencies of 50%, with the understanding that this would be assumed to account for losses from these systems during irrigation. Thus, individuals with systems which are actually more efficient than 50% because of site-specific characteristics would benefit by having a larger fraction of their permitted water available for plant use. Those individuals with systems which

are actually less efficient than 50% because of lateral flows or other site-specific factors would be limited to wasting only 50% of the water permitted for their use. They would be penalized by poorer crop yields per unit of water permitted because of waste, and would therefore be encouraged to make a transition to a more efficient type of irrigation system.

Drainage

In the AFSIRS model, drainage was defined as that portion of rainfall in excess of rain stored in the soil profile to field capacity or extracted by ET as the water redistributed in the soil. If rainfall was less than the depth required to restore the crop root zone to field capacity, then all of the rainfall was effective, and drainage was zero. If rainfall exceeded the depth required to restore the soil water content in the crop root zone to field capacity, then effective rainfall was calculated as the difference between the current and maximum soil water contents, plus the amount used by ET while the soil water redistributed to field capacity. Drainage was then calculated as the difference between rainfall and effective rainfall.

The time required for redistribution to field capacity was calculated as a function of both the irrigated crop root zone depth and the rainfall depth. For sprinkler- or micro-irrigated crops, redistribution time was calculated as a minimum of 1 day for irrigated crop root zone depths of less than 12 inches, 2 days for 12-24 inch root zone depths, and 3 days for root depths of greater than 24 inches. A second criterium was that redistribution required a minimum of 1 day per inch of rainfall up to a maximum of 5 days. This was used to simulate the effects of local flooding following large rainfall events.

For seepage- and flood-irrigated crops, the time required for redistribution was defined as 3 days or 1 day per inch of rainfall up to a maximum of 7 days. This accounts for the slow drainage from the flat, high water table soils irrigated using seepage or flood systems.

The definition of times required for redistribution to field capacity adequately defined the dynamic processes of drainage following rainfall on a daily basis. No drainage was assumed to occur as a result of irrigation.

Evapotranspiration

Evapotranspiration (ET) is the combined processes of evaporation and transpiration. The AFSIRS model was based on the assumptions that crop water use is proportional to climatic demand, and that climatic demand can be estimated using the Penman equation for potential evapotranspiration (ET_p). These assumptions have often been shown to be valid for Florida conditions (Jones et al., 1984; Shih et al., 1984; Rogers et al., 1983). This approach does not separate the processes of evaporation and transpiration. Rather, these processes were combined as ET for the water budget model since both processes result in water extraction from soil water storage.

A data base of daily potential ET for nine locations in and near Florida is provided as one of the AFSIRS model data bases. Potential ET was calculated using the Penman equation as given by Jones et al. (1984). Where climate data were available, the length of data record was 25 years. For other locations the record lengths ranged from 18-24 years. Data bases were limited to these durations because of the limitations of availability of solar radiation data.

In the AFSIRS model, daily ET for each crop was calculated as the multiple of potential ET and the crop water use coefficient (KC) for that day. KC is the ratio of ET for a specific crop to the reference value of potential ET. KC values range from about 0.4 to 1.2 for most agricultural crops. The low values occur early in the crop growing seasons when vegetative canopies are incomplete,

or when for other reasons the crop is not actively growing. The large values occur during peak crop growth stages, and are typically greatest for crops which are tall and have canopies which completely cover the soil surface.

Crop water use coefficients were obtained from the literature as documented in Appendix B. Most KC data were obtained from non-Florida research studies because relatively few studies have been conducted in Florida. Also, no data were available to allow distinctions in KC values to be made on the basis of management practices, such as the use of plastic mulch versus bare soil in vegetable crop production systems, for example. As a result, KC values were assumed to be constants for a given crop type.

Crop water use coefficient data were provided as a part of the AFSIRS model data base. Data were presented differently for perennial and annual crops:

Perennial Crop Water Use Coefficients: KC values for perennial crops are given in Table 1. They are listed by month on the same line and immediately following the crop listings. For example, for alfalfa, KC for January is 0.60, KC for February is 0.75, etc.

A daily crop coefficient was calculated for each day of the perennial crop irrigation season (for many perennial crops in Florida this is the entire year). The daily KC values were calculated by linearly interpolating between monthly values. The monthly KC value was assigned to the 15th of each month, and linear interpolations were performed from that date to the 15th of the next month. At the end of the calendar year, data were interpolated between the 15th of December and the 15th of January.

Annual Crop Water Use Coefficients: KC values for annual crops are listed in Table 2. Two values are listed for each crop under the heading ...KC... These values are the crop coefficients for crop Growth Stages 3 and 4. For barley, for example, the KC for crop Growth Stage 3 (peak growth) is 1.05. For Growth Stage 4 (maturity to harvest), KC is 0.25. These data are used to interpolate daily crop coefficients using the method shown in Figure 7.

In Figure 7 the changing magnitudes of KC values during an annual crop growth cycle are shown. During crop Growth Stage 1 (planting to plant establishment), KC values were near 0.4 because of incomplete crop canopies, except for days during which rainfall occurred (Doorenbos and Pruitt, 1977). Actual Growth Stage 1 KC values were calculated from the soil water-holding capacity. Greater KC values were calculated for heavier soils because these soils transport water to the surface for evaporation more readily than lighter (sandy) soils.

When rainfall occurred in amounts that exceeded daily potential ET, KC was set equal to 1.0, and ET was calculated to occur at the potential rate because of the wet soil surface. When amounts of rainfall smaller than potential ET occurred, KC was calculated as the ratio of rain to potential ET, with a minimum value based on the soil water-holding capacity. KC values were decreased exponentially as a function of days since the last rain occurred, with a minimum value based on the long-term average KC values from Tables 1 or 2.

In Figure 7, KC values for crop Growth Stage 2 were linearly interpolated between the KC values for Growth Stages 1 and 3. This caused KC values to increase as the crop developed to the point of peak growth. KC values were assumed to be constant at the peak value during Growth Stage 3 (for barley this was 1.05 from Table 2), or to be 1.0 for rainy days.

The final KC value read from Table 2 was the crop coefficient at harvest or at the end of the irrigation season. Daily KC values during crop Growth Stage 4 were computed by interpolating linearly between the peak KC value and the value

at harvest. This resulted in linearly decreasing KC values during crop Growth Stage 4, except for rainy days, as shown in Figure 7. For barley this function decreased linearly from 1.05 at peak growth to 0.25 at harvest.

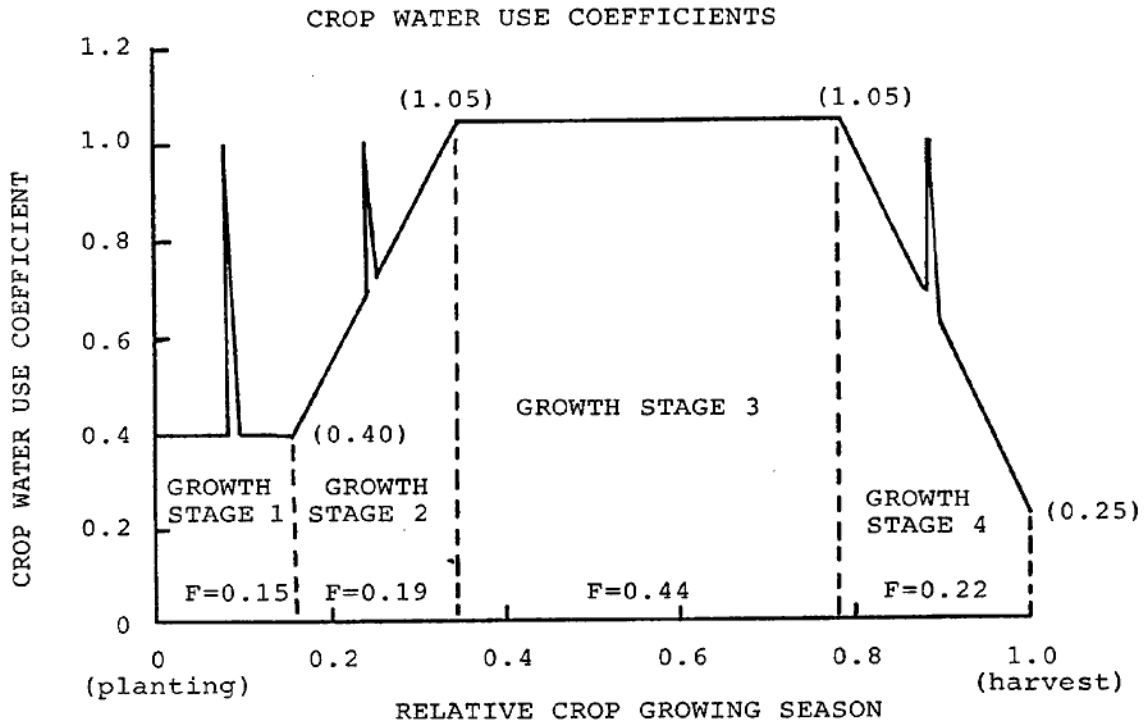


Figure 7: Annual crop water use coefficient function. The example shown is for barley.

AFSIRS MODEL STRUCTURE

The structure of the AFSIRS model is presented and the computational techniques used are discussed in the following sections of this manual. For clarity, the discussion follows the format of the FORTRAN computer programs (See Appendices E, F and G).

General

Both user-interactive and batch versions of the AFSIRS model were developed. See the AFSIRS model User's Guide for specific information on each of the individual inputs required to use each model version. Both model versions consist of a main FORTRAN program and eleven subroutines.

In the interactive model version, all inputs required of the model user are prompted. Most inputs are made by selecting from data bases provided with the model. Inputs are prompted by questions written to the computer monitor. Responses from the user's keyboard are also displayed on the monitor. Responses are read, and then displayed on the monitor for user verification.

If user inputs were not correctly made so that they are not readable by the computer, or if they are out of the range of expected responses, the prompt will be repeated. An error message may also appear.

In the batch model version (AFSIRS-B), only a few interactive inputs are required from the model user to initiate the model use. The remaining inputs are then read from an input data file created by the user.

All model outputs are made to both a computer (CRT) monitor and an output file whose name and location are specified by the user. The monitor output provides immediate feedback of results to the model user, while that to the output file provides a more permanent record for printing, or saving to tape or disk.

Main Program

The AFSIRS main program establishes the structure of the model. It defines the data storage vectors and arrays required. It opens the output file for printing of the model results. It initializes counters and defines other parameters required by the model.

The main program writes a header to both the computer monitor and to the output file. It requests entry of the current date. That date is then printed at the top of each simulation output. The user is next prompted for the entry of the location or site description for which IRR will be simulated. That information is written to the output file and to the computer screen.

The main program calls a sequence of subroutines which request information, perform calculations, and output simulation results. The subroutines called from the main program and the order in which they are called are: INPUT, CLIMAT, IRR1, DCOEF, SW, BAL, and SUMX. Some of these also call other subroutines. The function of each is discussed in the immediately following sections of this manual.

Following the execution of subroutine SUMX, the main program inquires whether the current results should be printed without exiting the model. If the user's response is yes, the current simulation results are sent to the printer in addition to being saved to the output disk file. If the response is no, the current results are only written to the output disk file.

Next, the model inquires whether another simulation is to be performed. If

the user's response is yes, control is transferred to near the beginning of the main program and the request is made for a new site description. The program then proceeds with the next simulation, calling each subroutine in turn as previously described. If the user responds that another simulation is not desired, the main program closes the output file, and exit to the operating system. This concludes the simulation session.

Subroutine INPUT

Subroutine INPUT allows the AFSIRS model user to enter data required to run the model. Each input required is prompted by the model for the interactive model version or read from the input data file for the batch model version.

Style of Output

The first input requires that the user specify the style of output desired. There are 4 valid entries: -1, 0, 1, and 2.

-1: When -1 is entered, the basic (minimal) output will result. This style of output will probably be most often used for both irrigation system design and water management planning purposes. This output consists of a specification of the entries made by the user, including simulation date, location or site description, irrigation season, climate data base location, and soil characteristics.

The output also includes the model-generated values of the length of growing season (days), length of climate record for the climate data base used, irrigation system design efficiency, fraction of the soil surface assumed to be irrigated with the irrigation system specified, soil water-holding capacity for the soil type specified, and tables of the simulated IRR and statistical characteristics.

Seasonal and monthly IRR tables are output. The first table lists IRR summarized for the entire growing season (for annual crops) or for the entire year (for perennial crops). The second table lists the simulation results summarized by month.

0: When 0 is entered to define the style of output, the output consists of all of the items described for an entry of -1 above, plus bi-weekly and weekly IRR tables. The latter will summarize IRR for 14- and 7-day periods, respectively.

1: When 1 is entered to define the style of output, the output consists of all of the items described for an entry of 0 above, plus outputs of intermediate parameters used in the simulations. The intermediate parameters include daily values of the irrigated and total crop root depths, crop water use coefficients, soil water-holding capacities, allowable soil water depletions between irrigations, and the definitions of crop growth stages for annual crops. In addition, outputs of potential ET, RAIN, and IRR are summarized and listed for the seasonal, monthly, bi-weekly, and weekly analysis periods.

2: When 2 is entered to define the style of output, the output consists of all of the items previously described for an entry of 1, plus outputs of the daily water budgets for each day of the irrigation season for all years of climate record. This produces a very extensive output. It is recommended that this style of output be used only with abbreviated climate data bases and/or irrigation seasons. This output will normally be used only to study the mechanisms of operation of the AFSIRS model. The output should be expected to

be many pages in length when this option is selected.

Graphics Output

The model user must specify whether graphs of the simulation results are to be produced. Graphs are limited to monthly, bi-weekly, and weekly distributions of irrigation requirements during the year.

Input Style

The model user must specify the input style that will be used. The user may elect to use model default values at every opportunity. The alternative requires that the user specify the crop root depth, fraction of the root zone irrigated, and irrigation efficiency to over-ride the default values.

Crop Type

The crop type is selected from a data file, CROP.DAT, provided as a part of the model data base. Table 4 presents the crop types and codes used in the AFSIRS model. The model user selects a crop type by entering the appropriate numerical code.

The contents of the CROP.DAT file are shown in Tables 1 and 2 for perennial and annual crops, respectively. The model user may specify other crop types by entering the codes to specify the generic annual or perennial crops included in these tables. When generic crops are specified, the user may elect to use the data contained in Tables 1 and 2, or all crop data may also be specified by the user.

Irrigation Season

The AFSIRS model user must specify the beginning and ending dates (month and day) of the irrigation season. These dates will define the duration of the irrigation season. This is the period of each year for which the water budget and irrigation requirements will be calculated.

If January 1 (1,1) is specified as the beginning of the irrigation season and December 31 (12,31) is specified as the end of the season, then the irrigation season will be defined as the entire year and IRR will be calculated for that period, that is, assuming that irrigation is practiced throughout the year.

The irrigation season may be defined to extend from one calendar year to the next. Thus, if the beginning of the irrigation season is defined as November 1 (11,1) and the end of the season as March 1 (3,1), IRR will be calculated for that period, beginning with the November 1 data from the first year of the climate record, and extending through March 1 of the last year of the climate record. This overlap of climate records between years will reduce the length of the overall climate record by 1 year.

Table 4. List of crop types and codes generated by the AFSIRS model.

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	

Subroutine CLIMAT

Subroutine CLIMAT reads the climate data file name and disk drive location. It then opens the climate data file and reads the location and number of years of climate record. Daily values of potential ET and RAIN are read for all years of record.

Each climate data file contains data for only one location because of the large size of the climate data base. Thus, to simulate IRR for various geographical locations, the AFSIRS model user must specify the appropriate climate data base file for each location.

Because of the climate data base size, all climate data are not listed in this technical manual. Only an example 4-year data file is listed in Appendix D, so that the model user can observe the required formats. This is an abbreviated data base, containing only the first 4 years of climate data for Tampa. The complete data bases for all 9 locations are, however, provided on disk as a part of the AFSIRS model.

Subroutine CLIMAT rearranges the climate data for simulations in which the irrigation season extends beyond the calendar year (December 31). The model uses FORTRAN "Do Loops" to step the simulation in time from one day to the next. The procedure used requires that the climate data be rearranged so that they are numbered consecutively from the beginning to the end of each irrigation season.

Reading the climate data bases requires a relatively large amount of computer time. Therefore, for successive simulations which use the same climate data base, the data base is not re-read unless its form has been changed by rearranging, and the next simulation is of an irrigation season which is different than the previous one.

Subroutine IRR1

Subroutine IRR1 reads the data file IR.DAT for the available types of irrigation systems and the irrigation system data used with the AFSIRS model. The IR.DAT file is shown as Table 3 in this report.

Subroutine IRR1 reads the irrigation system code, the type of irrigation system, the irrigation system efficiency (EFF), the area of the soil surface assumed to be irrigated (ARZI) with each type of system, and the fraction of ET assumed to be extracted from the irrigated portion of the crop root zone (EXIR) for those irrigation systems where the entire crop root zone is not irrigated.

This subroutine reads a code which specifies whether net or gross irrigation requirements will be calculated. It also reads a code to specify the irrigation management option to be used. Three options are available: irrigate to field capacity at each irrigation (the normal practice), apply a fixed depth of water at each irrigation, or irrigation to a fraction of field capacity at each irrigation. If one of the last two options is specified, this subroutine also reads the fixed depth of water to apply or the fraction of field capacity to be used.

Depending on the user's previous specification of the style of input, this subroutine either assigns the values of the irrigation coefficients to be used from Table 3, or it prompts the user to enter coefficients from the keyboard. Finally, it writes the specified irrigation system and coefficients to the computer monitor and to the output file.

Subroutine DCOEF

This subroutine reads crop coefficients from the CROP.DAT file. The contents of this file are shown in Tables 1 and 2.

Perennial Crops

For perennial crops, subroutine DCOEF reads the crop type, monthly KC values, root zone depths, and monthly allowable soil water depletions. Depending on an earlier option selected, it may also read these values as user inputs.

Seepage Irrigation Systems: If the seepage irrigation method and user input of data were previously specified, this subroutine reads depth to the water table. The irrigated and total crop root zone depths are assigned this depth. Monthly KC values are set to a minimum of 1.0 for all crops because the soil surface remains wet and ET is assumed to occur at the potential ET rate, even during incomplete canopy conditions. For peak growth stages, KC values are based on crop data if they exceed 1.0.

Crown Flood Irrigation Systems: If the crown flood irrigation method was specified, the user must enter the height of the crown flood irrigation system beds. This height is then used to calculate the irrigated crop root zone (DRZIRR) as 6 inches less than the bed height. This 6-inch zone is assumed to remain saturated at the bottom of the beds, thus roots would not penetrate to this depth.

For crown flood irrigation systems, the concept of the total crop root zone was used to simulate water extraction by capillarity from the saturated zone near the bottom of the ditches. Although roots will not penetrate into this saturated zone, the total root zone (DRZTOT) is calculated as the irrigated root zone plus the underlying saturated zone. This approach permits the effects of upward movement of water from a saturated zone to the crop root zone to be included in the water budget. The total root zone is defined as a function of the bed height because capillarity was assumed to be more effective for lower beds and less effective for taller beds.

For crown flood irrigation systems, subroutine DCOEF sets the minimum allowable soil water depletion to 0.50. This change from the citrus data in the CROP.DAT file reflects the fact that crown flood irrigation systems cannot be used for frequent irrigation because of the nature of the system (the time required per irrigation).

All Irrigation Systems: For all irrigation systems subroutine DCOEF calculates daily crop root depths, allowable soil water depletions, and crop water use coefficients. Irrigated and total crop root depths are assigned as constants throughout the year. Allowable soil water depletions are assigned as constants for each month, using monthly data read from CROP.DAT. Daily crop water use coefficients are calculated by assigning the monthly values read from CROP.DAT to the 15th of each month, and then interpolating linearly between each month.

For irrigation seasons which extend beyond the calendar year, subroutine DCOEF rearranges the daily data in terms of consecutive days of the growing season rather than calendar days. This allows FORTRAN "Do Loops" to be used to continuously simulate the irrigation season.

Annual Crops

For annual crops subroutine DCOEF reads crop type, root zone depths, crop coefficients, fraction of the crop growing season in each growth stage, and allowable water depletion data from the CROP.DAT file. Depending on the style

of input selected earlier, it may also read these values as user inputs.

Seepage Irrigation Systems: For seepage irrigation systems, subroutine DCOEF assigns depths to the water table of 18 inches, minimum crop coefficients of 1.0 to all crop growth stages, and allowable water depletions of 0.0. This water table depth is believed to be typical of Florida seepage irrigation systems, but it may be changed by user entry if desired. The minimum crop coefficients reflect the fact that ET occurs at the rate of potential ET when the surface is continuously wet when seepage irrigation is used. The assignment of AWD values of 0.0 establishes the structure for the simulation of continuous (daily) irrigation from a seepage irrigation system.

All Irrigation Systems: For all annual crop irrigation systems, subroutine DCOEF calculates the number of days in each crop growth stage from the multiples of the fractions read from CROP.DAT times the irrigation season length. It then calculates the root zone depths, and KC and AWD values for each day of the irrigation season. For annual crops, the irrigation season is assumed to be the entire crop growing season.

Finally, if output style 1 or 2 was previously selected by the model user, subroutine DCOEF writes the coefficients calculated to the computer monitor and to the output file.

Subroutine SW

Subroutine SW calculates the available soil water and the soil water content at which irrigations will be scheduled for each day of the irrigation season. This subroutine reads the soil type, depths, and water-holding capacities from the soil data base file SOIL.DAT. Depending on an earlier option selected, it may also read these values as user inputs.

Subroutine SW reads depth to the water table. This value must be entered by the user because it can be highly variable and water tables near the soil surface can significantly affect IRR.

Perennial Crops

Subroutine SW checks for soil depth limiting root expansion. It compares soil depths with crop root zone depths, and if soil depths are not sufficient, it reduces crop root zone depths to the maximum soil depth. If the water table depth limits root expansion, the irrigated root zone depth is limited to the water table depth, while the total root depth is extended into the saturated zone to simulate the effects of capillary movement of water upward from the water table.

Subroutine SW next calculates the available water in the irrigated (SWCIX) and total (SWMAX) crop root zones by multiplying the depths by the water contents of the soil layers to the bottom of the root zones. For micro irrigation systems, the available water in the irrigated zone is reduced by multiplying it by the fraction of the crop root zone irrigated. Then the available water in the nonirrigated root zone (SCWNX) is determined by subtracting SWCIX from SWMAX. These data are assigned to each day of the crop irrigation season.

Annual Crops

For annual crops the total and irrigated crop root zone depths are calculated for each day of the crop growing season because of expansion of the root zone as the growing season progresses. If soil depths or high water tables limit the root zone, expansion is stopped when the maximum soil depth or water

table is encountered.

Available soil water is calculated for both the irrigated (SWCIX) and total (SWMAX) root zones by multiplying the root zone depths by the water contents of the soil layers to the bottom of the root zones. For micro irrigation systems, the available water in the irrigated zone is reduced by multiplying it by the fraction of the crop root zone irrigated. Then the available water in the nonirrigated root zone (SCWNX) is determined by subtracting SWCIX from SWMAX.

Rice Flood Irrigation Systems: For rice flood irrigation systems, the soil profile remains saturated and a depth of water stands on the soil surface until near the end of the growing season. A 3-inch depth of water is assumed in the AFSIRS model, although the exact magnitude is unimportant because the model simulates changes in water content only. The AFSIRS model does not simulate the amount of water required to saturate the soil and raise the water table above the soil surface, unless it is considered to be included indirectly in the irrigation application efficiency term.

Because rice production systems remain flooded during most of the growing season, the AFSIRS model prompts the user to enter the maximum permissible flood storage depth for the production system. This is the maximum permissible change in water level that can be tolerated as a result of rainfall. This depth affects IRR because it is assumed to be the amount of rainfall which is effectively used, thereby reducing IRR.

All Irrigation Systems: The initial water contents for all irrigation systems were assumed to be 90% of field capacity. This was thought to be a reasonable value for a humid climate area. Also, for perennial crops which are irrigated the entire year, the starting water content is defined for the first year only. For successive years, the soil water content is continuously simulated and thus no assumptions are required.

Soil water contents at which irrigations are scheduled (SWIRR) are calculated for each day of the crop irrigation season by multiplying SWCIX times (1.0-AWD).

Finally, subroutine SW writes values of the soil water content parameters for each day of the irrigation season if that option was previously selected by the model user.

Subroutine BAL

Subroutine BAL calculates a water balance for a crop root zone on a daily basis. The soil water content is updated based on ET, rainfall, and drainage. Irrigations are scheduled when the soil water content falls below the level required to initiate an irrigation. Irrigation depths are calculated to restore the soil water content to field capacity, to a fraction of field capacity, or a fixed irrigation amount is applied, depending upon the options previously specified.

The water balance equation for the crop root zone is written as:

$$STO = RAIN + NIR - DRAIN - RUNOFF - ET \quad (1)$$

where STO = change in soil water storage (inches),
RAIN = rainfall (inches),
NIR = net irrigation requirement (inches),
DRAIN = drainage (inches),
RUNOFF = surface runoff (inches), and
ET = evapotranspiration (inches).

In Equation (1) surface runoff was assumed to be negligible or combined with drainage for Florida's sandy soils, and each of the other parameters was determined as discussed in the following sections of this manual. The objective of this approach to modeling the crop root zone was to determine the irrigation requirement. Thus Equation (1) was rearranged as:

$$\text{NIR} = \text{STO} - \text{RAIN} + \text{DRAIN} + \text{ET} \quad (2)$$

where all parameters are as previously defined.

Redistribution to Field Capacity

On each simulation day, subroutine BAL calculates the number of days required for redistribution (NRR) of soil water to field capacity following rainfall. For crops which are not irrigated by seepage or flood systems, NRR was defined by the maximum of two criteria: root depth and rainfall. NRR was set equal to 1 for crop root zones less than 12 inches, NRR = 2 for root zones 12-24 inches deep, and NRR = 3 for root zones deeper than 24 inches. NRR was also defined as 1 day per inch of rain up to a maximum of 5. The model used the larger of the two above values. For crops which are seepage- or flood-irrigated, NRR was calculated as the maximum of 3 days or 1 day per inch of rain up to a maximum of 7.

Crop Water Use Coefficients

Crop ET was calculated as the multiple of KC and potential ET. KC values used are those previously calculated in subroutine DCOEF, except for rainy days. On rainy days, KC was calculated as the minimum of 1.0 or the ratio of rain/potential ET. The exception was those days when the crop KC (calculated in subroutine DCOEF) was greater than 1.0. In that case KC was used without modification for rainfall. Crop coefficients were calculated to decrease exponentially with time (days) for the days following rainfall events.

Root Zone Expansion

Subroutine BAL updates the soil water content for annual crops as a function of root zone expansion. As the crop grows, the root zone expands as calculated in subroutine DCOEF, and both the irrigated (SWCI) and nonirrigated (SWCN) crop root zone water contents are updated. SWCI is updated by adding the increment of water contained in the soil zone into which crop roots have expanded. This increment is calculated as the multiple of the increased root depth and the average soil water content of the nonirrigated zone into which the roots are expanding.

SWCN is updated by adding the water contained in the increased root depth zone and subtracting that just lost to the irrigated root zone. The added increment is calculated as the multiple of the increased nonirrigated root zone depth and 0.9 times field capacity for the soil in this portion of the root zone.

For perennial crops the root zone depths were assumed to be constants. Root zones were not expanded during the irrigation season. Values in the AFSIRS model data base are estimated root zone depths for mature crops. Other values can be input by the model user if desired.

Rainfall

Subroutine BAL updates the soil water contents for rainfall. Rain is added

to the irrigated root zone first since it is input from above. If rainfall amount is sufficient to exceed field capacity in the irrigated root zone, the excess is added to the nonirrigated root zone. For micro irrigation systems, where the entire soil surface is not irrigated, rain is also added to the nonirrigated root zone, in proportion to the nonirrigated surface area.

Evapotranspiration

Evapotranspiration (ET) is extracted from the irrigated and nonirrigated portions of the crop root zone in the proportions read from IR.DAT in subroutine IRR1. If water is not available in the nonirrigated portion of the crop root zone, then a greater proportion of ET is extracted from the irrigated portion of the root zone. Water is assumed to be available in the nonirrigated portion of the root zone as required until 50% of the available water has been depleted from that zone. After that point, the rate of extraction is decreased linearly to zero.

Drainage

Drainage is calculated for days on which rainfall occurs and the amount of rain exceeds the soil water-holding capacity. When that occurs, the water which is percolating through the profile, is considered to be effective until redistribution to field capacity has occurred. This portion of effective rain is calculated as the ET for the next NRR days, where NRR depends on the depth of the crop root zone and the rainfall amount as calculated in subroutine BAL.

Drainage from the irrigated zone is calculated as the amount of water which is in excess of that required to restore the irrigated root zone to field capacity and to provide crop ET while it is redistributing. Drainage from the irrigated root zone moves either to the nonirrigated root zone or from the entire crop root zone, depending on the relationship between the irrigated and nonirrigated root zones.

Drainage from the nonirrigated root zone is calculated as the amount of water which is in excess of that required to restore this zone to field capacity and to provide the nonirrigated portion of crop ET while it is redistributing. Drainage from this zone leaves the entire crop root zone. This is drainage from the entire crop production system.

Effective Rainfall

Effective rainfall is rain that is stored in the crop root zone and available for crop use. From this definition effective rainfall is calculated as the difference between rainfall and drainage.

Irrigation

Net Irrigation Requirement: Irrigation is scheduled whenever the water content in the irrigated portion of the crop root zone drops below the previously calculated SWIRR. Depending on the irrigation management option previously chosen, the net irrigation requirement (NIR) is calculated as the difference between the maximum soil water content in the irrigated zone (at field capacity) and the current soil water content in this zone, a fraction of this amount for deficit irrigation, or a fixed irrigation amount.

Seepage Irrigation Systems: For seepage irrigation systems NIR was calculated as the depth of water required to restore the soil water content to 90% of field capacity in the irrigated zone. Rather than 100% of field capacity, 90% was used to simulate the gradient in soil water content from the surface down to the water table for seepage-irrigated crops. Although rainfall restores the water content near the soil surface to field capacity, the water content near the surface is normally less than field capacity when the water is supplied from below.

Crown Flood Irrigation Systems: For crown flood-irrigated citrus, it was assumed

that 2 days are required to flood the grove being irrigated and to allow the water to stand and infiltrate into the beds. It was also assumed that an additional 2 days are required to drain the beds to field capacity in the crop root zone following irrigation. Thus, NIR was calculated to include the crop ET during this 4-day period plus the water required to restore the root zone to field capacity.

Container Nursery Irrigation Systems: For container nursery irrigation systems, evaporation from the soil areas between container plants contributes significantly to ET because these soil surface areas are frequently irrigated. Therefore, a separate water budget was maintained for the upper 3 inches of the soil surface between containers. Evaporation from this zone and evaporation of intercepted water on plant canopies was assumed to reduce the crop's ET requirements by 30% when water was available in this zone.

Gross Irrigation Requirements: The gross irrigation requirement (IRR) was calculated as NIR divided by the irrigation system application efficiency (EFF), where EFF was expressed as a decimal fraction. IRR therefore includes the irrigation requirements for crop production plus additional water required because of waste during application.

Rice Flood Irrigation Systems

IRR for rice flood irrigation systems was computed separately from the above computational steps in subroutine BAL. Irrigation is assumed to be applied continuously to maintain a predetermined water level in the rice paddies. The water level fluctuates upward as a result of rainfall before drainage begins. The amount of upward movement of the water table is a measure of the water storage from rainfall which is effectively used by the crop. The site-specific amount of water table fluctuation or storage must be entered by the model user.

Subroutine SUMX

Subroutine SUMX totals and summarizes data for seasonal, monthly, and (optionally) bi-weekly and weekly periods of time. It calls statistical subroutines for data analysis. It outputs results to the computer monitor and/or to the output file.

Seasonal Totals

This section of subroutine SUMX calculates seasonal totals of potential ET (ET_p), ET, RAIN, DR, and IRR. A statistical analysis subroutine, STATX, is called to analyze IRR data. The following statistical characteristics of seasonal IRR are output to the computer monitor and to the output file OUT.AF: mean, median, coefficient of variation, maximum and minimum values, proportion of years with no IRR, coefficient of determination of the extreme value distribution fit to the data set, and probabilities of extreme values of IRR. Probability values reported are 50%, 80%, 90%, and 95% values of IRR.

Rearrange Data

For crop irrigation seasons which extend beyond the end of the calendar years, data are rearranged from the continuous "Do Loop" format to calendar dates, so that monthly, bi-weekly, and weekly data summaries can easily be calculated.

Monthly Totals

This section of subroutine SUMX calculates monthly totals of ETp, ET, RAIN, DR, and IRR. STATX is called to analyze monthly data in the same manner as reported for seasonal or annual data.

Bi-weekly and Weekly Totals

As an option, this section of subroutine SUMX calculates bi-weekly and weekly totals of ETp, ET, RAIN, DR, and IRR. STATX is called to analyze monthly data in the same manner as reported for seasonal and monthly data.

Subroutine STATX

Subroutine STATX computes statistical properties of the IRR data sets. The statistics calculated are the mean, median, coefficient of variation, maximum and minimum values, and proportion of years with no IRR.

The mean value of IRR is the arithmetic average IRR for all years of record. The median value is the centermost value of the data set. For 25 years of record, this is IRR for year number 13 after IRR data are arranged in order from smallest to largest. The coefficient of variation is the sample standard deviation divided by the mean.

The maximum and minimum values are the largest and smallest IRR values observed for the years of record analyzed. These should not be confused with the largest and smallest possible IRR values. The smallest possible IRR is zero, while the largest possible value is approximately the ET for the production system being studied divided by the irrigation system efficiency.

The proportion of years with no IRR was calculated as the ratio of the number of years with no irrigation applications to the total number of years of climate data record. A large proportion of zero IRR years is an indication that the data are not normally distributed, but skewed.

Subroutine PROBX

Subroutine PROBX calculates probabilities of extreme values of IRR. Probability values calculated are the 50%, 80%, 90%, and 95% values. Probabilities were calculated based on the method presented by James et al. (1983). First, the data were arranged in descending order of magnitude. Then plotting positions were calculated using the Kimball (1946) formula:

$$P = 100 n / (N + 1) \quad (3)$$

where P = probability that a given value will not be exceeded in percent,
n = number of the given IRR data point when individual data points are numbered consecutively from the largest, and
N = the total number of data points.

The IRR data were fit to a Type I Extreme Value Distribution to permit interpolation to determine the 50%, 80%, 90%, and 95% probability values. The two-parameter Weibull probability distribution was used to transform the P values so that a linear relationship resulted between the transformed P and Log IRR. P was transformed as:

$$W = \text{Log}(-\text{Log}(P/100)) \quad (4)$$

where W = the Weibull transform of P. After transforming all P values, the slope and intercept of the following linear equation were determined by least squares curve fitting using subroutine LSQ:

$$\text{Log(IRR)} = (M)(W) + B \quad (5)$$

where M = the slope, and B = the intercept of the resulting linear equation.

After M and B were determined for Equation (5), values of W which corresponded to P values of 50%, 80%, 90%, and 95% were substituted into Equation (5) to calculate Log(IRR) and then IRR for those P values.

Subroutine LSQ

Subroutine LSQ calculates the least squares curve fit for a set of data points to fit an assumed linear distribution. The correlation coefficient and coefficient of determination are also calculated and they provide an indication of how well the data fit the assumed Extreme Value Distribution. The coefficient of determination is printed as part of the data output. Values near 1.0 indicate excellent agreement with the assumed distribution, while values near 0.0 indicate that the data do not fit the assumed distribution.

The length of climate record provided with the AFSIRS model is relatively short (18-25 years) to estimate IRR at extreme probability levels. However, when the data set fits the assumed distribution well, estimates of extreme values can be made with a greater degree of confidence than when the data set does not fit well. Therefore, the coefficient of determination is printed with each data output line to enable the model user to judge the adequacy of the data base.

In the AFSIRS model outputs, IRR values of -1 are printed for those probability levels where the coefficient of determination is less than 0.5, and thus the assumed Extreme Value Distribution is not well fit. Also, if fewer than three years have non-zero IRR values, the least squares curve fitting procedure cannot be used, and the coefficient of determination is printed as -9.99. This indicates that the data base is not adequate to estimate the desired extreme value. This normally occurs only when short (weekly and bi-weekly) data summaries are analyzed and IRR = 0 for most years.

Subroutine PLOT

Subroutine plot graphs the annual distribution of IRR data for monthly, 2-week, and weekly periods of analysis. Graphs are optional based on user inputs. Typical graphs for a perennial and an annual crop are shown in Fig. 8.

STATISTICAL OUTPUTS

The AFSIRS model computes statistical characteristics of irrigation requirements (IRR) simulated for the periods of climate record available. Subroutine STATX computes the mean, median, standard deviation, maximum and minimum values for the period of record, and the proportion of years with no IRR. Subroutine PROBX computes the probabilities of extreme values of IRR. Probability values calculated are the 50%, 80%, 90%, and 95% values of IRR, when the data set is of adequate length and the data fit the assumed extreme value distribution well enough to allow calculation of these extreme values. Simple statistical characteristics were calculated using formulas presented by Steel and Torrie (1960).

Mean

The mean value of IRR was calculated as the arithmetic average for all years of record. It was calculated by summing IRR for all years and dividing by the total number of years of record.

Median

The median value of IRR is the centermost value of the data set. It was calculated by ordering the IRR output data set from smallest to largest, and then choosing the centermost value. For the typical 25-year length of climate data record, the median value was the 13th value after the data set was ordered. For climate data records with even numbers of years of record, the median value was calculated as the average of the two centermost values. As a specific example, for a 24-year length of climate record, the median value was calculated as the arithmetic average of the 12th and 13th values, after the data set was ordered.

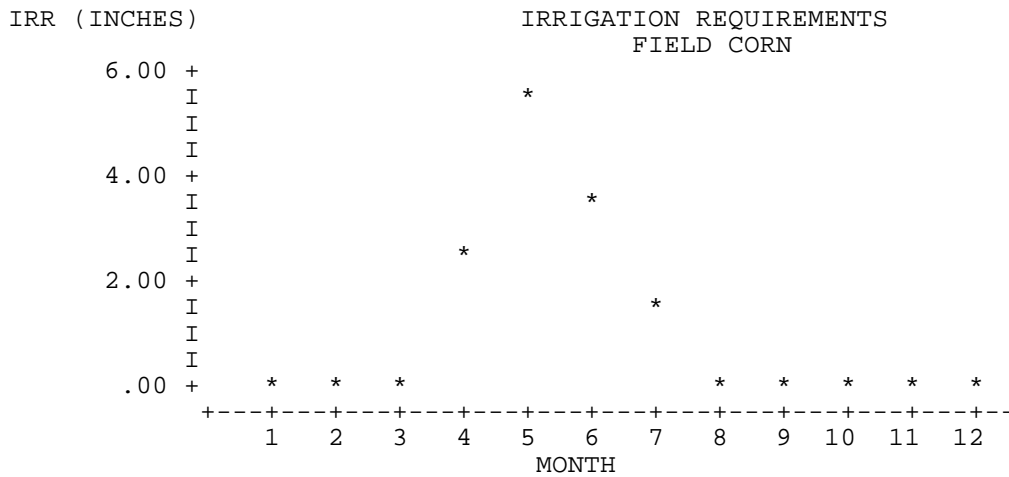
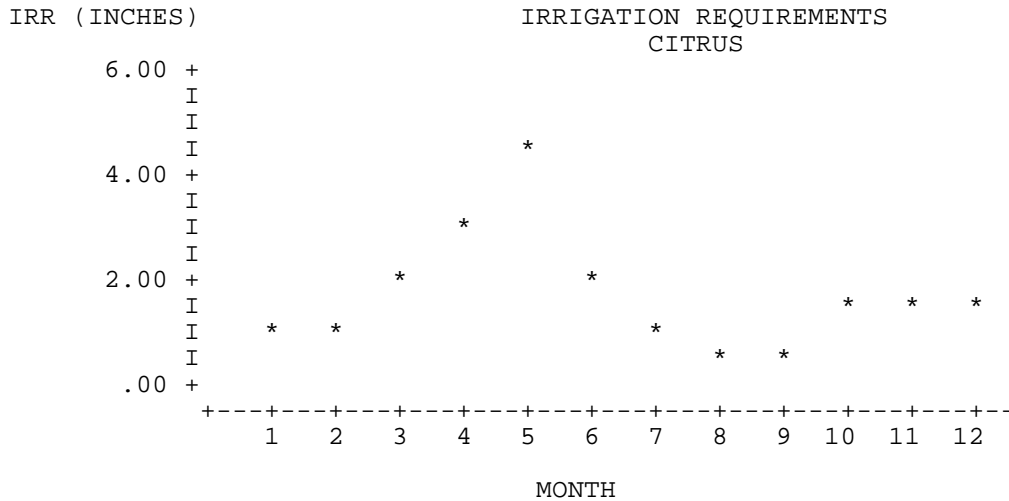


Figure 8. Typical graphs of monthly distributions of simulated irrigation requirements for citrus and field corn.

A comparison of the mean and median values provides information concerning the nature of the distribution of IRR data. One well-understood distribution is the normal distribution. This distribution is the basis of much of the statistical theory applicable in biological systems (Steel and Torrie, 1960). If IRR data sets are normally distributed, extreme values can readily be calculated. A characteristic of the normal distribution is that the data are grouped near the mean. Thus, if the mean and median values are approximately equal, the data set may be normally distributed. If the mean and median values are greatly different, the data set is not normally distributed.

Coefficient of Variation

The coefficient of variation of a data set is a measure of the relative dispersion of the data about the mean. It was calculated as the standard deviation divided by the mean. The standard deviation was calculated as the

square root of the sums of the squares of the deviations of the individual IRR values from the mean, divided by the number of years of climate record minus one. This is the statistical sample standard deviation. Small standard deviations with respect to the mean indicate that the data are grouped near the mean. A large coefficient of variation indicates that the data are widely dispersed from the mean.

Maximum and Minimum Values

The maximum and minimum values are the largest and smallest IRR values observed for the years of record analyzed. These should not be confused with the largest and smallest possible IRR values. The smallest possible IRR value is zero, and the largest possible IRR value is that if no rain occurred. That is, the largest possible value is approximately the ET divided by the irrigation system efficiency for the production system being studied.

Proportion of Zero Values

The proportion of years with no IRR was calculated as the ratio of the number of years with no irrigation applications to the total number of years of climate data record. A large proportion of zero IRR values is an indication that the data are not normally distributed.

Probabilities of Extreme Values

Probabilities of occurrence of extreme IRR values must be understood to correctly interpret the AFSIRS model outputs. A 50% probability IRR value is the value that would be expected to be exceeded in 1 of every 2 years. That is, it has a return period of 2 years. If the data base is normally-distributed, the 50% value would be equal to the mean value. Conversely, if the mean and 50% probability values are equal, this is an indication that the data base may be normally distributed. If the data base is skewed, such as when many 0.0 values are present, then the 50% value would be different than the mean value.

The 80% probability IRR would be expected to exceed the actual IRR in 80% of the years observed, as a long-term average. It would be expected to be exceeded in 20% of the years observed (a return period of $1/0.2 = 5$ years). The 80% probability value is always a larger value than the 50% value, as can be determined from the fact that the 80% value is exceeded in only 20% of the years observed, as compared to 50% for the 50% probability value. Thus, as defined here, the greater the probability value, the greater would be the magnitude of IRR, and the less frequently the IRR would be expected to be exceeded.

The fact that an 80% probability level of IRR is used for design or water use allocation purposes does not mean that this value will be exceeded exactly twice in each 10 years, once in each 5 years, nor exactly 20 in each 100 years, but only that this frequency would be expected as the long-term average. A time sequence of IRR distributions is also not implied. Thus, the probability levels as calculated by the AFSIRS model does not imply that the 80% IRR value will be exceeded every fifth year, nor does it imply any other sequence of wet and dry years. Each year is treated as a completely random event in this method of analysis.

Probabilities of occurrence of extreme values of IRR were calculated from a Type I Extreme Value Distribution (Haan, 1977; James, 1988; James et al., 1983). This distribution fits both normally distributed and skewed data sets well. Seasonal or annual IRR data sets were often observed to be normally distributed. Weekly and bi-weekly data sets were, in general, observed to be non-normal because of the large proportion of zero values. Monthly data sets

were normally distributed during high irrigation months, but non-normal during low irrigation months because of the large proportion of zero values.

The IRR data sets analyzed were transformed to linearize them. The transformed data were then fit to the assumed Extreme Value Distribution using least squares curve fitting procedures. In the AFSIRS model outputs, IRR values of -1 are printed for those probability levels where the coefficient of determination was less than 0.5. This indicates that the data set does not fit the assumed distribution well.

In the method of data analysis used, the zero and non-zero portions of the data sets are separately analyzed. If most of the data are zeros so that too few non-zero values remain to permit calculation of extreme IRR values, IRR values of -1 are printed and the least squares coefficient of determination is output as -9.99.

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APPENDICES

APPENDIX A

SOILS DATA BASES

This Appendix lists the soils data bases provided with the AFSIRS model. Two soils data bases are included: (a) a generic soils data base containing average soils data as a function of texture, and (b) 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 soil types.

Information given includes the soil identification code (CODE), the soil series name (SERIES), the textural classification (TEXTURE), the soil layer dimensions (DEPTH) and the lower (.WCL) and upper (.WCU) available water contents in each layer.

There are as many as 3 textural classifications and 6 soil layers given for each soil. Definitions of abbreviations are given at the end of this Appendix. Soil depths are given in inches. Water contents are given as decimal fractions on a volumetric basis. The depth to the bottom of each layer from the soil surface is listed first, followed by the lower and then the upper water content volumetric fractions.

As an example of the use of this Appendix, the first soil series listed in the generic soils data base is sandy soils. The soil code number is 1, and the textural classification is sand or fine sand. The soil profile is described by one layer which has a depth of 96 inches (8 ft). The range in available water contents expected for this layer is 0.04 (4%, WCL) to 0.10 (10%, WCU).

As another example, the first soil series listed in the Florida soils data base is Adamsville fine sand or Adamsville sand. Its code number is 1. Its profile is described by two layers. The first layer extends from the soil surface to a depth of 12 inches. The range in available water contents expected for this layer is 0.05 (5%, WCL) to 0.10 (10%, WCU). The second layer extends from 12 to 72 inches in depth. The range in available water contents of this layer is 0.03 to 0.08.

GENERIC SOILS, SOIL TEXTURES AND TYPICAL AVAILABLE WATER CAPACITIES

8 = NUMBER OF SOILS

CODE	SERIES	TEXTURE	DEPTH.WCL.WCU
1	SANDY SOILS	FS S	96.04.10
2	SANDY LOAM SOILS	SL	96.09.15
3	LOAM SOILS	L LS LFS	96.14.20
4	CLAY LOAM SOILS	CL SCL	96.16.22
5	SILTY CLAY SOILS	SiC	96.18.24
6	CLAY SOILS	C	96.20.26
7	MUCK SOILS	MK MKS	96.20.50
8	PEAT SOILS	PT SPT	96.20.50

FLORIDA SOIL SERIES, TEXTURES, AND AVAILABLE WATER CAPACITIES

766 = NUMBER OF SOIL TYPES

CODE	SERIES	TEXTURE	DEPTH.WCL.WCU
1	ADAMSVILLE	FS S	12.05.10 72.03.08
2	ADAMSVILLE, BD.	FS S	8.05.10 80.03.08
3	ADAMSVILLE VAR.	FS	33.02.05 49.20.25 80.02.05
4	ADAMSVILLE VAR.	S	54.02.05 70.20.20 80.02.05
5	ADAMSVILLE VAR.	S FS	8.05.10 80.05.05
6	ADAMSVILLE VAR.	FS	10.10.15 80.05.10
7	ADAMSVILLE VAR.	SIL ML	26.12.20 80.20.20
8	ADAMSVILL. VAR, DK	LFS	11.08.11 24.05.10 80.04.08
9	ALAGA	LS LFS FS	6.05.09 80.05.09
10	ALAGA, MOD. WET	LS LFS FS	9.05.09 80.05.09
11	ALAPAHA	LS S LFS	33.05.08 48.10.13 70.08.10
12	ALBANY	S FS	48.02.04 56.08.10 88.10.16
13	ALBANY	LS LFS	48.02.04 56.08.10 88.10.16
14	ALLANTON	S FS LFS	18.02.06 52.02.06 80.02.06
15	ALPIN	FS S LS	3.05.10 54.03.09 99.06.09
16	ALPIN, OCC. FL.	FS S LS	4.05.10 54.03.09 99.06.09
17	AMERICUS	LS S LFS	7.05.08 47.09.12 72.09.12
18	ANCLOTE	S FS	19.10.15 72.03.10
19	ANCLOTE	LS LFS	19.10.15 72.03.10
20	ANCLOTE, DP.	S FS	19.10.15 72.03.10
21	ANCLOTE, DP.	LS LFS	19.10.15 72.03.10
22	ANCLOTE, FREQ. FL.	S FS	18.10.15 80.03.10
23	ANCLOTE VAR.	MK	15.10.35 27.08.12 80.05.10
24	ANGIE	FSL SL	10.10.15 65.12.18
25	ANGIE	VFS SIL	10.13.24 65.12.18
26	ANGIE VAR.	L FSL SL	4.15.20 7.10.15 76.10.15
27	ANKONA	S FS	38.02.05 48.10.20 57.13.17 80.05.10
28	ANKONA, DP.	S FS	38.02.08 48.10.20 57.13.17 80.05.10
29	APALACHEE	C	25.12.18 60.12.18
30	APOPKA	S FS	55.03.05 80.12.17
31	APOPKA VAR.	FS	7.03.08 24.02.05 60.05.10 88.10.15
32	ARCHBOLD	S FS	4.03.05 80.02.03
33	ARCHER	LS LFS	12.10.25 16.10.18 36.10.20
34	ARCHER	S FS	12.05.10 16.10.18 36.10.20
35	ARDILLA	SL FSL	9.10.15 30.10.14 60.10.15
36	ARDILLA	LS LFS COS	9.06.11 30.10.14 60.10.15

37	ARENTS	S	FS		80.02.05				
38	ARENTS,MOD.WET	S	FS	S	10.02.08	32.02.08	60.02.08		
39	ARENTS,MOD.WET	LS	SL		10.05.10	32.02.08	60.02.08		
40	ARENTS,ORG.SUBS.	S	FS	S	12.02.10	38.02.10	52.30.50	72.02.10	
41	ARENTS,V.ST.	VAR			80.02.10				
42	ARENTS,SAN.LNDF.	S	FS		24.02.08				
43	ARIPEKA	FS	LFS		13.05.10	21.10.15			
44	ARREDONDO	FS	S		65.05.10	70.08.15	77.12.17	90.15.20	
45	ARREDONDO	LS	LFS		65.08.12	70.08.15	77.12.17	90.15.20	
46	ARREDONDO,BD.	FS	S		58.05.10	65.08.15	95.12.17		
47	ASTATULA	S	FS		3.04.10	86.02.05			
48	ASTOR	S	FS	LS	32.20.25	80.05.10			
49	ASTOR	S	FS	LS	32.15.20	80.05.10			
50	ASTOR,FL.	S	FS	LS	32.20.25	80.05.10			
51	ASTOR,FL.	S	FS	LS	32.15.20	80.05.10			
52	BAKERSVILLE	MK			5.20.25	41.10.20	59.10.20	86.05.15	
53	BASINGER	S	FS		18.03.07	36.10.15	60.05.10		
54	BASINGER,DP.	S	FS		4.03.07	28.05.10	42.10.15	80.05.10	
55	BASINGER,DP.	MK			4.30.50	28.05.10	42.10.15	80.05.10	
56	BASINGER,FL.	S	FS		28.03.07	42.10.15	80.05.10		
57	BAYBORO	FSL			14.11.15	64.14.18			
58	BAYBORO	L	CL		14.15.20	64.14.18			
59	BAYBORO	FSL	L		14.20.26	64.14.18			
60	BAYBORO,PD.	FSL			14.11.15	64.14.18			
61	BAYBORO,PD.	L	CL		14.15.20	64.14.18			
62	BAYBORO,PD.	FSL	L		14.20.26	64.14.18			
63	BAYVI	LS	FS	S	28.01.03	80.01.03			
64	BENNDALE	FSL	SL		5.10.15	33.12.18	68.12.18	73.10.15	
65	BENNDALE	L			5.10.15	33.12.18	68.12.18	73.10.15	
66	BENNDALE	LS			5.05.10	33.12.18	68.12.18	73.10.15	
67	BESSIE	MK			18.25.35	44.15.18	80.05.10		
68	BETHERA	FSL			7.11.16	68.14.18	80.12.16		
69	BETHERA	L	SIL		7.11.16	68.14.18	80.12.16		
70	BETHERA	CL			7.11.16	68.14.18	80.12.16		
71	BETHERA,FL.	FSL	SL		7.11.16	68.14.18	80.12.16		
72	BETHERA,FL.	L	SIL		7.11.16	68.14.18	80.12.16		
73	BETHERA,FL.	CL			7.11.16	68.14.18	80.12.16		
74	BIBB	SL	FSL		12.12.18	60.12.20			
75	BIBB	L	SIL		12.15.20	60.12.20			
76	BIBB	S	LS		12.06.10	60.12.20			
77	BIGBEE	LS	LFS		17.05.10	80.05.08			
78	BIGBEE	S	FS		17.05.10	80.05.08			
79	BINNSVILLE	SIC	SIC		8.15.18	12.12.16			
80	BIVANS	S	LS	LFS	15.10.20	45.10.15	61.05.15	81.05.15	
81	BLADEN	FSL	SL		14.10.13	41.12.16	62.12.16		
82	BLADEN	L	SIL		14.14.18	41.12.16	62.12.16		
83	BLADEN,PD.	FSL	SL		14.10.13	41.12.16	62.12.16		
84	BLADEN,PD.	L	SIL		14.14.18	41.12.16	62.12.16		
85	BLANTON	S	FS	COS	58.03.07	62.10.15	80.10.15		
86	BLANTON	LS	LFS		58.05.10	62.10.15	80.10.15		
87	BLANTON	S			58.02.04	62.10.15	80.10.15		
88	BLANTON,OCC.FL.	FS			7.08.12	52.05.12	80.07.15		
89	BLICHTON	S	LS	LFS	26.05.10	30.10.15	45.10.15	77.05.15	
						80.08.12			
90	BLUFF	SCL			17.18.20	29.12.17	38.12.17	60.12.17	
91	BLUFF,LM.SUBS.	SCL			22.18.20	45.12.17	50.12.17		
92	BOARDMAN	S LS	LFS	16.05.10	22.07.12	34.12.15	45.13.17	56.15.18	
						68.15.18			
93	BOCA	S	FS		7.05.10	25.02.05	32.10.15		
94	BOCA,DP.	S	FS		5.05.10	28.02.05	36.10.15		
95	BOCA,SL.	FS			3.05.10	33.03.05	38.10.15		
96	BOCA,TD.	FS			5.05.10	26.05.10	32.10.15		
97	BOHICKET	SIC	SIC	C	10.02.06	49.02.06			

98	BONIFAY	S	FS	57.03.08	63.10.15	73.10.15		
99	BONIFAY	LS	LFS	57.05.10	63.10.15	73.10.15		
100	BONIFAY VAR.	S	FS	42.03.08	80.10.15			
101	BONNEAU	LS	LFS	22.05.11	50.10.15	74.10.16		
102	BONNEAU	S	FS	22.04.08	50.10.15	74.10.16		
103	BOSWELL	FSL	SL	5.15.20	70.14.18			
104	BOSWELL	SIL	L	5.15.20	70.14.18			
105	BOSWELL	CL	SIC C	5.14.18	70.14.18			
106	BOWIE	FSL		14.10.15	48.13.18	72.13.18	85.13.18	
107	BOWIE	LFS		14.07.09	48.13.18	72.13.18	85.13.18	
108	BRADEN	S	FS	4.10.15	28.05.10	40.10.15	70.05.10	
109	BRADENTON	S	FS	4.08.12	10.03.07	26.10.15	70.03.10	
110	BRADENTON	LS	LFS	4.10.15	10.03.07	26.10.15	70.03.10	
111	BRADENTON, FL.	S	FS	4.08.12	10.03.07	26.10.15	70.03.10	
112	BRADENTON, FL.	LS	LFS	4.10.15	10.03.07	26.10.15	70.03.10	
113	BRADENTON, LM. SUB	S	FS	6.05.10	13.05.10	47.10.15		
114	BRADENTON, LM. SUB	LS	LFS	6.10.15	13.05.10	47.10.15		
115	BRIGHTON	PT		63.20.25				
116	BROWARD	S	FS	4.05.10	26.03.08			
117	BROWARD VAR.	S	FS	14.05.05	20.10.15	27.05.10	34.05.10	
118	BULOW	S	COS	5.05.07	20.02.05	45.02.05	50.10.15	
119	BUSHNELL	FS	LFS	10.05.08	35.15.18			
120	CADILLAC	S	FS	7.05.10	52.04.08	76.06.15	99.08.18	
121	CAHABA	SL	FSL	9.10.14	53.12.20	80.05.10		
122	CAHABA	LS	LFS	9.05.10	53.12.20	80.05.10		
123	CAHABA	L		9.11.15	53.12.20	80.05.10		
124	CALOOSA	S	FS	27.02.05	80.15.20			
125	CANAVERAL	FS	S COS	12.02.05	80.02.05			
126	CANAVERAL, ORG. SU	FS	S COS	45.05.05	70.20.20	80.05.05		
127	CANAVERAL VAR.	S		50.01.04	55.20.25	60.10.15		
128	CANDLER	S	FS	5.04.08	67.02.06	95.05.08	99.10.15	
129	CANDLER, BD.	S	FS	65.02.06	80.05.08			
130	CANDLER VAR.	FS		72.05.10	80.05.10			
131	CANDLER VAR, OVWS	C		17.15.20	78.02.05			
132	CANOVA	S	FS	13.02.05	23.10.15	57.10.15	80.10.15	
133	CANOVA VAR.	FS		5.10.15	18.05.10	24.12.15		
134	CAPTIVA	S	FS	6.10.15	15.05.10	26.05.10	30.05.05	
					80.05.05			
135	CARNEGIE	SL	LS SL	5.05.08	20.10.14	32.10.12	65.10.12	
136	CARNEGIE	SCL		5.10.14	20.10.14	32.10.12	65.10.12	
137	CASSIA	S	FS	25.03.07	37.10.15	80.03.07		
138	CASSIA, MOD. WELL	S	FS	29.05.05	41.10.15	80.05.05		
139	CENTENARY	S	FS	9.03.08	58.03.05	72.03.08		
140	CHAIRES	S	FS	28.02.05	54.05.10	68.10.15	80.12.17	
141	CHAIRES, DP.	S	FS	28.02.05	54.05.10	68.10.15	80.12.17	
142	CHARLOTTE	FS	S	6.05.10	19.03.07	46.05.08	65.03.07	
143	CHEWACLA	FSL	SL	8.10.15	24.15.24	34.12.20	58.15.24	
144	CHEWACLA	SIL	L	8.15.24	24.15.24	34.12.20	58.15.24	
145	CHIEFLAND	S	FS	8.02.05	33.02.05	39.07.12		
146	CHIPLEY	S	FS	6.05.10	77.03.08			
147	CHIPOLA	S	LS LFS	35.06.10	56.10.17	75.06.14	94.02.06	
148	CHOBEE	SL	FSL	7.10.15	63.12.17	75.06.10		
149	CHOBEE	LS	LFS	7.10.15	63.12.17	75.06.10		
150	CHOBEE, DP.	MK		4.30.50	16.10.15	53.12.17	80.10.15	
151	CHOBEE, DP.	FS	LFS	4.15.25	16.10.15	53.12.17	80.10.15	
152	CHOBEE, FL.	SL	FSL	7.10.15	63.12.17	75.06.10		
153	CHOBEE, FL.	LS	LFS	7.10.15	63.12.17	75.06.10		
154	CHOBEE VAR.	SCL		20.20.20	35.20.20	40.10.20	80.05.15	
155	CITRONELLE	FS	S	2.05.10	9.05.10			
156	CLARENDON	LS	LFS S	15.08.12	40.10.15	80.08.12		
157	CLARENDON	SL	FSL	15.10.14	40.10.15	80.08.12		
158	COCOA	S	FS LS	32.02.05	38.05.10			
159	COCOA VAR.	S		14.50.10	25.50.50			

160	COCOA VAR.	FS			13.03.05	27.03.05	31.05.08		
161	COMPASS	LS	LFS		16.05.10	33.10.15	57.10.15	74.14.18	
162	CONGAREE	FSL	SL		8.12.18	38.12.20			
163	CONGAREE	L	SIL		8.12.20	38.12.20			
164	COPELAND	FS	LS	LFS	14.10.15	18.05.10	24.10.15	30.05.10	
165	COPELAND, DP.	FS	LS	LFS	12.10.15	17.05.10	25.10.15	31.05.10	
166	CORNELIA	S	FS		39.02.05	92.05.10			
167	COROLLA	S	FS		72.01.03				
168	COWARTS	LS	LFS		8.06.10	19.10.14	25.10.16	60.08.12	
169	COWARTS	FSL	SL		8.08.13	19.10.14	25.10.16	60.08.12	
170	COWARTS, GRV.	LS	LFS		8.04.08	19.10.14	25.10.16	60.08.12	
171	COWARTS, GRV.	SL	FSL		8.06.12	19.10.14	25.10.16	60.08.12	
172	COXVILLE	FSL	SL	L	11.12.17	72.14.18			
173	CROATAN	MK			28.35.45	38.10.15	60.12.20		
174	CROATAN, FL.	SP			28.35.45	38.10.15	60.12.20		
175	CROATAN, PD.	MK			28.35.45	38.10.15	60.12.20		
176	CUTHBERT	LFS	FSL		8.11.15	29.10.15	34.09.15	60.08.15	
177	CUTHBERT	LFS	FSL		8.10.14	29.10.15	34.09.15	60.08.15	
178	CUTHBERT	LFS	FSL		8.08.12	29.10.15	34.09.15	60.08.15	
179	CUTHBERT, GRAD.	C	SC		29.10.15	34.09.15	60.08.15		
180	CUTHBERT, ST.	FSL	LFS		8.08.12	29.12.18	60.10.15		
181	DADE	FS	S		27.02.05	35.02.05			
182	DANIA	MK			14.20.30	18.02.10			
183	DAYTONA	S	FS	COS	36.02.05	47.10.15	80.02.05		
184	DELAND	S	FS		4.02.05	55.02.05	67.10.15	94.10.15	
185	DELKS	S	FS		4.05.10	27.02.05	46.10.15	60.12.17	
186	DELRAY	FS	S	LS	18.10.15	46.05.08	60.10.15	75.07.10	
187	DELRAY	FS	LFS		18.15.25	46.05.08	60.10.15	75.07.10	
188	DELRAY, DP.	FS	S	LS	6.10.15	18.10.15	46.05.08	80.10.15	
189	DELRAY, DP.	FS			6.15.25	18.10.15	46.05.08	80.10.15	
190	DELRAY, DP.	MK			6.30.50	18.10.15	46.05.08	80.10.15	
191	DELRAY, FL.	FS	S	LS	18.10.15	46.05.08	60.10.15	75.07.10	
192	DELRAY, FL.	FS	LFS		18.15.25	46.05.08	60.10.15	75.07.10	
193	DENAUD	MK			11.20.30	20.02.10	23.02.05	42.10.15	
194	DOROVAN	MPT	MK		3.25.50	74.25.50	99.05.08		
195	DOTHAN	LFS	LS		13.06.10	33.12.16	60.08.12		
196	DOTHAN	FSL	SL		13.08.13	33.12.16	60.08.12		
197	DOTHAN, GRV.	LFS	LS		13.04.08	33.12.16	60.06.12		
198	DOTHAN, GRV.	FSL	SL		13.06.11	33.12.16	60.06.12		
199	DUCKSTON	S	FS		72.02.05				
200	DUETTE	FS	S		3.03.06	66.02.05	80.10.15		
201	DUNBAR	SL	FSL	L	8.10.15	80.13.18			
202	DUNBAR	LS			8.06.10	80.13.18			
203	DUPLIN	SL	FSL		8.10.15	80.13.18			
204	DUPLIN	LS			8.06.10	80.13.18			
205	DURBIN	MK			59.20.25	80.10.15			
206	EATON	LS	LFS		30.05.08	33.12.17	78.12.17	80.10.14	
207	EATON	S	FS		30.03.05	33.12.17	78.12.17	80.10.14	
208	EATON, DP.	MK			6.25.40	29.05.10	33.12.17	80.10.15	
209	EATON, DP.	FS	S		6.15.20	29.05.10	33.12.17	80.10.15	
210	EATON, DP.	LS	LFS		6.10.15	29.05.10	33.12.17	80.10.15	
211	EAUGALLIE	S	FS		22.02.07	35.15.25	55.02.05	61.10.20	
						84.05.15			
212	EAUGALLIE, BD. SUB	S	FS		8.02.07	25.03.08	36.15.25	57.02.05	
						80.10.20			
213	EAUGALLIE, DP.	S	FS		24.02.07	37.15.25	55.02.05	63.10.20	
						80.05.15			
214	EAUGALLIE, LM. SUB	S	FS		27.02.05	40.05.10	55.02.05	65.10.15	
						68.05.15			
215	EBRO	MK			65.35.45				
216	ECONFINA	S	FS		49.05.10	73.03.08	77.06.12	80.05.13	
217	EGLIN	S	FS		2.05.10	60.05.10	80.07.13		
218	ELECTRA	S	FS		7.05.10	47.02.07	60.10.15	80.10.15	

219	ELECTRA, BD.	S	FS	3.05.10	35.02.07	40.10.15	46.02.07	
					80.10.15			
220	ELECTRA VAR.	S	FS	5.05.05	39.05.05	51.10.15	70.05.10	
					78.10.15			
221	ELECTRA VAR.	FS		4.10.15	38.10.15	53.15.20	80.10.15	
222	ELECTRA VAR, OCC.	FS		2.10.15	39.10.15	58.15.20	80.10.15	
223	ELLABELLE	LS	LFS	27.05.08	72.12.18			
224	ELLZEY	FS	S	12.10.20	37.10.15	58.15.20	80.10.15	
225	ELRED	COS	S FS	16.05.05	33.05.05	48.10.15	62.05.05	
226	EMERALDA	LFS	FSL	6.15.20	11.05.10	56.10.20	66.10.20	
227	EMERALDA	FS	LS	6.10.15	11.05.10	56.10.20	66.10.20	
228	ESCAMBIA	FSL	VFS SL	13.11.15	35.15.20	72.10.18		
229	ESCAMBIA	L	SIL	13.11.15	35.15.20	72.10.18		
230	ESTERO	MK		5.20.35	13.10.15	33.07.13	55.10.15	
					80.05.10			
231	ESTO	LS	LFS	8.06.10	13.12.17	62.12.18		
232	ESTO	FSL	SL L	8.11.15	13.12.17	62.12.18		
233	EULONIA	LS	LFS	13.06.09	48.12.16	58.10.14		
234	EULONIA	SL	FSL	13.08.12	48.12.16	58.10.14		
235	EUREKA	LFS	FS	11.10.15	72.15.20			
236	EUSTIS	S	FS	6.08.10	24.05.08	76.07.11	98.05.07	
237	EUSTIS	LS	LFS	6.08.10	24.05.08	76.07.11	98.05.07	
238	EVERGLADES	MK	MPT	8.20.25	28.45.50	80.45.50		
239	FACEVILLE	LS	LFS	5.06.09	11.12.15	72.12.18		
240	FACEVILLE	SL	FSL	5.06.09	11.12.15	72.12.18		
241	FACEVILLE	SCL		5.10.13	11.12.15	72.12.18		
242	FARMTON	FS	S	7.08.20	34.02.10	50.10.25	80.10.17	
243	FELDA	S	FS	22.02.05	32.10.15	60.02.05		
244	FELDA, DP.	S	FS	22.02.05	32.10.15	60.02.05		
245	FELDA, FL.	S	FS	22.02.05	32.10.15	60.02.05		
246	FELLOWSHIP	LS	LFS SL	11.07.12	18.10.14	25.15.20	42.15.20	
					80.15.20			
247	FELLOWSHIP, DP.	LS	LFS FSL	11.07.12	18.10.14	25.15.20	42.15.20	
					80.15.20			
248	FELLOWSHIP VAR, G	LFS	LS	14.02.05	20.05.07	36.06.09	43.13.17	
					70.13.17			
249	FLEMINGTON	LS	LFS FSL	9.08.13	27.12.15	53.12.18	75.15.18	
250	FLEMINGTON VAR.	FS		5.05.15	80.10.20			
251	FLORAHOME	S	FS	36.07.12	80.03.10			
252	FLORIDANA	FS	S	12.10.20	29.05.10	62.10.20		
253	FLORIDANA	FS		12.15.20	29.05.10	62.10.20		
254	FLORIDANA, DP.	S	FS FS	21.10.20	25.05.10	80.10.20		
255	FLORIDANA, FL.	FS	S FS	18.10.20	28.05.10	80.10.20		
256	FLORIDANA VAR.	S	FS LFS	11.10.20	23.05.10	70.10.20		
257	FLORIDANA VAR.	FS	LFS	8.10.15	22.05.10	42.10.15	59.06.15	
					80.14.18			
258	FLUVAQUENTS	C	7.12.18	19.06.14	25.12.18	38.06.14	47.12.18	
					65.02.10			
259	FORT MEADE	LS	LFS FS	17.08.15	80.06.10			
260	FORT MEADE VAR.	LFS		16.08.12	80.06.10			
261	FOXWORTH	S	FS	52.02.10	80.02.08			
262	FOXWORTH VAR.	S	FS	9.05.10	73.03.08	80.10.15		
263	FRIPP	FS	S	5.02.08	80.01.03			
264	FT. DRUM	S	FS	5.05.10	17.05.08	25.10.15	70.05.08	
265	FT. GREEN	S	FS	17.10.15	31.02.10	42.10.15	80.12.18	
266	FT. GREEN, BD.	S	FS	28.05.10	38.12.18	58.12.18	80.10.15	
267	FUQUAY	LS	LFS	34.04.09	45.12.15	96.10.13		
268	FUQUAY	S	FS	34.03.07	45.12.15	96.10.13		
269	FUQUAY, GRV.	LS	LFS	34.04.09	45.12.15	96.10.13		
270	FUQUAY, GRV.	S	FS	34.03.07	45.12.15	96.10.13		
271	GAINESVILLE	LS	LFS FS	80.05.10				
272	GALVESTON	FS	S LFS	4.05.10	70.05.10			

273	GARCON	LFS	LS	FS	8.10.15	31.05.10	51.10.15	58.07.10
						80.05.08		
274	GARCON, FL.	LFS	LS	FS	18.10.15	28.05.10	51.10.15	80.05.08
275	GATOR	MK	PT		29.30.40	34.03.05	68.10.15	80.03.05
276	GATOR, FL.	MK	SP		34.30.40	46.10.15	52.10.15	58.03.05
277	GENTRY	S	FS		24.10.15	64.10.20	80.05.10	
278	GILEAD	LS	LS		5.05.09	8.10.15	42.12.16	72.10.15
279	GILEAD	SL	SL		5.08.12	8.10.15	42.12.16	72.10.15
280	GOLDSBORO	SL	FSL		15.08.12	45.11.15	65.11.15	
281	GOLDSBORO	LS	LFS		15.06.11	45.11.15	65.11.15	
282	GRADY	L	CL		5.10.18	11.10.15	62.12.16	
283	GRADY	SL	FSL		5.10.15	11.10.15	62.12.16	
284	GRADY, DR.	L	CL		5.10.18	11.10.15	62.12.16	
285	GRADY, DR.	SL	FSL		5.10.15	11.10.15	62.12.16	
286	GREENVILLE	SL	FSL		9.07.14	80.14.18		
287	GREENVILLE	L	SCL	CL	9.12.18	80.14.18		
288	GREENVILLE	LS	LFS		9.06.11	80.14.18		
289	GRITNEY	LS	LFS		7.05.08	12.10.15	31.10.15	50.10.15
290	GRITNEY	SL	FSL		7.10.15	12.10.15	31.10.15	50.10.15
291	GUNTER	FS	LFS	LS	46.05.10	57.08.12	75.10.15	
292	HAGUE	S	FS		24.05.08	49.12.17	74.10.14	80.06.10
293	HAGUE	LS	LFS		24.06.10	49.12.17	74.10.14	80.06.10
294	HALLANDALE	FS	S		4.05.11	10.03.08	14.03.08	16.05.10
295	HALLANDALE, DP.	S	FS		3.05.10	15.03.05		
296	HALLANDALE, SL.	FS	S		2.03.05	11.05.08		
297	HALLANDALE, TD.	FS	S		2.03.05	16.05.10	19.03.05	
298	HANDBORO	SIL	L	SIC	2.20.30			
299	HANNAHATCHEE	FSL			7.11.15	80.12.20		
300	HANNAHATCHEE	L	SCL	CL	7.12.20	80.12.20		
301	HAPLAQUENTS, CLY.	C			80.15.20			
302	HEIGHTS	S	FS		29.05.08	36.10.16	42.12.18	80.12.20
303	HEROD	SL			12.10.16	50.14.20	62.12.16	
304	HEROD	L			12.12.20	50.14.20	62.12.16	
305	HILOLO	S	FS		7.05.10	12.10.15	28.10.15	53.10.15
						80.05.10		
306	HILOLO	LS	LFS		7.08.12	12.10.15	28.10.15	53.10.15
						80.05.10		
307	HOBE	S	FS		4.05.08	70.01.05	74.10.15	78.08.12
						88.11.15		
308	HOLOPAW	S	FS		45.07.10	62.15.20	71.05.10	
309	HOLOPAW, DP.	S	FS		43.03.10	65.10.20	75.05.10	
310	HOLOPAW, FREQ. FL.	FS	S		50.03.07	68.10.15	80.05.10	
311	HOLOPAW, LM. SUBS.	S	FS		45.07.10	60.15.20		
312	HOMOSASSA	LFS	FSL		8.20.25	15.10.15	27.07.12	
313	HONTOON	MK			60.20.25	65.15.20		
314	HORNSVILLE	LS	LFS		9.06.09	43.12.16	76.10.14	
315	HORNSVILLE	SL	FSL		9.08.12	43.12.16	76.10.14	
316	HURRICANE	S	FS		51.03.07	55.10.15	80.03.10	
317	HURRICANE, FL.	LS	LFS		6.05.10	51.03.07	55.10.15	80.03.10
318	HURRICANE, FL.	S	FS		6.03.07	51.03.07	55.10.15	80.03.10
319	HYDRAQUENTS	SIC			80.15.20			
320	IBERIA	SIC			5.17.22	37.14.18	75.14.20	
321	IBERIA	SIC	C		5.15.19	37.14.18	75.14.20	
322	ICHETUCKNEE	FS	S	LFS	13.05.08	55.12.18		
323	IMMOKALEE	FS	S		6.05.10	35.02.05	54.10.25	72.02.05
324	IMMOKALEE, DP.	FS	S		6.05.10	35.02.05	54.10.25	72.02.05
325	IMMOKALEE, LM. SUB	S	FS		5.05.10	48.02.05	58.10.25	
326	IRVINGTON	FSL	SL	L	6.10.15	33.12.18	61.12.18	82.13.19
327	ISLES	MK	SP		5.10.15	11.05.14	39.05.08	47.12.18
328	ISLES	S	FS	FS	5.05.14	11.05.14	39.05.08	47.12.18
329	ISLES, DP.	S	FS		5.05.10	21.05.10	47.12.18	
330	ISLES, SL.	S	FS		6.05.10	33.05.10	51.12.18	
331	ISTOKPOGA	MK			11.20.25	79.20.25		

332	IUKA	LS	LFS	13.06.10	22.10.20	60.10.20		
333	IUKA	FSL	SL	13.10.15	22.10.20	60.10.20		
334	IUKA	L	SIL	13.15.20	22.10.20	60.10.20		
335	IZAGORA	VFS	FSL SL	11.11.20	46.12.20	91.16.20		
336	IZAGORA	LS	LFS	11.06.11	46.12.20	91.16.20		
337	IZAGORA	L	SIL	11.16.22	46.12.20	91.16.20		
338	JOHNS	LS	LFS	15.06.11	32.12.15	60.03.06		
339	JOHNS	SL	FSL	15.10.15	32.12.15	60.03.06		
340	JOHNSTON	L		30.20.26	34.02.07	60.06.12		
341	JOHNSTON	L	SL FSL	30.10.20	34.02.07	60.06.12		
342	JONATHAN	FS	S	5.05.08	56.01.05	99.10.15		
343	JONESVILLE	S	FS	7.05.10	29.02.08	33.05.10		
344	JUMPER	S	FS	29.03.08	35.10.15	69.10.15	80.10.15	
345	JUMPER	LS	LFS	29.05.08	35.10.15	69.10.15	80.10.15	
346	JUPITER	S	FS	11.12.18	14.02.08			
347	KALIGA	MK		26.20.25	37.10.15	65.10.20	80.10.15	
348	KALIGA VAR.	MK		35.20.25	52.10.15			
349	KALMIA	LS	LFS	14.06.10	32.12.16	60.03.06		
350	KALMIA	SL	FSL	14.10.15	32.12.16	60.03.06		
351	KALMIA,WET SUBS.	LS	LFS FSL	22.06.10	34.12.16	72.03.06		
352	KANAPAHA	S	FS	48.03.10	55.10.15	70.07.15	80.07.15	
353	KANAPAHA, BD.	S	FS	3.03.10	55.03.08	80.07.15		
354	KENANSVILLE	LS	LFS	24.04.10	36.10.14	80.05.05		
355	KENANSVILLE	FS	S	24.03.07	36.10.14	80.05.05		
356	KENANSVILLE,WET	FS	LS LFS	23.04.10	56.10.15	72.05.05		
357	KENDRICK	LS	LFS	26.08.10	32.10.15	79.12.20	80.12.15	
358	KENDRICK	S	FS	26.05.07	32.10.15	79.12.20	80.12.15	
359	KENNEY	FS	LFS	60.06.10	80.11.15			
360	KERSHAW	S	COS FS	80.02.05				
361	KERSHAW VAR.	S	FS	28.05.10	99.05.05			
362	KESSON	S	FS	6.10.15	23.05.10	38.05.15	80.05.15	
363	KESSON	MK		6.30.50	23.05.10	38.05.15	80.05.15	
364	KINSTON	FSL		12.13.19	60.14.18			
365	KINSTON	L	SIL	12.14.20	60.14.18			
366	KLEJ	LS	FS LFS	39.06.11	47.06.08	60.11.17		
367	KLEJ,C.SUBS.	S	LS	6.06.11	48.06.08	60.16.20		
368	KLEJ,SY.SUBS.	LS	FS LFS	39.06.11	47.06.08	60.04.05		
369	KUREB	S	COS FS	80.05.05				
370	LACOOCHEE	FS	LFS	10.15.20	15.10.15			
371	LACOOCHEE	FSL		10.15.20	15.10.15			
372	LAKE	S	FS	86.03.08				
373	LAKE,CLY.SUR.	C		11.15.20	80.03.08			
374	LAKELAND	S	FS	43.05.09	80.02.08			
375	LAKEWOOD	S	FS	10.04.09	36.04.10	60.04.10		
376	LAUDERHILL	MK		31.20.30				
377	LAWNWOOD	S	FS	8.03.08	28.01.03	52.10.15	58.10.15	
					80.07.11			
378	LAWNWOOD,DP.	S	FS	3.03.08	22.01.03	29.10.15	80.07.11	
379	LEAF	SIL	VFS	9.20.22	72.18.21			
380	LEAF	FSL	L	9.12.18	72.18.21			
381	LEDWITH	MK		9.25.40	15.10.18	17.10.15	44.04.15	
					93.04.15			
382	LEEFIELD	LS	S FS	23.04.07	33.10.13	75.08.12		
383	LEON	S	FS	15.02.05	30.05.10	80.02.05		
384	LEON,FL.	FS	S	12.02.05	23.10.20	80.02.20		
385	LOCHLOOSA	S	FS LS	28.05.20	32.10.15	57.12.15	69.13.18	
					75.10.15			
386	LOKOSEE	S	FS	27.02.08	35.05.10	43.05.10	49.02.08	
					57.10.15			
387	LUCY	LS	S LFS	24.06.10	35.10.12	70.12.14		
388	LUMBEE	LS	SL FSL	14.08.12	36.12.16	60.03.06		
389	LUTTERLOH	S	FS	59.02.05	71.10.15	94.10.15		
390	LUTTERLOH	LS	LFS	59.05.10	71.10.15	94.10.15		

391	LYNCHBURG	LS	LFS		10.07.10	62.12.16			
392	LYNCHBURG	SL	FSL	L	10.09.13	62.12.16			
393	LYNCHBURG, FL.	LS	LFS		10.07.10	62.12.16			
394	LYNCHBURG, FL.	SL	FSL	L	10.09.13	62.12.16			
395	LYNN HAVEN	S	FS		16.05.10	30.10.20	75.01.05		
396	LYNN HAVEN VAR.	LS			22.06.12	60.04.08	80.10.15		
397	LYNN HAVEN VAR.	S	FS		22.05.10	60.04.08	80.10.15		
398	LYNNE	S	FS	6.08.15	20.03.08	34.10.15	38.05.10	43.13.17	
						67.13.17			
399	MABEL	FS	S		11.10.15	14.13.18	30.15.18	80.13.18	
400	MALABAR	S	FS		14.03.08	35.05.10	45.02.05	61.10.15	
						65.05.08			
401	MALABAR, DP.	S	FS		14.03.08	35.05.10	45.02.05	61.10.15	
						65.05.08			
402	MALABAR, FREQ. FL.	S	FS		6.03.08	48.05.10	80.10.15		
403	MALABAR, HIGH	S	FS		17.03.05	37.05.10	49.03.05	68.10.15	
						80.03.05			
404	MALBIS	FSL	L	SL	7.10.15	26.12.20	54.12.17	71.06.12	
405	MANATEE	LFS	LS	FS	18.15.20	36.10.15	48.08.15	60.08.15	
406	MANATEE	LFS	FS	LS	18.15.25	36.10.15	48.08.15	60.08.15	
407	MANATEE	FSL	SL		18.15.25	36.10.15	48.08.15	60.08.15	
408	MANATEE, DP.	LFS	LS	FS	18.15.20	36.10.15	48.08.15	60.08.15	
409	MANATEE, DP.	FSL	SL		18.15.25	36.10.15	48.08.15	60.08.15	
410	MANATEE, DP.	LFS	FS	LS	18.15.25	36.10.15	48.08.15	60.08.15	
411	MANATEE, FL.	LFS	LS	FS	18.15.20	36.10.15	48.08.15	60.08.15	
412	MANATEE, FL.	FSL	SL		18.15.25	36.10.15	48.08.15	60.08.15	
413	MANDARIN	FS	S		26.03.07	40.10.15	73.03.07	80.10.15	
414	MANTACHIE	SIL			11.16.20	61.14.20			
415	MANTACHIE	CL			11.10.15	61.14.20			
416	MANTACHIE	FSL	SL	L	11.16.20	61.14.20			
417	MARGATE	FS	S		8.05.10	16.03.06	28.03.06	32.03.10	
418	MARLBORO	LS	LFS		9.06.09	60.14.18	72.12.18		
419	MARLBORO	SL	FSL	VFS	9.09.14	60.14.18	72.12.18		
420	MARTEL	SL	SCL		19.15.20	72.13.18			
421	MASARYK	VFS			70.05.10	90.10.15			
422	MASCOTTE	FS	S		16.03.08	28.10.15	34.03.08	60.10.15	
						80.07.10			
423	MASCOTTE, DP.	FS			20.05.12	36.15.25	80.08.12		
424	MASCOTTE, OCC. FL.	FS			19.05.12	34.15.25	38.08.12	80.08.12	
425	MATLACHA	S	FS		35.05.08	80.03.05			
426	MATLACHA, LM. SUBS	S	FS		23.05.10	44.03.05	48.10.15		
427	MAUREPAS	MK			72.20.50				
428	MAUREPAS, DR.	MK			72.20.50				
429	MAXTON	SL	FSL		12.10.14	33.13.18	60.03.06		
430	MAXTON	LS	LFS		12.06.10	33.13.18	60.03.06		
431	MCKEE	C	CL	CL	1.12.20	60.12.20	80.05.10		
432	MEGGETT	FSL	SL	LS	8.10.15	16.13.18	52.13.18	65.12.16	
433	MEGGETT	L	CL		8.15.20	16.13.18	52.13.18	65.12.16	
434	MICANOPY	FS	LFS	LS	15.05.10	20.10.15	26.10.18	57.10.18	
						68.10.15			
435	MICCO	MK	MPT	PT	12.20.25	30.20.25	38.05.10	55.08.12	
436	MILLHOPPER	S	FS	LS	58.05.10	64.08.12	89.08.15		
437	MILLHOPPER, BD.	S	FS		7.05.10	45.05.08	80.10.15		
438	MONTEOCHA	S	FS	LS	12.15.30	48.10.15	85.10.15	94.05.15	
439	MONTVERDE	MK	PT		11.20.25	80.45.50			
440	MOULTRIE	S	FS		22.02.05	29.10.15	80.02.05		
441	MULAT	LFS	LS		10.10.15	27.05.20	49.10.15	80.05.10	
442	MULAT	FS	S		10.10.15	27.05.20	49.10.15	80.05.10	
443	MYAKKA	S	FS		20.02.05	36.10.20	80.02.10		
444	MYAKKA, DP.	S	FS		20.02.05	36.10.15	80.02.05		
445	MYAKKA, LM. SUBS.	S	FS		23.02.05	34.10.20	62.10.20		
446	MYAKKA, SH. SUBS.	S	FS		26.05.05	41.10.15	80.05.05		
447	MYAKKA, TD.	S	FS		15.05.10	37.10.15	75.05.10		

448	MYAKKA VAR.	S	FS		17.10.15	72.10.15			
449	MYAKKA VAR.	S			7.05.10	28.02.05	40.10.15	45.05.10	
						80.02.05			
450	MYATT	FSL	SL	VFS	10.11.20	50.12.20	72.10.20		
451	MYATT	SIL	L		10.16.24	50.12.20	72.10.20		
452	MYATT	LS	LFS		10.08.11	50.12.20	72.10.20		
453	NARCOOSSEE	S	FS		5.03.08	22.02.05	26.05.08	80.02.05	
454	NARCOOSSEE, SH. SU	FS	S		3.03.10	11.02.05	14.05.10	80.05.10	
455	NETTLES	S	FS		8.05.10	33.02.05	39.10.15	55.10.15	
						90.10.15			
456	NETTLES, DP.	S	FS		5.05.10	34.02.05	40.10.15	57.10.15	
						80.10.15			
457	NEWHAN	FS	S		64.05.05				
458	NEWNAN	S	FS		12.03.10	16.07.15	56.05.12	59.08.13	
						82.07.15			
459	NITTAW	MK	SP		7.20.25	15.05.15	71.15.18	83.05.10	
460	NOBLETON	FS	LFS		33.05.10	37.12.18	60.14.18	80.12.18	
						85.11.18			
461	NORFOLK	SL	FSL		17.10.15	38.10.20	70.10.15		
462	NORFOLK	LS	LFS		17.06.11	38.10.20	70.10.15		
463	NORFOLK VAR.	LS			7.05.10	14.05.10	64.10.15	80.10.15	
464	NUTALL	S	FS		17.05.10	30.15.20			
465	NUTALL, DP.	S	FS		17.05.10	30.15.20			
466	OCILLA	LS	LFS		28.05.08	59.09.12	67.09.12		
467	OCILLA	LCO	S		28.05.07	59.09.12	67.09.12		
468	OCILLA, FREQ. FL.	LS	LFS	S	28.05.08	67.09.12			
469	OCOOE	MK	PT		7.20.25	38.45.50	75.02.05		
470	OCOOE VAR.	MK			8.20.25	30.45.50	65.02.05		
471	OKEECHOBEE	MK			28.30.50	50.45.65	66.30.50		
472	OKEELANTA	MK	PT		31.20.30	65.05.10			
473	OKEELANTA, DP.	MK	PT		29.30.40	34.03.05	68.10.15	80.03.05	
474	OKEELANTA, FL.	MK			19.20.45	80.05.10			
475	OKEELANTA, TD.	MK	PT		39.20.30	60.05.10			
476	OKEELANTA VAR.	MK			4.20.35	20.20.35	54.02.10		
477	OKLAWAHA	PT	MPT	MK	9.20.25	25.20.25	31.05.10	54.10.15	
478	OKTIBBEHA	FSL	SL		4.10.15	41.12.16	70.05.10		
479	OKTIBBEHA	L	SIL		4.15.22	41.12.16	70.05.10		
480	OKTIBBEHA	CL	SIC		4.13.17	41.12.16	70.05.10		
481	OKTIBBEHA, CLY. SU	C	SIC		4.12.16	41.12.16	70.05.10		
482	OLDSMAR	FS	S		34.02.05	44.10.15	65.10.15		
483	OLDSMAR, BD.	S	FS		5.02.07	31.02.05	48.10.15	80.10.15	
484	OLDSMAR, DP.	S	FS		34.02.05	44.10.15	65.10.15		
485	OLDSMAR, LM. SUBS.	S	FS		34.05.10	49.05.10	60.10.15		
486	OLENO	C			32.20.33	71.01.05	77.05.12	82.20.27	
487	OLUSTEE	S	FS		8.05.10	21.10.15	35.03.08	62.10.15	
						74.10.15			
488	OLUSTEE, THICK SU	FS			18.05.10	23.10.15	37.03.08	63.10.15	
						80.10.15			
489	ONA	FS	S		6.10.15	20.10.15	82.03.08		
490	ONA, ORTS. SUBS.	S	FS		5.10.15	16.10.15	52.05.10	68.10.15	
						80.10.15			
491	ORANGEBURG	LS	LFS	S	7.06.09	12.09.12	54.11.14	64.11.14	
492	ORANGEBURG	SL	FSL	SCL	7.07.10	12.09.12	54.11.14	64.11.14	
493	ORANGEBURG	SCL			7.09.13	12.09.12	54.11.14	64.11.14	
494	ORANGEBURG, OVWSH	SL	FSL		14.10.15	54.11.14	64.11.14		
495	ORANGEBURG, OVWSH	L			14.13.17	54.11.14	64.11.14		
496	ORLANDO	S	FS		20.07.12	88.03.06			
497	ORSINO	S	FS		22.02.08	80.02.08			
498	ORSINO VAR.	S	FS		80.02.05				
499	ORTEGA	FS	S		5.05.08	82.03.06			
500	OSIER	S	LS	FS	8.03.10	48.03.10	75.02.05		
501	OSIER	FSL	LFS		8.10.15	48.03.10	75.02.05		
502	OSIER, FL.	S	LS	FS	8.03.10	48.03.10	75.02.05		

503	OSIER, FL.	FSL	LFS		8.10.15	48.03.10	75.02.05		
504	OSIER, PD.	S	LS	FS	8.03.10	48.03.10	75.02.05		
505	OSIER, PD.	FSL	LFS		8.10.15	48.03.10	75.02.05		
506	PACTOLUS	LS	LFS	S	40.05.10	80.03.07			
507	PAHOKEE	MK			42.20.25				
508	PAISLEY	LFS	LS		9.06.10	80.15.18			
509	PAISLEY	FS			9.05.08	80.15.18			
510	PAISLEY, BD.	FS	S		17.10.15	22.13.18	80.15.18		
511	PAISLEY, DP.	FS			13.05.08	80.15.18			
512	PALM BEACH	S	FS		80.02.05				
513	PALMETTO	S	FS		25.05.10	45.05.10	64.10.15	68.08.12	
514	PALMETTO, DP.	S	FS		25.05.10	45.05.10	64.10.15	68.08.12	
515	PAMLICO	MK			30.24.26	60.03.06			
516	PAMLICO, FL.	MK			30.24.40	60.10.20			
517	PAMLICO, LY. SUBS.	MK			24.24.26	48.03.06	72.03.06		
518	PAMLICO, PD.	MK			30.24.40	60.02.10			
519	PANASOFFKEE	S	FS		5.02.05	27.02.08	30.05.10	80.14.18	
520	PANASOFFKEE	LS	LFS		5.03.07	27.02.08	30.05.10	80.14.18	
521	PANSEY	FSL	SL		10.10.15	20.10.14	35.12.16	70.12.17	
522	PANSEY	LFS	LS		10.06.10	20.10.14	35.12.16	70.12.17	
523	PANTEGO	L			18.20.30	42.12.20	65.15.20		
524	PANTEGO	L	FSL	SL	18.10.20	42.12.20	65.15.20		
525	PANTEGO	LFS	LS		18.06.10	42.12.20	65.15.20		
526	PAOLA	S	FS		25.02.05	80.02.05			
527	PARKWOOD	FS	LFS		9.05.11	22.10.20	70.05.22		
528	PARKWOOD	FSL			9.15.26	22.10.20	70.05.22		
529	PARKWOOD VAR.	FS	LFS		9.05.11	37.10.14			
530	PECKISH	FS	FS	S	9.15.20	36.05.10	48.10.15	61.05.10	
531	PEDRO	S	FS		13.03.08	16.10.15			
532	PEDRO VAR.	S	FS		8.03.08	11.12.15			
533	PEDRO VAR, OCC. FL	S	FS		8.03.08	11.12.15			
534	PELHAM	LS	LFS		27.05.08	56.10.13	68.10.16		
535	PELHAM	S	FS		27.04.07	56.10.13	68.10.16		
536	PELHAM, FL.	LS	LFS		27.05.08	56.10.13	68.10.16		
537	PELHAM, FL.	S	FS		27.04.07	56.10.13	68.10.16		
538	PELHAM, PD.	LS	LFS		27.05.08	56.10.13	68.10.16		
539	PELHAM, PD.	S	FS		27.04.07	56.10.13	68.10.16		
540	PELHAM VAR.	S	FS		27.05.08	68.10.13			
541	PELLICER	SIC	CL		10.20.30	70.15.20	80.05.10		
542	PENDARVIS	S	FS		48.02.05	62.10.15	76.10.15	80.05.10	
543	PENNEKAMP	L	MK		2.10.15	12.10.15			
544	PENNSUCO	SIL	SIC		5.15.20	38.20.45	53.10.20		
545	PENNSUCO, TD.	SIL	SIC		5.15.20	38.20.45	53.10.20		
546	PEPPER	S	FS		6.05.10	23.02.05	33.10.15	57.05.10	
						99.10.15			
547	PERRINE	SIL	SIC		10.15.20	26.20.45			
548	PERRINE VAR.	SIL	SIC		8.15.20	26.20.20	80.20.20		
549	PERRINE VAR.	SIL	SIC	SIL	10.15.20				
550	PICKNEY	LFS	LS		34.10.20	40.03.11			
551	PICKNEY	S	FS		34.04.10	40.03.11			
552	PINEDA	S	FS		36.02.05	54.10.15	80.02.05		
553	PINEDA, DP.	S	FS		24.02.05	30.10.15	80.02.05		
554	PINEDA, FL.	S	FS		36.02.05	54.10.15	80.02.05		
555	PINEDA, FL.	S	FS		24.02.05	37.10.15	80.02.05		
556	PINEDA, LM. SUBS.	FS			27.02.05	52.10.15			
557	PINELLAS	S	FS		18.02.05	35.10.15	54.10.15	80.02.05	
558	PLACID	FS	S	LFS	20.15.20	75.05.08			
559	PLACID, DP.	S	FS	LFS	20.15.20	80.05.08			
560	PLACID, FREQ. FL.	FS	S	LFS	11.15.20	80.05.08			
561	PLACID VAR.	S	FS		17.15.20	33.05.08	82.05.08		
562	PLANTATION	S	FS		25.02.05				
563	PLUMMER	S	FS	LS	50.03.20	72.07.15			
564	PLUMMER, PD.	S	FS	LS	8.03.08	50.03.20	72.07.15		

565	PLUMMER, PD.	MK			8.20.26	50.03.20	72.07.15		
566	POCOMOKE	SL	FSL	LS	28.12.20	40.06.10	60.06.18		
567	POMELLO	COS	S	FS	42.02.05	64.10.30	80.02.05		
568	POMELLO, OCC. FL.	S	FS		32.05.05	42.10.15	80.05.05		
569	POMELLO VAR.	S	FS		52.02.05	64.10.15	80.04.08		
570	POMONA	S	FS		5.05.10	26.03.08	39.10.20	51.03.15	
						72.10.17			
571	POMONA, DP.	S	FS		5.05.10	26.03.08	39.10.20	51.03.15	
						72.10.17			
572	POMPANO	FS	S		80.02.05				
573	POMPANO, DP.	FS	S		80.02.05				
574	POMPANO, FL.	FS	S		6.02.05	80.02.05			
575	POMPANO VAR.	FS			80.05.10				
576	PONZER	MK			24.35.45	52.10.24			
577	POOLER	FSL	L	CL	6.10.16	12.11.17	52.12.18	72.12.16	
578	POOLER, PD.	FSL	L	CL	6.10.16	12.11.17	52.12.18	72.12.16	
579	POPASH	FS	S	LS	10.15.25	21.10.15	52.05.08	80.10.15	
580	POPLE	S	FS		9.03.08	29.03.08	56.10.15	80.10.15	
581	PORTSMOUTH	SL	FSL	L	19.12.18	35.14.20	38.06.10	72.02.05	
582	POTTING MEDIA	POT	MIX		36.10.50				
583	POTTSBURG	S	FS		57.03.10	80.10.25			
584	POTTSBURG VAR.	S	FS		6.03.07	51.02.05	55.10.15	80.10.15	
585	PUNTA	FS	S		4.05.10	57.02.05	83.05.10		
586	QUARTZIPSAMENTS	FS			80.03.05				
587	RAINS	LS	LFS	S	12.07.10	40.11.15	62.10.15	79.10.15	
588	RAINS	SL	FSL		12.10.14	40.11.15	62.10.15	79.10.15	
589	RAINS, FL.	SL	FSL		12.08.12	40.12.16	62.12.16	79.10.15	
590	RAINS, FL.	VFS	L		12.10.15	40.12.16	62.12.16	79.10.15	
591	RAINS VAR.	S	FS		12.08.12	62.10.15	85.10.15		
592	RED BAY	SL	FSL	L	6.07.14	20.10.14	52.12.17	72.11.14	
593	RED BAY	LS	LFS		6.06.11	20.10.14	52.12.17	72.11.14	
594	RED BAY	SCL			6.10.14	20.10.14	52.12.17	72.11.14	
595	REDLEVEL	FS	S		7.05.10	55.05.10			
596	RESOTA	S	FS		80.02.05				
597	RIDGELAND	S	FS	LFS	8.05.10	15.04.08	35.04.08	80.04.08	
598	RIVERVIEW	SIL	L	VFS	6.16.24	39.15.22	70.07.11		
599	RIVERVIEW	LS	LFS		6.10.14	39.15.22	70.07.11		
600	RIVERVIEW	SL	FSL		6.12.18	39.15.22	70.07.11		
601	RIVIERA	S	FS		28.05.08	36.10.14	42.12.15	62.05.08	
602	RIVIERA, DP.	S	FS		28.05.08	36.10.14	42.12.15	62.05.08	
603	RIVIERA, LM. SUBS.	S	FS		35.02.05	45.10.15	50.02.10		
604	RIVIERA, LM. SUBS,	S	FS		35.02.05	58.10.15	60.05.08		
605	ROBERTSDALE	FSL	L		6.10.15	21.12.16	74.12.16		
606	ROCKDALE	S	FS	S	2.02.08	6.15.20			
607	ROCKDALE	FSL	FSL		2.12.18	6.15.20			
608	RUSTON	FSL	SL	L	16.09.14	41.12.17	47.12.15	80.12.17	
609	RUSTON	FSL	SL		16.09.16	41.12.17	47.12.15	80.12.17	
610	RUSTON	LFS			16.07.11	41.12.17	47.12.15	80.12.17	
611	RUTLEGE	LS	LFS	S	18.04.10	60.04.08			
612	RUTLEGE, PD.	LS	LFS		18.06.10	60.04.08			
613	RUTLEGE, PD.	S			18.04.06	60.04.08			
614	SALERNO	S	FS		9.05.10	61.02.05	76.05.10	99.02.10	
615	SAMSULA	MK	SP		36.20.25	55.02.05			
616	SAMSULA VAR.	MK			25.20.25	36.10.18	52.10.15		
617	SANIBEL	S	FS		60.10.15				
618	SAPELO	FS	S		17.03.07	25.10.15	49.03.07	84.12.17	
619	SATELLITE	COS	S	FS	6.02.10	80.02.05			
620	SATELLITE VAR.	FS	S		80.02.05				
621	SATELLITE VAR.	S	FS		80.02.05				
622	SAVANNAH	L	SIL		11.16.20	28.13.20	68.05.10		
623	SAVANNAH	FSL	SL		11.10.15	28.13.20	68.05.10		
624	SAWYER	SIL	L		5.15.24	29.15.24	80.12.18		
625	SCOGGIN	S	FS		7.10.15	36.02.05	49.10.15	54.05.10	

626	SCRANTON	LS	LFS	7.07.11	41.05.11	72.04.08		
627	SCRANTON	S	FS	7.05.10	41.05.11	72.04.08		
628	SEEWEE	LFS	LS	FS	21.05.08	30.04.07	65.04.07	
629	SEFFNER	FS	S		13.07.12	21.07.12	80.04.08	
630	SEFFNER, CEM. SUBS	FS	S		18.07.12	46.07.12	80.04.08	
631	SELLERS	FS	LFS	S	5.15.20	28.10.15	84.03.08	
632	SELLERS	S	FS	LFS	5.10.15	28.10.15	84.03.08	
633	SHENKS	MK			21.25.40	28.18.30	82.10.20	
634	SHENKS, FL.	MK			18.25.40	60.10.20	80.10.15	
635	SHUBUTA	SL	FSL	L	8.12.16	52.14.18	70.14.18	
636	SHUBUTA	LS			8.05.10	52.14.18	70.14.18	
637	SHUBUTA	CL	SCL		8.15.18	52.14.18	70.14.18	
638	SMYRNA	S	FS		13.03.07	28.10.20	80.03.07	
639	SPARR	S	FS		8.08.12	48.05.08	56.10.15	72.10.18
						99.10.15		
640	SPARR, BD.	S	FS		8.08.12	46.05.08	58.10.15	80.10.18
641	ST. AUGUSTINE	S	FS		10.02.05	80.05.10		
642	ST. AUGUSTINE, CLY	S	FS		21.02.05	48.05.10	53.10.20	80.15.20
643	ST. AUGUSTINE, ORG	S	FS		51.05.10	80.15.20		
644	ST. JOHNS	S	FS		14.10.15	22.03.08	42.10.30	72.03.08
645	ST. JOHNS, DP.	S	FS		14.10.15	22.03.08	42.10.30	80.03.08
646	ST. JOHNS VAR.	S	FS		14.10.15	48.05.10	62.10.15	72.05.10
647	ST. LUCIE	S	FS		80.02.05			
648	ST. LUCIE VAR.	S	FS		80.02.05			
649	ST. LUCIE VAR, DIS	S	FS		80.02.05			
650	ST. LUCIE VAR, MOD	S	FS		80.02.05			
651	STILSON	LS	S		24.06.09	43.09.12	72.08.10	
652	STOCKADE	FSL	L		12.15.20	46.12.17		
653	STOCKADE	LFS	FS		12.10.15	46.12.17		
654	STOCKADE	L	FSL	SL	12.15.24	46.12.17		
655	STOCKADE, FL.	FSL	L		12.15.20	46.12.17		
656	STOCKADE, FL.	LFS	FS		12.10.15	46.12.17		
657	STOCKADE, FL.	L	FSL	SL	12.15.24	46.12.17		
658	STOUGH	L			20.12.18	26.07.11	68.07.11	
659	STOUGH	FSL	SL		20.12.18	26.07.11	68.07.11	
660	SUMTERVILLE	S	FS		9.08.12	29.05.08	80.10.18	
661	SUNSWEET	SL	LS		4.09.12	11.07.10	60.07.10	
662	SUNSWEET	SL	LS		4.09.12	11.07.10	60.07.10	
663	SURRENCY	LS	LFS		32.05.10	48.06.10	65.10.15	
664	SURRENCY	S	FS		32.05.10	48.06.10	65.10.15	
665	SURRENCY, PD.	LS	LFS		32.05.10	48.06.10	65.10.15	
666	SURRENCY, PD.	S	FS		32.05.10	48.06.10	65.10.15	
667	SUSANNA	S	FS		6.05.10	25.02.05	29.10.15	48.10.15
						80.05.10		
668	SUSQUEHANNA	FSL	SL		5.10.15	77.15.20		
669	SUSQUEHANNA	SIL	L		5.18.20	77.15.20		
670	SUSQUEHANNA	LS			5.05.09	77.15.20		
671	TALQUIN	S	FS		25.02.05	37.05.10	80.02.05	
672	TANTILE	S	FS		5.05.10	26.02.05	34.10.15	49.10.15
						69.02.05	80.10.15	
673	TARRYTOWN	FSL	SCL		7.10.15	14.12.17	50.12.15	80.05.08
674	TAVARES	S	FS		7.05.10	80.02.05		
675	TAVARES, BD.	S	FS		7.05.10	80.02.05		
676	TAVARES, CEM. SUBS	S	FS		7.05.10	60.02.05	80.02.05	
677	TAVARES, OCC. FL.	S	FS		6.02.05	80.02.10		
678	TEQUESTA	MK			12.20.25	44.05.10	72.10.15	82.02.05
679	TEQUESTA VAR.	S	FS		12.10.15	16.05.10	26.10.15	34.05.10
						50.02.05		
680	TERRA CEIA	MK	PT		65.30.50	80.02.08		
681	TERRA CEIA, FREQ.	MK	PT		65.30.50			
682	TERRA CEIA, TD.	MK	PT		66.20.50	80.02.08		
683	TERRA CEIA VAR.	MK			60.20.35			
684	TIFTON	LS	S	FS	9.03.08	14.08.12	39.12.16	72.10.13

685	TIFTON	SL	FSL	LFS	9.06.10	14.08.12	39.12.16	72.10.13
686	TISONIA	HM	MPT		18.25.35	65.15.20		
687	TOCOI	S	FS		13.02.10	23.05.15	45.02.10	76.10.20
						80.05.15		
688	TOMOKA	MK			27.30.50	35.05.10	55.10.15	
689	TOOLES	S	FS		32.05.10	46.15.20		
690	TOOLES, FL.	S	FS		32.05.10	46.15.20		
691	TOOLES, PD.	S	FS		32.05.10	46.15.20		
692	TORRY	MK			36.20.25	65.20.30		
693	TROUP	LS	LFS		53.08.12	80.10.13		
694	TROUP	S	FS	COS	53.05.10	80.10.13		
695	TURNBULL	C			36.15.20	80.05.10		
696	TURNBULL VAR.	SCL			6.20.25	23.10.20	36.10.15	50.05.10
						80.05.10		
697	TUSCAWILLA	S	FS		10.05.10	40.08.12	62.03.08	80.03.12
698	TYPIC HYDRAQUENT	C	CL	SCL	8.17.19	15.16.18	25.16.18	
699	UDORTHENTS	S			57.02.05			
700	UDORTHENTS, MOD. W	S	FS		30.02.05	50.02.08		
701	UDORTHENTS VAR.	SIL	CL	C	72.10.20	90.05.10		
702	UDORTHENTS VAR.	SR	SIL	FS	72.05.20	90.05.10		
703	UDORTHENTS, ML. SU	S	S		32.02.05	60.15.20		
704	VALKARIA	S	FS		9.05.10	15.03.08	41.05.10	80.03.08
705	VALKARIA, DP.	S	FS		7.05.10	14.03.08	38.05.10	80.03.08
706	VAUCLUSE	LS	S	LCO	15.04.08	29.10.15	58.04.08	72.04.08
707	VAUCLUSE	FSL	SL		15.08.12	29.10.15	58.04.08	72.04.08
708	VAUCLUSE	SCL			15.10.13	29.10.15	58.04.08	72.04.08
709	VAUCLUSE, GRV.	LS	LS	S	15.02.06	29.10.15	65.04.08	80.04.08
710	VAUCLUSE, GRV.	SL	SL		15.06.10	29.10.15	65.04.08	80.04.08
711	VERO	S	FS		21.03.08	28.10.15	62.10.15	99.05.10
712	VERO, BD.	S	FS		4.03.08	15.02.05	21.10.15	60.15.20
						80.10.15		
713	VERO, DP.	S	FS		17.03.08	33.10.15	60.10.15	80.05.10
714	VERO, LM. SUBS.	S	FS		16.02.07	26.10.15	29.05.10	39.10.15
715	WABASSO	S	FS		16.02.05	28.10.15	32.02.05	48.10.15
						75.05.10		
716	WABASSO, DP.	S	FS		21.02.05	26.10.15	40.10.15	80.05.10
717	WABASSO, FL.	S	FS		21.05.05	31.10.15	37.05.05	65.10.15
						80.05.10		
718	WABASSO, LM. SUBS.	S	FS		6.02.07	25.10.15	35.05.10	55.10.15
719	WABASSO VAR.	S	FS		20.02.05	23.10.15	25.02.05	32.10.15
720	WABASSO VAR.	S			20.02.05	23.10.15	25.02.05	32.10.10
						36.05.08	80.02.15	
721	WABASSO VAR.	S	FS		23.05.05	30.10.15	36.10.15	
722	WACAHOOTA	S	LS	LFS	5.08.12	29.05.08	78.08.12	
723	WAGRAM	LS	LFS		24.05.08	75.12.16		
724	WAGRAM	FS	S		24.03.07	75.12.16		
725	WAHEE	SL	FSL		11.10.15	56.12.20	65.12.20	
726	WAHEE	L	SIL	VFS	11.15.20	56.12.20	65.12.20	
727	WAKULLA	LS	LFS		24.05.10	42.05.10	80.05.05	
728	WAKULLA	S	FS		24.05.05	42.05.10	80.05.05	
729	WAUBERG	S	FS	LS	9.05.15	24.03.10	40.07.13	63.05.13
						81.08.15		
730	WAUCHULA	S	FS		6.08.15	22.02.10	34.15.25	38.08.15
						80.15.20	50.10.17	
731	WAUCHULA, DP.	S	FS		7.08.15	21.02.10	28.15.25	37.08.15
						80.10.17		
732	WAVELAND	S	FS		4.03.08	32.01.03	40.10.15	53.10.15
						81.05.10	66.10.15	
733	WAVELAND, DP.	S	FS		4.03.08	37.01.03	43.10.15	50.10.15
						80.05.10		
734	WEEKIWACHEE	MK			32.20.25	36.10.15		
735	WELAKA	S	FS		18.02.05	55.02.05	80.02.05	
736	WELAKA VAR.	S	FS		18.02.05	96.02.05		

737	WESCONNETT	FS	S	2.10.15	32.10.15	44.05.08	80.10.15
738	WESTON	FSL	SL	9.10.15	44.10.20	54.10.18	
739	WESTON	LFS		9.07.11	44.10.20	54.10.18	
740	WICKSBURG	COS		26.02.06	30.12.18	65.14.18	
741	WICKSBURG	LS	LFS	26.05.11	30.12.18	65.14.18	
742	WICKSBURG	S	FS	26.04.08	30.12.18	65.14.18	
743	WILLISTON	LS	LFS	12.08.10	18.12.17	37.14.18	
744	WILLISTON	S	FS	12.05.07	18.12.17	37.14.18	
745	WILLISTON VAR.	LS	LFS	4.08.10	12.14.18		
746	WINDER	S	FS	12.03.08	17.06.10	31.10.15	47.06.12
					65.03.10		
747	WINDER	LS	LFS	12.06.10	17.06.10	31.10.15	47.06.12
					65.03.10		
748	WINDER, DP.	S	FS	12.03.08	17.06.10	31.10.15	47.06.12
					65.03.10		
749	WINDER, DP.	LS	LFS	12.06.10	17.06.10	31.10.15	47.06.12
					65.03.10		
750	WINDER, FL.	S	FS	12.03.08	17.06.10	31.10.15	47.06.12
					65.03.10		
751	WINDER, FL.	LS	LFS	12.06.10	17.06.10	31.10.15	47.06.12
					65.03.10		
752	WINDER VAR.	S	6.08.12	9.05.08	27.10.15	29.05.10	32.05.08
					80.10.15		
753	WULFERT	MK		12.20.25	36.10.15	60.02.08	
754	YEMASSE	LS	LFS	12.06.11	50.11.18	75.11.17	
755	YEMASSE	SL	FSL	12.10.15	50.11.18	75.11.17	
756	YEMASSE, FL.	LS	LFS	12.06.11	50.11.18	75.11.17	
757	YEMASSE, FL.	SL	FSL	12.10.15	50.11.18	75.11.17	
758	YONGES	LFS		14.09.14	42.13.18	60.12.16	
759	YONGES	FSL		14.11.15	42.13.18	60.12.16	
760	YONGES, FL.	SL	FSL	14.11.14	42.13.18	60.12.16	
761	YONGES, FL.	L	SIL	14.15.20	42.13.18	60.12.16	
762	YULEE	C	SC CL	14.15.20	66.12.17	82.12.17	
763	ZEPHYR	S	FS	18.05.10	48.10.15	67.07.12	
764	ZOLFO	FS	S	7.10.15	63.03.10	80.10.25	
765	ZUBER	LS	LFS	7.08.10	15.08.10	20.12.17	70.13.18
					80.13.18		
766	ZUBER	S	FS	7.05.07	15.08.10	20.12.17	70.13.18
					80.13.18		

ABBREVIATIONS FOR SOIL CHARACTERISTICS DATA
USED IN APPENDIX A

BD = bouldery	C = clay
CEM = cemented	CL = clay loam
CLY = clayey	COS = coarse sand
DIS = disturbed	DK = dark
DP = depressional	DR = drained
FL = flooded	FREQ = frequently
FS = fine sand	FSL = fine sandy loam
GRV = gravelly	L = loam
LFS = loamy fine sand	LM = limestone
LCOS = loamy coarse sand	LS = loamy sand
LY = loamy	MK = muck
ML = mucky loam	MOD = moderately
MPT = mucky peat	OCC = occasionally
ORG = organic	ORT = ortstein
OVWS = overwash	PD = ponded
POT MIX = potting media mixture	PT = peat
S = sand	SAN.LNDF = sanitary landfill
SC = sandy clay	SCL = sandy clay loam
SH = shale	SI = silt
SIC = silty clay	SICL = silty clay loam
SIL = silt loam	SL = sandy loam
SP = sandy peat	SUBS = substratum
SY = sandy	TD = tidal
V = very	VAR = variant, variable
VFS = very fine sand	VFSL = very fine sandy loam

APPENDIX B

CROP CHARACTERISTICS DATA

The AFSIRS model requires data inputs to describe the crop production systems simulated. Crop data required are: 1) Crop water use coefficients, 2) Crop root depths, and 3) Depletions of available soil water allowed between irrigations without significantly reducing yields. Because crop growth and development is a dynamic process, these factors are not always constant. Rather, for example, crop root depths may change as a function of site-specific soil, water table, and management practices. Crop factors may also change with time as crops grow and develop. The sensitivity of crops to water stresses also often changes during the year, and allowable soil water depletions change correspondingly.

The time distributions of crop water use coefficients (KC), were determined from the literature. For perennial crops, monthly values of KC were required because crop water use is affected by annual changes in climate and stages of vegetative or reproductive growth. KC values included in this model are crop water use coefficients specific for the Penman method of ET estimation. Also, Florida data or data from other humid areas was used where available.

Sources of the data required for the AFSIRS model include field as well as lysimeter studies. However, Berliner and Oosterhuis (1987) warned that lysimeter plant root distributions must be taken into account to determine plant water status from soil water status. They cautioned that lysimeter soil profiles must be deeper than field root zones in order to be able to extrapolate lysimeter data to the field.

Jagtap and Jones (1989) demonstrated that significant errors could occur when KC values developed under one set of conditions are used under other conditions. They reported that the largest errors could occur when humidity, wind speed or solar radiation conditions were much different between sites. Stegman (1988) reported that crop coefficient curves were different even within a region, depending on production practices. These studies point out the importance of using data for the specific production systems to be simulated when data are available.

The time distributions of crop root depths (DRZ), and allowable soil water depletions (AWD) were also determined from the literature. Monthly values of AWD were required because the sensitivity of crop yields to water availability changes during the year with stage of plant development. Both irrigated and total crop root depth data were required to simulate a water budget for a crop production system. For perennial crops, these data were assumed to be constant throughout each simulation year. For annual crops, KC, DRZ, and AWD values all change as functions of time as a crop grows and develops. Thus, coefficients expressed as a function of the stage of crop growth were required for each. Length of growing season and irrigation season were not required because the AFSIRS model was developed so that these data are entered by the model user.

Because KC, DRZ, and AWD values often vary as a function of climate, soils, production system management, and other site-specific conditions, studies in which these parameters were assessed in Florida were first sought. There were, however, few Florida studies of the above parameters reported in the literature. Thus, most of the required crop data were obtained from studies conducted at non-Florida locations, and they were assumed to be applicable in Florida. Sadler and Camp (1986) conducted a detailed literature search of crop water use data in the southeastern U.S. They found that very few detailed studies were available. As a result, they concluded that there existed insufficient data for conclusive tests of transferability of western irrigation management technology to the humid southeastern U.S.

This Appendix presents the crop coefficient data and sources of data for the crop types which are included in the AFSIRS model data base. Data are presented by crop type, and crops are classified as perennial crops, field and fruit crops, and

vegetable crops in the following sections of this Appendix.

PERENNIAL CROPS

Perennial crops are those which grow and are productive for more than one crop year. These crops vary from tree crops like citrus which may have a life expectancy of 50 or more years to field crops like sugarcane in which one crop is grown from seed cane and then only one or two ratoon crops are produced before the cane must be replanted. For the purposes of the AFSIRS model, perennial crops are treated differently than annual crops. Perennial crop coefficients are considered to be constants on a monthly basis, while for annual crops, crop coefficients are functions of the stage of crop growth measured from planting or transplanting of the crop.

For some perennial crops the crop establishment and development stages require more than a year, and the crop may not be productive for one or several years after planting. An example is citrus, which is transplanted as seedlings which require several years of growth before maturity is achieved. In these cases, the immature crop growth stages are not simulated by the AFSIRS model. Coefficients used in the AFSIRS model are those for typical production systems for mature crops. The reasons for this approach were the lack of data required to model the immature crop growth stages and the fact that these early growth stages are relatively small fractions of the crop growth cycle.

This Appendix presents sources of data used as inputs to the AFSIRS model for perennial crops. References on ET data, crop rooting depths, and irrigation scheduling strategies are given.

Alfalfa

Alfalfa is a forage grown for grazing, hay or silage in Florida. It is dormant during the winter months, only begins active growth when mean daily air temperatures exceed 50 F. It remains active until the first 28 F frost (SCS, 1970). It is irrigated only during active growth periods. Those dates will vary depending upon location in Florida.

Finkel (1983) reported that alfalfa may have roots to 9 to 12 ft depths, but that 2/3 of the roots occur in the upper 2 ft of a typical profile, and 80% of the roots are in the upper 3 ft. Doorenbos and Pruitt (1977) stated that most of the roots are in the upper 3 ft of the soil profile and this should be the zone irrigated. They recommended irrigating when 55% of the available soil water has been depleted. They pointed out that ET and crop coefficients on specific days will vary depending upon time since last cutting or grazing. Therefore they gave average values only.

In the Florida Irrigation Guide, the SCS (1982) stated that a minimum root zone of 24 inches is required for production. They stated that water is extracted from a 36-inch depth in unrestricted soils, and that critical irrigation times are those shortly following each cutting. They recommended irrigating when about 50% of the available soil water has been depleted.

Keller and Carlson (1967) and Doorenbos and Kassam (1979) recommended irrigating at 50% depletion of available water in the crop root zone. Jensen (1980) stated that crop water use coefficients vary from 0.5 at early season growth to 1.0 at full growth.

Doorenbos and Kassam (1979) reported that seasonal water use may vary from 32 inches in humid areas to 64 inches in arid areas. Israelsen and Hansen (1962) reported peak water use rates of 0.17 to 0.20 inches per day after full cover was attained.

Avocado

Avocados are grown in extreme south Florida where they are free from freezing temperatures or where they can be protected against infrequent freezes. Few studies of avocados in which crop water use data were given were found. Finkel (1983) listed average seasonal crop coefficients as ranging from 0.65 to 0.75.

Hilgeman and Reuther (1967) reported research which demonstrated that avocado is very sensitive to water stress. They recommended irrigating when 50% of the available soil water in the upper 2 ft of the soil profile is depleted.

Israelsen and Hansen (1962) reported the expected peak water use rate for avocados to be 0.16 inches per day. They estimated seasonal water requirements as 18 inches.

The SCS (1982) stated that the minimum root zone depth required for avocados is 30 inches, and that water is extracted from a root zone depth of 60 inches in unrestricted soils.

Crop water use coefficients for the Penman equation were not found for avocados. Therefore, for the AFSIRS model, coefficients were assumed to be equal to those measured for citrus. It is thought that this is a conservative estimate as these are near potential values for most of the year.

Blueberries

Blueberries are rapidly becoming an important fruit crop in Florida. In Florida studies, Andersen et al. (1979) demonstrated yield increases of 20% to 25% for irrigated versus nonirrigated blueberries. Davies and Johnson (1982) reported better survival percentage and better growth of young berries under irrigated conditions.

Scott et al. (1978) point out that blueberries are not drought tolerant. Rather they are native to moist areas, and irrigation is required. One to two inches every 10 days is recommended. Kender and Brightwell (1966) stated that blueberries require 1 to 2 inches of rain or irrigation per week.

Lyrene and Crocker (1984), in the IFAS blueberry production guide, recommend drip or sprinkler irrigation for Florida production. They point out that too much water will damage production, and irrigation will be required primarily during the dry spring months and during dry periods in the summer. Ballinger (1966) recommended irrigating when 30% to 50% of the available water remains in the crop root zone.

The SCS (1982) reported that a minimum root zone depth of 18 inches is required for blueberry production. They stated that water would be extracted from a root zone depth of 24 inches in unrestricted soils, and that from bloom until harvest is a critical irrigation period.

Haman et al. (1988) and Smajstrla et al. (1988a) reported that blueberries were successfully irrigated using automated irrigation systems based on tensiometers. They found that best growth of young blueberries occurred when irrigations were scheduled at a 10 cb water tension and when the plants were mulched with pine bark.

No reports of crop water use coefficients for Florida conditions were found. Byers and Moore (1987) recommended the use of 0.75 times pan evaporation for irrigation of blueberries in Arkansas. Potential ET is often estimated as 0.7 to 0.8 times pan evaporation for Florida conditions. Therefore, it was assumed that irrigations will be scheduled based on potential ET for the months that the crop is actively growing (crop water use coefficients = 1.0 for all months). The months of active growth depend on location in the state -- normally irrigations are not scheduled while the crop is dormant. Irrigations are scheduled when 50% of the

available water in the root zone has been depleted.

Citrus

Several studies of citrus water requirements have been conducted in Florida. Tucker (1983) summarized irrigation management practices required for Florida citrus production. He estimated peak ET rates of 0.17 to 0.20 inches per day.

Reitz et al. (1977) and Gerber et al. (1973) summarized information on water requirements for Florida citrus. They estimated annual citrus ET as 48 inches. They estimated irrigation requirements ranging from 17 to 24 inches per year for soil water storage values of 1 to 4 inches in the crop root zone. Graser and Allen (1987) pointed out that citrus irrigation requirements were reduced by water extractions from high water tables on flatwoods soils.

Koo (1963), Gerber et al. (1973), and Krezdorn (1981) stated that soil water depletions allowed before irrigations are scheduled should be 33% during the spring months (March through June) and 67% during the remainder of the year. Zekri and Parsons (1988) found greater stress levels for drip, then spray, and lowest stress levels for sprinkler-irrigated grapefruit as measured by leaf water potentials. They demonstrated the importance of irrigating a sufficient volume of the root zone when micro systems are used for citrus irrigation.

Smajstrla et al. (1987) developed a tabular and graphical procedure for determining when to irrigate and how much water to apply for micro irrigation of citrus. They also presented a method for determining the length of time to delay irrigations due to rainfall. These procedures were based on water budgeting in the tree root zone.

Rogers et al. (1983) conducted an eight-year study of ET from citrus grown on high water table (flatwoods) soils with grass cover in the alleyways between tree rows. They presented crop coefficients that were near 1.0 for most of the year for the Penman potential ET equation. These are the data used in the AFSIRS model. Doorenbos and Pruitt (1977) presented humid region citrus crop coefficients for trees with grass cover that are consistent with those reported by Rogers et al. (1983). For trees without grass cover, crop coefficients may be expected to be 20% lower (Doorenbos and Pruitt, 1977).

The SCS (1982) stated that the minimum root zone depth required for citrus production is 18-24 inches. They stated that the water extraction zone is 36-60 inches in unrestricted soils. They recommended that soil water depletions not be allowed to exceed 30% from fruit set until fruit size of 1-inch is attained. During the remaining months, they state that soil water depletions should not exceed 50%.

Ferns

Fern production is a major agronomic industry in Florida. Ferns are typically sprinkler-irrigated because sprinkler irrigation must be used for freeze protection (Harrison et al., 1974). Leatherleaf and plumosus ferns are those species typically grown in Florida (Harrison and Conover, 1970). They are shallow-rooted. Root depths are 8 to 10 inches for leatherleaf and 12 inches for plumosus ferns.

The SCS (1982) stated that fern root depths range from 10 to 12 inches and that most of the soil water is extracted in this region in unrestricted soils. They recommended irrigating when 50%-60% of the available soil water is depleted in this region.

Harrison and Conover (1970) recommend irrigating at 50% to 60% depletion of available soil water in the root zone. Crop water use coefficient data are unavailable for use with the Penman equation. Therefore, for the AFSIRS model, monthly crop coefficients of 1.0 are used. These are thought to be conservative,

even though ferns are very sensitive to water stress, because fern production is under shade where potential ET is less than that for crops directly exposed to solar radiation.

Grapes

Grapes remain dormant and do not require irrigation until mean daily temperatures reach 50 F in the spring. The period of most active growth occurs 3 to 4 weeks later (Kasimatis, 1967). Grapes remain active and require irrigation until mean daily air temperatures again drop to 50 F in the fall (SCS, 1970).

Monthly crop coefficients for the Penman method were given by Doorenbos and Pruitt (1977). They stated that grapes are deep-rooted, with root zones of 3 to 6 ft in depth. They recommended irrigating when 35% of the available soil water is depleted.

Doorenbos and Kassam (1979) estimated seasonal water use as 20 inches in humid areas and up to 48 inches in arid areas. They point out that most of the water is depleted from the upper 20 inches of the root zone. They recommended irrigating when 35% to 45% of the available soil water has been depleted in the most active portion of the root zone.

The SCS (1982) stated that the minimum root zone depth required for grape production is 36 inches. They stated that water is extracted from a root zone depth of 60 inches in unrestricted soils, and that critical irrigation periods are during the sizing of the fruit.

Lawns

See "TURF" in a following section of this manual.

Nursery and Ornamental Crops

A wide range of nursery crops with wide ranges in water use characteristics are produced in Florida. Also, crop with wide ranges of production characteristics, ranging from field to container grown crops are produced. Generally, these crops are sensitive to water stress and must be well-irrigated because they are sold on the basis of quality. Clark et al. (1988) discussed irrigation systems and presented management guidelines for container and field-grown ornamental plants in Florida.

Many studies of ornamental crop response to irrigation have been conducted in Florida. Smajstrla and Zazueta (1987) demonstrated that IRR of sprinkler-irrigated container nurseries can vary widely depending on specific production system and management characteristics. Poole and Conover (1986) reported that several species studied responded best to irrigations 4 times per week rather than twice per week. Overman and Harbaugh (1988) found that Caladium irrigated 3 times per week were 5 times larger than those irrigated only once per week.

Knox and Zimet (1988) reported results of irrigation based on pan evaporation for woody ornamental production. They found that the most frequent irrigations based on allowable water depletions of only 0.1 inch significantly increased growth of 2 of the 3 species studied. Harbaugh et al. (1986) reported water use rates for cut flower production of about 1.0 cm per day.

Because Florida studies which reported KC values for nursery and ornamental plants were not found, and because of the reported sensitivity of these crops and their need for frequent irrigation, crop water use coefficients of 1.0 and allowable water depletions of 0.25 are used for each month in the AFSIRS model data base.

For container-grown crops, the root depth (container depth) was assumed to be 8 inches, while for field grown plants an irrigated root zone of 8 inches and a total root zone of 16 inches was assumed. Although these values are believed to be conservative, for specific crops actual coefficients may vary from these values and would need to be input to the AFSIRS model by the user.

Pasture

Pasture ET data were presented by Jones et al. (1984) for Florida conditions. Data reported by Stewart and Mills (1967), Allen et al. (1978) for south Florida were compared with those reported by Doss et al. (1965) for Alabama. Crop coefficients for the Florida data ranged from 0.65 in the winter months to 0.9 in the summer. Alabama crop coefficients ranged from 0.7 to 1.0, and averaged about 0.9. Doorenbos and Pruitt (1977) reported a range of crop coefficients of from 0.55 to 1.05 with a mean of 0.95. Israelsen and Hansen (1962) presented a seasonal average crop coefficient of 0.9 for pastures.

Keller and Carlson (1967) and Doorenbos and Pruitt (1977) both stated that pasture ET can be expected to be highly variable depending upon management variables, plant density, grazing pressure, frequency of irrigation, frequency of mowing, etc. For the AFSIRS model, an average of the Florida and Alabama field data and the data presented by Doorenbos and Pruitt (1977) were used.

Israelsen and Hansen (1962) estimated peak ET rates of 0.17 to 0.20 inches per day for pastures under humid climate conditions. Choate et al. (1952) recommended scheduling irrigations at 50% available soil water depletion in the crop root zone.

The earliest growth date for pasture occurs when the mean daily air temperature reaches 45 F. The last growth date in the fall occurs when the mean daily air temperature again drops to 45 F. Irrigations should be scheduled only during the active growth period.

The SCS (1982) stated that the minimum root zone depth required for pasture production is 30 inches. They presented the soil water extraction depth for unrestricted soils as 36 inches and stated that critical periods for irrigation are after grazing.

Peaches

Irrigation response of peaches has been extensively studied in Florida. Ryan et al. (1973) reported that intermittent sprinkling significantly increased fruit size. Chesness and Couvillon (1978) reported that peach response to irrigation made irrigation pay. Harrison et al. (1976) reported a water savings of 50% with drip as compared to sprinkler irrigation for peaches.

Harrison and Buchanan (1972) stated that peaches should be irrigated at 50% available soil water depletion in the crop root zone. They reported that 68% of the roots are in the upper 1 ft, and 19.5% are in the next ft of the crop root zone. Garnier et al. (1986) reported that all of the water uptake by peach trees came from the upper 2 ft of the root zone because of the shallow rooting characteristics of peach trees. Thus irrigations should be concentrated in the upper 2 ft.

Buchanan and Harrison (1974) reported that greatest yields resulted at 50% allowable soil water depletion, the upper 2 ft of the root zone should be irrigated, and peak water use rates would be expected to range from 0.16 to 0.20 inches per day. The SCS (1982) stated that peaches require a minimum root depth of 36 inches. The root zone depth from which water is extracted in unrestricted soils was reported as 60 inches. They reported that the critical stages for irrigation are during fruit enlargement prior to maturity.

Arnold and Crocker (1977) estimated average water requirements for Florida peaches and nectarines of 4 inches per month. They also stated that irrigation

applications of 2 to 3 inches every 10 days may be required during peak growth stages.

Israelsen and Hansen (1962) estimated peak water use rates of up to 0.20 inches per day for peaches. ET data for Florida conditions were measured by Phung and Bartholic (1976), and they were summarized by Jones et al. (1984). They reported an average of about 36 inches in 1972 and 1973. Phung and Bartholic (1976) reported crop coefficients with reference to pan evaporation rather than the Penman equation. Adjusting these by an assumed pan coefficient of 0.7 resulted in peak growth rate (summer) crop coefficients of 1.0. Spring and winter coefficients were 0.86. Fall coefficients were 0.42.

In Colorado, Renquist (1987) reported that optimum peach irrigation occurred when trees were irrigated at 1.5 times pan evaporation based on the tree canopy area. ET was not linearly related to tree canopy area. Orchards with 50% canopy areas had water use of 100% of potential ET.

ET and crop coefficients vary depending upon whether the soil remains bare between and under the trees. For the AFSIRS model, it was assumed that a grass cover would exist between trees. Crop coefficients for this condition were given by Doorenbos and Pruitt (1977). They ranged from 0.7 in the winter months to 1.0 in the summer months. These data are in agreement with those previously presented by Phung and Bartholic (1976) for all except the fall months.

Peaches are dormant and do not require irrigation during most winter months. The earliest spring growth date occurs when the mean daily air temperature reaches 50 F. Growth and IRR continue until mean daily air temperatures drop to 45 F in the fall (SCS, 1970).

Pecans

Irrigation of pecans in north Florida is rapidly increasing (Harrison et al., 1983). Crocker (1978) presented production requirements for pecans. He stated that it is critical that trees not be allowed to wilt, especially young trees. Uriu and Magness (1967) reported that irrigations should be scheduled at 50% depletion of available water to optimize production.

Doorenbos and Pruitt (1977) presented crop water use coefficients for pecans. Coefficients ranged from 0.7 in the winter months to 1.0 in the summer for humid climate conditions with light to moderate winds. Ground cover under trees and tree canopies covering about 70% of the soil surface were assumed. They stated that crop coefficients should be reduced about 20% if there is no ground cover under the trees.

The SCS (1982) reported that the minimum root zone depth required for pecan production is 48 inches. The water extraction zone in unrestricted soils was reported as 60 inches. They also reported that critical stages for irrigation are during nut formation and nut filling.

Pecans are dormant and do not require irrigation during the winter months. Earliest growth occurs when mean daily air temperatures reach 50 F in the spring. Growth occurs until mean daily air temperatures drop to 45 F in the fall.

Sod

See "TURF" in a following section of this publication.

Sugarcane

Water use of sugarcane has been extensively studied for Florida conditions. Shih (1980) presented water requirements for sugarcane production in Florida based on his work in the Belle Glade area. Jones et al. (1984) presented expected average monthly ET data for Florida. These data were divided by long-term average potential ET data from West Palm Beach (Smajstrla et al., 1984) to estimate crop water use coefficients. Coefficients ranged from 0.55 at planting to 1.25 at peak growth to 0.3 at harvest.

Campbell (1967) reported that most cane roots are in the upper 2 to 3 ft of the root zone, and that this depth should be irrigated when soil water tensions reach 25 to 35 cb. Finkel (1983) reported that growth and yields were greatest when irrigated at soil water tensions of less than 50 cb. Pitts et al. (1989) demonstrated that only about 1/9 of the irrigation water used for seepage irrigation was required when drip irrigation systems were used for sugarcane production in south Florida.

Shih (1988) presented regression equations for the estimation of sugarcane yield as a function of ET. Pitts et al. (1989) reported that sugarcane yields were comparable but that irrigation water applied was reduced by a factor of 9 by using drip rather than seepage irrigation.

The SCS (1982) reported that the minimum root zone depth required for sugarcane production is 24 inches. The water extraction zone in unrestricted soils was reported as 36 inches, although under Florida conditions, most sugarcane is produced with seepage irrigation which limits root development.

Campbell (1967) presented crop coefficients given as ratios to standard evaporation pans. These were adjusted to approximate Penman crop coefficients by dividing by an assumed pan coefficient of 0.75. The coefficients calculated ranged from 0.50 at planting to 1.30 at peak growth to 1.0 at harvest.

Doorenbos and Pruitt (1977) presented crop coefficients that ranged from 0.55 at planting to 1.05 at peak growth to 0.6 at harvest. They estimated that the root zone would vary from 4 to 6 ft in deep soils. They recommended scheduling irrigations at 65% available soil water depletion, and stopping irrigations at 4 to 6 weeks before harvest. Doorenbos and Kassam (1979) recommended an allowable soil water depletion level of 30% during the establishment of vegetative growth, and then an increase to 65% depletions for the remainder of the growing season.

Turf

Water requirements for turf and sod production are discussed in this section. Turf includes lawns, landscaping, and golf course grasses. Many Florida studies of these grasses have been conducted.

McCloud (1970) presented a temperature-based method of estimating ET for turf grasses. Augustine (1984) used that procedure to estimate monthly and seasonal ET for several Florida locations. This method greatly over-predicted ET estimates by the Penman method in Miami. According to McCloud, this may have been due to boundary effects on ET rates from the small plots he used. Stewart et al. (1969) demonstrated this effect in their lysimeter studies. With incomplete grass cover, ET was greater than the proportion to the area irrigated.

Tovey et al. (1969) demonstrated that lawngrass ET was adequately predicted by the Penman method. It was shown to be considerably less than pan evaporation. Pair (1983) recommended the use of a crop water use coefficient of 1.0 for all actively-growing grasses. Feldhake et al. (1985) demonstrated that turfgrass ET was not affected by shade preconditioning, but only by turf density and available energy.

Doorenbos and Pruitt (1977) reported that crop coefficients of 1.0 should be

used to represent well-managed actively-growing grass covers. They stated that the irrigation season depends on the grass being grown and its period of dormancy. Also, because of the range in climate conditions in Florida, some grasses may become dormant in north Florida but remain active all year in south Florida.

Myers and Horn (1972) estimated that the turf root zone that should be irrigated ranges from 6 to 12 inches. Augustine (1982) recommended watering lawn grasses to a depth of 12 inches to encourage deeper root growth. Lunt and Seeley (1967) stated that very frequent irrigations will encourage a shallow root system and detract from the quality of the turf. They recommended delaying irrigations until 50% of the available soil water is depleted.

Zazueta et al. (1988) developed normalized irrigation schedules for Florida based on long-term climate records. Zazueta and Smajstrla (1988) and Zazueta et al. (1989) reported that typical lawn irrigation intervals range from 2 to 5 days from summer to winter months in south Florida and 2 to 7 days in north Florida. Haman et al. (1989) adopted this approach in their irrigation scheduling recommendations. Using these same intervals, Gilpin-Hudson (1988) developed a slide chart for lawn irrigation scheduling in south Florida.

The AFSIRS model estimates irrigation requirements for "SOD", "TURF, LANDSCAPING" (Lawn), and "TURF, GOLF COURSE" categories. For all three of these, crop water use coefficients of 1.0 are assumed to accurately reflect crop water requirements.

Management of irrigation systems for these production systems, and thus irrigation requirements are different. Management levels reflect the required quality of the sod or turf produced. For the AFSIRS model, turf production for lawns or landscaping is assumed to be irrigated to a depth of 12 inches and at an allowable soil water depletion of 50%.

For sod production, irrigation is required to quickly produce a high quality turf. When sprinkler irrigation is used, small, frequent irrigations are scheduled in order to encourage shallow root development for sod harvesting. In the AFSIRS model this is simulated by limiting the irrigated root zone to 8 inches and irrigating at 50% available water depletion. In Florida, large areas of sod are also produced with seepage irrigation systems. In those cases, the soil hydraulic characteristics dictate the water table depth and the root zone.

For golf courses, irrigations or rainfall are required very frequently to promote the high quality turf required. Pira (1982) recommended that tees and greens be irrigated daily to apply 1-inch per week (1/7 inch per day), while fairways be irrigated every other day to apply 1-inch per week (2/7 inch per day). In Florida, the weekly depths of irrigation required would be expected to approach 2-inches per week during peak water use periods.

These guidelines result in small depths of soil irrigated on greens and tees, but greater depths in fairways, even for sandy soils. For this reason, small, frequent irrigations are scheduled by the AFSIRS model. The irrigated root zone is assumed to average 9 inches and irrigations are scheduled at 50% depletion of available soil water in this zone.

In practice, tees and greens are irrigated separately from fairways, and the model user can simulate the irrigation requirements of these two zones by running the model for each of the separate areas. In that case, a 1-ft irrigated root zone should be used for fairways, while greens should be irrigated to replace ET daily.

ANNUAL FIELD AND FRUIT CROPS

Characteristics of annual field and fruit crops are discussed in this section of this Appendix. Annual crops are those which are produced within a one-year

period of time. They are typically planted in spring and harvested in fall, although because of Florida's favorable climate, they are often grown at other times of the year as well. They may also be planted in the fall and have growing seasons which extend into the next calendar year. In all cases, their growing seasons are less than 1 year in duration, and the crop must be replanted each year. Perennial crops, which grow for more than one year without replanting, and vegetable crops are discussed in other sections of this Appendix.

Many reports of water requirements of annual field crops have been made for Florida conditions. Rogers and Harrison (1977) and Harrison (1983) summarized ET and net irrigation requirements for several major Florida crops. Jones et al. (1984) discussed several annual field crops in the IFAS "ET Bulletin" which was co-authored by a committee of researchers in the ET subject area.

Smajstrla and Zazueta (1988) discussed the AFSIRS water budget model for estimating IRR of Florida agronomic crops. They demonstrated that IRR is very sensitive to many factors, including crop water use coefficients and growing season length and timing.

Chesness et al. (1986) presented a seasonal water budget irrigation model for coarse-textured soils using pan evaporation as an index of climate factors. Their model functioned well for corn and soybeans in the southeastern U.S. Doorenbos and Pruitt (1977) surveyed literature from throughout the world and summarized crop water requirements and irrigation scheduling strategies for many crops. Doorenbos and Kassam (1979) presented data on yield response to water for many crops of major importance throughout the world.

The following sections of this Appendix present the sources of data used as inputs to the AFSIRS model. References for data on ET, crop root development patterns, and irrigation scheduling strategies are given.

Barley

The water use and water extraction patterns of barley are similar to those of oats and other small grains (Robins, et al., 1967; Doorenbos and Pruitt, 1977). For the AFSIRS model, the crop coefficient data used are identical to those used for oats. The source of this information was primarily Doorenbos and Pruitt (1977).

The SCS (1982) stated that the minimum root zone depth required for small grain production is 18 inches. They also reported that the water extraction depth in unrestricted soils is 24 inches, and that the critical crop growth stages for irrigation are the boot, bloom, and early head stages.

Beans, Field

In this model, field beans (dry beans) are classified as a field crop. For water use characteristics of fresh beans (green beans, snap beans, pole beans, or lima beans) see the vegetable crops section of this Appendix.

Israelsen and Hansen (1962) reported an expected range in peak ET of 0.16 to 0.18 inches per day for field beans. Robins et al. (1967) stated that most roots are concentrated in the upper 3 ft of the root zone, and that yield depressions will be negligible until 55% to 65% of the available soil water in this zone has been depleted. During the ripening stage, the allowable water depletion can be increased to 80% to 90%.

Doorenbos and Pruitt (1977) listed crop coefficients of 1.05 for beans during peak growth and 0.3 during the ripening stage. They recommended irrigating the upper 1.5 to 2.3 ft of the root zone where most of the roots are concentrated. They recommend irrigating at an allowable soil water depletion of 45%, and at greater depletions during the ripening growth stage. Doorenbos and Kassam (1979) stated that the allowable soil water depletion during growth stage (4) should not exceed 60% to 70%.

Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979) both stated that irrigations should be applied to the upper 2 ft of the soil profile where most of the roots are concentrated. The SCS (1982) stated that the minimum root zone depth required for field bean production is 12 inches. They also reported that the water extraction depth in unrestricted soils is 18 inches, and that the critical growth stage is at flowering.

Clover

Clover is grown primarily as a forage crop during the early spring months (cool season) in Florida. It typically requires irrigation because this is not the normal rainy season.

Keller and Carlson (1967) cited reports that clovers are relatively shallow-rooted pasture species. The reports indicated that clovers respond well to irrigation. Best yields were obtained when irrigation was confined to the upper 1-ft of the root zone and when irrigations were scheduled when 30% to 35% of the available soil water had been extracted from this zone.

Doorenbos and Pruitt (1977) listed maximum rooting depths of 24 to 36 inches for clover. They agreed that irrigations should be scheduled when 35% of the available soil water has been depleted. They listed the peak growth stage crop water use coefficient as 1.05 and the mean value as 1.00. They pointed out that the mean is a more appropriate value to use since ET decreases after cutting or grazing, cycling between high and low values throughout the season.

Corn, Field

Field corn is often irrigated because it responds well to irrigation in Florida (Harrison, 1978; Wright and Rhoads, 1980; Rhoads et al., 1980). Water use data for Florida conditions have been reported by several researchers. Jones et al. (1984) presented Penman crop coefficients for field corn data presented by Doss et al. (1965) at Thorsby, Alabama. Crop coefficients ranged from a low of 0.4 at planting to a peak of 1.2 and then declined to 0.8 near harvest. Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979) recommended the use of lower values, 1.05 at peak and 0.55 near harvest for humid conditions. Jensen (1980) cited these same values for humid conditions.

Rogers and Harrison (1977) estimated seasonal ET for corn as 25 inches for average Florida conditions. They also estimated the average and 80% probability irrigation requirement as 10 and 12 inches, respectively. Shih (1985) estimated that ET would range from 14.5 to 17 inches for Florida conditions, but up to 21.5 inches for non-Florida locations.

Camp et al. (1988) scheduled corn irrigation by tensiometer, evaporation pan, and a water budget model. They found no differences in water use or yields and concluded that scheduling methods can then be selected based on personal preference since all work equally well.

Bennett (1982) estimated peak ET rates for corn as 0.22 to 0.28 inches per day for Florida conditions. Israelsen and Hansen (1962) estimated the range as 0.14 to 0.18 inches per day.

Rhoads et al. (1981) reported optimum yields when corn was irrigated at 20 cb (approximately 2/3 allowable water depletion in the plow layer). Robins et al. (1967) reported that yield depressions of corn would be negligible if no more than 55% to 65% of the available water storage capacity in the crop root zone is depleted between irrigations during the active crop growth stages. Near maturity, they recommended 70% to 80%. Doorenbos and Pruitt (1977) recommended the use of a 60% allowable water depletion during the active growth stages. Doorenbos and Kassam (1979) recommended 55%.

The SCS (1982) stated that the minimum root zone depth required for field corn production for grain or silage is 24 inches. They also reported that the water extraction depth in unrestricted soils is 36 inches, and that the critical crop growth stages for irrigation are the tasseling through grain filling stages. Ragab and Amer (1986) reported that a water table that ranged from 10 to 14 inches from the surface contributed 40% of the ET of a corn crop.

Cotton

Cotton is grown on limited acreage in north and northwest Florida. Crop water use coefficients for cotton were given by Doorenbos and Pruitt (1977). They recommended allowable water depletions of 65% between irrigations and higher values during ripening. They stated that cotton is deep-rooted, with normal root zones ranging from 3 to 4.5 ft.

The SCS (1982) stated that the minimum root zone depth required for cotton production is 24 inches. They also reported that the water extraction depth in unrestricted soils is 36 inches, and that the critical crop growth stages for irrigation are the first bloom through boll maturing stages.

Doorenbos and Kassam (1979) recommended allowable soil water depletions of 60% during the early vegetative stage, 70% during flowering to reduce vegetative growth, 60% during boll formation and filling, and higher values (80%) during ripening. They pointed out that 70% to 80% of the water extracted is from the upper 3 ft of the root zone.

Ayalon (1983) estimated that about 60% of ET is extracted from the upper 2 ft and 75% from the upper 3 ft of the root zone. He recommended irrigating at 2/3 depletion of available water. Pair (1983) stated that the peak water use period occurred about 140 days after planting, during the boll-filling stage.

Field Crops

The field crops category contains average data for field crop water use coefficients, rooting characteristics, allowable water depletions, and fractions of the growing season in each growth stage. These data were obtained by averaging these data categories for all field crops included in the AFSIRS model.

This category can be used to estimate irrigation requirements for field crop production systems where the specific crop grown varies from year to year, or where the specific field crop to be grown is unknown for other reasons. Although these data would be expected to approximate long-term average IRR, greater year-to-year accuracy would be expected by simulating the actual crop rotational sequence.

Millet

Millet is grown primarily as a forage in Florida. It is also grown for grain production. Thus, two millet categories are used in the AFSIRS model: Millet, forage and Millet, grain. The differences in terms of irrigation requirements are the length of growing season and the crop water use coefficient for growth stage (4), the ripening stage for grain crops.

Studies of water use and yield of millet were conducted by Allison et al. (1958) in South Carolina and Bennett et al. (1964) in Alabama. They reported a range in ET of 19 to 44 inches for climate conditions similar to Florida's. The greatest ET was for millet grown for forage production.

Doorenbos and Pruitt (1977) gave crop water use coefficients for millet grown for grain production. The peak crop coefficient was 1.0 for growth stage (3) and declined to 0.3 for the grain ripening stage (4). For the AFSIRS model, it was

assumed that the water use coefficient during stage (4) was 0.95. This is similar to that given for other grazed forage crops (see pasture, for example). Dorrenbos and Pruitt (1977) recommended the use of allowable water extractions of 60% of the available water in the irrigated crop root zone, and 90% extractions were recommended during the grain ripening stage (4).

Rogers and Harrison (1977) estimated seasonal ET of small grains in Florida as 20 inches. They estimated 50% and 80% net irrigation requirements as 7 and 8 inches, respectively. The SCS (1982) stated that the minimum root zone depth required for small grain production is 18 inches. They also reported that the water extraction depth in unrestricted soils is 24 inches, and that the critical crop growth stages for irrigation are the boot, bloom, and early head stages.

Rooting characteristics and water extraction patterns for millet were assumed to be similar to that of wheat and other small grains. Robins et al. (1967) and Doorenbos and Kassam (1979) were the sources of these data.

Oats

No studies of water requirements or crop water use coefficients which were conducted in Florida were found for oats. Rogers and Harrison (1977) estimated ET for small grain crops as 20 inches annually. They estimated 50% and 80% net irrigation requirements of 7 and 8 inches, respectively.

Dorrenbos and Pruitt (1977) presented the crop coefficients and other data for oats used in this work. Crop coefficients ranged from a peak of 1.05 to 0.25 at harvest. They recommend an allowable water depletion of 60% between irrigations for the first three crop growth stages. They recommend a 90% allowable water depletion for the ripening growth stage (4).

Rooting depths are similar for all small grains (Robins et al., 1967). Total root depths of 3 to 4.5 ft may be expected (Doorenbos and Pruitt, 1979). The SCS (1982) stated that the minimum root zone depth required for small grain production is 18 inches. They reported a water extraction depth in unrestricted soils of 24 inches, and that the boot, bloom, and early head stages are the critical crop growth stages for irrigation.

Peanuts

Peanuts have been studied extensively in Florida and in the southeastern U.S. Harrison (1976) and Whitty et al. (1975) reported that peanuts require 4 to 8 inches of irrigation per year in Florida. They recommended applications of 1-inch at each irrigation.

Rogers and Harrison (1977) estimated water use by peanuts as 22 inches per year. They gave average and 80% probability net irrigation requirements of 5 and 7 inches, respectively. Shih (1985) reported that peanut ET could be expected to range from 15 to 19 inches per year in Florida. Bennett (1982) reported peanut peak water use rates of 0.22 inches per day at 45 to 90 days after planting. He stated that this was the most critical stage for irrigation.

Feldman (1983) reported expected peanut root depths of 3 to 6 ft. He stated that irrigations should be scheduled at 40% available water depletion in the crop root zone. Doorenbos and Pruitt (1977) stated that the most active root zone is 1.5 to 3 ft, and that the allowable water depletion in this zone should not exceed 40%. They gave peak growth rate crop water use coefficients of 0.95, and values of 0.55 at harvest.

Elliott et al. (1988) reported crop coefficients for peanuts grown in Oklahoma. They developed a regression equation which allowed KC values to be calculated as a function of days of the growing season. They suggested that 0.4 is a reasonable minimum value to represent water use just after planting.

Peanut peak crop water use coefficients of 1.0 were given by Davidson et al. (1973). Jones et al. (1984) reported peak crop coefficients of 1.25 from work done in Georgia by Stansell et al. (1976). Doorenbos and Kassam (1979) reported peak crop water use coefficients of 0.95 to 1.0. They recommended 50% available soil water depletions in growth stages (1), (3), and (4), and 40% depletion in growth stage (2). They reported that most of the water used is extracted from the upper 20 to 24 inches of the profile, and almost 100% is extracted from the upper 40 inches.

The SCS (1982) stated that the minimum root zone depth required for peanut production is 18 inches. They also reported that the water extraction depth in unrestricted soils is 24 inches, and that the critical crop growth stages for irrigation are the first bloom through nut forming stages.

Potatoes

Commercial production of potatoes requires irrigation in Florida. Almost all Florida potato production is seepage-irrigated. Haman et al. (1986) reported that substantial water savings resulted from recycling tailwater runoff from seepage-irrigated potatoes.

Robins et al. (1967) reported that potatoes are sensitive to large allowable soil water depletions in the crop root zone. They recommended that allowable soil water depletions not be allowed to exceed 40% to 50% on coarse textured soils. They stated that the maximum plant root zone that should be irrigated is 36 inches.

Doorenbos and Pruitt (1977) recommended irrigating the upper 16 to 24 inches of the root zone. They stated that allowable soil water depletions should not be allowed to exceed 25% in this zone. They reported crop coefficients of 1.05 at peak growth and 0.7 at harvest.

Doorenbos and Kassam (1979) estimated seasonal water requirements as ranging from 20 to 27 inches. They reported that 70% of the water extraction occurs in the upper 12 inches and nearly 100% from the upper 24 inches of the soil profile. They recommended irrigating before 25% of the soil water in this zone is depleted.

The SCS (1982) stated that the minimum root depth required for potato production is 12 inches. They also reported that the water extraction depth in unrestricted soils is 18 inches.

Rice

Rice is typically grown in paddies. That is, it is flooded and remains flooded throughout most of the growing season. Paddies are drained about 4 weeks before harvest to permit field traffic. Tripathi et al. (1986) reported a savings of 34% to 43% by intermittent irrigation of rice, but yields were also decreased.

Rice ET has been studied by Shih and Rahi (1981) and Shih et al. (1983) in Florida. These studies were conducted in lysimeters and reported ET rates much greater than pan evaporation. Jones et al. (1984) reported ET data of Shih et al. (1982) from Belle Glade, Fla. When divided by long-term average potential ET data from West Palm Beach, the resulting crop coefficients ranged from 0.7 early in the growing season, to about 1.2 at peak growth, and 1.05 near harvest. Hendrix et al. (1986) reported crop coefficients of 1.0 at 70% ground cover and values of 1.25 at 100% ground cover.

Doorenbos and Pruitt (1977) reported crop coefficients which ranged from 1.1 during early and peak growth periods to 0.95 during the last 4 weeks of the growing season when the fields are drained in preparation for harvest. Doorenbos and Kassam (1979) reported the same crop coefficients. They also reported that the expected root depth is about 3 ft unless restricted.

Small Grains

The small grains category contains average data for small grain water use coefficients, rooting characteristics, allowable water depletions, and fractions of the growing season in each crop growth stage. These data were obtained by averaging each of these data categories for all of the small grains included in the AFSIRS model.

This category can be used to estimate irrigation requirements for production systems where the specific grain crop grown varies from year to year, or where the specific grain to be grown is unknown for other reasons. Although these data would be expected to approximate long-term average IRR, greater year-to-year accuracy would be expected by simulating the actual crop rotational sequence.

Sorghum

Few data are available for sorghum water use or irrigation requirements for Florida conditions. Sorghum water relationships have not been studied here because it is not a major Florida crop. Jones et al. (1984) discussed the applicability to Florida of data on 'Sart' sorghum studied by Doss et al. (1965) at Thorsby, Alabama. Those data show ET rates of about 0.60 times potential ET early in the growing season, increasing by 1.0 to 1.05 times potential ET at the peak growth stage and thereafter.

Robins et al. (1967) stated that yield depression of sorghum will be negligible if no more than 55% to 65% of the available soil water is allowed to be depleted during all but the last stage of crop growth. During the ripening stage (nearing maturity) they stated that 70% to 80% depletions can be safely allowed.

Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979) reported a peak growth stage crop coefficient of 1.00 and a coefficient of 0.50 at harvest. They recommended irrigation at an allowable water depletion of 55% for the first 3 crop growth stages. During stage 4 (ripening), they stated that an 80% depletion could be used because of the drought tolerance of this species. These are the data used in the AFSIRS model.

Bennett (1982) estimated a maximum water use rate of 0.22 inches per day for sorghum under Florida climate conditions. The SCS (1982) stated that the minimum root zone depth required for sorghum production is 24 inches. They also reported that the water extraction depth in unrestricted soils is 36 inches, and that the critical crop growth stages for irrigation are the boot, bloom, and dough stages.

Soybeans

Water use and irrigation requirements of soybeans have been studied extensively in Florida and other southeastern states (Smajstrla and Clark, 1982; Sadler and Camp, 1985). Crop water use coefficients used in this work were reported by Smajstrla (1982) from lysimeter studies. These ranged from a low of 0.2 at planting, to 1.05 at peak growth, to 0.45 at harvest. The 0.2 value occurred at planting because rain shelters were used to cover the crop, and irrigations were scheduled to wet the soil only infrequently. Under field conditions, the AFSIRS model generated value of about 0.4 for this growth stage was thought to be a better approximation.

The Florida data presented by Smajstrla (1982) agreed very closely with those reported for other locations by Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979), differing only in the peak crop water use coefficient of 1.00 rather than 1.05. This agreement supports the use of the Doorenbos and Pruitt (1977) and the Doorenbos and Kassam (1979) data for other crops where Florida data are unavailable.

A regional research committee on soybean production (Bonner et al., 1985)

reported that soybean should be irrigated when 50% of the available soil water has been depleted. They felt that serious stress would not result until after 60% of the water was depleted.

Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979) recommended that irrigations be scheduled at 50% available water depletion. The 50% depletion level was used for all except the late season (senescence) growth stage where 67% depletion was specified.

Bennett (1982) and Bennett et al. (1982) reported that the early to late pod fill stages of growth were most sensitive to water stress. They estimated the peak daily water use rate as 0.20 - 0.25 inches per day. Ritter and Scarborough (1988) found no benefit from irrigation before the flowering stage of growth.

Camp et al. (1988) scheduled soybean irrigation by tensiometer, evaporation pan, and a water budget model. They found no differences in water use or yields and concluded that scheduling methods can be selected based on personal preference since all worked equally well.

Rogers and Harrison (1977) estimated seasonal soybean water use to be 23 inches for Florida conditions. Shih (1985) reported an expected range of 14.5 inches to 16.9 inches depending on plant growth and yield. Bennett et al. (1982) stated that full-season soybeans require 20 to 23 inches of water per season.

The SCS (1982) stated that the minimum root zone depth required for soybean production is 24 inches. They also reported that the water extraction depth in unrestricted soils is 30 inches, and that the critical crop growth stages for irrigation are the first bloom to seed enlargement stages.

Strawberries

Strawberry water use and response to irrigation have been studied by several researchers in Florida. Myers and Locascio (1972), Locascio et al. (1975), and Locascio et al. (1977) reported irrigation requirements of 4 to 14 inches for different years and different irrigation systems. All of the above studies found micro irrigation methods to be much more efficient than other system types. Locascio et al. (1975) and Locascio et al. (1977) found micro systems resulted in improved crop yields as compared to sprinkler systems.

Clark et al. (1989) studied runoff from sprinkler-irrigated mulched bed strawberry production systems. They found that considerable runoff occurs because water is shed from the plastic mulched beds.

Myers and Locascio (1972) reported that the bed and mulch system used limit the crop root zone to 15 inches, and the upper 8 inches should be the irrigated zone. Because of the limited root zone, irrigations more frequent than once per day may be required. Smajstrla and Zazueta (1985) stated that micro irrigation systems for strawberries should be designed to permit irrigation more than once per day.

Voth (1967) reported that 80% to 90% of the crop roots are located in the top 12 inches of the root zone. Some roots penetrate to 2 ft in deep soils. Strawberries respond well to frequent irrigations, and stress which occurs during the growing season will reduce yields which cannot be recovered by later optimum irrigation. Voth recommended that irrigations be scheduled at about 20 cb soil water tension.

Doorenbos and Pruitt (1977) estimated strawberry root zones as ranging from 8 to 12 inches in depth. They recommended irrigating when 15% of the available soil water has been depleted.

The SCS (1982) stated that the minimum root zone depth required for strawberry production is 10 inches. They also reported that the water extraction depth in unrestricted soils is 12 inches, and that the critical crop growth stages for

irrigation are the fruit enlargement and bud set stages.

Sunflowers

Sunflower production has become increasingly popular in Florida in recent years. Little research has been done on crop water use coefficients in Florida.

Doorenbos and Pruitt (1977) reported crop coefficients of 1.05 for peak growth and 0.40 at harvest of sunflowers. Rooting depth was estimated to range from 2.5 to 5 ft. Irrigation was recommended when 45% of the available soil water is depleted.

Doorenbos and Kassam (1979) estimated the seasonal ET of sunflowers as 24 to 40 inches. They stated that most of the water is extracted from the surface 32 inches of the root zone. Irrigation is recommended at an allowable soil water depletion of 45% for all but growth stage (4), where that percentage can be increased.

Tobacco

Only irrigated tobacco is produced in Florida. Studies of tobacco response to irrigation were conducted by Clark and Myers (1956) and Clark et al. (1956). Myers and Clark (1958) presented recommendations for irrigation scheduling. They stated that about 6 to 8 inches of irrigation are required in a typical growing season. They estimated peak tobacco water use rate as 0.25 inches per day. Harrison and Whitty (1971) recommended irrigating the upper 18 inches of the crop root zone. They recommended irrigation applications of 0.5 to 0.75 inches at each application.

Pereira (1967) reported that tobacco is somewhat drought tolerant, but that irrigation is critical because water stress reduces its quality, and therefore, its marketability. Pereira summarized studies of a large number of researchers that reported improved yields and quality using irrigation.

Doorenbos and Pruitt (1977) estimated the extent of tobacco root zone as 1.5 to 3 ft. They recommended scheduling irrigations at 35% available soil water depletion early in the growing season and at 65% depletion during growth stage (4). Crop coefficients were estimated to be 1.05 during peak growth and 0.60 at harvest.

The SCS (1982) stated that the minimum root zone depth required for tobacco production is 18 inches. They reported that the water extraction depth in unrestricted soils is also 18 inches, and that the critical crop growth stages for irrigation are from knee high to full bloom stages.

Wheat

Wheat will tolerate water withdrawal of 70% to 80% of the available water capacity during most of the growth period and up to 90% near maturity (Robins et al., 1967). Doorenbos and Pruitt (1977) recommended the use of 55% depletions up to ripening and 90% depletions during ripening. Doorenbos and Kassam (1979) recommended 50% to 60% depletions during the active growth stages.

Crop coefficients were given by Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979) for humid climate conditions. Rogers and Harrison (1977) estimated seasonal ET of 20 inches for wheat under average Florida conditions. They also estimated 50% and 80% net irrigation requirements of 7 and 8 inches, respectively.

Wheat is deep-rooted, but at least 80% of the roots are located in the upper 3 ft. 50% to 60% of the root are normally in the upper 1-ft of the root zone (Finkel, 1983b). Doorenbos and Kassam (1979) are in agreement with the above water

extraction pattern. They also stated that at least 90% of the water extraction occurs in the upper 3 ft. Doorenbos and Pruitt (1977) reported a maximum root depth of 3 to 4.5 ft.

The SCS (1982) stated that the minimum root zone depth required for small grain production is 18 inches. They also reported that the water extraction depth in unrestricted soils is 24 inches, and that the critical crop growth stages for irrigation are the boot, bloom, and early head formation stages.

VEGETABLE CROPS

Few studies of water use and irrigation requirements of vegetable crops in Florida have resulted in the determination of crop water use coefficients and water extraction patterns. Therefore, these parameters have been obtained from the best available sources, specifically, neighboring states, locations with similar climate conditions, locations where research has resulted in the computation of Penman crop coefficients, or textbooks which present expected values of the parameters for humid climate conditions such as Florida.

Kovach (1984) stated that although crop water use coefficients were available for other locations, none were available from Florida studies. He recommended using crop coefficients of 1.0 for all vegetable crops for all stages of growth until future research studies indicated otherwise.

Jones et al. (1984) reported crop water use coefficients for tomatoes from research conducted in Florida. Their publication was the result of a thorough review of the literature of Florida and the southeastern U.S. seeking data on crop ET. Tomato was the only vegetable crop on which data were found that allowed the analysis of crop coefficients to be made.

In an earlier report, Rogers and Marlowe (1977) presented estimated ET and irrigation requirements for Florida vegetable crops. Their report was based entirely on the use of the Blaney-Criddle method of ET estimation. No Florida crop water use research data were presented or used in their analysis. Bennett et al. (1982) discussed ways to conserve irrigation water in vegetable production. However, they did not present crop-specific water use data for Florida conditions. Clark et al. (1988b) presented management guidelines for the management of mulched bed production systems in Florida.

The primary sources of vegetable crop water use and water extraction pattern data used in the AFSIRS model are the Food and Agriculture Organization of the United Nations reports by Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979). These reports present crop water use coefficients for the Penman method of ET calculation. They also present data on crop development, water extraction patterns, and allowable soil water depletions to optimize irrigation scheduling. Data were presented for both humid and arid climate conditions. Humid climate condition data were used to approximate Florida conditions.

The other major source of information on vegetable crop irrigation was the Florida Irrigation Guide (SCS, 1982). This publication provided information on water extraction patterns, root depths, critical irrigation stages, and ranges of water use of vegetable crops for Florida conditions. Water use data were obtained using the Blaney-Criddle method and crop water use coefficients developed in other locations for that method. As a result, crop water use coefficients were not available for the AFSIRS model from this source.

Other sources of vegetable crop data for the AFSIRS model were textbooks in the subject areas of irrigation and crop production. The primary texts used were those

by Hagen et al. (1967), Israelsen and Hansen (1962), and Jensen (1980). Other specific references are cited in the individual crop discussions that follow.

Beans

As discussed here, the category beans includes green or snap beans, pole beans and lima beans produced for the fresh market. Dry or field beans are discussed in the field crops section of this report. Fresh beans have many growth properties similar to those of field beans. Vittum and Flocker (1967) reported that beans are rapidly-growing vegetables with relatively limited root systems. Thus, they respond well to irrigation. Estimated seasonal water requirements range from 12 to 24 inches because of the wide ranges in varieties and growing seasons.

Doorenbos and Pruitt (1977) recommended the use of a crop water use coefficient of 0.95 during peak growth stages and 0.85 at harvest. For field or dry beans, the crop water use coefficient at harvest is considerably reduced as compared to that for green beans. The root zone is estimated to range from 20 to 28 inches. Irrigations should be scheduled at an available soil water depletion of 45%.

Doorenbos and Kassam (1979) stated that irrigations should be concentrated in the upper 24 inches of the root zone, where most roots are concentrated. They also recommended irrigating at an available soil water depletion of 45%.

The SCS (1982) stated that Lima beans have a minimum required root zone depth of 18 inches, while pole and snap beans have minimum depths of 12 inches. In unrestricted soils, the root zone water extraction depth was estimated to be 24 inches for Lima beans and 18 inches for pole and snap beans. The critical crop growth stage for irrigation was reported as the flowering stage.

Beets

Beets were estimated by Doorenbos and Pruitt (1977) to have a crop water use coefficient of 1.0 at peak growth. This value declined to 0.9 at harvest. They stated that the expected rooting depth is 2 to 3 ft. The allowable soil water depletion to optimize production was given as 50% for all crop growth stages.

The SCS (1982) estimated the minimum root zone depth required for beet production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They estimated the critical irrigation period to be the root expansion growth stage.

Vittum and Flocker (1967) stated that beets are rapidly growing root crops that respond readily to irrigation. They are also very sensitive to water deficit. Seasonal water use was estimated to range from 18 to 24 inches.

Broccoli

Broccoli is one of a family of crucifers (which includes cabbage, Brussels sprouts, and cauliflower) that respond similarly to water stress and irrigation. Doorenbos and Pruitt (1977) reported a peak water use coefficient value of 1.0. They stated that it declines to 0.85 at harvest.

Vittum and Flocker (1967) recommended irrigating at 50% available water in the top 24 inches of the root zone. They stated that adequate water must be available throughout the season to produce a marketable yield. They estimated seasonal water demands that ranged from 12 to 17 inches.

The SCS (1982) estimated the minimum root zone depth required for broccoli production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They estimated the most critical irrigation period to be the head development growth stage.

Brussels Sprouts

Brussels sprouts is one of a family of crucifers (which includes cabbage, cauliflower, and broccoli) that respond similarly to water stress and irrigation. Doorenbos and Pruitt (1977) reported a peak water use coefficient value of 1.0. They stated that it declines to 0.85 at harvest.

Vittum and Flocker (1967) recommended irrigating at 50% available water in the top 24 inches of the root zone. They stated that adequate water must be available throughout the season to produce a marketable yield. They estimated a seasonal water demand of 12 to 17 inches.

The SCS (1982) estimated the minimum root zone depth required for brussels sprouts production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They estimated the critical irrigation period to be the sprout formation growth stage.

Cabbage

Cabbage (and other crucifers) have water use coefficients of 1.0 at peak growth. This value declines to 0.85 at harvest (Doorenbos and Pruitt, 1977). They recommended limiting irrigation to the upper 16 to 18 inches of the root zone, using an allowable soil water depletion of 45%.

Vittum and Flocker (1967) recommended maintaining the available soil water above 50% in the upper 16 inches of soil. They stated that irrigation is necessary for top yields because of the sensitivity of cabbage to water stress, and that it is important that water never becomes limiting during growth. They estimated seasonal water use as 12 to 17 inches.

The SCS (1982) estimated the minimum root zone depth required for cabbage production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They estimated the critical irrigation period to be the head development growth stage.

Carrots

Doorenbos and Pruitt (1977) presented the crop water use coefficient for the peak water use period for carrots as 1.0. They stated that this value decreased to 0.7 by harvest. Root depths expected range from 1.5 to 3.0 ft. The allowable soil water depletion for optimum production should be limited to 35% of the available soil water in the crop root zone for all crop growth stages.

Carrots are a rapidly-growing root crop that respond readily to irrigation (Vittum and Flocker, 1967). Carrots are normally seepage-irrigated and require a high water table to germinate seeds at the beginning of the crop growing season. Seasonal water use is estimated to range from 18 to 24 inches.

The SCS (1982) estimated the minimum root zone depth required for carrot production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They reported the critical irrigation periods to be the seed germination and root expansion growth stages.

Cauliflower

Cauliflower is one of a family of crucifers (which includes cabbage, Brussels sprouts, and broccoli) that respond similarly to water stress and irrigation. Doorenbos and Pruitt (1977) reported a peak water use coefficient value of 1.0. They stated that it declines to 0.85 at harvest.

Vittum and Flocker (1967) recommended irrigating at 50% available water in the top 24 inches of the root zone. They stated that adequate water must be available throughout the season to produce a marketable yield. They estimated a seasonal water demand of 12 to 17 inches.

The SCS (1982) estimated the minimum root zone depth required for cauliflower production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They reported the critical irrigation period to be the head development growth stage.

Celery

Celery has a peak water use crop coefficient of 1.0 (Dorrenbos and Pruitt, 1977). This value declines only to 0.9 at harvest. Rooting depth ranges from 1 to 1.5 ft. The allowable soil water depletion for optimum production is only 20% of the available soil water in the crop root zone. Growth rate was reported to be retarded when soil water was depleted to 40% of the available water (Vittum and Flocker, 1967).

Celery is a relatively long-season crop with a limited root system. Thus, it is more susceptible to water stress than deeper rooted crops (Vittum and Flocker, 1967). They estimated seasonal water use for celery to exceed 24 inches. Shih (1987) reported that using 5 and 10-day irrigation cycles rather than continuous seepage irrigation resulted in water savings of up to 45%, but also produced yield reductions of up to 30%.

The SCS (1982) estimated the minimum root zone depth required for celery production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They reported that there is not a single critical irrigation period, but that irrigation is required continuously throughout the growing season.

Cucumber

Cucumber is one member of a family of vegetables known as cucurbits. This family also includes melon, squash and others. All are long-season crops with medium to deep root systems. All require large amounts of water, and that water stress be avoided throughout the season to produce marketable yields (Vittum and Flocker, 1967). For these reasons irrigation is critical to cucumber production in Florida.

Doorenbos and Pruitt (1977) estimated that the crop water use coefficient at peak growth is 0.9, and that it declines to 0.8 at harvest. They estimated the range of effective root zone to range from 28 to 48 inches. They recommended irrigating when 50% of the available soil water in the root zone has been depleted. Vittum and Flocker (1967) estimated seasonal water crop water requirements as 12 to 17 inches.

The SCS (1982) estimated the minimum root zone depth required for cucumber production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They reported the critical irrigation periods to be the flowering and fruiting growth stages.

Eggplant

Eggplant data were obtained from Doorenbos and Pruitt (1977). They stated that the peak growth rate crop coefficient is 0.95, and that it declines to 0.8 at harvest. Vittum and Flocker (1967) classified eggplant as a moderately deep rooted plant (2 to 4 ft). They estimated seasonal water use as 18 to 24 inches.

For the AFSIRS model, the allowable soil water depletion between irrigations

was assumed to be 40%.

The SCS (1982) estimated the minimum root zone depth required for eggplant production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They reported the critical irrigation periods to be the flowering and fruiting growth stages.

Greens or Potherbs

This category includes spinach, kale, mustard, and collard greens. These are shallow-rooted crops normally grown during the cooler part of the year when ET rates are relatively low. They require an adequate supply of water throughout the growing season for production (Vittum and Flocker, 1967). For the AFSIRS model, the crop coefficients for the above four crops were assumed to be identical.

Doorenbos and Pruitt (1977) listed peak growing season crop coefficients of 0.95 for spinach. These declined only slightly to 0.90 at harvest. The rooting depth ranges from 12 to 20 inches. The allowable soil water depletions between irrigations should not exceed 20% for optimum production. Because these are cool season crops, Vittum and Flocker (1967) estimated their seasonal ET as less than 12 inches.

The SCS (1982) estimated the minimum root zone depth required for production of greens to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They reported irrigation to be critical continuously during the growing season.

Lettuce

Lettuce is a shallow-rooted, rapidly-growing cool-season crop requiring a nearly constant water supply from planting to harvest (Vittum and Flocker, 1967). The estimated root zone was less than 2 ft and the seasonal water use less than 12 inches. Shih reported that using 5 and 10-day irrigation cycles rather than continuous seepage irrigation resulted in water savings of up to 45%, but also produced yield reductions of up to 30%.

Doorenbos and Pruitt (1977) listed the peak growth period crop water use coefficient as 0.95. They stated that it declines only slightly to 0.90 at harvest. They estimated rooting depths as 12 to 20 inches. Lettuce should be irrigated at an allowable soil water depletion of 30%.

The SCS (1982) estimated the minimum root zone depth required for lettuce production to be 18 inches. They reported the root zone water extraction depth to be 24 inches in unrestricted soils. They reported the critical irrigation period to be the head expansion growth stage.

Melons

Melons (including watermelons, muskmelons, and cantaloupes) are members of a family of vegetables known as cucurbits. This family also includes cucumbers, squash and others. All are long-season crops with medium to deep root systems. All require large amounts of water, and that water stress be avoided throughout the season to produce marketable yields (Vittum and Flocker, 1967). For these reasons irrigation is critical to production in Florida.

The SCS (1982) estimated the minimum root zone depth required to be 12 inches for cantaloupes and 24 inches for melons. They reported the root zone water extraction depths in unrestricted soils to be 18 inches for cantaloupes and 36 inches for melons. They reported the critical irrigation period to be the flowering and fruit development stages for cantaloupes and the fruit expansion stage for

melons.

Doorenbos and Pruitt (1977) estimated that the crop water use coefficient at peak growth is 0.95, and that it declines to 0.65 at harvest. They estimated the range of effective rooting zones as 3 to 4.5 ft. They recommended irrigating when 35% of the available soil water in the root zone has been depleted.

Vittum and Flocker (1967) estimated seasonal water crop water requirements as 12 to 17 inches. Rogers and Marlowe (1977) stated that melons use more water than typical vegetable crop usages. They recommended estimating ET for typical 90-day growing season melons as equivalent to 100-day growing seasons for other vegetables.

Onion

Onions are one of a group of bulb crops which also includes garlic, leek, shallot, and chive (Vittum and Flocker, 1967). Water use by these crops can be estimated as that of onions for the same growing period. Onions have relatively limited root systems and high demands for water. They may require from 12 to 24 inches of water depending on length and timing of the growing season.

Onions are harvested in both a dry and green form. Both categories are available options in the AFSIRS model. Doorenbos and Pruitt (1977) list peak growth rate crop water use coefficients of 0.95 for both dry and green onions. For growth stage (4), the green onion water use coefficient remains at 0.95, while the dry onion coefficient is reduced to 0.75 at harvest. The rooting zone depth may range from 12 to 20 inches. The allowable soil water depletion for optimum production should be limited to 25%.

The SCS (1982) estimated the minimum root zone depth required for onion production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They reported the critical irrigation periods to be the bulbing and bulb expansion growth stages.

Doorenbos and Kassam (1979) stated that irrigations should be scheduled when 25% of the water in the top 12 inches of soil have been depleted. They stated that irrigations can be discontinued 15 to 25 days before harvest for dry onion production.

Peas

Peas are rapidly-growing vegetables with relatively limited root systems. Root depths were estimated to range from 2 to 4 ft by Vittum and Flocker (1967). They also estimated seasonal water requirements of less than 12 inches because peas are normally grown during the cooler parts of the year.

Doorenbos and Pruitt (1977) list peak growth stage crop water use coefficients of 1.05 for peas. They stated that coefficients decline to 0.95 at harvest. Expected rooting depths range from 24 to 40 inches. Allowable soil water depletions between irrigations should not exceed 35% for optimum production.

Doorenbos and Kassam (1979) stated that most water is extracted from the upper 24 inches of the root zone. They also stated that yields will be unaffected by allowable soil water depletions of up to 40% in this zone.

The SCS (1982) estimated the minimum root zone depth required for pea production to be 12 inches. They reported the root zone water extraction depth to be 18 inches in unrestricted soils. They reported the critical irrigation periods to be the flowering and pod swelling growth stages.

Peppers

Vittum and Flocker (1967) classify peppers as moderately deep-rooted (2 to 4 ft). They estimated seasonal water usages of 18 to 24 inches.

Peppers grown for the fresh markets have peak growth rate crop water use coefficients of 0.95 (Doorenbos and Pruitt, 1977). These values decline to 0.80 at harvest. Depth of rooting zones were estimated to range from 20 to 40 inches. Allowable soil water depletion should be limited to 25% to optimize production.

Doorenbos and Kassam (1979) stated that although the root system can extend to 40 inches, most of the water uptake is concentrated in the upper 12-18 inches, and this should be the zone in which irrigations are concentrated. When the upper 12-18 inch root zone is irrigated, the allowable soil water depletion should not be allowed to exceed 30% to 40%. The SCS (1982) reported the critical irrigation period to be the transplanting, flowering, and early fruit development growth stages.

Radish

Radishes are very short-season crops, maturing in 4 to 6 weeks. They are rapidly-growing and have a limited root system that responds well to irrigation (Vittum and Flocker, 1967). They reported that the root zone is limited to 6-8 inches, and it should be maintained at a water content very near field capacity. The SCS (1982) reported that it is critical that radishes be adequately watered continuously throughout their growing season.

Hegde (1987) reported that radish yield was greatest when irrigations were scheduled with tensiometers at -20 cb as compared to -40 cb water potentials. They reported that method of irrigation did not affect ET.

Doorenbos and Pruitt (1977) gave peak growth rate crop coefficients of 0.80 for radishes. Coefficients are reduced to 0.75 at harvest. Because additional data were not available, it was assumed for the AFSIRS model that the allowable soil water depletion for optimum growth is 33% for the entire growing season.

Small Vegetables

The small vegetables category contains average data for small vegetable water use coefficients, rooting characteristics, allowable water depletions, and fractions of the growing season in each crop growth stage. These data were obtained by averaging each of these data categories for all of the annual vegetable crops included in the AFSIRS model.

This category can be used to estimate irrigation requirements for production systems where the specific vegetable crop grown varies from year to year, or where the specific vegetable to be grown is unknown for other reasons. Although these data would be expected to approximate long-term average IRR, greater year-to-year accuracy would be expected by simulating the actual crop rotational sequence.

Squash

Squash is one member of a family of vegetables known as cucurbits. This family also includes melon, cucumber and others. All are long-season crops with medium to deep root systems. All require large amounts of water, and that water stress be avoided throughout the season to produce marketable yields (Vittum and Flocker, 1967). For these reasons irrigation is critical to production in Florida.

Doorenbos and Pruitt (1977) estimated that the crop water use coefficient at peak growth is 0.9, and that it declines to 0.7 at harvest. Stansell and Smittle (1989) recommend that irrigations be scheduled at -25 cb water potentials in Georgia. They presented regression equations for crop age to pan evaporation coefficients for summer squash.

Vittum and Flocker (1967) stated that squash has root zones of 2 ft to more than 4 ft. They estimated the seasonal irrigation requirement as 18 to 24 inches.

The SCS (1982) estimated the minimum root zone depth required to be 12 inches for summer squash and 18 inches for winter squash. They reported the root zone water extraction depth in unrestricted soils to be 18 inches for summer squash and 24 inches for winter squash. They reported the critical irrigation period to be the fruit sizing growth stage.

Sweet Corn

Sweet corn has a peak crop water use coefficient of 1.05 at peak growth. It decreases only slightly to 0.95 at harvest (Doorenbos and Pruitt, 1977). Rogers and Marlowe (1977) stated that sweet corn has higher ET rates than other typical vegetable crops with the same growing season.

Sweet corn is shallow-rooted (less than 2 ft) and does not yield well if water is not readily available (Vittum and Flocker, 1967). Estimated seasonal water use was 18 to 24 inches. Bruanworth and Mack (1987a, 1987b, 1989) found no yield differences when sweet corn was irrigated at 46% to 57% available soil water depletion. They recommended irrigating at 50% available soil water depletion.

Shih reported that using 5 and 10-day irrigation cycles rather than continuous seepage irrigation resulted in water savings of up to 45%, but also produced yield reductions of up to 30%.

The SCS (1982) estimated the minimum root zone depth required for sweet corn production to be 18 inches. They reported the root zone water extraction depth to be 30 inches in unrestricted soils. They reported the critical irrigation periods to be the tasseling through grain filling growth stages.

Sweet Potatoes

Sweet potatoes are normally grown in sandy soils and have been reported to respond well to irrigation. Sweet potatoes are deep-rooted. Root zones may extend well below 4 ft in deep soils. Estimated seasonal water requirement is 18 to 24 inches (Vittum and Flocker, 1967).

The SCS (1982) estimated the minimum root zone depth required for sweet potato production to be 18 inches. They reported the root zone water extraction depth to be 24 inches in unrestricted soils. They reported the critical irrigation periods to be the first and last 40 days of the growing season.

Doorenbos and Pruitt (1977) reported a range in rooting depths of 3.0 to 4.5 ft. They recommended scheduling irrigations only after 65% of the available soil water in the root zone was depleted. Crop water use coefficient data were not found in the literature. Therefore, crop coefficients similar to those for other root crops were assumed. They may need refinement as other data become available.

Tomatoes

Tomatoes have been studied by many researchers throughout the world and under Florida conditions. Locascio and Myers (1974) and Stall and Bryan (1975) reported substantial yield increases from tomato irrigation in Florida. Jones et al. (1984) gave crop coefficients for tomatoes grown by Saxena et al. (1971) in north Florida. These ranged from a low of 0.5 at the beginning of the growing season, to 1.05 at peak growth, to 0.75 near harvest.

In his Florida tomato production guide, Hochmuth (1989) reported that tomato water needs range from 0.5 inches per week at transplanting to 1.5 inches per week

during fruiting.

Pitts et al. (1988) found that yields of stake tomatoes were similar when only 10% of the water applied with seepage was applied with drip irrigation. Csizinszky et al. (1987) reported that response of tomato to drip and seepage irrigation showed only slight, nonsignificant differences in a 3-year study. Thus, they concluded that the choice of an irrigation system for Florida conditions depends primarily on system cost and water availability rather than production levels.

Pitts and Smajstrla (1989) reported that although drip irrigation systems can dramatically reduce the amount of water applied as compared to other methods, drip systems have higher initial costs, required higher levels of management, and usually require water treatment to avoid emitter clogging. Clark et al. (1988) outlined management requirements for mulched-bed drip irrigation systems.

Vellidis et al. (1988a) reported that as much as 30% of drip-irrigated tomato ET requirements were provided by extractions from a water table 30 inches below the root zone. Vellidis et al. (1988b) demonstrated that the amount of extraction from a water table strongly depends on soil hydraulic properties.

Sammis and Wu (1986) reported that tomatoes subject to water stress uniformly distributed over the growing season had relative yield reductions directly proportional to relative reduction in ET and independent of the type of irrigation system used. Bogle et al. (1989) reported greater yields with drip versus furrow irrigation when furrow irrigation was applied at pan evaporation rates and drip was applied at 45% of pan evaporation.

Vittum and Flocker (1967) reported that tomatoes are long-season deep-rooted crops with high water requirements. They estimated seasonal water requirements in the range of 12 to 24 inches because of the wide range in growing seasons. Israelsen and Hansen (1962) estimated peak daily water requirements of 0.16 inches per day for the humid southeastern US.

The SCS (1982) estimated the minimum root zone depth required for tomato production to be 18 inches. They reported the root zone water extraction depth to be 24 inches in unrestricted soils. They reported the critical irrigation period to be the fruit expansion growth stage.

Doorenbos and Pruitt (1977) reported peak crop water use coefficients of 1.05. They stated that water use coefficients would be expected to decline to 0.6 at harvest. These data are in good agreement with those determined for Florida conditions. Rooting depths were reported as 28 to 60 inches for deep soils. The allowable soil water depletion was given as 40% of the available water in the crop root zone.

Doorenbos and Kassam (1979) stated that 80% of the crop roots are concentrated in the upper 24 inches of the root zone, and thus this should be the zone irrigated. They reported that a 40% allowable water depletion was adequate for only the first 3 crop growth stages. They recommended scheduling irrigations at the 65% depletion level for growth stage (4).

WATERMELONS

See melons in this section (vegetable crops) of this report.

APPENDIX C

IRRIGATION SYSTEMS

The AFSIRS model contains default data for 9 different types of irrigation systems. The system types, their characteristics, and the coefficients necessary for their use are an integral part of the model. An irrigation system type is identified to the computer by specifying a code (IR), selected from a list provided. The irrigation system types and their codes are as follows:

<u>IR CODE</u>	<u>IRRIGATION SYSTEM TYPE</u>
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)

The primary types of irrigation systems in use in Florida can be classified in one of four categories: micro, sprinkler, subirrigation, and flood irrigation, based on method of water application (Pitts and Smajstrla, 1989). However, it was necessary to subdivide the micro, sprinkler, and flood categories because of differences in irrigation application efficiencies for various types of micro and sprinkler systems, and because of differences in the methods of operation of flood irrigation systems.

Category 1, User-Specified Systems, permits the model user to input irrigation system data from the computer keyboard for the interactive version of the model, or using the INPUT.DAT file for the batch version of the model. This capability allows the model user to specify irrigation system characteristics other than the model default values.

Micro and Sprinkler Irrigation Systems

For micro and sprinkler irrigation systems, the AFSIRS model schedules irrigations based on one of three user-specified criteria. Irrigation applications are either (1) the amount of water required to restore the soil water content to field capacity in the irrigated zone, (2) a fixed (constant) depth of water at each irrigation, or (3) the amount of water to restore the soil water content to a specified fraction of field capacity in the irrigated zone. The irrigated zone is defined based on the crop being irrigated (depth of effective root zone) and on the area of the soil surface irrigated with the system specified. Micro and container nursery sprinkler systems are assumed to irrigate only a fraction of the soil surface, while all other system types are assumed to irrigate the entire soil surface.

The net irrigation requirement (NIR) is defined as the amount (depth) of water applied to meet one of the three irrigation scheduling criteria, assuming that no losses occur due to the method of water application. The gross irrigation requirement (IRR) is defined as NIR divided by the irrigation system application efficiency (EFF). Because application efficiencies of all irrigation systems are less than 1.0, IRR is always greater than NIR. The difference between NIR and IRR is the amount of water wasted during application due to inefficiency in water application. This includes such losses as those due to evaporation, interception, and wind drift for sprinkler and micro spray systems, and nonuniform water

applications for both system types. For a detailed discussion of Florida irrigation system efficiencies, see IFAS Ext. Bul. 247 (Smajstrla et al., 1988b).

The depth to water table must be input by the model user when field grown crops are being irrigated with sprinkler or micro irrigation systems. This site-specific information is required because water extraction from the nonirrigated zone is reduced and IRR is increased as the nonirrigated zone is depleted. Thus, IRR may be very sensitive to the depth to the water table for shallow water tables. Several research reports have demonstrated that water extraction from a high water table contributed significantly to the crop water requirements and thus reduced irrigation requirements (Graser and Allen, 1987; Melmon et al., 1986; Shih, 1986; Shaykewich and Stroosnijder, 1977; Vellidis et al., 1988a, 1988b).

Seepage and Flood Irrigation Systems

For seepage and flood irrigation systems, water contents in at least part of the soil profile are saturated, and water moves into the root zone by capillarity (seepage), mass flow (rice, flood), or both (citrus crown flood). The irrigated zone is the entire crop root zone, with root zone depths being defined by the depth to the water table (seepage and crown flood) or being irrelevant (rice flood) because the entire root zone is flooded.

NIR is defined differently for seepage and flood irrigation systems. For seepage systems, NIR is calculated on a daily basis as the amount of water that is depleted from the root zone by ET, and which must therefore be replaced by capillary flow from the water table below. For citrus crown flood systems, there is some depletion from the crop root zone and some upward movement from the water table also. Irrigations occur infrequently, but capillary movement occurs daily. For rice flood systems, the depletion is directly from the water table and NIR is calculated on a daily basis as the amount of water that is depleted from the water table by ET. The pumping system is assumed to continuously replace that being depleted.

As with micro and sprinkler systems, IRR is calculated by dividing NIR by EFF. Again, because EFF is always less than 1.0, IRR is always greater than NIR. Irrigation application efficiency losses for seepage and flood irrigation systems primarily occur due to deep percolation, lateral flow, runoff, and nonuniform water applications (Smajstrla et al., 1988b). Efficiencies of these systems may vary widely due to management and site characteristics (Haman et al., 1986; Pitts et al., 1988, 1989; Smajstrla et al., 1982, 1984c, 1988b).

IRRIGATION SYSTEM CHARACTERISTICS

Details of the mechanism of operation of the AFSIRS model for the nine types of irrigation systems are given in the following sections of this report. System definitions and mechanisms of operation are consistent with those used in prominent irrigation texts (James, 1988; Jensen, 1973; Jensen, 1980; Karmeli and Keller, 1975; Nakayama and Bucks, 1986; Pair, 1983; Schwab et al., 1981).

User-Specified Systems

The category user-specified systems allows the model user to specify the irrigation system type or description, irrigation application efficiency, fraction of the root zone irrigated, and fraction of water extracted from the irrigated versus the nonirrigated portions of the root zone. Choosing this category allows to model user to completely specify the irrigation system characteristics without using any of the model default values, or to change only selected values to study their effects on IRR. These values are input from the keyboard for the interactive model version and from the INPUT.DAT file for the batch model version.

Micro, Drip

Micro irrigation systems are those which use a network of small plastic pipe to distribute water into or near the root zone of the crop being irrigated. Drip types of micro systems are those in which water is placed on or beneath the soil surface at low flow rates as a series of individual drops or small streams. Water emitting devices (emitters) are small diameter tubes, porous pipes, small plastic emitters, or other devices which serve the same function.

The above definitions are currently recognized by national standards developed by the American Society of Agricultural Engineers, ASAE (Hahn et al., 1989) and the national Irrigation Association, IA. These definitions are also consistent with the terminology of the International Standards Organization, ISO.

In Florida, approximately 360,000 acres of agricultural crops are micro-irrigated, including both drip and spray irrigation categories (Irrigation Journal, 1989). This acreage is primarily in citrus, vegetable and nursery crops. Because of investment costs per acre, drip systems are typically used on only relatively high cash value crops.

Drip Irrigation Efficiency

Drip irrigation systems have the capability of being very efficient in the application of water. Because water is applied very near or directly into the crop root zones, little is lost to evaporation or wind drift during application. Efficiencies are typically considered to be identical for both night and daytime irrigation.

The primary reasons for inefficiency in drip irrigation water application are nonuniformity of water application and poor management. Management problems are avoidable by irrigating only when required by the crop, and in amounts that will not exceed the soil water-holding capacity. The assumption used in the AFSIRS model is that irrigations are scheduled only when the available soil water content has dropped to a predetermined level of depletion that requires irrigation and that application depths are consistent with soil and crop characteristics. Thus, optimum management levels are assumed.

A uniformity of water application which is less than perfect (less than 100%) is unavoidable because friction losses in pressurized water systems cause flow rates from emitters to vary throughout the system. Micro irrigation systems which are designed for high uniformities of water application are more expensive than those designed for lower uniformities. This occurs because to achieve high uniformities, large pipe sizes and/or pressure compensating emitters are required, and these are more expensive than smaller pipe sizes and non-pressure compensating emitters.

Drip irrigation efficiencies will be reduced by the use of poor quality (saline) irrigation water. In that case, excess water applications will be required for leaching of soluble salts, thus reducing the effectiveness of water applications (see previously-referenced irrigation texts and Parnell, 1988).

National standards for micro irrigation system design have been developed by ASAE (Hahn et al., 1989). Similar standards were developed by the Soil Conservation Service, SCS, (1983a) and the Florida Irrigation Society, FIS (FIS, 1982d). These include guidelines for uniformity of water application. They agree that well-designed systems for Florida conditions will have uniformities in the range of approximately 80%-90%.

For the above reasons, default value of the irrigation application efficiency for drip micro irrigation systems was assumed to be 85% (Smajstrla et al., 1988b) in the AFSIRS model. This assumes good water quality and an irrigation system which is well-designed and well-managed for Florida conditions.

Area of the Root Zone Irrigated

The area of the crop root zone irrigated with drip irrigation systems was assigned a default value of 0.50 in the AFSIRS model. This value was used based on research results which have reported ranges of values of from 0.25 to 0.80 to maximize production (Karmeli and Keller, 1975; Smajstrla and Koo, 1984), and based on design standards (SCS, 1983a; Hahn et al., 1989).

The soil area irrigated must be a significant fraction of the crop root zone because irrigation of only a small fraction of the crop root zone will limit production. The plant will not be able to extract all of its water needs through a small fraction of the root system. Because this fraction has not been defined for all Florida production systems, it may be entered by the AFSIRS model user.

Water Extraction from the Irrigated Zone

For drip irrigation systems, the fraction of the water extracted from the irrigated portion of the crop root zone is assumed to not be linearly proportional to the fraction of the root zone irrigated. Rather, it is assumed that there is a preferential root development under drip irrigation emitters because of the desirable soil water status in these areas. This effect has been observed in citrus irrigation systems by the author. The fraction extracted from the irrigated root zone was calculated as:

$$\text{EXIR} = 0.7 * \text{ARZI} + 0.10 * (1.0 - \text{ARZI}) \quad (\text{C-1})$$

where EXIR = fraction of water extracted from the irrigated root zone, and

ARZI = fraction of the crop surface area irrigated with the drip irrigation system.

Equation (C-1) assumes that the management of the irrigation system confines water to the upper 1/2 of the crop root zone where most of the roots are located and from where 70% of the water is extracted (SCS, 1982). The second term in equation (C-1) assumes that the fraction extracted from the irrigated zone is increased by 10% of that which would be extracted from the nonirrigated zone if water was extracted from the irrigated and nonirrigated areas in direct proportion to their areas. This simulates a slight preference for water extraction from the irrigated zone when the irrigated zone is large, and a greater preference when the irrigated zone is small. Also, as previously discussed, the presence of a high water table can significantly contribute to a crop's water requirements.

Micro, Spray

Spray types of micro irrigation systems are those in which water is sprayed short distances from the emitters in order to cover greater fractions of the crop root zone. As with other types of micro systems, water is distributed through a network of plastic pipes to very near the crop root zone, and it is sprayed at low pressures as compared to sprinkler irrigation systems.

In Florida, approximately 360,000 acres of agricultural crops are micro-irrigated, including both drip and spray irrigation (Irrigation Journal, 1989). By far the most common application of this type of system is spray irrigation in citrus production. Other applications include but are not limited to nursery, blueberries, and orchard crops other than citrus. This is a rapidly-expanding type of irrigation system. Most new citrus groves are being installed with this type of system because of its proven abilities to increase young tree growth, increase production, and provide freeze protection. Micro systems are also less costly than sprinkler irrigation systems.

Spray Irrigation Efficiency

Spray irrigation systems can be very efficient in the application of water, if they are properly designed and installed. As with the previously discussed drip irrigation systems, the primary reasons for inefficiency are poor management and nonuniformity of water application, with the exception that losses due to wind drift and evaporation are normally greater because water is sprayed through the air rather than being dripped directly onto the soil surface. Also, the same standards for system design apply for both spray and drip systems.

For the above reasons, the default value of the application efficiency for spray micro irrigation systems was 80% (Smajstrla et al., 1988b) for application in the AFSIRS model. This assumes good water quality and an irrigation system which is well-designed and well-managed for Florida conditions.

Area of the Root Zone Irrigated

The area of the root zone irrigated with spray irrigation systems was assigned a default value of 0.50 in the AFSIRS model for the same reasons as discussed for drip irrigation systems. This parameter may also be changed by inputs by the model user.

Water Extraction from the Irrigated Zone

The fraction of water extracted from the irrigated zone was defined identically for spray and drip irrigation systems as given in Equation (C-1). Again, as discussed for drip systems, shallow water tables may contribute significantly to a crop's water requirements.

Multiple Sprinkler

Multiple sprinkler irrigation systems are systems which spray water onto the crops irrigated using sprinklers with overlapping patterns of water application and the pressure in the irrigation system. Approximately 350,000 acres are irrigated with multiple sprinkler systems in Florida (Irrigation Journal, 1989). These systems are used in a large number of production systems, including citrus, strawberries, vegetables, nurseries, ferns, and field crops.

Just as multiple sprinkler irrigation systems are used to irrigate many crops, so they also take many forms. These include permanent solid set systems commonly used in citrus (permanent overhead or undertree sprinklers), nursery, fern, and strawberry production. These systems use permanently installed (typically buried) pipe networks which supply water to sprinklers mounted on risers above the ground surface.

Multiple sprinkler irrigation systems also include portable sprinkler systems often used for vegetable production. These systems typically use portable aluminum pipe on which sprinklers are mounted. Pipes are set in place for irrigation and may be manually moved between irrigations.

Multiple sprinkler irrigation systems also include center pivot and lateral move systems. These systems have sprinklers mounted on movable laterals. Some of the laterals are self-propelled, while others are mechanically or manually moved. On sandy soils, these systems often use low pressure spray nozzles rather than high pressure sprinklers.

Multiple Sprinkler Efficiency

Multiple sprinkler irrigation systems have in common the fact that water is sprayed through the air from sprinklers, and they use the high exit velocity to break the stream of water into droplets. This causes the formation of both large and small drops of water. Small drops are readily lost to wind drift or evaporation. Evaporation and wind effects are greater during day rather than night irrigation.

Sprinkler systems, like micro systems, cannot apply water at 100% uniformity. Uniformity is further decreased from those of micro systems because of wind effects on water distribution patterns.

The combination of the above factors causes sprinkler water application efficiencies to typically range from 70% to 80% (SCS, 1982, 1983b). For the AFSIRS model, the default application efficiency assumed for multiple sprinkler irrigation systems is 75% (Smajstrla et al., 1988b).

Area of the Root Zone Irrigated

Multiple sprinkler irrigation systems spray water from overlapping, widely-spaced sprinklers onto the entire crop and soil surface between sprinklers. Thus, the AFSIRS model default value of the area of the root zone irrigated with sprinkler systems is 1.0.

Water Extraction from the Irrigated Zone

The pattern of water extraction from root zones of well-irrigated crops that is typically presented in irrigation texts was shown by the SCS (1982). It is given as Figure 2 in this manual. This pattern demonstrates that 70% of ET is extracted from the upper 1/2 of the crop root zone, where most of the crop roots are concentrated. Only 30% is extracted from the lower 1/2 of the crop root zone. This proportion was used to define water extraction patterns in the AFSIRS model.

The AFSIRS model assumes that only the upper 1/2 of the crop root zone is irrigated. Thus, when water is available in the nonirrigated portion of the crop root zone, 0.3 of the crop's ET is extracted from this region, and 0.7 is extracted from the irrigated region. These fractions change as water is depleted from the nonirrigated zone. As depletions from the nonirrigated zone occur, a smaller fraction is extracted from this zone, and a correspondingly larger fraction is extracted from the irrigated zone, so that all of the crop's water requirements are met. As previously discussed for micro irrigation systems, high water tables can contribute significantly to a crop's water requirements.

Sprinkler, Container Nursery

Sprinkler irrigation systems used in container nurseries are multiple sprinkler systems which are applied specifically to irrigating plants in containers. Container-grown plants are placed in groups under a sprinkler system. The system is operated frequently because of the limited water-holding capacity in containers and to avoid water stress because nursery crops are sold on a quality basis. The container root zones are relatively small as compared to the root zones that would exist if roots were allowed to expand under field conditions. Also, many nursery crops are very sensitive to water stress, and because they are sold on a quality basis, they are irrigated at low water depletions to avoid water stress.

Sprinkler irrigation systems are used in container nursery production systems because they can quickly irrigate crops to reduce stress by wetting the foliage as well as the soil. They are reliable, and they do not clog, require water filtration, or water treatment as compared to micro irrigation systems. Since water and pumping costs are low in Florida, they are economical, even as compared to micro irrigation, because of low labor and water treatment requirements.

Container Nursery Sprinkler Irrigation Efficiency

The water application efficiency of a container nursery sprinkler irrigation system is much less than that of the same sprinkler system applied to a field-grown crop. The reason is that water which falls between the containers is largely ineffective in meeting the crop's water requirements. EFF of multiple sprinkler irrigation systems ranges from 70% to 80%. The AFSIRS model uses 75% as the default application efficiency for a system which irrigates the entire soil surface when roots are present throughout the soil as with complete crop canopies.

For container nurseries, the surface area occupied by containers and available to intercept irrigation water is relatively small. It may range from 20% to 40% of the ground surface area, depending on the type of crop being produced. Also, canopies of many plants tend to shed water to the drip line of the canopy. For these reasons, the default sprinkler irrigation application efficiency for container nurseries used in the AFSIRS model is 20% (Smajstrla et al., 1988b). This efficiency is consistent with that measured in a woody ornamental nursery in north Florida (Weatherspoon and Harrell, 1980) and that recommended by the IFAS Ornamental Horticulture Department (Dr. George E. Fitzpatrick, IFAS Ft. Lauderdale Research and Education Center, personal communication).

Fraction of the Soil Surface Irrigated

The soil surface area occupied by plant roots is that occupied by containers in a container nursery production system. For this production system, the area between containers is also irrigated, but because there are no plant roots in this area, water which falls here was assumed to be largely ineffective.

Because ground surface areas occupied by containers typically range from 20% to 40%, the average was assumed to be 30%. This number may, however, be changed by input by the model user depending on the input option selected when the AFSIRS model is run.

Water Extraction from the Containers

The water which falls outside of the containers is not entirely ineffective. It wets the soil surface and contributes to ET from the production system by direct evaporation from the soil surface. It also wets the crop foliage and contributes to ET by direct evaporation from the foliage. Both of these factors reduce transpiration from the container plants because total ET is largely a function of climatic demand (potential ET) for the entire production system (Jones et al., 1984). Monthly and seasonal ET from well-irrigated soybeans were shown to be unaffected by method of irrigation when sprinkler, surface, and subsurface irrigation methods were compared under Florida climate conditions (Calvert and Smajstrla, 1984).

ET of container nursery plants has been measured by several researchers under Florida conditions. Barrett and Nell (1982) separated evaporation and transpiration effects from individual containers. Stanley and Harbaugh (1981, 1984) correlated ET from container nursery plants with an index of potential ET. Fitzpatrick (1980, 1983) correlated water use from individual container plants with the Thornthwaite method of potential ET estimation. All of the above studies were however, limited to extractions from individual containers, and did not consider rainfall effectiveness.

The magnitudes of the effects of evaporation from the soil surface and evaporation from crop canopies on reducing transpiration from container grown plants should be studied for Florida climate conditions. Studies conducted to this time have not determined the relative contributions of each of these factors, and the resulting effects on irrigation requirements.

Because of the lack of data on this subject, it was assumed that 70% of ET was contributed from the nursery containers, while 30% was contributed from evaporation from the soil surface and interception on the plant canopies. Although data are lacking, it was felt that this distribution was conservative (would cause IRR to be overestimated, thus assuring adequate water for production) with respect to estimating irrigation requirements for adequate crop production, because both soil and canopy surfaces are very frequently irrigated in typical sprinkler- irrigated nursery production systems.

The above 30% of ET was assumed to be contributed by evaporation from soil and crop canopies when water was available in the upper 3 inches of the soil surface. When water was not available in this zone because of infrequent irrigation, an increasingly greater fraction of ET was extracted from the containers until at the extreme, ET was entirely extracted from the containers. The soil was assumed to be a typical Florida fine sand with an available volumetric water-holding capacity of 6%.

Sprinkler, Large Guns

Large gun irrigation systems are those which use one or a relatively few large sprinklers which operate at high pressures and high flow rates. Guns normally have nozzles approximately 1-inch in diameter, operate at 80 to 120 psi, and discharge 300 to 500 gpm. Most irrigation systems use only one sprinkler of this type, while some use two or more.

Large guns may be self-propelled; that is, they travel through a field as they irrigate. Examples of traveling guns are cable tow and hose reel (or hard hose) irrigation machines. Large guns may also be manually or tractor moved; that is, they are moved after applying the desired amount of irrigation at a location, rather than moving continuously through a field as they irrigate.

Currently an estimated 42,000 acres are irrigated in Florida using portable or tractor moved guns. An additional 152,000 acres are irrigated with travelling guns (Irrigation Journal, 1989). Large gun irrigation systems are used in Florida because they are versatile --they can irrigate oddly-shaped fields or fields at different locations easily because of their portability. They also have a relatively low initial cost as compared to other types of irrigation systems.

Large gun irrigation systems have the disadvantages of requiring large pumping costs per unit of water delivered because of their high operating pressures, and of having relatively high labor costs to operate the guns, especially the non-traveling types.

The primary gun-irrigated crops in Florida are citrus, tobacco, vegetables, and field crops. For some crops, such as citrus, guns are being replaced by micro irrigation systems as growers strive to reduce operating costs or obtain freeze protection.

Large Gun Irrigation Efficiencies

Large gun irrigation efficiencies are less than 100% because of losses in application due to wind drift of small spray droplets, evaporation from spray droplets, nonuniformity of water application and deep percolation. The amounts of losses by the above mechanisms depend on climate conditions during irrigation and management of the irrigation system.

Large gun irrigation efficiencies have been studied by Rochester (1980) and Oakes and Rochester (1981) for conditions of the humid southeastern U.S. Shull and Dylla (1976a, 1976b) reported that wind greatly affects uniformity of water application and thus application efficiencies of large guns. Koo and Reese (1975) measured evaporation losses from citrus irrigation with guns. The Soil Conservation Service (SCS, 1982) reported that gun application efficiencies may be expected to average 70% for daytime operation and 80% for night operation in Florida.

In the AFSIRS model, large gun application efficiencies are assumed to be 70% for all conditions of operation. This number is used because labor requirements and other gun operating characteristics require operation for both day and night conditions, the large operating pressures and high nozzle velocities result in more wind drift and evaporation losses than conventional multiple sprinkler systems, and uniformity is typically less than that of well-designed multiple sprinkler irrigation systems because of overlap between travel lanes and wind effects. The combination of these factors result in large gun EFF of 70%, which is less than the 75% typical of conventional multiple sprinkler irrigation systems (Smajstrla et al., 1988b).

Area of the Root Zone Irrigated

Large gun water application patterns are overlapped to assure uniformity of

water application. The entire soil surface area is irrigated when these systems are used (ARZI = 1.00 in the AFSIRS model).

Water Extraction from the Irrigated Zone

Water is extracted from large gun-irrigated root zones in the same manner as it is extracted from the root zones of other sprinkler-irrigated crops. For the same reasons as discussed for multiple sprinkler-irrigated crops, the upper 1/2 of the crop root zone is assumed to be the irrigated zone, 70% of the crop's ET requirements is assumed to be extracted from this zone, and the remaining 30% is extracted from the nonirrigated zone when water is available in this zone. When water is not available in the nonirrigated root zone, all of the ET is extracted from the irrigated root zone.

Seepage, Subirrigation

Seepage (subirrigation) irrigation systems are those which use an existing high water table or a restrictive soil layer to establish a water table immediately below the crop root zone. Irrigation is then by capillary movement of water upward from the water table and into the crop root zone.

Subirrigation is the term that is recognized by national standards (Hahn et al., 1989) as that preferred to describe irrigation systems in which water table control, and upward and lateral movement of water to a crop root zone are the mechanisms of irrigation. However, because of the wide acceptance of the term "seepage" in Florida, and because of the possibility of confusion of subirrigation with subsurface irrigation systems (those in which irrigation is applied below the soil surface, as with buried micro irrigation systems), the terms seepage irrigation or seepage (subirrigation) are used in this report.

Large acreages are seepage-irrigated in Florida. The Irrigation Journal (1989) reported that almost 1,000,000 acres are currently seepage or flood-irrigated. These estimates represent about 50% of the total irrigated acreage in Florida.

Primary seepage-irrigated crops in Florida are sugarcane, citrus, and vegetables. Almost all of the muck soil areas of the state are seepage-irrigated. Tomatoes, potatoes, and cabbage are the primary vegetable crops seepage-irrigated on sandy soils.

Seepage Irrigation Efficiencies

Irrigation application efficiencies are very site-specific for seepage systems. At a specific site, EFF depends on losses from the irrigated field due to deep percolation and lateral flow. Fields that are underlain by highly restrictive layers and that are surrounded by areas in which water tables are maintained at similar levels will have less water loss, and thus higher efficiencies than fields with soil layers that are not as restrictive, or that are surrounded by areas with lower water tables.

Seepage irrigation efficiencies are highly dependent on field size and shape if surrounding fields are not managed identically to the one in question. Large square fields have less perimeter per unit area, and thus less surface for lateral movement losses per unit area than small or oddly-shaped fields.

Topography may affect attainable seepage irrigation system efficiencies. Field slopes are required to drain excess rainfall in Florida. Slopes, however, cause runoff of irrigation water and will reduce EFF if tailwater is not recycled.

Management of seepage systems affects EFF. Prevatt et al. (1980) reported that only 38% of the water used on a 200 acre farm had to be pumped from a well when a

water conveyance and recovery system was used. Smajstrla et al. (1984c) reported a water savings of 16% and an increase in efficiency of 8% when the irrigation pump was cycled on and off in response to field water table elevations. Haman et al. (1986) reported larger increases in efficiency (21% to 46%) when tailwater was recycled rather than being discharged from seepage irrigation systems for vegetable production. The SCS (1982, 1985a) stated that seepage EFF would range from 50%-60% and that open supply ditch systems would be expected to have lower EFF than those of pipeline supply systems.

These factors illustrate that seepage irrigation system efficiencies are very site-specific. Because it was desired to develop the AFSIRS model with as few user inputs as possible, and with only relatively easily obtainable user inputs, and because the water management districts funding this work desired to encourage the use of seepage irrigation systems only in situations where their application efficiencies were at least 50%, the water management districts funding this work directed that a seepage irrigation application efficiency default value of 50% should be used in the AFSIRS model (Dr. Patrick Gleason, SFWMD, personal communication).

The AFSIRS model uses a default irrigation application efficiency of 50% for all seepage irrigation system simulations. This factor results in the calculation of a gross irrigation requirement that is double the net irrigation requirement. Irrigation requirements computed using this factor will be over-estimated for growers who are more efficient, and under-estimated for growers who are less efficient than 50%.

The AFSIRS model makes no specific calculation of irrigation required to establish water tables at the beginning of an irrigation season or after interruptions in irrigation due to rainfall or other causes. The volume required for this purpose must be assumed to be included in the irrigation application efficiency assumed, or it must be added to the simulated gross irrigation requirement by the model user.

Crown Flood (Citrus)

Crown flood irrigation systems are systems which are specifically applied only to irrigation of citrus on flatwoods soils. Because of high water tables and the danger of damage to tree roots, these soils are bedded before planting. Beds typically 2-4 ft high provide sufficient elevation to protect crops from high water tables following heavy rainfalls. Beds also provide a means of both surface and subsurface drainage.

Crown flood irrigation systems are irrigated by flooding the ditches between beds and allowing time for water to seep into and saturate the lower parts of the beds. Water is then drained from the field before the saturated conditions damage tree roots.

Specifications for crown flood irrigation system design were given by the SCS (1985b). Initial costs of land leveling and forming operations for crown flood irrigation are high (\$2,000-\$2,500 per acre), but operating and maintenance costs are sufficiently low that total annual costs are less than that of other system types (Harrison, 1976). Also, much of the land forming work is required for drainage, regardless of the type of irrigation system used. As long as water and pumping costs remain low, the total annual costs of crown flood irrigation systems will remain lower than that of other irrigation system types. Thus, crown flood irrigation systems will probably remain in use as long as water is available in sufficient quantities to flood the groves.

Crown Flood Irrigation Efficiency

The water application efficiency of a crown flood irrigation system is very

site-specific. It depends greatly on soil properties and on management of the land area being irrigated and surrounding land areas. If the soil is relatively impermeable to deep percolation losses, EFF can be high. If the soil is permeable, EFF can be low because of deep percolation losses.

If water drained from a crown flood-irrigated grove is reused on other groves, EFF can be high. If water is not reused, EFF can be very low. Smajstrla et al. (1982) reported a range in EFF of 24% to 76% depending on management.

If surrounding land areas have water tables which are near the elevations of those in the groves being irrigated, EFF may be high. If surrounding areas are not irrigated and water tables are lower than those in the irrigated groves, lateral movement of water will occur. Depending on soil properties, significant reductions in EFF may occur.

Because of all of the above factors, it is not possible to determine crown flood irrigation application efficiencies without site-specific soil, water table, and system management data. For these reasons, the fact that the AFSIRS model was developed to function for long-term average conditions, and the reasons discussed for seepage irrigation systems, the default value of the crown flood irrigation application efficiency was 0.5. As discussed for seepage irrigations systems, this value was obtained following consultation with representatives of the water management districts funding this work (Dr. Patrick Gleason, South Florida Water Management District, personal communication).

Flood (Rice)

Rice is a relatively new crop being produced in Florida. It is primarily being produced in the Everglades Agricultural Area where flood irrigation also reduces oxidation and subsidence of organic soils. At that location ET studies of rice were conducted by Shih et al. (1982).

Rice is produced under almost continuously flooded conditions. Water levels are established by levees and water control structures, and they are maintained until near the end of the growing season when the production areas are drained for harvest. Water levels are only permitted to fluctuate within small limits for optimum production and to control weed growth. Water is pumped continuously to maintain the required levels in the field.

In rice production, the permissible level of water table fluctuation following a rainfall largely defines the effectiveness of rainfall. If no fluctuation is permitted, rainfall will be ineffective as most of it will drain. If small amounts of fluctuation are permissible, then small amounts of rainfall will be effective. Likewise, if water levels are maintained low by irrigation, but allowed to raise a larger amount as a result of rainfall, then a greater portion of rainfall will be effective. Irrigation applications will be discontinued while rainfall stored in the field as the additional height of water is used. As a result, IRR will be reduced.

Because IRR is affected by the management of the flood irrigation system, and specifically the amount of fluctuation allowed in the water table, the allowable water table fluctuation must be input by the AFSIRS model user. The model requests this input from the keyboard when the rice flood irrigation system is selected.

Rice Flood Irrigation System Efficiency

The application efficiency of rice flood irrigation systems, like seepage and crown flood systems, and for the same reasons as for these systems, is very site-specific. Because it is highly site-specific and for the other reasons as previously discussed for seepage and crown flood systems, the default EFF of rice flood systems used in the AFSIRS model is 0.50.

Area of the Root Zone Irrigated

Because rice flood irrigation systems are flooded during irrigation, the entire soil surface is irrigated. Thus, the area of the crop root zone irrigated used in the AFSIRS model IR.DAT data base was 1.0.

Water Extraction from the Irrigated Zone

Because the water level is established above the soil surface for rice production, the entire crop root zone is irrigated, and the water extracted for irrigation is entirely from the irrigated zone. Thus EXIR for rice flood irrigation systems is 1.0 in the IR.DAT data base of the AFSIRS model.

APPENDIX D

EXAMPLE CLIMATE DATA BASE

The following is an example of a climate data base used in the AFSIRS model. This is a 4-year data base (1952-1955) of potential evapotranspiration (ETp) and rainfall (RAIN) for Tampa, Florida. Because of their length, the complete 25-year climate data bases for all 9 locations are not listed here. Rather, only 4 years of data are listed in order to display the format of these files.

TAMPA	DAILY POTENTIAL ET DATA (INCHES), 1952-1976													
4	YEARS OF RECORD													
1952	.083	.083	.075	.075	.091	.083	.079	.071	.083	.098	.091	.059	.063	.071
	.079	.071	.083	.075	.071	.083	.071	.094	.106	.110	.094	.083	.114	.059
	.102	.079	.091	.110	.059	.118	.110	.094	.102	.102	.102	.102	.098	.114
	.106	.110	.110	.094	.087	.122	.110	.118	.130	.122	.118	.094	.059	.063
	.075	.134	.106	.106	.102	.150	.110	.106	.083	.138	.154	.161	.213	.118
	.134	.122	.087	.154	.150	.150	.185	.106	.134	.173	.197	.185	.177	.075
	.055	.087	.150	.150	.177	.177	.130	.165	.173	.193	.165	.154	.161	.173
	.181	.181	.157	.205	.138	.209	.197	.169	.165	.177	.185	.138	.177	.193
	.181	.154	.177	.185	.232	.272	.240	.205	.189	.173	.193	.201	.205	.201
	.197	.201	.205	.228	.185	.224	.213	.213	.213	.220	.154	.157	.197	.197
	.205	.177	.209	.217	.224	.220	.177	.169	.138	.122	.220	.201	.228	.205
	.213	.197	.193	.134	.146	.154	.240	.236	.228	.154	.217	.185	.185	.169
	.217	.209	.181	.193	.209	.205	.201	.224	.209	.130	.220	.217	.173	.126
	.146	.213	.173	.142	.150	.189	.177	.201	.169	.169	.189	.130	.134	.181
	.189	.197	.213	.181	.173	.154	.217	.201	.213	.213	.205	.173	.169	.185
	.197	.165	.138	.098	.138	.165	.122	.154	.201	.165	.185	.173	.134	.193
	.189	.173	.134	.126	.146	.154	.098	.142	.161	.193	.197	.154	.134	.236
	.193	.150	.193	.138	.189	.181	.189	.161	.157	.161	.161	.146	.193	.232
	.213	.150	.110	.213	.165	.181	.130	.161	.173	.146	.154	.098	.122	.106
	.118	.161	.102	.161	.150	.161	.185	.098	.138	.165	.165	.130	.110	.075
	.067	.087	.091	.102	.094	.130	.118	.114	.102	.063	.067	.063	.075	.134
	.126	.126	.161	.161	.138	.106	.150	.169	.169	.122	.146	.142	.126	.130
	.110	.059	.134	.142	.102	.091	.075	.063	.098	.075	.102	.102	.130	.122
	.075	.059	.091	.075	.087	.110	.102	.087	.087	.146	.102	.102	.102	.075
	.083	.106	.071	.106	.102	.091	.098	.087	.102	.075	.043	.059	.079	.079
	.063	.071	.075	.071	.059	.059	.059	.079	.067	.063	.094	.059	.079	.071
.083														
1953	.087	.071	.122	.083	.063	.094	.094	.063	.067	.067	.079	.094	.102	.102
	.114	.110	.106	.075	.075	.055	.075	.094	.106	.126	.110	.087	.083	.087
	.083	.118	.091	.087	.071	.067	.091	.126	.126	.094	.154	.150	.146	.110
	.098	.114	.134	.161	.098	.110	.157	.154	.157	.154	.118	.126	.114	.106
	.110	.150	.130	.154	.150	.173	.157	.161	.154	.146	.177	.213	.161	.126
	.126	.106	.134	.146	.154	.185	.157	.165	.138	.094	.146	.142	.165	.236
	.177	.146	.161	.177	.150	.154	.161	.114	.114	.189	.177	.213	.154	.165
	.205	.150	.161	.130	.185	.244	.169	.197	.217	.185	.157	.220	.181	.201
	.185	.201	.201	.102	.193	.177	.205	.209	.213	.217	.240	.240	.220	.150
	.142	.157	.197	.217	.213	.220	.220	.224	.240	.228	.244	.232	.209	.213
	.217	.220	.213	.236	.205	.252	.272	.299	.291	.268	.240	.197	.240	.295
	.181	.114	.138	.146	.138	.205	.177	.189	.201	.213	.201	.197	.193	.197
	.154	.224	.220	.169	.205	.205	.181	.142	.126	.193	.240	.260	.244	.197
	.205	.173	.201	.197	.201	.224	.209	.205	.169	.181	.236	.209	.209	.161
	.169	.177	.217	.173	.181	.185	.193	.094	.118	.193	.154	.154	.150	.177
	.118	.185	.189	.173	.185	.193	.106	.197	.142	.142	.169	.154	.181	.201
	.165	.157	.177	.154	.157	.126	.122	.150	.118	.122	.130	.102	.138	.134
	.150	.130	.165	.177	.142	.087	.157	.106	.146	.169	.150	.114	.134	.169
	.177	.201	.177	.154	.114	.075	.067	.106	.114	.142	.146	.130	.130	.169
	.169	.118	.114	.150	.165	.142	.102	.110	.161	.150	.130	.138	.118	.165
	.071	.091	.161	.142	.134	.161	.165	.161	.150	.122	.063	.150	.165	.142

.161 .122 .130 .106 .122 .102 .083 .138 .122 .110 .114 .126 .130 .106
.079 .075 .106 .118 .083 .051 .102 .134 .130 .138 .122 .106 .126 .118
.130 .098 .091 .075 .063 .063 .126 .094 .079 .094 .122 .102 .098 .114
.110 .087 .083 .102 .114 .098 .091 .067 .098 .091 .083 .165 .079 .063
.102 .102 .098 .083 .079 .079 .047 .055 .051 .087 .087 .067 .079 .075
.102

1954

.110 .083 .079 .055 .063 .091 .110 .098 .098 .075 .075 .083 .106 .102
.087 .083 .087 .098 .083 .087 .094 .083 .094 .098 .110 .098 .087 .138
.110 .091 .079 .150 .110 .114 .122 .122 .118 .106 .134 .130 .110 .098
.106 .173 .146 .150 .146 .118 .138 .150 .150 .110 .154 .126 .157 .142
.118 .110 .114 .146 .126 .098 .161 .138 .075 .138 .118 .083 .118 .157
.154 .146 .126 .185 .185 .154 .142 .126 .110 .181 .173 .161 .154 .185
.165 .161 .138 .169 .161 .177 .173 .157 .169 .173 .248 .201 .169 .181
.177 .169 .169 .181 .173 .177 .154 .201 .209 .173 .205 .193 .209 .181
.130 .173 .181 .169 .181 .154 .197 .213 .193 .205 .201 .181 .213 .209
.213 .217 .236 .240 .224 .161 .154 .193 .185 .201 .197 .209 .224 .213
.236 .224 .236 .240 .197 .142 .157 .150 .102 .126 .177 .189 .189 .201
.154 .209 .209 .181 .193 .228 .244 .217 .205 .201 .197 .142 .173 .193
.142 .165 .181 .185 .130 .134 .165 .181 .185 .217 .220 .209 .197 .185
.201 .197 .193 .173 .142 .126 .094 .106 .118 .106 .126 .154 .173 .154
.150 .173 .201 .201 .193 .209 .209 .130 .146 .154 .150 .083 .110 .165
.189 .185 .169 .185 .201 .197 .201 .201 .161 .110 .165 .181 .165 .177
.185 .173 .201 .185 .177 .150 .181 .185 .154 .189 .197 .146 .181 .154
.134 .201 .094 .173 .142 .130 .173 .197 .165 .157 .213 .197 .193 .185
.193 .173 .138 .142 .122 .142 .169 .157 .154 .150 .165 .157 .098 .106
.130 .134 .110 .106 .134 .161 .173 .185 .138 .169 .173 .169 .134 .126
.110 .169 .165 .154 .142 .165 .169 .146 .169 .165 .157 .169 .150 .142
.157 .169 .150 .146 .138 .118 .110 .102 .114 .114 .094 .091 .118 .098
.071 .114 .130 .118 .114 .130 .094 .106 .122 .091 .083 .083 .079 .087
.087 .094 .087 .094 .071 .083 .091 .094 .098 .106 .083 .142 .087 .063
.087 .079 .091 .075 .098 .102 .083 .106 .083 .087 .051 .059 .071 .071
.071 .087 .083 .079 .071 .055 .059 .047 .059 .091 .079 .098 .083 .059
.075

1955

.083 .091 .094 .087 .079 .071 .079 .083 .059 .094 .091 .075 .114 .087
.075 .079 .083 .106 .114 .083 .075 .075 .063 .039 .071 .079 .071 .071
.071 .083 .091 .098 .110 .098 .142 .189 .161 .079 .079 .126 .114 .098
.110 .138 .114 .118 .122 .110 .150 .118 .161 .122 .110 .142 .094 .130
.126 .130 .134 .130 .126 .138 .142 .134 .142 .134 .173 .146 .138 .134
.134 .150 .146 .161 .154 .138 .150 .157 .169 .181 .126 .118 .071 .110
.075 .142 .083 .134 .110 .134 .173 .087 .169 .154 .197 .177 .161 .154
.185 .157 .154 .169 .161 .122 .150 .185 .181 .224 .201 .189 .177 .173
.189 .177 .185 .220 .201 .173 .213 .228 .220 .236 .220 .189 .193 .228
.213 .213 .213 .224 .217 .213 .205 .150 .189 .181 .189 .150 .126 .177
.142 .220 .205 .189 .201 .201 .197 .217 .189 .213 .228 .252 .248 .240
.240 .236 .244 .189 .244 .260 .224 .134 .236 .224 .213 .173 .122 .150
.173 .213 .193 .185 .213 .173 .213 .213 .173 .193 .126 .193 .185 .146
.185 .217 .213 .197 .201 .209 .142 .185 .134 .138 .154 .185 .173 .185
.189 .157 .177 .220 .181 .138 .177 .209 .146 .142 .213 .197 .138 .130
.181 .091 .161 .181 .189 .165 .177 .189 .169 .205 .193 .213 .220 .232
.201 .114 .142 .205 .213 .193 .138 .154 .181 .193 .193 .205 .126 .177
.157 .169 .177 .177 .130 .154 .130 .122 .181 .181 .142 .130 .134 .122
.094 .157 .181 .185 .197 .193 .185 .165 .146 .134 .110 .146 .138 .161
.185 .157 .185 .201 .181 .177 .177 .169 .134 .118 .134 .142 .161 .165
.130 .169 .157 .134 .118 .146 .110 .138 .134 .114 .134 .134 .146 .142
.154 .161 .142 .134 .134 .134 .138 .098 .114 .126 .110 .118 .102 .130
.102 .110 .102 .102 .055 .075 .094 .118 .130 .106 .098 .114 .102 .122
.106 .118 .094 .102 .106 .098 .091 .059 .079 .094 .142 .134 .118 .102
.087 .091 .055 .059 .067 .075 .094 .075 .071 .059 .079 .098 .067 .087
.071 .075 .067 .094 .083 .071 .059 .067 .055 .063 .067 .091 .122 .083
.094

TAMPA

DAILY RAINFALL DATA (INCHES), 1952-1955

1952

0.000	0.000	0.000	0.000	0.000	0.240	0.000	0.000	0.000	0.010	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000
0.000	0.005	0.000	0.640	0.000	0.000	0.000	0.000	0.520	0.030	0.130	0.460
0.000	0.230	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.250	0.010
0.000	0.000	0.290	0.000	0.000	0.005	0.290	0.100	1.210	0.220	0.000	0.000
0.000	0.000	0.020	0.005	0.090	0.000	0.000	0.000	0.000	0.050	0.000	0.005
0.340	1.630	0.000	0.000	0.000	0.090	0.000	0.000	0.000	0.000	0.005	1.650
2.230	0.390	0.000	0.005	0.000	0.000	0.005	0.000	0.000	0.100	0.005	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.220	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.930	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.010	0.000	0.000	0.120	0.005
0.005	0.000	0.070	1.070	0.000	0.740	0.000	0.005	0.000	0.000	0.000	0.005
0.000	0.030	0.005	0.005	0.005	0.000	0.000	1.370	0.000	0.070	0.005	0.070
0.000	0.000	0.000	0.050	0.005	0.005	0.010	0.005	0.080	0.380	0.160	0.000
0.610	1.150	1.170	0.000	1.380	0.005	0.890	0.000	0.000	0.000	0.360	0.060
0.980	0.100	0.005	0.350	0.005	0.005	0.000	0.000	0.000	0.950	0.000	0.000
0.000	0.000	0.030	0.080	0.270	0.700	0.080	2.150	0.060	0.050	0.000	0.005
0.580	0.005	0.000	0.005	0.000	0.000	0.005	0.000	0.000	0.005	0.220	0.005
0.260	0.005	0.040	0.005	0.260	0.000	0.000	0.005	0.200	0.000	0.340	0.010
0.000	0.100	0.230	0.000	0.000	0.010	1.540	0.005	0.000	0.000	0.005	0.000
0.040	0.050	0.210	0.000	0.020	0.000	0.000	0.000	0.005	0.140	0.330	0.080
1.290	0.010	1.290	0.000	0.005	0.005	0.250	0.005	0.000	0.005	0.000	0.000
0.005	0.005	0.630	0.310	1.040	0.005	0.000	0.005	0.005	0.420	0.005	1.710
0.000	0.370	0.140	1.700	0.540	0.010	0.005	0.010	0.000	0.000	0.005	0.180
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000
0.000	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.670
0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.040	0.040
0.005	0.000	0.000	0.000	0.000	0.060	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.060	0.000	0.000	0.500							

1953

0.000	0.010	0.010	0.000	0.040	0.000	0.000	0.005	3.290	0.210	0.005	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.005	0.000	0.460	0.010
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.440	0.000	0.000	0.000
0.000	1.520	0.040	0.000	0.000	0.000	0.005	0.000	0.000	0.480	0.000	0.000
0.000	0.000	0.010	0.000	0.005	0.005	0.005	0.000	0.020	0.005	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.050	0.005	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.300	0.360	0.030	0.000	0.000
0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.005	0.005	0.000	0.000	0.000
0.310	0.000	0.005	0.000	0.005	0.340	0.780	0.000	0.720	0.005	0.000	0.000
0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.800	0.000	0.000	0.000	0.005
0.000	0.000	0.000	0.000	0.000	0.000	0.470	0.000	0.000	0.005	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.210	2.280
0.220	0.000	0.240	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.005	0.000
1.430	0.000	0.005	0.430	0.010	1.070	0.900	0.270	0.650	0.180	0.005	0.000
0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.340
0.000	0.000	0.000	0.005	1.080	0.040	1.190	0.005	0.005	0.020	0.030	1.150
0.380	0.900	0.140	0.000	0.000	1.480	0.040	0.000	0.000	0.100	0.160	0.000
0.350	0.000	0.290	0.900	0.000	0.020	0.080	0.220	0.230	0.000	0.140	0.530
0.000	0.020	0.000	0.060	0.005	0.070	0.005	0.150	0.070	0.720	0.005	0.100
0.005	0.610	0.510	0.440	0.140	0.010	0.005	0.005	0.005	0.110	0.000	0.500
0.005	0.000	0.000	0.000	0.100	1.770	2.690	0.150	0.500	0.050	0.460	0.090
0.460	0.020	0.670	0.005	1.970	0.270	0.000	0.000	1.160	0.090	0.020	0.130
0.100	0.005	0.040	0.005	0.150	0.440	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.130	0.180	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000
0.420	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.540	0.005	0.000	0.000
0.005	0.160	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.300
0.000	0.005	0.100	3.110	0.360	0.320	0.000	0.000	0.000	0.000	0.000	0.000
0.000	1.540	0.030	0.020	0.005	0.000	0.000	0.005	0.000	0.000	0.790	0.005
0.000	0.000	0.000	0.000	0.000	0.000	0.240	0.060	1.540	0.005	0.010	0.000

0.000 0.000 0.000 0.030 0.020

1954

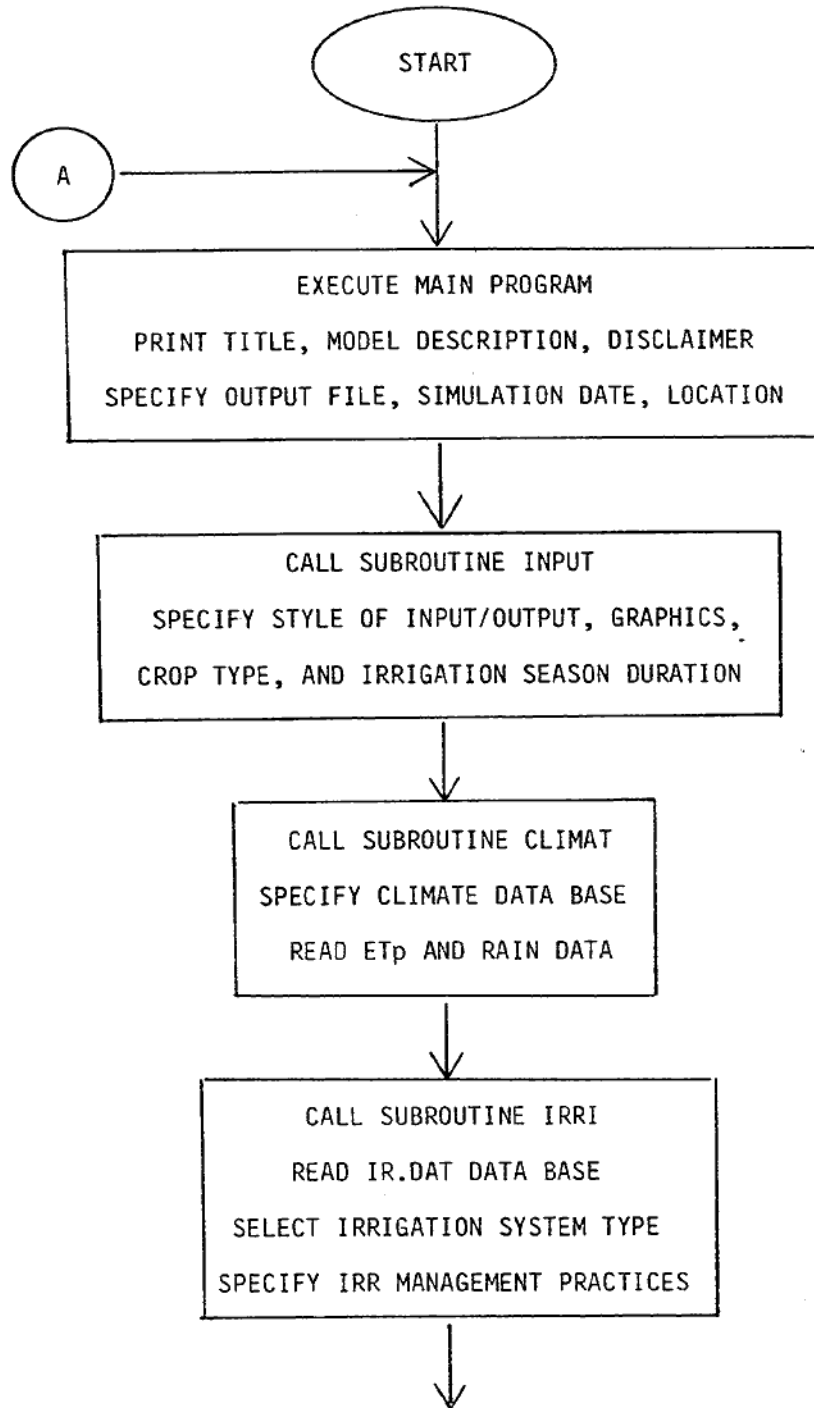
0.000	0.380	0.020	0.000	0.040	0.000	0.000	0.000	0.000	0.000	0.530	0.000
0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000
0.005	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.005	0.000	0.000	0.000
0.000	0.030	0.320	0.000	0.000	0.005	0.005	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.010	0.690	0.000	0.000	0.480	0.000	0.000	0.000	0.050	0.000
0.000	0.270	0.000	0.000	0.410	0.005	0.000	0.110	0.000	0.000	0.000	0.000
0.060	0.000	0.000	0.000	0.000	0.910	0.250	0.005	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.000	0.020	0.005	0.370
0.140	0.000	0.430	0.000	0.110	0.000	0.005	0.000	0.020	0.190	0.000	0.000
0.000	0.005	0.005	0.005	0.120	0.070	0.940	0.070	0.000	0.000	0.000	0.000
0.180	0.005	0.000	0.410	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.760
0.610	0.040	0.000	0.000	0.000	0.000	0.000	1.130	0.000	0.000	0.000	0.000
0.000	0.005	0.140	0.130	0.050	0.005	2.450	0.000	0.000	0.005	0.470	0.000
0.000	0.040	0.020	0.000	0.000	0.000	0.000	0.320	0.860	1.400	0.000	0.110
0.005	0.080	0.470	0.000	0.460	0.070	0.005	0.005	0.005	0.000	0.000	0.000
0.270	0.140	0.010	0.480	0.070	0.140	0.110	0.060	0.540	0.140	0.160	0.350
0.920	0.005	0.140	0.000	0.390	0.060	0.060	0.000	0.000	0.000	0.230	0.290
0.220	0.070	0.120	0.920	0.750	0.005	0.005	0.360	0.005	0.090	0.000	0.000
0.000	0.000	0.410	0.070	0.000	0.005	0.070	0.005	0.130	0.790	0.000	0.490
0.005	0.005	0.000	0.070	0.250	0.230	0.005	0.170	0.020	0.005	0.120	0.150
1.620	0.050	0.000	0.005	0.005	0.005	0.040	0.760	0.000	0.000	0.000	0.000
0.000	0.730	0.050	0.010	0.110	0.005	0.005	0.010	1.380	0.210	0.000	0.000
0.180	1.570	0.040	0.890	0.300	0.000	0.000	0.070	0.000	0.010	0.150	0.000
0.000	0.000	0.140	0.000	0.020	0.000	0.000	0.005	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.310	0.000	0.000	0.000	0.000	0.000	0.000	0.080	0.000	0.000	0.000
0.000	0.000	0.420	0.000	0.070	3.490	0.000	0.100	0.460	0.000	0.120	0.080
0.000	0.230	0.260	0.000	0.060	0.000	0.000	0.000	0.010	0.000	0.000	0.000
0.000	0.000	0.000	0.370	0.000	0.000	0.005	0.020	0.000	0.000	0.910	0.005
0.000	0.000	0.000	0.550	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000							

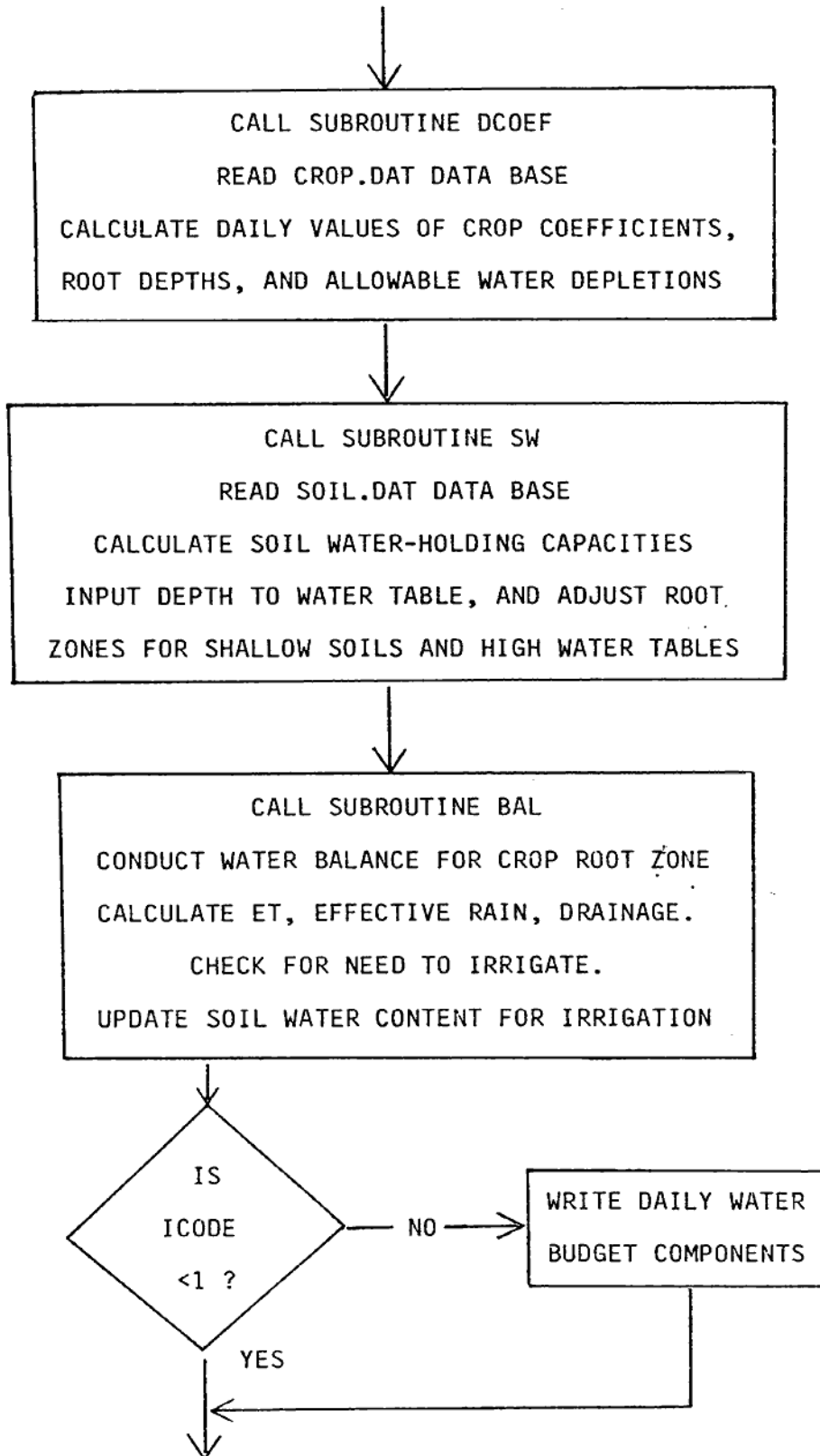
1955

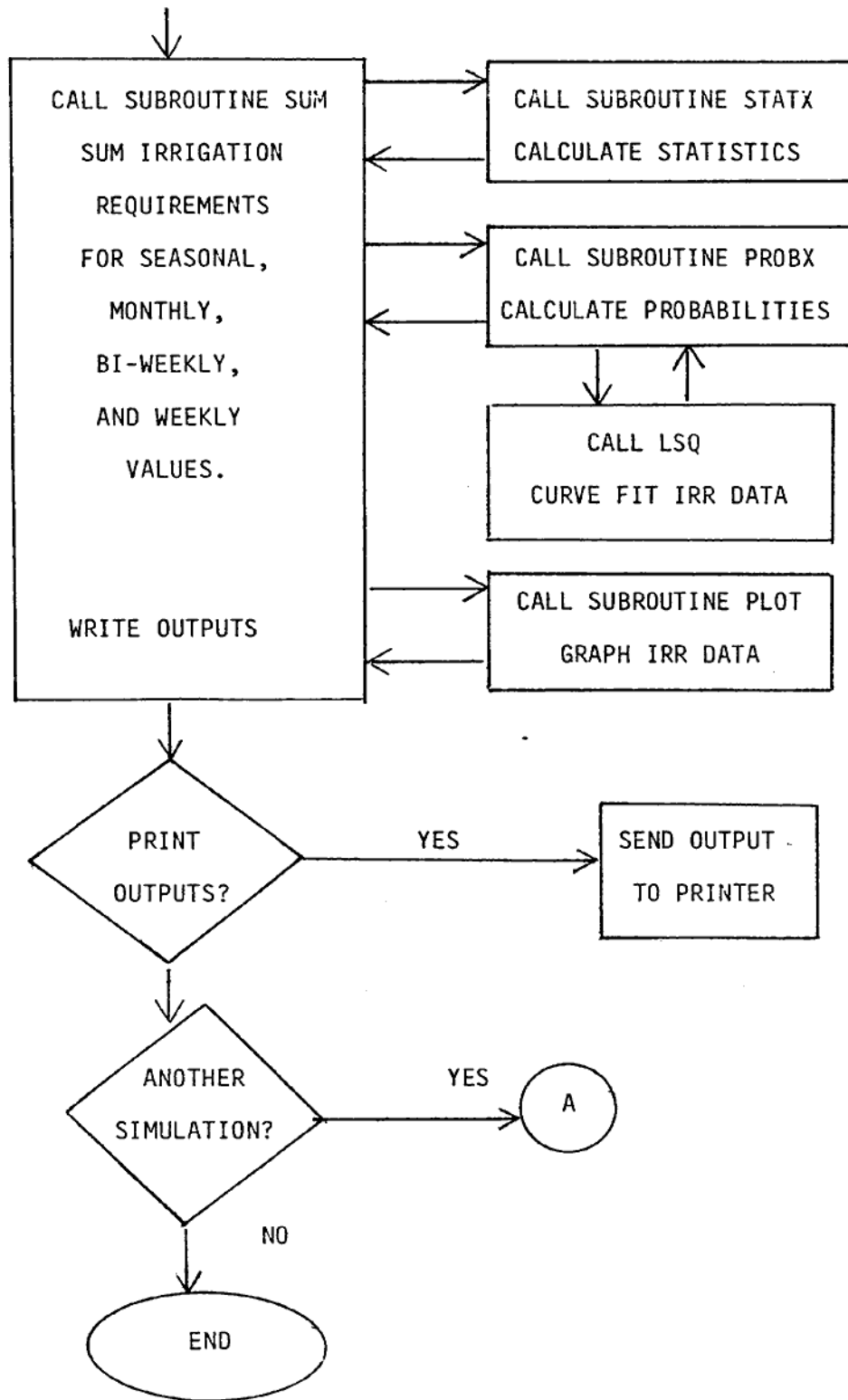
0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.020	0.000
0.000	0.000	0.000	0.750	0.240	0.350	0.005	0.000	0.000	0.005	0.380	0.850
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000
0.000	0.030	0.350	0.000	0.005	2.350	0.000	0.000	0.000	0.000	0.000	0.005
0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.000	1.280	0.150
0.620	0.005	0.450	0.050	0.000	0.000	0.000	0.920	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.005	0.070	0.000	0.240	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.230	0.005	0.010	0.000	0.005	0.005	0.005	0.000
0.000	0.070	0.210	0.190	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.550	0.000	0.000	0.000	0.005	0.380	0.050
0.490	0.070	0.000	0.005	0.000	0.050	0.000	0.000	0.005	0.630	0.120	0.000
0.210	2.840	0.400	0.080	0.005	0.000	0.420	1.240	0.470	0.050	0.030	0.005
0.570	0.020	0.000	0.170	1.300	0.180	0.020	0.110	0.020	0.110	0.020	0.060
0.010	0.000	0.000	1.710	0.060	1.090	0.000	0.920	0.780	0.060	1.080	0.150
0.005	0.000	0.370	0.000	0.100	0.000	0.000	0.000	0.200	0.880	0.010	0.000
0.000	0.000	0.380	0.300	0.000	0.000	0.000	0.660	0.610	0.200	0.000	0.005
0.000	2.330	1.460	0.430	1.800	0.090	1.000	0.180	0.005	0.110	0.290	0.005
1.450	0.090	0.230	0.005	0.000	0.005	0.000	0.005	0.040	0.000	1.200	0.000
0.220	0.070	0.000	0.550	0.350	0.000	0.720	0.000	0.000	0.000	0.210	0.740
0.050	0.005	0.005	0.000	0.000	0.005	0.140	0.005	0.005	0.000	0.030	0.000
0.000	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

0.000	1.970	0.050	0.000	0.000	0.000	0.005	0.005	0.000	0.000	0.000	0.000
0.690	1.310	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.150	0.005	0.005	0.000	0.000	0.000	0.000
0.000	0.000	0.150	0.140	0.005	0.000	0.005	0.000	0.030	0.200	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
0.030	0.120	0.000	0.000	0.000							

APPENDIX E
AFSIRS MODEL FLOW CHART







APPENDIX F

LISTING OF AFSIRS MODEL FORTRAN COMPUTER CODE,
INTERACTIVE MODEL VERSION

```
C*****
C
C           AFSIRS MODEL - INTERACTIVE VERSION
C
C           VERSION 5.5:   January, 1990
C
C           AGRICULTURAL FIELD SCALE IRRIGATION REQUIREMENTS
C           SIMULATION MODEL
C
C           BY
C           A.G. SMAJSTRLA
C           AGRICULTURAL ENGINEERING DEPARTMENT
C           UNIVERSITY OF FLORIDA
C*****
C
C           THIS MODEL CALCULATES IRRIGATION REQUIREMENTS FOR FLORIDA
C           AGRICULTURAL CROPS, AND FOR GIVEN SOIL, IRRIGATION SYSTEM,
C           CLIMATE, AND MANAGEMENT CONDITIONS.
C
C           ALTHOUGH THIS MODEL IS BELIEVED TO BE COMPLETE AND ACCURATE,
C           NO EXPLICIT OR IMPLICIT WARRANTIES ARE MADE WITH REGARD TO ITS
C           USE.  THE RESPONSIBILITY FOR THE USE OF THIS MODEL FOR ANY
C           SPECIFIC PURPOSE LIES SOLELY WITH THE USER.
C
C           INSTRUCTIONS FOR THE USE OF THIS MODEL ARE GIVEN IN THE AFSIRS
C           MODEL USER'S GUIDE.  DETAILS OF THE MECHANISMS OF OPERATION OF
C           THE MODEL, ITS APPLICATIONS, AND LIMITATIONS ARE GIVEN IN THE
C           AFSIRS MODEL TECHNICAL MANUAL.
C*****
C
C           DEFINITIONS....
C
C           IR = IRRIGATION SYSTEM IDENTIFICATION CODE
C           IRCRFL = CROWN FLOOD IRRIGATION SYSTEM CODE
C           IRNSCY = CONTAINER NURSERY IRRIGATION SYSTEM CODE
C           IRRICE = RICE FLOOD IRRIGATION SYSTEM CODE
C           IRSEEP = SEEPAGE (SUBIRRIGATION) IRRIGATION SYSTEM CODE
C           ISIM = COUNTER FOR MULTIPLE SIMULATIONS
C           JDAY = CALENDAR DAY OF CROP IRRIGATION SEASON
C           J1SAVE = CALENDAR DAY OF FIRST DAY OF IRRIGATION SEASON FOR
C                   PREVIOUS SIMULATION
C           JNSAVE = CALENDAR DAY OF LAST DAY OF IRRIGATION SEASON FOR
C                   PREVIOUS SIMULATION
C           NCP = NUMBER OF DIFFERENT PERENNIAL CROP TYPES
C           SITE = DESCRIPTION OF LOCATION OF THE PRODUCTION SYSTEM SIMULATED
C
C           REAL IRR(25,365),NIR(365)
C           CHARACTER SITE*36, CTYPE*12, OUTFIL*20, TEXT*80
C
C           COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C           $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C           $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
C           $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C           $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C           $ ICODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,CTYPE
C
```

```

IR = 0
ISIM = 0
ICIT = 4
INSCY = 8
IRICE = 48
IRNSYC = 5
IRCRFL = 8
IRSEEP = 7
IRRICE = 9
J1SAVE = 0
JNSAVE = 0
ICGP = 6
ICGA = 34
EPS = 0.000001

```

C

C..... WRITE HEADER PAGE

```

WRITE(*,108)
WRITE(*,70)
WRITE(*,30)

```

```

30  FORMAT(/,26X,'AGRICULTURAL',/,26X,'FIELD',/,26X,'SCALE',/,26X,'IRR
$IGATION',/,26X,'REQUIREMENTS',/,26X,'SIMULATION',/,29X,'MODEL')

```

```

WRITE(*,40)

```

```

40  FORMAT(//,14X,'AFSIRS MODEL: INTERACTIVE VERSION 5.5')

```

```

WRITE(*,50)

```

```

50  FORMAT(//,11X,'THIS MODEL SIMULATES IRRIGATION REQUIREMENTS',/,
$9X,'FOR FLORIDA CROPS, SOILS, AND CLIMATE CONDITIONS.')

```

```

WRITE(*,60)

```

```

60  FORMAT(/,6X,'PROBABILITIES OF OCCURRENCE OF IRRIGATION REQUIREMENT
$$',/,8X,'ARE CALCULATED USING HISTORICAL WEATHER DATA BASES',/,
$19X,'FOR NINE FLORIDA LOCATIONS.')

```

C

```

WRITE(*,70)

```

```

PAUSE '

```

```

PRESS <RETURN> TO CONTINUE : '

```

C

```

WRITE(*,108)

```

```

WRITE(*,70)

```

```

70  FORMAT(/,70('*'))

```

```

WRITE(*,75)

```

```

75  FORMAT(//,6X,

```

```

$'ALTHOUGH THIS MODEL IS BELIEVED TO BE COMPLETE AND ACCURATE',/,
$2X,'NO EXPLICIT OR IMPLICIT WARRANTIES ARE MADE WITH REGARD TO ITS
$ USE.',/,9X,'THE RESPONSIBILITY FOR THE USE OF THIS MODEL FOR ANY
$ ',/,14X,'SPECIFIC PURPOSE LIES SOLELY WITH THE USER.')

```

C

```

WRITE(*,80)

```

```

80  FORMAT(//,10X,'INSTRUCTIONS FOR THE USE OF THIS MODEL ARE GIVEN',

```

```

$ /,17X,'IN THE AFSIRS MODEL USER'S GUIDE.',/,7X,

```

```

$ 'DETAILS OF THE OPERATION OF THIS MODEL, ITS APPLICATIONS',/,4X,

```

```

$ 'AND LIMITATIONS ARE GIVEN IN THE AFSIRS MODEL TECHNICAL MANUAL.')

```

C

```

WRITE(*,70)

```

C

C..... READ OUTPUT FILE NAME FROM KEYBOARD

```

82  WRITE(*,85)

```

```

85  FORMAT(//,20X,'ENTER OUTPUT FILE NAME:',/)

```

```

READ(*,'(A20)',ERR=82) OUTFIL

```

```

WRITE(*,86) OUTFIL

```

```

86  FORMAT(//,15X,'OUTPUT FILE NAME ENTERED = ',A20)

```

C

C..... OPEN OUTPUT FILE

```

OPEN(6,FILE=OUTFIL,STATUS='NEW',ERR=88)

```

```

GO TO 94

```

```

88  WRITE(*,90)

```

```

90  FORMAT(//,14X,'FILE ALREADY EXISTS OR ILLEGAL FILE NAME',/,21X,

```

```

$ 'ENTER 1 TO OVER-WRITE:',/,13X,
$ 'ENTER 0 TO SPECIFY NEW OUTPUT FILE NAME:')
  READ(*,*,ERR=88) IFILE
  IF(IFILE .EQ. 0) GO TO 82
  IF(IFILE .EQ. 1) GO TO 92
  GO TO 88
92 OPEN(6,FILE=OUTFIL)
C
94 WRITE(6,95)
95 FORMAT(1H1)
  WRITE(6,70)
  WRITE(6,30)
  WRITE(6,40)
  WRITE(6,50)
  WRITE(6,60)
  WRITE(6,70)
  WRITE(6,80)
  WRITE(6,70)
C
C..... ITERATE SIMULATIONS
100 CONTINUE
  FRIR = 1.00
  FIX = 0.00
  DO 105 JD =1,365
105 JDAY(JD) = JD
  ISIM = ISIM + 1
  J1REP = J1SAVE
  JNREP = JNSAVE
C
C..... OPEN SCRATCH PRINT FILE
  OPEN(4,FILE='AF.OUT',STATUS='UNKNOWN')
C
  WRITE(*,108)
108 FORMAT(10(/))
  WRITE(*,70)
  WRITE(6,95)
  WRITE(4,95)
  WRITE(*,40)
  WRITE(6,40)
  WRITE(4,40)
  WRITE(*,50)
  WRITE(6,50)
  WRITE(4,50)
  WRITE(6,70)
  WRITE(4,70)
  WRITE(*,70)
C
  IF(ISIM .GT. 1) GO TO 130
110 WRITE(*,120)
120 FORMAT(/,15X,'ENTER TODAY'S DATE (MONTH, DAY, YEAR) :')
  READ(*,*,ERR=110)MONTH,IIDAY,IYEAR
130 WRITE(*,140)MONTH,IIDAY,IYEAR
140 FORMAT(/,43X,'DATE: ',I2,' - ',I2,' - ',I4)
C
150 WRITE(*,160)
160 FORMAT(/,18X,'ENTER LOCATION / SITE DESCRIPTION :')
  READ(*,170,ERR=150) SITE
170 FORMAT(A36)
  WRITE(*,180) SITE
180 FORMAT(/,21X,'LOCATION : ',A36)
  WRITE(6,190) SITE,MONTH,IIDAY,IYEAR
  WRITE(4,190) SITE,MONTH,IIDAY,IYEAR
190 FORMAT(/,1X,'LOCATION = ',A36,2X,'DATE = ',I2,'-',I2,'-',I4)
C

```

```

C..... CALL SUBROUTINES
      CALL INPUT
      CALL CLIMAT
      CALL IRRI
      CALL DCOEF(ICGP,ICGA)
      CALL SW
C
      WRITE(*,108)
200  WRITE(*,210)
210  FORMAT(////,23X,'THIS COMPLETES DATA ENTRY',///,26X,'ENTER 1 TO
$COMPUTE',/,17X,'ENTER 0 TO RETURN TO DATA ENTRY MODE:')
      READ(*,*,ERR=200) IXX
      IF(IXX .EQ. 0) GO TO 100
      WRITE(*,250)
250  FORMAT(/,24X,'***** COMPUTING *****')
C
      CALL BAL
      CALL SUMX
      CLOSE(4)
C
300  WRITE(*,320)
320  FORMAT(///,23X,'PRINT SIMULATION RESULTS?',///,18X,'1 = YES, PRINT
$AND SAVE TO DISK FILE',/,18X,'0 = NO, SAVE TO DISK FILE ONLY')
      READ(*,*,ERR=300) IPRT
      IF(IPRT .EQ. 0) GO TO 400
      IF(IPRT.LT.0 .OR. IPRT.GT.1) GO TO 300
C
C..... PRINT AF.OUT FILE
      OPEN(4,FILE='AF.OUT')
      OPEN(10,FILE='PRN')
340  READ(4,350,END=360) TEXT
      WRITE(10,350) TEXT
350  FORMAT(A80)
      GO TO 340
360  CLOSE(4)
      CLOSE(10)
C
400  WRITE(*,500)
500  FORMAT(///,19X,'DO YOU WANT TO RUN ANOTHER SIMULATION?',///,33X,
$ '1 = YES',/,33X,'0 = NO')
      READ(*,*,ERR=400) IRPT
      IF(IRPT .EQ. 1) GO TO 100
C
C..... DELETE SCRATCH PRINT FILE
      OPEN(4,FILE='AF.OUT')
      CLOSE(4,STATUS='DELETE')
C
      CLOSE(6)
      END
C
C*****
C
      SUBROUTINE INPUT
C*****
C..... THIS SUBROUTINE ALLOWS THE AFSIRS MODEL USER TO INTERACTIVELY
C      ENTER DATA TO RUN THE MODEL
C
C      DEFINITIONS....
C
C      CROP = CROP TYPE
C      DAY1 = 1ST DAY OF IRRIGATION SEASON
C      DAYN = LAST DAY OF IRRIGATION SEASON
C      CDAY = CONSECUTIVE DAYS OF CROP IRRIGATION SEASON
C      ICROP = CROP TYPE CODE

```

```

C  ICODE = CODE TO SPECIFY STYLE OF OUTPUT
C  IPRT = CODE WHICH SUPPRESSES PRINTING OF ROWS OF ZEROS WHEN = 1
C  IVERS = CODE TO SPECIFY USE OF DEFAULT DATA BASES WHEN = 0, OR
C          TO SPECIFY DATA ENTRY FROM KEYBOARD WHEN = 1
C  JDAY = CALENDAR DAY OF CROP IRRIGATION SEASON
C  J1 = FIRST DAY OF CROP IRRIGATION SEASON
C  JN = LAST DAY OF CROP IRRIGATION SEASON
C  MO1 = 1ST MONTH OF IRRIGATION SEASON
C  MON = LAST MONTH OF IRRIGATION SEASON
C  NCA = NUMBER OF DIFFERENT ANNUAL CROPS
C  NCP = NUMBER OF DIFFERENT PERENNIAL CROP TYPES
C  NCROP = TOTAL NUMBER OF DIFFERENT CROPS
C  NDAYS = LENGTH OF IRRIGATION SEASON (DAYS)
C
C      REAL IRR(25,365),NIR(365)
C      CHARACTER*12 CROP(60), DUMMY, CTYPE
C      INTEGER DAY1, DAYN, MDAY(12)
C
C      COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C      $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C      $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,IILSAVE,ISIM,
C      $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C      $ JLSAVE,JNSAVE,JLREP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C      $ ICODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,CTYPE
C
C      DATA MDAY/31,28,31,30,31,30,31,31,30,31,30,31/
C
C..... SPECIFY STYLE OF OUTPUT (ICODE)
100  WRITE(*,110)
110  FORMAT(///,17X,'ENTER ICODE TO DEFINE STYLE OF OUTPUT:',//,
C      $ 16X,'ICODE = -1 FOR BASIC (MINIMAL) OUTPUT',/,
C      $ 7X,'ICODE = 0 FOR BASIC PLUS BIWEEKLY & WEEKLY SUMMARIES',/,
C      $ 9X,'ICODE = 1 FOR OUTPUT OF INTERMEDIATE PARAMETERS',/,4X,
C      $ 'ICODE = 2 FOR EXTENSIVE OUTPUT (NORMALLY FOR DEBUGGING ONLY)')
      READ(*,*,ERR=100) ICODE
      IF(ICODE .GT. 2) GO TO 100
      IF(ICODE .LT. -1) GO TO 100
      WRITE(*,120) ICODE
120  FORMAT(22X,'ICODE ENTERED WAS = ',I2)
C
      IPRT = 0
      IF(ICODE .EQ. -1) GO TO 150
130  WRITE(*,140)
140  FORMAT(///,10X,'ENTER CODE TO SUPPRESS PRINTING OF DATA SUMMARIES'
C      $,/,17X,'WHEN IRRIGATION REQUIREMENTS = 0.0 :',//,18X,'PRINT CODE =
C      $ 1 TO SUPPRESS PRINTING', /,18X,'PRINT CODE = 0 TO PRINT ALL ZER
C      $OS',//,26X,'ENTER PRINT CODE :')
      READ(*,*,ERR=130) IPRT
      IF(IPRT .LT. -98) GO TO 100
      WRITE(*,145) IPRT
145  FORMAT(/,23X,'PRINT CODE ENTERED =',I2)
      IF(IPRT .GT. 1) GO TO 130
      IF(IPRT .LT. 0) GO TO 130
C
C..... SPECIFY GRAPHICS OUTPUT OPTION
150  WRITE(*,152)
152  FORMAT(///,20X,'ENTER 1 TO GRAPH OUTPUTS:',/,20X,'ENTER 0 FOR
C      $NO GRAPHS:')
      READ(*,*,ERR=150) IPLLOT
      IF(IPLLOT.LT.-98 .AND. ICODE.EQ.-1) GO TO 100
      IF(IPLLOT.LT.-98 .AND. ICODE.GT.-1) GO TO 130
      IF(IPLLOT.LT.0 .OR. IPLLOT.GT.1) GO TO 150
      IF(IPLLOT .EQ. 0) WRITE(*,154)
154  FORMAT(/,21X,'NO GRAPHS WILL BE PRODUCED')

```

```

        IF(IPLOT .EQ. 1) WRITE(*,156)
156  FORMAT(/,22X,'RESULTS WILL BE GRAPHED')
C
C..... SPECIFY STYLE OF INPUT
160  WRITE(*,170)
170  FORMAT(///,7X,'IRRIGATION REQUIREMENTS CALCULATED USING THE AFSIRS
$ MODEL',/,10X,'ARE VERY SENSITIVE TO THE CROP ROOT DEPTH, FRACTION
$',/,9X,'OF THE ROOT ZONE IRRIGATED, AND IRRIGATION EFFICIENCY.',/,
$,7X,'ENTER 0 TO USE THE MODEL DEFAULT VALUES FOR THESE DATA.',/,
$ 7X,'ENTER 1 IF THESE DATA WILL BE ENTERED FROM THE KEYBOARD.')
```

```

        READ(*,*,ERR=160) IVERS
        IF(IVERS .LT. -98) GO TO 150
        WRITE(*,180) IVERS
180  FORMAT(23X,'INPUT CODE ENTERED =',I2)
        IF(IVERS .GT. 1) GO TO 160
        IF(IVERS .LT. 0) GO TO 160
C
C..... SPECIFY CROP TYPE
        OPEN(8,FILE='CROP.DAT')
C
        READ(8,200) NCP
200  FORMAT(I3)
        READ(8,210) DUMMY
C
        DO 220 ICP =1,NCP
        READ(8,210) CROP(ICP)
210  FORMAT(A12)
220  READ(8,210) DUMMY
C
        READ(8,210) DUMMY
        READ(8,200) NCA
        READ(8,210) DUMMY
        NCP1 = NCP + 1
        NCROP = NCP + NCA
        READ(8,210) (CROP(ICP),ICP=NCP1,NCROP)
C
        CLOSE(8)
C
C..... WRITE LIST OF CROPS
        IF(ICODE .LT. 1) GO TO 300
        WRITE(6,230) NCROP
        WRITE(4,230) NCROP
230  FORMAT(/,17X,'CROP LIST : TOTAL NUMBER =',I3)
        WRITE(6,240) NCP
        WRITE(4,240) NCP
240  FORMAT(/,17X,'NUMBER OF PERENNIAL CROPS =',I3)
        WRITE(6,350) (ICP,CROP(ICP),ICP=1,NCP)
        WRITE(4,350) (ICP,CROP(ICP),ICP=1,NCP)
        WRITE(6,250) NCA
        WRITE(4,250) NCA
250  FORMAT(/,16X,'NUMBER OF ANNUAL CROPS =',I3)
        WRITE(6,350) (ICP,CROP(ICP),ICP=NCP1,NCROP)
        WRITE(4,350) (ICP,CROP(ICP),ICP=NCP1,NCROP)
C
300  WRITE(*,320)
320  FORMAT(///,14X,'***** PERENNIAL CROPS *****')
        WRITE(*,350) (ICP,CROP(ICP),ICP=1,NCP)
        WRITE(*,340)
340  FORMAT(15X,'***** ANNUAL CROPS *****')
        WRITE(*,350) (ICP,CROP(ICP),ICP=NCP1,NCROP)
350  FORMAT(5X,I3,1X,A12,3X,I3,1X,A12,3X,I3,1X,A12)
C
360  WRITE(*,370)
370  FORMAT(24X,'ENTER CROP CODE:')

```

```

        READ(*,*,ERR=360) ICROP
        IF(ICROP .LT. -98) GO TO 160
380    IF(ICROP .LT. 1) GO TO 400
        IF(ICROP .GT. NCROP) GO TO 400
        GO TO 440
C
C..... READ CROP CODE AND CROP TYPE
400    WRITE(*,420) ICROP
420    FORMAT(//,10X,'THE CROP CODE WAS INCORRECTLY SPECIFIED AS ',I3)
        GO TO 300
440    WRITE(*,460) ICROP,CROP(ICROP)
460    FORMAT(/,20X,'THE CROP CODE SELECTED = ',I2,/,
$ 17X,'THE CROP TYPE SELECTED IS : ',A12)
        WRITE(6,480) CROP(ICROP)
        WRITE(4,480) CROP(ICROP)
480    FORMAT(/,22X,'CROP TYPE = ',A12)
        CTYPE = CROP(ICROP)
C
C..... SPECIFY LENGTH OF IRRIGATION SEASON
500    WRITE(*,520)
520    FORMAT(///,7X,'ENTER BEGINNING DATE OF CROP IRRIGATION SEASON (MON
$TH, DAY):')
        READ(*,*,ERR=500) MO1, DAY1
        IF(MO1 .LT. -98) GO TO 300
        IF(MO1.LT.1 .OR. MO1.GT.12) GO TO 500
        IF(DAY1.LT.1 .OR. DAY1.GT.31) GO TO 500
C
600    WRITE(*,620)
620    FORMAT(/, 9X,'ENTER ENDING DATE OF CROP IRRIGATION SEASON (MONTH,
$DAY):')
        READ(*,*,ERR=600) MON, DAYN
        IF(MON .LT. -98) GO TO 500
        IF(MON.LT.1 .OR. MON.GT.12) GO TO 600
        IF(DAYN.LT.1 .OR. DAYN.GT.31) GO TO 600
C
        WRITE(*,640) MO1, DAY1, MON, DAYN
640    FORMAT(/,11X,'THE IRRIGATION SEASON SPECIFIED WAS ',I2,'-',I2,
$ ' TO ',I2,'-',I2)
C
C..... CALCULATE LENGTH OF IRRIGATION SEASON
        MO11 = MO1 - 1
        MON1 = MON - 1
C
        J1 = DAY1
        IF(MO1 .EQ. 1) GO TO 720
        DO 700 IMO = 1,MO11
700    J1 = J1 + MDAY(IMO)
720    JN = DAYN
        IF(MON .EQ. 1)GO TO 800
        DO 740 IMO = 1,MON1
740    JN = JN + MDAY(IMO)
800    IF(J1 .GT. JN) GO TO 820
        NDAYS = JN - J1 + 1
        GO TO 840
C
820    NDAYS = JN + (366 - J1)
840    WRITE(*,860) NDAYS
860    FORMAT(/,18X,'LENGTH OF IRRIGATION SEASON = ',I3,' DAYS')
        WRITE(6,880) MO1,DAY1,MON,DAYN,NDAYS
        WRITE(4,880) MO1,DAY1,MON,DAYN,NDAYS
880    FORMAT(/,1X,'IRRIGATION SEASON = ',I2,'-',I2,' TO ',I2,'-',I2,
$ 15X,'LENGTH = ',I3,' DAYS')
        WRITE(*,900)J1,JN
900    FORMAT(28X,'J1=',I4,3X,'JN=',I4)

```

```

C
C..... SAVE GROWING SEASON DATA FOR NEXT SIMULATION
      J1SAVE = J1
      JNSAVE = JN
      IF(J1 .LT. JN) GO TO 990
      J1 = 1
      JN = NDAYS
C
990 CONTINUE
      END
C
C*****
C
      SUBROUTINE CLIMAT
C*****
C..... THIS SUBROUTINE READS CLIMATE DATA (ETP AND RAIN) FOR THE
C      SIMULATION LOCATION AND FOR ALL YEARS OF RECORD.
C
C      ALOC = WEATHER DATA BASE LOCATION
C      ETP = DAILY POTENTIAL EVAPOTRANSPIRATION (INCHES)
C      NLOC = NUMBER OF WEATHER DATA BASE LOCATIONS
C      NYR = NUMBER OF YEARS OF RECORD IN THE CLIMATE DATA BASE
C      RAIN = DAILY RAINFALL (INCHES)
C
      REAL IRR(25,365),NIR(365)
      CHARACTER ALOC*16, CTYPE*12, CLMFIL*20
C
      COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
      $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
      $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
      $ ICROP,SWC11,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
      $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
      $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,CTYPE
C
C..... CHECK WHETHER CLIMATE DATA BASES HAVE ALREADY BEEN READ
      IF(ISIM .EQ. 1) GO TO 100
      IF(J1SAVE .LT. JNSAVE .AND. J1REP .LT. JNREP) GO TO 920
      IF(J1REP .LT. JNREP) GO TO 600
      IF(J1SAVE.NE.J1REP .OR. JNSAVE.NE.JNREP) GO TO 100
      GO TO 600
C
C..... READ CLIMATE DATA BASE FILE NAME FROM KEYBOARD
100 WRITE(*,115)
115 FORMAT(///,18X,'ENTER CLIMATE DATA BASE FILE NAME:',/)
      READ(*,'(A20)',ERR=100) CLMFIL
      WRITE(*,118) CLMFIL
118 FORMAT(/,16X,'CLIMATE DATA BASE FILE NAME ENTERED = ',A20)
C
      OPEN(5,FILE=CLMFIL,STATUS='OLD',ERR=120)
      GO TO 130
120 WRITE(*,125)
125 FORMAT(/,23X,'FILE NAME DOES NOT EXIST!')
      GO TO 100
C
C..... READ CLIMATE DATA BASE LOCATION AND YRS OF RECORD
130 READ(5,140) ALOC
140 FORMAT(A16)
      READ(5,160) NYR
160 FORMAT(I5)
C
C..... READ CLIMATE DATA FILES
      WRITE(*,300)
300 FORMAT(///,19X,'***** READING DATA FILES *****',/)
C

```



```

C..... ETP DATA
      DO 350 IY = 1,NYR
      READ(5,320) IYEAR
320   FORMAT(I4)
      WRITE(*,340) IYEAR
340   FORMAT('+',26X,'ETP',   YEAR = ',I4)
350   READ(5,360) (ETP(IY,JD),JD=1,365)
360   FORMAT(14(1X,F4.3))
C
C..... RAIN DATA
      READ(5,420) DUMMY
420   FORMAT(A4)
      DO 450 IY = 1,NYR
      READ(5,320) IYEAR
      WRITE(*,430) IYEAR
430   FORMAT('+',26X,'RAIN',  YEAR = ',I4)
450   READ(5,460) (RAIN(IY,JD),JD=1,365)
460   FORMAT(12F6.3)
      CLOSE(5)
C
C..... REARRANGE DATA FOR CROP YEARS THAT EXTEND BEYOND 1 CALENDAR YEAR
      IF(J1SAVE .LT. JNSAVE) GO TO 920
600   NYR = NYR - 1
      DO 900 IY = 1,NYR
      J = 0
      IY1 = IY + 1
      DO 700 JD = J1SAVE,365
      J = J + 1
      JDAY(J) = JD
      ETP(IY,J) = ETP(IY,JD)
700   RAIN(IY,J) = RAIN(IY,JD)
      DO 800 JD = 1,JNSAVE
      J = J + 1
      JDAY(J) = JD
      ETP(IY,J) = ETP(IY1,JD)
800   RAIN(IY,J) = RAIN(IY1,JD)
900   CONTINUE
C
C..... WRITE DATA BASE LOCATIONS AND YEARS OF RECORD
920   WRITE(*,940) ALOC
940   FORMAT(//,14X,'THE CLIMATE DATA BASE LOCATION IS : ',A16)
      WRITE(*,960) NYR
960   FORMAT(/,16X,'LENGTH OF CLIMATE DATA RECORD =',I4,' YEARS')
      WRITE(6,980) ALOC, NYR
      WRITE(4,980) ALOC, NYR
980   FORMAT(/,1X,'CLIMATE DATA BASE: LOCATION = ',A16,2X,'LENGTH = '
      $,I3,' YEARS')
      END
C
C*****
C
      SUBROUTINE IIRI
C*****
C.....THIS SUBROUTINE OBTAINS INFORMATION ON THE TYPE OF IRRIGATION
C      SYSTEM TO BE USED AND ASSIGNS IRRIGATION SYSTEM EFFICIENCIES
C
C      DEFINITIONS....
C
C      AREA, ARZI = FRACTION OF THE SOIL SURFACE IRRIGATED (DECIMAL)
C      EFF = IRRIGATION SYSTEM DESIGN APPLICATION EFFICIENCY (DECIMAL)
C      EX, EXIR = FRACTION OF ET EXTRACTED FROM THE IRRIGATED ZONE WHEN
C      WATER IS AVAILABLE IN THE NONIRRIGATED ZONE
C      ICROP = CROP TYPE CODE
C      IR = IRRIGATION SYSTEM IDENTIFICATION CODE

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C   NIRRI = TOTAL NUMBER OF IRRIGATION SYSTEM TYPES INCLUDED IN THE
C   AFSIRS MODEL DATA BASE
C
C   DIMENSION AREA(10),EX(10)
C   REAL IRR(25,365),NIR(365)
C   CHARACTER*28 SYS(10)
C   CHARACTER CTYPE*12
C
C   COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C   $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C   $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
C   $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C   $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C   $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,CTYPE
C
C   OPEN(7,FILE='IR.DAT')
C
C   C..... READ IRRIGATION SYSTEM PARAMETERS
C   READ(7,100) NIRRI
100  FORMAT(I2)
C   READ(7,120) DUMMY
120  FORMAT(A4)
C   DO 150 IR = 1,NIRRI
C   READ(7,140) EFF(IR),AREA(IR),EX(IR),SYS(IR)
140  FORMAT(3X,3F6.2,2X,A28)
150  CONTINUE
C
C   C..... SELECT THE TYPE OF IRRIGATION SYSTEM TO BE USED
160  WRITE(*,180)
180  FORMAT(////,25X,'IRRIGATION SYSTEM DATA',//,12X,
C   $'SELECT THE TYPE OF IRRIGATION SYSTEM TO BE USED :',/)
C   DO 200 IR = 1,NIRRI
200  WRITE(*,210) IR,SYS(IR)
210  FORMAT(20X,I3,' = ',1X,A28)
C
C   WRITE(*,220)
220  FORMAT(/,18X,'ENTER THE IRRIGATION SYSTEM CODE :')
C   READ(*,*,ERR=160) IR
C   IF(IR .EQ. 1) GO TO 440
C   IF(IR.LT.1 .OR. IR.GT.NIRRI) GO TO 240
C   IF(IR .EQ. IRCRFL .AND. ICROP .NE. ICIT) GO TO 280
C   IF(IR .EQ. IRNSYC .AND. ICROP .NE. INSCY) GO TO 320
C   IF(IR .EQ. IRRICE .AND. ICROP .NE. IRICE) GO TO 360
C   GO TO 400
C
C   240 WRITE(*,260) IR
260  FORMAT(/,6X,'THE IRRIGATION SYSTEM CODE WAS INCORRECTLY ENTERED AS
C   $', I4)
C   GO TO 160
280  WRITE(*,300)
300  FORMAT(/,13X,'CROWN FLOOD APPLIES ONLY TO CITRUS IRRIGATION.')
C   GO TO 160
320  WRITE(*,340)
340  FORMAT(/,9X,'THIS IRRIGATION SYSTEM IS FOR CONTAINER NURSERIES ONL
C   $Y. ')
C   GO TO 160
360  WRITE(*,380)
380  FORMAT(/,11X,'THIS IRRIGATION SYSTEM IS FOR RICE PRODUCTION ONLY')
C   GO TO 160
C
C   C..... WRITE IRRIGATION SYSTEM TYPE FOR SYSTEMS SELECTED FROM THE MODEL
C   DATA BASE
400  WRITE(*,420) IR,SYS(IR)
420  FORMAT(/,16X,'THE IRRIGATION SYSTEM CODE ENTERED = ',I2,/,13X,

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$ 'THE IRRIGATION SYSTEM TYPE IS : ',A28)
C
C..... ENTER CODE TO CALCULATE NET OR GROSS IRRIGATION REQUIREMENTS
440 WRITE(*,460)
460 FORMAT(///,12X,'ENTER 0 TO CALCULATE NET IRRIGATION REQUIREMENTS
$: ',/,11X,'ENTER 1 TO CALCULATE GROSS IRRIGATION REQUIREMENTS:')
READ(*,*,ERR=440) INET
IF(INET .LT. -98) GO TO 160
IF(INET.LT.0 .OR. INET.GT.1) GO TO 440
IF(INET .EQ. 0) EFF(IR)=1.00
IF(INET .EQ. 0) WRITE(*,480)
480 FORMAT(14X,'NET IRRIGATION REQUIREMENTS WILL BE CALCULATED')
IF(INET .EQ. 1) WRITE(*,500)
500 FORMAT(13X,'GROSS IRRIGATION REQUIREMENTS WILL BE CALCULATED')
C
C..... ENTER CODE TO DEFINE IRRIGATION DEPTHS PER APPLICATION
IF(IR .GT. 6) GO TO 650
520 WRITE(*,540)
540 FORMAT(///,8X,'ENTER 0 TO IRRIGATE TO FIELD CAPACITY (NORMAL PRA
$CTICE): ',/,13X,'ENTER 1 TO APPLY A FIXED DEPTH PER IRRIGATION:',
$,/,20X,'ENTER 2 FOR DEFICIT IRRIGATION:')
READ(*,*,ERR=520) IDCODE
IF(IDCODE .LT. -98) GO TO 440
IF(IDCODE.LT.0 .OR. IDCODE.GT.2) GO TO 520
IF(IDCODE .EQ. 0) WRITE(*,550)
IF(IDCODE .EQ. 0) WRITE(6,550)
IF(IDCODE .EQ. 0) WRITE(4,550)
550 FORMAT(9X,'NORMAL IRRIGATION: SOIL WILL BE IRRIGATED TO FIELD CAPA
$CITY',/,29X,'AT EACH IRRIGATION')
IF(IDCODE .EQ. 1) WRITE(*,552)
IF(IDCODE .EQ. 1) WRITE(6,552)
IF(IDCODE .EQ. 1) WRITE(4,552)
552 FORMAT(10X,'FIXED DEPTH IRRIGATION: A FIXED (CONSTANT) DEPTH OF WA
$TER',/,21X,'WILL BE APPLIED AT EACH IRRIGATION')
IF(IDCODE .EQ. 2) WRITE(*,554)
IF(IDCODE .EQ. 2) WRITE(6,554)
IF(IDCODE .EQ. 2) WRITE(4,554)
554 FORMAT(9X,'DEFICIT IRRIGATION: THE SOIL WILL BE IRRIGATED TO A FRA
$CTION',/,21X,'OF FIELD CAPACITY AT EACH IRRIGATION')
IF(IDCODE .EQ. 0) GO TO 640
IF(IDCODE .EQ. 2) GO TO 600
C..... DEFINE IRRIGATION DEPTH PER IRRIGATION
560 WRITE(*,580)
580 FORMAT(/,12X,'ENTER DEPTH OF WATER TO APPLY PER IRRIGATION (INCHES
$): ')
READ(*,*,ERR=560) FIX
IF(FIX .LT. -98.0) GO TO 520
IF(FIX .LT. 0.10) GO TO 560
WRITE(*,590) FIX
WRITE(6,590) FIX
WRITE(4,590) FIX
590 FORMAT(/,10X,'DEPTH OF WATER TO APPLY PER IRRIGATION =',F5.2,' INC
$HES')
GO TO 640
C..... DEFINE DEFICIT FRACTION FOR DEFICIT IRRIGATION
600 WRITE(*,620)
620 FORMAT(/,5X,'ENTER PERCENT OF FIELD CAPACITY TO APPLY FOR DEFICIT
$IRRIGATION (%): ',/,24X,'ALLOWABLE RANGE = 50% TO 100%')
READ(*,*,ERR=600) PIR
IF(PIR .LT. -98.0) GO TO 520
IF(PIR .LT. 50.0) GO TO 600
FRIR = PIR /100.0
WRITE(*,630) PIR
WRITE(6,630) PIR

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        WRITE(4,630) PIR
630  FORMAT(/,6X,'PERCENT OF FIELD CAPACITY ENTERED FOR DEFICIT IRRIGAT
$ION =',F5.1,'%')
640  IF(IR .EQ. 1) GO TO 740
C
C..... FOR USER ENTRY OF IRRIGATION APPLICATION EFFICIENCY
650  IF(IVERS .EQ. 0) GO TO 860
      IF(INET .EQ. 0) GO TO 700
660  WRITE(*,680)
680  FORMAT(/,9X,'ENTER IRRIGATION APPLICATION EFFICIENCY (DECIMAL):')
      READ(*,*,ERR=660) EFF(IR)
      IF(EFF(IR) .LT. -98.0) GO TO 160
      IF(EFF(IR).LT.0.01 .OR. EFF(IR).GT.1.00) GO TO 660
C
C..... FOR USER ENTRY OF AREA(IR) FOR MICRO SYSTEMS
700  IF(IR .GT. 3) GO TO 860
710  WRITE(*,720)
720  FORMAT(/,14X,'ENTER FRACTION OF THE SOIL SURFACE IRRIGATED:')
      READ(*,*,ERR=710) AREA(IR)
      IF(AREA(IR) .LT. -98.0) GO TO 660
      IF(AREA(IR).LT.0.01 .OR. AREA(IR).GT.1.00) GO TO 710
      GO TO 860
C
C..... FOR USER ENTRY OF IRRIGATION DATA
740  IF(INET .EQ. 0) GO TO 800
C
760  WRITE(*,780)
780  FORMAT(/,9X,'ENTER IRRIGATION APPLICATION EFFICIENCY (DECIMAL):')
      READ(*,*,ERR=760) EFF(1)
      IF(EFF(1) .LT. -98.0) GO TO 160
      IF(EFF(1).LT.0.01 .OR. EFF(1).GT.1.00) GO TO 760
C
800  WRITE(*,810)
810  FORMAT(/,14X,'ENTER FRACTION OF SOIL SURFACE IRRIGATED:')
      READ(*,*,ERR=800) AREA(1)
      IF(AREA(1) .LT. -98.0) GO TO 760
      IF(AREA(1).LT.0.01 .OR. AREA(1).GT.1.00) GO TO 800
C
820  WRITE(*,840)
840  FORMAT(/,7X,'ENTER FRACTION OF ET EXTRACTED FROM THE IRRIGATED ZO
$NE:')
      READ(*,*,ERR=820) EX(1)
      IF(EX(1) .LT. -98.0) GO TO 800
      IF(EX(1).LT.0.01 .OR. EX(1).GT.1.00) GO TO 820
C
C..... ASSIGN AND WRITE IRRIGATION PARAMETERS
860  ARZI = AREA(IR)
      EXIR = EX(IR)
      IF(IR.EQ.2 .OR. IR.EQ.3) EXIR = 0.7*ARZI + 0.10*(1.0-ARZI)
C
      WRITE(*,880) EFF(IR),ARZI,EXIR
880  FORMAT(/,15X,'IRRIGATION DESIGN APPLICATION EFFICIENCY =',F5.2,/,
$ 19X,'FRACTION OF SOIL SURFACE IRRIGATED =',F5.2,/,
$ 17X,'FRACTION EXTRACTED FROM IRRIGATED ZONE =',F5.2)
      IEFF = 100.0001 * EFF(IR)
      IP = 100.0001 * ARZI
C
      WRITE(6,900) SYS(IR),IEFF,IP,EXIR
      WRITE(4,900) SYS(IR),IEFF,IP,EXIR
900  FORMAT(/,1X,'IRRIGATION SYSTEM : TYPE = ',A28,/,
$ 21X,'DESIGN APPLICATION EFFICIENCY = ',I3,' %',/,
$ 21X,'FRACTION OF SOIL SURFACE IRRIGATED =',I3,' %',/,
$ 21X,'FRACTION EXTRACTED FROM IRRIGATED ZONE =',F5.2)
C

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```

CLOSE(7)
END
C
C*****
C
SUBROUTINE DCOEF(ICGP,ICGA)
C*****
C.....THIS SUBROUTINE CALCULATES CROP WATER USE COEFFICIENTS AND ROOT
C    ZONE DEPTHS FOR EACH DAY OF THE CROP GROWING SEASON.
C
C    DEFINITIONS.....
C
C    ALD(I) = ALLOWABLE SOIL WATER DEPLETION BEFORE IRRIGATION
C             FOR EACH ANNUAL CROP GROWTH STAGE (DECIMAL)
C    AWD(JD) = ALLOWABLE WATER DEPLETION FOR EACH DAY OF THE IRRIGATION
C             SEASON (DECIMAL)
C    ALDP(IMO) = MONTHLY ALLOWABLE SOIL WATER DEPLETION FOR PERENNIAL
C              CROPS (DECIMAL)
C    DRZ(JD) = TOTAL EFFECTIVE CROP ROOT ZONE DEPTH (INCHES)
C    DRZI(JD) = CROP ROOT ZONE DEPTH IRRIGATED (INCHES)
C    DRZIRR = ANNUAL AVERAGE DEPTH OF ROOT ZONE IRRIGATED FOR
C             PERENNIAL CROPS (INCHES)
C    DRZONE = AVERAGE ANNUAL EFFECTIVE ROOT ZONE DEPTH FOR PERENNIAL
C            CROPS (INCHES)
C    DRZTOT = ANNUAL AVERAGE EFFECTIVE ROOT ZONE DEPTH FOR PERENNIAL
C            CROPS (INCHES)
C    DZN = MINIMUM EFFECTIVE ROOT ZONE DEPTH, AT BEGINNING OF GROWING
C          SEASON FOR ANNUAL CROPS (INCHES)
C    DZX = MAXIMUM EFFECTIVE ROOT ZONE DEPTH, AFTER MAXIMUM ROOT DEVELOP-
C          MENT FOR ANNUAL CROPS (INCHES)
C    F(I) = FRACTION OF ANNUAL CROP GROWING SEASON THAT OCCURS IN
C          EACH OF 4 GROWTH STAGES
C    HGT = HEIGHT OF CROWN FLOOD SYSTEM BED (FT)
C    AKC(MO) = MONTHLY CROP COEFFICIENTS FOR PERENNIAL CROPS
C    KC1 = CROP WATER USE COEFFICIENT FOR GROWTH STAGE 1 FOR ANNUAL CROPS
C    AKC3 =CROP WATER USE COEFFICIENT FOR GROWTH STAGE 3 FOR ANNUAL CROPS
C    AKC4 =CROP WATER USE COEFFICIENT FOR GROWTH STAGE 4 FOR ANNUAL CROPS
C    NKC(MO) = DAY OF YEAR AT WHICH MONTHLY KCs OCCUR
C    NMO(MO) = NUMBER OF DAYS PER MONTH FOR ITH MONTH
C    RKC(JD) = DAILY CROP COEFFICIENT FOR EACH DAY OF THE IRRIGATION
C             SEASON
C
C    REAL IRR(25,365),NIR(365)
C    DIMENSION NKC(12),NMO(12),F(4),ALD(4),RKTMP(365),AWTMP(365),
C    $ AKC(12),ALDP(12)
C    CHARACTER*12 CTYPE, DUMMY
C
C    COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C    $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C    $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
C    $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C    $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C    $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,CTYPE
C
C    DATA NMO/31,28,31,30,31,30,31,31,30,31,30,31/
C    DATA NKC/15,45,74,105,135,166,196,227,258,288,319,349/
C
C    OPEN(8,FILE='CROP.DAT')
C
C..... ZERO PARAMETERS
DO 120 JD = 1,365
AWD(JD) = 0.0
DRZ(JD) = 0.0
DRZI(JD) = 0.0

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120 RKC(JD) = 0.0
C
C..... FOR SEEPAGE IRRIGATION SYSTEMS
      IF(IVERS .EQ. 0) GO TO 140
      IF(IR .NE. IRSEEP) GO TO 140
130 WRITE(*,135)
135 FORMAT(/,15X,'ENTER DEPTH TO WATER TABLE (INCHES):')
      READ(*,*,ERR=130) DWT
      IF(DWT.LT.1.0 .OR. DWT.GT.60.0) GO TO 130
      WRITE(*,138) DWT
      WRITE(6,138) DWT
      WRITE(4,138) DWT
138 FORMAT(/,13X,'WATER TABLE DEPTH ENTERED =',F5.1,' INCHES')
C
C..... READ CROP DATA
C-----
140 READ(8,150) NCP
150 FORMAT(I3)
      IF(ICROP .GT. NCP) GO TO 500
C
C..... FOR PERENNIAL CROPS
C-----
C..... READ MONTHLY VALUES OF CROP COEFFICIENTS
      IC = 2*(ICROP-1) + 1
      DO 160 I=1,IC
160 READ(8,180) DUMMY
      READ(8,180) CTYPE,(AKC(IMO),IMO=1,12)
180 FORMAT(A12,1X,12F5.2)
      READ(8,190) DRZIRR,DRZTOT,(ALDP(IMO),IMO=1,12)
190 FORMAT(7X,2F3.0,12F5.2)
      IF(ICROP .NE. ICGP) GO TO 280
C
C..... FOR GENERIC PERENNIAL CROPS
200 WRITE(*,210)
210 FORMAT(/,12X,'ENTER 0 TO USE GENERIC CROP DATA FROM DATA FILE:',
$,/,15X,'ENTER 1 TO INPUT CROP DATA FROM KEYBOARD:')
      READ(*,*,ERR=200) IG
215 WRITE(*,220)
220 FORMAT(/,18X,'ENTER CROP TYPE (NAME OR VARIETY):')
      READ(*,'(A12)',ERR=215) CTYPE
      IF(IG .EQ. 0) GO TO 280
230 WRITE(*,240)
240 FORMAT(/,12X,'ENTER IRRIGATED ROOT ZONE DEPTH, DRZIRR (INCHES):',
$,/,12X,' AND TOTAL CROP ROOT ZONE DEPTH, DRZTOT (INCHES):')
      READ(*,*,ERR=230) DRZIRR, DRZTOT
      IF(DRZIRR .GT. DRZTOT) GO TO 230
      WRITE(*,250)
250 FORMAT(/,15X,'ENTER MONTHLY CROP WATER USE COEFFICIENTS',/,17X,'AN
$,D ALLOWABLE SOIL WATER DEPLETIONS:',/,24X,'MONTH      KC      AWD')
      DO 270 I = 1,12
260 IMO = I
262 WRITE(*,264) IMO
264 FORMAT(1X,'MONTH = ',I2)
      READ(*,*,ERR=262) AKC(IMO), ALDP(IMO)
      IF(AKC(IMO) .GT. -98.0 .AND. ALDP(IMO) .GT. -98.0) GO TO 266
      IMO = IMO - 1
      GO TO 262
266 WRITE(*,268) IMO, AKC(IMO), ALDP(IMO)
268 FORMAT(25X,I2,2F9.2)
      IF(IMO .EQ. I) GO TO 270
      GO TO 260
270 CONTINUE
C
C..... FOR SEEPAGE IRRIGATION SYSTEMS

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280 IF(IR .NE. IRSEEP) GO TO 290
    IF(IVERS .EQ. 1) GO TO 285
    DWT = 20.0
285 DRZIRR = DWT
    DRZTOT = 1.5 * DWT
    DO 288 IMO = 1,12
    ALDP(IMO) = 0.0
288 IF(AKC(IMO) .LT. 1.0) AKC(IMO) = 1.0
    GO TO 340
C
C..... FOR CITRUS CROWN FLOOD IRRIGATION SYSTEMS
290 IF(IR .NE. IRCRFL) GO TO 300
294 WRITE(*,295)
295 FORMAT(//,15X,'ENTER HEIGHT OF CROWN FLOOD SYSTEM BED (FT) :')
    READ(*,*,ERR=294) HGT
    IF(HGT.GT.5.0 .OR. HGT.LT.1.0) GO TO 294
    WRITE(*,296) HGT
    WRITE(6,296) HGT
    WRITE(4,296) HGT
296 FORMAT(11X,'HEIGHT OF CROWN FLOOD IRRIGATION SYSTEM BEDS =',
    $ F4.1,' FT')
    HGTIN = 12.0 * HGT
    DWT = HGTIN
    DRZIRR = HGTIN - 6.0
    DRZTOT = HGTIN + 12.0 / HGT
    DO 298 IMO = 1,12
298 IF(ALDP(IMO) .LT. 0.5) ALDP(IMO) = 0.5
    GO TO 340
C
C..... ENTER ROOT ZONE DATA FROM KEYBOARD IF DESIRED
300 IF(IVERS .EQ. 0) GO TO 340
    IF(ICROP .EQ. ICGP) GO TO 340
310 WRITE(*,240)
    READ(*,*,ERR=310) DRZIRR, DRZTOT
    IF(DRZIRR.LT.1.0 .OR. DRZTOT.LT.1.0) GO TO 310
    IF(DRZTOT .GT. DRZIRR-EPS) GO TO 340
    WRITE(*,330)
330 FORMAT(/,7X,'TOTAL ROOT ZONE MUST BE EQUAL TO OR GREATER THAN IRRI
    $GATED DEPTH')
    GO TO 310
C
C..... WRITE INTERMEDIATE PARAMETERS
340 WRITE(6,360) CTYPE,DRZIRR,DRZTOT
    WRITE(4,360) CTYPE,DRZIRR,DRZTOT
    WRITE(*,360) CTYPE,DRZIRR,DRZTOT
360 FORMAT(//,22X,'CROP TYPE = ',A12,//,15X,'ROOT ZONE DEPTH IRRIGATED
    $ (INCHES) = ',F5.1,/,15X,'TOTAL CROP ROOT ZONE DEPTH (INCHES)=',
    $ F5.1)
    WRITE(6,370)(IMO,IMO=1,12),(AKC(IMO),IMO=1,12),(ALDP(IMO),IMO=1,
    $ 12)
    WRITE(4,370)(IMO,IMO=1,12),(AKC(IMO),IMO=1,12),(ALDP(IMO),IMO=1,
    $ 12)
    WRITE(*,370)(IMO,IMO=1,12),(AKC(IMO),IMO=1,12),(ALDP(IMO),IMO=1,
    $ 12)
370 FORMAT(/,32X,'MONTH'/,10X,12(I4,1X),/,5X,'KC=',1X,12F5.2,/,3X,
    $ 'ALDP=',1X,12F5.2)
C
C..... CALCULATE DAILY ROOT DEPTHS & ALLOWABLE SOIL WATER DEPLETIONS
    DO 380 JD=1,365
    DRZI(JD) = DRZIRR
380 DRZ(JD) = DRZTOT
C
    JD = 0
    DO 400 IMO = 1,12

```

```

DO 400 J=1,NMO(IMO)
JD = JD + 1
400 AWD(JD) = ALDP(IMO)
C
C..... CALCULATE DAILY CROP WATER USE COEFFICIENTS
C..... FIRST 1/2 OF JANUARY
RJ = -1
RJDIF = 14
RKDIF = 0.5 * (AKC(1) - AKC(12))
RK2 = 0.5 * (AKC(1)+AKC(12))
DO 420 JD=1,14
RJ = RJ + 1
RKC(JD) = RK2 + RJ/RJDIF * RKDIF
420 CONTINUE
C
C..... JANUARY 15 THROUGH DECEMBER 15
DO 440 JMO = 1,11
JMO1 = JMO + 1
NKM1 = NKC(JMO1) - 1
RJDIF = NKC(JMO1) - NKC(JMO)
RKDIF = AKC(JMO1) - AKC(JMO)
RJ = -1
DO 440 JD = NKC(JMO), NKM1
RJ = RJ + 1
440 RKC(JD) = AKC(JMO) + RJ/RJDIF * RKDIF
C
C..... DECEMBER 16 THROUGH DECEMBER 31
RJ = -1
RJDIF = 16
RKDIF = 0.5 * (AKC(1) - AKC(12))
DO 460 JD = 349, 365
RJ = RJ + 1
460 RKC(JD) = AKC(12) + RJ/RJDIF * RKDIF
C
IF(J1SAVE .LT. JNSAVE) GO TO 900
C
C..... REARRANGE DATA FOR CROP YEAR THAT EXTENDS BEYOND 1 CALENDAR YEAR
J = 0
DO 470 JD = J1SAVE, 365
J = J + 1
AWTMP(J) = AWD(JD)
470 RKTMP(J) = RKC(JD)
C
DO 480 JD = 1, JNSAVE
J = J + 1
AWTMP(J) = AWD(JD)
480 RKTMP(J) = RKC(JD)
C
DO 490 JD = J1,JN
AWD(JD) = AWTMP(JD)
490 RKC(JD) = RKTMP(JD)
C
GO TO 900
C
C..... FOR ANNUAL CROPS
-----
C.... READ 2 KC VALUES, FOR THE PEAK GROWTH PERIOD AND AT MATURITY
C      OR HARVEST.
C.... READ PROPORTION OF THE GROWING SEASON IN EACH GROWTH STAGE.
500 IC = ICROP + NCP + 3
DO 520 I=1,IC
520 READ(8,180) DUMMY
READ(8,550) CTYPE,DZN,DZX,AKC3,AKC4,(F(I),I=1,4),(ALD(I),I=1,4)
550 FORMAT(A12,2F3.0,10F5.2)

```



```

        IF(ICROP .NE. ICGA) GO TO 680
C
C..... FOR GENERIC ANNUAL CROPS
600  WRITE(*,210)
      READ(*,*,ERR=600) IG
615  WRITE(*,220)
      READ(*,'(A12)',ERR=615) CTYPE
      IF(IG .EQ. 0) GO TO 680
630  WRITE(*,640)
640  FORMAT(//,9X,'ENTER INITIAL IRRIGATED ROOT ZONE DEPTH, DZN (INCHES
$):',/,6X,'AND MAXIMUM (FINAL) IRRIGATED ROOT ZONE DEPTH, DZX (INCH
$ES):')
      READ(*,*,ERR=630) DZN, DZX
      IF(DZX .GE. DZN) GO TO 644
      WRITE(*,642)
642  FORMAT(/,10X,'MAXIMUM ROOT ZONE DEPTH MUST BE GREATER THAN INITIAL
$ DEPTH')
      GO TO 630
C
644  WRITE(*,650)
650  FORMAT(//,7X,'ENTER CROP WATER USE COEFFICIENTS FOR GROWTH STAGES
$3 AND 4:')
      READ(*,*,ERR=644) AKC3,AKC4
      WRITE(*,655)
655  FORMAT(//,5X,'ENTER FRACTION OF GROWING SEASON AND ALLOWABLE SOIL
$WATER DEPLETIONS',/,15X,'IN EACH OF THE 4 GROWTH STAGES OF ANNUAL
$CROPS:',/,24X,'STAGE FRACTION AWD')
      DO 670 I = 1,4
660  IST = I
662  WRITE(*,664) IST
664  FORMAT(1X,'STAGE =',I2)
      READ(*,*,ERR=662) F(IST), ALD(IST)
      IF(F(IST) .GT. -98.0 .AND. ALD(IST) .GT. -98.0) GO TO 666
      IST = IST - 1
      GO TO 662
666  WRITE(*,268) IST, F(IST), ALD(IST)
      IF(IST .EQ. I) GO TO 670
      GO TO 660
670  CONTINUE
C
C..... ENTER ANNUAL CROP ROOT ZONE DEPTHS FROM KEYBOARD
680  IF(IVERS .EQ. 0) GO TO 700
      IF(ICROP .EQ. ICGA) GO TO 700
685  WRITE(*,640)
      READ(*,*,ERR=685) DZN, DZX
      IF(DZN.LT.1 .OR. DZX.LT.1) GO TO 685
      IF(DZN .GT. DZX) GO TO 685
C
C..... FOR SEEPAGE IRRIGATION SYSTEMS
700  IF(IR .NE. IRSEEP) GO TO 750
      IF(IVERS .EQ. 1) GO TO 710
      DWT = 20.0
710  IF(DZN .GT. DWT) DZN = DWT
      IF(DZX .GT. DWT) DZX = DWT
      IF(AKC3 .LT. 1.0) AKC3 = 1.0
      IF(AKC4 .LT. 1.0) AKC4 = 1.0
      DO 720 I=1,4
720  ALD(I) = 0.0
C
C..... WRITE INTERMEDIATE PARAMETERS
750  WRITE(*,760) CTYPE
      WRITE(6,760) CTYPE
      WRITE(4,760) CTYPE
760  FORMAT(//,25X,'CROP TYPE = ',A12)

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```

WRITE (*,780)DZN,DZX,AKC3,AKC4,(F(I),I=1,4),(ALD(I),I=1,4)
WRITE(6,780)DZN,DZX,AKC3,AKC4,(F(I),I=1,4),(ALD(I),I=1,4)
WRITE(4,780)DZN,DZX,AKC3,AKC4,(F(I),I=1,4),(ALD(I),I=1,4)
780  FORMAT(/, 4X,'DZN  DZX  AKC3  AKC4  F1  F2  F3  F4  ALD1
$  ALD2  ALD3  ALD4 ',/, 3X,2F5.0,10F6.2,/)
C
C..... CALCULATE NUMBER OF DAYS IN EACH GROWTH STAGE
      FF = EPS
      DO 820 I=1,4
      FF = FF + F(I)
      NF(I) = J1 + FF * (JN-J1)
      IF(ICODE .GT. 1)WRITE(*,800) I,FF,NF(I),J1,JN
      IF(ICODE .GT. 1)WRITE(6,800) I,FF,NF(I),J1,JN
      IF(ICODE .GT. 1)WRITE(4,800) I,FF,NF(I),J1,JN
800  FORMAT(10X,'I,FF,NF(I),J1,JN = ',I5,F7.3,3I5)
820  CONTINUE
C
C..... CALCULATE DAILY ROOT ZONE DEPTHS AND DEPTHS IRRIGATED
      IF(ICODE .EQ. 2) WRITE(*,840)
      IF(ICODE .EQ. 2) WRITE(6,840)
      IF(ICODE .EQ. 2) WRITE(4,840)
840  FORMAT(/,3X,'CDAY JDAY NF1  NF2  NF3  DRZI DRZ  RKC ALD1 ALD2 ALD3
$  ALD4  AWD')
C
      AKKC = 0.4
      IF(IR .EQ. IRSEEP) AKKC = 1.0
      IF(IR .EQ. IRRICE) AKKC = 1.0
C
      DO 880 JD = J1, JN
      RJD = JD
      DRZI(JD) = DZN + (RJD-NF(1)) * (DZX-DZN) / (NF(2)-NF(1))
      IF(JD .LT. NF(1)) DRZI(JD) = DZN
      IF(JD .GT. NF(2)) DRZI(JD) = DZX
      DRZ(JD) = 2.0 * DRZI(JD)
      IF(IR .EQ. IRRICE) DRZ(JD) = DRZI(JD)
C
C..... CALCULATE DAILY CROP COEFFICIENTS
      RKC(JD) = AKKC
      IF(JD .GT. NF(1)) RKC(JD) = AKKC + (RJD-NF(1)) / (NF(2)-NF(1)) *
$ (AKC3-AKKC)
      IF(JD .GT. NF(2)) RKC(JD) = AKC3
      IF(JD .GT. NF(3)) RKC(JD) =AKC3-(RJD-NF(3))/(JN-NF(3))*(AKC3-AK4)
C
C..... ASSIGN DAILY VALUES OF ALLOWABLE WATER DEPLETION
      AWD(JD) = ALD(1)
      IF(JD .GT. NF(1)) AWD(JD) = ALD(2)
      IF(JD .GT. NF(2)) AWD(JD) = ALD(3)
      IF(JD .GT. NF(3)) AWD(JD) = ALD(4)
C
C..... WRITE INTERMEDIATE DATA
      IF(ICODE .LT. 2) GO TO 880
      WRITE(*,860)JD,JDAY(JD),NF(1),NF(2),NF(3),DRZI(JD),DRZ(JD),RKC(JD)
$ ,ALD(1),ALD(2),ALD(3),ALD(4),AWD(JD)
      WRITE(6,860)JD,JDAY(JD),NF(1),NF(2),NF(3),DRZI(JD),DRZ(JD),RKC(JD)
$ ,ALD(1),ALD(2),ALD(3),ALD(4),AWD(JD)
      WRITE(4,860)JD,JDAY(JD),NF(1),NF(2),NF(3),DRZI(JD),DRZ(JD),RKC(JD)
$ ,ALD(1),ALD(2),ALD(3),ALD(4),AWD(JD)
860  FORMAT(1X,5I5,2F5.1,5F5.2,F6.2)
880  CONTINUE
C
C..... OUTPUT PARAMETERS FOR DEBUGGING
900  IF(ICODE .LT. 1) GO TO 990
      WRITE(*,940)
      WRITE(6,940)

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        WRITE(4,940)
940  FORMAT(/,1X,'DAILY ROOT ZONE DEPTHS, CROP COEFFICIENTS, & ALLOWABL
      $E WATER DEPLETIONS')
        WRITE(*,960)
        WRITE(6,960)
        WRITE(4,960)
960  FORMAT(15X,'CDAY JDAY  DRZI(JD) DRZ(JD) RKC(JD) AWD(JD)')
      DO 970 JD = J1,JN
        WRITE(*,980) JD,JDAY(JD),DRZI(JD),DRZ(JD),RKC(JD),AWD(JD)
        WRITE(4,980) JD,JDAY(JD),DRZI(JD),DRZ(JD),RKC(JD),AWD(JD)
970  WRITE(6,980) JD,JDAY(JD),DRZI(JD),DRZ(JD),RKC(JD),AWD(JD)
980  FORMAT(15X,I3,2X,I3,2X,2F8.2,F8.3,F8.2)
C
990  CLOSE(8)
      END
C
C*****
C
      SUBROUTINE SW
C*****
C.....THIS SUBROUTINE CALCULATES THE AVAILABLE SOIL WATER AND THE
C      SOIL WATER CONTENT AT WHICH IRRIGATIONS WILL BE SCHEDULED
C      FOR EACH DAY OF THE CROP IRRIGATION SEASON.
C
C..... DEFINITIONS ...
C
C  ARZI = FRACTION OF THE SURFACE AREA IRRIGATED BY THE IRRIGATION
C        SYSTEM USED (DECIMAL FRACTION)
C  DRINC = RICE FLOOD STORAGE DEPTH (INCHES)
C  DRZ(JD) = TOTAL EFFECTIVE CROP ROOT ZONE DEPTH (INCHES)
C  DRZI(JD) = CROP ROOT ZONE DEPTH IRRIGATED (INCHES)
C  DU(I) = DEPTH TO THE TOP OF THE ITH SOIL LAYER (INCHES)
C  ISOIL = CODE FOR SOIL TYPE TO BE USED IN THE SIMULATION
C  NL = NUMBER OF LAYERS IN THE SOIL PROFILE
C  NSOILS = TOTAL NUMBER OF SOILS IN THE SOILS DATA BASE
C  SWCIX(JD) = MAXIMUM SOIL WATER-HOLDING CAPACITY OF THE IRRIGATED
C            PORTION OF THE CROP ROOT ZONE (INCHES)
C  SWCNX(JD) = MAXIMUM SOIL WATER-HOLDING CAPACITY OF THE NON-
C            IRRIGATED PORTION OF THE CROP ROOT ZONE (INCHES)
C  SWIRR(JD) = SOIL WATER CONTENT AT WHICH IRRIGATION IS SCHEDULED
C            (INCHES)
C  SWMAX(JD) = MAXIMUM SOIL WATER-HOLDING CAPACITY OF THE TOTAL CROP
C            ROOT ZONE (INCHES)
C  WCL(I) = MINIMUM VOLUMETRIC WATER CONTENT OF THE ITH SOIL LAYER
C  WCU(I) = MAXIMUM VOLUMETRIC WATER CONTENT OF THE ITH SOIL LAYER
C
      REAL IRR(25,365),NIR(365)
      CHARACTER SNAME*20, SNAME1*20, SNAME2*20, CTYPE*12
      CHARACTER*4 TXT(3), TXT1(3), TXT2(3)
C
      COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
      $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
      $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
      $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
      $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
      $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,CTYPE
C
      DIMENSION DL(6),DU(6),WCL(6),WCU(6),WC(6)
      DATA BLANK /'  '/
C
C..... OPEN DIRECT ACCESS SOIL DATA BASE
      10 OPEN(9,FILE='SOIL.DAT',ACCESS='DIRECT',RECL=56,FORM='FORMATTED')
C
C..... ZERO PARAMETERS

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```

        IW0 = 0
        IW1 = 0
        IW2 = 0
        IW3 = 0
C
        DO 15 JD=1,365
        SWMAX(JD) = 0.0
        SWCIX(JD) = 0.0
        SWCNX(JD) = 0.0
15    SWIRR(JD) = 0.0
C
C..... READ NUMBER OF SOIL TYPES
20    READ(9,'(I4)',REC=2) NSOILS
        WRITE(*,22) NSOILS
22    FORMAT(////////,27X,'SOILS DATA ENTRY',//,24X,'NUMBER OF SOILS =',
        $I4)
C
C..... OBTAIN SOIL CODE INTERACTIVELY FROM THE MODEL USER
25    WRITE(*,30)
30    FORMAT(//,19X,'ENTER CODE FOR SOIL TYPE DESIRED :',//,18X,
        $ 'ENTER 0 IF YOU WANT A LIST OF SOILS:',//,12X,
        $ 'ENTER -1 TO INPUT SOILS DATA FROM THE KEYBOARD :')
        READ(*,*,ERR=25) ISOIL
        IF(ISOIL .EQ. 0) GO TO 50
        IF(ISOIL .EQ. -1) GO TO 102
        GO TO 84
C
C..... READ AND WRITE TO SCREEN A LIST OF SOILS
50    WRITE(*,52)
52    FORMAT(//,19X,'ENTER SOIL CODE TO BEGIN LIST:')
        READ(*,*,ERR=50) ISOIL
        IF(ISOIL.LT.1 .OR. ISOIL.GT.NSOILS) GO TO 50
        GO TO 56
C
54    WRITE(*,55)
55    FORMAT(//,17X,'ENTER SOIL CODE TO CONTINUE LIST:')
        READ(*,*,ERR=54) ISOIL
        IF(ISOIL.LT.1 .OR. ISOIL.GT.NSOILS) GO TO 54
C
56    ISP = ISOIL + 39
        DO 60 II = ISOIL,ISP,2
        NREC1 = 2 * II + 2
        READ(9,58,END=64,REC=NREC1) NS1,SNAME1,(TXT1(I),I=1,3)
        READ(9,58,END=64) IDUM
        READ(9,58,END=64) NS2,SNAME2,(TXT2(I),I=1,3)
58    FORMAT(I3,1X,A20,3(1X,A4))
60    WRITE(*,62)NS1,SNAME1,(TXT1(I),I=1,3),NS2,SNAME2,(TXT2(I),I=1,3)
62    FORMAT(2(1X,I3,1X,A20,3(1X,A4)))
C
64    WRITE(*,68)
68    FORMAT(//,15X,'ENTER 0 TO STOP.  ENTER 1 TO CONTINUE LIST.')
        READ(*,*,ERR=64) ICT
        IF(ICT .EQ. 0) GO TO 80
        GO TO 50
C
80    WRITE(*,82)
82    FORMAT(//,23X,'ENTER CODE FOR SOIL TYPE :')
        READ(*,*,ERR=80) ISOIL
C
C..... READ SOIL SERIES SPECIFIED
84    IF(ISOIL .EQ. -99) GO TO 20
        WRITE(*,85) ISOIL
85    FORMAT(//,19X,'THE SOIL TYPE CODE ENTERED WAS :',I4)
C

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        IF(ISOIL.LT.1 .OR. ISOIL.GT.NSOILS) GO TO 86
        GO TO 88
86     WRITE(*,87)
87     FORMAT(/,12X,'THE SOIL CODE THAT YOU ENTERED IS OUT-OF-BOUNDS !')
        GO TO 20
C
88     NREC = 2*ISOIL +2
        READ(9, '(I3,1X,A20,3(1X,A4))',REC=NREC) NS,SNAME,TXT(1),TXT(2),
$     TXT(3)
        READ(9,98)NL,(DU(I),WCL(I),WCU(I),I=1,NL)
98     FORMAT(I1,1X,6(F3.0,2F3.2))
C
99     CLOSE(9)
C
        IF(ISOIL .NE. NS) WRITE(*,100)
100    FORMAT(/,18X,'*** WARNING *** SOIL CODE DISCREPANCY!')
        GO TO 115
C
C..... READ SOILS DATA FROM KEYBOARD
102    WRITE(*,103)
103    FORMAT(//,24X,'ENTER SOIL SERIES NAME:')
        READ(*,'(A20)',ERR=102) SNAME
105    WRITE(*,106)
106    FORMAT(/,26X,'ENTER SOIL TEXTURE:')
        READ(*,'(A4)',ERR=105) TXT(1)
C
107    WRITE(*,108)
108    FORMAT(/,17X,'ENTER NUMBER OF SOIL LAYERS (UP TO 6):')
        READ(*,*,ERR=107) NL
        IF(NL.LT.1 .OR. NL.GT.6) GO TO 107
        DO 112 IL=1,NL
110    WRITE(*,111) IL, IL
111    FORMAT(/,8X,'ENTER DEPTH (INCHES) FROM SOIL SURFACE TO BOTTOM OF L
$AYER #',I2,/,10X,'AND VOLUMETRIC WATER CONTENT (DECIMAL) OF SOIL L
$AYER #',I2)
        READ(*,*,ERR=110) DU(IL),WC(IL)
112    IF(WC(IL).LT.0.01 .OR. WC(IL).GT.0.90) GO TO 110
        WRITE(*,113) SNAME, TXT(1)
113    FORMAT(//,16X,'THE SOIL SERIES SPECIFIED WAS : ',A20,/,21X,
$ 'THE SOIL TEXTURE IS : ',A4)
        WRITE(6,114) SNAME, TXT(1)
        WRITE(4,114) SNAME, TXT(1)
114    FORMAT(/,6X,'SOIL :  SERIES = ',A20,6X,'TEXTURE = ',A4)
        GO TO 130
C
115    WRITE(*,116) SNAME,(TXT(I),I=1,3)
116    FORMAT(//,16X,'THE SOIL SERIES SPECIFIED WAS : ',A20,/,19X,
$ 'THE SOIL TEXTURE IS : ',3(1X,A4))
        WRITE(6,117) SNAME,(TXT(I),I=1,3)
        WRITE(4,117) SNAME,(TXT(I),I=1,3)
117    FORMAT(/,5X,'SOIL :  SERIES = ',A20,3X,'TEXTURE = ',3(1X,A4))
C
C..... WRITE SOIL LAYER DEPTHS AND AVAILABLE WATER CAPACITIES
        WRITE(*,118)
        WRITE(*,120) (DU(I),I=1,NL)
        WRITE(*,122) (WCL(I),I=1,NL)
        WRITE(*,124) (WCU(I),I=1,NL)
        WRITE(6,118)
        WRITE(4,118)
        IF(ICODE .LT. 1) GO TO 125
        WRITE(6,120) (DU(I),I=1,NL)
        WRITE(4,120) (DU(I),I=1,NL)
        WRITE(6,122) (WCL(I),I=1,NL)
        WRITE(4,122) (WCL(I),I=1,NL)

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        WRITE(6,124)(WCU(I),I=1,NL)
        WRITE(4,124)(WCU(I),I=1,NL)
118  FORMAT(/,15X,'SOIL LAYER DEPTHS (INCHES) AND WATER CONTENTS')
120  FORMAT(18X,'DEPTH(I)=' ,6F6.0)
122  FORMAT(15X,'MIN.WCON(I)=' ,6F6.2)
124  FORMAT(15X,'MAX.WCON(I)=' ,6F6.2)
C
125  WRITE(*,126)
126  FORMAT(//,15X,'DO YOU WANT TO USE MINIMUM, AVERAGE, OR MAXIMUM' ,/,
$ 15X,' WATER-HOLDING CAPACITY FOR THIS SOIL SERIES ?' ,/,13X,
$ 'MINIMUM = 0          AVERAGE = 1          MAXIMUM = 2' ,/,12X,
$ ' ENTER THE SOIL CODE FOR THE APPROPRIATE CONDITION : ' ,/)
    READ(*,*,ERR=125) ISCODE
    IF(ISCODE .EQ. -99) GO TO 10
C
    DO 128 I=1,NL
    WC(I)=0.5*(WCL(I)+WCU(I))
    IF(ISCODE .EQ. 0) WC(I)=WCL(I)
128  IF(ISCODE .EQ. 2) WC(I)=WCU(I)
C
130  WRITE(*,120)(DU(I),I=1,NL)
    WRITE(6,120)(DU(I),I=1,NL)
    WRITE(4,120)(DU(I),I=1,NL)
    WRITE(*,132)(WC(I),I=1,NL)
    WRITE(6,132)(WC(I),I=1,NL)
    WRITE(4,132)(WC(I),I=1,NL)
132  FORMAT(11X,'WCON(I) ENTERED=' ,6F6.2)
C
C..... DEFINE LOWER SOIL LAYER DIMENSIONS
    DL(1) = 0.0
    IF(NL .EQ. 1) GO TO 140
    DO 135 I=2,NL
135  DL(I) = DU(I-1)
C
C*****
C..... ENTER DEPTH TO WATER TABLE
C
140  IF(IR .EQ. IRSEEP) GO TO 150
    DWT = 10.0
    IF(IR .EQ. IRNSCY) GO TO 150
    IF(IR .EQ. IRCRFL) GO TO 150
    IF(IR .EQ. IRRICE) GO TO 150
142  WRITE(*,144)
144  FORMAT(////,19X,'ENTER DEPTH TO WATER TABLE (FEET):')
    READ(*,*,ERR=142) DWT
    IF(DWT .LT. 0.01) GO TO 142
    WRITE(*,145) DWT
    WRITE(6,145) DWT
    WRITE(4,145) DWT
145  FORMAT(/,16X,'DEPTH TO WATER TABLE ENTERED =' ,F5.1,' FEET')
    IF(DWT .LT. 1.50) WRITE(*,146)
146  FORMAT(//,12X,'***** WARNING ***** WATER TABLE NEAR SOIL SURFACE',
$ /,11X,'MOST CROPS WILL NOT GROW WELL UNDER THESE CONDITIONS')
    DWT = DWT * 12.0
C
C*****
C..... CALCULATE MAXIMUM SOIL WATER-HOLDING CAPACITIES
C
C..... FOR PERENNIAL CROPS
C-----
C..... ROOT ZONE DEPTH IS ASSUMED TO BE FIXED
150  IF(ICROP .GT. NCP) GO TO 240
C
C..... FOR IRRIGATED ROOT ZONE

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C          CHECK FOR HIGH WATER TABLE LIMITING IRRIGATED ROOT ZONE
          IF(DRZI(J1) .LT. DWT) GO TO 164
          WRITE(*,160)
160  FORMAT(//,11X,'*** WARNING *** WATER TABLE DEPTH LIMITS ROOT EXPAN
$SION.'//,16X,'IRRIGATED ROOT ZONE IS SET = WATER TABLE DEPTH.')
          DRZI(J1) = DWT
C
C..... CHECK FOR SOIL DEPTH LIMITING IRRIGATED ROOT ZONE
164  DO 166 I=1,NL
          IS = I
166  IF(DRZI(J1) .LT. DU(I)) GO TO 182
C
          WRITE(*,174)
174  FORMAT(//,14X,'*** WARNING *** SOIL DEPTH LIMITS ROOT EXPANSION.'
$,//,15X,'IRRIGATED ROOT ZONE IS SET = MAXIMUM SOIL DEPTH.')
          DO 180 JD = J1,JN
180  DRZI(JD) = DU(NL)
C
C..... CALCULATE AVAILABLE SOIL WATER IN IRRIGATED ROOT ZONE
182  IS1 = IS - 1
          SWI = 0.0
          IF(IS .EQ. 1) GO TO 188
          DO 186 I=1,IS1
186  SWI = SWI + (DU(I)-DL(I)) * WC(I)
188  SWI = SWI + (DRZI(J1) - DL(IS)) * WC(IS)
C
C..... FOR TOTAL ROOT ZONE
C          CHECK FOR HIGH WATER TABLE LIMITING ROOT EXPANSION
          IF(DRZ(J1) .LT. DWT) GO TO 192
          WRITE(*,190)
190  FORMAT(//,11X,'*** WARNING *** WATER TABLE DEPTH LIMITS ROOT EXPAN
$SION.'//,14X,'TOTAL ROOT ZONE IS ADJUSTED FOR WATER TABLE DEPTH.')
          DRZ(J1) = DWT
          IF(DWT .LT. 2.0*DRZI(J1)) DRZ(J1) = 2.0 * DRZI(J1)
C
C..... CHECK FOR SOIL DEPTH LIMITING ROOT EXPANSION
192  DO 194 I=1,NL
          IS = I
194  IF(DRZ(J1) .LT. DU(I)) GO TO 204
          WRITE(*,198)
198  FORMAT(//,14X,'*** WARNING *** SOIL DEPTH LIMITS ROOT EXPANSION.',
$,//,14X,'TOTAL ROOT ZONE IS ADJUSTED FOR WATER TABLE DEPTH.')
          DRZ(J1) = DU(NL)
          IF(DRZ(J1) .LT. 2.0*DRZI(J1)) DRZ(J1) = 2.0 * DRZI(J1)
          DO 202 JD = J1,JN
202  DRZ(JD) = DRZ(J1)
C
C..... CALCULATE AVAILABLE SOIL WATER IN TOTAL ROOT ZONE
204  IS1 = IS - 1
          SWX = 0.0
          IF(IS .EQ. 1) GO TO 214
          DO 212 I=1,IS1
          WCX = WC(I)
          IF(IR .EQ. IRCRFL) WCX = 0.4
212  SWX = SWX + (DU(I)-DL(I)) * WCX
214  WCX = WC(IS)
          IF(IR .EQ. IRCRFL) WCX = 0.4
          SWX = SWX + (DRZ(J1) - DL(IS)) * WCX
          IF(DRZ(J1) .GT. DWT .AND. WCX .LT. 0.4) SWX=SWX+(DRZ(J1)-DWT)*(0.4-WCX)
C
C..... CORRECT FOR IRRIGATION OF ONLY A FRACTION OF THE ROOT ZONE
          SWI = ARZI * SWI
          SWN = SWX - SWI
C..... CORRECT FOR NONIRRIGATED ZONE IN CONTAINER NURSERIES

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        IF(ICROP .EQ. INSCY) SWN = 0.20
C..... CORRECT FOR BEDDED SURFACE IN CROWN FLOOD CITRUS IRRIGATION
        IF(IR .EQ. IRCRFL) SWI = SWI * 0.667
        SWX = SWI + SWN
        IF(SWN .LT. EPS) EXIR = 1.00
C
C..... ASSIGN DAILY SOIL WATER CAPACITY DATA
218 DO 220 JD = J1,JN
        SWMAX(JD) = SWX
        SWCIX(JD) = SWI
220 SWCNX(JD) = SWN
C
        GO TO 350
C
C..... FOR ANNUAL CROPS
C-----
C..... CALCULATE DAILY MAXIMUM SOIL WATER CONTENTS
240 IF(IR .EQ. IRRICE) GO TO 345
C
C..... FOR IRRIGATED ROOT ZONE
C        CHECK FOR HIGH WATER TABLE LIMITING ROOT EXPANSION
        DO 248 JD = J1,JN
        IF(DRZI(JD) .LT. DWT) GO TO 248
        IF(IW0 .EQ. 0) WRITE(*,246) JD
246 FORMAT(//,1X,'*** WARNING *** WATER TABLE DEPTH LIMITS ROOT EXPANSION BEGINNING ON CDAY =',I4,/,12X,'IRRIGATED ROOT ZONE IS SET EQUAL TO WATER TABLE DEPTH')
        DRZI(JD) = DWT
        IW0 = 1
248 CONTINUE
C
C..... CHECK FOR SOIL DEPTH LIMITING IRRIGATED ROOT ZONE
        DO 300 JD = J1,JN
        DO 250 I=1,NL
        IS = I
250 IF(DRZI(JD) .LT. DU(I)) GO TO 260
        IF(IW1 .EQ. 0)WRITE(*,255) JD
255 FORMAT(//,1X,'*** WARNING *** SOIL DEPTH LIMITS ROOT EXPANSION BEGINNING ON CDAY =',I4,/,11X,'IRRIGATED ROOT ZONE IS SET EQUAL TO MAXIMUM SOIL DEPTH')
        IW1 = 1
        DRZI(JD) = DU(NL)
C
C..... CALCULATE IRRIGATED ZONE AVAILABLE SOIL WATER FOR EACH DAY FROM ROOT ZONE EXPANSION
C
260 SWI = 0.0
        IF(IS .EQ. 1) GO TO 280
        IS1 = IS - 1
        DO 270 I=1,IS1
270 SWI = SWI + (DU(I)-DL(I)) * WC(I)
280 SWI = SWI + (DRZI(JD)-DL(IS)) * WC(IS)
C
C..... CORRECT FOR IRRIGATION OF ONLY A FRACTION OF THE ROOT ZONE
300 SWCIX(JD) = ARZI * SWI
C
C..... CORRECT CROP WATER USE COEFFICIENTS FOR GROWTH STAGES 1 AND 2, BASED ON SOIL PROPERTIES AND STAGE 1 CROP GROWTH
C..... FOR GROWTH STAGE 1
        AKKC = 0.8 * SQRT(WC(1)+0.05)
        J5 = J1 + 4
        DO 302 JD=J1,NF(1)
        RKC(JD) = AKKC
302 IF(JD .GT. J5) RKC(JD) = AKKC + 0.12 * (JD-J5)/(NF(1)-J5)
C

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C..... FOR GROWTH STAGE 2
      NFP = NF(1) + 1
      AKKC = AKKC + 0.12
      DO 304 JD=NFP,NF(2)
      RJD = JD
      RKC(JD) = AKKC + (RJD-NF(1)) / (NF(2)-NF(1)) * (AKC3-AKKC)
304  IF(RKC(JD) .GT. AKC3) RKC(JD)=AKC3
C
C..... FOR TOTAL ROOT ZONE
C      CHECK FOR HIGH WATER TABLE LIMITING TOTAL ROOT ZONE
      DO 308 JD = J1,JN
      IF(DRZ(JD) .LT. DWT) GO TO 308
      IF(IW2 .EQ. 0) WRITE(*,306) JD
306  FORMAT(//,1X,'*** WARNING *** WATER TABLE DEPTH LIMITS ROOT EXPANSION BEGINNING ON CDAY =',I4,/,14X,'TOTAL ROOT DEPTH IS ADJUSTED FOR WATER TABLE DEPTH')
      DRZ(JD) = DWT
      IF(DRZ(JD) .LT. 2.0*DRZI(JD)) DRZ(JD) = 2.0 * DRZI(JD)
      IW2 = 1
308  CONTINUE
C
      DO 340 JD = J1,JN
C
C..... CHECK FOR SOIL DEPTH LIMITING TOTAL ROOT ZONE
      DO 310 I=1,NL
      IS = I
310  IF(DRZ(JD) .LT. DU(I)) GO TO 320
      IF(IW3 .EQ. 0) WRITE(*,315) JD
315  FORMAT(//,1X,'*** WARNING *** SOIL DEPTH LIMITS ROOT EXPANSION BEGINNING ON CDAY =',I4,/,13X,'TOTAL ROOT DEPTH IS ADJUSTED FOR MAXIMUM SOIL DEPTH')
      IW3 = 1
      DRZ(JD) = DU(NL)
      IF(DRZ(JD) .LT. 2.0*DRZI(JD)) DRZ(JD) = 2.0 * DRZI(JD)
C
C..... CALCULATE MAXIMUM SOIL WATER-HOLDING CAPACITY FOR EACH DAY FROM ROOT ZONE EXPANSION
C
320  SWMAX(JD) = 0.0
      IF(IS .EQ. 1) GO TO 335
      IS1 = IS - 1
      DO 330 I=1,IS1
330  SWMAX(JD) = SWMAX(JD) + (DU(I)-DL(I)) * WC(I)
335  SWMAX(JD) = SWMAX(JD) + (DRZ(JD)-DL(IS)) * WC(IS)
      IF(DRZ(JD) .GT. DWT .AND. WC(IS) .LT. 0.4) SWMAX(JD) = SWMAX(JD) + $ (DRZ(JD)-DWT) * (0.4-WC(IS))
      SWCNX(JD) = SWMAX(JD) - SWCIX(JD)
340  CONTINUE
      GO TO 350
C
C..... FOR RICE FLOOD IRRIGATION SYSTEMS
345  WRITE(*,346)
346  FORMAT(//,18X,'ENTER RICE FLOOD STORAGE DEPTH (INCHES):')
      READ(*,*,ERR=345) DRINC
      WRITE(*,347) DRINC
347  FORMAT(14X,'RICE FLOOD STORAGE DEPTH ENTERED = ',F4.1,' INCHES')
      IF(DRINC .LT. 0.00) GO TO 345
      IF(DRINC .GT. 3.00) GO TO 345
      WRITE(6,347) DRINC
      WRITE(4,347) DRINC
C
      DO 348 JD=J1,JN
      SWCIX(JD) = 3.00
      SWMAX(JD) = SWCIX(JD) + DRINC
348  SWCNX(JD) = 0.00

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C
C..... CALCULATE STARTING SOIL WATER CONTENT AS 0.9 * FIELD CAPACITY
350 SWC11 = 0.9 * SWCIX(J1)
    SWCN1 = 0.9 * SWCNX(J1)
    IF(SWCN1 .LT. EPS) EXIR = 1.00
C
C..... CALCULATE SOIL WATER CONTENT AT WHICH IRRIGATION WILL BE
C      SCHEDULED
    DO 400 JD = J1,JN
400 SWIRR(JD) = (1.0-AWD(JD)) * SWCIX(JD)
C
C..... OUTPUT PARAMETERS FOR DEBUGGING
    IF(ICODE .LT. 1) GO TO 500
    WRITE(*,408)
    WRITE(6,408)
    WRITE(4,408)
408 FORMAT(//,5X,'OUTPUT PARAMETERS - ROOT DEPTHS, KCs, AND SOIL WATER
$ CONTENTS')
    WRITE(*,410)
    WRITE(6,410)
    WRITE(4,410)
410 FORMAT(7X,'CDAY JDAY    DRZ    DRZI    RKC    SWMAX  SWCIX  SWCNX  SW
$IRR')
    DO 430 JD = J1,JN
    WRITE(*,440) JD,JDAY(JD),DRZ(JD),DRZI(JD),RKC(JD),SWMAX(JD),
$ SWCIX(JD),SWCNX(JD),SWIRR(JD)
430 WRITE(6,440) JD,JDAY(JD),DRZ(JD),DRZI(JD),RKC(JD),SWMAX(JD),
$ SWCIX(JD),SWCNX(JD),SWIRR(JD)
    WRITE(4,440) JD,JDAY(JD),DRZ(JD),DRZI(JD),RKC(JD),SWMAX(JD),
$ SWCIX(JD),SWCNX(JD),SWIRR(JD)
440 FORMAT(6X,2I5,2F7.1,F7.3,4F7.2)
C
500 END
C
C*****
C
SUBROUTINE BAL
C*****
C.....THIS ROUTINE CALCULATES A WATER BALANCE FOR A CROP ROOT ZONE
C      ON A DAILY BASIS. THE SOIL WATER CONTENT IS UPDATED BASED ON
C      ET, RAIN, AND IRRIGATION. DRAINAGE AND EFFECTIVE RAINFALL ARE
C      ALSO CALCULATED.
C
C.....DEFINITIONS...
C
C      DR = DRAINAGE (INCHES)
C      ER = EFFECTIVE RAINFALL (INCHES)
C      ET = CROP EVAPOTRANSPIRATION (INCHES)
C      ETP = POTENTIAL CROP EVAPOTRANSPIRATION (INCHES)
C      EXIR = FRACTION OF ET EXTRACTED FROM IRRIGATED PORTION OF CROP
C            ROOT ZONE
C      FRIR = FRACTION OF NIR APPLIED PER IRRIG. FOR DEFICIT IRRIGATION
C      FIX = FIXED IRRIGATION DEPTH PER IRRIGATION (INCHES)
C      IRR = GROSS IRRIGATION REQUIREMENT (INCHES)
C      IY = YEAR COUNTER
C      JD = CALENDAR DAY COUNTER
C      NIR = NET IRRIGATION REQUIREMENT (INCHES)
C      NR = NUMBER OF DAYS REQUIRED FOR WATER TO REDISTRIBUTE TO FIELD
C            CAPACITY
C      NYR = NUMBER OF YEARS OF RECORD IN THE CLIMATE DATA BASE
C      RAIN = DAILY RAINFALL (INCHES)
C      RKC = CROP COEFFICIENT
C      SDR = DAILY DRAINAGE SUMMED FOR ALL YEARS OF RECORD (INCHES)
C      SET = DAILY ET SUMMED FOR ALL YEARS OF RECORD (INCHES)

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C   SETP = DAILY POTENTIAL ET SUMMED FOR ALL YEARS OF RECORD (INCHES)
C   SRAIN = DAILY RAINFALL SUMMED FOR ALL YEARS OF RECORD (INCHES)
C   SWCI1 = INITIAL IRRIGATED SOIL WATER CONTENT (INCHES AT START
C         OF IRRIGATION SEASON)
C   SWCN1 = INITIAL NON-IRRIGATED SOIL WATER CONTENT (INCHES AT
C         START OF IRRIGATION SEASON)
C   SWCI = SOIL WATER CONTENT IN THE IRRIGATED PORTION OF THE PLANT
C         EFFECTIVE ROOT ZONE (INCHES)
C   SWCN = SOIL WATER CONTENT IN THE NON-IRRIGATED PORTION OF THE
C         PLANT EFFECTIVE ROOT ZONE (INCHES)
C   SWIRR = SOIL WATER CONTENT WHICH TRIGGERS AN IRRIGATION (INCHES)
C   SWMAX = MAXIMUM AVAILABLE WATER CAPACITY IN THE TOTAL CROP
C         ROOT ZONE (INCHES)
C   SWCIX = MAXIMUM AVAILABLE WATER CAPACITY IN THE IRRIGATED
C         PORTION OF THE CROP ROOT ZONE (INCHES)
C   SWCNX = MAXIMUM AVAILABLE WATER CAPACITY IN THE NON-IRRIGATED
C         PORTION OF THE CROP ROOT ZONE (INCHES)
C
C   REAL IRR(25,365),NIR(365),KC(365)
C   CHARACTER CTYPE*12
C
C   COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C   $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C   $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
C   $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C   $ JLSAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C   $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,CTYPE
C
C   COMMON /BLOCK2/ ET(365),SET(365),SETP(365),SDR(365),SRAIN(365),
C   $ ER(365),DR(365)
C
C..... INITIALIZE / DEFINE PARAMETERS
C   NYX = NYR
C   REWAT = 1.0
C   IF(JLSAVE .GT. JNSAVE) NYX = NYR + 1
C   EXNR = 1.0 - EXIR
C
C..... ZERO PARAMETERS FOR ALL YEARS
C   DO 50 JD = 1, 365
C   KC(JD) = 0.0
C   SDR(JD) = 0.0
C   SET(JD) = 0.0
C   SETP(JD) = 0.0
C   SRAIN(JD) = 0.0
C   DO 50 IY = 1, NYX
50  IRR(IY,JD) = 0.0
C
C.....ITERATE YEARS
C   DO 500 IY = 1,NYR
C
C..... ZERO PARAMETERS FOR CURRENT YEAR
C   DO 55 JD = 1, 365
C   ET(JD) = 0.0
C   SWCI(JD) = 0.0
C   SWCN(JD) = 0.0
C   ER(JD) = 0.0
C   NIR(JD) = 0.0
55  DR(JD) = 0.0
C
C..... FOR RICE FLOOD IRRIGATION SYSTEMS
C   IF(IR .EQ. IRRICE) GO TO 182
C
C.....ITERATE DAYS
C   DO 180 JD = J1,JN

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      JD1 = JD - 1
      REWAT = REWAT + 1.0
C
C..... CALCULATE NUMBER OF DAYS REQUIRED FOR REDISTRIBUTION TO FIELD
C      CAPACITY.
      IF(IR .EQ. IRSEEP) GO TO 70
      IF(IR .EQ. IRCRFL) GO TO 70
      NRR = RAIN(IY,JD) + 1
      NR = 2
      IF(DRZI(JD) .LT. 12) NR = 1
      IF(DRZI(JD) .GT. 24) NR = 3
      IF(NRR .GT. NR) NR=NRR
      IF(NR .GT. 5) NR = 5
      GO TO 80
70  NR = 2
      IF(RAIN(IY,JD) .GT. 0.50) NR = 2.0 * RAIN(IY,JD) + 1
      IF(NR .GT. 7) NR = 7
C
C..... CALCULATE CROP ET FROM ETP AND CROP COEFFICIENT
80  KC(JD) = RKC(JD)
      RKCS = 0.00
      IF(ICROP .LT. NCP+1) GO TO 84
C..... DO NOT INCREASE CROP COEFFICIENT FOR RAIN IF RKC = 0.0 (NO CROP
C      BEING GROWN).
      IF(KC(JD) .LT. EPS) GO TO 90
C..... MODIFIES KC BASED ON DAYS SINCE LAST RAIN OR IRRIGATION DURING
C      GROWTH STAGES 1 AND 2
      IF(JD .GT. NF(2)) GO TO 84
      RKCS = 1.0 / SQRT(REWAT)
C..... ADJUSTS KC FOR LOW VERSUS HIGH ETP DAYS
84  KC(JD) = KC(JD) - 0.03 * (ETP(IY,JD)-0.20)
      IF(RKCS .GT. KC(JD)) KC(JD) = RKCS
C..... DO NOT REDUCE CROP COEFFICIENT FOR RAIN IF KC IS ALREADY > 1.0.
      IF(KC(JD) .GT. 1.0) GO TO 88
C..... CALCULATE ET AT POTENTIAL RATE FOR THE DAY THAT RAIN OCCURS.
      IF(ETP(IY,JD) .GT. EPS) RKCR = RAIN(IY,JD) / ETP(IY,JD)
      IF(RKCR .GT. 1.00) RKCR = 1.00
      IF(RKCR .GT. KC(JD)) KC(JD) = RKCR
88  IF(KC(JD) .GT. 1.25) KC(JD) = 1.25
90  ET(JD) = KC(JD) * ETP(IY,JD)
C
C.....UPDATE SOIL WATER CONTENT IN CROP ROOT ZONE FOR EXPANDING
C      ROOT ZONE, RAIN, AND ET
      IF(JD .NE. J1) GO TO 91
      IF(IY .EQ. 1) GO TO 106
      IF(NDAYS .LT. 365) GO TO 106
      IF(NDAYS .EQ. 365) GO TO 108
C
C..... FOR EXPANDING ROOT ZONE DUE TO CROP GROWTH
91  SWCEPS = SWCIX(JD1) + EPS
      IF(SWCIX(JD) .GT. SWCEPS) GO TO 92
      GO TO 96
C..... FOR CASE WHERE IRRIGATED ROOT DEPTH = TOTAL ROOT DEPTH
92  DRZEPS = DRZ(JD) - EPS
      IF(DRZI(JD) .LT. DRZEPS) GO TO 94
      SWCI(JD) = SWCI(JD1) + (SWCIX(JD)-SWCIX(JD1))
      SWCN(JD) = SWCN(JD1) + (SWCNX(JD)-SWCNX(JD1))
      GO TO 98
C..... FOR CASE WHERE IRRIGATED ROOT DEPTH < TOTAL ROOT DEPTH
94  IF(SWCNX(JD1) .LT. EPS) GO TO 98
      ADX = SWCN(JD1)/SWCNX(JD1) * (SWCIX(JD)-SWCIX(JD1))
      SWCI(JD) = SWCI(JD1) + ADX
      SWCN(JD) = SWCN(JD1) + (SWMAX(JD) - SWMAX(JD1)) - ADX
      GO TO 98

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C
C..... FOR NON-EXPANDING ROOT ZONE
96  SWCI(JD) = SWCI(JD1)
    SWCN(JD) = SWCN(JD1)
C
C..... FOR RAIN
98  WCISAVE = SWCI(JD)
    WCNSAVE = SWCN(JD)
    SWCI(JD) = SWCI(JD) + ARZI*RAIN(IY,JD)
    SWCN(JD) = SWCN(JD) + (1.0-ARZI)*RAIN(IY,JD)
C
C..... FOR ET
    IF(SWCI(JD).GT.SWCIX(JD) .OR. SWCN(JD).GT.SWCNX(JD)) GO TO 102
    IF(SWCN(JD) .LT. EPS) GO TO 100
C..... EXTRACT WATER FROM THE NON-IRRIGATED ZONE ONLY IF AVAILABLE
    XX = 0.5 * SWCNX(JD) + EPS
    ETNMAX = EXNR * ET(JD)
    IF(SWCN(JD).GT.XX .AND. XX.GT.ETNMAX) GO TO 102
    XET = SWCN(JD) / XX
    IF(XET .GT. 0.5) XET = 0.5
    ETN = ETNMAX * XET
    SWCI(JD) = SWCI(JD) - (ET(JD)-ETN)
    SWCN(JD) = SWCN(JD) - ETN
    IF(SWCN(JD) .GT. 0.0) GO TO 112
    SWCI(JD) = SWCI(JD) + SWCN(JD)
    SWCN(JD) = 0.0
    GO TO 112
C
C..... EXTRACT ALL ET FROM IRRIGATED ZONE IF NON-IRRIGATED ZONE IS DRY
100 SWCI(JD) = SWCI(JD) - ET(JD)
    GO TO 112
C
C..... EXTRACT EXIR FRACTION OF ET FROM IRRIGATED ZONE AND EXNR
C      FRACTION FROM THE NON-IRRIGATED ZONE WHEN WATER IS AVAILABLE
102  SWCI(JD) = SWCI(JD) - EXIR*ET(JD)
    SWCN(JD) = SWCN(JD) - EXNR*ET(JD)
    GO TO 112
C
C..... FOR FIRST DAY OF CROP GROWING SEASON FOR ANNUAL CROPS, FIRST
C      DAY OF FIRST YEAR FOR PERENNIAL CROPS, AND FOR PERENNIAL CROPS
C      THAT ARE IRRIGATED LESS THAN 365 DAYS PER YEAR
106  SWCI(JD) = SWCI1 - EXIR*ET(JD) + ARZI*RAIN(IY,JD)
    SWCN(JD) = SWCN1 - EXNR*ET(JD) + (1.0-ARZI)*RAIN(IY,JD)
    GO TO 112
C
C..... FOR FIRST DAY OF EACH SUCCESSIVE YEAR FOR PERENNIAL CROPS THAT
C      ARE IRRIGATED 365 DAYS PER YEAR
108  SWCI(JD) = SWCISV - EXIR*ET(JD) + ARZI*RAIN(IY,JD)
    SWCN(JD) = SWCNSV - EXNR*ET(JD) + (1.0-ARZI)*RAIN(IY,JD)
    IF(SWCN(JD) .GT. 0.0) GO TO 112
    SWCI(JD) = SWCI(JD) + SWCN(JD)
    SWCN(JD) = 0.0
C
C.....CHECK FOR DRAINAGE FROM ROOT ZONE
112  IF(RAIN(IY,JD) .LT. EPS) GO TO 118
    IF(SWCI(JD).LT.SWCIX(JD) .AND. SWCN(JD).LT.SWCNX(JD)) GO TO 118
    IF(SWCI(JD).LT.SWCIX(JD) .AND. SWCN(JD).LT. EPS) GO TO 118
    PERCI = 0.0
    RINCI = 0.0
    PERCN = 0.0
    RINCN = 0.0
C
C.....CALCULATE PERCOLATE
DO 113 JJ = 1,NR

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        JDINC = JJ + JD
        IF(JDINC .GT. JN) GO TO 113
        RINCI = RINCI + RKC(JDINC) *EXIR*ETP(IY,JDINC)
        RINCN = RINCN + RKC(JDINC) *EXNR*ETP(IY,JDINC)
113  CONTINUE
C
C..... CALCULATE DRAINAGE FROM IRRIGATED ZONE
        PERCI = SWCI(JD) - SWCIX(JD)
        IF(PERCI .LT. RINCI) RINCI = PERCI
        DRI = PERCI - RINCI
        SWCI(JD) = SWCIX(JD) + RINCI
        IF(SWCNX(JD) .GT. EPS) GO TO 114
        DR(JD) = DRI
        GO TO 116
C
C..... CALCULATE DRAINAGE FROM NON-IRRIGATED ZONE
C.....      WHEN DRZ = DRZI
114  IF(DRZI(JD) .LT. DRZ(JD)-EPS) GO TO 115
        PERCN = SWCN(JD) - SWCNX(JD)
        IF(PERCN .LT. RINCN) RINCN = PERCN
        DRN = PERCN - RINCN
        SWCN(JD) = SWCNX(JD) + RINCN
        DR(JD) = DRI + DRN
        GO TO 116
C
C.....      WHEN DRZ > DRZI
115  SWCX = SWCN(JD) + DRI
        PERCN = SWCN(JD) - SWCNX(JD) + DRI
        IF(PERCN .LT. RINCN) RINCN = PERCN
        SWCZ = SWCNX(JD) + RINCN
        SWCN(JD) = AMIN1(SWCX, SWCZ)
        DR(JD) = SWCX - SWCN(JD)
C
C.....CALCULATE EFFECTIVE RAINFALL
116  ER(JD) = RAIN(IY,JD) - DR(JD)
        IF(ER(JD) .LT. 0.0) GO TO 117
        GO TO 120
C
C..... CORRECT FOR REDISTRIBUTION INCREMENT
117  EXINC = -ER(JD)
        SWCI(JD) = SWCI(JD) + EXIR * EXINC
        SWCN(JD) = SWCN(JD) + EXNR * EXINC
        ER(JD) = 0.0
        GO TO 120
C
C..... CALCULATE EFFECTIVE RAINFALL WHEN DRAINAGE = 0.0
118  DR(JD) = 0.0
        ER(JD) = RAIN(IY,JD)
C
C.....CHECK FOR NEED TO IRRIGATE
120  IF(SWCI(JD) .GT. SWIRR(JD)) GO TO 140
C
C..... CALCULATE NET IRRIGATION AMOUNT
        IF(IR .EQ. IRSEEP) GO TO 130
        IF(IR .EQ. IRCRFL) GO TO 135
C..... IRRIGATE TO RESTORE SOIL WATER CONTENT TO FIELD CAPACITY
        NIR(JD) = SWCIX(JD) - SWCI(JD)
C..... IRRIGATE TO ONLY A FRACTION OF FIELD CAPACITY
        IF(IDCODE .EQ. 2) NIR(JD) = FRIR * SWCIX(JD) - SWCI(JD)
C..... IRRIGATE A FIXED IRRIGATION AMOUNT
        IF(IDCODE .EQ. 1) NIR(JD) = FIX
        GO TO 150
C
C..... FOR SEEPAGE IRRIGATION SYSTEMS

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```

130 NIR(JD) = 0.9 * SWCIX(JD) - SWCI(JD)
    IF(NIR(JD) .LT. 0.0) NIR(JD) = 0.0
    GO TO 150
C
C..... FOR CROWN FLOOD IRRIGATION SYSTEMS
C      ASSUME 3 DAYS REQUIRED TO IRRIGATE, AND
C      3 DAYS FOR DRAINAGE AFTER IRRIGATION
135 ETINC = 0.0
    DO 136 J = 1,5
      JDP = JD + J
      IF(JDP .GT. JN) GO TO 138
136 ETINC = ETINC + ETP(IY,JDP)
138 NIR(JD) = SWCIX(JD) - SWCI(JD) + ETINC
    GO TO 150
C
140 NIR(JD) = 0.0
C
C..... UPDATE SOIL WATER CONTENT FOR IRRIGATION
150 SWCI(JD) = SWCI(JD) + NIR(JD)
    IF(IR .EQ. IRNSYC) GO TO 160
    GO TO 170
C
C..... FOR CONTAINER NURSERY SPRINKLER IRRIGATION SYSTEMS
160 SWCN(JD) = SWCN(JD) + (1.0-ARZI)/ARZI * NIR(JD)
    IF(SWCN(JD) .GT. SWCNX(JD)) SWCN(JD) = SWCNX(JD)
C
C..... CALCULATE GROSS IRRIGATION REQUIREMENT
170 IRR(IY,JD) = NIR(JD) / EFF(IR)
C
180 IF(RAIN(IY,JD) .GT. 0.1 .OR. IRR(IY,JD) .GT. EPS) REWAT = 1.0
C
C..... SAVE LAST DAY'S SOIL WATER CONTENTS TO BEGIN FIRST DAY OF
C      NEXT YEAR FOR PERENNIAL CROPS.
    SWCISV = SWCI(JN)
    SWCNSV = SWCN(JN)
    GO TO 192
C
C..... FOR RICE FLOOD IRRIGATION SYSTEMS
182 DO 190 JD = J1,JN
      JD1 = JD - 1
      ET(JD) = RKC(JD) * ETP(IY,JD)
      IF(JD .EQ. J1) SWCI(JD) = SWCI1
      IF(JD .GT. J1) SWCI(JD) = SWCI(JD1)
      SWCI(JD) = SWCI(JD) + RAIN(IY,JD) - ET(JD)
      XX = SWCI(JD)
      DR(JD) = 0.0
      IF(SWCI(JD) .GT. SWMAX(JD)) GO TO 184
      GO TO 186
184 SWCI(JD) = SWMAX(JD)
      DR(JD) = XX - SWMAX(JD)
186 ER(JD) = RAIN(IY,JD) - DR(JD)
      NIR(JD) = 0.0
      IF(SWCI(JD) .LT. SWIRR(JD)) NIR(JD) = SWCIX(JD) - SWCI(JD)
      SWCI(JD) = SWCI(JD) + NIR(JD)
190 IRR(IY,JD) = NIR(JD) / EFF(IR)
C
C..... SUM PARAMETERS FOR EACH DAY OF THE IRRIGATION SEASON
192 DO 195 JD = J1,JN
      SDR(JD) = SDR(JD) + DR(JD)
      SET(JD) = SET(JD) + ET(JD)
      SETP(JD) = SETP(JD) + ETP(IY,JD)
195 SRRAIN(JD) = SRRAIN(JD) + RAIN(IY,JD)
C
C..... OUTPUT PARAMETERS FOR DEBUGGING

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C..... THIS SECTION OUTPUTS DAILY VALUES OF ALL COMPONENTS OF THE SOIL
C WATER BLANCE. BECAUSE OF THE VOLUME OF OUTPUT, IT IS NORMALLY
C USED FOR DEBUGGING ONLY.
C
      IF(ICODE .LT. 2) GO TO 500
      WRITE(6,200)
      WRITE(4,200)
      WRITE(*,200)
200  FORMAT(/, 7X, 'OUTPUT DAILY COMPONENTS OF SOIL WATER BUDGET FOR DE
      $BUGGING')
      WRITE(6,300) IY
      WRITE(4,300) IY
      WRITE(*,300) IY
300  FORMAT(/,28X, 'YEAR = ',I3,/, ' CDY JDY SWCN SWCI ETP KC ET RA
      $IN ER DR SWMX SWIX SWIR NIR IRR')
C
      DO 330 JD = J1,JN
      WRITE(6,350)JD,JDAY(JD),SWCN(JD),SWCI(JD),ETP(IY,JD),KC(JD),ET(JD)
      $ ,RAIN(IY,JD),ER(JD),DR(JD),SWMAX(JD),SWCIX(JD),SWIRR(JD),NIR(JD),
      $ IRR(IY,JD)
      WRITE(4,350)JD,JDAY(JD),SWCN(JD),SWCI(JD),ETP(IY,JD),KC(JD),ET(JD)
      $ ,RAIN(IY,JD),ER(JD),DR(JD),SWMAX(JD),SWCIX(JD),SWIRR(JD),NIR(JD),
      $ IRR(IY,JD)
330  WRITE(*,350)JD,JDAY(JD),SWCN(JD),SWCI(JD),ETP(IY,JD),KC(JD),ET(JD)
      $ ,RAIN(IY,JD),ER(JD),DR(JD),SWMAX(JD),SWCIX(JD),SWIRR(JD),NIR(JD),
      $ IRR(IY,JD)
350  FORMAT(1X,I3,I4,F6.2,F5.2,1X,F4.3,F5.2,1X,F4.3,3F5.2,F6.2,4F5.2)
C
500  CONTINUE
      END
C
C*****
C
      SUBROUTINE SUMX
C*****
C..... THIS SUBROUTINE SUMS IRR, RAIN, AND ETP DATA TO OBTAIN SEASONAL,
C MONTHLY, BI-WEEKLY, AND WEEKLY TOTALS.
C
C..... DEFINITIONS...
C
      DR = DRAINAGE (INCHES)
      ET = CROP EVAPOTRANSPIRATION (INCHES)
      ETP = POTENTIAL CROP EVAPOTRANSPIRATION (INCHES)
      IRR = GROSS IRRIGATION REQUIREMENT (INCHES)
      IY = YEAR COUNTER
      JD = CALENDAR DAY COUNTER
      NYR = NUMBER OF YEARS OF RECORD IN THE CLIMATE DATA BASE
      RAIN = DAILY RAINFALL (INCHES)
      XMEAN = MEAN ETP FOR PERIOD OF ANALYSIS (INCHES)
      XMED = MEDIAN ETP FOR PERIOD OF ANALYSIS (INCHES)
      XSDEV = STANDARD DEVIATION OF ETP FOR PERIOD OF ANALYSIS (INCHES)
      XMAX = MAXIMUM IRR FOR PERIOD OF ANALYSIS (INCHES)
      XMIN = MINIMUM IRR FOR PERIOD OF ANALYSIS (INCHES)
      X00 = FRACTION OF YEARS WITH IRR=0 FOR THE PERIOD OF RECORD ANALYZED
      X50 = 50% PROBABILITY IRR (INCHES)
      X80 = 80% PROBABILITY IRR (INCHES)
      X90 = 90% PROBABILITY IRR (INCHES)
      X95 = 95% PROBABILITY IRR (INCHES)
C
      REAL IRR(25,365),NIR(365)
      DIMENSION AETP(25,52),ARAIN(25,52),AIRR(25,52),TET(52),TETP(52),
      $ TDR(52),TRAIN(52),AI(25),PROB(25),NMO(12),PDAT(52)
      CHARACTER CTYPE*12
C

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COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
$ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
$ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
$ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
$ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
$ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,CTYPE
C
COMMON /BLOCK2/ ET(365),SET(365),SETP(365),SDR(365),SRAIN(365),
$ ER(365),DR(365)
C
DATA NMO/31,28,31,30,31,30,31,31,30,31,30,31/
C
-----
C..... OBTAIN SEASONAL TOTALS
C-----
      IS = 1
      DO 100 IY = 1,NYR
      AETP(IY,1) = 0.0
      ARAIN(IY,1) = 0.0
      AIRR(IY,1) = 0.0
      DO 100 JD = J1,JN
      AETP(IY,1) = AETP(IY,1) + ETP(IY,JD)
      ARAIN(IY,1) = ARAIN(IY,1) + RAIN(IY,JD)
      AIRR(IY,1) = AIRR(IY,1) + IRR(IY,JD)
100  CONTINUE
C
      TET(1) = 0.0
      TETP(1) = 0.0
      TDR(1) = 0.0
      TRAIN(1) = 0.0
      DO 110 JD = J1,JN
      TET(1) = TET(1) + SET(JD)
      TETP(1) = TETP(1) + SETP(JD)
      TDR(1) = TDR(1) + SDR(JD)
110  TRAIN(1) = TRAIN(1) + SRAIN(JD)
      TET(1) = TET(1) / NYR
      TETP(1) = TETP(1) / NYR
      TDR(1) = TDR(1) / NYR
      TRAIN(1) = TRAIN(1) / NYR
C
      IF(EFF(IR) .GT. 0.999) WRITE(6,120)
      IF(EFF(IR) .GT. 0.999) WRITE(4,120)
      IF(EFF(IR) .GT. 0.999) WRITE(*,120)
120  FORMAT(//,11X,'SEASONAL OR ANNUAL NET IRRIGATION REQUIREMENT (INCH
$ES)',/,11X,54('-'))
      IF(EFF(IR) .LT. 1.00) WRITE(6,122)
      IF(EFF(IR) .LT. 1.00) WRITE(4,122)
      IF(EFF(IR) .LT. 1.00) WRITE(*,122)
122  FORMAT(//,10X,'SEASONAL OR ANNUAL GROSS IRRIGATION REQUIREMENT (IN
$CHES)',/,10X,56('-'))
C
C..... OUTPUTS FOR DEBUGGING
      IF(ICODE .GT. 0)WRITE(6,130)
      IF(ICODE .GT. 0)WRITE(4,130)
130  FORMAT(15X,'SUMMARY OF WATER BUDGET COMPONENTS',
$/,18X,'YEAR      ETP      RAIN  IRR.RQD. ')
      DO 140 IY = 1,NYR
      IF(ICODE .GT. 0)WRITE(6,135)IY,AETP(IY,1),ARAIN(IY,1),AIRR(IY,1)
      IF(ICODE .GT. 0)WRITE(4,135)IY,AETP(IY,1),ARAIN(IY,1),AIRR(IY,1)
135  FORMAT(17X,I4,3F8.2)
140  AI(IY) = AIRR(IY,1)
C
C..... OUTPUT STATISTICS
      WRITE(6,150)

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        WRITE(4,150)
        WRITE(*,150)
150  FORMAT(/,3X,'MEAN  MED.  CV  XMAX  XMIN ZERO  RSQ  50%  80%  90%
      $95% RAIN  ETP  ET  DR')
C
        CALL STATX(AI,NYR,XMEAN,XMED,XCV,XMAX,XMIN,PROB)
        CALL PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C
C..... CHECK THAT EXTREME VALUES OF IRR DO NOT EXCEED ET
        XIRR = TET(1) / EFF(IR)
        IF(X50 .GT. XIRR) X50 = XIRR
        IF(X80 .GT. XIRR) X80 = XIRR
        IF(X90 .GT. XIRR) X90 = XIRR
        IF(X95 .GT. XIRR) X95 = XIRR
C
        IF(XMEAN .GT. 100.0) GO TO 164
        WRITE(6,160)XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,TRAIN
        $(1),TETP(1),TET(1),TDR(1)
        WRITE(4,160)XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,TRAIN
        $(1),TETP(1),TET(1),TDR(1)
        WRITE(*,160)XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,TRAIN
        $(1),TETP(1),TET(1),TDR(1)
160  FORMAT(1X,2F6.1,F5.2,F6.1,F5.1,2F5.2,8F5.1)
        GO TO 168
164  WRITE(6,165)XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,TRAIN
        $(1),TETP(1),TET(1),TDR(1)
        WRITE(4,165)XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,TRAIN
        $(1),TETP(1),TET(1),TDR(1)
        WRITE(*,165)XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,TRAIN
        $(1),TETP(1),TET(1),TDR(1)
165  FORMAT(1X,2F6.0,F5.2,F6.0,F5.0,2F5.2,4F5.0,4F5.1)
C
C-----
C..... REASSIGN DATA TO CALENDAR DATES FOR IRRIGATION SEASONS WHICH
C      EXTEND BEYOND 1 CALENDAR YEAR.
C-----
168  IF(J1SAVE .LT. JNSAVE) GO TO 270
C
        DO 190 IY = 1,NYR
        NY = NYR - IY + 1
        NY1 = NY + 1
        JJ = 366 - J1SAVE
C
        DO 170 JD = 1,JNSAVE
        J = JJ + JD
        ETP(NY1,JD) = ETP(NY,J)
        RAIN(NY1,JD) = RAIN(NY,J)
170  IRR(NY1,JD) = IRR(NY,J)
C
        J = 0
        DO 180 JJ = J1SAVE,365
        JD = 366 - JJ
        J = J + 1
        JX = 366 - J
        ETP(NY,JX) = ETP(NY,JD)
        RAIN(NY,JX) = RAIN(NY,JD)
180  IRR(NY,JX) = IRR(NY,JD)
190  CONTINUE
C
C..... MOVE DATA FROM LAST YEAR TO FIRST FOR ANALYSIS
        NYX = NYR + 1
        DO 210 JD = 1,JNSAVE
        ETP(1,JD) = ETP(NYX,JD)
        RAIN(1,JD) = RAIN(NYX,JD)

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210 IRR(1,JD) = IRR(NYX,JD)
C
C..... ZERO ALL DATA BETWEEN JNSAVE AND J1SAVE FOR EACH YEAR
      IF(J1SAVE-JNSAVE .LT. 2) GO TO 270
      J1M = J1SAVE - 1
      JNP = JNSAVE + 1
      DO 230 IY = 1,NYR
      DO 230 JD = JNP,J1M
      ETP(IY,JD) = 0.0
      RAIN(IY,JD) = 0.0
230 IRR(IY,JD) = 0.0
C-----
C..... OBTAIN MONTHLY TOTALS
C-----
270 IF(EFF(IR) .GT. 0.999) WRITE(6,272)
      IF(EFF(IR) .GT. 0.999) WRITE(4,272)
      IF(EFF(IR) .GT. 0.999) WRITE(*,272)
272 FORMAT(//,16X,'MONTHLY NET IRRIGATION REQUIREMENT (INCHES)',/,
      $ 16X,43('-'))
      IF(EFF(IR) .LT. 1.00) WRITE(6,275)
      IF(EFF(IR) .LT. 1.00) WRITE(4,275)
      IF(EFF(IR) .LT. 1.00) WRITE(*,275)
275 FORMAT(//,15X,'MONTHLY GROSS IRRIGATION REQUIREMENT (INCHES)',/,
      $ 15X,45('-'))
      IF(IPRT .EQ. 1) WRITE(6,276)
      IF(IPRT .EQ. 1) WRITE(4,276)
      IF(IPRT .EQ. 1) WRITE(*,276)
276 FORMAT(18X,'NOTE: ONLY NON-ZERO MONTHS ARE PRINTED.')
      IF(ICODE .LT. 1) WRITE(6,296)
      IF(ICODE .LT. 1) WRITE(4,296)
      WRITE(*,296)
C
      NX = 0
      DO 350 IMO = 1,12
      NN = NX + 1
      NX = NN + NMO(IMO) - 1
C
      DO 290 IY = 1,NYR
      AETP(IY,IMO) = 0.0
      ARAIN(IY,IMO) = 0.0
      AIRR(IY,IMO) = 0.0
C
      DO 280 JD = NN,NX
      AETP(IY,IMO) = AETP(IY,IMO) + ETP(IY,JD)
      ARAIN(IY,IMO) = ARAIN(IY,IMO) + RAIN(IY,JD)
280 AIRR(IY,IMO) = AIRR(IY,IMO) + IRR(IY,JD)
290 CONTINUE
C
      TET(IMO) = 0.0
      TETP(IMO) = 0.0
      TDR(IMO) = 0.0
      TRAIN(IMO) = 0.0
      DO 292 JD = NN,NX
      TET(IMO) = TET(IMO) + SET(JD)
      TETP(IMO) = TETP(IMO) + SETP(JD)
      TDR(IMO) = TDR(IMO) + SDR(JD)
292 TRAIN(IMO) = TRAIN(IMO) + SRAIN(JD)
      TET(IMO) = TET(IMO) / NYR
      TETP(IMO) = TETP(IMO) / NYR
      TDR(IMO) = TDR(IMO) / NYR
      TRAIN(IMO) = TRAIN(IMO) / NYR
C
      AISUM = 0.0
      DO 295 IY = 1,NYR

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AISUM = AISUM + AIRR(IY,IMO)
295 AI(IY) = AIRR(IY,IMO)
    IF(IPRT .EQ. 1 .AND. AISUM .LT. 0.0001) GO TO 340
    IF(ICODE .GT. 0)WRITE(6,296)
    IF(ICODE .GT. 0)WRITE(4,296)
296 FORMAT(/,1X,'MO MEAN MED. CV XMAX XMIN ZERO RSQ 50% 80% 90%
    $ 95% RAIN ETP ET DR')
C
C..... OUTPUT STATISTICS
    CALL STATX(AI,NYR,XMEAN,XMED,XCV,XMAX,XMIN,PROB)
    CALL PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C
C..... CHECK THAT EXTREME VALUES OF IRR DO NOT EXCEED NIR
    XIRR = TET(IMO) / EFF(IR)
    IF(X50 .GT. XIRR) X50 = XIRR
    IF(X80 .GT. XIRR) X80 = XIRR
    IF(X90 .GT. XIRR) X90 = XIRR
    IF(X95 .GT. XIRR) X95 = XIRR
C
    WRITE(6,300)IMO,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
    $ TRAIN(IMO),TETP(IMO),TET(IMO),TDR(IMO)
    WRITE(4,300)IMO,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
    $ TRAIN(IMO),TETP(IMO),TET(IMO),TDR(IMO)
    WRITE(*,300)IMO,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
    $ TRAIN(IMO),TETP(IMO),TET(IMO),TDR(IMO)
300 FORMAT(1X,I2,F6.1,F5.1,F5.2,2F5.1,2F5.2,8F5.1)
C
C..... SAVE MONTHLY MEAN DATA FOR PLOTTING
    PDAT(IMO) = XMEAN
C
C..... OUTPUTS FOR DEBUGGING
    IF(ICODE .LT. 1) GO TO 350
    WRITE(6,310) IMO
    WRITE(4,310) IMO
310 FORMAT(/,28X,'MONTH = ',I2)
    WRITE(6,130)
    WRITE(4,130)
    DO 320 IY = 1,NYR
    WRITE(4,135)IY,AETP(IY,IMO),ARAIN(IY,IMO),AIRR(IY,IMO)
320 WRITE(6,135)IY,AETP(IY,IMO),ARAIN(IY,IMO),AIRR(IY,IMO)
    GO TO 350
340 PDAT(IMO) = 0.0
350 CONTINUE
C
C..... PLOT MONTHLY MEAN DATA
    NPLOT = 12
    IF(IPLOT .EQ. 1) CALL PLOT(PDAT,NPLOT,CTYPE)
C
    IF(ICODE .EQ. -1) GO TO 990
C-----
C..... OBTAIN 2-WEEK TOTALS
C-----
    IF(EFF(IR) .GT. 0.999) WRITE(6,372)
    IF(EFF(IR) .GT. 0.999) WRITE(4,372)
    IF(EFF(IR) .GT. 0.999) WRITE(*,372)
372 FORMAT(//,16X,'2-WEEK NET IRRIGATION REQUIREMENT (INCHES)',/,
    $ 16X,42('-'))
    IF(EFF(IR) .LT. 1.00) WRITE(6,375)
    IF(EFF(IR) .LT. 1.00) WRITE(4,375)
    IF(EFF(IR) .LT. 1.00) WRITE(*,375)
375 FORMAT(//,15X,'2-WEEK GROSS IRRIGATION REQUIREMENT (INCHES)',/,
    $ 15X,44('-'))
    IF(IPRT .EQ. 1) WRITE(6,376)
    IF(IPRT .EQ. 1) WRITE(4,376)

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IF(IPRT .EQ. 1) WRITE(*,376)
376 FORMAT(17X,'NOTE: ONLY NON-ZERO PERIODS ARE PRINTED.')
IF(ICODE .EQ. 0) WRITE(6,396)
IF(ICODE .EQ. 0) WRITE(4,396)
WRITE(*,396)
C
NX = 0
DO 450 I2W = 1,26
NN = NX + 1
NX = NN + 13
IF(I2W .EQ. 26) NX = 365
C
DO 390 IY = 1,NYR
AETP(IY,I2W) = 0.0
ARAIN(IY,I2W) = 0.0
AIRR(IY,I2W) = 0.0
C
DO 380 JD = NN,NX
AETP(IY,I2W) = AETP(IY,I2W) + ETP(IY,JD)
ARAIN(IY,I2W) = ARAIN(IY,I2W) + RAIN(IY,JD)
380 AIRR(IY,I2W) = AIRR(IY,I2W) + IRR(IY,JD)
390 CONTINUE
C
TET(I2W) = 0.0
TETP(I2W) = 0.0
TDR(I2W) = 0.0
TRAIN(I2W) = 0.0
DO 392 JD = NN,NX
TET(I2W) = TET(I2W) + SET(JD)
TETP(I2W) = TETP(I2W) + SETP(JD)
TDR(I2W) = TDR(I2W) + SDR(JD)
392 TRAIN(I2W) = TRAIN(I2W) + SRAIN(JD)
TET(I2W) = TET(I2W) / NYR
TETP(I2W) = TETP(I2W) / NYR
TDR(I2W) = TDR(I2W) / NYR
TRAIN(I2W) = TRAIN(I2W) / NYR
C
AISUM = 0.0
DO 395 IY = 1,NYR
AISUM = AISUM + AIRR(IY,I2W)
395 AI(IY) = AIRR(IY,I2W)
IF(IPRT .EQ. 1 .AND. AISUM .LT. 0.0001) GO TO 440
IF(ICODE .GT. 0)WRITE(6,396)
IF(ICODE .GT. 0)WRITE(4,396)
396 FORMAT(/,1X,'I2W MEAN MED. CV XMAX XMIN ZERO RSQ 50% 80% 90%
$ 95% RAIN ETP ET DR')
C
C..... OUTPUT STATISTICS
CALL STATX(AI,NYR,XMEAN,XMED,XCV,XMAX,XMIN,PROB)
CALL PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C
C..... CHECK THAT EXTREME VALUES OF IRR DO NOT EXCEED NIR
XIRR = TET(I2W) / EFF(IR)
IF(X50 .GT. XIRR) X50 = XIRR
IF(X80 .GT. XIRR) X80 = XIRR
IF(X90 .GT. XIRR) X90 = XIRR
IF(X95 .GT. XIRR) X95 = XIRR
C
WRITE(6,300)I2W,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
$ TRAIN(I2W),TETP(I2W),TET(I2W),TDR(I2W)
WRITE(4,300)I2W,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
$ TRAIN(I2W),TETP(I2W),TET(I2W),TDR(I2W)
WRITE(*,300)I2W,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
$ TRAIN(I2W),TETP(I2W),TET(I2W),TDR(I2W)

```

```

C
C..... SAVE 2-WEEK MEAN DATA FOR PLOTTING
      PDAT(I2W) = XMEAN
C
      IF(ICODE .LT. 1) GO TO 450
      WRITE(6,410) I2W
      WRITE(4,410) I2W
410  FORMAT(/,23X,'2-WEEK PERIOD = ',I2)
      WRITE(6,130)
      WRITE(4,130)
      DO 420 IY = 1,NYR
      WRITE(4,135) IY, AETP(IY,I2W), ARAIN(IY,I2W), AIRR(IY,I2W)
420  WRITE(6,135) IY, AETP(IY,I2W), ARAIN(IY,I2W), AIRR(IY,I2W)
      GO TO 450
440  PDAT(I2W) = 0.0
450  CONTINUE
C
C..... PLOT 2-WEEK MEAN DATA
      NPLOT = 26
      IF(IPLOT .EQ. 1) CALL PLOT(PDAT,NPLOT,CTYPE)
C
-----
C..... OBTAIN WEEKLY TOTALS
-----
      IF(EFF(IR) .GT. 0.999) WRITE(6,472)
      IF(EFF(IR) .GT. 0.999) WRITE(4,472)
      IF(EFF(IR) .GT. 0.999) WRITE(*,472)
472  FORMAT(/,16X,'WEEKLY NET IRRIGATION REQUIREMENT (INCHES)',/,
$ 16X,42('-'))
      IF(EFF(IR) .LT. 1.00) WRITE(6,475)
      IF(EFF(IR) .LT. 1.00) WRITE(4,475)
      IF(EFF(IR) .LT. 1.00) WRITE(*,475)
475  FORMAT(/,15X,'WEEKLY GROSS IRRIGATION REQUIREMENT (INCHES)',/,
$ 15X,44('-'))
      IF(IPRT .EQ. 1) WRITE(6,476)
      IF(IPRT .EQ. 1) WRITE(4,476)
      IF(IPRT .EQ. 1) WRITE(*,476)
476  FORMAT(18X,'NOTE: ONLY NON-ZERO WEEKS ARE PRINTED.')
      IF(ICODE .EQ. 0) WRITE(6,496)
      IF(ICODE .EQ. 0) WRITE(4,496)
      WRITE(*,496)
C
      NX = 0
      DO 550 I7 = 1,52
      NN = NX + 1
      NX = NN + 6
      IF(I7 .EQ. 52) NX = 365
C
      DO 490 IY = 1,NYR
      AETP(IY,I7) = 0.0
      ARAIN(IY,I7) = 0.0
      AIRR(IY,I7) = 0.0
C
      DO 480 JD = NN,NX
      AETP(IY,I7) = AETP(IY,I7) + ETP(IY,JD)
      ARAIN(IY,I7) = ARAIN(IY,I7) + RAIN(IY,JD)
480  AIRR(IY,I7) = AIRR(IY,I7) + IRR(IY,JD)
490  CONTINUE
C
      TET(I7) = 0.0
      TETP(I7) = 0.0
      TDR(I7) = 0.0
      TRAIN(I7) = 0.0
      DO 492 JD = NN,NX

```

```

TET(I7) = TET(I7) + SET(JD)
TETP(I7) = TETP(I7) + SETP(JD)
TDR(I7) = TDR(I7) + SDR(JD)
492 TRAIN(I7) = TRAIN(I7) + SRRAIN(JD)
TET(I7) = TET(I7) / NYR
TETP(I7) = TETP(I7) / NYR
TDR(I7) = TDR(I7) / NYR
TRAIN(I7) = TRAIN(I7) / NYR
C
AISUM = 0.0
DO 495 IY = 1, NYR
AISUM = AISUM + AIRR(IY, I7)
495 AI(IY) = AIRR(IY, I7)
IF(IPRT .EQ. 1 .AND. AISUM .LT. 0.0001) GO TO 540
IF(ICODE .GT. 0)WRITE(6,496)
IF(ICODE .GT. 0)WRITE(4,496)
496 FORMAT(/,1X,'WK MEAN MED. CV XMAX XMIN ZERO RSQ 50% 80% 90%
$ 95% RAIN ETP ET DR')
C
C..... OUTPUT STATISTICS
CALL STATX(AI, NYR, XMEAN, XMED, XCV, XMAX, XMIN, PROB)
CALL PROBX(AI, NYR, PROB, XMEAN, X00, RSQ, X50, X80, X90, X95)
C
C..... CHECK THAT EXTREME VALUES OF IRR DO NOT EXCEED NIR
XIRR = TET(I7) / EFF(IR)
IF(X50 .GT. XIRR) X50 = XIRR
IF(X80 .GT. XIRR) X80 = XIRR
IF(X90 .GT. XIRR) X90 = XIRR
IF(X95 .GT. XIRR) X95 = XIRR
C
WRITE(6,300)I7,XMEAN, XMED, XCV, XMAX, XMIN, X00, RSQ, X50, X80, X90, X95,
$ TRAIN(I7), TETP(I7), TET(I7), TDR(I7)
WRITE(4,300)I7,XMEAN, XMED, XCV, XMAX, XMIN, X00, RSQ, X50, X80, X90, X95,
$ TRAIN(I7), TETP(I7), TET(I7), TDR(I7)
WRITE(*,300)I7,XMEAN, XMED, XCV, XMAX, XMIN, X00, RSQ, X50, X80, X90, X95,
$ TRAIN(I7), TETP(I7), TET(I7), TDR(I7)
C
C..... SAVE WEEKLY MEAN DATA FOR PLOTTING
PDAT(I7) = XMEAN
C
C..... OUTPUTS FOR DEBUGGING
IF(ICODE .LT. 1) GO TO 550
WRITE(6,497) I7
WRITE(4,497) I7
497 FORMAT(/,23X,'WEEKLY PERIOD = ',I2)
WRITE(6,130)
WRITE(4,130)
DO 499 IY = 1, NYR
WRITE(4,135)IY, AETP(IY, I7), ARAIN(IY, I7), AIRR(IY, I7)
499 WRITE(6,135)IY, AETP(IY, I7), ARAIN(IY, I7), AIRR(IY, I7)
GO TO 550
540 PDAT(I7) = 0.0
550 CONTINUE
C
C..... PLOT WEEKLY MEAN DATA
NPLOT = 52
IF(IPLOT .EQ. 1) CALL PLOT(PDAT, NPLOT, CTYPE)
C
990 CONTINUE
END
C
C*****
C
SUBROUTINE STATX(X, N, XMEAN, XMED, XCV, XMAX, XMIN, PROB)

```

```

C*****
C..... THIS SUBROUTINE ORDERS THE IRRIGATION REQUIREMENTS DATA BASE
C      FROM LARGEST TO SMALLEST, AND IT CALCULATES THE PLOTTING
C      POSITIONS FOR THE IRR DATA.
C
C.....THIS SUBROUTINE COMPUTES THE STATISTICAL PARAMETERS MEAN, MEDIAN,
C      VARIANCE, STANDARD DEVIATION, COEFFICIENT OF VARIATION, MAXIMUM,
C      MINIMUM, AND FRACTION OF YEARS WITH NO IRRIGATION
C
C.....DEFINITIONS...
C
C      N = NUMBER OF YEARS OF DATA ANALYZED
C      PROB = PLOTTING POSITION PROBABILITY THAT A GIVEN VALUE WILL BE
C            EQUALLED OR EXCEEDED
C      XMEAN = MEAN IRR FOR PERIOD OF ANALYSIS (INCHES)
C      XMED = MEDIAN IRR FOR PERIOD OF ANALYSIS (INCHES)
C      XSDEV = STANDARD DEVIATION OF IRR FOR PERIOD OF ANALYSIS (INCHES)
C      XMAX = MAXIMUM IRR FOR PERIOD OF ANALYSIS (INCHES)
C      XMIN = MINIMUM IRR FOR PERIOD OF ANALYSIS (INCHES)
C      X00 = FRACTION OF YEARS WITH IRR=0 FOR THE PERIOD OF RECORD ANALYZED
C      ZERO = NUMBER OF YEARS WITH NO IRRIGATION
C
C      DIMENSION X(25),PROB(25)
C
C..... INITIALIZE PROBABILITIES
C
C      DO 10 I = 1,N
10  PROB(I) = 1.0
C
C      NP = N + 1
C      NM = N - 1
C      DATP = N + 1.0
C
C..... ORDER DATA FROM LARGEST TO SMALLEST
C      DO 30 I=1,NM
C      IP = I + 1
C
C      DO 20 J=IP,N
C      IF(X(J) .LT. X(I)) GO TO 20
C      TEMP = X(I)
C      X(I) = X(J)
C      X(J) = TEMP
20  CONTINUE
C
C..... CALCULATE PLOTTING POSTIONS
30  PROB(I) = I / DATP
C      PROB(N) = N / DATP
C
C..... COMPUTE MEAN
C      XSUM = 0
C      DO 100 I = 1,N
C      XSUM = XSUM + X(I)
100 CONTINUE
C      XMEAN = XSUM/N
C
C..... COMPUTE VARIANCE, STANDARD DEVIATION, AND XCV
C      VSUM = 0
C      DO 200 I = 1,N
C      VSUM = VSUM + (X(I)-XMEAN)*(X(I)-XMEAN)
200 CONTINUE
C      XVAR = VSUM/(N-1)
C      IF(XVAR .GT. 0.0) XSDEV = SQRT(XVAR)
C      XCV = 0.0
C      IF(XMEAN .GT. 0.0001) XCV = XSDEV/XMEAN

```



```

C
C..... DEFINE MAXIMUM AND MINIMUM VALUES
      XMAX = X(1)
      XMIN = X(N)
C
C..... DETERMINE THE MEDIAN
      NT = N/2
      NNT = NT*2
      XMED = X(NT+1)
      IF(NNT .EQ. N) XMED = 0.5 * (X(NT) + X(NT+1))
C
      END
C
C*****
C
      SUBROUTINE PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C*****
C.....THIS SUBROUTINE CALCULATES THE 50%, 80%, 90%, AND 95%
C      PROBABILITY VALUES OF IRR BASED ON AN EXTREME VALUE
C      TYPE I PROBABILITY DISTRIBUTION
C
C.....DEFINITIONS...
C
C      NYR = NUMBER OF YEARS OF RECORD IN THE CLIMATE DATA BASE
C      XMEAN = MEAN IRR FOR PERIOD OF ANALYSIS (INCHES)
C      X00 = FRACTION OF YEARS WITH NO IRR
C      X50 = 50% PROBABILITY IRR (INCHES)
C      X80 = 80% PROBABILITY IRR (INCHES)
C      X90 = 90% PROBABILITY IRR (INCHES)
C      X95 = 95% PROBABILITY IRR (INCHES)
C
      REAL AI(25),PROB(25),W(25),ALIRR(25),INTCPT
C
      EPS = 0.000001
      RNYR = NYR
C
C..... RETURN -1.0 IF DATA BASE IS NOT ADEQUATE TO CALCULATE INDICATED
C      EXTREME VALUE
      X00 = -1.0
      X50 = -1.0
      X80 = -1.0
      X90 = -1.0
      X95 = -1.0
      RSQ = -1.0
C
C..... RETURN 0.0 FOR ALL VALUES IF THE MEAN IS 0.0
      IF(XMEAN .GT. 0.0001) GO TO 20
      X00 = 0.0
      X50 = 0.0
      X80 = 0.0
      X90 = 0.0
      X95 = 0.0
      RSQ = 1.0
      GO TO 990
C
C..... ELIMINATE ZERO DATA VALUES FROM ANALYSIS
      20 IPOS = 0
         DO 30 IY = 1,NYR
            IF(AI(IY) .LT. EPS) GO TO 40
         30 IPOS = IY
C..... CALCULATE FRACTION OF ZERO VALUES
      40 X00 = (NYR-IPOS)/RNYR
         XPOS = 1.0 - X00
C

```

```

C..... CALCULATE PLOTTING POSITIONS FOR PROBS AND IRRs
      RSQ = -9.99
      IF(IPOS .LT. 3) GO TO 990
C
      DO 100 IY = 1,IPOS
      IYM = IY - 1
      W(IY) = ALOG10(-ALOG10(PROB(IY)))
      ALIRR(IY) = ALOG10(AI(IY))
100  CONTINUE
C
C..... CALL SUBROUTINE LSQ TO FIT STRAIGHT LINE TO TRANSFORMED DATA
C      BY THE METHOD OF LEAST SQUARES
      CALL LSQ(W,ALIRR,IPOS,INTCPT,SLOPE,R,RSQ)
C
C..... IF COEFFICIENT OF DETERMINATION IS LOW, EXTREME VALUES CANNOT
C      BE CALCULATED USING THIS METHOD
      IF(RSQ .LT. 0.500) GO TO 990
      IF(IPOS .LT. NYR) GO TO 300
C
C..... CALCULATE EXTREME VALUES OF IRR FROM REGRESSION EQUATION WHEN NO
C      VALUES ARE = 0.0
      X50 = 10.0 ** (-0.52139*SLOPE + INTCPT)
      X80 = 10.0 ** (-0.15554*SLOPE + INTCPT)
      X90 = 10.0 ** INTCPT
      X95 = 10.0 ** (0.11429*SLOPE + INTCPT)
      GO TO 990
C
C..... CALCULATE EXTREME VALUES OF IRR WHEN SOME VALUES = 0.0
300  C50 = (XPOS-0.5)/XPOS
      IF(C50 .GT. EPS) GO TO 310
      X50 = 0.0
      GO TO 320
310  C50 = ALOG10(-ALOG10(1.0-C50))
      X50 = 10.0 ** (C50 * SLOPE + INTCPT)
C
320  C80 = (XPOS-0.2)/XPOS
      IF(C80 .GT. EPS) GO TO 330
      X80 = 0.0
      GO TO 340
330  C80 = ALOG10(-ALOG10(1.0-C80))
      X80 = 10.0 ** (C80 * SLOPE + INTCPT)
C
340  C90 = (XPOS-0.1)/XPOS
      IF(C90 .GT. EPS) GO TO 350
      X90 = 0.0
      GO TO 360
350  C90 = ALOG10(-ALOG10(1.0-C90))
      X90 = 10.0 ** (C90 * SLOPE + INTCPT)
C
360  C95 = (XPOS-0.05)/XPOS
      IF(C95 .GT. EPS) GO TO 370
      X95 = 0.0
      GO TO 990
370  C95 = ALOG10(-ALOG10(1.0-C95))
      X95 = 10.0 ** (C95 * SLOPE + INTCPT)
990  END
C
C*****
C
      SUBROUTINE LSQ(X,Y,N,INTCPT,SLOPE,R,RSQ)
C*****
C      THIS SUBROUTINE CALCULATES THE LEAST SQUARES CURVE FIT FOR A
C      SET OF N LINEARLY DISTRIBUTED DATA POINTS TO FIT THE EQUATION
C      Y = SLOPE * X + INTCPT

```

```

C      REAL X(25),Y(25),INTCPT
C
C..... CALCULATE MEANS OF Xs AND Ys
      SUMX = 0.0
      SUMY = 0.0
      DO 20 I=1,N
20     SUMX = SUMX + X(I)
      SUMY = SUMY + Y(I)
      XBAR = SUMX / N
      YBAR = SUMY / N
C
C..... CALCULATE SUMS OF DEVIATIONS SQUARED AND CROSS PRODUCTS
      SX2 = 0.0
      SY2 = 0.0
      SXY = 0.0
      DO 30 I=1,N
30     SX2 = SX2 + (X(I)-XBAR)*(X(I)-XBAR)
      SY2 = SY2 + (Y(I)-YBAR)*(Y(I)-YBAR)
      SXY = SXY + (X(I)-XBAR)*(Y(I)-YBAR)
C
C..... CALCULATE INTCPT AND SLOPE
      SLOPE = SXY / SX2
      INTCPT = YBAR - SLOPE * XBAR
C
C..... CALCULATE SAMPLE CORRELATION COEFFICIENT, R, AND COEFFICIENT OF
C      DETERMINATION, RSQ
      R = SXY / SQRT(SX2 * SY2)
      RSQ = R * R
C
      END
C
C*****
C      SUBROUTINE PLOT(Y,NDAT,CTYPE)
C*****
C..... THIS SUBROUTINE GRAPHS THE IRRIGATION REQUIREMENTS DATA
C      FOR MONTHLY, 2-WEEK, AND WEEKLY PERIODS OF ANALYSIS
C
      DIMENSION ARRAY(22,54),IAXIS(13),YAXIS(6),Y(52),X(52),YSC(12)
      CHARACTER CTYPE*12
      DATA EYE, BLANK, DASH, PLUS, SYMBOL/1HI,1H-,1H+,1H*/
      DATA YSC/1,2.5,5,10,20,40,50,60,75,100,150,200/
C
C..... LOCATE MAXIMUM Y VALUE
      YMAX = 0.0
      DO 50 I = 1,NDAT
50     IF(Y(I) .GT. YMAX) YMAX = Y(I)
C
C..... SET Y AXIS SCALE
      DO 60 I = 1,10
      ISC = I
60     IF(YSC(I) .GT. YMAX) GO TO 70
70     YMAX = YSC(ISC)
C
      XMAX = NDAT
      XSP = 52
      IF(NDAT .EQ. 12) XSP = 48
      DEL = YMAX / 20.0
      DELX = XMAX / XSP
C
C..... INITIALIZE VECTOR X
      DO 80 I = 1,NDAT
80     X(I) = I

```

```

C
C..... ZERO ARRAY
      DO 100 I = 1,22
      DO 100 J = 1,54
100   ARRAY(I,J) = BLANK
C
C..... LABEL Y AXIS
      DO 110 I = 1,21
110   ARRAY(I,1) = EYE
      DO 120 I=1,21,4
120   ARRAY(I,1) = PLUS
C
      DO 125 I = 1,6
      IM = I-1
125   YAXIS(I) = YMAX - IM * 4.0 * DEL
C
C..... LABEL X AXIS
      DO 130 J = 2,54
130   ARRAY(22,J) = DASH
      DO 140 J = 2,54,4
140   ARRAY(22,J) = PLUS
C
      IF(NDAT .EQ. 26) GO TO 160
      IF(NDAT .EQ. 52) GO TO 180
      NI = 12
      IG = 7
150   IAXIS(I) = I
      GO TO 200
C
160   NI = 13
      IG = 5
      DO 170 I = 1,NI
170   IAXIS(I) = 2 * I
      GO TO 200
C
180   NI = 13
      IG = 4
      DO 190 I = 1,NI
190   IAXIS(I) = 4 * I
C
C..... CHECK FOR DATA POINTS OUTSIDE OF GRAPH BOUNDS
200   DO 250 K = 1,NDAT
      IF(Y(K) .GT. YMAX) Y(K) = YMAX
      IF(Y(K) .LT. 0.00) Y(K) = 0.00
      IF(X(K) .GT. XMAX) X(K) = XMAX
      IF(X(K) .LT. 1.0) X(K) = 1.0
C
C..... CALCULATE PLOTTING POSITIONS
      I = 21 - (Y(K) - DEL/2.0) / DEL
      J = IG + (X(K) - DELX/2.0 - 1.0) / DELX
250   ARRAY(I,J) = SYMBOL
C
C..... PRINT GRAPH
      WRITE(*,280)
      WRITE(6,280)
      WRITE(4,280)
280   FORMAT(////////,2X,'IRR (INCHES)',18X,'IRRIGATION REQUIREMENTS')
      WRITE(*,290) CTYPE
      WRITE(6,290) CTYPE
      WRITE(4,290) CTYPE
290   FORMAT(39X,A12)
C
      ICOUNT = 0

```

```

DO 400 K = 1,5
ICOUNT = ICOUNT + 1
WRITE(*,300) YAXIS(K), (ARRAY(ICOUNT,J),J=1,54)
WRITE(6,300) YAXIS(K), (ARRAY(ICOUNT,J),J=1,54)
WRITE(4,300) YAXIS(K), (ARRAY(ICOUNT,J),J=1,54)
300 FORMAT(3X,F9.2,1X,54A1)
C
DO 400 M = 1,3
ICOUNT = ICOUNT + 1
WRITE(*,350) (ARRAY(ICOUNT,J),J=1,54)
WRITE(6,350) (ARRAY(ICOUNT,J),J=1,54)
WRITE(4,350) (ARRAY(ICOUNT,J),J=1,54)
350 FORMAT(13X,54A1)
400 CONTINUE
C
WRITE(*,300) YAXIS(6), (ARRAY(21,J),J=1,54)
WRITE(6,300) YAXIS(6), (ARRAY(21,J),J=1,54)
WRITE(4,300) YAXIS(6), (ARRAY(21,J),J=1,54)
WRITE(*,350) (ARRAY(22,J),J=1,54)
WRITE(6,350) (ARRAY(22,J),J=1,54)
WRITE(4,350) (ARRAY(22,J),J=1,54)
WRITE(*,500) (IAXIS(K),K=1,NI)
WRITE(6,500) (IAXIS(K),K=1,NI)
WRITE(4,500) (IAXIS(K),K=1,NI)
500 FORMAT(15X,13I4)
C
IF(NDAT .EQ. 12) WRITE(*,520)
IF(NDAT .EQ. 12) WRITE(6,520)
IF(NDAT .EQ. 12) WRITE(4,520)
520 FORMAT(37X,'MONTH',///)
IF(NDAT .EQ. 26) WRITE(*,540)
IF(NDAT .EQ. 26) WRITE(6,540)
IF(NDAT .EQ. 26) WRITE(4,540)
540 FORMAT(34X,'2-WEEK PERIOD',///)
IF(NDAT .EQ. 52) WRITE(*,560)
IF(NDAT .EQ. 52) WRITE(6,560)
IF(NDAT .EQ. 52) WRITE(4,560)
560 FORMAT(39X,'WEEK',///)
END
C*****

```

APPENDIX G

LISTING OF AFSIRS MODEL FORTRAN COMPUTER CODE,
BATCH MODEL VERSION

```

C*****
C
C           AFSIRS MODEL - BATCH VERSION
C
C           VERSION 5.5: JANUARY, 1990
C
C           AGRICULTURAL FIELD SCALE IRRIGATION REQUIREMENTS
C           SIMULATION MODEL
C
C           BY
C           A.G. SMAJSTRLA
C           AGRICULTURAL ENGINEERING DEPARTMENT
C           UNIVERSITY OF FLORIDA
C*****
C
C           THIS MODEL CALCULATES IRRIGATION REQUIREMENTS FOR FLORIDA
C           AGRICULTURAL CROPS, AND FOR GIVEN SOIL, IRRIGATION SYSTEM,
C           CLIMATE, AND MANAGEMENT CONDITIONS.
C
C           ALTHOUGH THIS MODEL IS BELIEVED TO BE COMPLETE AND ACCURATE,
C           NO EXPLICIT OR IMPLICIT WARRANTIES ARE MADE WITH REGARD TO ITS
C           USE. THE RESPONSIBILITY FOR THE USE OF THIS MODEL FOR ANY
C           SPECIFIC PURPOSE LIES SOLELY WITH THE USER.
C
C           INSTRUCTIONS FOR THE USE OF THIS MODEL ARE GIVEN IN THE AFSIRS
C           MODEL USER'S GUIDE. DETAILS OF THE MECHANISMS OF OPERATION OF
C           THE MODEL, ITS APPLICATIONS, AND LIMITATIONS ARE GIVEN IN THE
C           AFSIRS MODEL TECHNICAL MANUAL.
C*****
C
C           DEFINITIONS....
C
C           IR = IRRIGATION SYSTEM IDENTIFICATION CODE
C           IRCRFL = CROWN FLOOD IRRIGATION SYSTEM CODE
C           IRNSCY = CONTAINER NURSERY IRRIGATION SYSTEM CODE
C           IRRICE = RICE FLOOD IRRIGATION SYSTEM CODE
C           IRSEEP = SEEPAGE (SUBIRRIGATION) IRRIGATION SYSTEM CODE
C           ISIM = COUNTER FOR MULTIPLE SIMULATIONS
C           JDAY = CALENDAR DAY OF CROP IRRIGATION SEASON
C           J1SAVE = CALENDAR DAY OF FIRST DAY OF IRRIGATION SEASON FOR
C                   PREVIOUS SIMULATION
C           JNSAVE = CALENDAR DAY OF LAST DAY OF IRRIGATION SEASON FOR
C                   PREVIOUS SIMULATION
C           NCP = NUMBER OF DIFFERENT PERENNIAL CROP TYPES
C           SITE = DESCRIPTION OF LOCATION OF THE PRODUCTION SYSTEM SIMULATED
C
C           REAL IRR(25,365),NIR(365)
C           CHARACTER SITE*36, CTYPE*12, OUTFIL*20
C
C           COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C           $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C           $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,IILSAVE,ISIM,
C           $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C           $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C           $ ICODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,DRINC,HGT,CTYPE
C

```

```

IR = 0
ISIM = 0
ICIT = 4
INSCY = 8
IRICE = 48
IRNSYC = 5
IRCRFL = 8
IRSEEP = 7
IRRICE = 9
J1SAVE = 0
JNSAVE = 0
ICGP = 6
ICGA = 34
EPS = 0.000001

```

C

C..... WRITE HEADER PAGE

```

WRITE(*,70)
WRITE(*,30)
30  FORMAT(/,26X,'AGRICULTURAL',/,26X,'FIELD',/,26X,'SCALE',/,26X,'IRR
$IGATION',/,26X,'REQUIREMENTS',/,26X,'SIMULATION',/,29X,'MODEL')
WRITE(*,40)
40  FORMAT(/,17X,'AFSIRS MODEL:  BATCH VERSION 5.5')
WRITE(*,50)
50  FORMAT(/,11X,'THIS MODEL SIMULATES IRRIGATION REQUIREMENTS',/,
$9X,'FOR FLORIDA CROPS, SOILS, AND CLIMATE CONDITIONS.')
WRITE(*,60)
60  FORMAT(/,6X,'PROBABILITIES OF OCCURRENCE OF IRRIGATION REQUIREMENT
$$',/,8X,'ARE CALCULATED USING HISTORICAL WEATHER DATA BASES',/,
$19X,'FOR NINE FLORIDA LOCATIONS.')
```

C

```

WRITE(*,70)
70  FORMAT(/,70('*'))
WRITE(*,75)
75  FORMAT(/,6X,
$'ALTHOUGH THIS MODEL IS BELIEVED TO BE COMPLETE AND ACCURATE',/,
$2X,'NO EXPLICIT OR IMPLICIT WARRANTIES ARE MADE WITH REGARD TO ITS
$ USE.',/,9X,'THE RESPONSIBILITY FOR THE USE OF THIS MODEL FOR ANY
$',/,14X,'SPECIFIC PURPOSE LIES SOLELY WITH THE USER.')
```

C

```

WRITE(*,80)
80  FORMAT(/,10X,'INSTRUCTIONS FOR THE USE OF THIS MODEL ARE GIVEN',
$ /,17X,'IN THE AFSIRS MODEL USER'S GUIDE.',/,7X,
$ 'DETAILS OF THE OPERATION OF THIS MODEL, ITS APPLICATIONS',/,4X,
$ 'AND LIMITATIONS ARE GIVEN IN THE AFSIRS MODEL TECHNICAL MANUAL.')
```

C

```
WRITE(*,70)
```

C

C..... READ OUTPUT FILE NAME FROM KEYBOARD

```

82  WRITE(*,85)
85  FORMAT(/,22X,'ENTER OUTPUT FILE NAME:',/)
READ(*,'(A20)',ERR=82) OUTFIL
WRITE(*,86) OUTFIL
86  FORMAT(/,18X,'OUTPUT FILE NAME ENTERED = ',A20)
```

C

C..... OPEN OUTPUT FILE

```

OPEN(6,FILE=OUTFIL,STATUS='NEW',ERR=88)
GO TO 94
88  WRITE(*,90)
90  FORMAT(/,14X,'FILE ALREADY EXISTS OR ILLEGAL FILE NAME',/,21X,
$ 'ENTER 1 TO OVER-WRITE:',/,13X,
$ 'ENTER 0 TO SPECIFY NEW OUTPUT FILE NAME:')
READ(*,*,ERR=88) IFILE
IF(IFILE .EQ. 0) GO TO 82
IF(IFILE .EQ. 1) GO TO 92
```

```

      GO TO 88
92  OPEN(6,FILE=OUTFIL)
C
94  WRITE(6,95)
95  FORMAT(1H1)
      WRITE(6,70)
      WRITE(6,30)
      WRITE(6,40)
      WRITE(6,50)
      WRITE(6,60)
      WRITE(6,70)
      WRITE(6,75)
      WRITE(6,80)
      WRITE(6,70)
C
C..... OPEN BATCH INPUT DATA FILE
      OPEN(1,FILE='INPUT.DAT')
C
C..... READ TODAY'S DATE
96  WRITE(*,97)
97  FORMAT(/,15X,'ENTER TODAY'S DATE (MONTH, DAY, YEAR) :')
      READ(*,*,ERR=96)MONTH,IIDAY,IYEAR
      WRITE(*,98)MONTH,IIDAY,IYEAR
98  FORMAT(/,43X,'DATE: ',I2,' - ',I2,' - ',I4)
C
C..... ITERATE SUCCESSIVE SIMULATIONS
100 CONTINUE
      FRIR = 1.00
      FIX = 0.00
      DO 105 JD =1,365
105  JDAY(JD) = JD
      ISIM = ISIM + 1
      J1REP = J1SAVE
      JNREP = JNSAVE
C
      READ(1,170,END=990) SITE
170  FORMAT(A36)
      WRITE(*,180) SITE
180  FORMAT(/,21X,'LOCATION :',A36)
C
      WRITE(6,95)
      WRITE(6,40)
      WRITE(6,50)
      WRITE(6,70)
      WRITE(6,190) SITE,MONTH,IIDAY,IYEAR
190  FORMAT(/,1X,'LOCATION = ',A36,2X,'DATE = ',I2,'-',I2,'-',I4)
C
C..... CALL SUBROUTINES
      CALL INPUT
      CALL CLIMAT
      CALL IRRI(ICGP,ICGA)
      CALL DCOEF(ICGP,ICGA)
      CALL SW
      CALL BAL
      CALL SUMX
      GO TO 100
C
990  CLOSE(6)
      CLOSE(1)
      END
C
C*****
C
SUBROUTINE INPUT

```



```

C*****
C..... THIS SUBROUTINE READS BASIC DATA NECESSARY TO RUN THE MODEL
C
C   DEFINITIONS....
C
C   CROP = CROP TYPE
C   DAY1 = 1ST DAY OF IRRIGATION SEASON
C   DAYN = LAST DAY OF IRRIGATION SEASON
C   CDAY = CONSECUTIVE DAYS OF CROP IRRIGATION SEASON
C   ICROP = CROP TYPE CODE
C   ICODE = CODE TO SPECIFY STYLE OF OUTPUT
C   IR = IRRIGATION SYSTEM TYPE CODE
C   IPRT = CODE WHICH SUPPRESSES PRINTING OF ROWS OF ZEROS WHEN = 1
C   IVERS = CODE TO SPECIFY USE OF DEFAULT DATA BASES WHEN = 0, OR
C           TO SPECIFY DATA ENTRY FROM KEYBOARD WHEN = 1
C   JDAY = CALENDAR DAY OF CROP IRRIGATION SEASON
C   J1 = FIRST DAY OF CROP IRRIGATION SEASON
C   JN = LAST DAY OF CROP IRRIGATION SEASON
C   MO1 = 1ST MONTH OF IRRIGATION SEASON
C   MON = LAST MONTH OF IRRIGATION SEASON
C   NCA = NUMBER OF DIFFERENT ANNUAL CROPS
C   NCP = NUMBER OF DIFFERENT PERENNIAL CROP TYPES
C   NCROP = TOTAL NUMBER OF DIFFERENT CROPS
C   NDAYS = LENGTH OF IRRIGATION SEASON (DAYS)
C
C   REAL IRR(25,365),NIR(365)
C   CHARACTER*12 CROP(60), DUMMY, CTYPE
C   INTEGER DAY1, DAYN, MDAY(12)
C
C   COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C   $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C   $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,IISAVE,ISIM,
C   $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C   $ JISAVE,JNSAVE,JIREP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C   $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,DRINC,HGT,CTYPE
C
C   DATA MDAY/31,28,31,30,31,30,31,31,30,31,30,31/
C
C..... READ INPUT PARAMETERS
C   READ(1,90) ICODE,IPRT,IPLLOT,IVERS
C   90  FORMAT(I2,3(1X,I1))
C
C   READ(1,100) ICROP,MO1,DAY1,MON,DAYN
C   100  FORMAT(I2,4(1X,I2))
C
C..... SPECIFY CROP TYPE
C   IF(ISIM .GT. 1) GO TO 400
C   OPEN(8,FILE='CROP.DAT')
C   READ(8,200) NCP
C   200  FORMAT(I3)
C   READ(8,210) DUMMY
C
C   DO 220 ICP = 1,NCP
C   READ(8,210) CROP(ICP)
C   210  FORMAT(A12)
C   220  READ(8,210) DUMMY
C
C   READ(8,210) DUMMY
C   READ(8,200) NCA
C   READ(8,210) DUMMY
C   NCP1 = NCP + 1
C   NCROP = NCP + NCA
C   READ(8,210) (CROP(ICP),ICP=NCP1,NCROP)
C   CLOSE(8)

```

```

C
400 WRITE(6,480) CROP(ICROP)
480 FORMAT(/,22X,'CROP TYPE = ',A12)
    CTYPE = CROP(ICROP)
C
C..... CALCULATE LENGTH OF IRRIGATION SEASON
    MO11 = MO1 - 1
    MON1 = MON - 1
C
    J1 = DAY1
    IF(MO1 .EQ. 1) GO TO 720
    DO 700 IMO = 1,MO11
700   J1 = J1 + MDAY(IMO)
720   JN = DAYN
    IF(MON .EQ. 1)GO TO 800
    DO 740 IMO = 1,MON1
740   JN = JN + MDAY(IMO)
800   IF(J1 .GT. JN) GO TO 820
    NDAYS = JN - J1 + 1
    GO TO 840
820   NDAYS = JN + (366 - J1)
840   WRITE(6,880) MO1,DAY1,MON,DAYN,NDAYS
880   FORMAT(/,1X,'IRRIGATION SEASON = ',I2,'-',I2,' TO ',I2,'-',I2,
    $ 15X,'LENGTH = ',I3,' DAYS')
C
C..... SAVE GROWING SEASON DATA FOR NEXT SIMULATION
    J1SAVE = J1
    JNSAVE = JN
    IF(J1 .LT. JN) GO TO 990
    J1 = 1
    JN = NDAYS
C
990 CONTINUE
    END
C
C*****
C
    SUBROUTINE CLIMAT
C*****
C..... THIS SUBROUTINE READS CLIMATE DATA (ETP AND RAIN) FOR THE
C      SIMULATION LOCATION AND FOR ALL YEARS OF RECORD.
C
C   ALOC = WEATHER DATA BASE LOCATION
C   ETP = DAILY POTENTIAL EVAPOTRANSPIRATION (INCHES)
C   NLOC = NUMBER OF WEATHER DATA BASE LOCATIONS
C   NYR = NUMBER OF YEARS OF RECORD IN THE CLIMATE DATA BASE
C   RAIN = DAILY RAINFALL (INCHES)
C
    REAL IRR(25,365),NIR(365)
    CHARACTER ALOC*16, FNAME*20, CTYPE*12
C
    COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
    $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
    $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
    $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
    $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
    $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,DRINC,HGT,CTYPE
C
C..... READ CLIMATE DATA BASE FILE NAME
    READ(1,115) FNAME
115  FORMAT(A20)
C
C..... CHECK WHETHER CLIMATE DATA BASES HAVE ALREADY BEEN READ
    IF(ISIM .EQ. 1) GO TO 100

```

```

        IF(J1SAVE .LT. JNSAVE .AND. J1REP .LT. JNREP) GO TO 920
        IF(J1REP .LT. JNREP) GO TO 600
        IF(J1SAVE.NE.J1REP .OR. JNSAVE.NE.JNREP) GO TO 100
        GO TO 600
C
100 OPEN(5,FILE=FNAME)
C
C..... READ CLIMATE DATA BASE LOCATION AND YRS OF RECORD
        READ(5,120) ALOC
120  FORMAT(A16)
        READ(5,160) NYR
160  FORMAT(I5)
C
C..... READ CLIMATE DATA FILES
C..... ETP DATA
        DO 350 IY = 1,NYR
        READ(5,320) IYEAR
320  FORMAT(I4)
350  READ(5,360) (ETP(IY,JD),JD=1,365)
360  FORMAT(14(1X,F4.3))
C
C..... RAIN DATA
        READ(5,420) DUMMY
420  FORMAT(A4)
        DO 450 IY = 1,NYR
        READ(5,320) IYEAR
450  READ(5,460) (RAIN(IY,JD),JD=1,365)
460  FORMAT(12F6.3)
        CLOSE(5)
C
C.... REARRANGE DATA FOR CROP YEARS THAT EXTEND BEYOND 1 CALENDAR YEAR
        IF(J1SAVE .LT. JNSAVE) GO TO 920
600  NYR = NYR - 1
        DO 900 IY = 1,NYR
        J = 0
        IY1 = IY + 1
        DO 700 JD = J1SAVE,365
        J = J + 1
        JDAY(J) = JD
        ETP(IY,J) = ETP(IY,JD)
700  RAIN(IY,J) = RAIN(IY,JD)
        DO 800 JD = 1,JNSAVE
        J = J + 1
        JDAY(J) = JD
        ETP(IY,J) = ETP(IY1,JD)
800  RAIN(IY,J) = RAIN(IY1,JD)
900  CONTINUE
C
C..... WRITE DATA BASE LOCATIONS AND YEARS OF RECORD
920  WRITE(6,980) ALOC, NYR
980  FORMAT(/,1X,'CLIMATE DATA BASE: LOCATION = ',A16,2X,'LENGTH = '
        $,I3,' YEARS')
        END
C
C*****
C
        SUBROUTINE IRRI(ICGP,ICGA)
C*****
C....THIS SUBROUTINE OBTAINS INFORMATION ON THE TYPE OF IRRIGATION
C     SYSTEM TO BE USED AND ASSIGNS IRRIGATION SYSTEM EFFICIENCIES
C
C     DEFINITIONS....
C
C     AREA, ARZI = FRACTION OF THE SOIL SURFACE IRRIGATED (DECIMAL)

```

```

C   EFF = IRRIGATION SYSTEM DESIGN APPLICATION EFFICIENCY (DECIMAL)
C   EX, EXIR = FRACTION OF ET EXTRACTED FROM THE IRRIGATED ZONE WHEN
C               WATER IS AVAILABLE IN THE NONIRRIGATED ZONE
C   ICROP = CROP TYPE CODE
C   IR = IRRIGATION SYSTEM IDENTIFICATION CODE
C   NIRRI = TOTAL NUMBER OF IRRIGATION SYSTEM TYPES INCLUDED IN THE
C           AFSIRS MODEL DATA BASE
C
C           DIMENSION AREA(10),EX(10)
C           REAL IRR(25,365),NIR(365)
C           CHARACTER*28 SYS(10),SYSIN
C           CHARACTER CTYPE*12
C
C           COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C           $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C           $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
C           $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C           $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C           $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,DRINC,HGT,CTYPE
C
C           OPEN(7,FILE='IR.DAT')
C
C
C..... READ IRRIGATION SYSTEM PARAMETERS
C           READ(7,100) NIRRI
100  FORMAT(I2)
C           READ(7,120) DUMMY
120  FORMAT(A4)
C           DO 150 IR = 1,NIRRI
C           READ(7,140) EFF(IR),AREA(IR),EX(IR),SYS(IR)
140  FORMAT(3X,3F6.2,2X,A28)
150  CONTINUE
C
C           READ(1,200) IR,INET,IDCODE,FIX,PIR,EFFIN,AREAIN,EXIN,SYSIN
200  FORMAT(I2,2(1X,I1),5F5.1,1X,A28)
C           FRIR = PIR / 100.0
C
C
C..... ENTER CODE TO DEFINE IRRIGATION DEPTHS PER APPLICATION
C           IF(IR .GT. 6) GO TO 650
C           IF(IDCODE .EQ. 0) WRITE(6,550)
550  FORMAT(/,9X,'NORMAL IRRIGATION: SOIL WILL BE IRRIGATED TO FIELD CA
C           $PACITY',/,29X,'AT EACH IRRIGATION')
C           IF(IDCODE .EQ. 1) WRITE(6,552)
552  FORMAT(/,10X,'FIXED DEPTH IRRIGATION: A FIXED (CONSTANT) DEPTH OF
C           $WATER',/,21X,'WILL BE APPLIED AT EACH IRRIGATION')
C           IF(IDCODE .EQ. 2) WRITE(6,554)
554  FORMAT(/,9X,'DEFICIT IRRIGATION: THE SOIL WILL BE IRRIGATED TO A F
C           $RACTION',/,21X,'OF FIELD CAPACITY AT EACH IRRIGATION')
C
C           IF(IDCODE .EQ. 1) WRITE(6,590) FIX
590  FORMAT(/,10X,'DEPTH OF WATER TO APPLY PER IRRIGATION =',F5.2,' INC
C           $HES')
C           IF(IDCODE .EQ. 2) WRITE(6,630) PIR
630  FORMAT(/,6X,'PERCENT OF FIELD CAPACITY ENTERED FOR DEFICIT IRRIGAT
C           $ION =',F5.1,'%')
C
C
C..... FOR USER ENTRY OF IRRIGATION SYSTEM PARAMETERS
C           IF(IVERS .EQ. 0) GO TO 860
C           IF(ICROP.EQ.ICGP .OR. ICROP.EQ.ICGA) GO TO 700
C           GO TO 860
700  EFF(IR) = EFFIN
C           AREA(IR) = AREAIN
C           EX(IR) = EXIN
C           SYS(IR) = SYSIN
C
C

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860 IF(INET .EQ. 0) EFF(IR)=1.00
C
C..... ASSIGN AND WRITE IRRIGATION PARAMETERS
      ARZI = AREA(IR)
      EXIR = EX(IR)
      IF(IR.EQ.2 .OR. IR.EQ.3) EXIR = 0.7*ARZI + 0.10*(1.0-ARZI)
C
      IEFF = 100.0001 * EFF(IR)
      IP = 100.0001 * ARZI
C
      WRITE(6,900) SYS(IR),IEFF,IP, EXIR
900  FORMAT(/,1X,'IRRIGATION SYSTEM : TYPE = ',A28,/,
      $ 21X,'DESIGN APPLICATION EFFICIENCY = ',I3,' %',/,
      $ 21X,'FRACTION OF SOIL SURFACE IRRIGATED = ',I3,' %',/,
      $ 21X,'FRACTION EXTRACTED FROM IRRIGATED ZONE = 'F5.2)
C
      CLOSE(7)
      END
C
C*****
C
      SUBROUTINE DCOEF(ICGP,ICGA)
C*****
C.....THIS SUBROUTINE CALCULATES CROP WATER USE COEFFICIENTS AND ROOT
C      ZONE DEPTHS FOR EACH DAY OF THE CROP GROWING SEASON.
C
C      DEFINITIONS.....
C
C      ALD(I) = ALLOWABLE SOIL WATER DEPLETION BEFORE IRRIGATION
C              FOR EACH ANNUAL CROP GROWTH STAGE (DECIMAL)
C      AWD(JD) = ALLOWABLE WATER DEPLETION FOR EACH DAY OF THE IRRIGATION
C              SEASON (DECIMAL)
C      ALDP(IMO) = MONTHLY ALLOWABLE SOIL WATER DEPLETION FOR PERENNIAL
C                CROPS (DECIMAL)
C      DRZ(JD) = TOTAL EFFECTIVE CROP ROOT ZONE DEPTH (INCHES)
C      DRZI(JD) = CROP ROOT ZONE DEPTH IRRIGATED (INCHES)
C      DRZIRR = ANNUAL AVERAGE DEPTH OF ROOT ZONE IRRIGATED FOR
C              PERENNIAL CROPS (INCHES)
C      DRZONE = AVERAGE ANNUAL EFFECTIVE ROOT ZONE DEPTH FOR PERENNIAL
C              CROPS (INCHES)
C      DRZTOT = ANNUAL AVERAGE EFFECTIVE ROOT ZONE DEPTH FOR PERENNIAL
C              CROPS (INCHES)
C      DZN = MINIMUM EFFECTIVE ROOT ZONE DEPTH, AT BEGINNING OF GROWING
C           SEASON FOR ANNUAL CROPS (INCHES)
C      DZX = MAXIMUM EFFECTIVE ROOT ZONE DEPTH, AFTER MAXIMUM ROOT DEVELOP-
C           MENT FOR ANNUAL CROPS (INCHES)
C      F(I) = FRACTION OF ANNUAL CROP GROWING SEASON THAT OCCURS IN
C           EACH OF 4 GROWTH STAGES
C      HGT = HEIGHT OF CROWN FLOOD SYSTEM BED (FT)
C      AKC(MO) = MONTHLY CROP COEFFICIENTS FOR PERENNIAL CROPS
C      KC1 = CROP WATER USE COEFFICIENT FOR GROWTH STAGE 1 FOR ANNUAL CROPS
C      AKC3 =CROP WATER USE COEFFICIENT FOR GROWTH STAGE 3 FOR ANNUAL CROPS
C      AKC4 =CROP WATER USE COEFFICIENT FOR GROWTH STAGE 4 FOR ANNUAL CROPS
C      NKC(MO) = DAY OF YEAR AT WHICH MONTHLY KCs OCCUR
C      NMO(MO) = NUMBER OF DAYS PER MONTH FOR ITH MONTH
C      RKC(JD) = DAILY CROP COEFFICIENT FOR EACH DAY OF THE IRRIGATION
C              SEASON
C
      REAL IRR(25,365),NIR(365)
      DIMENSION NKC(12),NMO(12),F(4),ALD(4),RKTMP(365),AWTMP(365),
      $ AKC(12),ALDP(12)
      CHARACTER*12 CTYPE, DUMMY
C
      COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),

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```

$ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
$ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
$ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
$ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
$ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,DRINC,HGT,CTYPE
C
DATA NMO/31,28,31,30,31,30,31,31,30,31,30,31/
DATA NKC/15,45,74,105,135,166,196,227,258,288,319,349/
C
OPEN(8,FILE='CROP.DAT')
C
C..... ZERO PARAMETERS
DO 120 JD = 1,365
AWD(JD) = 0.0
DRZ(JD) = 0.0
DRZI(JD) = 0.0
120 RKC(JD) = 0.0
C
C..... READ DEPTH TO WATER TABLE (FT), CROWN FLOOD BED HEIGHT (FT),
C AND RICE FLOOD STORAGE DEPTH (INCHES)
READ(1,130) DWT, HGT, DRINC
130 FORMAT(3F5.1)
DWT = 12.0 * DWT
C
C..... READ CROP DATA
C-----
READ(8,150) NCP
150 FORMAT(I3)
IF(ICROP .GT. NCP) GO TO 500
C
C..... FOR PERENNIAL CROPS
C-----
C..... READ MONTHLY VALUES OF CROP COEFFICIENTS
IC = 2*(ICROP-1) + 1
DO 160 I=1,IC
160 READ(8,180) DUMMY
READ(8,180) CTYPE,(AKC(IMO),IMO=1,12)
180 FORMAT(A12,1X,12F5.2)
READ(8,190) DRZIRR,DRZTOT,(ALDP(IMO),IMO=1,12)
190 FORMAT(7X,2F3.0,12F5.2)
IF(ICROP .NE. ICGP) GO TO 280
C
C..... FOR GENERIC PERENNIAL CROPS
READ(1,200) CTYPE,DRZIRR,DRZTOT
READ(1,210)(AKC(IMO),IMO=1,12)
READ(1,210)(ALDP(IMO),IMO=1,12)
200 FORMAT(A12,2F5.0)
210 FORMAT(12F5.2)
C
C..... FOR SEEPAGE IRRIGATION SYSTEMS
280 IF(IR .NE. IRSEEP) GO TO 290
DRZIRR = DWT
DRZTOT = 1.5 * DWT
DO 288 IMO = 1,12
ALDP(IMO) = 0.0
288 IF(AKC(IMO) .LT. 1.0) AKC(IMO) = 1.0
GO TO 340
C
C..... FOR CITRUS CROWN FLOOD IRRIGATION SYSTEMS
290 IF(IR .NE. IRCRFL) GO TO 300
WRITE(6,296) HGT
296 FORMAT(11X,'HEIGHT OF CROWN FLOOD IRRIGATION SYSTEM BEDS =',
$ F4.1,' FT')
HGTIN = 12.0 * HGT

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DWT = HGTIN
DRZIRR = HGTIN - 6.0
DRZTOT = HGTIN + 12.0 / HGT
DO 298 IMO = 1,12
298 IF(ALDP(IMO) .LT. 0.5) ALDP(IMO) = 0.5
GO TO 340
C
C..... ENTER ROOT ZONE DATA FROM KEYBOARD IF DESIRED
300 IF(IVERS .EQ. 0) GO TO 340
IF(ICROP .EQ. ICGP) GO TO 340
READ(1,320) DRZIRR,DRZTOT
320 FORMAT(2F5.0)
C
C..... WRITE INTERMEDIATE PARAMETERS
340 WRITE(6,360) CTYPE,DRZIRR,DRZTOT
360 FORMAT(/,22X,'CROP TYPE = ',A12,/,15X,'ROOT ZONE DEPTH IRRIGATED (
$INCHES) = ',F5.1,/,15X,'TOTAL CROP ROOT ZONE DEPTH (INCHES)=' ,F5.1)
WRITE(6,370)(IMO,IMO=1,12),(AKC(IMO),IMO=1,12),(ALDP(IMO),IMO=1,
$ 12)
370 FORMAT(/,32X,'MONTH'/,10X,12(I4,1X),/,5X,'KC=' ,1X,12F5.2,/,3X,
$ 'ALDP=' ,1X,12F5.2)
C
C..... CALCULATE DAILY ROOT DEPTHS & ALLOWABLE SOIL WATER DEPLETIONS
DO 380 JD=1,365
DRZI(JD) = DRZIRR
380 DRZ(JD) = DRZTOT
C
JD = 0
DO 400 IMO = 1,12
DO 400 J=1,NMO(IMO)
JD = JD + 1
400 AWD(JD) = ALDP(IMO)
C
C..... CALCULATE DAILY CROP WATER USE COEFFICIENTS
C..... FIRST 1/2 OF JANUARY
RJ = -1
RJDIF = 14
RKDIF = 0.5 * (AKC(1) - AKC(12))
RK2 = 0.5 * (AKC(1)+AKC(12))
DO 420 JD=1,14
RJ = RJ + 1
RKC(JD) = RK2 + RJ/RJDIF * RKDIF
420 CONTINUE
C
C..... JANUARY 15 THROUGH DECEMBER 15
DO 440 JMO = 1,11
JMO1 = JMO + 1
NKM1 = NKC(JMO1) - 1
RJDIF = NKC(JMO1) - NKC(JMO)
RKDIF = AKC(JMO1) - AKC(JMO)
RJ = -1
DO 440 JD = NKC(JMO), NKM1
RJ = RJ + 1
440 RKC(JD) = AKC(JMO) + RJ/RJDIF * RKDIF
C
C..... DECEMBER 16 THROUGH DECEMBER 31
RJ = -1
RJDIF = 16
RKDIF = 0.5 * (AKC(1) - AKC(12))
DO 460 JD = 349, 365
RJ = RJ + 1
460 RKC(JD) = AKC(12) + RJ/RJDIF * RKDIF
C
IF(J1SAVE .LT. JNSAVE) GO TO 900

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C
C..... REARRANGE DATA FOR CROP YEAR THAT EXTENDS BEYOND 1 CALENDAR YEAR
      J = 0
      DO 470 JD = J1SAVE, 365
      J = J + 1
      AWTMP(J) = AWD(JD)
470   RKTMP(J) = RKC(JD)
C
      DO 480 JD = 1, JNSAVE
      J = J + 1
      AWTMP(J) = AWD(JD)
480   RKTMP(J) = RKC(JD)
C
      DO 490 JD = J1,JN
      AWD(JD) = AWTMP(JD)
490   RKC(JD) = RKTMP(JD)
C
      GO TO 900
C
C..... FOR ANNUAL CROPS
C-----
C.... READ 2 KC VALUES, FOR THE PEAK GROWTH PERIOD AND AT MATURITY
C      OR HARVEST.
C.... READ PROPORTION OF THE GROWING SEASON IN EACH GROWTH STAGE.
500   IC = ICROP + NCP + 3
      DO 520 I=1,IC
520   READ(8,180) DUMMY
      READ(8,550) CTYPE,DZN,DZX,AKC3,AKC4,(F(I),I=1,4),(ALD(I),I=1,4)
550   FORMAT(A12,2F3.0,10F5.2)
      IF(ICROP .NE. ICGA) GO TO 680
C
C..... FOR GENERIC ANNUAL CROPS
      READ(1,600)CTYPE,DZN,DZX,AKC3,AKC4,F(1),F(2),F(3),F(4),ALD(1),
      $ ALD(2),ALD(3),ALD(4)
600   FORMAT(A12,2F5.0,10F5.2)
C
C..... ENTER ANNUAL CROP ROOT ZONE DEPTHS FROM KEYBOARD
680   IF(IVERS .EQ. 0) GO TO 700
      IF(ICROP .EQ. ICGA) GO TO 700
      READ(1,690) DZN,DZX
690   FORMAT(2F5.0)
C
C..... FOR SEEPAGE IRRIGATION SYSTEMS
700   IF(IR .NE. IRSEEP) GO TO 750
      IF(DZN .GT. DWT) DZN = DWT
      IF(DZX .GT. DWT) DZX = DWT
      IF(AKC3 .LT. 1.0) AKC3 = 1.0
      IF(AKC4 .LT. 1.0) AKC4 = 1.0
      DO 720 I=1,4
720   ALD(I) = 0.0
C
C..... WRITE INTERMEDIATE PARAMETERS
750   WRITE(6,760) CTYPE
760   FORMAT(/,25X,'CROP TYPE = ',A12)
      WRITE(6,780)DZN,DZX,AKC3,AKC4,(F(I),I=1,4),(ALD(I),I=1,4)
780   FORMAT(/, 4X,'DZN  DZX  AKC3  AKC4  F1  F2  F3  F4  ALD1
      $ ALD2  ALD3  ALD4',/,3X,2F5.0,10F6.2,/)
C
C..... CALCULATE NUMBER OF DAYS IN EACH GROWTH STAGE
      FF = EPS
      DO 820 I=1,4
      FF = FF + F(I)
      NF(I) = J1 + FF * (JN-J1)
      IF(ICODE .GT. 1)WRITE(6,800) I,FF,NF(I),J1,JN

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800  FORMAT(10X,'I,FF,NF(I),J1,JN = ',I5,F7.3,3I5)
820  CONTINUE
C
C..... CALCULATE DAILY ROOT ZONE DEPTHS AND DEPTHS IRRIGATED
      IF(ICODE .EQ. 2) WRITE(6,840)
840  FORMAT(/,3X,'CDAY JDAY NF1  NF2  NF3  DRZI DRZ  RKC ALD1 ALD2 ALD3
      $ ALD4  AWD')
C
      AKKC = 0.4
      IF(IR .EQ. IRSEEP) AKKC = 1.0
      IF(IR .EQ. IRRICE) AKKC = 1.0
C
      DO 880 JD = J1, JN
      RJD = JD
      DRZI(JD) = DZN + (RJD-NF(1)) * (DZX-DZN) / (NF(2)-NF(1))
      IF(JD .LT. NF(1)) DRZI(JD) = DZN
      IF(JD .GT. NF(2)) DRZI(JD) = DZX
      DRZ(JD) = 2.0 * DRZI(JD)
      IF(IR .EQ. IRRICE) DRZ(JD) = DRZI(JD)
C
C..... CALCULATE DAILY CROP COEFFICIENTS
      RKC(JD) = AKKC
      IF(JD .GT. NF(1)) RKC(JD) = AKKC + (RJD-NF(1)) / (NF(2)-NF(1)) *
      $ (AKC3-AKKC)
      IF(JD .GT. NF(2)) RKC(JD) = AKC3
      IF(JD .GT. NF(3)) RKC(JD) =AKC3-(RJD-NF(3))/(JN-NF(3))*(AKC3-AK4)
C
C..... ASSIGN DAILY VALUES OF ALLOWABLE WATER DEPLETION
      AWD(JD) = ALD(1)
      IF(JD .GT. NF(1)) AWD(JD) = ALD(2)
      IF(JD .GT. NF(2)) AWD(JD) = ALD(3)
      IF(JD .GT. NF(3)) AWD(JD) = ALD(4)
C
C..... WRITE INTERMEDIATE DATA
      IF(ICODE .LT. 2) GO TO 880
      WRITE(6,860)JD,JDAY(JD),NF(1),NF(2),NF(3),DRZI(JD),DRZ(JD),RKC(JD)
      $ ,ALD(1),ALD(2),ALD(3),ALD(4),AWD(JD)
860  FORMAT(1X,5I5,2F5.1,5F5.2,F6.2)
880  CONTINUE
C
C..... OUTPUT PARAMETERS FOR DEBUGGING
900  IF(ICODE .LT. 1) GO TO 990
      WRITE(6,940)
940  FORMAT(/,1X,'DAILY ROOT ZONE DEPTHS, CROP COEFFICIENTS, & ALLOWABL
      $E WATER DEPLETIONS')
      WRITE(6,960)
960  FORMAT(15X,'CDAY JDAY  DRZI(JD) DRZ(JD) RKC(JD) AWD(JD)')
      DO 970 JD = J1,JN
970  WRITE(6,980) JD,JDAY(JD),DRZI(JD),DRZ(JD),RKC(JD),AWD(JD)
980  FORMAT(15X,I3,2X,I3,2X,2F8.2,F8.3,F8.2)
C
990  CLOSE(8)
      END
C
C*****
C
      SUBROUTINE SW
C*****
C.....THIS SUBROUTINE CALCULATES THE AVAILABLE SOIL WATER AND THE
C      SOIL WATER CONTENT AT WHICH IRRIGATIONS WILL BE SCHEDULED
C      FOR EACH DAY OF THE CROP IRRIGATION SEASON.
C
C..... DEFINITIONS ...
C

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C   ARZI = FRACTION OF THE SURFACE AREA IRRIGATED BY THE IRRIGATION
C       SYSTEM USED (DECIMAL FRACTION)
C   DRINC = RICE FLOOD STORAGE DEPTH (INCHES)
C   DRZ(JD) = TOTAL EFFECTIVE CROP ROOT ZONE DEPTH (INCHES)
C   DRZI(JD) = CROP ROOT ZONE DEPTH IRRIGATED (INCHES)
C   DU(I) = DEPTH TO THE TOP OF THE ITH SOIL LAYER (INCHES)
C   ISOIL = CODE FOR SOIL TYPE TO BE USED IN THE SIMULATION
C   NL = NUMBER OF LAYERS IN THE SOIL PROFILE
C   NSOILS = TOTAL NUMBER OF SOILS IN THE SOILS DATA BASE
C   SWCIX(JD) = MAXIMUM SOIL WATER-HOLDING CAPACITY OF THE IRRIGATED
C       PORTION OF THE CROP ROOT ZONE (INCHES)
C   SWCNX(JD) = MAXIMUM SOIL WATER-HOLDING CAPACITY OF THE NON-
C       IRRIGATED PORTION OF THE CROP ROOT ZONE (INCHES)
C   SWIRR(JD) = SOIL WATER CONTENT AT WHICH IRRIGATION IS SCHEDULED
C       (INCHES)
C   SWMAX(JD) = MAXIMUM SOIL WATER-HOLDING CAPACITY OF THE TOTAL CROP
C       ROOT ZONE (INCHES)
C   WCL(I) = MINIMUM VOLUMETRIC WATER CONTENT OF THE ITH SOIL LAYER
C   WCU(I) = MAXIMUM VOLUMETRIC WATER CONTENT OF THE ITH SOIL LAYER
C
C       REAL IRR(25,365),NIR(365)
C       CHARACTER SNAME*20, SNAME1*20, SNAME2*20, CTYPE*12
C       CHARACTER*4 TXT(3), TXT1(3), TXT2(3)
C
C       COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C       $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C       $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
C       $ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C       $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C       $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,DRINC,HGT,CTYPE
C
C       DIMENSION DL(6),DU(6),WCL(6),WCU(6),WC(6)
C       DATA BLANK / ' ' /
C
C..... OPEN DIRECT ACCESS SOIL DATA BASE
10 OPEN(9,FILE='SOIL.DAT',ACCESS='DIRECT',RECL=56,FORM='FORMATTED')
C
C..... ZERO PARAMETERS
IW0 = 0
IW1 = 0
IW2 = 0
IW3 = 0
C
DO 15 JD=1,365
SWMAX(JD) = 0.0
SWCIX(JD) = 0.0
SWCNX(JD) = 0.0
15 SWIRR(JD) = 0.0
C
C..... READ NUMBER OF SOIL TYPES
READ(9,'(I4)',REC=2) NSOILS
C
C..... READ SOILS DATA
READ(1,30) ISOIL,ISCODE,SNAME,TXT(1),NL
IF(ISOIL .LT. 1) READ(1,40) (DU(IL),WC(IL),IL=1,NL)
30 FORMAT(I3,1X,I1,A20,A4,1X,I1)
40 FORMAT(6(F5.0,F5.2))
IF(ISOIL .LT. 1) GO TO 102
C
NREC = 2*ISOIL +2
READ(9,'(I3,1X,A20,3(1X,A4))',REC=NREC) NS,SNAME,TXT(1),TXT(2),
$ TXT(3)
READ(9,98)NL,(DU(I),WCL(I),WCU(I),I=1,NL)
98 FORMAT(I1,1X,6(F3.0,2F3.2))

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C
      CLOSE(9)
      GO TO 115
C
102  WRITE(6,114) SNAME, TXT(1)
114  FORMAT(/,6X,'SOIL :  SERIES = ',A20,6X,'TEXTURE = ',A4)
      GO TO 130
C
115  WRITE(6,117) SNAME,(TXT(I),I=1,3)
117  FORMAT(/,5X,'SOIL :  SERIES = ',A20,3X,'TEXTURE = ',3(1X,A4))
C
C..... WRITE SOIL LAYER DEPTHS AND AVAILABLE WATER CAPACITIES
      WRITE(6,118)
      IF(ICODE .LT. 1) GO TO 125
      WRITE(6,120)(DU(I),I=1,NL)
      WRITE(6,122)(WCL(I),I=1,NL)
      WRITE(6,124)(WCU(I),I=1,NL)
118  FORMAT(15X,'SOIL LAYER DEPTHS (INCHES) AND WATER CONTENTS')
120  FORMAT(18X,'DEPTH(I)=' ,6F6.0)
122  FORMAT(15X,'MIN.WCON(I)=' ,6F6.2)
124  FORMAT(15X,'MAX.WCON(I)=' ,6F6.2)
C
125  DO 128 I=1,NL
      WC(I)=0.5*(WCL(I)+WCU(I))
      IF(ISCODE .EQ. 0) WC(I)=WCL(I)
128  IF(ISCODE .EQ. 2) WC(I)=WCU(I)
C
130  WRITE(6,120)(DU(I),I=1,NL)
      WRITE(6,132)(WC(I),I=1,NL)
132  FORMAT(11X,'WCON(I) ENTERED=' ,6F6.2)
C
C..... DEFINE LOWER SOIL LAYER DIMENSIONS
      DL(1) = 0.0
      IF(NL .EQ. 1) GO TO 140
      DO 135 I=2,NL
135  DL(I) = DU(I-1)
C
C*****
C..... WRITE DEPTH TO WATER TABLE
C
140  IF(IR .EQ. IRNSCY) GO TO 150
      IF(IR .EQ. IRCRFL) GO TO 150
      IF(IR .EQ. IRRICE) GO TO 150
      DWT = DWT / 12.0
      WRITE(6,145) DWT
145  FORMAT(/,16X,'DEPTH TO WATER TABLE ENTERED =',F5.1,' FEET')
      DWT = DWT * 12.0
C
C*****
C..... CALCULATE MAXIMUM SOIL WATER-HOLDING CAPACITIES
C
C..... FOR PERENNIAL CROPS
-----
C..... ROOT ZONE DEPTH IS ASSUMED TO BE FIXED
150  IF(ICROP .GT. NCP) GO TO 240
C
C..... FOR IRRIGATED ROOT ZONE
C      CHECK FOR HIGH WATER TABLE LIMITING IRRIGATED ROOT ZONE
      IF(DRZI(J1) .LT. DWT) GO TO 164
      DRZI(J1) = DWT
C
C..... CHECK FOR SOIL DEPTH LIMITING IRRIGATED ROOT ZONE
164  DO 166 I=1,NL
      IS = I

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166 IF(DRZI(J1) .LT. DU(I)) GO TO 182
C
DO 180 JD = J1,JN
180 DRZI(JD) = DU(NL)
C
C..... CALCULATE AVAILABLE SOIL WATER IN IRRIGATED ROOT ZONE
182 IS1 = IS - 1
SWI = 0.0
IF(IS .EQ. 1) GO TO 188
DO 186 I=1,IS1
186 SWI = SWI + (DU(I)-DL(I)) * WC(I)
188 SWI = SWI + (DRZI(J1) - DL(IS)) * WC(IS)
C
C..... FOR TOTAL ROOT ZONE
C CHECK FOR HIGH WATER TABLE LIMITING ROOT EXPANSION
IF(DRZ(J1) .LT. DWT) GO TO 192
DRZ(J1) = DWT
IF(DWT .LT. 2.0*DRZI(J1)) DRZ(J1) = 2.0 * DRZI(J1)
C
C..... CHECK FOR SOIL DEPTH LIMITING ROOT EXPANSION
192 DO 194 I=1,NL
IS = I
194 IF(DRZ(J1) .LT. DU(I)) GO TO 204
DRZ(J1) = DU(NL)
IF(DRZ(J1) .LT. 2.0*DRZI(J1)) DRZ(J1) = 2.0 * DRZI(J1)
DO 202 JD = J1,JN
202 DRZ(JD) = DRZ(J1)
C
C..... CALCULATE AVAILABLE SOIL WATER IN TOTAL ROOT ZONE
204 IS1 = IS - 1
SWX = 0.0
IF(IS .EQ. 1) GO TO 214
DO 212 I=1,IS1
WCX = WC(I)
IF(IR .EQ. IRCRFL) WCX = 0.4
212 SWX = SWX + (DU(I)-DL(I)) * WCX
214 WCX = WC(IS)
IF(IR .EQ. IRCRFL) WCX = 0.4
SWX = SWX + (DRZ(J1) - DL(IS)) * WCX
IF(DRZ(J1) .GT. DWT .AND. WCX .LT. 0.4) SWX = SWX + (DRZ(J1) - DWT) * (0.4 - WCX)
C
C..... CORRECT FOR IRRIGATION OF ONLY A FRACTION OF THE ROOT ZONE
SWI = ARZI * SWI
SWN = SWX - SWI
C..... CORRECT FOR NONIRRIGATED ZONE IN CONTAINER NURSERIES
IF(ICROP .EQ. INSCY) SWN = 0.20
C..... CORRECT FOR BEDDED SURFACE IN CROWN FLOOD CITRUS IRRIGATION
IF(IR .EQ. IRCRFL) SWI = SWI * 0.667
SWX = SWI + SWN
IF(SWN .LT. EPS) EXIR = 1.00
C
C..... ASSIGN DAILY SOIL WATER CAPACITY DATA
218 DO 220 JD = J1,JN
SWMAX(JD) = SWX
SWCIX(JD) = SWI
220 SWCNX(JD) = SWN
C
GO TO 350
C
C..... FOR ANNUAL CROPS
C-----
C..... CALCULATE DAILY MAXIMUM SOIL WATER CONTENTS
240 IF(IR .EQ. IRRICE) GO TO 345
C

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C..... FOR IRRIGATED ROOT ZONE
C      CHECK FOR HIGH WATER TABLE LIMITING ROOT EXPANSION
      DO 248 JD = J1,JN
      IF(DRZI(JD) .LT. DWT) GO TO 248
      DRZI(JD) = DWT
      IW0 = 1
248   CONTINUE
C
C..... CHECK FOR SOIL DEPTH LIMITING IRRIGATED ROOT ZONE
      DO 300 JD = J1,JN
      DO 250 I=1,NL
      IS = I
250   IF(DRZI(JD) .LT. DU(I)) GO TO 260
      IW1 = 1
      DRZI(JD) = DU(NL)
C
C..... CALCULATE IRRIGATED ZONE AVAILABLE SOIL WATER FOR EACH DAY
      FROM ROOT ZONE EXPANSION
260   SWI = 0.0
      IF(IS .EQ. 1) GO TO 280
      IS1 = IS - 1
      DO 270 I=1,IS1
270   SWI = SWI + (DU(I)-DL(I)) * WC(I)
280   SWI = SWI + (DRZI(JD)-DL(IS)) * WC(IS)
C
C..... CORRECT FOR IRRIGATION OF ONLY A FRACTION OF THE ROOT ZONE
300   SWCIX(JD) = ARZI * SWI
C
C..... CORRECT CROP WATER USE COEFFICIENTS FOR GROWTH STAGES 1 AND 2,
      BASED ON SOIL PROPERTIES AND STAGE 1 CROP GROWTH
C..... FOR GROWTH STAGE 1
      AKKC = 0.8 * SQRT(WC(1)+0.05)
      J5 = J1 + 4
      DO 302 JD=J1,NF(1)
      RKC(JD) = AKKC
302   IF(JD .GT. J5) RKC(JD) = AKKC + 0.12 * (JD-J5)/(NF(1)-J5)
C
C..... FOR GROWTH STAGE 2
      NFP = NF(1) + 1
      AKKC = AKKC + 0.12
      DO 304 JD=NFP,NF(2)
      RJD = JD
      RKC(JD) = AKKC + (RJD-NF(1)) / (NF(2)-NF(1)) * (AKC3-AKKC)
304   IF(RKC(JD) .GT. AKC3) RKC(JD)=AKC3
C
C..... FOR TOTAL ROOT ZONE
C      CHECK FOR HIGH WATER TABLE LIMITING TOTAL ROOT ZONE
      DO 308 JD = J1,JN
      IF(DRZ(JD) .LT. DWT) GO TO 308
      DRZ(JD) = DWT
      IF(DRZ(JD) .LT. 2.0*DRZI(JD)) DRZ(JD) = 2.0 * DRZI(JD)
      IW2 = 1
308   CONTINUE
C
      DO 340 JD = J1,JN
C
C..... CHECK FOR SOIL DEPTH LIMITING TOTAL ROOT ZONE
      DO 310 I=1,NL
      IS = I
310   IF(DRZ(JD) .LT. DU(I)) GO TO 320
      IW3 = 1
      DRZ(JD) = DU(NL)
      IF(DRZ(JD) .LT. 2.0*DRZI(JD)) DRZ(JD) = 2.0 * DRZI(JD)
C

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C..... CALCULATE MAXIMUM SOIL WATER-HOLDING CAPACITY FOR EACH DAY
C      FROM ROOT ZONE EXPANSION
320  SWMAX(JD) = 0.0
      IF(IS .EQ. 1) GO TO 335
      IS1 = IS - 1
      DO 330 I=1,IS1
330  SWMAX(JD) = SWMAX(JD) + (DU(I)-DL(I)) * WC(I)
335  SWMAX(JD) = SWMAX(JD) + (DRZ(JD)-DL(IS)) * WC(IS)
      IF(DRZ(JD).GT.DWT .AND. WC(IS).LT.0.4) SWMAX(JD) = SWMAX(JD) +
      $ (DRZ(JD)-DWT) * (0.4-WC(IS))
      SWCNX(JD) = SWMAX(JD) - SWCIX(JD)
340  CONTINUE
      GO TO 350
C
C..... FOR RICE FLOOD IRRIGATION SYSTEMS
345  WRITE(6,347) DRINC
347  FORMAT(14X,'RICE FLOOD STORAGE DEPTH ENTERED = ',F4.1,' INCHES')
C
      DO 348 JD=J1,JN
      SWCIX(JD) = 3.00
      SWMAX(JD) = SWCIX(JD) + DRINC
348  SWCNX(JD) = 0.00
C
C..... CALCULATE STARTING SOIL WATER CONTENT AS 0.9 * FIELD CAPACITY
350  SWC11 = 0.9 * SWCIX(J1)
      SWCN1 = 0.9 * SWCNX(J1)
      IF(SWCN1 .LT. EPS) EXIR = 1.00
C
C..... CALCULATE SOIL WATER CONTENT AT WHICH IRRIGATION WILL BE
C      SCHEDULED
      DO 400 JD = J1,JN
400  SWIRR(JD) = (1.0-AWD(JD)) * SWCIX(JD)
C
C..... OUTPUT PARAMETERS FOR DEBUGGING
      IF(ICODE .LT. 1) GO TO 500
      WRITE(6,408)
408  FORMAT(//,5X,'OUTPUT PARAMETERS - ROOT DEPTHS, KCs, AND SOIL WATER
      $ CONTENTS')
      WRITE(6,410)
410  FORMAT(7X,'CDAY JDAY   DRZ   DRZI   RKC   SWMAX  SWCIX  SWCNX  SW
      $IRR')
      DO 430 JD = J1,JN
430  WRITE(6,440) JD,JDAY(JD),DRZ(JD),DRZI(JD),RKC(JD),SWMAX(JD),
      $ SWCIX(JD),SWCNX(JD),SWIRR(JD)
440  FORMAT(6X,2I5,2F7.1,F7.3,4F7.2)
C
500  END
C
C*****
C
      SUBROUTINE BAL
C*****
C.....THIS ROUTINE CALCULATES A WATER BALANCE FOR A CROP ROOT ZONE
C      ON A DAILY BASIS.  THE SOIL WATER CONTENT IS UPDATED BASED ON
C      ET, RAIN, AND IRRIGATION. DRAINAGE AND EFFECTIVE RAINFALL ARE
C      ALSO CALCULATED.
C
C.....DEFINITIONS...
C
C      DR = DRAINAGE (INCHES)
C      ER = EFFECTIVE RAINFALL (INCHES)
C      ET = CROP EVAPOTRANSPIRATION (INCHES)
C      ETP = POTENTIAL CROP EVAPOTRANSPIRATION (INCHES)
C      EXIR = FRACTION OF ET EXTRACTED FROM IRRIGATED PORTION OF CROP

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C          ROOT ZONE
C  FRIR = FRACTION OF NIR APPLIED PER IRRIG. FOR DEFICIT IRRIGATION
C  FIX = FIXED IRRIGATION DEPTH PER IRRIGATION (INCHES)
C  IRR = GROSS IRRIGATION REQUIREMENT (INCHES)
C  IY = YEAR COUNTER
C  JD = CALENDAR DAY COUNTER
C  NIR = NET IRRIGATION REQUIREMENT (INCHES)
C  NR = NUMBER OF DAYS REQUIRED FOR WATER TO REDISTRIBUTE TO FIELD
C  CAPACITY
C  NYR = NUMBER OF YEARS OF RECORD IN THE CLIMATE DATA BASE
C  RAIN = DAILY RAINFALL (INCHES)
C  RKC = CROP COEFFICIENT
C  SDR = DAILY DRAINAGE SUMMED FOR ALL YEARS OF RECORD (INCHES)
C  SET = DAILY ET SUMMED FOR ALL YEARS OF RECORD (INCHES)
C  SETP = DAILY POTENTIAL ET SUMMED FOR ALL YEARS OF RECORD (INCHES)
C  SRAIN = DAILY RAINFALL SUMMED FOR ALL YEARS OF RECORD (INCHES)
C  SWC11 = INITIAL IRRIGATED SOIL WATER CONTENT (INCHES AT START
C  OF IRRIGATION SEASON)
C  SWCN1 = INITIAL NON-IRRIGATED SOIL WATER CONTENT (INCHES AT
C  START OF IRRIGATION SEASON)
C  SWCI = SOIL WATER CONTENT IN THE IRRIGATED PORTION OF THE PLANT
C  EFFECTIVE ROOT ZONE (INCHES)
C  SWCN = SOIL WATER CONTENT IN THE NON-IRRIGATED PORTION OF THE
C  PLANT EFFECTIVE ROOT ZONE (INCHES)
C  SWIRR = SOIL WATER CONTENT WHICH TRIGGERS AN IRRIGATION (INCHES)
C  SWMAX = MAXIMUM AVAILABLE WATER CAPACITY IN THE TOTAL CROP
C  ROOT ZONE (INCHES)
C  SWCIX = MAXIMUM AVAILABLE WATER CAPACITY IN THE IRRIGATED
C  PORTION OF THE CROP ROOT ZONE (INCHES)
C  SWCNX = MAXIMUM AVAILABLE WATER CAPACITY IN THE NON-IRRIGATED
C  PORTION OF THE CROP ROOT ZONE (INCHES)
C
C  REAL IRR(25,365),NIR(365),KC(365)
C  CHARACTER CTYPE*12
C
C  COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
C  $ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
C  $ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
C  $ ICROP,SWC11,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
C  $ J1SAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
C  $ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,DRINC,HGT,CTYPE
C
C  COMMON /BLOCK2/ ET(365),SET(365),SETP(365),SDR(365),SRAIN(365),
C  $ ER(365),DR(365)
C
C..... INITIALIZE / DEFINE PARAMETERS
C  NYX = NYR
C  REWAT = 1.0
C  IF(J1SAVE .GT. JNSAVE) NYX = NYR + 1
C  EXNR = 1.0 - EXIR
C
C..... ZERO PARAMETERS FOR ALL YEARS
C  DO 50 JD = 1, 365
C  KC(JD) = 0.0
C  SDR(JD) = 0.0
C  SET(JD) = 0.0
C  SETP(JD) = 0.0
C  SRAIN(JD) = 0.0
C  DO 50 IY = 1, NYX
50  IRR(IY,JD) = 0.0
C
C.....ITERATE YEARS
C  DO 500 IY = 1,NYR
C

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C..... ZERO PARAMETERS FOR CURRENT YEAR
      DO 55 JD = 1, 365
      ET(JD) = 0.0
      SWCI(JD) = 0.0
      SWCN(JD) = 0.0
      ER(JD) = 0.0
      NIR(JD) = 0.0
55   DR(JD) = 0.0
C
C..... FOR RICE FLOOD IRRIGATION SYSTEMS
      IF(IR .EQ. IRRICE) GO TO 182
C
C.....ITERATE DAYS
      DO 180 JD = J1,JN
      JD1 = JD - 1
      REWAT = REWAT + 1.0
C
C..... CALCULATE NUMBER OF DAYS REQUIRED FOR REDISTRIBUTION TO FIELD
C      CAPACITY.
      IF(IR .EQ. IRSEEP) GO TO 70
      IF(IR .EQ. IRCRFL) GO TO 70
      NRR = RAIN(IY,JD) + 1
      NR = 2
      IF(DRZI(JD) .LT. 12) NR = 1
      IF(DRZI(JD) .GT. 24) NR = 3
      IF(NRR .GT. NR) NR=NRR
      IF(NR .GT. 5) NR = 5
      GO TO 80
70   NR = 2
      IF(RAIN(IY,JD) .GT. 0.50) NR = 2.0 * RAIN(IY,JD) + 1
      IF(NR .GT. 7) NR = 7
C
C..... CALCULATE CROP ET FROM ETP AND CROP COEFFICIENT
80   KC(JD) = RKC(JD)
      RKCS = 0.00
      IF(ICROP .LT. NCP+1) GO TO 84
C..... DO NOT INCREASE CROP COEFFICIENT FOR RAIN IF RKC = 0.0 (NO CROP
C      BEING GROWN).
      IF(KC(JD) .LT. EPS) GO TO 90
C..... MODIFIES KC BASED ON DAYS SINCE LAST RAIN OR IRRIGATION DURING
C      GROWTH STAGES 1 AND 2
      IF(JD .GT. NF(2)) GO TO 84
      RKCS = 1.0 / SQRT(REWAT)
C..... ADJUSTS KC FOR LOW VERSUS HIGH ETP DAYS
84   KC(JD) = KC(JD) - 0.03 * (ETP(IY,JD)-0.20)
      IF(RKCS .GT. KC(JD)) KC(JD) = RKCS
C..... DO NOT REDUCE CROP COEFFICIENT FOR RAIN IF KC IS ALREADY > 1.0.
      IF(KC(JD) .GT. 1.0) GO TO 88
C..... CALCULATE ET AT POTENTIAL RATE FOR THE DAY THAT RAIN OCCURS.
      IF(ETP(IY,JD) .GT. EPS) RKCR = RAIN(IY,JD) / ETP(IY,JD)
      IF(RKCR .GT. 1.00) RKCR = 1.00
      IF(RKCR .GT. KC(JD)) KC(JD) = RKCR
88   IF(KC(JD) .GT. 1.25) KC(JD) = 1.25
90   ET(JD) = KC(JD) * ETP(IY,JD)
C
C.....UPDATE SOIL WATER CONTENT IN CROP ROOT ZONE FOR EXPANDING
C      ROOT ZONE, RAIN, AND ET
      IF(JD .NE. J1) GO TO 91
      IF(IY .EQ. 1) GO TO 106
      IF(NDAYS .LT. 365) GO TO 106
      IF(NDAYS .EQ. 365) GO TO 108
C
C..... FOR EXPANDING ROOT ZONE DUE TO CROP GROWTH
91   SWCEPS = SWCIX(JD1) + EPS

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        IF(SWCIX(JD) .GT. SWCEPS) GO TO 92
        GO TO 96
C..... FOR CASE WHERE IRRIGATED ROOT DEPTH = TOTAL ROOT DEPTH
92  DRZEPS = DRZ(JD) - EPS
    IF(DRZI(JD) .LT. DRZEPS) GO TO 94
    SWCI(JD) = SWCI(JD1) + (SWCIX(JD)-SWCIX(JD1))
    SWCN(JD) = SWCN(JD1) + (SWCNX(JD)-SWCNX(JD1))
    GO TO 98
C..... FOR CASE WHERE IRRIGATED ROOT DEPTH < TOTAL ROOT DEPTH
94  IF(SWCNX(JD1) .LT. EPS) GO TO 98
    ADX = SWCN(JD1)/SWCNX(JD1) * (SWCIX(JD)-SWCIX(JD1))
    SWCI(JD) = SWCI(JD1) + ADX
    SWCN(JD) = SWCN(JD1) + (SWMAX(JD) - SWMAX(JD1)) - ADX
    GO TO 98
C
C..... FOR NON-EXPANDING ROOT ZONE
96  SWCI(JD) = SWCI(JD1)
    SWCN(JD) = SWCN(JD1)
C
C..... FOR RAIN
98  WCISAVE = SWCI(JD)
    WCNSAVE = SWCN(JD)
    SWCI(JD) = SWCI(JD) + ARZI*RAIN(IY,JD)
    SWCN(JD) = SWCN(JD) + (1.0-ARZI)*RAIN(IY,JD)
C
C..... FOR ET
    IF(SWCI(JD).GT.SWCIX(JD) .OR. SWCN(JD).GT.SWCNX(JD)) GO TO 102
    IF(SWCN(JD) .LT. EPS) GO TO 100
C..... EXTRACT WATER FROM THE NON-IRRIGATED ZONE ONLY IF AVAILABLE
    XX = 0.5 * SWCNX(JD) + EPS
    ETNMAX = EXNR * ET(JD)
    IF(SWCN(JD).GT.XX .AND. XX.GT.ETNMAX) GO TO 102
    XET = SWCN(JD) / XX
    IF(XET .GT. 0.5) XET = 0.5
    ETN = ETNMAX * XET
    SWCI(JD) = SWCI(JD) - (ET(JD)-ETN)
    SWCN(JD) = SWCN(JD) - ETN
    IF(SWCN(JD) .GT. 0.0) GO TO 112
    SWCI(JD) = SWCI(JD) + SWCN(JD)
    SWCN(JD) = 0.0
    GO TO 112
C
C..... EXTRACT ALL ET FROM IRRIGATED ZONE IF NON-IRRIGATED ZONE IS DRY
100 SWCI(JD) = SWCI(JD) - ET(JD)
    GO TO 112
C
C..... EXTRACT EXIR FRACTION OF ET FROM IRRIGATED ZONE AND EXNR
C      FRACTION FROM THE NON-IRRIGATED ZONE WHEN WATER IS AVAILABLE
102 SWCI(JD) = SWCI(JD) - EXIR*ET(JD)
    SWCN(JD) = SWCN(JD) - EXNR*ET(JD)
    GO TO 112
C
C..... FOR FIRST DAY OF CROP GROWING SEASON FOR ANNUAL CROPS, FIRST
C      DAY OF FIRST YEAR FOR PERENNIAL CROPS, AND FOR PERENNIAL CROPS
C      THAT ARE IRRIGATED LESS THAN 365 DAYS PER YEAR
106 SWCI(JD) = SWCI1 - EXIR*ET(JD) + ARZI*RAIN(IY,JD)
    SWCN(JD) = SWCN1 - EXNR*ET(JD) + (1.0-ARZI)*RAIN(IY,JD)
    GO TO 112
C
C..... FOR FIRST DAY OF EACH SUCCESSIVE YEAR FOR PERENNIAL CROPS THAT
C      ARE IRRIGATED 365 DAYS PER YEAR
108 SWCI(JD) = SWCISV - EXIR*ET(JD) + ARZI*RAIN(IY,JD)
    SWCN(JD) = SWCN1 - EXNR*ET(JD) + (1.0-ARZI)*RAIN(IY,JD)
    IF(SWCN(JD) .GT. 0.0) GO TO 112

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        SWCI(JD) = SWCI(JD) + SWCN(JD)
        SWCN(JD) = 0.0
C
C.....CHECK FOR DRAINAGE FROM ROOT ZONE
112  IF(RAIN(IY,JD) .LT. EPS) GO TO 118
      IF(SWCI(JD).LT.SWCIX(JD) .AND. SWCN(JD).LT.SWCNX(JD)) GO TO 118
      IF(SWCI(JD).LT.SWCIX(JD) .AND. SWCN(JD).LT. EPS) GO TO 118
      PERCI = 0.0
      RINCI = 0.0
      PERCN = 0.0
      RINCN = 0.0
C
C.....CALCULATE PERCOLATE
      DO 113 JJ = 1,NR
      JDINC = JJ + JD
      IF(JDINC .GT. JN) GO TO 113
      RINCI = RINCI + RKC(JDINC) *EXIR*ETP(IY,JDINC)
      RINCN = RINCN + RKC(JDINC) *EXNR*ETP(IY,JDINC)
113  CONTINUE
C
C..... CALCULATE DRAINAGE FROM IRRIGATED ZONE
      PERCI = SWCI(JD) - SWCIX(JD)
      IF(PERCI .LT. RINCI) RINCI = PERCI
      DRI = PERCI - RINCI
      SWCI(JD) = SWCIX(JD) + RINCI
      IF(SWCNX(JD) .GT. EPS) GO TO 114
      DR(JD) = DRI
      GO TO 116
C
C..... CALCULATE DRAINAGE FROM NON-IRRIGATED ZONE
C.....      WHEN DRZ = DRZI
114  IF(DRZI(JD) .LT. DRZ(JD)-EPS) GO TO 115
      PERCN = SWCN(JD) - SWCNX(JD)
      IF(PERCN .LT. RINCN) RINCN = PERCN
      DRN = PERCN - RINCN
      SWCN(JD) = SWCNX(JD) + RINCN
      DR(JD) = DRI + DRN
      GO TO 116
C
C.....      WHEN DRZ > DRZI
115  SWCX = SWCN(JD) + DRI
      PERCN = SWCN(JD) - SWCNX(JD) + DRI
      IF(PERCN .LT. RINCN) RINCN = PERCN
      SWCZ = SWCNX(JD) + RINCN
      SWCN(JD) = AMIN1(SWCX, SWCZ)
      DR(JD) = SWCX - SWCN(JD)
C
C.....CALCULATE EFFECTIVE RAINFALL
116  ER(JD) = RAIN(IY,JD) - DR(JD)
      IF(ER(JD) .LT. 0.0) GO TO 117
      GO TO 120
C
C..... CORRECT FOR REDISTRIBUTION INCREMENT
117  EXINC = -ER(JD)
      SWCI(JD) = SWCI(JD) + EXIR * EXINC
      SWCN(JD) = SWCN(JD) + EXNR * EXINC
      ER(JD) = 0.0
      GO TO 120
C
C..... CALCULATE EFFECTIVE RAINFALL WHEN DRAINAGE = 0.0
118  DR(JD) = 0.0
      ER(JD) = RAIN(IY,JD)
C
C.....CHECK FOR NEED TO IRRIGATE

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120 IF(SWCI(JD) .GT. SWIRR(JD)) GO TO 140
C
C..... CALCULATE NET IRRIGATION AMOUNT
      IF(IR .EQ. IRSEEP) GO TO 130
      IF(IR .EQ. IRCRFL) GO TO 135
C..... IRRIGATE TO RESTORE SOIL WATER CONTENT TO FIELD CAPACITY
      NIR(JD) = SWCIX(JD) - SWCI(JD)
C..... IRRIGATE TO ONLY A FRACTION OF FIELD CAPACITY
      IF(IDCODE .EQ. 2) NIR(JD) = FRIR * SWCIX(JD) - SWCI(JD)
C..... IRRIGATE A FIXED IRRIGATION AMOUNT
      IF(IDCODE .EQ. 1) NIR(JD) = FIX
      GO TO 150
C
C..... FOR SEEPAGE IRRIGATION SYSTEMS
130 NIR(JD) = 0.9 * SWCIX(JD) - SWCI(JD)
      IF(NIR(JD) .LT. 0.0) NIR(JD) = 0.0
      GO TO 150
C
C..... FOR CROWN FLOOD IRRIGATION SYSTEMS
C      ASSUME 3 DAYS REQUIRED TO IRRIGATE, AND
C      3 DAYS FOR DRAINAGE AFTER IRRIGATION
135 ETINC = 0.0
      DO 136 J = 1,5
      JDP = JD + J
      IF(JDP .GT. JN) GO TO 138
136 ETINC = ETINC + ETP(IY,JDP)
138 NIR(JD) = SWCIX(JD) - SWCI(JD) + ETINC
      GO TO 150
C
140 NIR(JD) = 0.0
C
C..... UPDATE SOIL WATER CONTENT FOR IRRIGATION
150 SWCI(JD) = SWCI(JD) + NIR(JD)
      IF(IR .EQ. IRNSYC) GO TO 160
      GO TO 170
C
C..... FOR CONTAINER NURSERY SPRINKLER IRRIGATION SYSTEMS
160 SWCN(JD) = SWCN(JD) + (1.0-ARZI)/ARZI * NIR(JD)
      IF(SWCN(JD) .GT. SWCNX(JD)) SWCN(JD) = SWCNX(JD)
C
C..... CALCULATE GROSS IRRIGATION REQUIREMENT
170 IRR(IY,JD) = NIR(JD) / EFF(IR)
C
180 IF(RAIN(IY,JD).GT.0.1 .OR. IRR(IY,JD).GT.EPS) REWAT = 1.0
C
C..... SAVE LAST DAY'S SOIL WATER CONTENTS TO BEGIN FIRST DAY OF
C      NEXT YEAR FOR PERENNIAL CROPS.
      SWCISV = SWCI(JN)
      SWCNSV = SWCN(JN)
      GO TO 192
C
C..... FOR RICE FLOOD IRRIGATION SYSTEMS
182 DO 190 JD = J1,JN
      JD1 = JD - 1
      ET(JD) = RKC(JD) * ETP(IY,JD)
      IF(JD .EQ. J1) SWCI(JD) = SWCI1
      IF(JD .GT. J1) SWCI(JD) = SWCI(JD1)
      SWCI(JD) = SWCI(JD) + RAIN(IY,JD) - ET(JD)
      XX = SWCI(JD)
      DR(JD) = 0.0
      IF(SWCI(JD) .GT. SWMAX(JD)) GO TO 184
      GO TO 186
184 SWCI(JD) = SWMAX(JD)
      DR(JD) = XX - SWMAX(JD)

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186 ER(JD) = RAIN(IY,JD) - DR(JD)
    NIR(JD) = 0.0
    IF(SWCI(JD) .LT. SWIRR(JD)) NIR(JD) = SWCIX(JD) - SWCI(JD)
    SWCI(JD) = SWCI(JD) + NIR(JD)
190 IRR(IY,JD) = NIR(JD) / EFF(IR)
C
C..... SUM PARAMETERS FOR EACH DAY OF THE IRRIGATION SEASON
192 DO 195 JD = J1,JN
    SDR(JD) = SDR(JD) + DR(JD)
    SET(JD) = SET(JD) + ET(JD)
    SETP(JD) = SETP(JD) + ETP(IY,JD)
195 SRRAIN(JD) = SRRAIN(JD) + RAIN(IY,JD)
C
C..... OUTPUT PARAMETERS FOR DEBUGGING
C..... THIS SECTION OUTPUTS DAILY VALUES OF ALL COMPONENTS OF THE SOIL
C      WATER BLANCE. BECAUSE OF THE VOLUME OF OUTPUT, IT IS NORMALLY
C      USED FOR DEBUGGING ONLY.
C
    IF(ICODE .LT. 2) GO TO 500
    WRITE(6,200)
200 FORMAT(/, 7X, 'OUTPUT DAILY COMPONENTS OF SOIL WATER BUDGET FOR DE
    $BUGGING')
    WRITE(6,300) IY
300 FORMAT(/, 28X, 'YEAR = ', I3, /, ' CDY JDY SWCN SWCI ETP KC ET RA
    $ IN ER DR SWMX SWIX SWIR NIR IRR')
C
    DO 330 JD = J1,JN
330 WRITE(6,350) JD, JDAY(JD), SWCN(JD), SWCI(JD), ETP(IY,JD), KC(JD), ET(JD)
    $ ,RAIN(IY,JD), ER(JD), DR(JD), SWMAX(JD), SWCIX(JD), SWIRR(JD), NIR(JD),
    $ IRR(IY,JD)
350 FORMAT(1X, I3, I4, F6.2, F5.2, 1X, F4.3, F5.2, 1X, F4.3, 3F5.2, F6.2, 4F5.2)
C
500 CONTINUE
    END
C
C*****
C
SUBROUTINE SUMX
C*****
C..... THIS SUBROUTINE SUMS IRR, RAIN, AND ETP DATA TO OBTAIN SEASONAL,
C      MONTHLY, BI-WEEKLY, AND WEEKLY TOTALS.
C
C..... DEFINITIONS...
C
C DR = DRAINAGE (INCHES)
C ET = CROP EVAPOTRANSPIRATION (INCHES)
C ETP = POTENTIAL CROP EVAPOTRANSPIRATION (INCHES)
C IRR = GROSS IRRIGATION REQUIREMENT (INCHES)
C IY = YEAR COUNTER
C JD = CALENDAR DAY COUNTER
C NYR = NUMBER OF YEARS OF RECORD IN THE CLIMATE DATA BASE
C RAIN = DAILY RAINFALL (INCHES)
C XMEAN = MEAN ETP FOR PERIOD OF ANALYSIS (INCHES)
C XMED = MEDIAN ETP FOR PERIOD OF ANALYSIS (INCHES)
C XSDEV = STANDARD DEVIATION OF ETP FOR PERIOD OF ANALYSIS (INCHES)
C XMAX = MAXIMUM IRR FOR PERIOD OF ANALYSIS (INCHES)
C XMIN = MINIMUM IRR FOR PERIOD OF ANALYSIS (INCHES)
C X00 = FRACTION OF YEARS WITH IRR=0 FOR THE PERIOD OF RECORD ANALYZED
C X50 = 50% PROBABILITY IRR (INCHES)
C X80 = 80% PROBABILITY IRR (INCHES)
C X90 = 90% PROBABILITY IRR (INCHES)
C X95 = 95% PROBABILITY IRR (INCHES)
C
    REAL IRR(25,365), NIR(365)

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DIMENSION AETP(25,52),ARAIN(25,52),AIRR(25,52),TET(52),TETP(52),
$ TDR(52),TRAIN(52),AI(25),PROB(25),NMO(12),PDAT(52)
CHARACTER CTYPE*12
C
COMMON /BLOCK1/ ETP(25,365),SWCI(365),SWCN(365),JDAY(365),NF(4),
$ RAIN(25,365),DRZ(365),DRZI(365),RKC(365),SWMAX(365),SWIRR(365),
$ SWCIX(365),SWCNX(365),AWD(365),EFF(10),IRR,NIR,ILOC,ILSAVE,ISIM,
$ ICROP,SWCI1,SWCN1,DWT,EPS,IR,ICODE,J1,JN,NDAYS,NYR,WTD,ARZI,EXIR,
$ JLSAVE,JNSAVE,J1REP,JNREP,IRCRFL,IRSEEP,INSCY,IRNSYC,IRRICE,NCP,
$ IDCODE,IPLLOT,ICIT,IRICE,IVERS,IPRT,AKC3,FRIR,FIX,DRINC,HGT,CTYPE
C
COMMON /BLOCK2/ ET(365),SET(365),SETP(365),SDR(365),SRAIN(365),
$ ER(365),DR(365)
C
DATA NMO/31,28,31,30,31,30,31,31,30,31,30,31/
C
C-----
C..... OBTAIN SEASONAL TOTALS
C-----
IS = 1
DO 100 IY = 1,NYR
AETP(IY,1) = 0.0
ARAIN(IY,1) = 0.0
AIRR(IY,1) = 0.0
DO 100 JD = J1,JN
AETP(IY,1) = AETP(IY,1) + ETP(IY,JD)
ARAIN(IY,1) = ARAIN(IY,1) + RAIN(IY,JD)
AIRR(IY,1) = AIRR(IY,1) + IRR(IY,JD)
100 CONTINUE
C
TET(1) = 0.0
TETP(1) = 0.0
TDR(1) = 0.0
TRAIN(1) = 0.0
DO 110 JD = J1,JN
TET(1) = TET(1) + SET(JD)
TETP(1) = TETP(1) + SETP(JD)
TDR(1) = TDR(1) + SDR(JD)
110 TRAIN(1) = TRAIN(1) + SRAIN(JD)
TET(1) = TET(1) / NYR
TETP(1) = TETP(1) / NYR
TDR(1) = TDR(1) / NYR
TRAIN(1) = TRAIN(1) / NYR
C
IF(EFF(IR) .GT. 0.999) WRITE(6,120)
120 FORMAT(//,11X,'SEASONAL OR ANNUAL NET IRRIGATION REQUIREMENT (INCH
$ES)',/,11X,54('-'))
IF(EFF(IR) .LT. 1.00) WRITE(6,122)
122 FORMAT(//,10X,'SEASONAL OR ANNUAL GROSS IRRIGATION REQUIREMENT (IN
$CHES)',/,10X,56('-'))
C
C..... OUTPUTS FOR DEBUGGING
IF(ICODE .GT. 0)WRITE(6,130)
130 FORMAT(15X,'SUMMARY OF WATER BUDGET COMPONENTS',
$/,18X,'YEAR ETP RAIN IRR.RQD.')
DO 140 IY = 1,NYR
IF(ICODE .GT. 0)WRITE(6,135)IY,AETP(IY,1),ARAIN(IY,1),AIRR(IY,1)
135 FORMAT(17X,I4,3F8.2)
140 AI(IY) = AIRR(IY,1)
C
C..... OUTPUT STATISTICS
WRITE(6,150)
150 FORMAT(/,3X,'MEAN MED. CV XMAX XMIN ZERO RSQ 50% 80% 90%
$95% RAIN ETP ET DR')

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C
CALL STATX(AI,NYR,XMEAN,XMED,XCV,XMAX,XMIN,PROB)
CALL PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C
C..... CHECK THAT EXTREME VALUES OF IRR DO NOT EXCEED ET
XIRR = TET(1) / EFF(IR)
IF(X50 .GT. XIRR) X50 = XIRR
IF(X80 .GT. XIRR) X80 = XIRR
IF(X90 .GT. XIRR) X90 = XIRR
IF(X95 .GT. XIRR) X95 = XIRR
C
IF(XMEAN .LT. 100.0) WRITE(6,160)XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,
$ X50,X80,X90,X95,TRAIN(1),TETP(1),TET(1),TDR(1)
160 FORMAT(1X,2F6.1,F5.2,F6.1,F5.1,2F5.2,8F5.1)
IF(XMEAN .GE. 100.0) WRITE(6,165)XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,
$ X50,X80,X90,X95,TRAIN(1),TETP(1),TET(1),TDR(1)
165 FORMAT(1X,2F6.0,F5.2,F6.0,F5.0,2F5.2,4F5.0,4F5.1)
C
C-----
C..... REASSIGN DATA TO CALENDAR DATES FOR IRRIGATION SEASONS WHICH
C EXTEND BEYOND 1 CALENDAR YEAR.
C-----
IF(J1SAVE .LT. JNSAVE) GO TO 270
C
DO 190 IY = 1,NYR
NY = NYR - IY + 1
NY1 = NY + 1
JJ = 366 - J1SAVE
C
DO 170 JD = 1,JNSAVE
J = JJ + JD
ETP(NY1,JD) = ETP(NY,J)
RAIN(NY1,JD) = RAIN(NY,J)
170 IRR(NY1,JD) = IRR(NY,J)
C
J = 0
DO 180 JJ = J1SAVE,365
JD = 366 - JJ
J = J + 1
JX = 366 - J
ETP(NY,JX) = ETP(NY,JD)
RAIN(NY,JX) = RAIN(NY,JD)
180 IRR(NY,JX) = IRR(NY,JD)
190 CONTINUE
C
C..... MOVE DATA FROM LAST YEAR TO FIRST FOR ANALYSIS
NYX = NYR + 1
DO 210 JD = 1,JNSAVE
ETP(1,JD) = ETP(NYX,JD)
RAIN(1,JD) = RAIN(NYX,JD)
210 IRR(1,JD) = IRR(NYX,JD)
C
C..... ZERO ALL DATA BETWEEN JNSAVE AND J1SAVE FOR EACH YEAR
IF(J1SAVE-JNSAVE .LT. 2) GO TO 270
J1M = J1SAVE - 1
JNP = JNSAVE + 1
DO 230 IY = 1,NYR
DO 230 JD = JNP,J1M
ETP(IY,JD) = 0.0
RAIN(IY,JD) = 0.0
230 IRR(IY,JD) = 0.0
C
C-----
C..... OBTAIN MONTHLY TOTALS
C-----

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270 IF(EFF(IR) .GT. 0.999) WRITE(6,272)
272 FORMAT(//,16X,'MONTHLY NET IRRIGATION REQUIREMENT (INCHES)',/,
$ 16X,43('-'))
IF(EFF(IR) .LT. 1.00) WRITE(6,275)
275 FORMAT(//,15X,'MONTHLY GROSS IRRIGATION REQUIREMENT (INCHES)',/,
$ 15X,45('-'))
IF(IPRT .EQ. 1) WRITE(6,276)
276 FORMAT(18X,'NOTE: ONLY NON-ZERO MONTHS ARE PRINTED.')
IF(ICODE .LT. 1) WRITE(6,296)
C
NX = 0
DO 350 IMO = 1,12
NN = NX + 1
NX = NN + NMO(IMO) - 1
C
DO 290 IY = 1,NYR
AETP(IY,IMO) = 0.0
ARAIN(IY,IMO) = 0.0
AIRR(IY,IMO) = 0.0
C
DO 280 JD = NN,NX
AETP(IY,IMO) = AETP(IY,IMO) + ETP(IY,JD)
ARAIN(IY,IMO) = ARAIN(IY,IMO) + RAIN(IY,JD)
280 AIRR(IY,IMO) = AIRR(IY,IMO) + IRR(IY,JD)
290 CONTINUE
C
TET(IMO) = 0.0
TETP(IMO) = 0.0
TDR(IMO) = 0.0
TRAIN(IMO) = 0.0
DO 292 JD = NN,NX
TET(IMO) = TET(IMO) + SET(JD)
TETP(IMO) = TETP(IMO) + SETP(JD)
TDR(IMO) = TDR(IMO) + SDR(JD)
292 TRAIN(IMO) = TRAIN(IMO) + SRAIN(JD)
TET(IMO) = TET(IMO) / NYR
TETP(IMO) = TETP(IMO) / NYR
TDR(IMO) = TDR(IMO) / NYR
TRAIN(IMO) = TRAIN(IMO) / NYR
C
AISUM = 0.0
DO 295 IY = 1,NYR
AISUM = AISUM + AIRR(IY,IMO)
295 AI(IY) = AIRR(IY,IMO)
IF(IPRT .EQ. 1 .AND. AISUM .LT. 0.0001) GO TO 340
IF(ICODE .GT. 0)WRITE(6,296)
296 FORMAT(/,1X,'MO MEAN MED. CV XMAX XMIN ZERO RSQ 50% 80% 90%
$ 95% RAIN ETP ET DR')
C
C..... OUTPUT STATISTICS
CALL STATX(AI,NYR,XMEAN,XMED,XCV,XMAX,XMIN,PROB)
CALL PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C
C..... CHECK THAT EXTREME VALUES OF IRR DO NOT EXCEED NIR
XIRR = TET(IMO) / EFF(IR)
IF(X50 .GT. XIRR) X50 = XIRR
IF(X80 .GT. XIRR) X80 = XIRR
IF(X90 .GT. XIRR) X90 = XIRR
IF(X95 .GT. XIRR) X95 = XIRR
C
WRITE(6,300)IMO,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
$ TRAIN(IMO),TETP(IMO),TET(IMO),TDR(IMO)
300 FORMAT(1X,I2,F6.1,F5.1,F5.2,2F5.1,2F5.2,8F5.1)
C

```

```

C..... SAVE MONTHLY MEAN DATA FOR PLOTTING
      PDAT(IMO) = XMEAN
C
C..... OUTPUTS FOR DEBUGGING
      IF(ICODE .LT. 1) GO TO 350
      WRITE(6,310) IMO
310  FORMAT(/,28X,'MONTH = ',I2)
      WRITE(6,130)
      DO 320 IY = 1,NYR
320  WRITE(6,135) IY,AETP(IY,IMO),ARAIN(IY,IMO),AIRR(IY,IMO)
      GO TO 350
340  PDAT(IMO) = 0.0
350  CONTINUE
C
C..... PLOT MONTHLY MEAN DATA
      NPLOT = 12
      IF(IPLOT .EQ. 1) CALL PLOT(PDAT,NPLOT,CTYPE)
C
      IF(ICODE .EQ. -1) GO TO 990
C-----
C..... OBTAIN 2-WEEK TOTALS
C-----
      IF(EFF(IR) .GT. 0.999) WRITE(6,372)
372  FORMAT(//,16X,'2-WEEK NET IRRIGATION REQUIREMENT (INCHES)',/,
      $ 16X,42('-'))
      IF(EFF(IR) .LT. 1.00) WRITE(6,375)
375  FORMAT(//,15X,'2-WEEK GROSS IRRIGATION REQUIREMENT (INCHES)',/,
      $ 15X,44('-'))
      IF(IPRT .EQ. 1) WRITE(6,376)
376  FORMAT(17X,'NOTE: ONLY NON-ZERO PERIODS ARE PRINTED.')
      IF(ICODE .EQ. 0) WRITE(6,396)
C
      NX = 0
      DO 450 I2W = 1,26
      NN = NX + 1
      NX = NN + 13
      IF(I2W .EQ. 26) NX = 365
C
      DO 390 IY = 1,NYR
      AETP(IY,I2W) = 0.0
      ARAIN(IY,I2W) = 0.0
      AIRR(IY,I2W) = 0.0
C
      DO 380 JD = NN,NX
      AETP(IY,I2W) = AETP(IY,I2W) + ETP(IY,JD)
      ARAIN(IY,I2W) = ARAIN(IY,I2W) + RAIN(IY,JD)
380  AIRR(IY,I2W) = AIRR(IY,I2W) + IRR(IY,JD)
390  CONTINUE
C
      TET(I2W) = 0.0
      TETP(I2W) = 0.0
      TDR(I2W) = 0.0
      TRAIN(I2W) = 0.0
      DO 392 JD = NN,NX
      TET(I2W) = TET(I2W) + SET(JD)
      TETP(I2W) = TETP(I2W) + SETP(JD)
      TDR(I2W) = TDR(I2W) + SDR(JD)
392  TRAIN(I2W) = TRAIN(I2W) + SRRAIN(JD)
      TET(I2W) = TET(I2W) / NYR
      TETP(I2W) = TETP(I2W) / NYR
      TDR(I2W) = TDR(I2W) / NYR
      TRAIN(I2W) = TRAIN(I2W) / NYR
C
      AISUM = 0.0

```



```

DO 395 IY = 1,NYR
AISUM = AISUM + AIRR(IY,I2W)
395 AI(IY) = AIRR(IY,I2W)
IF(IPRT .EQ. 1 .AND. AISUM .LT. 0.0001) GO TO 440
IF(ICODE .GT. 0)WRITE(6,396)
396 FORMAT(/,1X,'I2W MEAN MED. CV XMAX XMIN ZERO RSQ 50% 80% 90%
$ 95% RAIN ETP ET DR')
C
C..... OUTPUT STATISTICS
CALL STATX(AI,NYR,XMEAN,XMED,XCV,XMAX,XMIN,PROB)
CALL PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C
C..... CHECK THAT EXTREME VALUES OF IRR DO NOT EXCEED NIR
XIRR = TET(I2W) / EFF(IR)
IF(X50 .GT. XIRR) X50 = XIRR
IF(X80 .GT. XIRR) X80 = XIRR
IF(X90 .GT. XIRR) X90 = XIRR
IF(X95 .GT. XIRR) X95 = XIRR
C
WRITE(6,300)I2W,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
$ TRAIN(I2W),TETP(I2W),TET(I2W),TDR(I2W)
C
C..... SAVE 2-WEEK MEAN DATA FOR PLOTTING
PDAT(I2W) = XMEAN
C
IF(ICODE .LT. 1) GO TO 450
WRITE(6,410) I2W
410 FORMAT(/,23X,'2-WEEK PERIOD = ',I2)
WRITE(6,130)
DO 420 IY = 1,NYR
420 WRITE(6,135)IY,AETP(IY,I2W),ARAIN(IY,I2W),AIRR(IY,I2W)
GO TO 450
440 PDAT(I2W) = 0.0
450 CONTINUE
C
C..... PLOT 2-WEEK MEAN DATA
NPLOT = 26
IF(IPLOT .EQ. 1) CALL PLOT(PDAT,NPLOT,CTYPE)
C
C-----
C..... OBTAIN WEEKLY TOTALS
C-----
IF(EFF(IR) .GT. 0.999) WRITE(6,472)
472 FORMAT(//,16X,'WEEKLY NET IRRIGATION REQUIREMENT (INCHES)',/,
$ 16X,42('-'))
IF(EFF(IR) .LT. 1.00) WRITE(6,475)
475 FORMAT(//,15X,'WEEKLY GROSS IRRIGATION REQUIREMENT (INCHES)',/,
$ 15X,44('-'))
IF(IPRT .EQ. 1) WRITE(6,476)
476 FORMAT(18X,'NOTE: ONLY NON-ZERO WEEKS ARE PRINTED.')
IF(ICODE .EQ. 0) WRITE(6,496)
C
NX = 0
DO 550 I7 = 1,52
NN = NX + 1
NX = NN + 6
IF(I7 .EQ. 52) NX = 365
C
DO 490 IY = 1,NYR
AETP(IY,I7) = 0.0
ARAIN(IY,I7) = 0.0
AIRR(IY,I7) = 0.0
C
DO 480 JD = NN,NX

```

```

      AETP(IY,I7) = AETP(IY,I7) + ETP(IY,JD)
      ARAIN(IY,I7) = ARAIN(IY,I7) + RAIN(IY,JD)
480 AIRR(IY,I7) = AIRR(IY,I7) + IRR(IY,JD)
490 CONTINUE
C
      TET(I7) = 0.0
      TETP(I7) = 0.0
      TDR(I7) = 0.0
      TRAIN(I7) = 0.0
      DO 492 JD = NN,NX
      TET(I7) = TET(I7) + SET(JD)
      TETP(I7) = TETP(I7) + SETP(JD)
      TDR(I7) = TDR(I7) + SDR(JD)
492 TRAIN(I7) = TRAIN(I7) + SRRAIN(JD)
      TET(I7) = TET(I7) / NYR
      TETP(I7) = TETP(I7) / NYR
      TDR(I7) = TDR(I7) / NYR
      TRAIN(I7) = TRAIN(I7) / NYR
C
      AISUM = 0.0
      DO 495 IY = 1,NYR
      AISUM = AISUM + AIRR(IY,I7)
495 AI(IY) = AIRR(IY,I7)
      IF(IPRT .EQ. 1 .AND. AISUM .LT. 0.0001) GO TO 540
      IF(ICODE .GT. 0)WRITE(6,496)
496 FORMAT(/,1X,'1WK MEAN MED. CV XMAX XMIN ZERO RSQ 50% 80% 90%
      $ 95% RAIN ETP ET DR')
C
C..... OUTPUT STATISTICS
      CALL STATX(AI,NYR,XMEAN,XMED,XCV,XMAX,XMIN,PROB)
      CALL PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C
C..... CHECK THAT EXTREME VALUES OF IRR DO NOT EXCEED NIR
      XIRR = TET(I7) / EFF(IR)
      IF(X50 .GT. XIRR) X50 = XIRR
      IF(X80 .GT. XIRR) X80 = XIRR
      IF(X90 .GT. XIRR) X90 = XIRR
      IF(X95 .GT. XIRR) X95 = XIRR
C
      WRITE(6,300)I7,XMEAN,XMED,XCV,XMAX,XMIN,X00,RSQ,X50,X80,X90,X95,
      $ TRAIN(I7),TETP(I7),TET(I7),TDR(I7)
C
C..... SAVE WEEKLY MEAN DATA FOR PLOTTING
      PDAT(I7) = XMEAN
C
C..... OUTPUTS FOR DEBUGGING
      IF(ICODE .LT. 1) GO TO 550
      WRITE(6,497) I7
497 FORMAT(/,23X,'WEEKLY PERIOD = ',I2)
      WRITE(6,130)
      DO 499 IY = 1,NYR
499 WRITE(6,135)IY,AETP(IY,I7),ARAIN(IY,I7),AIRR(IY,I7)
      GO TO 550
540 PDAT(I7) = 0.0
550 CONTINUE
C
C..... PLOT WEEKLY MEAN DATA
      NPLOT = 52
      IF(IPLOT .EQ. 1) CALL PLOT(PDAT,NPLOT,CTYPE)
C
990 CONTINUE
      END
C
C*****

```

```

C
C          SUBROUTINE STATX(X,N,XMEAN,XMED,XCV,XMAX,XMIN,PROB)
C*****
C..... THIS SUBROUTINE ORDERS THE IRRIGATION REQUIREMENTS DATA BASE
C          FROM LARGEST TO SMALLEST, AND IT CALCULATES THE PLOTTING
C          POSITIONS FOR THE IRR DATA.
C
C.....THIS SUBROUTINE COMPUTES THE STATISTICAL PARAMETERS MEAN, MEDIAN,
C          VARIANCE, STANDARD DEVIATION, COEFFICIENT OF VARIATION, MAXIMUM,
C          MINIMUM, AND FRACTION OF YEARS WITH NO IRRIGATION
C
C.....DEFINITIONS...
C
C  N = NUMBER OF YEARS OF DATA ANALYZED
C  PROB = PLOTTING POSTION PROBABILITY THAT A GIVEN VALUE WILL BE
C          EQUALLED OR EXCEEDED
C  XMEAN = MEAN IRR FOR PERIOD OF ANALYSIS (INCHES)
C  XMED = MEDIAN IRR FOR PERIOD OF ANALYSIS (INCHES)
C  XSDEV = STANDARD DEVIATION OF IRR FOR PERIOD OF ANALYSIS (INCHES)
C  XMAX = MAXIMUM IRR FOR PERIOD OF ANALYSIS (INCHES)
C  XMIN = MINIMUM IRR FOR PERIOD OF ANALYSIS (INCHES)
C  X00 = FRACTION OF YEARS WITH IRR=0 FOR THE PERIOD OF RECORD ANALYZED
C  ZERO = NUMBER OF YEARS WITH NO IRRIGATION
C
C          DIMENSION X(25),PROB(25)
C
C..... INITIALIZE PROBABILITIES
C
C          DO 10 I = 1,N
10      PROB(I) = 1.0
C
C          NP = N + 1
C          NM = N - 1
C          DATP = N + 1.0
C
C..... ORDER DATA FROM LARGEST TO SMALLEST
C          DO 30 I=1,NM
C          IP = I + 1
C
C          DO 20 J=IP,N
C          IF(X(J) .LT. X(I)) GO TO 20
C          TEMP = X(I)
C          X(I) = X(J)
C          X(J) = TEMP
20      CONTINUE
C
C..... CALCULATE PLOTTING POSTIONS
30      PROB(I) = I / DATP
C          PROB(N) = N / DATP
C
C..... COMPUTE MEAN
C          XSUM = 0
C          DO 100 I = 1,N
C          XSUM = XSUM + X(I)
100     CONTINUE
C          XMEAN = XSUM/N
C
C..... COMPUTE VARIANCE, STANDARD DEVIATION, AND XCV
C          VSUM = 0
C          DO 200 I = 1,N
C          VSUM = VSUM + (X(I)-XMEAN)*(X(I)-XMEAN)
200     CONTINUE
C          XVAR = VSUM/(N-1)
C          IF(XVAR .GT. 0.0) XSDEV = SQRT(XVAR)

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XCV = 0.0
IF(XMEAN .GT. 0.0001) XCV = XSDEV/XMEAN
C
C..... DEFINE MAXIMUM AND MINIMUM VALUES
XMAX = X(1)
XMIN = X(N)
C
C..... DETERMINE THE MEDIAN
NT = N/2
NNT = NT*2
XMED = X(NT+1)
IF(NNT .EQ. N) XMED = 0.5 * (X(NT) + X(NT+1))
C
END
C
C*****
C
SUBROUTINE PROBX(AI,NYR,PROB,XMEAN,X00,RSQ,X50,X80,X90,X95)
C*****
C..... THIS SUBROUTINE CALCULATES THE 50%, 80%, 90%, AND 95%
C PROBABILITY VALUES OF IRR BASED ON AN EXTREME VALUE
C TYPE I PROBABILITY DISTRIBUTION
C
C..... DEFINITIONS...
C
C NYR = NUMBER OF YEARS OF RECORD IN THE CLIMATE DATA BASE
C XMEAN = MEAN IRR FOR PERIOD OF ANALYSIS (INCHES)
C X00 = FRACTION OF YEARS WITH NO IRR
C X50 = 50% PROBABILITY IRR (INCHES)
C X80 = 80% PROBABILITY IRR (INCHES)
C X90 = 90% PROBABILITY IRR (INCHES)
C X95 = 95% PROBABILITY IRR (INCHES)
C
REAL AI(25),PROB(25),W(25),ALIRR(25),INTCPT
C
EPS = 0.000001
RNYR = NYR
C
C..... RETURN -1.0 IF DATA BASE IS NOT ADEQUATE TO CALCULATE INDICATED
C EXTREME VALUE
X00 = -1.0
X50 = -1.0
X80 = -1.0
X90 = -1.0
X95 = -1.0
RSQ = -1.0
C
C..... RETURN 0.0 FOR ALL VALUES IF THE MEAN IS 0.0
IF(XMEAN .GT. 0.0001) GO TO 20
X00 = 0.0
X50 = 0.0
X80 = 0.0
X90 = 0.0
X95 = 0.0
RSQ = 1.0
GO TO 990
C
C..... ELIMINATE ZERO DATA VALUES FROM ANALYSIS
20 IPOS = 0
DO 30 IY = 1,NYR
IF(AI(IY) .LT. EPS) GO TO 40
30 IPOS = IY
C..... CALCULATE FRACTION OF ZERO VALUES
40 X00 = (NYR-IPOS)/RNYR

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```

XPOS = 1.0 - X00
C
C..... CALCULATE PLOTTING POSITIONS FOR PROBS AND IRRs
RSQ = -9.99
IF(IPOS .LT. 3) GO TO 990
C
DO 100 IY = 1,IPOS
IYM = IY - 1
W(IY) = ALOG10(-ALOG10(PROB(IY)))
ALIRR(IY) = ALOG10(AI(IY))
100 CONTINUE
C
C..... CALL SUBROUTINE LSQ TO FIT STRAIGHT LINE TO TRANSFORMED DATA
C BY THE METHOD OF LEAST SQUARES
CALL LSQ(W,ALIRR,IPOS,INTCPT,SLOPE,R,RSQ)
C
C..... IF COEFFICIENT OF DETERMINATION IS LOW, EXTREME VALUES CANNOT
C BE CALCULATED USING THIS METHOD
IF(RSQ .LT. 0.500) GO TO 990
IF(IPOS .LT. NYR) GO TO 300
C
C..... CALCULATE EXTREME VALUES OF IRR FROM REGRESSION EQUATION WHEN NO
C VALUES ARE = 0.0
X50 = 10.0 ** (-0.52139*SLOPE + INTCPT)
X80 = 10.0 ** (-0.15554*SLOPE + INTCPT)
X90 = 10.0 ** INTCPT
X95 = 10.0 ** (0.11429*SLOPE + INTCPT)
GO TO 990
C
C..... CALCULATE EXTREME VALUES OF IRR WHEN SOME VALUES = 0.0
300 C50 = (XPOS-0.5)/XPOS
IF(C50 .GT. EPS) GO TO 310
X50 = 0.0
GO TO 320
310 C50 = ALOG10(-ALOG10(1.0-C50))
X50 = 10.0 ** (C50 * SLOPE + INTCPT)
C
320 C80 = (XPOS-0.2)/XPOS
IF(C80 .GT. EPS) GO TO 330
X80 = 0.0
GO TO 340
330 C80 = ALOG10(-ALOG10(1.0-C80))
X80 = 10.0 ** (C80 * SLOPE + INTCPT)
C
340 C90 = (XPOS-0.1)/XPOS
IF(C90 .GT. EPS) GO TO 350
X90 = 0.0
GO TO 360
350 C90 = ALOG10(-ALOG10(1.0-C90))
X90 = 10.0 ** (C90 * SLOPE + INTCPT)
C
360 C95 = (XPOS-0.05)/XPOS
IF(C95 .GT. EPS) GO TO 370
X95 = 0.0
GO TO 990
370 C95 = ALOG10(-ALOG10(1.0-C95))
X95 = 10.0 ** (C95 * SLOPE + INTCPT)
990 END
C
C*****
C
SUBROUTINE LSQ(X,Y,N,INTCPT,SLOPE,R,RSQ)
C*****
C THIS SUBROUTINE CALCULATES THE LEAST SQUARES CURVE FIT FOR A

```

```

C      SET OF N LINEARLY DISTRIBUTED DATA POINTS TO FIT THE EQUATION
C      Y = SLOPE * X + INTCPT
C
C      REAL X(25),Y(25),INTCPT
C
C..... CALCULATE MEANS OF Xs AND Ys
      SUMX = 0.0
      SUMY = 0.0
      DO 20 I=1,N
      SUMX = SUMX + X(I)
20    SUMY = SUMY + Y(I)
      XBAR = SUMX / N
      YBAR = SUMY / N
C
C..... CALCULATE SUMS OF DEVIATIONS SQUARED AND CROSS PRODUCTS
      SX2 = 0.0
      SY2 = 0.0
      SXY = 0.0
      DO 30 I=1,N
      SX2 = SX2 + (X(I)-XBAR)*(X(I)-XBAR)
      SY2 = SY2 + (Y(I)-YBAR)*(Y(I)-YBAR)
30    SXY = SXY + (X(I)-XBAR)*(Y(I)-YBAR)
C
C..... CALCULATE INTCPT AND SLOPE
      SLOPE = SXY / SX2
      INTCPT = YBAR - SLOPE * XBAR
C
C..... CALCULATE SAMPLE CORRELATION COEFFICIENT, R, AND COEFFICIENT OF
C      DETERMINATION, RSQ
      R = SXY / SQRT(SX2 * SY2)
      RSQ = R * R
C
C      END
C
C*****
C
C      SUBROUTINE PLOT(Y,NDAT,CTYPE)
C*****
C..... THIS SUBROUTINE GRAPHS THE IRRIGATION REQUIREMENTS DATA
C      FOR MONTHLY, 2-WEEK, AND WEEKLY PERIODS OF ANALYSIS
C
C      DIMENSION ARRAY(22,54),IAXIS(13),YAXIS(6),Y(52),X(52),YSC(12)
C      CHARACTER CTYPE*12
C      DATA EYE, BLANK, DASH, PLUS, SYMBOL/1HI,1H ,1H-,1H+,1H*/
C      DATA YSC/1,2.5,5,10,20,40,50,60,75,100,150,200/
C
C..... LOCATE MAXIMUM Y VALUE
      YMAX = 0.0
      DO 50 I = 1,NDAT
50    IF(Y(I) .GT. YMAX) YMAX = Y(I)
C
C..... SET Y AXIS SCALE
      DO 60 I = 1,10
      ISC = I
60    IF(YSC(I) .GT. YMAX) GO TO 70
70    YMAX = YSC(ISC)
C
      XMAX = NDAT
      XSP = 52
      IF(NDAT .EQ. 12) XSP = 48
      DEL = YMAX / 20.0
      DELX = XMAX / XSP
C
C..... INITIALIZE VECTOR X

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```

      DO 80 I = 1,NDAT
80    X(I) = I
C
C..... ZERO ARRAY
      DO 100 I = 1,22
      DO 100 J = 1,54
100   ARRAY(I,J) = BLANK
C
C..... LABEL Y AXIS
      DO 110 I = 1,21
110   ARRAY(I,1) = EYE
      DO 120 I=1,21,4
120   ARRAY(I,1) = PLUS
C
      DO 125 I = 1,6
      IM = I-1
125   YAXIS(I) = YMAX - IM * 4.0 * DEL
C
C..... LABEL X AXIS
      DO 130 J = 2,54
130   ARRAY(22,J) = DASH
      DO 140 J = 2,54,4
140   ARRAY(22,J) = PLUS
C
      IF(NDAT .EQ. 26) GO TO 160
      IF(NDAT .EQ. 52) GO TO 180
      NI = 12
      IG = 7
      DO 150 I = 1,NI
150   IAXIS(I) = I
      GO TO 200
C
160   NI = 13
      IG = 5
      DO 170 I = 1,NI
170   IAXIS(I) = 2 * I
      GO TO 200
C
180   NI = 13
      IG = 4
      DO 190 I = 1,NI
190   IAXIS(I) = 4 * I
C
C..... CHECK FOR DATA POINTS OUTSIDE OF GRAPH BOUNDS
200   DO 250 K = 1,NDAT
      IF(Y(K) .GT. YMAX) Y(K) = YMAX
      IF(Y(K) .LT. 0.00) Y(K) = 0.00
      IF(X(K) .GT. XMAX) X(K) = XMAX
      IF(X(K) .LT. 1.0) X(K) = 1.0
C
C..... CALCULATE PLOTTING POSITIONS
      I = 21 - (Y(K) - DEL/2.0) / DEL
      J = IG + (X(K) - DELX/2.0 - 1.0) / DELX
250   ARRAY(I,J) = SYMBOL
C
C..... PRINT GRAPH
      WRITE(6,280)
280   FORMAT(//////,2X,'IRR (INCHES)',18X,'IRRIGATION REQUIREMENTS')
      WRITE(6,290) CTYPE
290   FORMAT(39X,A12)
C
      ICOUNT = 0
      DO 400 K = 1,5
      ICOUNT = ICOUNT + 1

```

```

        WRITE(6,300) YAXIS(K), (ARRAY(ICOUNT,J),J=1,54)
300    FORMAT(3X,F9.2,1X,54A1)
C
        DO 400 M = 1,3
        ICOUNT = ICOUNT + 1
        WRITE(6,350) (ARRAY(ICOUNT,J),J=1,54)
350    FORMAT(13X,54A1)
400    CONTINUE
C
        WRITE(6,300) YAXIS(6), (ARRAY(21,J),J=1,54)
        WRITE(6,350) (ARRAY(22,J),J=1,54)
        WRITE(6,500) (IAXIS(K),K=1,NI)
500    FORMAT(15X,13I4)
C
        IF(NDAT .EQ. 12) WRITE(6,520)
520    FORMAT(37X,'MONTH',///)
        IF(NDAT .EQ. 26) WRITE(6,540)
540    FORMAT(34X,'2-WEEK PERIOD',///)
        IF(NDAT .EQ. 52) WRITE(6,560)
560    FORMAT(39X,'WEEK',///)
C
        END
C*****

```


APPENDIX H

ABBREVIATIONS USED IN THE AFSIRS MODEL TECHNICAL MANUAL

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).