ESTIMATING GROUNDWATER RECHARGE IN IRRIGATED AREAS OF AN AGRICULTURAL BASIN

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ABSTRACT

Monthly groundwater recharge was estimated for the period of 1979 to 1984 for the irrigated areas in the Oakley Fan area of southern Idaho. Data on surface-water and groundwater irrigation diversions, crop distribution data, climatic data, canal and creek seepage loss data, and estimated soil water characteristics were obtained for the study area. Deep percolation losses were computed using an inflow-outflow water budget which allowed unsaturated flow to occur during periods of soil moisture depletion. Canal seepage losses were estimated using a deterministic relationship.

Canal seepage losses were between fourteen and twenty-nine percent of the irrigation project diversions during the study period from 1979 to 1984. Total deep percolation losses averaged sixty percent of irrigation deliveries in surface-water irrigated areas. In groundwater irrigated areas, crop evapotranspiration was greater than irrigation pumpage, and deep percolation losses were due mostly to precipitation. Deep percolation losses averaged fourteen percent of total precipitation in groundwater irrigated areas.

CHAPTER I

INTRODUCTION

Introduction and Purpose

The Oakley Fan area of southern Idaho has experienced rapid declines in groundwater levels due to increased pumping for irrigation water. The U. S. Geological Survey is investigating the feasibility of recharging the groundwater flow system in this area. A digital computer simulation model of the groundwater flow system is to be used to evaluate the effects of artificially recharging the aquifers. Part of the input needed for the digital simulation model is the amount of recharge occurring from surface-water and groundwater irrigated areas. The purpose of this study is to determine the amount of recharge to the groundwater systems from deep percolation and canal seepage in the irrigated portions of the Oakley Fan study area.

Objectives

Specific objectives of the study are listed below.

1. Develop a simple, easy, and accurate method to estimate deep percolation and canal seepage in irrigated areas.

2. Determine crop distributions and crop evapotranspiration, and determine irrigation water deliveries for the period of 1979 to 1984 in the Oakley Fan study area.
3. Determine groundwater recharge on a monthly basis for the period of 1979 to 1984 in the Oakley Fan area.
4. Examine other methods for obtaining parameters needed to estimate recharge.

CHAPTER II

LITERATURE REVIEW

Groundwater Recharge Models

Several articles such as Freeze (1969), Manbeck and Arbad (1977), Neuman et al (1974), King and Lambert (1976), and Knoch et al (1983) describe models to simulate or estimate groundwater recharge in semi-arid and irrigated areas. These models compute runoff and the amount of infiltrated water after irrigation and precipitation occurs. The infiltrated water is allowed to move through the soil strata under saturated and unsaturated conditions. These models are generally for use in small watersheds and/or require extensive data and time to set up and run. They are not easily applicable to large agricultural basins with varying climatic and hydrologic conditions.

Other models are available to estimate groundwater recharge in large irrigated areas, but these models do not consider unsaturated flow conditions in the soil or the time rate of movement through the unsaturated zone.

Otradovsky (1981) has developed a computer program to calculate groundwater recharge in large irrigated basins on a monthly timestep. Soil and evapotranspiration data built into the program are for the midwestern portion of the United

States. Groundwater recharge occurs during each period when precipitation and irrigation exceed evapotranspiration. Canal seepage rates can be input to the computer program and included in the calculated recharge.

Johnson and Brockway (1983) have modified a groundwater recharge model originally developed by de Sonneville (1974) to calculate groundwater recharge from deep percolation and canal seepage in each cell of a groundwater flow model. Deep percolation is computed using a water balance between irrigation, precipitation, evapotranspiration, and soil moisture deficit. A soil moisture deficit exists when soil moisture is below the field capacity level. If precipitation plus irrigation exceed evapotranspiration, the excess water decreases the soil moisture deficit. If no soil moisture deficit exists, the excess water is deep percolation or groundwater recharge. The computer model can be used in nonirrigated areas also if evapotranspiration rates are known. Wytzes (1980) discusses some of the problems with de Sonneville's (1974) original version of this model, such as calculated canal seepage exceeding total irrigation project diversions.

Bauer and Vaccaro (in review) have developed a computer program to estimate groundwater recharge in arid and semi-aird areas. The model runs on a daily timestep and requires daily climatic data. This model computes recharge using a water balance approach similar to Johnson and Brockway (1983).

Previous Studies

Several previous studies estimate groundwater recharge from surface-water irrigation in the Oakley Fan area of southern Idaho. Crosthwaite (1969) estimated annual average groundwater recharge from four irrigation projects in the area. He estimated annual crop consumptive use and percentage of average annual diversions that became return flow. These two outflow components were subtracted from average annual irrigation diversions to estimate groundwater recharge. Average annual recharge was estimated as 26,000 acre-feet, 180,000 acre-feet, 35,000 acre-feet, and 130,000 acre-feet for the Oakley Canal Company, Burley and Milner Low Lift Irrigation Districts, and the Twin Falls Canal Company, respectively.

As part of an irrigation efficiency study, Claiborn (1975) computed deep percolation losses on a bi-monthly basis for the Burley Irrigation District in the Oakley Fan study area. He used an inflow-outflow water budget method and assumed that no change in soil moisture occurred during the period of evaluation. Annual canal seepage was estimated at 58,041 acre-feet and average annual deep percolation during the 1974 irrigation season was estimated to be 5.08 acre-feet per irrigated acre. Above average snowfall occurred in the winter prior to the 1974 irrigation season, and canal diversions in the spring of that year were greater than normal to minimize flood risks from the high runoff. Much of these early spring canal diversions were delivered to farms resulting in rather high deep percolation losses in this irrigation season.

Allen and Brockway (1979) evaluated water usage and efficiencies for the Burley and Milner Low Lift irrigation projects in the Oakley Fan area during the 1977 irrigation season. Deep percolation was computed using an inflow-outflow water budget. Soil moisture changes at crop harvest and planting times were taken into account. Average deep percolation was estimated at 2.4 and 1.8 acre-feet per irrigated acre for the Burley and Milner Low Lift projects, respectively. Canal seepage losses were estimated at 46,377 acre-feet and 8,543 acre-feet for the Burley and Milner Low Lift projects, respectively.

CHAPTER III

DESCRIPTION OF STUDY AREA

General Description

The study area, known as the Oakley Fan, is located in south central Idaho and is comprised of parts of western Cassia County and eastern Twin Falls County (Figure 1). Irrigated agriculture is the major land use. Irrigation water comes from the Snake River, several tributary streams, and wells.

The study area, consisting of approximately 240,000 acres, is bound on the south and southwest by foothills and mountains. The Albion Mountains form the eastern boundary, and the approximate western boundary is a north-south line through the community of Hansen, Idaho. The northern portion of the area is bound by the Snake River.

Geological and Geographical Description

Alluvium deposits from the Snake River underly the area south of the river and north of the J-Canal in the Burley Irrigation District. Alluvium also underlies portions of the area between the cities of Oakley and Burley in the old Goose Creek stream channel, and aeolian deposits cover most of the

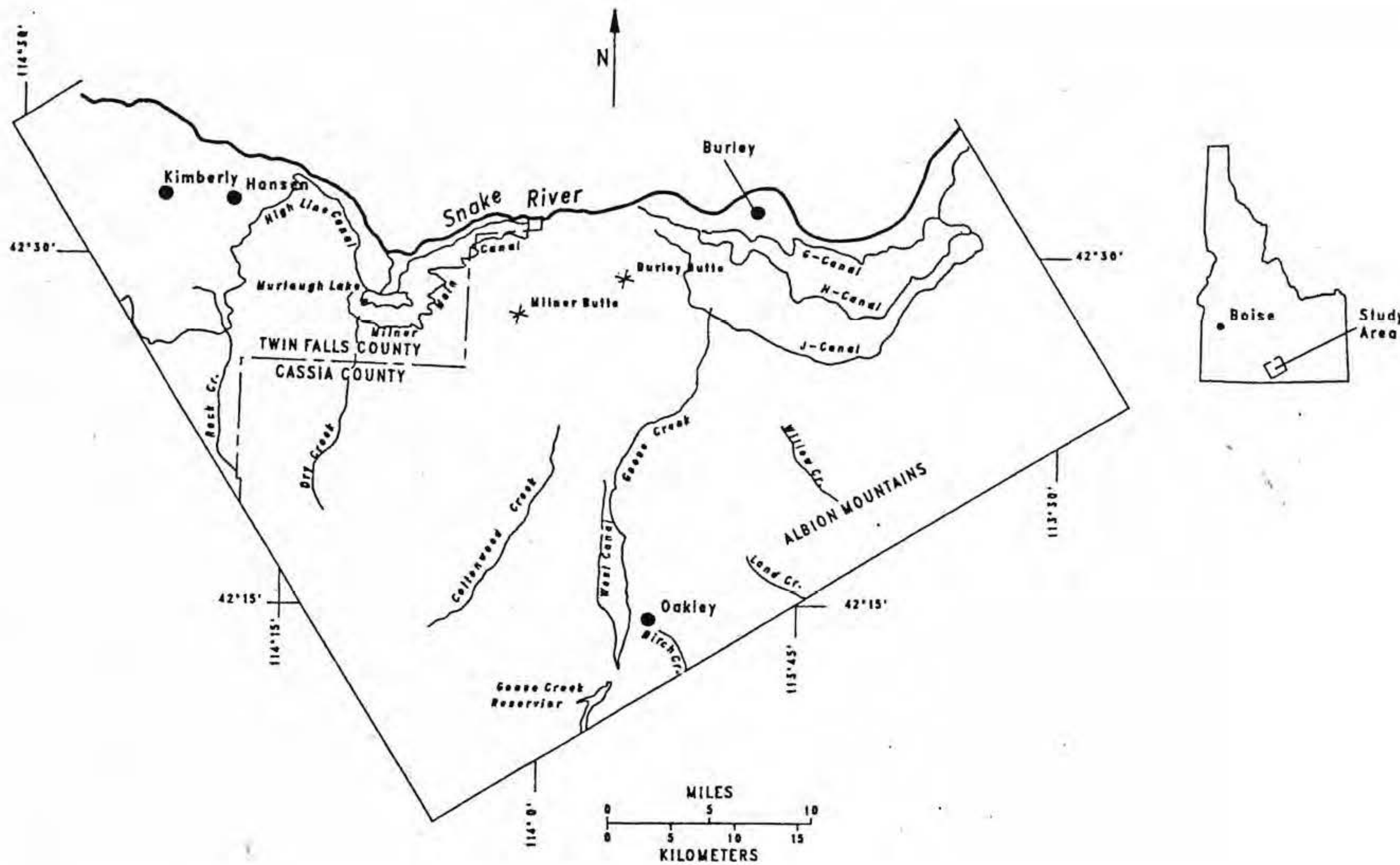


Figure 1. Location and map of study area.

northwestern part of the area. Alluvial fans are well developed at the base of the Albion Mountains along the eastern boundary. Alluvial fans are less distinguishable along the west and southwestern boundaries of the Oakley Fan. The valley floor slopes northward at approximately twenty-three feet per mile from Oakley to the city of Burley. Several basalt domes, most notably Burley and Milner Buttes, rise 200 to 350 feet above the valley floor.

Several tributary streams flow out of drainage basins in the surrounding mountains to the south and east. Goose Creek, the largest stream, flows into Goose Creek Reservoir at the southernmost end of the Oakley Fan. This water irrigates much of the fertile farm land north of the city of Oakley. Other smaller streams such as Birch, Cottonwood, Dry, and Land Creeks are used mostly as irrigation water for individual farms.

Irrigated agriculture and food processing are the major economic activities in the area. Major crops grown are potatoes, small grains, beans, alfalfa, and sugar beets. Burley is the major city in the area and is the county seat of Cassia County.

Climate

The climate of the valley floor is characterized by moderately hot and dry summers and moderate winters. Annual precipitation averages eight to ten inches on the valley floor, and the average snowfall is thirty-one inches. Fifty-eight percent of the total yearly precipitation falls between April and September. One or more inches of snow are on the ground on an average of thirteen days during the winter. Mean winter temperature is thirty-one degrees F and mean summer temperature is sixty-seven degrees F. The growing season is approximately 150 days. The wind generally blows from the southwest and averages ten m.p.h.

Soils

Soils in the area are primarily loams and silt loams. In the eastern part of the study area mostly loam, silt loam, silty clay loam, and clay loam soils are formed in alluvium. The soils are generally deep, moderately level to strongly sloping and well drained. These soils are very gravelly when on upper levels of the alluvial fans near the base of the Albion Mountains or in old ephermal stream beds. In the central portion of the area along the old Goose Creek stream bed, deep, moderately, well-drained loam soils are underlain by sand and gravel bars, and in some areas they are intermixed in alluvium. Silt loam and silty clay loam soils are also found in the central portion of the area. In the western portion deep, well-drained, silt loams are formed in alluvium and loess deposits that cover the Snake River plain. A calciferous layer has formed at shallow depths in some of the western portions of the area.

Description and History of Irrigated Areas

Burley Irrigation District

Water is lifted from the Snake River to the Burley Irrigation District, originally known as the South Side Pumping Project (Figure 2). Three pumping plants built in the early 1900's raise the water thirty feet at each of the three lifts. Delivery of water began in 1909. In 1926, the Burley Irrigation District took over operation of the South Side Pumping Project. Presently, about 41,000 acres of land are irrigated in the district. Water is distributed through approximately 267 miles of canals and laterals. Reaches about a mile long in two of the main canals, the G- and H-Canals, are lined to prevent seepage. Delivered water is measured with the use of weirs and submerged rectangulars orifices. Slopes range from zero to four percent. Approximately eighty-five percent of the lands in the district are watered with gravity irrigation, the rest with sprinkler irrigation.

Milner Low Lift Irrigation District

The Milner Low Lift Irrigation District is located in Twin Falls and Cassia Counties (Figure 2). It originated in 1916 and incorporated into an irrigation district in 1952. Water is lifted from the Snake River at Milner Dam and is

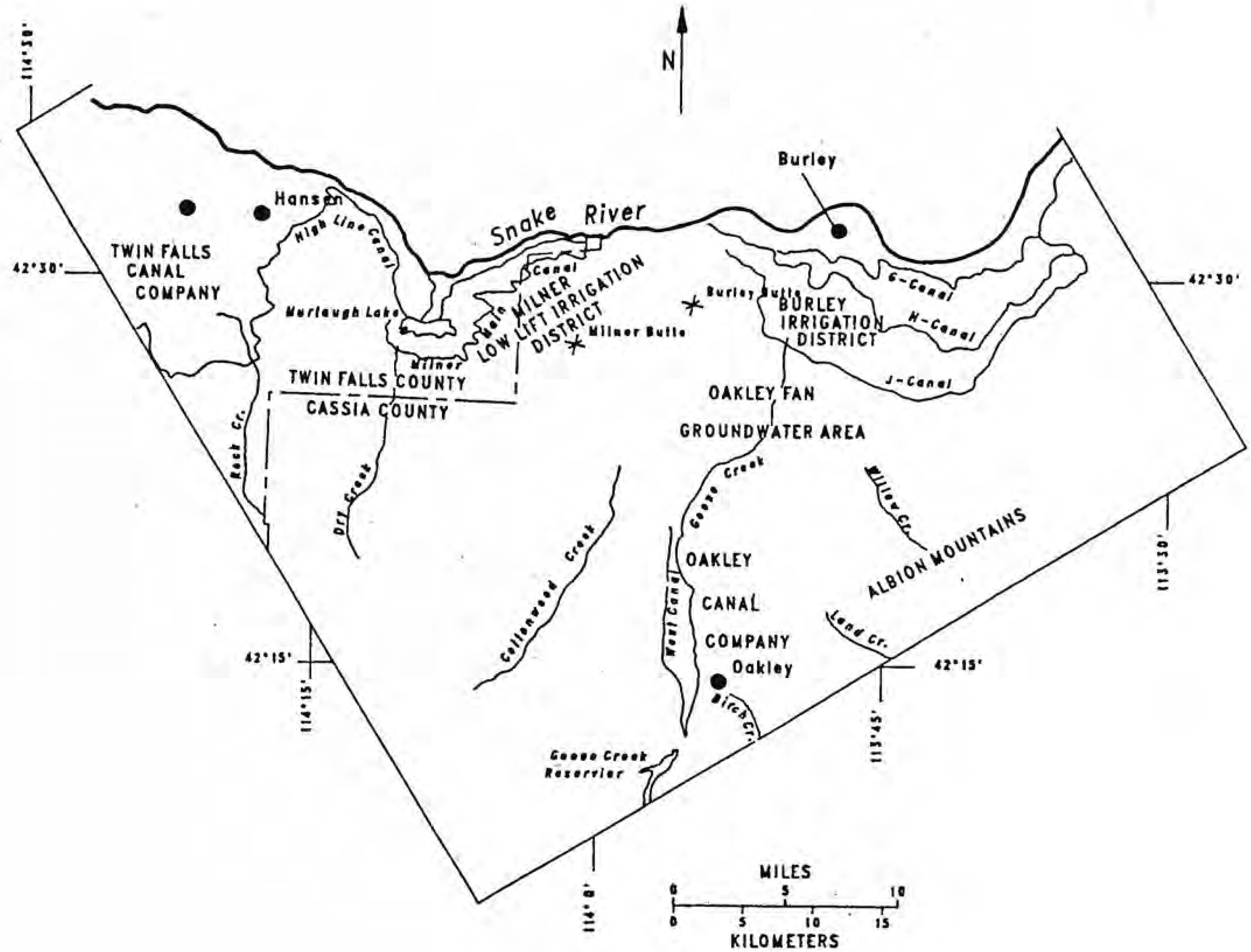


Figure 2. Major irrigation projects in the Oakley Fan study area.

distributed to about 13,400 acres of farm land. Approximately fifty miles of unlined canals and laterals convey water throughout the system. Slopes average between zero and four percent. About ninety-eight percent of the lands are irrigated with gravity irrigation, the rest with sprinkler irrigation.

Oakley Canal Company

Approximately 16,000 acres of land are supplied with irrigation water by the Oakley Canal Company (Figure 2). The first ditches dug in 1879 delivered irrigation water from Goose Creek. An earth dam originally stored the water. Presently, a concrete dam, completed in the late 1920's, stores water for the irrigation project. Forty-five wells supplement surface-water supplies with groundwater at the northern end of the irrigation project. Approximately forty percent of the irrigated area is watered with sprinkler irrigation and the remaining sixty percent uses gravity irrigation. Approximately forty-one miles of unlined canals and laterals, completed in 1911, are in the project.

Twin Falls Canal Company

A portion of the Twin Falls Canal Company is included in the study area (Figure 2). The Twin Falls Land and Water

Company built the High Line Canal in the early 1900's. The present irrigation project includes about 198,000 acres of irrigated land. The study area includes about 38,000 acres. Twenty-three miles of main canals and forty miles of laterals and ditches are located in the study area.

Critical Groundwater Areas

A major portion of the Oakley Fan study area is irrigated with water from wells. This area is called the Oakley Fan groundwater area in this study (Figure 2). Development of groundwater in this area for irrigation occurred rapidly in the 1940's and through the early 1960's. Declines in water levels in the area became evident around 1947. Irrigators had to begin deepening wells. In January 1962 the Idaho Department of Reclamation, now the Idaho Department of Water Resources, quit issuing permits for new wells. After completing a study with the U. S. Geological Survey in 1967, the Idaho Department of Reclamation began allowing new wells in some portions of the area. Continuing declines caused the remainder of the area to be classified as a critical groundwater area in 1982. New groundwater development for irrigation is prohibited. Most farmers use sprinkler irrigation in the Oakley Fan groundwater area. Approximately 123,000 acres of this area is irrigated.

Water User's Associations

Several small water districts obtain water from intermittent streams that flow primarily in the spring and early summer. Groundwater supplements stream flow to meet crop water requirements later in the irrigation season. The names of these are Birch Creek, Cottonwood Creek, Dry Creek, and Rock Creek Water User's Associations. Each of these small irrigation projects is located in close proximity to the creek after which it is named (Figure 2). The irrigated area of these four associations totals about 3,000 acres.

CHAPTER IV

GROUNDWATER RECHARGE SIMULATION MODEL

Computer Program

A computer program developed in this study calculates evapotranspiration, change in soil moisture, deep percolation, and canal seepage losses on a monthly timestep for the irrigated agricultural area. The program is written to allow the study area to be broken into square grid cells (Figure 3). Each cell in this study is one-half mile by one-half mile, containing 160 acres. Groundwater recharge is calculated in each grid cell and is the sum of the following seven components,

$$Qin = SEEPAG + CREEK + [(APPLRT + PTOT - ETPCRP + DSM)/12] * AREA \qquad (1)$$

where

Qin = groundwater recharge in acre-feet,

SEEPAG = canal seepage in acre-feet,

CREEK = river or creek seepage losses in acre-feet,

APPLRT = net applied irrigation water in inches,

PTOT = monthly precipitation and snow melt in inches,

ETPCRP = evapotranspiration in inches,

DSM = change in soil moisture in inches, and

AREA = irrigated area of the grid cell in acres.

Figure 4 is a general flow chart that shows the major mathematical computations the program steps through each month in each cell. At the first of each month, calculated evapotranspiration is removed from stored water in the soil root zone lowering the soil water content. Total monthly precipitation and net irrigation applications are then added to the soil. Depending on the new soil water content after the removal of evapotranspiration, some, none, or all of the added water is stored in the soil, and any extra water becomes deep percolation. When canals are present in the cell, seepage is calculated and added to deep percolation to give total groundwater recharge for the month in the cell.

Information input to the program consists of data on irrigation diversions, farm deliveries, return flows, groundwater pumpage, crop distributions, climate, canal seepage, river reach losses, soil depths, and soil water characteristics. Characteristics of the study area and characteristics of individual grid cells are determined, and input to the program also. Weather stations in or near the study area for which temperature and precipitation are

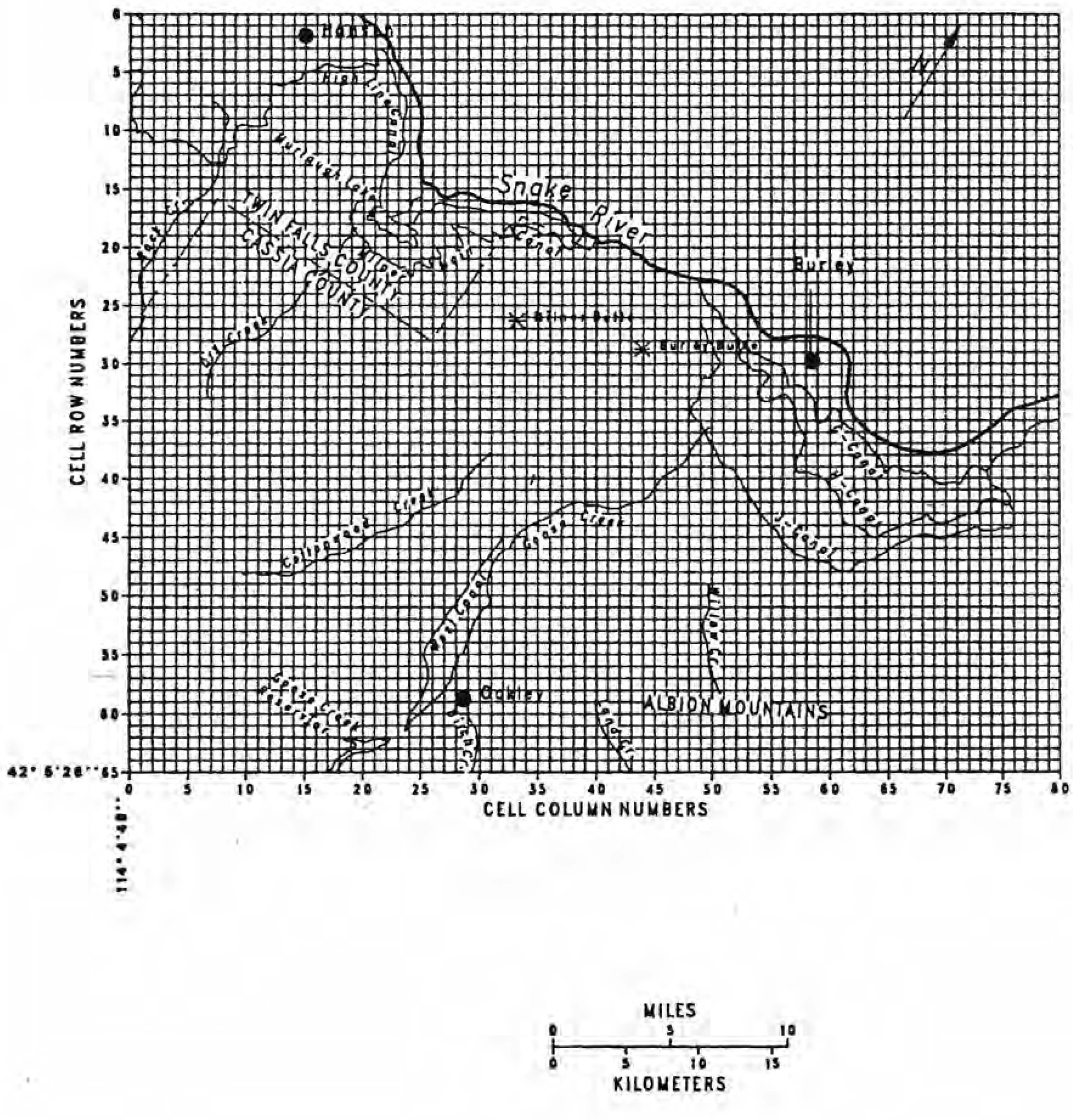


Figure 3. Grid mesh used in the Oakley Fan study area.

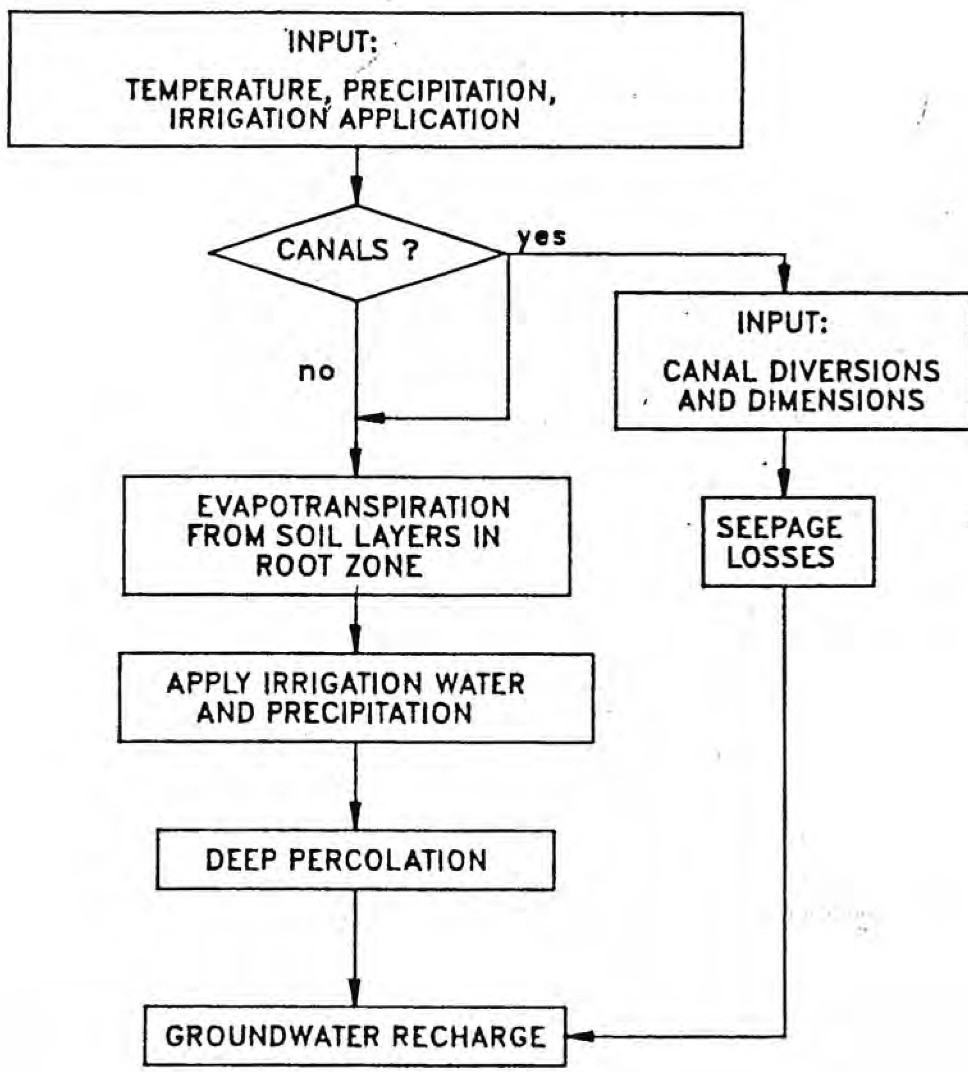


Figure 4. General flow chart of recharge program showing primary mathematical computations.

available are given identification numbers. Regions with similar crop distributions and climate in the study area are outlined and given code numbers. For each crop region, an identification number of a weather station, crop types, and planting and harvesting dates are input to the program. Regions with similar soil depths and soil textures are outlined and given code numbers also. Soil profiles in each soil region are divided into ten-inch layers. The soil water characteristics are identified for each layer, and input to the program. All surface-water irrigation projects and any groundwater irrigated areas are assigned code numbers. A code number for a crop region, a soil region, and an irrigation project or area are assigned to each irrigated cell. For each irrigated cell, the irrigated acreage, code numbers, and row and column number of the cell are input to the program. For each cell with one or more canals or creeks, canal dimensions are input to the program.

A complete description of the program input, a user's guide, and a program listing are included in Appendices A and B. A discussion of methods used to estimate recharge components in the program follows. Variable names used match those in the program unless they are in lower case. Program variable names have any subscripts omitted.

Irrigation Application Rates

A uniform application rate in inches per month is computed from either monthly project diversions or monthly project farm deliveries and annual groundwater pumpage. The amounts of total annual groundwater pumpage used each month are estimated for computing application rates in groundwater irrigated areas.

Surface-water Irrigated Areas

When farm deliveries are known for a project, they are input directly as the variable DEL. When project farm deliveries are not available, but project diversions are, project farm deliveries are estimated by subtracting canal seepage and project return flows from project diversions by the formula

$$DEL = DIV - SEEPSUM - RTNFL * (1 - FARMWST) \qquad (2)$$

where

DEL = farm deliveries for the month in acre-feet,

DIV = project diversion in acre-feet,

SEEPSUM = project canal seepage in acre-feet,

RTNFL = decimal percentage of project diversions that becomes project return flow, and

FARMWST = decimal percentage of project return flow that comes from farms.

Project return flow is estimated as a percentage of project diversions. Return flow originating from canal spills back to the river is the difference between project return flows and farm runoff. The formula is:

$$RNFF = DIV * RTNFL * (1 - FARMWST) \quad (3)$$

where

RNFF = project return flow originating from canal spills in acre-feet.

Farm runoff is estimated as a percentage of the project return flow by the formula

$$frmro = FARMWST * RTNFL * DIV \quad (4)$$

where

frmro = farm runoff in acre-feet.

Some surface-water irrigation projects use groundwater to supplement surface-water supplies. Annual pumpage data are available for irrigation projects in the study area. Monthly pumpage is estimated using ratios of monthly pumpage to annual pumpage (Table 1). These ratios are calculated from two years of monthly pumpage measured by the Idaho Department of Water Resources in the Golden Valley Water District, a small irrigation district in the study area.

Application rates for irrigation projects are computed as

$$APPLRT = (DEL - frmro + pumpage) * 12/AREASM \qquad (5)$$

where

APPLRT = application rate in inches/month,
pumpage = monthly pumpage in acre-feet, and
AREASM = total area of irrigation project in acres.

If no project diversion or farm delivery records are available, application rates are used from another similar irrigation project with known application rates. When only part of an irrigation project is in the study area and project farm deliveries are known, application rates are computed and input to the program directly in APPLRT.

Table 1. Ratios of monthly pumpage to total annual pumpage used in surface-water irrigation projects.

May	June	July	August	September	October
.03	.17	.31	.25	.18	.06

Groundwater Irrigated Areas

Annual pumpage data for the groundwater irrigated area in this study are available. Portions of the annual pumpage are used each month during the irrigation season when precipitation cannot restore all stored soil water extracted for evapotranspiration. Monthly pumpage is equal to the extra water needed to completely restore all the extracted soil water. If the total annual pumpage is already used up, no monthly pumpage is calculated, and soil water is only restored with the amount of precipitation that month. Since it is assumed no runoff occurs in groundwater irrigated areas, net application rates are the monthly pumpage divided by the irrigated acreage of the area.

Evapotranspiration

Crop Evapotranspiration

The formula used to compute evapotranspiration is the FAO Blaney-Criddle method modified for Idaho. This method computes accurate evapotranspiration values on a monthly timestep and requires a minimum amount of data. The formula is

$$ETR = (AP + BP + [P * (0.46 * TAVEC + 8.13)]) * [1 + 0.1 * (ELEV/1000)] \quad (6)$$

where

ETR = evapotranspiration from a grass reference crop in mm/day for the month,

AP = factor to adjust estimates for minimum relative humidity,

BP = coefficient to adjust estimates for minimum relative humidity, mean daily wind, and NRATIO (ratio of actual to maximum possible sunshine hours),

P = mean daily percentage of daylight hours for a given month and latitude,

TAVEC = mean monthly temperature in degrees celsius, and

ELEV = elevation of weather station in meters.

This modified version of the FAO Blaney-Criddle formula requires mean monthly temperature of the crop region and secondary parameters. Secondary parameters are: measured or estimated monthly values of minimum relative humidity, mean daytime wind speed, and mean daytime solar radiation. A more thorough discussion of the FAO Blaney-Criddle formula modified for Idaho is found in Allen and Brockway (1983).

Reported weather station temperatures are adjusted for aridity effects to make them more typical of temperatures over an irrigated field. Aridity ratings for Idaho weather stations presented in Allen and Brockway (1983) are used.

Temperatures are adjusted for lapse rates between elevations of weather stations and the middle of each crop region. A lapse rate of 3.8 degrees F per 1,000 feet change in elevation is used.

Evapotranspiration computed from a grass reference crop is converted to evapotranspiration from an alfalfa reference crop using coefficients presented in Allen and Brockway (1983) for Kimberly, Idaho (Table 2). These coefficients are for an actively growing, well-watered, disease-free alfalfa crop. Daily crop coefficients are used to convert evapotranspiration from an alfalfa reference crop to evapotranspiration for other field crops. These crop coefficients increase from zero at planting time and reach a maximum as the crop becomes fully mature. The crop coefficient decreases from the maximum towards harvest time. Daily crop coefficients from Wright (1982) are used to convert alfalfa reference evapotranspiration to evapotranspiration rates for beans, field corn, peas, potatoes, sugar beets, spring grain, and sweet corn. Daily crop coefficients from Wright (1981) are used for alfalfa hay and alfalfa seed. Alfalfa hay evapotranspiration is reduced twenty-three percent to account for possible disease and effects of windrowing after cutting (Allen and Brockway, 1983). Daily crop coefficients presented in Allen and Brockway (1983) are used for small vegetables.

Crop evapotranspiration is computed each day of the month in the growing season and is the product of mean daily reference evapotranspiration and the daily crop coefficient. Daily evapotranspiration of the crop is totalled for the month. Monthly evapotranspiration from individual crops is multiplied by the percent area the crop occupies in the crop region, converted to inches, and summed. The result for all crops is evapotranspiration in inches, ETPCRP, for the month in the crop region.

Table 2. Coefficients to convert FAO Blaney-Criddle formula from grass references to alfalfa reference (from Allen and Brockway, 1983).

March	April	May	June	July	August	September	October
1.15	1.21	1.14	1.07	1.01	1.00	1.08	1.22

Water to satisfy evapotranspiration is removed from the average depth of the root zone in each crop region. The maximum root depths of crops are built into the computer program. The root depth of each crop is proportional to the mean crop coefficient of the month up until the month that the maximum crop coefficient is reached. From then until harvest, root depths remain constant at their maximum. In each crop region, the root depths of all crops are summed for the month and divided by the number of crops, resulting in the average depth of the root zone. The number of ten-inch soil layers included in the root zone is calculated. All the stored soil water is extracted up to the permanent wilting point of the soil. If the extracted water from the soil layers in the root zone is greater than or equal to evapotranspiration, any extra water is redistributed evenly back to each layer. Any evapotranspiration in excess of the available water in the soil root zone is not considered effective.

Winter Evapotranspiration

Winter evapotranspiration measured during three rather wet and warm winters is reported as being up to six inches for the months of November through March at Kimberly, Idaho (Wright, 1972). Winters are not abnormally warm during this study period, and for this study the total winter evapotranspiration is assumed to be 2.4 inches for the months of November through March. Winter evapotranspiration is removed from the topmost ten-inch soil layer. Winter evapotranspiration is not considered effective if the moisture content of the top soil layer is at or below the permanent wilting point of the soil layer.

Precipitation and Snow

If the mean monthly temperature is below twenty-six degrees F, any precipitation in the crop region during the month is assumed to be snow. During the next month when mean monthly temperature is above twenty-six degrees F, the snow is melted, and the depth of melted snow is assumed to be .30 of the reported monthly precipitation. The melted snow is added to the precipitation for the month in which it is melted.

Deep Percolation

Infiltration and Surface Runoff

Net irrigation applications and precipitation are assumed to infiltrate into the top soil layer with no runoff. Methods for estimating runoff such as the Green-Ampt formula as presented by Brakensik and Rawls (1984) are for discreet storm events or a single irrigation application. In a monthly timestep several storms or irrigations may occur, and estimation methods such as the Green-Ampt formula as presented by Brakensik and Rawls (1984) cannot be used to predict accurate runoff.

Percolation Through Soil Layers

Each month after evapotranspiration has been extracted from water stored in the soil layers in the root zone, net irrigation applications and precipitation are input to the top soil layer. The amount of water movement through each of the soil layers is calculated using a method similar to one presented in Manbeck and Arbad (1977) except that a different relationship for estimating unsaturated hydraulic conductivities is used.

The amount of water percolated through a layer depends on the amount of water input and initial soil water content in the layer. If water input to the layer increases the soil water content to the saturation level (the total pore space of the soil layer filled with water), saturated flow occurs, and water moves through the soil layer at a rate equal to the saturated hydraulic conductivity of the soil. Saturated hydraulic conductivity values for agricultural soils in the study area are high enough so that all water input will percolate through the layer. The moisture content in the current layer is assumed to increase to the saturation moisture content, and part of the water input to the layer is stored so the moisture content increases to saturation. The amount of water moved to the next layer is then

$$PERC = WI - (PHI - thetai) * lt \qquad (7)$$

where

PERC = water percolated to the next layer in inches,

WI = water input to the current layer in inches,

PHI = saturated moisture content (soil porosity) of the soil in the current layer in inches water per inch soil,

thetai = initial moisture content of the current layer in inches water per inch soil, and

lt = layer thickness in inches (equal to 10 inches).

If water input to a layer is not sufficient to increase the soil water content to saturation, the unsaturated hydraulic conductivity (in inches per day) corresponding to the initial water content in the layer is calculated. Water input to the layer is divided by the unsaturated hydraulic conductivity and the number of days in the month. If the result is greater than one (one month), the water percolated to the next layer is

$$PERC = UNSTK * DAY \quad (8)$$

where

PERC = water percolated to the next layer in inches,

UNSTK = unsaturated hydraulic conductivity of the soil in the current layer in inches per day, and

DAY = number of days in the month.

The soil moisture content of the current layer then becomes

$$THETA = thetai + [WI - (UNSTK * DAYS)]/lt \qquad (9)$$

where

THETA = new soil moisture content of current layer in inches water per inch soil.

If dividing water input to the layer by the unsaturated hydraulic conductivity and number of days in the month is less than one, percolation to the next layer is equal to the water input to the current layer. The soil water content of the current layer does not change.

Water percolating out of the bottom soil layer is deep percolation to the groundwater system.

The formula used to estimate the unsaturated hydraulic conductivity in soil layers is the Brooks and Corey relationship for drainage in soils (Corey, 1977). The formula is

$$UNSTK = PSAT * [PDIS/PCAP]^{(2 + 3 * BDLM)} \qquad (10)$$

where

UNSTK = unsaturated hydraulic conductivity of the soil in the current layer in inches per day,

PSAT = saturated hydraulic conductivity of the soil in the current layer in inches per day,

PDIS = displacement pressure of the soil in the current layer in inches: the pressure at which desaturation occurs when the soil is drained,

PCAP = capillary tension of the soil in the current layer in inches: the negative pressure in soil due to pressure difference between soil air and water when soil is not saturated, and

BDLM = slope on logarithmic axes of the capillary tension-saturation curve of the soil in the current layer.

Figure 5 shows the capillary tension-saturation relation, and Figure 6 shows the capillary tension-hydraulic conductivity curve for a typical silt loam soil. The Brooks and Corey relation (Corey, 1977) for the capillary tension-saturation curve is

$$\text{thetai} = \text{THETR} + (\text{PHI} - \text{THETR}) * \left(\frac{\text{PDIS}}{\text{PCAP}}\right)^{\text{BDLM}} \qquad (11)$$

where

thetai = initial soil moisture content of current layer in inches water per inch soil,

THETR = residual moisture content of the soil in the current layer in inches water per inch soil: the moisture content at which capillary pressure begins to increase rapidly with a small decrease in saturation,

PHI = saturated moisture content of the soil in the current layer in inches water per inch soil,

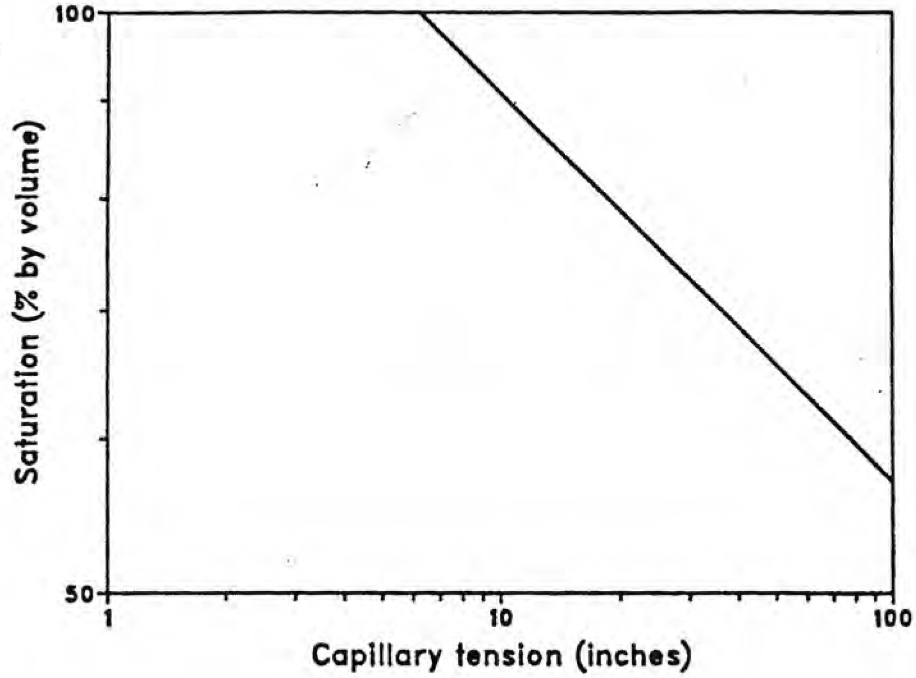


Figure 5. Capillary tension-saturation relation for silt loam soil (adapted from Rawls et al, 1981).

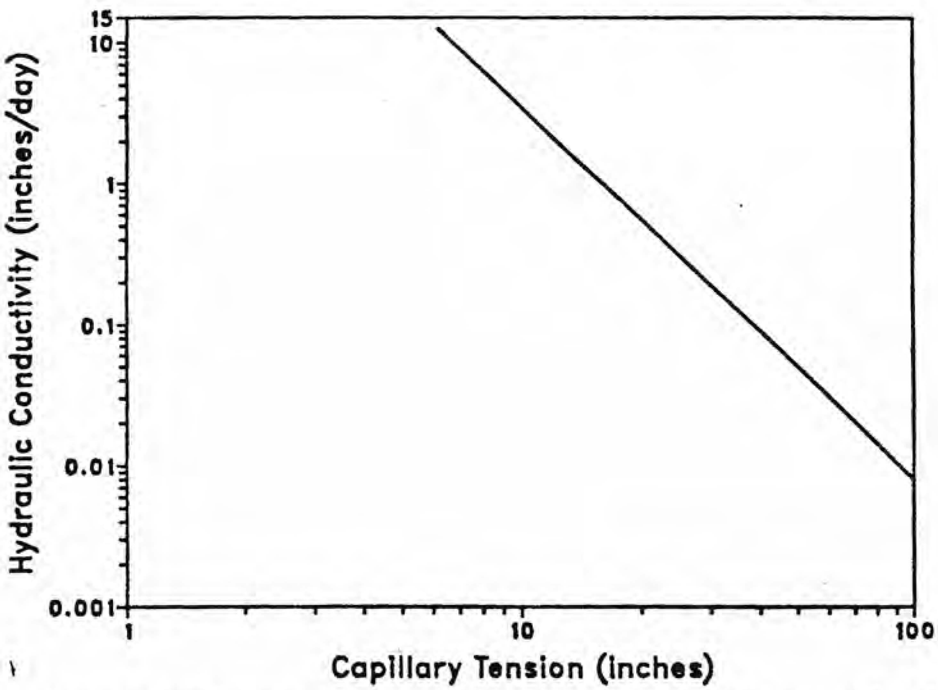


Figure 6. Capillary tension-hydraulic conductivity relation for silt loam soil (adapted from Rawls et al, 1981).

PDIS = displacement pressure of the soil in the current layer in inches,

PCAP = capillary tension of the soil in the current layer in inches, and

BDLM = slope of capillary tension-saturation curve of the soil in the current layer.

Equation 11 is rearranged to obtain PCAP for computing unsaturated hydraulic conductivity in Equation 10.

$$PCAP = \frac{PDIS}{\left(\frac{thetai - THETR}{PHI - THETR}\right)^{(1/BDLM)}} \qquad (12)$$

All terms in Equations 10, 11, and 12 except THETA and PCAP are constants input to the program for each soil layer in each soil region. At the beginning of the simulation period, an antecedent THETA is assumed and input to the program for all soil layers in all soil regions. The program will compute THETA from then on for each month of the simulation.

Canal Seepage

A method of calculating canal seepage losses over the irrigation season is presented by Claiborn (1975). Seepage losses for a canal system are proportional to the amount of surface-water diverted to the system, QD. Maximum seepage loss occurs when diversions are at the highest amount during the irrigation season. The formulas used to estimate seepage losses are for QD less than QMIN

$$\text{SEEPAGE} = 0.50 * \text{SLOSS} * \text{ADJ}, \tag{13}$$

and for QD greater than or equal to QMIN

$$\text{SEEPAGE} = .5 * \text{SLOSS} * \text{ADJ} * 1 + \left(\frac{\text{QD} - \text{QMIN}}{\text{QMAX} - \text{QMIN}}\right) \tag{14}$$

where

SEEPAGE = seepage loss for the canal reach in acre-feet,

SLOSS = maximum seepage rate from canal in cubic feet per day,

QD = daily, bi-monthly, or monthly diversion in cfs or acre-feet,

QMIN = minimum diversion for irrigation season (= .2 * QMAX) in same units as used for QD,

ADJ = an adjustment factor, and

QMAX = maximum river diversion for irrigation season in same units as used for QD.

Towards the end of the irrigation season, seepage losses will be lower because water is no long entering the now saturated canal banks, and canal bottoms tend to be sealed due to siltation. An adjustment factor presented by Allen and

Brockway (1979) is used to account for lower losses at the end of the irrigation season. The adjustment factor is

$$ADJ = 2.5 * T^{-.25} \qquad (15)$$

where

T = time in days since irrigation season began.

Equation 15 is used during periods after the first forty days of the irrigation season.

Seepage is also decreased during the beginning of the irrigation season to account for the time it takes water to travel through the system and fill all the canals. This adjustment factor is

$$ADJ = .275 * T^{-.35} \qquad (16)$$

Equation 16 is used during the first forty days of the irrigation season.

Depending on the diversion records used, seepage is computed each day or bi-monthly and summed for the month, or it is computed on a monthly basis. If daily diversions are not used, the T term in Equations 15 and 16 is equal to the mean number of days in each month or bi-monthly period plus the number of days in preceding periods of the irrigation season.

The maximum seepage rate, SLOSS, is the product of the canal length, the wetted perimeter, and the seepage coefficient specified for each canal. The seepage coefficient is determined from soil types or from field measurements of seepage in the canal.

Canal topwidths are input to the program and wetted perimeters are estimated by multiplying topwidths by coefficients reported by Claiborn (1975) (Table 3). Lengths of canal reaches are also input to the program and multiplied by the estimated wetted perimeters to obtain wetted areas of each canal reach in a cell. If wetted areas of canals are already known, these are substituted for topwidths and lengths. The program computes the seepage losses separately for each canal reach in the cell and sums the seepage from all canal reaches in the cell.

Table 3. Coefficients for determining canal wetted perimeters from canal topwidths (Claiborn, 1975).

Topwidth (feet)	Coefficient
12.5	1.3
25	1.2
200	1.1
$>$200	1.05

When networks of small laterals are included in an irrigation project, total lengths and average topwidths of individual laterals are input without specifying the cells in which they are located. The program computes the total seepage of all the individual laterals and distributes it equally in every cell occupied by the irrigation project.

Each month of the irrigation season, the recharge program maintains a water budget between the diversions, farm deliveries, canal seepage, and canal spills in each irrigation project. When farm deliveries are estimated from canal seepage losses, the recharge program checks to see if canal seepage is greater than the total diversions. If so, seepage losses are reduced by the same amount they exceed the diversions. When canal seepage is not used to estimate farm deliveries, the recharge program corrects for canal losses being greater than or less than the diversions minus the farm deliveries and canal spills. If losses are too high, the excess losses are subtracted from all cells containing canals using the proportion of seepage in that cell to the total seepage in the entire canal system. If seepage is too low, the extra water is added to each cell containing canals. When canal spills occur, such as in the Burley and Milner Low Lifts projects, half the extra water is added to canal spills, and the other half is added to each cell with canals. No adjustments are made in the Twin Falls Canal Company since farm deliveries and diversions are not known in the portion of the system under consideration.

Creek Seepage

Estimates of seepage losses in creek reaches are input to the program for each month. The length of the reach and the grid cells that contain the reach are input also. The program divides the reach seepage losses equally among the cells and inputs it to the CREEK term of the cell.

Assumptions and Limitations

Assumptions and limitations of the recharge program are listed below.

1. Movement of water through the soil profile is one-dimensional and in the vertical direction.
2. Movement through a soil layer is not affected by properties of the layer above or below it.
3. No runoff resulting from precipitation occurs.
4. Water percolating from the bottom soil layer is considered to be groundwater recharge.
5. The root zone depth is proportional to the average evapotranspiration crop coefficient for the time of year.
6. The hydraulic gradient in the soil profile is equal to one.
7. Water needed to satisfy evapotranspiration is removed from the soil root zone at the beginning of

each month before irrigation applications and precipitation are added.

8. Each soil layer is homogenous and isotropic.
9. Hysteresis effects in the soil layer are small enough to be neglected.
10. The amount of canal seepage is proportional to the ratio of irrigation project diversions and the difference of minimum and maximum project diversions for the irrigation season.
11. Evapotranspiration crop coefficients developed for Kimberly, Idaho (Wright, 1981 and Wright, 1982) are representative of the study area.
12. Evapotranspiration is not reduced until the wilting point moisture content of the soil is reached.
13. Crop evapotranspiration is uniform throughout a crop zone.
14. Irrigation application rates are uniform throughout an irrigation project.
15. The soil texture and soil moisture parameters are uniform in each soil layer.
16. Snow melts at a mean monthly temperature of twenty-six degrees F and its water content is .30 of the reported precipitation depth.
17. All canals in a canal system fill with water instantaneously at the beginning of the irrigation season and remain full until the end of the season.

18. All recharge components in each cell are not affected by the head in the aquifer.
19. Steady state conditions exist in the soil water system.
20. The calculated capillary tension in each soil layer is constant throughout the layer.
21. Any change of capillary tensions between soil layers occurs at the boundary of the layer, so no transition zone exists.

CHAPTER V

DATA COLLECTION

Recharge was needed for the six years from 1979 through 1984 to calibrate a U. S. Geological Survey groundwater flow model of the Oakley Fan study area. The study area was overlain with a square grid mesh corresponding to the groundwater model grid (see Figure 3). Each grid cell with irrigated crop land required an estimated recharge flux for each month of the six year period. Information to compute a water balance for each irrigation project or irrigated area was needed to determine the recharge flux.

Irrigated Area Boundaries

Irrigated areas for the portion of Cassia County in the study area were determined from maps in Water Related Land Use-1975 (Idaho Department of Water Resources, 1978) and from an updated version of this map for 1983 obtained from the Agricultural Stabilization and Conservation Service, USDA field office in Burley, Idaho. Areas with irrigation in the portion of Twin Falls County were determined from maps in Water Related Land Use-1975 also. New irrigated areas added since 1975 were identified using 1982 high altitude U-2 infrared photos obtained from the Idaho Department of Water

Resources. Grid cells located within these irrigated areas were identified. Each irrigation project and the Oakley Fan groundwater area were assigned to the irrigated grid cells in which they were located, and each project or area was given a code number (Figure 7).

Irrigated Acreage

Irrigated acreages were estimated by planimetering areas of typical irrigated areas from aerial photos of Cassia County. The photos were made available by the Burley field office of the Agricultural Stabilization and Conservation Service, USDA. The net irrigated acres; not including roads, houses, ditches, and other noncropped areas; were determined in several 640-acre sections typical of groundwater and surface-water irrigated areas. Ratios of the net irrigated acreage to total acreage (640 acres) were computed. Groundwater irrigated areas had ratios of .96 and surface-water irrigated areas had ratios averaging .92. These ratios were used to estimate net irrigated acreage in each grid cell with surface-water or groundwater irrigation. Table 4 lists average reported acreages and acreages calculated with these ratios. Calculated acreage for the Oakley Fan groundwater area includes irrigated areas in Twin Falls County, but the reported acreage does not.

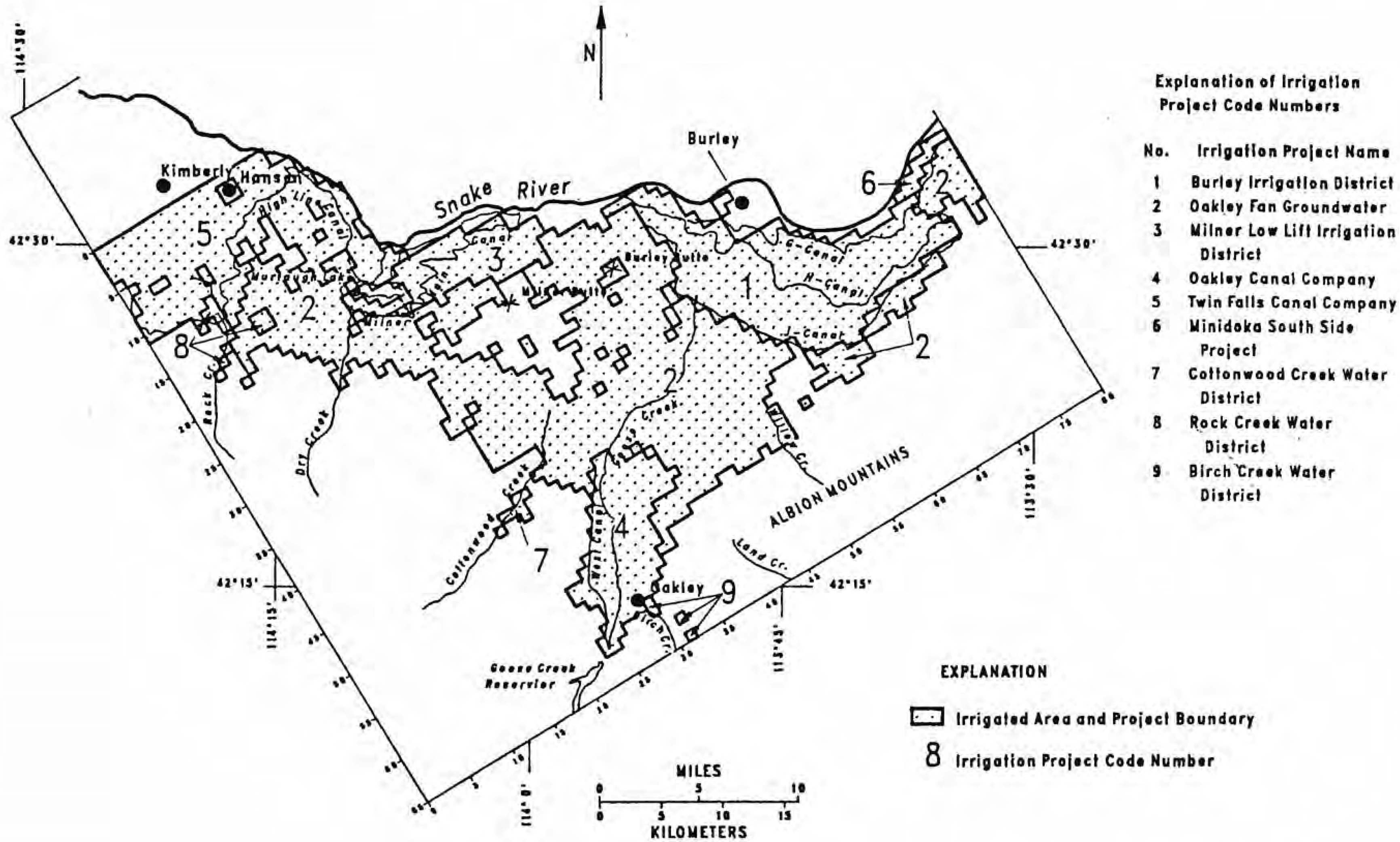


Figure 7. Boundaries of irrigated areas in the Oakley Fan study area.

Table 4. Calculated and reported irrigated acreages.

Irrigation Project Name	Calculated Acreage	Average Reported Acreage
Burley Irrigation District	41191	41450*
Milner Low Lift Irrigation District	13161	13400**
Oakley Fan Groundwater	122823	105000****
Cottonwood Creek Water User's Association	1046	658***
Birch Creek Water User's Association	614	759***
Oakley Canal Company	16108	16000****

Sources of reported acreage.

* Bureau of Reclamation crop reports.

** Irrigation project personnel.

*** Idaho Department of Water Resources, Water Related Land Use-1975 (Idaho Department of Water Resources, 1978).

**** Burley field office of the Soil Conservation Service.

Crop Distribution

Estimates of crop distribution were available from the Bureau of Reclamation for the Burley Irrigation District in their crop production reports. These reports covered the first five years of the study period. Preliminary reports were used for 1984.

Estimates of crop distributions in the Milner Low Lift Irrigation District were available for the years of 1984 and 1982 from reports provided by the irrigation project manager. Crop distributions for 1979, 1980, 1981, and 1983 were assumed to be the average of the 1982 and 1984 crop percentages.

Crop distributions for the rest of the study area were obtained from the field offices for west Cassia County of the Soil Conservation Service and Agricultural Stabilization and Conservation Service in Burley. Four crop regions were identifed: the Oakley Canal Company, Twin Falls Canal Company, Oakley Fan, and Golden Valley (Figure 8). Crop percentages were estimated for each of these regions (Table 5).

Crop planting and harvesting dates were obtained from lists of average dates for several counties in Idaho (Allen and Brockway, 1983) and from information provided by the Agricultural Stabilization and Conservation Service, USDA field office in Burley.

Surface-water Seepage

Canal Dimensions

Canal topwidths and lengths were determined for all major canals and laterals in the study area. A microscope with a small scale inset on one of the lenses was used to measure

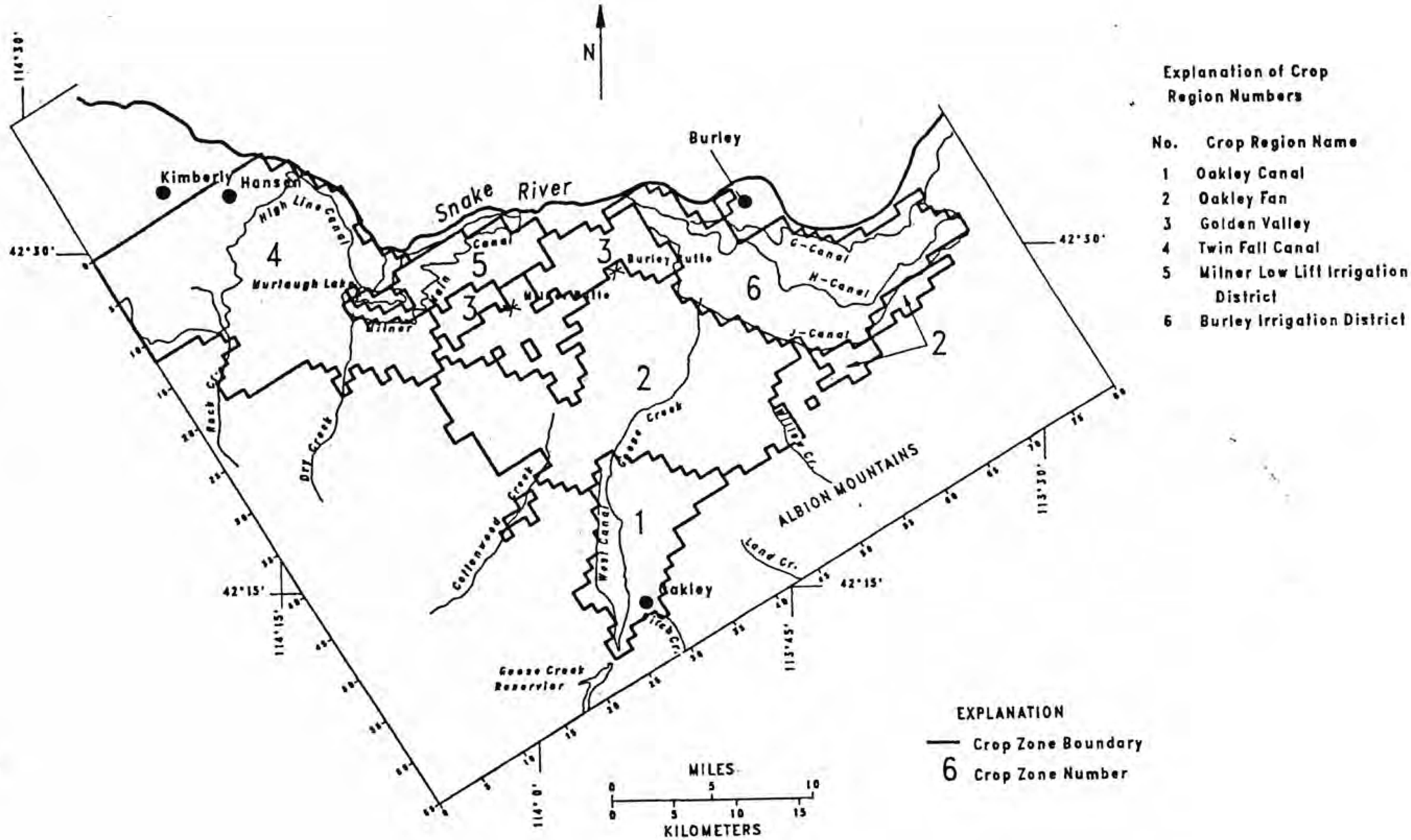


Figure 8. Crop regions in the Oakley Fan study area.

Table 5. Estimated crop distributions in the Oakley Fan study area (Glen Jensen, 1985, Agricultural Stabilization and Conservation Service, USDA, written communication and Kent Foster, 1985, U. S. Soil Conservation Service, written communication).

	Oakley Canal	Oakley Fan	Twin Falls Canal	Golden Valley
	Percent area of crops			
Potatoes	22	30	20	25
Beets	2	8	8	8
Beans	2	10	15	15
Peas	1	1	1	1
Corn	3	2	1	2
Alfalfa	15	6	15	6
Barley	15	6	5	6
Wheat	40	37	30	37
Pasture	0	0	5	0

topwidths from Agricultural Stabilization and Conservation Service, USDA aerial photos. Canal lengths passing through each model cell were measured from 7.5' quadrangle maps overlain with 7.5' maps of the model grid. All canal lengths passing through each model cell were measured except for laterals in the Burley Irrigation District with topwidths of ten feet and less. Total measured lengths and average topwidths of each of these smaller laterals were input to the computer program without row and column numbers. The program distributes the seepage from the laterals uniformly over the Burley project. This approach was appropriate since numerous small laterals were spread uniformly throughout the district.

Lengths and topwidths of all large canals in the study area were input on a cell by cell basis.

Murtaugh Lake

Murtaugh Lake is a regulating reservoir for flow in the Twin Falls Canal system. The lake area in each cell was planimetered from 7.5' quadrangle maps. These areas were assumed to be the wetted area of the lake and were input directly to the recharge program. The recharge program used the canal seepage formulas presented in Chapter IV to compute seepage losses from the lake.

Seepage Rates

The U. S. Geological Survey (USGS) measured seepage by inflow-outflow methods on the J-Canal in the Burley Irrigation District and Murtaugh Lake at the end of the 1984 irrigation season and two times during the 1985 irrigation season. The average seepage coefficient for the J-Canal was calculated as 2.73 feet per day, and that for Murtaugh Lake was .045 feet per day.

Seepage tests performed in 1914 in the Burley Irrigation District show average seepage coefficients of 1.08, 1.14, and .99 feet per day for the J-, H-, and G-Canals, respectively.

The U.S. Bureau of Reclamation (USBR) still uses these seepage rates for evaluating canal losses (U. S. Bureau of Reclamation, 1984). These USBR seepage coefficients were used for the G-Canal and H-Canal. An average of the USBR and USGS seepage coefficients of 1.95 feet per day was used for the J-Canal. The seepage rate of 2.73 feet per day measured by the USGS for the J-Canal was considered representative of one of the leakiest sections and not applicable to the entire canal.

Claiborn (1975) presents seepage coefficients for different soil types in southern Idaho. A value of .95 feet per day for silt loam soils was selected for the smaller laterals in the Burley Irrigation District.

Seepage measurements using inflow-outflow methods were made once in the summer of 1985 on two laterals in the Oakley Canal Company. The seepage coefficients were 8.15 and 8.05 feet per day for these laterals. The reaches tested were approximately .8 miles in length each with no irrigation turnouts operating.

Calculated canal seepage losses during initial runs of the recharge program were excessive using the average of measured seepage coefficients (8.10 feet per day) in the Oakley Canal system. The reason for the measured seepage coefficient being extremely high could be due to measurement error from using the inflow-outflow method. Worstell (1976) reported that measurement error resulting from water level fluctuations could overshadow the seepage losses in the canal when using the inflow-outflow method. This error was especially significant if seepage losses were less than ten percent of the total flow in the canal. Measurement error was probably what was recorded in the Oakley canals since reaches were short enough so that seepage losses were in all likelihood small. Several more measurements should have been made on longer reaches to obtain a wider distribution of seepage losses, and an average seepage coefficient could have been found. However, due to time and financial constraints, more measurements were not made. For the Oakley project canals, an estimated seepage coefficient of 1.45 feet per day was selected on the basis of soil types in the area.

CH2M Hill Engineers measured seepage on the Twin Falls High Line Canal during the summer of 1983 (Mike Mikleson, 1985, CH2M Hill Engineers, Boise, Idaho, oral communication). The seepage rates calculated from these measurements were 1.32 feet per day for the canal up to Murtaugh Lake and .65 feet per day below the lake. A seepage coefficient of 1.32 feet per day was used in the Twin Falls project canals above Murtaugh Lake, and a coefficient of .65 feet per day was used for canals below the lake. The value of 1.32 feet per day was used in the Milner Irrigation project canals which were located in the same soil types as the upper section of the Twin Falls High Line Canal.

Seepage from the Goose Creek Flood

An extremely wet winter in 1984 caused flooding in the old Goose Creek stream channel below the Goose Creek Reservoir. A canal was also built to help carry flood waters to Murtaugh Lake. The dimensions and locations of the old Goose Creek stream channel and the canal were assumed and included as input to the program. The seepage rates of Goose Creek and the canal, both estimated as 2.0 feet per day, were set equal to zero except for several months in 1984 when the flood occurred.

Seepage from Tributary Streams

Seepage measurements using inflow-outflow methods were performed on four tributary streams in the Oakley Fan in the summer of 1985. These streams were Land Creek, Willow Creek, Dry Creek, and Birch Creek. Except for Birch Creek, these measurements were made where streams begin crossing the valley floor below the base of the foothills and mountains.

The reach tested on Birch Creek was in a canyon south of the study area, and results showed the reach was gaining water. Water from springs along the canyon walls was probably entering the stream reach tested.

For the other three streams, seepage losses measured in percent loss per mile were fifteen, twenty-six, and fourteen for Willow, Land, and Dry Creeks, respectively. These were averaged, and a loss rate of eighteen percent per mile was used for all streams in the study area. This loss rate was applied to several tributary streams in the Oakley Fan using estimated mean monthly runoff volumes for the streams. Lengths of streams were measured from 1:250,000 scale maps. Stream seepage losses were estimated as the percent loss times the runoff volume and the stream length in miles.

Surface-water Irrigation Diversions and Deliveries

Monthly Water Distribution and Annual Operation and Maintenance Cost reports were obtained from the U. S. Bureau of Reclamation for the Burley Irrigation District. These were available for the year from 1979 to 1983. A preliminary report of Crop Production and Water Utilization Data was available for 1984. Project farm deliveries and project diversions were used from these reports.

Monthly diversions to Milner Low Lift Irrigation District were listed in the Annual Report for Water District 01 for the years of 1979 to 1982 (Water District 01, 1979-1982). Preliminary records of the diversions for 1983 and 1984 were obtained from the U. S. Bureau of Reclamation.

Farm deliveries in the Milner Low Lift project for the years 1979 through 1984 were copied from ditchrider records at the district office. In certain months recorded farm deliveries exceeded the recorded project diversions by as much as 200 percent. This was especially true in the first three months of 1981. In 1979 recorded farm deliveries were about sixty percent less than normal for July and August, but recorded project diversions in 1979 were within twenty percent of the recorded diversions in July and August in other years. The recorded farm deliveries in 1979 and 1981 were most likely in error, and monthly farm deliveries were estimated for these two years by subtracting calculated project canal seepage and return flows from project diversions.

Daily river diversions were used for computing canal seepage in the Burley and Milner Low Lift Irrigation Districts and the Twin Falls Canal Company. These diversion records were obtained from the Watermaster's Report for Water District 01 (Water District 01, 1979-1982) and the U. S. Bureau of Reclamation.

Records of reservoir storage for the Goose Creek reservoir and flow into the reservoir from two gauged streams were published in Water Resources Data for Idaho (U. S. Geological Survey, 1980-1985). Estimates of project diversions to the Oakley Canal Company were made by subtracting the change in the reservoir contents from the volume of water flowing into the reservoir for each month. Lake evaporation (estimated as .7 of pan evaporation reported for each month at Kimberly, Idaho) was taken out of the change in reservoir contents. Seepage out of the bottom of the reservoir was neglected since no seepage data were available for the reservoir.

Bi-monthly diversions were used to compute canal seepage in the Oakley project. These were calculated in the same manner as the monthly project diversions, but without taking lake evaporation into account.

Farm deliveries for the Oakley Canal Company were obtained from the project office for the years of 1979 and 1981 to 1983. Farm deliveries were not recorded in 1980 or 1984 because of problems with the outlet works at the Oakley Dam in 1980 and flooding in 1984. Farm deliveries for 1980 and 1984 were estimated by subtracting project canal seepage from monthly project diversions.

Farm deliveries for the Water User's Associations of Birch Creek, Dry Creek, Rock Creek, and Cottonwood Creek were available from the Idaho Department of Water Resources. Records for Dry Creek were not used since the exact location of the district could not be determined. Application rates from the Oakley Fan groundwater area were used for the general area of the Dry Creek Water District. In 1981 and 1982, no records could be found for Birch Creek or Rock Creek, and application rates from Cottonwood Creek were used.

The Twin Falls Canal Company retained monthly summaries of farm deliveries for each ditchrider service area, or ride, in 1983 and 1984. The study area included one ride and parts of two others. The records for two of the rides which contained approximate numbers of acres served by each ride were used to estimate application rates. For the years prior to 1983, application rates from the Milner Low Lift Irrigation District were used for the Twin Falls Canal Company lands.

In the Minidoka South Side Irrigation Project, a small project with approximately 1,700 acres in the study area, application rates from the Burley Irrigation District were used.

Return Flows

Canal spills and farm runoff back out of irrigation projects were usually not all measured by irrigation project personnel due to the cost and effort involved. Claiborn (1975) presented bi-monthly return flows from canal spills and farm runoff in the Burley Irrigation District. From Claiborn's data, monthly return flows were calculated as a percent of the monthly project diversions, and these return flow percents were used in the Burley project. Return flow estimates from both canal spills and farm runoff for the Milner Low Lift Irrigation District were obtained from Allen and Brockway (1979). No return flows occur in the Oakley

Canal Company from canal spills or farm runoff. Return flows from farm runoff in the Twin Falls project were already included in the estimated application rates from the Milner project used from 1979 to 1982. Return flows from farm runoff in 1983 and 1984 in the Twin Falls project were assumed to be negligible. Runoff from fields in the Oakley Fan groundwater area was assumed to be negligible since most farmers store runoff in holding ponds and reuse the water for irrigation.

Groundwater Irrigation

The U. S. Geological Survey provided well locations in the study area and annual groundwater pumpage for 1979 to 1984 (G. D. Newton, 1985, U. S. Geological Survey, written communication). Water pumped from wells located in surface-water irrigation projects was assumed to be used in the project, and the pumpage was included in the calculation of the monthly irrigation applications for the project. Pumpage from all wells not located in a surface-water irrigation project was used as water for irrigation applications in the Oakley Fan groundwater area.

Climatic Data

Total monthly precipitation and daily minimum and maximum temperature for 1979 through 1983 and total monthly precipitation and monthly mean temperature for 1984 were obtained from the state climatologist for weather stations in Burley, Oakley, and Kimberly. Temperatures for July 1981 were missing for the Oakley station, and Burley station temperatures were used for that month.

Estimates of secondary weather parameters; mean monthly-minimum relative humidity, mean daily wind, and mean daily-solar radiation; were obtained from Allen and Brockway (1983) for the Kimberly and Burley weather stations. Secondary parameters from Burley were used at the Oakley weather station.

Data from the Burley weather station were used in the Burley and Milner Low Lift Irrigation District crop regions and in the Golden Valley crop region. Oakley weather station data were used in the Oakley Canal Company and the Oakley Fan crop regions. Kimberly weather station data were used in the Twin Falls Canal Company crop region. Figure 8 on page 48 shows crop regions and weather station locations.

Soil Data

The study area was divided into seven different soil regions. Figure 9 shows some of the larger soil regions. These soil regions were identified with a general soils map of West Cassia County (U.S. Soil Conservation Service, 1981). Each soil zone was divided into ten-inch layers, and the

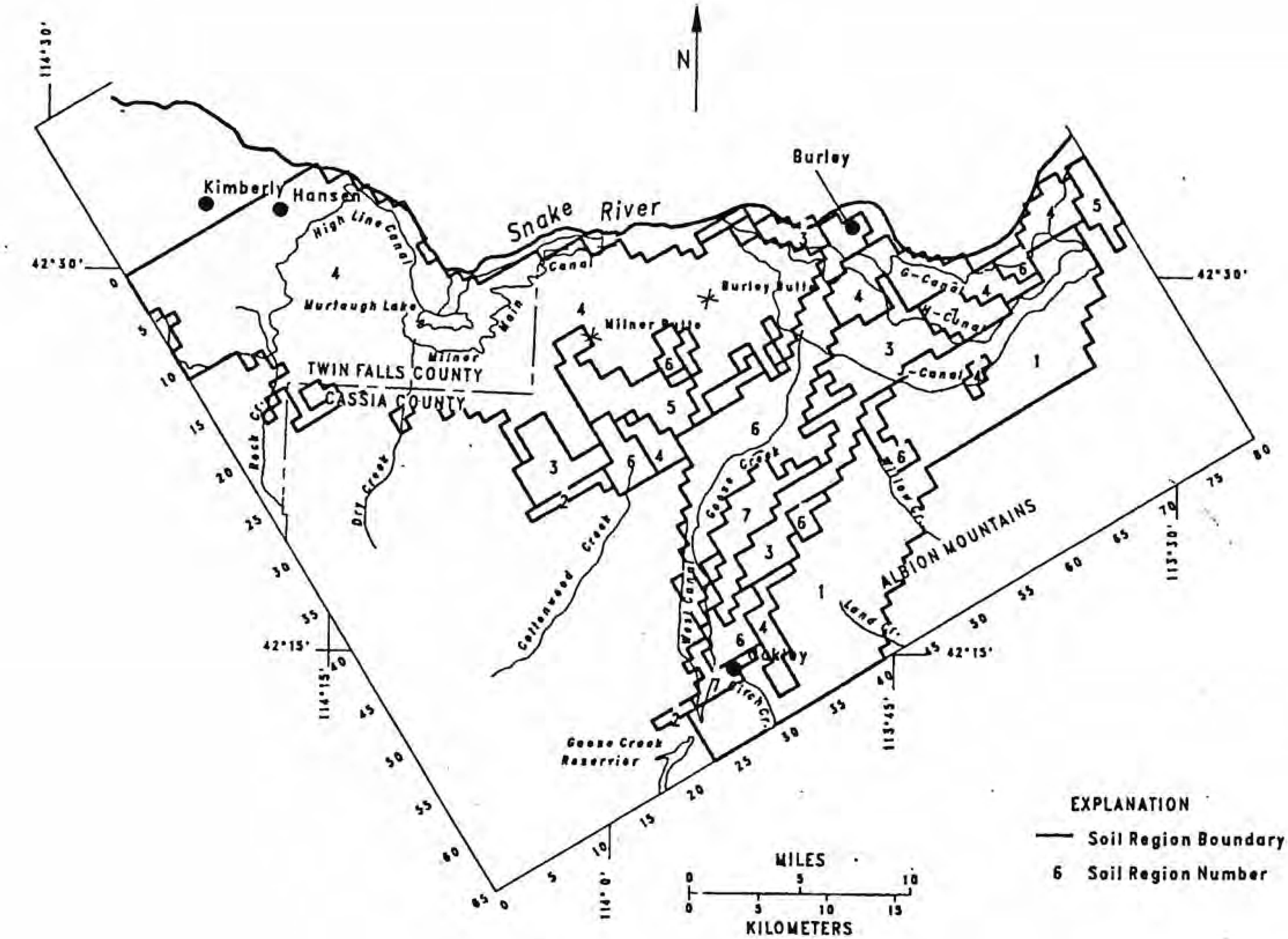


Figure 9. Soil regions in the Oakley Fan study area.

textural classification was determined for each layer (Table 6). Soil water characteristics were determined from Rawls et al (1981) for separate textural classifications (Table 7).

Initial soil moisture levels were assumed to be saturated in surface-water irrigated areas and seventy percent of saturation in groundwater irrigated areas.

Table 6. Soil textures in each soil region.

Soil Zone Number	Depth (inches)	Textural Classification
1	0-20	Silt Loam
	20-40	Silty Clay Loam
	40-60	Sand Loam
2	0-50	Silt Loam
	50-60	Clay Loam
3	0-20	Loam
	20-30	Silt Loam
	30-60	Sandy Loam
4	0-60	Silt Loam
5	0-30	Loam
6	0-10	Silt Loam
	10-60	Loam
7	0-50	Loam
	50-60	Sand

Table 7. Soil water characteristics for soil textures found in the Oakley Fan study area (Rawls et al, 1981).

Textural Classi-fication	Water Holding Capacity (in/in)	BDLM	THETR Residual Satrtn. (in/in)	PSAT Satd. Condctvty. (in/day)	PHI Porosity	Wilting Point Satrtn. (in/in)	PDIS Displcmnt. Pressure (in)
Sand	.058	.592	.020	198.45	.437	.033	2.860
Sandy Loam	.112	.322	.041	24.47	.453	.095	5.770
Loam	.153	.220	.027	6.43	.463	.117	4.390
Silt Loam	.197	.211	.015	12.47	.501	.133	6.170
Clay Loam	.121	.194	.075	2.17	.464	.197	10.190
Silty Clay Loam	.158	.151	.040	1.42	.471	.208	12.820

CHAPTER VI

GROUNDWATER RECHARGE IN THE OAKLEY FAN

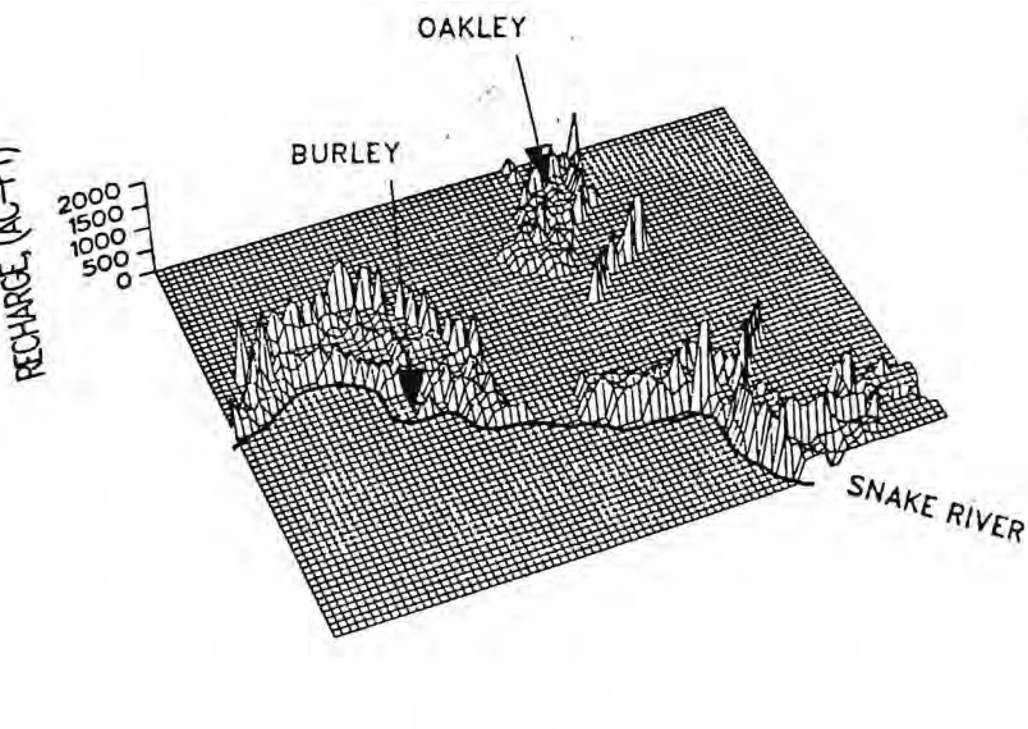
Groundwater recharge was calculated in the Oakley Fan on a monthly basis for the period from 1979 to 1984. Most recharge occurred in the surface-water irrigated areas of the Burley Irrigation District, Milner Low Lift Irrigation District, and the Twin Falls and Oakley Canal Companies. Figure 10 shows the distribution of annual recharge of these six years from 1979 to 1984.

The large peaks of recharge of Figure 10 were where seepage from major canals and tributary streams occurred. The height of the peaks of recharge appear to fluctuate from year to year in the Oakley Canal Company project near Oakley. These fluctuations were due to variations in the amount of annual canal seepage in the Oakley Canal Company project. As shown in Figure 10 (f) recharge from the Goose Creek flood in 1984 was distributed in the groundwater irrigated areas between Burley and Oakley.

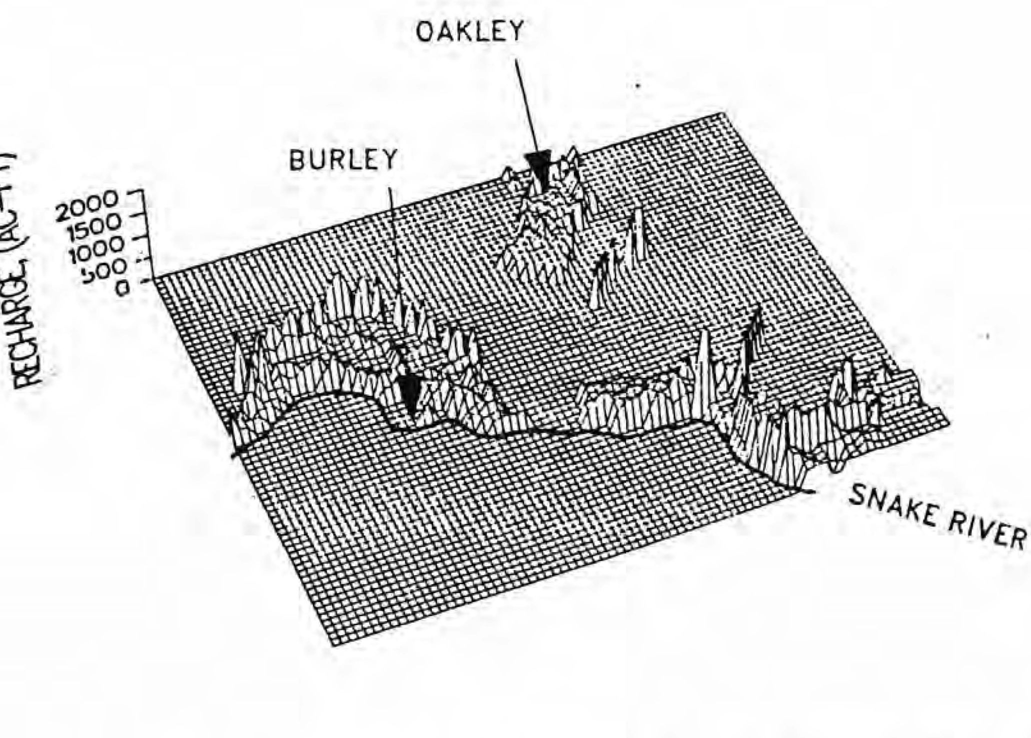
Project Water Use and Canal Seepage Estimates

Estimated Farm Deliveries

Farm deliveries that were estimated by subtracting calculated canal seepage losses from project diversions

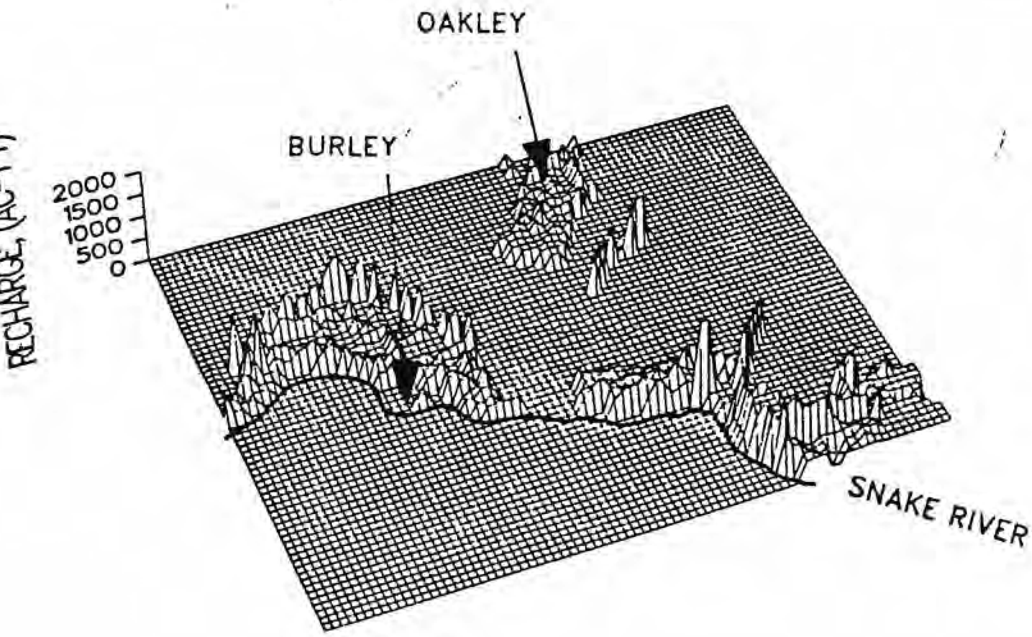


(a)

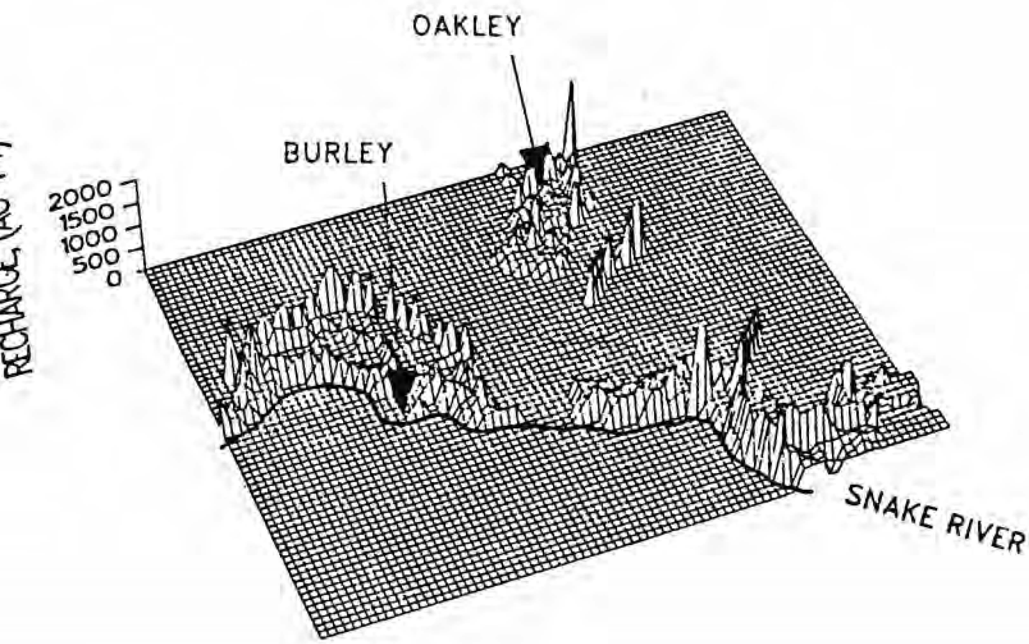


(b)

Figure 10. Annual groundwater recharge in the Oakley Fan: (a) 1979, (b) 1980, (c) 1981, (d) 1982, (e) 1983, and (f) 1984.

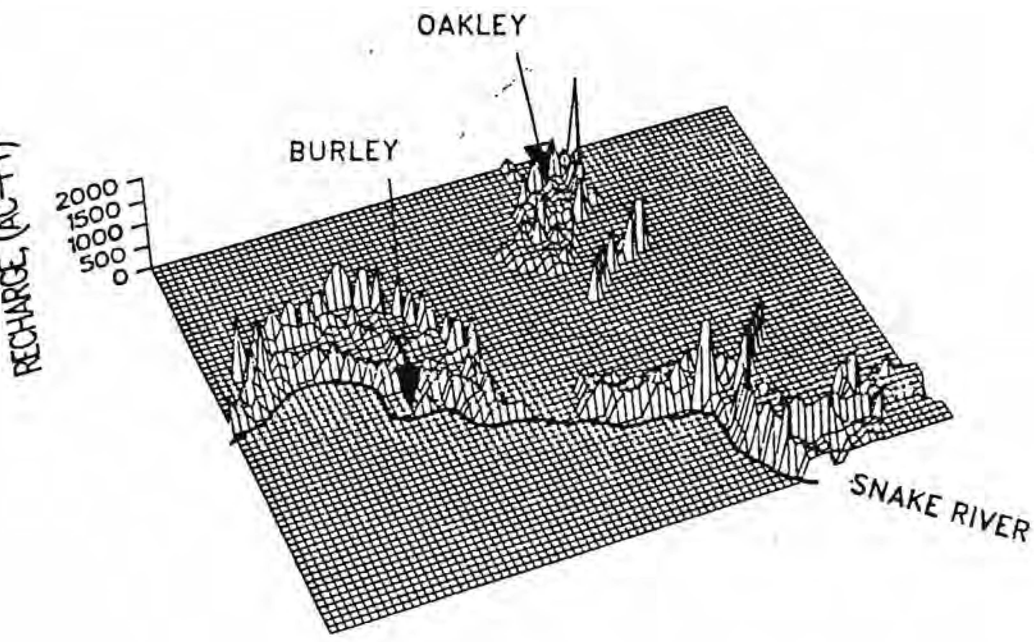


(c)

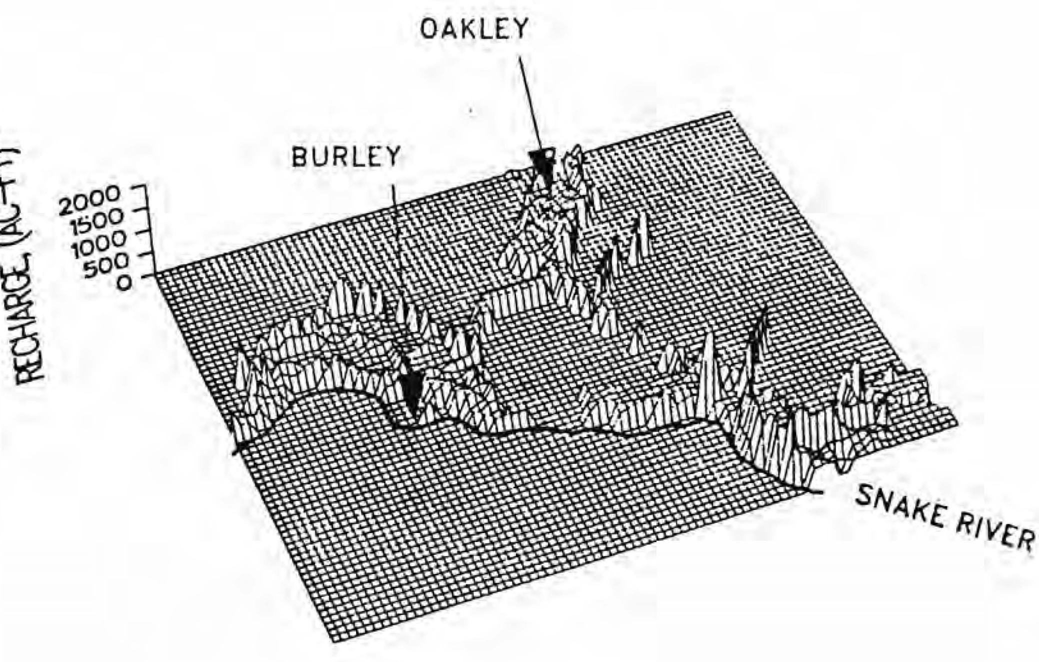


(d)

Figure 10. (continued)



(e)



(f)

Figure 10. (continued)

appeared to be reasonable. In the Oakley Canal Company in 1980 and 1984, estimated farm deliveries were similar to recorded farm deliveries as indicated by the area under the farm delivery curve in Figure 11. In 1984 when a flood occurred, estimated farm deliveries appear excessive towards the end of the 1984 irrigation season. Farm deliveries were excessive because seepage losses were underestimated. Seepage losses were underestimated because of the adjustment factor that lowers seepage during the end of the irrigation season. The adjustment factor lowered seepage as a function of time from the start of the first canal diversions of the year. Since canal diversions started in January in 1984, the adjustment factor apparently affected the seepage losses earlier in the irrigation season than normal. Seepage losses were lowered starting in midsummer, which caused excessively low seepage losses during the end of the irrigation season in 1984.

Farm deliveries were estimated in the Milner Low Lift Irrigation District in 1979 and 1981, and estimated monthly farm deliveries were similar to recorded monthly farm deliveries used in the other years (Figure 12). It was noted that in May 1981 calculated seepage exceeded recorded diversions because the recorded diversions in this month were about eighty percent lower than normal May diversions.

These results show that using calculated canal seepage losses to determine farm deliveries was a viable method except when recorded irrigation project diversions were abnormally low, or when diversions started earlier than the normal beginning of the irrigation season.

Project Water Use

Figures 11, 12, and 13 show computed canal seepage and total water use for three surface-water irrigation projects. These figures show that the calculated project canal seepage was proportional to the total project diversions. The canal seepage formula appears to work well, especially when project farm deliveries were estimated by subtracting the calculated seepage from the project diversions.

When recorded farm deliveries were used in these three irrigation projects, a problem occurred. Recorded project diversions either were greater than, or less than the sum of the recorded project farm deliveries, computed canal seepage, and estimated canal spills. The recharge program corrected the discrepancies each month in the water budget by adjusting canal seepage and return flows. Figure 14 shows the amount of discrepancy each month in the water budgets between the project diversions and the sum of the farm deliveries, canal seepage, and return flows.

Most of the differences in the monthly water budgets were probably caused by inaccuracies in estimated project canal spills and calculated project canal seepage. Canal spill estimates used for the Burley and Milner Low Lift

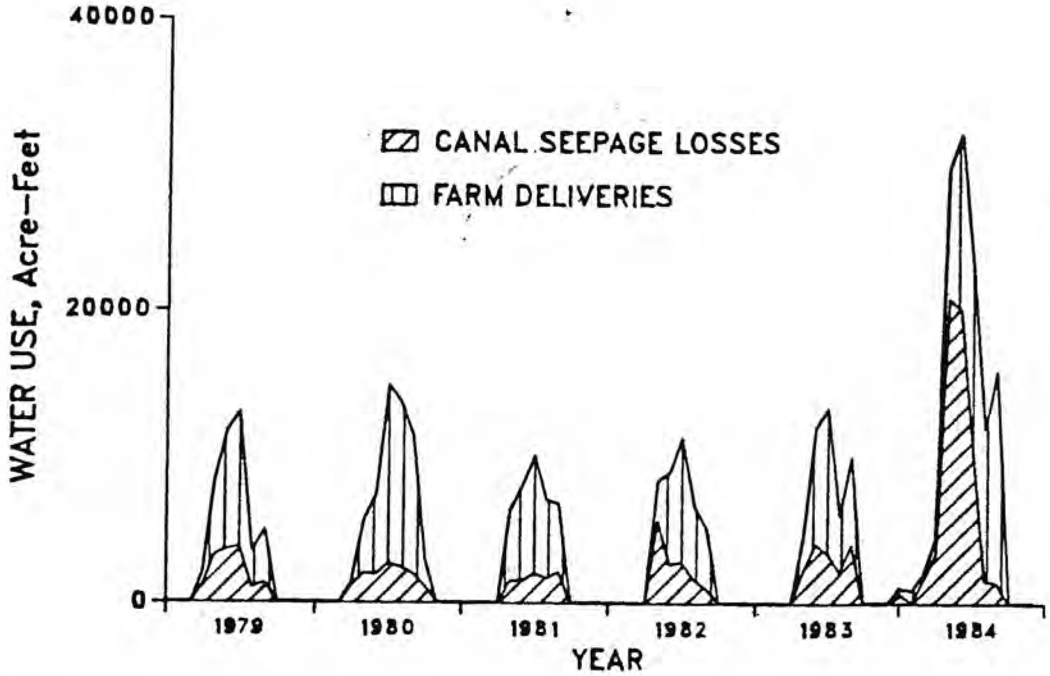


Figure 11. Project water use patterns in the Oakley Canal Company.

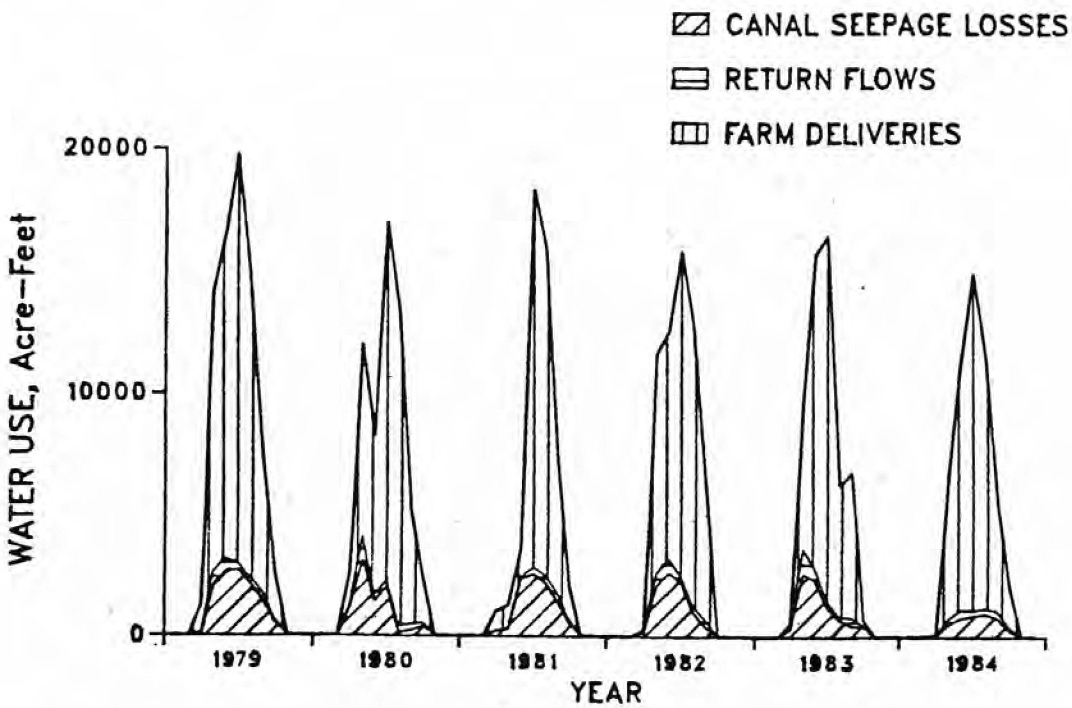


Figure 12. Project water use patterns in the Milner Low Lift Irrigation District.

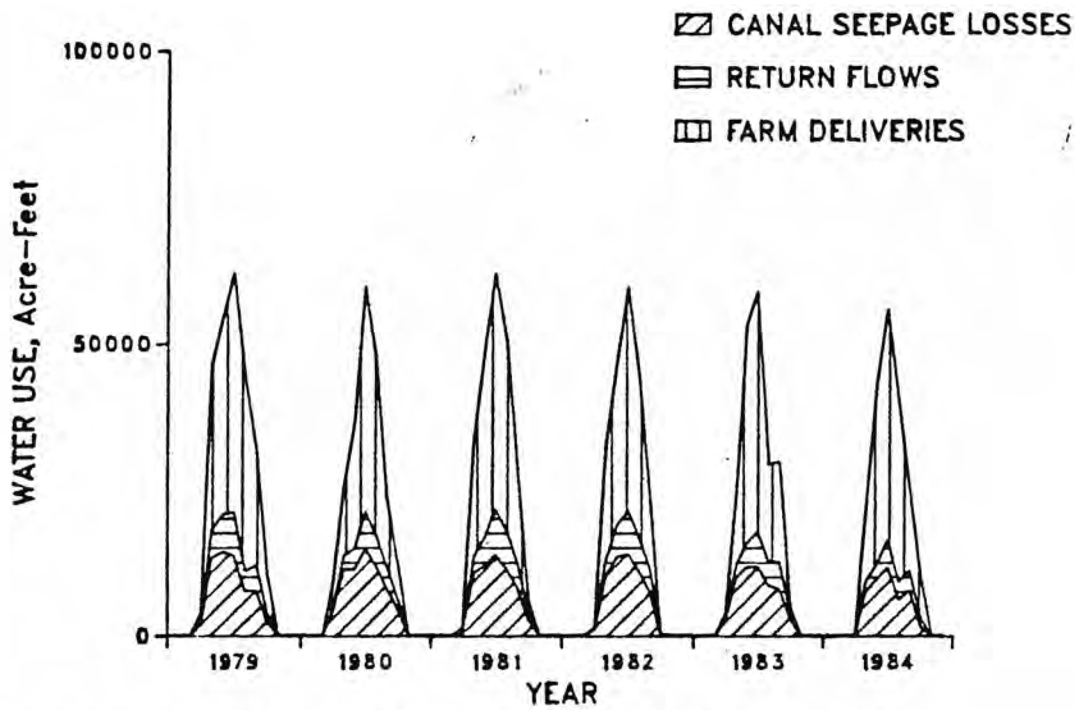


Figure 13. Project Water use patterns in the Burley Irrigation District.

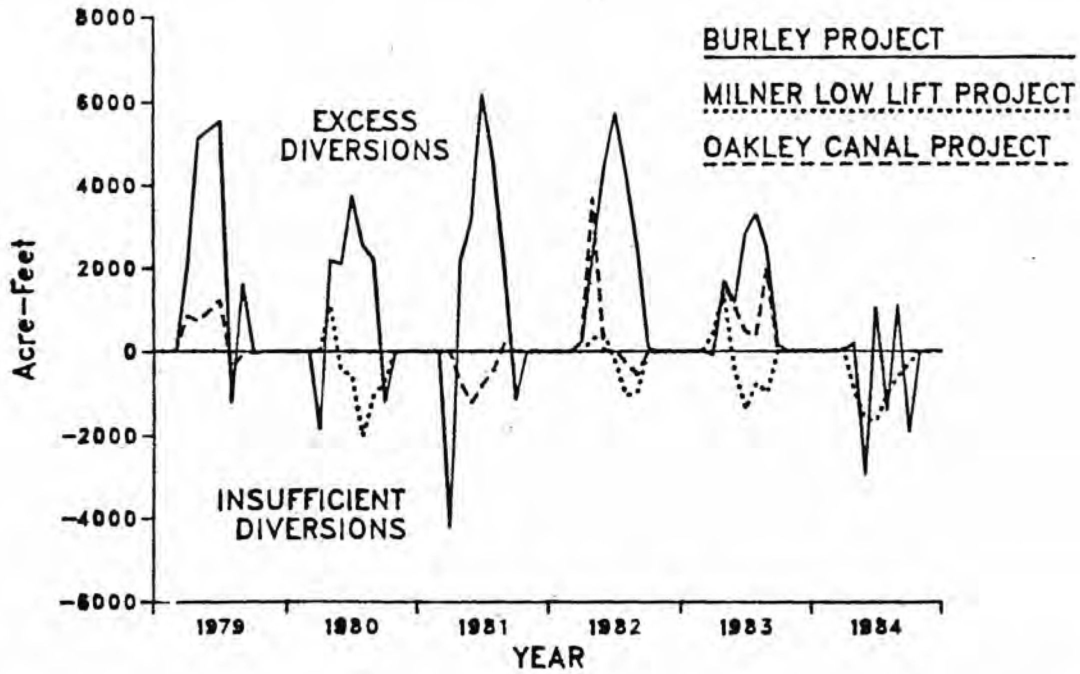


Figure 14. Errors in monthly project diversion water budgets.

projects were probably in error since the estimates were derived from measurements made during an irrigation season that was not in the period of study. In the Burley project, it appears that mid-season canal spill estimates should have been higher, and in the Milner Low Lift project it appears that the estimates should have been lower in mid-season (Figure 14). Calculated canal seepage losses were likely in error in the Oakley Canal project because the seepage coefficient and canal wetted areas were inaccurately estimated.

Canal Seepage

Table 8 lists total calculated seepage losses for the study simulation period. These seepage losses averaged 58,000 and 8,600 acre-feet per year for the Burley and Milner Low Lift irrigation projects, respectively. Estimated seepage losses reported by Allen and Brockway (1979) were 46,377 acre-feet and 8,543 acre-feet for the Burley and Milner Low Lift projects, respectively, during the 1977 irrigation season. Seepage estimates were higher in the Burley project in this study because higher seepage coefficients were used. Results of seepage tests in this study had shown seepage coefficients were higher than the coefficients Allen and Brockway (1979) had assumed.

The Soil Conservation Service reported measured seepage losses in the Oakley Canal Company of from sixteen to

Table 8. Total project canal seepage, estimated canal wetted areas, total project canal spills, and total project diversions in the Oakley Fan from 1979 to 1984.

	Seepage Losses (acre-feet)	Seepage Losses (% of divers.)	Canal Wetter Area (acres)	Canal Spills (acre-feet)	Diversions (acre-feet)
Burley Irrigation District	348242	27	423	142707	1308187
Oakley Canal Company*	66297	29	79	0	227022
Oakley Canal Company**	126370	36	291	0	348585
Milner Low Lift Irrigation District	50771	14	81	11750	355146
Twin Falls Canal Company	329396	--	526	0	--

* Totals through 1983.

** Totals through 1984. A flood occurred in 1984 and totals include losses and wetted areas in emergency flood channels.

twenty-seven percent of the project diversions (U.S. Soil Conservation Service, 1980). Canal seepage estimates in the Oakley Canal Company for this study were slightly higher.

Deep Percolation and Evapotranspiration

Total annual deep percolation and crop evapotranspiration in the larger irrigated areas of the Oakley Fan are shown in Table 9. Deep percolation losses in the Oakley Fan groundwater area occurred mostly from precipitation events in the non-irrigated season, and deep percolation losses averaged about fourteen percent of annual precipitation. Deep percolation losses in the three major surface-water irrigation projects within the study area (Burley, Milner Low Lift, and Oakley Canal projects) averaged sixty percent of total applied irrigation water.

In the surface-water irrigation project, most deep percolation loss occurred during the middle and the end of the irrigation season when delivered farm water plus precipitation (infiltrated water) was in excess of evapotranspiration (Figures 15 and 16). Due to the high irrigation applications in the surface-water irrigation projects, modelled soil moisture levels remained at saturation throughout most of the irrigation season. Any applied water in excess of evapotranspiration became groundwater recharge.

Most deep percolation losses in the Oakley Fan groundwater area were due to precipitation in the late spring

Table 9. Total deep percolation, evapotranspiration (ET), farm runoff, applied irrigation water, and precipitation in the Oakley Fan from 1979 to 1984.

	Farm Deliveries	Suppl. GW	ET	Deep Percolation	Farm Runoff	Precip.	Change in Soil Moisture
			(acre-feet)				
Burley Irrigation District	817233	0	534058	455174	30294	201282	- 1016
Oakley Canal Company*	160725	71906	174058	138764	0	79792	- 403
Oakley Canal Company**	222214	76670	209535	182756	0	93009	- 403
Milner Low Lift Irrigation District	292618	7868	153966	185102	27008	65269	- 334
Twin Falls Canal Company	795769	187	435365	567950	0	206401	- 959
Oakley Fan Groundwater Area	0	932745	1518791	133341	0	681242	-38156

* Totals through 1983.

** Totals through 1984 (a flood occurred in 1984).

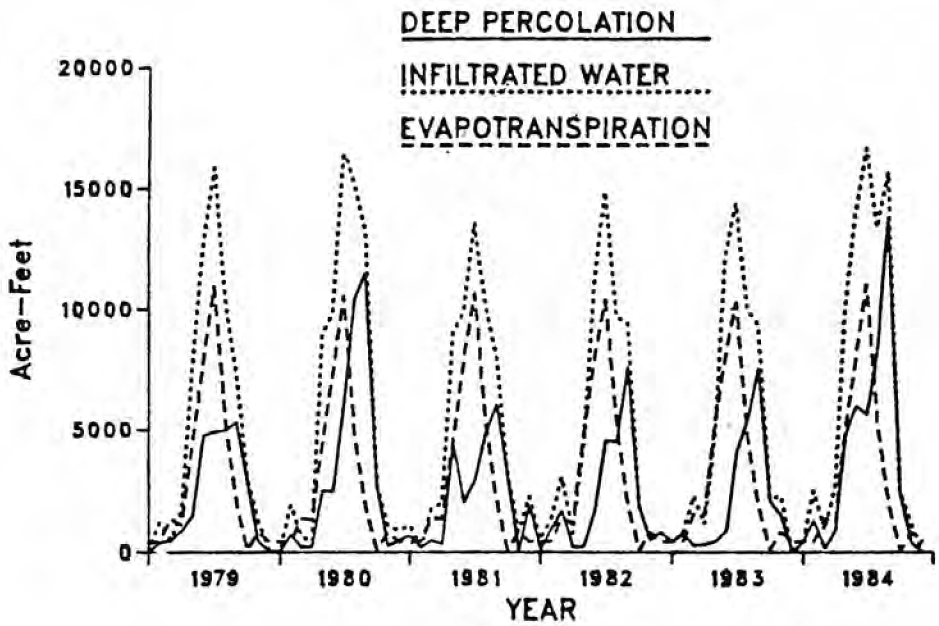


Figure 15. Patterns of deep percolation, evapotranspiration, and infiltrated water in the Oakley Canal Company.

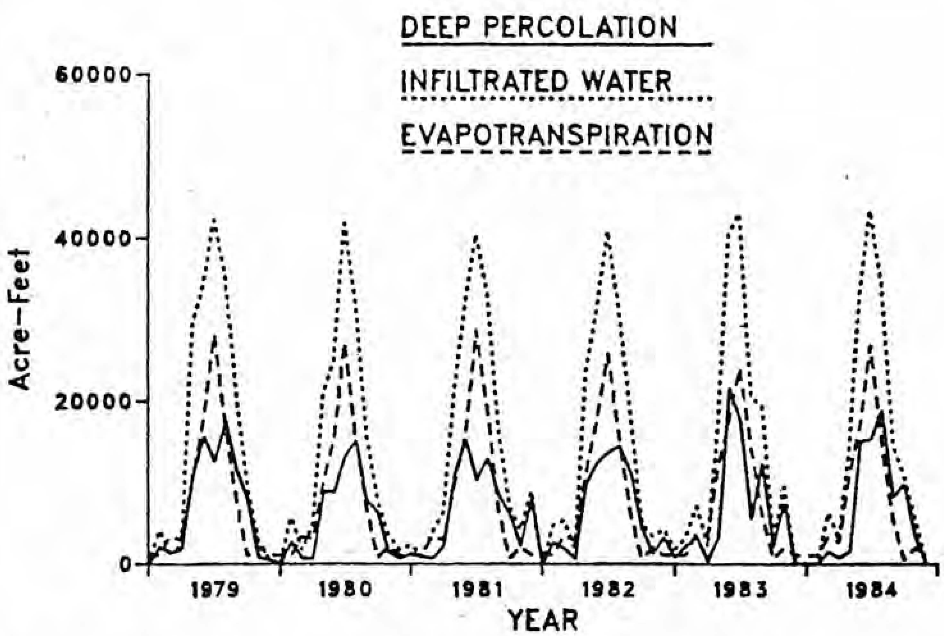


Figure 16. Patterns of deep percolation, evapotranspiration, and infiltrated water in the Burley Irrigation District.

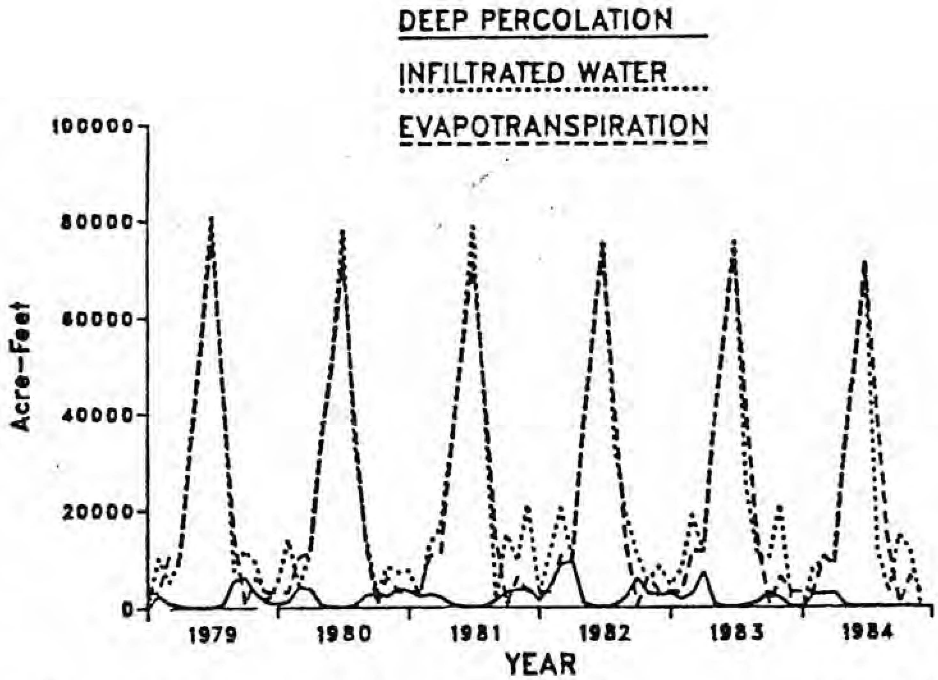


Figure 17. Patterns of deep percolation, evapotranspiration, and infiltrated water in the Oakley Fan groundwater area.

and early fall (Figure 17). Irrigation applications from groundwater pumpage were less than crop evapotranspiration. Most precipitation and irrigation applications were used for crop evapotranspiration during the growing season.

It can be seen in Figure 17 that during some periods such as April 1983, the sum of evapotranspiration and deep percolation appears greater than the infiltrated water (water from precipitation and any groundwater irrigation applications). This occurred because the water needed for evapotranspiration was removed from the stored soil water in the root zone. Since soil moisture levels were not depleted, the unsaturated hydraulic conductivity values in the soil layers were greater than zero (Table 10). The infiltrated water was allowed to move through the soil root zone and become deep percolation.

Comparison of Two Deep Percolation Models

Deep percolation in the Oakley Fan was computed for the study period using a soil moisture deficit approach used in recharge models such as Johnson and Brockway (1983). When irrigation plus precipitation exceeded evapotranspiration, any soil moisture deficits in the soil layers were reduced, and excess water became deep percolation for the month. A soil moisture deficit occurred when water contents were below field capacity of the soil.

Deep percolation totals computed using both the soil moisture deficit model and the unsaturated flow model were essentially the same for the years of 1979 through 1984 in all the irrigated areas in the study area. In the surface-water projects, both the models gave nearly identical results. In the Oakley Fan groundwater area, the total amounts of deep percolation computed by both the models were nearly the same.

Table 10. Simulated values of unsaturated hydraulic conductivities and percolation in soil layers in the Oakley Fan groundwater area during April 1983.

Soil Depth (inches)	Percent Field Capacity	Unsaturated Hydraulic Conductivity (in./mo.)	Applied Water (in./mo.)	Percolation (in./mo)
0 to 20	91	3.19	1.21	1.21
0 to 50	98	.56	1.21	.56
50 to 60	108	1.87	.56	.56

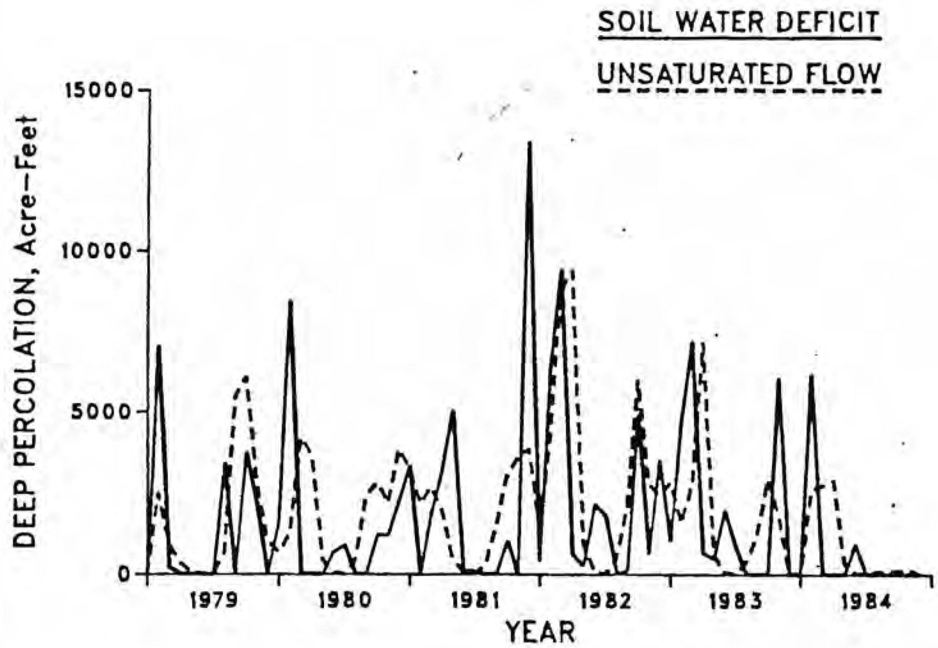


Figure 18. Monthly deep percolation in the Oakley Fan groundwater area calculated using a soil moisture deficit model and the unsaturated flow model.

However, the magnitude of deep percolation occurring during the months of the study period varied in the two models (Figure 18). This variation occurred primarily because the unsaturated flow model allowed deep percolation to occur when soil moisture levels were below field capacity (Table 10).

In groundwater irrigated areas, the unsaturated flow model appears to spread deep percolation losses uniformly throughout the the months when deep percolation occurs more than the soil moisture deficit model does. Other than this difference, both models will give the same results.

Statistical Model of Deep Percolation

A linear stepwise regression was run on the variables used to calculate deep percolation by the recharge simulation model in the three surface-water irrigation projects (Burley, Oakley Canal, and Milner Low Lift) and the Oakley Fan groundwater area. The regression analyses were run on both monthly and annual calculated deep percolation in order to find a linear statistical model, or equation, of deep percolation that included net irrigation applications and precipitation, but not crop evapotranspiration values. Kim et al (1983) reported that moving averages of evapotranspiration were correlated with net project irrigation diversions. It was suspected that evapotranspiration might also be highly correlated with net irrigation applications. Thus, the effects of evapotranspiration on the amount of deep percolation would be included in the net irrigation applications, and a linear statistical model of deep percolation would not require values of evapotranspiration as an input variable.

Stepwise regression analyses on simulated monthly deep percolation data showed that statistically valid models of monthly deep percolation had to include evapotranspiration. Evapotranspiration was not correlated strongly enough with net monthly irrigation applications to allow it to be left out of the statistical models.

The variables that were used in the physical simulation model to calculate monthly deep percolation were summed up for each year in the six year study period. Stepwise regression analysis were run on the summed variables. Results of the regression analyses showed linear models of annual deep percolation had low correlation coefficients in the Milner Low Lift and Oakley Canal projects, and in the Oakley Fan groundwater area. In the Milner Low Lift and Oakley Canal projects, this poor correlation was due to having used estimated rather than actual measured farm deliveries in the physical simulation model during some of the years. In the Oakley Fan groundwater area, the poor correlation was due to the low deep percolation losses during the irrigation season.

In the Burley Irrigation District, the following linear relationship was derived using stepwise linear regression analysis on the summed monthly variables:

$$DP = .881 * IA + 1.093 * Rain - 1.950 \qquad (17)$$

where

DP = estimated deep percolation in acre-feet per acre per year,

IA = recorded irrigation application in acre-feet per acre per year, and

Rain = reported precipitation in acre feet per acre per year.

The sum of the first two components on the right hand side of Equation 17 must be greater than 1.95 acre-feet per acre per year. Calculated annual evapotranspiration was not required

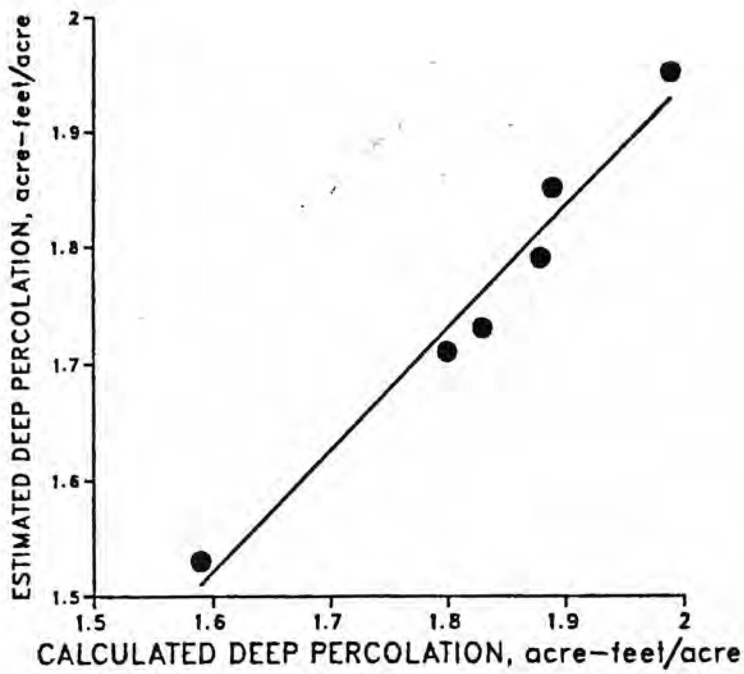


Figure 19. Calculated and estimated deep percolation in the Burley Irrigation District.

in this linear model because it was highly correlated with the recorded annual irrigation application or annual farm deliveries as shown by the correlation matrix in Table 11. The correlation coefficient or R^2 of the linear model is .97 and the standard error of estimation is .03 acre-feet per acre per year. Figure 19 shows the linear relation between calculated deep percolation from the physical simulation model and estimated deep percolation from Equation 17. Equation 17 could be used for obtaining estimates of monthly deep percolation in other irrigation projects with similar climate, crop distribution, farming practices, and irrigation methods as the Burley Irrigation District. However, since Equation 17 was developed with only six data points from six years of data, it should not be used to obtain accurate values of annual deep percolation. Equation 17 should only be used for obtaining general estimates of annual deep percolation in irrigation projects similar to the Burley Irrigation District.

Table 11. Correlation matrix of water balance components in the Burley Irrigation District.

	Rain	IA	ET	DP
Rain	100	-93	-86	-49
IA	-93	100	97	76
ET	-86	97	100	77
DP	-49	76	77	100

CHAPTER VII

SUMMARY AND CONCLUSIONS

A groundwater recharge simulation model that uses a monthly timestep was developed to estimate deep percolation from irrigation in surface-water and groundwater irrigated areas. Groundwater recharge was estimated for the period of 1979-1984 in the Oakley Fan area of southern Idaho. Project canal seepage losses were between fourteen and twenty-nine percent of project diversions. Deep percolation losses averaged sixty percent of net applied irrigation water in surface-water irrigation projects. In groundwater irrigated areas, most deep percolation losses resulted from precipitation, and total deep percolation losses averaged fourteen percent of total precipitation.

Seepage from canals is computed using a modification of a method developed by Claiborn (1975). Canal seepage estimates computed with the model do not always equal the leftover water after recorded farm irrigation deliveries, canal seepage, and canal spills are subtracted from recorded river diversions. It can be concluded that errors in canal spill estimates and canal seepage loss rates are a primary cause. It is apparent that more frequent and thorough measurement of return flows and seepage losses are needed in irrigation projects.

Estimates of seepage losses may be more than total river diversions during periods of abnormally low flow in the spring, and modifications of estimation methods is needed. In years of normal diversions, the canal seepage estimation method is accurate enough to calculate farm irrigation water deliveries by subtracting calculated canal seepage and canal spill estimates from irrigation project diversions.

The groundwater recharge simulation model computes deep percolation using simplified unsaturated flow theory. This method computes the same amount of total deep percolation as a simple water balance that allows deep percolation only when soil moisture levels are above field capacity. In groundwater irrigated areas where deep percolation rates are small, the values of unsaturated hydraulic conductivity will allow deep percolation when soil moisture levels are below field capacity. Thus, deep percolation occurs during some months when soil moisture levels are at deficit amounts.

It can be concluded that the groundwater recharge simulation model provides reasonably accurate values of groundwater recharge, and that the simulation model can be used in other areas with irrigated agriculture to estimate groundwater recharge.

Simple multiple linear regression analysis of recharge components shows that annual deep percolation is a linear function of annual recorded net irrigation applications and annual recorded precipitation in the Burley Irrigation District. A statistical model was found for estimating annual deep percolation. The statistical models is not considered to be as accurate as the physical simulation model used in deriving it; however, it may be beneficial for obtaining general estimates when the extensive data required for the physical model are unavailable.

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APPENDICES

APPENDIX A

RECHARGE PROGRAM USER'S GUIDE

Program Description

The program named RECHARGE.F77 computes evapotranspiration, infiltration of water through the soil profile, deep percolation, canal seepage, and river reach losses on a monthly timestep for an irrigated agricultural basin. The program may be used for more than one year of simulation. The basin is divided into cells by superimposing a rectangular grid over the area. The irrigated area for each cell is determined. Code numbers are assigned to the cell for the crop zone, irrigation project and soil type it is located in. Only one irrigation project is allowed per cell. Data for cells without irrigated agriculture are not input to the program. The program can only determine deep percolation in areas with irrigated agricultural crops.

The program numbers each cell and assumes that the top left corner of the model grid is the origin. The program uses up to 5200 cells, enough for a 80 by 65 grid array. Nine irrigation projects are allowed. Up to 4 of the irrigation districts can have as many as 6 canals, and 210 cells per canal. Twenty river reaches are allowed with forty cells per reach. Crop evapotranspiration in six crop zones is calculated; fifteen agricultural crops per zone are available. Climatic data for three weather stations may be used in the model. The user specifies which weather station's data are to be used in each crop zone.

The main program calls various subroutines to calculate different components of the water balance for each irrigation project in the basin. ZERO1 and ZERO2 initialize variables. The subroutine DATAIN reads in all data and stores it in COMMON BLOCKS until it is needed for calculations. DATAIN calls the subroutines RIVER, LAKE, SEEPAGE, SEEPAGE2, and LATERAL to estimate seepage from canals, rivers, lakes, and streams. Subroutine FAOBC calculates potential evapotranspiration for each crop zone of the basin. Subroutine DDPTHSM determines total acreages in each irrigation project and converts precipitation and evapotranspiration to a volume per unit area. Subroutine IRRIGATION determines irrigation application rates, removes water for evapotranspiration from the soil root zone, and determines deep percolation. IRRIGATION calls subroutine UNSAT to determine the rate of infiltration if a particular soil layer is not saturated. Subroutine MASSBAL sums components of the water balance and prints out errors if a discrepancy exists. MASSBAL will correct canal seepage if it has been underestimated or overestimated in the canal seepage subroutines. Subroutine OUTPUT prints out the results of each year of simulation.

Data Required

Surface-water Irrigation

For each irrigation project, application rates can be determined by one of four ways.

1. Determine monthly application rates for the project.
2. Determine total monthly farm deliveries in the project if canal seepage is negligible.
3. Determine monthly gross diversions and, if available, monthly farm deliveries. If farm deliveries are not available, the program can estimate them by subtracting canal seepage and return flows from total diversions. For each project with return flows, determine monthly percent of diversions that becomes return flow, and percent of return flow that comes from farm runoff.
4. Application rates may not be available for an irrigation project either because the records are lost, or it lies partially within the study area. The program will use application rates from another project with known application rates. The user specifies which project with known application rates is to be used for the unknown project.

Groundwater Pumpage

1. Determine annual groundwater pumpage for groundwater irrigated areas and irrigation projects with supplemental groundwater.

Irrigated Area

1. Determine irrigated acreage in each cell within each irrigation project.

Canal Seepage

Canal seepage may be determined on a cell by cell basis, or it may be distributed uniformly over an entire irrigation project. Both ways may be used in one irrigation project. Seepage from larger canals should be input for each cell and seepage from smaller laterals and ditches can be distributed uniformly. The following information is needed for calculating canal seepage.

1. Determine number of irrigation projects with canals.
2. Determine seepage coefficients (feet/day) for each canal or canal reach.

The following information is needed for cell by cell seepage calculations.

1. Determine dimensions for each canal in each cell by one of two ways: (a) topwidths in calibrated microscope units (1 unit = 25 feet) and lengths in feet, or (b) total wetted area (length times wetted perimeter) in square feet.

The following information is needed for uniform seepage calculations.

1. Determine average topwidths in calibrated microscope units and average lengths in feet for each uniform reach of canal.

Total diversions for the irrigation project that the canal is located in are used along with the seepage coefficient and canal wetted areas to compute canal seepage. The seepage subroutines may use the monthly diversions input for the required irrigation data, or if available daily or bi-monthly diversions may be determined and used instead. Daily or bi-monthly diversions generally give better estimates of seepage than monthly diversions. Daily or bi-monthly diversions must be used when monthly project diversions are not used as input for application rates in an irrigation project.

The following information regarding canal diversions is needed to calculate canal seepage.

1. Determine daily or bi-montly diversions if not using monthly diversions.
2. Determine maximum diversion for each year of simulation in each irrigation project with canals.

River Reach Losses

For each river reach, the following information is needed.

1. Determine length of the reach in feet.
2. Number of cells containing the reach.
3. Total volume of water (acre-feet) lost to seepage in the reach during each month and for each year of simulation.

Crop Evapotranspiration

For computing crop evapotranspiration, the following information is needed for each year of simulation.

1. Determine number of weather stations available in the study area with daily or monthly temperature and precipitation data.

2. Determine secondary weather parameters for each station: average daily wind, mimimum relative humidity for the month, and clear sky solar radiation.

3. Delineate the number of crop zones with uniform cropping practices and similar climatic conditions.

4. Determine which weather station is closest and best represents each crop zone.

5. Determine average elevation of each crop zone.

6. Determine crops grown in each crop zone; planting, harvesting, and effective cover dates; dates of cuttings for alfalfa; and percent of total area in each crop zone planted with the particular crop.

Soil Information

1. Determine number of zones with similar soil types.

2. Determine depth of soil in each zone, and divide into ten-inch layers.

3. Determine U.S.D.A. soil texture classification for each ten-inch layer.

4. Determine porosity, residual saturation moisture content, wilting point moisture content, saturated verticle hydraulic conductivity, and Brooks and Corey parameters for each soil layer.

Inputing Data to the Program

All data required by the program are read in by the subroutine DATAIN. The program reads the main data required from an input file on FORTRAN file unit 5. The program opens the file in the subroutine DATAIN. The name of the file is INPUT.

Data needed for monthly canal seepage and daily weather values are read for each month of simulation from separate input files whose names and FORTRAN file unit numbers for reading are specified by the user in the disk file INPUT.

Daily temperature and precipitation may be used for each weather station and read in from two direct access files. Record lengths are specified for these two files in the disk file INPUT. The beginning record numbers must be determined for each weather station for the first month's data of each year. These are read from the disk file INPUT.

A file containing dimensions and row and column locations of canals for each irrigation project that has canals is needed. If daily or bi-monthly diversions are used for estimating seepage in a project, a direct access file containing the diversions for every period in the year is made. The record length of the file and the order number of the beginning record of each year of data is read from the disk file INPUT.

Changing Parameters During a Simulation Period

The user may change from using daily temperatures and precipitation during one year to using monthly values in another year at a weather station. This may be necessary if daily records include missing values for a particular year.

When estimating canal seepage, one may change from using bi-monthly or daily diversions in one year to using monthly diversions in another year. This becomes necessary if daily or bi-monthly data is inaccurate or unavailable for a particular year in the middle of a simulation period. The user may change back to using daily or bi-monthly diversions during the next year's simulation.

The program allows one to change canal seepage coefficients from year to year. This is useful if canals are lined or dredged during a simulation period.

One may also include canals in the seepage calculations that are only used during springtime to carry away excess runoff. The canal dimensions and cell locations are included in the input file of canal data. The seepage coefficient for these canals is specified as zero in the disk file INPUT. During a year of high runoff, the user specifies a temporary seepage coefficient and months for which the coefficient is used. This is done in the section called option cards right after the canal maximum diversions card section in the disk file INPUT. If in the next year of simulation high runoff did not occur, the user must specify the temporary seepage coefficients as zero for those months they were used in the previous year's simulation. If this is not done, the canal will be included in the seepage calculations in the next year for those same months again.

Changing the irrigated area each year is done by inputing the actual area of the irrigation project in ACTAREA under the irrigation application cards. The program will modify the calculated area input for each cell in the project so that the total project area equals the reported area.

Program Output

The program will print the year of simulation, a list of the irrigation projects, and irrigation project areas to the user's terminal screen before each year of simulation. During the simulation, the program also prints out errors in canal seepage estimation when total diversions minus farm deliveries and return flows do not equal canal seepage. The program also prints out errors in the soil moisture balance.

A summary of the results of the program is written to a disk file named OUTPUT on a FORTRAN file unit number specified by the user in the output options. The output file includes a list of the soil parameters for each soil zone and a list of canals and their seepage coefficients. Evapotranspiration for each crop in every crop zone is printed on a monthly basis after each year of simulation. Summaries of water balances for each irrigation project are output for every month. Summaries of weather data are printed on a monthly basis for each weather station.

Unadjusted canal seepage for each canal is printed in a separate disk file for each irrigation project. The name of the disk file and the FORTRAN file unit number is specified by the user in the canal information section of the disk file INPUT. Summaries of canal seepage on a cell by cell basis for each month may be printed to these files. The user specifies that this be done for a particular canal in the disk file INPUT under canal information. Cell by cell seepage cannot be printed for canals that have their seepage spread uniformly over an irrigation project.

A disk file named RECHARGE_MAP summarizes the recharge for each row and column of the study area on an annual basis. Recharge for each cell model is written on a monthly and/or yearly basis to files named MONTHLY_RECHARGE and YEARLY_RECHARGE, respectively. The options to output these files are specified in the output options. The format for these output disk files is also specified for these files in the output options.

Canal seepage is not included in the monthly and yearly recharge arrays for any of the canals if the user chooses. This may be appropriate when the canal is going to be treated as separately connected in a groundwater flow model. This option is specified under canal information in the input data.

Soil moisture levels in each ten-inch layer of soil for one grid cell may be output to a file called UNSAT_OUT. The soil moisture levels are in inches of water per inch depth of soil at the beginning of each month. If unsaturated flow occurs in any of the layers of soil in the cell, values of capillary pressure and unsaturated hydraulic conductivity are listed for the soil layer. This option is chosen in the output options sections.

Input Description

This section describes variables and list formats used to read in the required data and optional data for the recharge program. Input required for the main input disk file INPUT, canal dimension files, and optional direct access weather data and canal diversion files is described.

Input format and variables used in the disk file "INPUT."
Records 1-21 are entered as a set for each model simulation run.

Record	Format	Variable	Description
		General Information	
1	A60	NAME1	Title printed at top of output.
2	*	BEGYR	Beginning year of simulation.
	*	ENDYR	Ending year of simulation.
3	*	EX	Number of columns.
	*	WYE	Number of rows.
	*	DELX	Spacing in X direction.
	*	DELY	Spacing in Y direction.
		Printing Options	
4	I5	NOPTN(1)	Flag for printing monthly recharge for use in groundwater flow model. NOPTN(1) greater than 0 to print out recharge array.

Record	Format	Variable	Description
	I5	NOPTN(2)	Flag for printing unsaturated hydraulic conductivity and soil moisture values in a cell. NOPTN(2) = cell number, N, to print values for, zero otherwise. N = EX * (row# - 1) + col#.
	I5	NOPTN(3)	Flag for printing yearly recharge summary for each row and column. NOPTN(3) greater than 0 to print out recharge summary.
	I5	NOPTN(4)	Flag for printing yearly recharge for use as input to a groundwater flow model. NOPTN(4) greater than 0 to print yearly recharge array.
5	A80	IFMT	Format for printing monthly and yearly recharge arrays. Leave blank if not printing out monthly or yearly recharge.
6	*	IOUT	F-UNIT for printing results of water balance.

Irrigation Project Information Cards

Record	Format	Variable	Description
7	*	NIDST	Number of irrigation projects in study area.

Record	Format	Variable	Description
	Records 8 and 9 are entered as a set for each irrigation project. The order number in which they are input becomes the irrigation code number for that irrigation project. Enter those projects with canal seepage first, except major groundwater areas which should be entered as the second project.		
8	A40	INAME(ID)	Name of irrigation project.
9	*	PFLAG(ID)	Flag for determining method of computing monthly pumpage from annual pumping data. PFLAG(ID)=1, use ratio of total annual pumpage to monthly pumpage. PFLAG(ID)=0, determine monthly pumpage based upon soil moisture depletion.

Weather Station Information Cards

If daily temperature and precipitation are not used, leave records 10 and 11 blank and input zeros for record 12.

Record	Format	Variable	Description
10	A40	TNAME	Name of direct access daily temperature file.
11	A40	PNAME	Name of direct access daily precipitation file.
12	*	INTN	F-UNIT for reading daily temp. file TNAME.
	*	IRECT	Record length of direct access file TNAME.
	*	INTX	F-UNIT for reading daily precip. file PNAME.
	*	IRECP	Record length of direct access file PNAME.

Canal Information Cards

Record	Format	Variable	Description
13	*	NCL	Number of irrigation projects with canal systems for which seepage is calculated.
	*	IND	F-UNIT for reading cell locations and canal dimensions from separate input file.
	*	INDV	F-UNIT for reading daily or bi-monthly diversions from separate direct access file.

Record	Format	Variable	Description
Records 14, 15, and 16 are input as a set for each irrigation project with canals.			
14	I5	IDC(I)	F-UNIT for printing summaries of canal seepage for each month of operations.
	A40	NAME	Name of output file where summaries of canal seepage are written.
15	A40	CNLDTL(I)	Name of input file with cell locations and/or canal dimensions.
	A40	CNLDVF(I)	Name of direct access file with daily or bi-monthly diversions; leave blank if monthly diversions are used for this project.
	F5.0	CNLFLG(I)	Flag for telling program what type of diversions to read. CNLFLG(I) = 0, read daily diversions from direct access file. CNLFLG(I) = 1, use same monthly diversions input for computing irrigation application rates.

Record	Format	Variable	Description
			CNLFLG(I) = 2, read bi-monthly diversions from direct access file.
	I5	IRCLDV(I)	Record length of direct access file with daily or bi-monthly diversions. Leave blank if monthly diversions are used.
	I5	KAND(I)	Code number of irrigation project canals are located in. Corresponds to order in which the irrigation projects were input previously.
16	I5	KCANL(I)	Number of canals in irrigation project for which seepage is to be computed.

Record 17 is repeated for each canal in the irrigation project. KCANL(I) cards for each irrigation project.

Record	Format	Variable	Description
17	I5	KNLNUM(KAND(I),IC)	Flag for determining whether to print seepage summaries on a cell by cell basis for this canal for each month.
			KNLNUM(KAND(I),IC) = 0, do not print seepage summaries on a cell by cell basis.

Record	Format	Variable	Description
			KNLNUM(KAND(I),IC) = 1, print seepage for this canal on a cell by cell basis.
	F5.3	PERM(KAND(I),IC)	Seepage coefficient for canal IC, in feet per day.
	I5	CNLDFLG(KAND(I),IC)	Flag for telling what type of dimensions and if row and columns are input for this canal. CNLDFLG(KAND(I),IC) = 0, row and column numbers, topwidths, and lengths in each cell. CNLDFLG(KAND(I),IC) = 1, no rows and columns just topwidths and lengths. CNLDFLG(KAND(I),IC) = 2, row and column numbers and total wetted area in each cell.
	I5	INKLD(KAND(I),IC)	Flag to tell program whether to include canal seepage for this canal in the recharge array for input to a groundwater model. INKLD(KAND(I),IC) = 0 don't include seepage in recharge array.

Record	Format	Variable	Description
			INKLD(KAND(I),IC) = 1 yes, include seepage in recharge array.
	A40	CANALNAME(KAND(I),IC)	Name of the canal.

Soil Zone and Soil Parameter Cards

Record	Format	Variable	Description
18	*	NMSLS	Number of soil zones in study area.
	*	ASMC	Initial soil moisture content at beginning of simulation expressed in decimal percent of saturation.
	*	ASMCGW	Initial soil moisture content of groundwater irrigated area (IDIST(I) = 2 in program) in decimal percent of saturation.

Records 19 and 20 are entered as a set for each soil zone in the study area. Soils must be input in consecutive order corresponding to the soil zone number.

Record	Format	Variable	Description
19	*	SLNUM(J)	Soil zone number of this soil.
	*	NLYRS(J)	Number of ten-inch soil layers in this soil zone.

Repeat record 20 for each soil layer, L, of the soil zone.

Record	Format	Variable	Description
20	*	LYRDP(JSZ,L)	Depth in inches of soil layer, from ground surface to bottom of layer.
	*	WHC(JSZ,L)	Water holding capacity of soil layer in inches per inch.
	*	BDLM(JSZ,L)	Slope on logarithmic axes of saturation-capillary pressure curve for the soil texture.
	*	THETR(JSZ,L)	Residual saturation in inches per inch.
	*	PSAT(JSZ,L)	Saturated hydraulic conductivity in inches per day.
	*	PHI(JSZ,L)	Porosity of soil.
	*	THETAWP(JSZ,L)	Wilting point moisture content in inches per inch.
	*	PDIS(JSZ,L)	Displacement pressure in inches.

Row and Column Identification Cards

Record 21 is repeated for each cell in recharge model that has irrigated acreage in it. Input zeros for all variables to indicate the end of data.

21	I6	NROW	Row number of cell.
	I6	NCOL	Column number of cell.

Record	Format	Variable	Description
	F6.2	ARIA	Net irrigated area in cell in acres.
	I2	ICZN	Crop zone code number for cell.
	I2	IRZN	Irrigation project code number for cell.
	I2	SLZN	Soil zone code number for cell.

Records 22-42 entered (if applicable) as a set for each year of simulation.

Weather Data Cards

22	*	NWST	Number of weather stations used in the recharge simulation.

Repeat records 23, 24, and 25 for each weather station.

23	*	KLIMAT(J)	Flag to tell if daily or monthly temperature and precipitation is to be input. KLIMAT(J) = 0, use daily minimum and maximum temperature and daily total precipitation input from a direct access file.

Record	Format	Variable	Description
			KLIMAT(J) = 1, use mean monthly temperature and monthly total precipitation.
	*	IR2(J)	Beginning record of daily temperature direct access file. Input zero if monthly mean temperature is used.
	*	IR3(J)	Beginning record of daily precipitation direct access file. Input zero when using monthly data.

Repeat records 26, 27, and if applicable, 24 and 25 for each weather station. Use records 24 and 25 if monthly weather data is used (KLIMAT(J) = 1).

Record	Format	Variable	Description
24	21X,12F5.0	TAVG(J,K)	Mean monthly temperature for weather station J, for K = 1,12 months.
25	21X,12F5.2	PTOT(J,K)	Total monthly precipitation for K = 1,12 months.
26	A20	STA(J)	Weather station name.
	I6	NAOO(J)	Weather station NAOO code number.
	I8	LAT(J)	Latitude of weather station in decimal degrees.

Record	Format	Variable	Description
	I8	LON(J)	Longitude of weather station in decimal degrees.
	I4	ALTF(J)	Altitude of weather station above mean sea level in feet.
	I4	ARIDITY(J)	Aridity rating of weather station in percent.
27	12(F5.1,F5.2,F5.1)	RHMIN(J,K)	Minimum monthly relative humidity in percent.
		SOLAR(J,K)	Average daily clear sky solar radiation in mm/day for month.
		DWIND(J,K)	Average monthly daytime wind speed in meters per second.
			These three variables entered as set for K = 1,12 months.

Crop Zone Cards

Record	Format	Variable	Description
28	*	NOAREAS	Number of crop zones in study area.

Repeat record 29 for each crop zone.

Record	Format	Variable	Description
29	A20	ICZNM(J)	Crop zone name.
	I4	JCPZN(J)	Crop zone code number.

Record	Format	Variable	Description
	I4	NCRPS(J)	Number of crops in crop zone.
	I4	IWST(J)	Weather station code number for the crop zone. Code number corresponds to the order in which the weather stations were input.
	F4.0	ELEV(J)	Average elevation of the crop zone in feet.

Repeat record 30 for each crop in the crop zone. If crop number equals 1 (alfalfa hay) use record 30(a).

30	*	NMCRP(JC,J)	Crop number (See SUBROUTINE CROPC in Appendix B for crop numbers).
	*	PCTA(JC,J)	Percent area of the crop.
	*	MPL(JC,J)	Month of planting.
	*	NDPL(JC,J)	Day of month of planting.
	*	MEC(JC,J)	Month of effective cover.
	*	NDEC(JC,J)	Day of month of effective cover.
	*	MHV(JC,J)	Month of harvest.
	*	NDHV(JC,J)	Day of month of harvest.
30(a)	*	NMCRP(JC,J)	Crop number (= 1).
	*	PCTA(JC,J)	Percent area of the crop.

Record	Format	Variable	Description
	*	MPL(JC,J)	Month of planting.
	*	NDPL(JC,J)	Day of month of planting.
	*	MEC(JC,J)	Month of effective cover.
	*	NDEC(JC,J)	Day of month of effective cover.
	*	MHV(JC,J)	Month of harvest.
	*	NDHV(JC,J)	Day of month of harvest.
	*	MCUT(I,JC,J)	Month of cutting of alfalfa, 4 cuttings possible, I=1,4.
	*	NDCUT(I,JC,J)	Day of month of alfalfa cutting, 4 cuttings possible, I=1,4

Project Irrigation Application Cards

Records 31 and 32 are input as a set for each irrigation district. Irrigation districts must be input in the same order as they were when names were read in under irrigation information cards.

Record	Format	Variable	Description
31	*	IDIST(ID)	Irrigation project code number. Code number corresponds to order number in which irrigation project names are input in record 8.

Record	Format	Variable	Description
	*	PUMPAGE(ID)	Seasonal groundwater pumpage in acre-feet.
	*	FLAG(ID)	Flag for determining how to read irrigation application information for the project. FLAG(ID) = 1, farm deliveries and total diversions in acre-feet, and percent return flow, and percent of return flow from farm runoff. FLAG(ID) = -1, total diversions in acre-feet, percent return flow, and percent of return flow from farm runoff. FLAG(ID) = 2, farm deliveries in acre-feet. FLAG(ID) = 3, total diversions and farm deliveries in acre-feet. FLAG(ID) = -3, total diversions in acre-feet. FLAG(ID) = 6, application rates in acre-feet/acre. FLAG(ID) = 0, use application rates from specified irrigation project.

Record	Format	Variable	Description
	*	ACTAREA	Actual reported area for the irrigation project for the year of simulation.

Record 32 is entered for each month K (K = 1,12) each year for each irrigation project, except when FLAG(ID) = 0. Use the record corresponding to the appropriate FLAG(ID).

Use this format for FLAG(ID) = 1.

32	5X,F10.0	DEL(K,ID)	Farm deliveries for month K in acre-feet.
	F10.0	DIV(K,ID)	Irrigation project diversions for month K in acre-feet.
	F5.4	RTNFL(K,ID)	Total return flow expressed as a decimal percent of total diversions.
	F5.4	FARMWST(K,ID)	Return flow from farm runoff expressed as decimal percent of RTNFL(K,ID).

Use this format for FLAG(ID) = -1.

32	5X,F10.0	DIV(K,ID)	Irrigation project diversions for month K in acre-feet.

Record	Format	Variable	Description
	F5.4	RTNFL(K,ID)	Total return flow in decimal percent of total diversions.
	F5.4	FARMWST(K,ID)	Decimal percent of RTNFL(K,ID) that comes from farm runoff.

Use this format for FLAG(ID) = 3.

32	5X,F10.0	DEL(K,ID)	Farm deliveries for month K in acre-feet.
	F10.0	DIV(K,ID)	Irrigation project diversions for month K in acre-feet.

Use this format for FLAG(ID) = -3.

32	5X,F10.0	DIV(K,ID)	Irrigation project diversions for month K in acre-feet.

Use this format for FLAG(ID) = 2.

32	5X,F10.0	DEL(K,ID)	Farm deliveries for month K in acre-feet.

Use this format for FLAG(ID) = 6.

Record	Format	Variable	Description
32	5X,F13.2	DEL(K,ID)	Irrigation application for month K in acre-feet per acre.

Use this format for FLAG(ID) = 0.

Record	Format	Variable	Description
32	*	IDNO(ID)	Irrigation project code number to use irrigation applications from. Application rate data cards for IDNO(ID) must have been input before this record.

River Reach Loss Cards

Record	Format	Variable	Description
33	*	NRCHS	Number of river reaches losing water to seepage.

Repeat records 34 and 35 for each river reach I.

Record	Format	Variable	Description
34	I5	LRCH(I)	Length of river reach in feet.
	I5	NNODES(I)	Number of cells containing the reach.
35	12F6.0	DISCH(I,K)	Total loss along reach for each month K = 1,12 in acre-feet.

Repeat record 36 for each of the cells containing the river reach I.

Record	Format	Variable	Description
36	I5	IX(I,J)	Column number of cell containing reach I.
	I5	IY(I,J)	Row number of cell containing reach I.

Canal Seepage Maximum Diversion Cards

Repeat record 37 for each irrigation project with canal seepage. Use same order for inputing data that is used in records 14, 15, and 16.

37	F5.0	QMAX(I)	Maximum diversion for this year of simulation entered in same units as diversions are in that are used for computing seepage on a monthly, bi-monthly, or daily basis.
	F5.0	BGRC(I)	Beginning record of direct access daily or bi-monthly diversions. Must enter zero if monthly diversions are used.

Option cards for changing seepage coefficients, canal diversions, and adding canals for carrying away spring runoff.

Record	Format	Variable	Description
38	*	INQ	Flag for changing seepage coefficients for one or more canals for this year of simulation. INQ = 0, no change in seepage coefficient. INQ = n, change in seepage coefficient in n canals.

Records 39 and 40 entered as a set for each of n canals if INQ is greater than 0.

Record	Format	Variable	Description
39	*	ITMP	Flag for changing seepage coefficient temporarily for specified months this year, or for changing seepage coefficients permanently. ITMP = 0, read permanent change in seepage coefficient. ITMP = 1, read temporary change in seepage coefficient.

Record 40(a) used if ITMP = 0. Record 40(b) used if ITMP = 1.

Record	Format	Variable	Description
40(a)	*	IPCN	Irrigation project code number in which canal is located that is to have seepage coefficient changed.
	*	KN	Canal number corresponding to order the canal names were input for the particular irrigation project in record 17 under canal information cards.
	*	SC	New seepage coefficient in feet per day.
40(b)	*	IPCN	Irrigation project code number in which canal is located that is to have seepage coefficient changed.
	*	KN	Canal number corresponding to order the canal names were input for the particular irrigation project in record 17.
	*	TSC	Temporary seepage coefficient in feet per day.
	*	IBM	Beginning month number when temporary seepage coefficient goes into effect.
	*	IEM	Ending month number when temporary seepage coefficient is last used. Original seepage coefficient goes back into effect after this month.

Record	Format	Variable	Description
41	*	INQ	Flag telling program whether to read changes in canal diversions (for seepage calculations) from daily or bi-monthly to monthly or vice versa for one or more irrigation projects. INQ = 0, no change in canal diversions. INQ = N, change canal diversions in N irrigation projects.

Record 42 read if INQ > 0, and is entered for each of the N irrigation projects.

Record	Format	Variable	Description
42	*	IPCN	Irrigation project code number in which canal is located that is to have canal diversions changed.
	*	CNF	New CNLFLG(I) CNF = 0, change from monthly or bi-monthly to daily diversions. CNF = 1, change from daily to monthly diversions. CNF = 2, change from monthly to bi-monthly diversions.

Record	Format	Variable	Description

Input description for file CNLDTL(I) read from F-UNIT IND. A file is needed for each irrigation project that has canals with seepage calculations.

Record	Format	Variable	Description
Repeat records 1 and 2 for each canal of irrigation project. Enter a 999 for first variable and any other number for other variables of appropriate form of record 2 to indicate end of data for the canal.			
1	*	IC1	Number of canal corresponding to order number that its name was read in main input file under canal information cards.
Use record 2(A) when CNLDTL(KAND(I),IC) = 0. Repeat record 2(A) for each cell that contains canal IC1.			
2(A)	*	COL	Column number of cell.
	*	ROW	Row number of cell.
	*	DXLENGTH	Length of canal reach in cell (feet).
	*	WIDTH	Average topwidth of canal reach in cell found from aerial photos with calibrated microscope. Enter in calibrated units (1 calibrated unit = 25 feet).

Record	Format	Variable	Description
Use record 2(B) when CNLDTL(KAND(I),IC) = 1. Repeat record 2(B) for each cell that contains canal IC1.			
2(B)	*	COL	Column number of cell.
	*	ROW	Row number of cell.
	*	WIDTH	Total wetted area of canal in cell (square feet).
Use record 2(C) when CNLDTL(KAND(I),IC) = 2. Repeat record 2(C) for each uniform reach of the canal IC1.			
2(C)	*	DXLENGTH	Length of canal in feet.
	*	WIDTH	Average topwidth of canal in calibrated microscope units (1 unit = 25 feet).

Input description for canal diversions direct access file CNLDVF(I) when CNLFLG(I) = 0.

Record	Format	Variable	Description
Repeat record 1 for each month of each year of simulation.			
1	I10	NYR	Year of simulation.

Record	Format	Variable	Description
	I10	NMO	Month of simulation.
	I10	NDAY	Number of days in month.
	31F6.0	QD(KAND(I),K)	Daily diversions through canals for irrigation project number KAND(I) for K = 1,31 days (cfs or acre-feet).

Input description for canal diversions direct access file CNLDVF(I) when CNLFLG(I) = 2.

Repeat record 1 for each bi-month period K (K=1,24) of each year of simulation.

Record	Format	Variable	Description
1	20X,F10.0	BDAY(KAND(I),K)	Number of days in this bi-monthly period K.
	F10.0	QBM(KAND(I),K)	Bi-monthly diversions for period K, in acre-feet or cfs.

Input description for daily temperature direct access file TNAME when KLIMAT(J) = 0.

Repeat record 1 for each month of year for each year that daily temperature is known.

Record	Format	Variable	Description
1	50X,I10	JNDAY	Number of days of month.

Record	Format	Variable	Description
	64F5.1	TMAX(J,K),TMIN(J,K)	Maximum and minimum daily temperature for weather station J for K=1,31 days, and mean monthly maximum and minimum temperature for K=32.

Input description for daily precipitation direct access file PNAME when KLIMAT(J) = 0.

Record	Format	Variable	Description
Repeat record 1 for each month of year for each year that daily temperature is known.			
1	50X,I10	JNDAY	Number of days of month.
	32E10.0	PRECIP(J,K),K=1,31, PTOT(J,MO)	Daily total precipitation for each weather station J for K=1,31 days, and monthly total precipitation.

APPENDIX B

LISTING OF RECHARGE PROGRAM

```
C*************************************************************
C                                                          ***
C     PROGRAM RECHARGE.F77                                 ***
C                                                          ***
C*************************************************************
C                                                            *
C     ESTIMATES AQUIFER RECHARGE FROM IRRIGATION AND CANAL   *
C     SEEPAGE FOR A 80 BY 65 GRID MESH.                      *
C                                                            *
C*************************************************************
C
C**** DECLARATION STATEMENTS.
C
      REAL PSAT,LYRDP
      INTEGER EX,WYE
      INTEGER YR,BEGYR
      CHARACTER STA*20
      CHARACTER ICZNM*20
      CHARACTER INAME*40
      CHARACTER CANALNAME*40,IFMT*80,NAME1*60
      COMMON /DATES/ YR,MO,DAY(12),IYR,JYR,BEGYR
      COMMON /SCNDPMT/ RHMIN(3,12),SOLAR(3,12),DWIND(3,12),SRTO(3,12)
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /CROPS/ NMCRP(15,6),PCTA(15,6),MPL(15,6),NDPL(15,6)
      COMMON /CROPS/ MEC(15,6),NDEC(15,6),MHV(15,6),NDHV(15,6)
      COMMON /CROPS/ NDCUT(4,15,6),MCUT(4,15,6),ET(12,15,6)
      COMMON /WEATHER/ STA(3),LAT(3),LON(3),ALTF(3),ARIDITY(3)
      COMMON /WEATHER/ NAOO(3)
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /SOILDAT/ SLNUM(10),LYRDP(10,6),WHC(10,6),BDLM(10,6)
      COMMON /SOILDAT/ THETR(10,6),PSAT(10,6),PDIS(10,6),NLYRS(10)
      COMMON /SOILDAT/ PHI(10,6),THETAWP(10,6)
      COMMON /FREEZE/ SNOMLT(3),TMEAN(3),SNO(3)
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
      COMMON /PTOPT/ NOPTN(4),IFMT,NAME1,IOUT
C
      IP=0
      IYY=0

C
      CALL DATAIN(IP,IYY)
C
C**** Yearly loop
C
      DO 200 JYR=1,IYR
      YR=BEGYR -1+JYR
C
C****** Monthly loop
C
        DO 100 MO=1,12
```

```
        CALL DATAIN(IP,IYY)
        CALL FAOBC
        CALL SNOW
        CALL DDPTHSM
        CALL IRRIGATION
        CALL MASSBAL
        CALL OUTPUT
C
        IF(MO.EQ.12)IYY=0
100     CONTINUE
200   CONTINUE
C
C**** CLOSE FILES
C
      ENDFILE(61)
      ENDFILE(IDC(1))
      ENDFILE(IDC(2))
      ENDFILE(IDC(3))
      ENDFILE(55)
      ENDFILE(IDC(4))
      ENDFILE(19)
      ENDFILE(IOUT)
C
      STOP
      END
C
C**********************************************************
      SUBROUTINE DATAIN(IP,IYY)

C**********************************************************
C
C**** Read in all yearly, monthly data.
c
      REAL PSAT,LYRDP
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      INTEGER ROW, COL
      CHARACTER INAME*40
      CHARACTER CNLDTL*40
      CHARACTER TNAME*40,PNAME*40,STA*20,NAME*40
      CHARACTER ICZNM*20,CNLDVF*40
      CHARACTER CANALNAME*40,IFMT*80,NAME1*60
      COMMON /DATES/ YR,MO,DAY(12),IYR,JYR,BEGYR
      COMMON /SCNDPMT/ RHMIN(3,12),SOLAR(3,12),DWIND(3,12),SRTO(3,12)
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /CROPS/ NMCRP(15,6),PCTA(15,6),MPL(15,6),NDPL(15,6)
      COMMON /CROPS/ MEC(15,6),NDEC(15,6),MHV(15,6),NDHV(15,6)
      COMMON /CROPS/ NDCUT(4,15,6),MCUT(4,15,6),ET(12,15,6)
      COMMON /WEATHER/ STA(3),LAT(3),LON(3),ALTF(3),ARIDITY(3)
      COMMON /WEATHER/ NAOO(3)
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /SOILDAT/ SLNUM(10),LYRDP(10,6),WHC(10,6),BDLM(10,6)
      COMMON /SOILDAT/ THETR(10,6),PSAT(10,6),PDIS(10,6),NLYRS(10)
      COMMON /SOILDAT/ PHI(10,6),THETAWP(10,6)
      COMMON /SEEPDAT/ CNLDFLG(5,6),NCL,NRCHS,LRCH(20),NNODES(20)
      COMMON /SEEPDAT/ IX(20,40),IY(20,40),DISCH(20,12),INDV,IND
      COMMON /SEEPDAT/ CNLDTL(6),CNLDVF(6),IRCLDV(6),CNLFLG(6)
```

```
      COMMON /SEEPDAT/ TRBFL(8),TRBQFL(8),BGRC(6),JBGRC(9)
      COMMON /WEATHDAT/ INTN,TNAME,IRECT,INTX,PNAME,IRECP,NWST
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
      COMMON /FREEZE/ SNOMLT(3),TMEAN(3),SNO(3)
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /BLOCK/ T1(6),KT(6)
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
      COMMON /PTOPT/ NOPTN(4),IFMT,NAME1,IOUT
      DATA DAY /31.,28.,31.,30.,31.,30.,31.,31.,30.,31.,30.,31./,
     &     AREASM /9*0/
     &     IZ /5200*0/
     &     SZ /5200*7/
     &     CZ /5200*3/
     &     AREA /5200*0/
     &     DELA /9*1./
     &     TM /9*0/
C
C**** CHECK TO SEE IF CONSTANT VALUES READ IN ALREADY
C
      IF(IP.EQ.1)GOTO 100
C
C**** OPEN INPUT FILE
C
      OPEN(5,FILE='INPUT')
C
C**** OPEN OUTPUT FILES FOR CELLULAR RECHARGE.
C
      OPEN(19,FILE='MONTHLY_RECHARGE')
      OPEN(49,FILE='RECH.MAP')
      OPEN(55,FILE='YEARLY_RECHARGE')
      OPEN(61,FILE='UNSAT_OUT')
C
C**** READ PROJECT NAME, BEGINNING AND ENDING YEARS OF SIMULATION
C
      READ(5,16)NAME1
16    FORMAT(A60)
      READ(5,*,ERR=800)BEGYR,ENDYR
C
C**** READ NUMBER OF COLUMNS, ROWS, AND X & Y GRID SPACING
C
      READ(5,*,ERR=800)EX,WYE,DELX,DELY
C
C**** COMPUTE TOTAL NUMBER OF GRID CELLS AND COUNTER FOR YEARLY LOOP
C
      IQ=EX*WYE
      IYR=ENDYR-BEGYR+1
C
C**** READ PRINTING OPTIONS, OUTPUT FILE UNIT NUMBER
C
      READ(5,6,ERR=800)NOPTN(1),NOPTN(2),NOPTN(3),NOPTN(4)
6     FORMAT(4I5)
      READ(5,8,ERR=800)IFMT
8     FORMAT(A80)
      READ(5,*)IOUT
      OPEN(IOUT,FILE='OUTPUT')
C
C**** READ NUMBER OF IRRIGATED AREAS
C
      READ(5,*,ERR=800)NIDST
C
C**** READ IRRIGATION DISTRICT NAMES.
C
      DO 20 ID=1,NIDST
      READ(5,32)INAME(ID)
      READ(5,*,ERR=400)PFLAG(ID)
20    CONTINUE
```

```
C
C**** READ NAMES OF DIRECT ACCESS DAILY VALUES TEMP AND PRECIP FILES
C
      READ(5,32,ERR=800)TNAME
      READ(5,32,ERR=800)PNAME
32    FORMAT(A40)
C
C**** READ FUNITS AND RECORD LENGTH FOR TEMP AND PRECIP DAM FILES
C
      READ(5,*,ERR=800)INTN,IRECT,INTX,IRECP
C
C**** READ NUMBER OF CANAL AREAS, FUNITS FOR DIVERSION AND DIMENSION INPUT FILES
C
      READ(5,*,ERR=800)NCL,IND,INDV
C
C**** READ FLAGS, NAMES OF CANALS, NAMES OF CANAL INPUT FILES, OUTPUT FILES AND FUNITS.
C
      DO 60 I=1,NCL
      READ(5,41,ERR=800)IDC(I),NAME
      OPEN(IDC(I),FILE=NAME)
      READ(5,44,ERR=800)CNLDTL(I),CNLDVF(I),
     &CNLFLG(I),IRCLDV(I),KAND(I)
      READ(5,45,ERR=800)KCANL(KAND(I))
        DO 40 IC=1,KCANL(KAND(I))
        READ(5,46,ERR=800)KNLNUM(KAND(I),IC),
     &  PERM(KAND(I),IC),CNLDFLG(KAND(I),IC),
     &  INKLD(KAND(I),IC),CANALNAME(KAND(I),IC)
40      CONTINUE
41    FORMAT(I5,A40)
44    FORMAT(2A40,3F5.0)
45    FORMAT(I5)
46    FORMAT(I5,F5.3,2I5,A40)
60    CONTINUE
C
C**** READ NUMBER OF SOIL ZONES AND SOIL PARAMETERS,
C**** ANTECEDENT MOISTURE CONTENT. WRITE TO OUTPUT FILE.
C
      ENDYR=BEGYR+IYR-1
      WRITE(IOUT,61)NAME1,BEGYR,ENDYR
61    FORMAT(/30X,A60,/30X,'Simulation for years ',I4,' to ',I4//
     & 30X,'Soil Parameters for Each Soil Zone')
      READ(5,*,ERR=800)NMSLS,ASMC,ASMCGW
      DO 70 J=1,NMSLS
      READ(5,*,ERR=800)SLNUM(J),NLYRS(J)
      JSZ=SLNUM(J)
      WRITE(IOUT,62)JSZ
62    FORMAT(/1X,'Soil Zone Number',I2,/9X,'Water',52X,'Wilting'/
     & 8X,'Holding',15X,'Residual',4X,'Saturated',15X,'Point',4X,
     & 'Displacement'/1X,'Depth',2X,'Capacity',2X,'Lambda',2X,
     & 2X,'Saturation',2X,'Conductivity',2X,'Porosity',2X,'Saturation',
     & 4X,'Pressure'/2X,'(in)',3X,'(in/in)',14X,'(in/in)',5x,'(in/day)'
     & ,17X,'(in/in)',9X,'(in)'/)
        DO 65 L=1,NLYRS(J)
        READ(5,*,ERR=800)LYRDP(JSZ,L),WHC(JSZ,L),BDLM(JSZ,L),
     &                   THETR(JSZ,L),PSAT(JSZ,L),PHI(JSZ,L),
     &                   THETAWP(JSZ,L),PDIS(JSZ,L)
        WRITE(IOUT,63)LYRDP(JSZ,L),WHC(JSZ,L),BDLM(JSZ,L),THETR(JSZ,L),
     &  PSAT(JSZ,L),PHI(JSZ,L),THETAWP(JSZ,L),PDIS(JSZ,L)
63      FORMAT(2X,I3,5X,F4.3,6X,F4.3,7X,F4.3,8X,F6.2,7X,F4.3,
     &         7X,F4.3,7X,F8.3)
65      CONTINUE
70    CONTINUE
C
C**** READ ROW AND COLUMN NUMBER, AREA, IRRIGATION ZONE, CROP ZONE, AND SOIL ZONE
C
80    READ(5,84,ERR=800)NROW,NCOL,ARIA,IRZN,ICZN,SLZN
84    FORMAT(2I6,F6.2,3I2)
C
C**** CHECK TO SEE IF THROUGH READING ROW AND COLUMN DATA
C
```

```
      IF(NROW.EQ.0) GO TO 90
C
C**** CONVERT ROW AND COLUMN TO A NUMBER AND STORE ZONES IN ARRAYS
C
      N=EX*(NROW-1)+NCOL
      AREA(N)=ARIA
      AREASM(IRZN)=AREASM(IRZN)+ARIA
      CZ(N)=ICZN
      IZ(N)=IRZN
      SZ(N)=SLZN
C
C**** INITIALIZE SOIL MOISTURE LEVELS IN EACH CELL
C
      JSZ=SLZN
      DO 88 L=1,NLYRS(JSZ)
        IF(IZ(N).EQ.2)THEN
        THETA(N,L)=ASMCGW*PHI(JSZ,L)
        ELSE
        THETA(N,L)=ASMC*PHI(JSZ,L)
        END IF
      TM(IZ(N))=TM(IZ(N))+(THETA(N,L)-THETAWP(JSZ,L))*AREA(N)*10/12
88    CONTINUE
      GO TO 80
90    CONTINUE
C
C**** SET FLAG SO DATA ISNT READ AGAIN AND RETURN TO MAIN PROGRAM
C
      IP=1
      RETURN
C*************************************************************
C**** ALL CONSTANT DATA FOR SIMULATION PERIOD READ IN *****
C*************************************************************
C                                                         ***
C**** READ IN YEARLY DATA IF YEAR CHANGED ( IYY = 0 )     ***
C*************************************************************
C
100   CONTINUE
      IF(IYY.EQ.1)GOTO 400
C
C**** INITIALIZE ARRAYS
C
      CALL ZERO1
C
C**** WRITE IRRIGATION DISTRICT CODE NUMBERS AND NAMES TO TERMINAL.
C
      WRITE(1,106)YR
106   FORMAT('YEAR OF SIMULATION ',I4,//2X,'IRRIGATION',8X,
     &       'IRRIGATION AREA NAME',15X,'AREA',/'AREA CODE NO.',
     &       42X,'Acres',/)
      DO 110 ID=1,NIDST
      WRITE(1,107)ID,INAME(ID),AREASM(ID)
107   FORMAT(4X,I2,4X,3X,A40,I6)
110   CONTINUE
C
C**** CANALS TO OUTPUT FILE (IOUT).
C
      IF(YR.EQ.BEGYR)THEN
      WRITE(IOUT,114)
114   FORMAT('1',30X,'Canals and Seepage Coefficients for Study Area'/)
      DO 140 I=1,NCL
      KAND(I)=KAND(I)
      WRITE(IOUT,117)KAND(I)
117   FORMAT(/1X,'Irrigation Area Code No.',I2,/' Canal No.',15X,
     &       'Canal Name',15X,'Seepage Coeff.',/50X,'feet/day')
        DO 120 IC=1,KCANL(KAND(I))
        WRITE(IOUT,118)IC,CANALNAME(KAND(I),IC),PERM(KAND(I),IC)
118     FORMAT(4X,I2,4X,A40,2X,F6.4)
120     CONTINUE
140   CONTINUE
      END IF
```

```
C
C**** READ NUMBER OF WEATHER STATIONS
C
      READ(5,*,ERR=800) NWST
C
C**** READ FLAG FOR READING MONTHLY OR DAILY WEATHER VALUES FOR EACH WEATHER
C**** STATION, READ BEGINNING RECORD FOR DAILY VALUES IN DAM FILE.
C
      DO 180 J = 1,NWST
      READ(5,*)KLIMAT(J),IR2(J),IR3(J)
C
C**** READ MONTHLY AVERAGE WEATHER VALUES
C
      IF(KLIMAT(J).GT.0.0)THEN
      READ(5,171)(TAVG(J,K),K=1,12)
      READ(5,172)(PTOT(J,K),K=1,12)
171   FORMAT(21X,12F5.0)
172   FORMAT(21X,12F5.2)
      END IF
C
C**** READ MONTHLY SECONDARY WEATHER PARAMETERS FOR EVAPOTRANSPIRATION COMPUTATIONS
C
      READ(5,173,ERR=800) STA(J),NAOO(J), LAT(J), LON(J), ALTF(J),
     &ARIDITY(J)
173   FORMAT(A20,I6,2I8,2I4)
      READ(5,175,ERR=800)(RHMIN(J,K),SOLAR(J,K),DWIND(J,K), K=1,12)
175   FORMAT(36(F5.0,F5.2,F5.1))
180   CONTINUE
C
C**** READ NUMBER OF CROP ZONES
C
      READ(5,*,ERR=800)NOAREAS
C
C**** READ WEATHER STATION NUMBER, NUMBER CROPS, LATITUDE AND ELEVATION
C**** FOR EACH CROP ZONE.
C
      DO 210 JCROP=1,NOAREAS
      READ(5,187)J
187   FORMAT(20X,I4)
      BACKSPACE (5)
      READ(5,188,ERR=800)ICZNM(J),JCPZN(J),NCRPS(J),IWST(J),ELV(J)
188   FORMAT(A20,3I4,F4.0)
      SUMPCT=0
      DO 200 JC = 1,NCRPS(J)
C
C**** READ CROP NUMBER, PERCENT AREA OF CROP,MO AND DAY OF PLANT,
C**** EFFECTIVE COVER, HARVEST,AND CUTTINGS IF ALFALFA.
C
C**** READ CUTTINGS IF CROP IS ALFALFA HAY.
C
      READ(5,*,ERR=800)NMC
      IF(NMC.EQ.1)THEN
      BACKSPACE (5)
      READ(5,*,ERR=800)NMCRP(JC,J),PCTA(JC,J),MPL(JC,J),NDPL(JC,J),
     &                 MEC(JC,J),NDEC(JC,J),MHV(JC,J),NDHV(JC,J),
     &                 (MCUT(I,JC,J),NDCUT(I,JC,J),  I=1,4)
C .
C**** READ IN REST OF CROPS.
C
      ELSE
      BACKSPACE (5)
      READ(5,*,ERR=800)NMCRP(JC,J),PCTA(JC,J),MPL(JC,J),NDPL(JC,J),
     &                 MEC(JC,J),NDEC(JC,J),MHV(JC,J),NDHV(JC,J)
      END IF
      SUMPCT=SUMPCT+PCTA(JC,J)
200   CONTINUE
C
C**** WRITE WARNING IF CROP PERCENTAGES DONT SUM TO 100
C
      IF(SUMPCT.NE.100.) WRITE(1,*)'WARNING: CROP AREA < 100%'
```

```
     &                       ,' PERCENT=',SUMPCT,'%',
     &                       'CROP ZONE NUMBER', JCPZN(J),'  YEAR',YR
210   CONTINUE
C
C**** READ IRRIGATED AREA CODE NUMBER, GROUNDWATER PUMPAGE, AND
C**** FLAG FOR CHOOSING METHOD OF DETERMINING APPLICATION RATE,
C**** AND ACTUAL IRRIGATED ACREAGE.
C
      DO 280 ID = 1,NIDST
      READ(5,*,ERR=800)IDIST(ID),PUMPAGE(ID),FLAG(ID),ACTAREA
C
C**** CONVERSION FOR ACTUAL AREA.
C
      IF(ACTAREA.GT.0.)THEN
      AREASM(ID)=AREASM(ID)/DELA(ID)
      DELA(ID)=ACTAREA/AREASM(ID)
      ELSE
      DELA(ID)=1.0
      END IF
C
C**** READ DELIVERIES, DIVERSIONS, RETURNFLOW %, FARM RUNOFF %.
C
      IF(FLAG(ID).EQ.1.)THEN
        DO 220 K=1,12
        READ(5,216,ERR=800)DEL(K,ID),DIV(K,ID),RTNFL(K,ID),FARMWST(K,ID)
216     FORMAT(5X,2F10.0,2F5.4)
220     CONTINUE
C
C**** READ DIVERSIONS, RETURNFLOW %, FARM RUNOFF %.
C
      ELSE IF(FLAG(ID).EQ.-1.)THEN
        DO 230 K=1,12
        READ(5,226,ERR=800)DIV(K,ID),RTNFL(K,ID),FARMWST(K,ID)
226     FORMAT(15X,F10.0,2F5.4)
230     CONTINUE
C
C**** READ DELIVERIES ONLY OR APPLICATION RATES ( STORED IN DEV(K,ID) )
C
      ELSE IF(FLAG(ID).EQ.2. .OR. FLAG(ID).EQ.6)THEN
        DO 240 K=1,12
        READ(5,236,ERR=800) DEL(K,ID)
236     FORMAT(5X,F13.2)
240     CONTINUE
C
C**** READ IRRIGATED AREA CODE NUMBER WHOSE APPLICATION RATES
C**** ARE TO BE USED IN THIS IRRIGATED AREA
C
      ELSE IF(FLAG(ID).EQ.0.)THEN
      READ(5,*,ERR=800)IDNO(ID)
C
C**** READ DELIVERIES AND DIVERSIONS
C
      ELSE IF(FLAG(ID).EQ.3.)THEN
        DO 250 K=1,12
        READ(5,246,ERR=800)DEL(K,ID),DIV(K,ID)
246     FORMAT(5X,2F10.0)
250     CONTINUE
C
C**** READ DIVERSIONS
C
      ELSE IF(FLAG(ID).EQ.-3.)THEN
        DO 260 K=1,12
        READ(5,256,ERR=800)DIV(K,ID)
256     FORMAT(15X,F10.0)
260     CONTINUE
      END IF
      PUMPING(ID)=PUMPAGE(ID)
280   CONTINUE
C
C**** READ NO. RIVER REACHES, LENGTH OF REACH, NO. CELLS INCLUDED
```

```
C**** IN THE REACH AND LOSS (+) OR GAIN (-) IN REACH.
C
      READ(5,*,ERR=800)NRCHS
      IF(NRCHS.GT.0.)THEN
        DO 310 I=1,NRCHS
        READ(5,293,ERR=800)LRCH(I),NNODES(I)
293     FORMAT(2I5)
        READ(5,294,ERR=800)(DISCH(I,K),K=1,12)
294     FORMAT(12F6.0)
          DO 300 J=1,NNODES(I)
          READ(5,296,ERR=800)IX(I,J),IY(I,J)
296       FORMAT(2I5)
300       CONTINUE
310     CONTINUE
      END IF
C
C**** MAX DIVERSIONS AND BEGINNING RECORD OF
C**** DIVERSIONS FOR CANAL SEEPAGE STIMATION.
C
      DO 320 I=1,NCL
      READ(5,313,ERR=800)QMAX(I),BGRC(I)
313   FORMAT(2F5.0)
320   CONTINUE
C
C**** CHANGE SEEPAGE COEFFICIENTS IF SPECIFIED.
C
      READ(5,*,ERR=800)INQ
      IF(INQ.GT.0)THEN
      DO 330 ICHNG=1,INQ
      READ(5,*,ERR=800) ITMP
        IF(ITMP.GT.0)THEN
        READ(5,*,ERR=800)IPCN,KN,TSC,IBM,IEM
        DO 325 KNC=1,NCL
        IF(KAND(KNC).EQ.IPCN)THEN
          DO 324 IMO=IBM,IEM
          TMPSC(IMO,KN,KNC)=TSC
324       CONTINUE
        END IF
325     CONTINUE
        ELSE
        READ(5,*,ERR=800)IPCN,KN,SC
        PERM(IPCN,KN)=SC
        END IF
330   CONTINUE
      END IF
C
C**** CHANGE CANAL DIVERSIONS IF SPECIFIED.
C
      READ(5,*,ERR=800)INQ
      IF(INQ.GT.0)THEN
      DO 350 ICHNG=1,INQ
      READ(5,*,ERR=800)IPCN,CNF
        DO 340 I=1,NCL
        IF(KAND(I).EQ.IPCN)CNLFLG(I)=CNF
340     CONTINUE
350   CONTINUE
      END IF
C
C**** SET FLAG SO YEARLY DATA ISNT RE-READ
C
      IYY=1
C
C**** REQUIRED YEARLY DATA READ*****************************
C**********************************************************
C                                                        *
C**** READ MONTHLY DATA IF MONTH CHANGED                 *
C**********************************************************
C
400   CONTINUE
C
```

```
C**** INITITAILIZE MONTHLY ARRAYS
C
      CALL ZERO2
C
C**** READ WEATHER DATA FOR EACH STATION.
C
      DO 420 J=1,NWST
      IF(KLIMAT(J).GT.0.0) GO TO 420
C
C**** READ DAILY WEATHER VALUES IF MONTHLY AVERAGES WERENT.
C**** OPEN INPUT WEATHER DATA DAM FILES
C
      OPEN (INTN,FILE=TNAME,FORM='FORMATTED',ACCESS='DIRECT',RECL=IRECT)
      OPEN (INTX,FILE=PNAME,FORM='FORMATTED',ACCESS='DIRECT',RECL=IRECP)
      IR1=(IR2(J)+MO-1)
      IR4=(IR3(J)+MO-1)
      READ (INTN'IR1,406,ERR=800)JNDAY,(TMAX(J,K),TMIN(J,K),
     &                            K=1,32)
406   FORMAT(50X,I10,64F5.1)
      READ(INTX'IR4,416,ERR=800)JNDAY,( PRECIP(J,K),K=1,31),
     &                            PTOT(J,MO)
416   FORMAT(50X,I10,32E10.0)
      CLOSE (INTX)
      CLOSE (INTN)
420   CONTINUE
C
C*******************************************************
C**** COMPUTE RIVER, CANAL, AND LAKE SEEPAGE.
C*******************************************************
C
C**** CALL SUBROUTINE TO COMPUTE RIVER GAINS OR LOSSES.
C
      CALL RIVER
C
C**** CALL APPROPRIATE SUBROUTINE FOR EACH CANAL AREA.
C
      DO 640 I=1,NCL
      QSUM=0
      KOUNT2=0
C
C**** INITIALIZE TIME CORRECTION FACTOR FOR SEEPAGE RATE
C
      IF(MO.EQ.1) THEN
      KT(I)=0
      END IF
C
C**** BEGGINING RECORD FOR  DIVERSION INPUT DAM FILE.
C
      IR5=BGRC(I)+MO-1
C
C**** OPEN DIVERSION AND DIMENSION-LOCATION INPUT FILES.
C
      OPEN(INDV,FILE=CNLDVF(I),FORM='FORMATTED',ACCESS='DIRECT',RECL=
     &     IRCLDV(I))
C
      OPEN (IND,FILE=CNLDTL(I))
      REWIND (IND)
C
C**** READ BI-MONTHLY DIVERSIONS
C
      IF(CNLFLG(I).EQ.2)THEN
      T1(I)=0
        DO 440 K=1,2
        IR5=BGRC(I)+2*(MO-1)+K-1
        READ(INDV'IR5,436,ERR=800)BDAY(KAND(I),K),QBM(KAND(I),K)
        IF(QBM(KAND(I),K).EQ.0)GOTO 440
        T1(I)=BDAY(KAND(I),K)/2
        KT(I)=KT(I)+BDAY(KAND(I),K)
        QSUM=QSUM+QBM(KAND(I),K)
436     FORMAT(20X,2F10.0)
```

```
 440     CONTINUE
         CLOSE(INDV)
 C
 C**** USE EXISTING DIVERSION RATES
 C
       ELSE IF(CNLFLG(I).EQ.1)THEN
       IF(DIV(MO,KAND(I)).GT.0.0)THEN
       NDAY=1
       KT(I)=KT(I)+DAY(MO)
       T1(I)=15
       END IF
       QD(KAND(I),1)=DIV(MO,KAND(I))
       QSUM=DIV(MO,KAND(I))
 C
 C**** READ DAILY DIVERSIONS FROM DAM FILE
 C
       ELSE
       READ(INDV'IR5,456,ERR=800) NYR,NMO,NDAY,(QD(KAND(I),K),K=1,31)
 456   FORMAT(3I10,31F6.0)
 C
 C****** DETERMINE TIME FACTOR FOR SEEPAGE RATE ADJUSTMENT
 C
         T1(I)=0
         DO 460 K=1,NDAY
         IF(QD(KAND(I),K).EQ.0) GOTO 460
         T1(I)=T1(I)+1
         KT(I)=KT(I)+1
         QSUM=QSUM+QD(KAND(I),K)
 460     CONTINUE
       CLOSE (INDV)
       END IF
 C
 C**** READ CANAL LOCATIONS-DIMENSIONS, CALL SUBROUTINES
 C**** TO COMPUTE SEEPAGE LOSSES.
 C****** DETERMINE APPROPRIATE DIMENSION-LOCATION INPUT FILE READ STATEMENT.
 C
         DO 620 IC=1,KCANL(KAND(I))
 C
 C****** READ DIMENSIONS OF SMALL LATERALS AND DITCHES
 C
         IF(CNLDFLG(KAND(I),IC).EQ.1.)THEN
         KOUNT=0
         READ(IND,*,END=640,ERR=800) IC1
 470      READ(IND,*,END = 640,ERR=800)DXLENGTH, WIDTH
           IF(DXLENGTH.EQ.999) THEN
           CALL LATERAL(I,IC,CNLFLG(I))
           GO TO 620
           END IF
         KOUNT=KOUNT+1
         DXLEN(KOUNT)=DXLENGTH
         WID(KOUNT)=WIDTH
         GO TO 470
 C
 C****** READ LOCATIONS AND WETTED AREA.
 C
         ELSE IF(CNLDFLG(KAND(I),IC).EQ.2.)THEN
         KOUNT=0
         READ(IND,*,END=640,ERR=800) IC1
 480      READ(IND,*,END = 640,ERR=800) COL,ROW, WIDTH
           IF(COL.EQ.999) THEN
           CALL LAKE(I,IC,CNLFLG(I),QSUM)
           GO TO 620
           END IF
         KOUNT=KOUNT+1
         IROW(KOUNT)=ROW
         ICOL(KOUNT)=COL
         WID(KOUNT)=WIDTH
         GO TO 480
 C
 C****** READ ROW,COLUMN, LENGTH, AND WIDTH.
```

```
C
        ELSE
        KOUNT=0
        READ(IND,*,END=640,ERR=800)IC1
 500    READ(IND,*,END = 640,ERR=800) COL,ROW,DXLENGTH, WIDTH
          IF(COL.EQ.999) THEN
C
C************ USE BI-MONTHLY DIVERSION SUBROUTINE
C
            IF(CNLFLG(I).EQ.2)THEN
            CALL SEEPAGE2(I,IC,QSUM)
            GO TO 620
C
C************ USE DAILY DIVERSION SUBROUTINE
C
            ELSE IF(CNLFLG(I).LE.1.)THEN
            CALL SEEPAGE(I,IC,CNLFLG(I),QSUM)
            GO TO 620
            END IF
          END IF
C
C**** LOAD ARRAYS WITH DIMENSIONS AND CELL LOCAION
C
        IF(INKLD(KAND(I),IC).EQ.0)GO TO 510
        KOUNT2=KOUNT2+1
        NSPND(KAND(I),KOUNT2)=EX*(ROW-1)+COL
 510    CONTINUE
        KOUNT=KOUNT+1
        IROW(KOUNT)=ROW
        ICOL(KOUNT)=COL
        DXLEN(KOUNT)=DXLENGTH
        WID(KOUNT)=WIDTH
        GO TO 500
        END IF
 620    CONTINUE
        CLOSE (IND)
 640  CONTINUE
C
C**** MONTHLY DATA READ AND SEEPAGE LOSSES COMPUTED********
C**** RETURN TO MAIN PROGRAM.******************************
C
      GO TO 900
C
C*****************************************
C**** WRITE WARNING FOR READ ERRORS.
C
800   WRITE(1,807) KOUNT
807   FORMAT('ERROR IN RECORDS',I4)
      STOP
C*****************************************
C
900   RETURN
      END
C
C***********************************************************
C***********************************************************
      SUBROUTINE FAOBC
C***********************************************************
C**** From University of Idaho, Kimberly
C
C**** COMPUTES POTENTIAL EVAPOTRANSPIRATION ON MONTHLY
C**** BASIS.  FAO Blaney-Criddle Formula adapted for use
C**** in Southern Idaho.
C
      INTEGER YR,BEGYR
      CHARACTER STA*20,ICZNM*20
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /CROPS/ NMCRP(15,6),PCTA(15,6),MPL(15,6),NDPL(15,6)
```

```
      COMMON /CROPS/MEC(15,6),NDEC(15,6),MHV(15,6),NDHV(15,6)
      COMMON /CROPS/ NDCUT(4,15,6),MCUT(4,15,6),ET(12,15,6)
      COMMON /WEATHER/ STA(3),LAT(3),LON(3),ALTF(3),ARIDITY(3)
      COMMON /WEATHER/ NAOO(3)
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /SCNDPMT/RHMIN(3,12),SOLAR(3,12),DWIND(3,12),SRTO(3,12)
      DIMENSION ALFCO(12),DESERT(12),DESEF(12)
      DIMENSION SUM(7),JCUT(4)
      DATA HEMIS/1HN/
      DATA ALFCO/0.0,0.0,1.15,1.21,1.14,1.07,1.01,1.00,1.08,1.22,0.,0./
      DATA DESERT /0.0,0.0,0.0,1.0,1.5,2.0,3.5,4.5,3.0,0.0,0.0,0.0/

C
      DO 200 JKROP=1,NOAREAS
      J=JCPZN(JKROP)
C
C****** LOOP FOR EACH CROP.
C
        DO 100 JC=1,NCRPS(J)
C
C****** CONVERT MONTH AND DAY TO JULIAN DATE
C
        CALL JDAY(MPL(JC,J),NDPL(JC,J),JPL)
        CALL JDAY(MHV(JC,J),NDHV(JC,J),JHV)
        CALL JDAY(MEC(JC,J),NDEC(JC,J),JEC)
C
C****** ALFALFA CUTTINGS
C
        IF(NMCRP(JC,J).NE.1) GO TO 30
        NCUT=0
          DO 20 I=1,4
          IF(MCUT(I,JC,J).LT.1) GO TO 20
          NCUT=NCUT+1
          CALL JDAY(MCUT(I,JC,J),NDCUT(I,JC,J),JCUT(NCUT))
20        CONTINUE
30      CONTINUE
C
C****** DESERT (ARIDITY) EFFECT
C
        DESEF(MO)=DESERT(MO)*ARIDITY(IWST(J))/100
C
C****** LATITUDE FOR SUNSHINE HOURS (P) FOR FAO-BC
C****** CONVERT DEGREES,MINUTES TO DEGREES
C
        MLAT =LAT(IWST(J))/100.
        DLAT=LAT(IWST(J))-MLAT*100
        DLAT=DLAT/60.+MLAT
C
C****** ELEVATION, METERS
C
        ELEV=ELV(J)*0.3048
C
C****** ELEVATION CORRECTION FOR FAO-BLANEY CRIDDLE.
C****** INCREASE CALCULATED ETR BY TEN PERCENT FOR EVERY 1000 METERS
C****** ELEVATION ABOVE SEA LEVEL
C
        ELEVC=1.+0.1*(ELEV)/1000.
        IF(ELEVC.LE.1.0) ELEVC=1.0
C
C****** DIFFERENCE IN ELEVATION BETWEEN WEATHER STATION AND MIDDLE OF CROP ZONE.
C
        DELTAL=(((ALTF(IWST(J))-ELV(J))/1000)*3.8)/1.8
C
C****** SUBSTITUTE SECONDARY WEATHER READINGS INTO PROPER MONTH ARRAY.
C
        RHMINI=RHMIN(IWST(J),MO)
        RS=SOLAR(IWST(J),MO)
        UDAYM=DWIND(IWST(J),MO)
C
```

```
C****** INITIALIZE MONTHLY SUMMARY ARRAYS.
C
         DO 40 I=1,7
         SUM(I)=0.
40      CONTINUE
C
C
C*********************************************
C****** THIS SECTION COMPUTES ET USING DAILY*
C****** CROP COEFFICIENTS.  *****************
C*********************************************
C
         JNDAY=DAY(MO)
         DO 80 NDAY = 1,JNDAY

C******** CONVERT TEMPERATURE TO DEGREES CELSIUS
C
        IF(KLIMAT(IWST(J)).GT.0.)THEN
        TMEAN=(TAVG(IWST(J),MO)-32.)/1.8
        ELSE
         TMAXC=(TMAX(IWST(J),32)-32.)/1.8
         TMINC=(TMIN(IWST(J),32)-32.)/1.8
         TMEAN=(TMAXC+TMINC)/2.
        END IF
C
C******** COMPUTE TEMPERATURE ADJUSTED FOR ARIDITY EFFECTS AND LAPSE RATE.
C
         TAVEC=TMEAN-DESEF(MO)+DELTAL
C
C******** F A O  ESTIMATES....
C******** GET A AND B COEFFICIENT FOR FAO-BLANEY-CRIDDLE
C
         N1DAY=NDAY
         IF(N1DAY.EQ.0)N1DAY=15
         CALL RSOL(DLAT,MO,N1DAY,RS,RTSOL,RCLR)
         CALL AANDB(RHMINI,RTSOL,UDAYM,AP,BP)
C
C******** GET FAO-BLANEY-CRIDDLE "P" FACTOR
C******** (SUNSHINE HOURS IN FAO-BC)
C
         CALL BLANP(DLAT,HEMIS,MO,NDAY,P)
C
C******** CALCULATION OF ETR GRASS USING FAO-BLANEY-CRIDDLE WITH A AND B
C******** COMPUTE F
C
         F = (0.46*TAVEC+8.13)*P
C
C******** MULTIPLY BY KIMBERLY CALIBRATION
C******** ALFALFA COEFFIENT TO CONVERT FROM GRASS REFERENCE TO ALFALFA REF.
C******** (ALLEN AND BROCKWAY, 1982)
C
         ETR = (AP + BP * F) * ALFCO(MO)
C
C******** ELEVATION CORRECTION
C
         ETR  = ETR*ELEVC
C
C******** GET CROP COEFFICIENT
C
         NNDAY=NDAY
         IF(NNDAY.EQ.0) NNDAY=15
         CALL JDAY(MO,NNDAY,JDATE)
         CALL CROPC(CK,JPL,0,JEC,JHV,NMCRP(JC,J),JDATE,
     &              NCUT,JCUT,NCUT,0)
C
C******** POTENTIAL CROP ET IN mm/day.
C
         CRPET =ETR*CK
C
C******** CHECK FOR ALFLAFA, LOWER ET FOR DISEASE EFFECTS
```

```
C********* WINDROWING, ETC.
C
          IF(NMCRP(JC,J).EQ.1)CRPET=CRPET*.77
C
C********* SUMMARIZE FOR MONTH
C
          SRTO(IWST(J),MO)=RTSOL
          SUM(6)=SUM(6)+ETR
          SUM(7)=SUM(7)+CRPET
C
80        CONTINUE
C
C****** DONE WITH DAILY LOOP FOR THIS CROP.
C****** GET ROOT DEPTHS BASED ON MEAN MONTHLY CROP COEFFICIENTS.
C
        NNDAY=15
        CALL JDAY(MO,NNDAY,JDATE)
        CALL CROPC(CC,JPL,0,JEC,JHV,NMCRP(JC,J),JDATE,
     &             NCUT,JCUT,NCUT,0)
        IF(JDATE.LE.JPL)CC=0
        CALL ROOTDPTH(CC,NMCRP(JC,J),J,JC)
C
C****** MEAN MONTHLY ET IN inches/month.
C
        ETPCRP(J)=ETPCRP(J)+SUM(7)*PCTA(JC,J)/2540
C
C****** CROP ET FOR THE MONTH.
C
        ET(MO,JC,J)=SUM(7)*PCTA(JC,J)*CPAREA(J)/(2540*12)
C
100     CONTINUE
200   CONTINUE
C
      RETURN
      END
C
C***************************************************************************************
      SUBROUTINE BLANP (LAT,HEMIS,MONTH,DAY,P)
C***************************************************************************************
C
C**** SUBROUTINE DESCENDED FROM FAO PROGRAM IN FAO24
C
      DIMENSION PP(11,12)
      REAL NRATIO, LAT
      INTEGER MONTH,DAY
      DATA S/1HS/
C*************************************************************************
C        THIS SECTION INTERPOLATES "P".
C*************************************************************************
      DATA PP
     1 / .267,.264,.261,.257,.252,.246,.239,.231,.220,.209,.195,
     2   .269,.268,.266,.264,.261,.257,.253,.248,.243,.236,.228,
     3   .269,.269,.269,.269,.269,.269,.268,.268,.268,.267,.266,
     4   .269,.270,.272,.275,.278,.282,.286,.291,.297,.303,.310,
     5   .271,.273,.276,.281,.287,.294,.303,.312,.322,.334,.346,
     6   .274,.280,.285,.291,.298,.307,.316,.328,.341,.355,.371,
     7   .275,.281,.287,.293,.299,.305,.313,.321,.330,.341,.354,
     8   .274,.278,.282,.287,.291,.295,.300,.304,.309,.315,.322,
     9   .271,.277,.280,.281,.281,.281,.281,.281,.281,.281,.281,
     A   .270,.269,.268,.267,.264,.261,.258,.254,.250,.245,.240,
     B   .269,.267,.264,.260,.254,.247,.240,.231,.222,.211,.200,
     C   .268,.266,.262,.257,.250,.242,.232,.221,.209,.195,.180 /
      IF (HEMIS.EQ.S) MONTH=MOD(MONTH+5,12) + 1
      LATI = LAT/5
      LL = INT(LATI)*5
      IF (LAT.GT.50) LL=50
      L1=LL/5 + 1
      L2 = L1 + 1
      IF (L2.GT.11) L2=11
      FAC=(LAT-LL)/5.0
```

```
      MONTH1=MONTH
      MONTH2=MONTH
      IF (DAY.GT.15 ) MONTH2=MOD(MONTH,12) + 1
      IF (DAY.LT.15.AND.DAY.NE.0) MONTH1=MOD(MONTH+10,12) + 1
      P1=PP(L1,MONTH1) + FAC * (PP(L2,MONTH1)-PP(L1,MONTH1))
      P2=PP(L1,MONTH2) + FAC * (PP(L2,MONTH2)-PP(L1,MONTH2))
      IF (HEMIS.EQ.S) MONTH=MOD(MONTH+5,12) + 1
      FAC=DAY - 15
      IF (FAC.LT.0.0) FAC=FAC+30.0
      FAC2=FAC/30.0
      P=P1 + FAC2 * (P2-P1)
      RETURN
      END
C
C******************************************************************************
      SUBROUTINE AANDB(RHMIN,NRATIO,UDAY,AP,BP)
C******************************************************************************
C
C**** THIS SUBROUTINE IS A DESCENDANT OF PROGRAMMING IN FAO24
C
      DIMENSION C(2,2),D(2),BB(6,6,6)
      REAL NRATIO, LAT
      INTEGER MO,DAY
C****************************************************************************
C        THIS SECTION INTERPOLATES FOR BLANEY CRIDDLE FAO A AND B COEF.
C****************************************************************************
      DATA BB/
     & .84, .80, .74, .64, .52, .38,1.03, .95, .87, .76, .63, .48,
     &1.22,1.10,1.01, .88, .74, .57,1.38,1.24,1.13, .99, .85, .66,
     &1.54,1.37,1.25,1.09, .94, .75,1.68,1.50,1.36,1.18,1.04, .84,
     & .97, .90, .81, .68, .54, .40,1.19,1.08, .96, .84, .66, .50,
     &1.41,1.26,1.11, .97, .77, .60,1.60,1.42,1.25,1.09, .89, .70,
     &1.79,1.59,1.39,1.21,1.01, .79,1.98,1.74,1.52,1.31,1.11, .89,
     &1.08, .98, .87, .72, .56, .42,1.33,1.18,1.03, .87, .69, .52,
     &1.56,1.38,1.19,1.02, .82, .62,1.78,1.56,1.34,1.15, .94, .73,
     &2.00,1.74,1.50,1.28,1.05, .83,2.19,1.90,1.64,1.39,1.16, .92,
     &1.18,1.06, .92, .74, .58, .43,1.44,1.27,1.10, .91, .72, .54,
     &1.70,1.48,1.27,1.06, .85, .64,1.94,1.67,1.44,1.21, .97, .75,
     &2.18,1.86,1.59,1.34,1.09, .85,2.39,2.03,1.74,1.46,1.20, .95,
     &1.26,1.11, .96, .76, .60, .44,1.52,1.34,1.14, .93, .74, .55,
     &1.79,1.56,1.32,1.10, .87, .66,2.05,1.76,1.49,1.25,1.00, .77,
     &2.30,1.96,1.66,1.39,1.12, .87,2.54,2.14,1.82,1.52,1.24, .98,
     &1.29,1.15, .98, .78, .61, .45,1.58,1.38,1.17, .96, .75, .56,
     &1.86,1.61,1.36,1.13, .89, .68,2.13,1.83,1.54,1.28,1.03, .79,
     &2.39,2.03,1.71,1.43,1.15, .89,2.63,2.22,1.86,1.56,1.27,1.00
     & /
C
C**** UDAY IS IN METERS PER SECOND AT TWO METERS
C
      X=RHMIN
      Y=NRATIO
      Z=UDAY
      I1=INT(X/20.) + 1
      I2=I1 + 1
      IF (I2.GT.6) I2=6
      J1=INT(Y/0.2) + 1
      J2=J1 + 1
      IF (J2.GT.6) J2=6
      K1=INT(Z/2) + 1
      K2=K1 + 1
      IF(K2.GT.6) K2=6
      IF(K1.GT.6) K1 =6
      X1=(I1-1) * 20
      X2=(I2-1) * 20
      Y1=(J1-1) * 0.2
      Y2=(J2-1) * 0.2
      Z1=(K1-1) * 2
      Z2 = (K2-1) * 2
      FACX=0.0
      FACY = 0.0
```

```
      FACZ = 0.0
      IF (K1.NE.K2) FACZ=(Z-Z1)/(Z2-Z1)
      C(1,1)=BB(I1,J1,K1) + FACZ * (BB(I1,J1,K2)-BB(I1,J1,K1))
      C(1,2)=BB(I1,J2,K1) + FACZ * (BB(I1,J2,K2)-BB(I1,J2,K1))
      C(2,1)=BB(I2,J1,K1) + FACZ * (BB(I2,J1,K2)-BB(I2,J1,K1))
      C(2,2)=BB(I2,J2,K1) + FACZ * (BB(I2,J2,K2)-BB(I2,J2,K1))
      IF (J1.NE.J2) FACY=(Y-Y1)/(Y2-Y1)
      IF (I1.NE.I2) FACX=(X-X1)/(X2-X1)
      D(1)=C(1,1) + FACY * (C(1,2)-C(1,1))
      D(2)=C(2,1) + FACY * (C(2,2)-C(2,1))
      BP=D(1) + FACX * (D(2)-D(1))
      AP=0.0043*X - Y - 1.41
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE RSOL(LAT,MO,DAY,RS,NRATIO,RCLR)                             *
C*****************************************************************************
C
C**** CALCULATE NRATIO FOR FAO-BC.....SUBROUTINE EXCERPTED FROM FAO24
C
      REAL LAT,NRATIO
      INTEGER DAY
      DIMENSION RRAN(11,12) ,RRAS(11,12)
C***************************************************************************
C             THIS SECTION CALCULATES A VALUE FOR RA IF IT IS NEEDED.
C         IN "RRAN" AND "RRAS" BELOW MO IS ON THE VERTICAL FROM
C         1 TO 12, AND LATITUDE IS HORIZONTAL FROM 0 TO 50.
C***************************************************************************
      DATA RRAN
     1 / 15.0,14.1,13.2,12.2,11.2,10.1, 8.9, 7.6, 6.4, 5.1, 3.8,
     2   15.5,14.9,14.3,13.5,12.7,11.7,10.7, 9.6, 8.5, 7.3, 6.1,
     3   15.7,15.6,15.3,14.9,14.4,13.7,13.0,12.2,11.3,10.3, 9.3,
     4   15.3,15.5,15.6,15.7,15.6,15.5,15.2,14.7,14.2,13.5,12.7,
     5   14.4,15.0,15.5,16.0,16.3,16.4,16.5,16.4,16.3,16.1,15.7,
     6   13.9,14.6,15.2,15.8,16.3,16.7,17.0,17.2,17.3,17.3,17.2,
     7   14.1,14.7,15.3,15.8,16.3,16.6,16.7,16.8,16.7,16.6,16.4,
     8   14.8,15.2,15.5,15.8,15.9,15.8,15.7,15.5,15.1,14.6,14.0,
     9   15.3,15.3,15.3,15.1,14.8,14.5,13.9,13.2,12.5,11.7,10.9,
     A   15.4,15.1,14.6,14.1,13.4,12.6,11.7,10.7, 9.6, 8.5, 7.2,
     B   15.1,14.4,13.6,12.7,11.7,10.6, 9.5, 8.2, 7.0, 5.6, 4.3,
     C   14.8,13.9,13.0,11.9,10.8, 9.5, 8.3, 7.0, 5.7, 4.3, 3.9 /
      DATA RRAS
     1 / 15.0,15.7,16.4,16.9,17.3,17.6,17.8,17.9,17.9,17.7,17.4,
     2   15.5,15.9,16.2,16.4,16.5,16.5,16.3,16.0,15.7,15.2,14.6,
     3   15.7,15.7,15.6,15.3,15.0,14.6,14.0,13.4,12.6,11.7,10.7,
     4   15.3,14.8,14.3,13.6,12.9,12.1,11.2,10.2, 9.2, 8.1, 7.0,
     5   14.4,13.7,12.9,12.0,11.0,10.0, 8.9, 7.8, 6.6, 5.4, 4.2,
     6   13.9,13.0,12.1,11.1,10.0, 8.9, 7.8, 6.6, 5.4, 4.2, 3.0,
     7   14.1,13.3,12.4,11.4,10.4, 9.3, 8.2, 7.1, 5.9, 4.7, 3.5,
     8   14.8,14.2,13.5,12.8,11.9,11.0,10.0, 9.0, 7.9, 6.7, 5.6,
     9   15.3,15.1,14.8,14.4,14.0,13.4,12.7,11.9,11.0,10.0, 8.8,
     A   15.4,15.7,15.9,15.9,15.8,15.6,15.2,14.8,14.2,13.6,12.8,
     B   15.1,15.7,16.2,16.7,17.0,17.2,17.2,17.1,17.0,16.7,16.4,
     C   14.8,15.6,16.3,16.9,17.4,17.7,18.0,18.2,18.3,18.3,18.1 /
      LL=INT(LAT/5) * 5
      IF (LAT.GT.50.0) LL=50
      L1=LL/5 + 1
      L2=L1 + 1
      IF (L2.GT.11) L2=11
      FAC1=(LAT-LL)/5.0
      MO1 = MO
      MO2 = MO
      IF (DAY.LT.15.AND.DAY.NE.0) MO1=MOD(MO+10,12) + 1
      IF (DAY.GT.15) MO2=MOD(MO,12) + 1
      RA1=RRAN(L1,MO1) + FAC1 * (RRAN(L2,MO1)-RRAN(L1,MO1))
      RA2=RRAN(L1,MO2) + FAC1 * (RRAN(L2,MO2)-RRAN(L1,MO2))
   75 FAC=DAY - 15
      IF (FAC.LT.0.0) FAC=FAC + 30.0
      FAC2=FAC/30.0
```

```
      RA=RA1 + FAC2 * (RA2-RA1)
C
C**** CLEAR DAY SOLAR  RADIATION..CALIBRATED TO KIMBERLY AS .78(RA) ALLEN
C
      RCLR=.78*RA
C***********************************************************************
C            HERE NRATIO AND RS ARE CALCULATED IF NOT GIVEN OR
C        CALCULATED ABOVE
C***********************************************************************
      NRATIO=2.0 * RS/RA - 0.5
C**** IF KIMBERLY CALIBRATION FOLLOWED,         (ALLEN)
      NRATIO=1.89* RS/RA - 0.47
      IF (NRATIO.GT.1.0) NRATIO=0.999
      IF(NRATIO.LT.0.0) NRATIO = 0.0
      RETURN
      END
C
C
C******************************************************************************
      SUBROUTINE CROPC(CK,JPL,JEM,JEC,JHV,ICRP,I2,NCUT,JCUT,NMB,MALF)      *
C******************************************************************************
C     EMA JPL,JEM,JEC,JHV,ICRP,I2,NCUT,JCUT(NMB)
C
C     ***************************************************************
C     *                                                             *
C     *  DAILY MEAN ET CROP COEFFICIENT FOR NORMAL IRRIGATION       *
C     *  AND PRECIPITATION CONDITIONS, FOR USE WITH ALFALFA         *
C     *  REFERENCE FOR CROPS GROWN IN AN ARID REGION WITH A         *
C     *  TEMPERATE INTERMOUNTAIN CLIMATE.  (WRIGHT,1981)            *
C     *                                                             *
C     * Programmed by Rick Allen  Univ. Idaho, Kimberly             *
C     ***************************************************************
C
C     MALF = 1 IF MEAN ALFALFA COEFFICIENT FOR HAY (CUTTING EFFECTS
C              AVERAGED)   JPL AND JHV USED, ONLY
C     MALF = 0 IF ACTUAL ALFALFA COEFFICIENT FOR HAY (CUTTING DATES
C              ADHERED TO)  JPL,JHV AND JCUT() USED.
C
C     NEW EVAPOTRANSPIRATION CROP COEFFICIENTS TAKEN FROM WRIGHT (1982),
C     FOR CROPS (2),(3), (5),(6),(7),(8), (9), (10).
C
      DIMENSION G(20,15),JCUT(4),ACUT4(10),ALFM(10)
C
      DATA G/
C**** ALFALFA HAY (1)
     %0.50,0.62,0.80,0.90,1.00,1.00,0.98,0.96,0.95,0.95,
     %0.30,0.40,0.70,0.90,0.95,1.00,1.00,0.98,0.95,0.95,
C**** BEANS     (2)
     %0.15,0.16,0.18,0.22,0.35,0.45,0.60,0.75,0.88,0.92,
     D0.92,0.86,0.65,0.30,0.10,0.05,0.05,0.05,0.05,0.05,
C**** CORN      (3)
     %0.15,0.15,0.16,0.17,0.18,0.25,0.38,0.55,0.74,0.93,
     D0.93,0.93,0.90,0.87,0.83,0.77,0.70,0.30,0.20,0.15,
C**** GRASS PASTURE  (4)  (0.1 LESS THAN GRASS REF (LOW STAND))R.G.A,82
     %0.34,0.43,0.52,0.59,0.66,0.73,0.77,0.77,0.77,0.77,
     D0.77,0.77,0.77,0.77,0.77,0.77,0.77,0.77,0.77,0.77,
C**** PEAS      (5)
     %0.20,0.17,0.16,0.20,0.29,0.38,0.47,0.65,0.80,0.90,
     D0.86,0.72,0.50,0.32,0.15,0.10,0.05,0.05,0.05,0.05,
C**** POTATOES (6)
     %0.15,0.15,0.15,0.20,0.35,0.48,0.60,0.72,0.78,0.80,
     D0.80,0.80,0.75,0.74,0.72,0.68,0.60,0.30,0.20,0.15,
C**** SUGAR BEETS (7)
     %0.20,0.17,0.15,0.15,0.16,0.20,0.27,0.40,0.70,1.00,
     D1.00,1.00,1.00,0.98,0.91,0.85,0.80,0.75,0.70,0.65,
C**** SPRING GRAIN(8)
     %0.15,0.16,0.20,0.28,0.50,0.75,0.90,0.96,1.00,1.00,
     D1.00,1.00,0.80,0.40,0.20,0.10,0.05,0.05,0.05,0.05,
C**** WINTER GRAIN(9)
     %0.15,0.15,0.30,0.55,0.80,0.95,1.00,1.00,1.00,1.00,
```

```
     D1.00,1.00,1.00,0.95,0.50,0.20,0.10,0.05,0.05,0.05,
C**** SWEET CORN (10)
     %0.15,0.15,0.16,0.17,0.18,0.25,0.38,0.55,0.74,0.93,
     D0.91,0.91,0.88,0.80,0.70,0.50,0.25,0.15,0.15,0.15,
C**** ALFALFA SEED (11)    CURVES 11-14 BY R.G.ALLEN 1981
     %0.55,0.65,0.72,0.78,0.84,0.87,0.88,0.89,0.89,0.90,
     D0.90,0.90,0.90,0.88,0.86,0.84,0.75,0.62,0.50,0.45,
C**** FRUIT TREES (12) --APPLE,CHERRY WITH BARE GROUND
     %0.40,0.46,0.51,0.58,0.66,0.73,0.77,0.81,0.85,0.85,
     D0.85,0.85,0.85,0.85,0.85,0.85,0.85,0.85,0.80,0.70,
C**** SMALL VEGETABLES (13)
     %0.30,0.35,0.40,0.50,0.55,0.60,0.65,0.70,0.75,0.80,
     D0.80,0.80,0.80,0.80,0.75,0.70,0.65,0.55,0.45,0.40,
C**** ONIONS  (14)
     %0.30,0.35,0.40,0.50,0.55,0.60,0.65,0.70,0.75,0.80,
     D0.80,0.80,0.80,0.80,0.80,0.80,0.75,0.70,0.65,0.60,
C**** HOPS    (15)
     %0.30,0.30,0.30,0.35,0.40,0.60,0.75,0.87,0.92,0.95,
     D0.95,0.95,0.95,0.95,0.95,0.95,0.95,0.95,0.93,0.90
     D/
C
C
C**** ALFALFA HAY DRYDOWN AFTER LAST CUT (AFTER 3RD AT KIMBERLY)
C
      DATA ACUT4/
     %0.30,0.40,0.50,0.55,0.45,0.40,0.35,0.25,0.20,0.15/
C
C**** MEAN ALFALFA COEFFICIENTS FOR AVERAGED CUTTING EFFECTS
C
      DATA ALFM/
C    %0.55,0.70,0.80,0.87,0.90,0.70,0.63,0.50,0.36,0.25/
     %0.55,0.71,0.83,0.91,0.95,0.70,0.63,0.50,0.36,0.25/
C
C
C**** CROP COEFFICIENTS
C
      IF(I2.LT.JPL .OR. I2.GE.JHV)THEN
      CK=0.0
      GO TO 327
      END IF
      J=ICRP
      IZ=I2
C
C****  BRANCH FOR ALFALFA HAY
C
      IF(J.EQ.1) GO TO 323
      REC=JEC-JPL
C
C**** LINEARLY INTERPOLATE BETWEEN COEFFICIENTS
C
      IF(IZ.GE.JEC)GO TO 321
C
C**** BEFORE EFFECTIVE COVER
C
315   P1=(IZ-JPL)/REC*100
      IF(P1.LT.10.)P1=10.01
      IP1=INT(P1/10.)
      DIFF=AMOD(P1,10.)/10.
  318 CK=G(IP1,J)+(G(IP1+1,J)-G(IP1,J))*DIFF
      GOTO 327
C
C**** AFTER EFFECTIVE COVER
C
  321 D1=IZ-JEC
      DIFF=AMOD(D1,10.)/10.
      ID1=INT(D1/10.)+10
C82   IF(ID1.LT.11)DIFF=0.
C82   IF(ID1.LT.11)ID1=11
C
C****  EXTRAPOLATE PAST 100 DAYS USING LINEAR CURVE THROUGH LAST TWO POINTS.
```

```
C
      IF(ID1.GT.19) DIFF=1.0*(ID1-19)
      IF(ID1.GT.19) ID1=19
  320 CK=G(ID1,J)+(G(ID1+1,J)-G(ID1,J))*DIFF
C82   IF(IZ.GT.JHV) CK=G(20,5)
C
C**** ALFALFA HAY
C
      IF(J.GT.1) GOTO 327
  323 CONTINUE
C
C**** CUTTINGS
C
      D9=IZ
C
C**** BRANCH FOR MEAN CUTTING EFFECTS
C
      IF(MALF.EQ.1) GO TO 350
      DO 310 NQ1=1,NCUT
      NC=NQ1
      IF(D9.LT.JCUT(NQ1)) GO TO 330
  310 CONTINUE
      NC=5
  330 IF(NC.EQ.1) D1=(D9-JPL)/(JCUT(NC)-JPL)*100.
      IF(NC.EQ.1) JAD=0
      IF(NC.GT.1) JAD=10
      IF(NC.GT.4) D1=(D9-JCUT(NCUT))/(JHV     -JCUT(NCUT))*100.
      IF(NC.GT.4) GO TO 340
      IF(NC.GT.1) D1=(D9-JCUT(NC-1))/(JCUT(NC)-JCUT(NC-1))*100.
C
C**** USE 1ST AND 2ND SET OF COEFFICIENTS TO DESCRIBE ET DURING
C**** GREENUP TO 1ST CUT  AND FOR 1ST CUT TO 2ND AND 2ND TO 3RD CUTS
C**** FIRST, SECOND AND THIRD CUTTINGS     ETC.
C
      DIFF=AMOD(D1,10.)/10.
      ID1=INT(D1/10.)+JAD
      JD1=ID1
      IF(ID1.LT.JAD+1)ID1=1+JAD
      CK=G(ID1,J)+(G(ID1+1,J)-G(ID1,J))*DIFF
      IF(JD1.GE.JAD+1) GO TO 327
C
C**** CALCULATE COEFFICIENT FROM 0 TO 10 %
C
      IF(JAD.EQ.0) CK=0.55+(G(ID1,J)-0.55)*DIFF
      IF(JAD.EQ.10)CK=0.30+(G(ID1,J)-0.30)*DIFF
      GOTO 327
C
C**** AFTER LAST CUT USE ACUT4 ARRAY FOR COEFFICIENT
C
  340 DIFF=AMOD(D1,10.)/10.
      ID1=INT(D1/10.)
      JD1=ID1
      IF(ID1.LT.1) ID1=1
      CK=ACUT4(ID1)+(ACUT4(ID1+1)-ACUT4(ID1))*DIFF.
C
C**** IF BETWEEN 0 AND 10 %
C
      IF(JD1.LT.1) CK=0.25+(ACUT4(ID1)-0.25) *DIFF
      GO TO 327
C
C**** MEAN ALFALFA COEFFICIENTS (CUTTING EFFECTS AVERAGED)
C**** DEVELOPED USING WRIGHT'81 COEFFICIENTS AND DATES FOR
C**** 3 CUTTINGS AT KIMBERLY AND DAILY ETR FROM 1965-78
C**** BY R.G.ALLEN
C**** JPL AND JHV ARE GREENUP (LAST AVE. DATE OF 24 F OCCURRENCE
C**** IN SPRING AND FIRST AVE. DATE OF 24 F OCCURRENCE IN FALL)
C
 350  LENG=JHV-JPL
      CK=0.30
      IF(IZ.LT.JPL) GO TO 327
```

```
      IF(IZ.GT.JHV) GO TO 327
      ID1=JPL+0.14*LENG-1
      ID2=ID1+0.69*LENG
      IF(IZ.GT.ID1) GO TO 360
C
C**** GREENUP TO 14% OF SEASON
C**** COEFFICIENTS ARE LISTED FOR 0,25,50,75 AND 100% OF PERIOD
C
      D1=(D9-JPL)/(ID1-JPL)*100.
      DIFF=AMOD(D1,25.)/25.
      ID1=INT(D1/25.)+1.
      CK=ALFM(ID1)+(ALFM(ID1+1)-ALFM(ID1))*DIFF
      GO TO 327
C
C**** BETWEEN 14 AND 83% OF SEASON
C
 360  IF(IZ.GE.ID2) GO TO 370
      DIFF=(D9-ID1)/(ID2-ID1)*100.
      CK=ALFM(5)+(ALFM(6)-ALFM(5))*DIFF/100.
      GO TO 327
C
C**** LAST 17% OF SEASON
C
 370  D1=(D9-ID2)/(JHV-ID2)*100.
      DIFF=AMOD(D1,25.)/25.
      ID1=INT(D1/25.)+1+5
      CK=ALFM(ID1)+(ALFM(ID1+1)-ALFM(ID1))*DIFF
  327 CONTINUE
      IF(CK.LT.0.0) CK=0.0
  328 RETURN
      END
C
C*****************************************************************************
      SUBROUTINE JDAY(M,ID,JD)                                               *
C*****************************************************************************
C
C**** THE SUBROUTINE DAY CHANGES MO AND DAY TO JULIAN DAY
C
      DIMENSION MD(12)
      DATA MD/31,28,31,30,31,30,31,31,30,31,30,31/
      ISUM=0
      DO 5 J=1,12
      IF(M.EQ.J)GOTO10
      ISUM=ISUM+MD(J)
    5 CONTINUE
   10 JD=ID+ISUM
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE DATE(JD,M,ID)                                               *
C*****************************************************************************
C
C**** THE SUBROUTINE DATE CHANGES JULIAN DAY TO MO AND DAY
C
      DIMENSION MD(12)
      DATA MD/31,28,31,30,31,30,31,31,30,31,30,31/
      ISUM=0
      DO 5 M=1,12
      ISUM=ISUM+MD(M)
      IF(JD.LE.ISUM)GOTO10
    5 CONTINUE
   10 ID=JD-ISUM+MD(M)
      RETURN
      END
C
C
C*****************************************************************************
      SUBROUTINE ROOTDPTH(CC,NMCRP,J,JC)                                     *
C*****************************************************************************
```

```
C
C**** COMPUTES AVERAGE ROOT DEPTHS FOR EACH CROP ZONE BASED UPON CROP COEFF.
C
      CHARACTER ICZNM*20
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /ROOT/ RTDP
      DIMENSION CRPDPTH(14),ZYU(15,6)
      REAL MXCRPCF(15)
      DATA MXCRPCF /1.,.92,.93,.77,.90,.80,1.,1.,1.,.93,.90,.85,.80,.80,
     &              .95/
      DATA CRPDPTH /5.,3.,3.,2.,2.,2.,3.5,3.,3.,3.,5.,5.,3.,2./
      DATA ZYU /90*0/
C
      IF(JC.EQ.1)RTDP=0
      RATIO=CC/MXCRPCF(NMCRP)
      IF(RATIO.GT..95) ZYU(NMCRP,J)=1.0
      IF(ZYU(NMCRP,J).EQ.1)RATIO=1.0
      DEPTH=RATIO*CRPDPTH(NMCRP)
      RTDP=RTDP+DEPTH
      IF(JC.EQ.NCRPS(J))THEN
      RTDPTH(J)=RTDP/NCRPS(J)
      RTDP=0
      END IF
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE SEEPAGE(I,IC,CNLFLG,QSUM)                                 **
C*****************************************************************************
C
C**** COMPUTES CANAL SEEPAGE USING DAILY OR MONTHLY DIVERSIONS.
C
C
      INTEGER YR,BEGYR
      INTEGER EX,WY
      CHARACTER CANALNAME*40
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /CELL/ CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /BLOCK/ T1(6),KT(6)
C
C**** WRITE HEADING FOR CELL SEEPAGE IF DESIRED.
C
      IF(KNLNUM(KAND(I),IC).GT.0)THEN
      IF(QSUM.EQ.0.)GO TO 10
      WRITE(IDC(I),6)CANALNAME(KAND(I),IC),YR,MO
6     FORMAT(//15X,'Cell seepage for ',A40,/15X,'Year ',I4,/15X,'Month '
     &       ,I2,//13X,'Wetted Perimeter   Length       Seepage',/
     &        'Column  Row',5X,'  (feet)  ',6X,'(feet)',
     &        '   (Acre feet/month)',/)
      END IF
10    CONTINUE
C
C**** LOOP THROUGH EACH CELL WITH CANALS.
C
      DO 200 KOUNT1=1,KOUNT
      T=KT(I)-T1(I)
      QCELL=0
C
C**** CALCULATE WETTED PERIMETER FROM TOPWIDTH
C**** FOUND WITH CALLIBRATED MICROSCOPE.
C
      AVG=WID(KOUNT1)*25.
```

```
      IF(AVG.LE.12.5)THEN
      WP=AVG*1.3
      ELSE IF(AVG.LE.25)THEN
      WP = AVG*1.2
      ELSE IF(AVG.LE.200.)THEN
      WP=AVG*1.1
      ELSE
      WP =AVG*1.05
      END IF
C
C**** TOTAL LENGTH AND WETTED PERIMETER FOR CANAL.
C
      TOTWP(KAND(I),IC)=TOTWP(KAND(I),IC)+
     &WP*DXLEN(KOUNT1)/43560
      TOTLNGTH(KAND(I),IC)=TOTLNGTH(KAND(I),IC)+DXLEN(KOUNT1)/
     &5280
      D2 = (3*AVG*WP-3*(AVG**2))/8
C
C**** SEEPAGE FACTOR
C
      IF(TMPSC(MO,IC,I).GT.0.)THEN
      SC=TMPSC(MO,IC,I)
      ELSE
      SC=PERM(KAND(I),IC)
      END IF
C
C**** DAILY OR MONTHLY SEEPAGE RATES.
C
      IF(CNLFLG.EQ.1)THEN
      SLOSS=SC*DXLEN(KOUNT1)*WP*DAY(MO)
      ELSE
      SLOSS=SC*DXLEN(KOUNT1)*WP
      END IF
C
C****** LOOP FOR DAILY OR MONTHLY SEEPAGE COMPUTATION.
C
        DO 100 K=1,NDAY
C
        IF(QD(KAND(I),K).EQ.0) GOTO 100
C
C****** ADJUSTMENT FACTOR FOR TIME OF YEAR.
C
        T=T+1
        IF(T.LT.40)THEN
        ADJ=1/((40/T)**.35)
        ELSE IF(T.GE.40) THEN
        ADJ=2.5/(T**.25)
        END IF
C
C
C****** SEEPAGE FORMULA.
C
        QMIN=QMAX(I)*.20
        IF(QD(KAND(I),K).LE.QMIN)THEN
        SEEPAGE=.5*SLOSS*ADJ
        ELSE
        SEEPAGE=0.5*SLOSS*(1+(QD(KAND(I),K)-QMIN)/
     &  (QMAX(I)-QMIN))*ADJ
        END IF
C
C****** TOTAL SEEPAGE FOR CANAL.
C
        QLOSS(MO,KAND(I),IC)=QLOSS(MO,KAND(I),IC)+SEEPAGE/43560
        SEEPSUM(KAND(I))=SEEPSUM(KAND(I))+(SEEPAGE)/43560
        QCELL=QCELL+SEEPAGE/43560
C
C****** CHECK IF CANAL INCLUDED IN CELL RECHARGE SUM.
C
        IF(INKLD(KAND(I),IC).EQ.0)GO TO 100
        N=EX*(IROW(KOUNT1)-1)+ICOL(KOUNT1)
```

```
          SEEPAG(N)=SEEPAG(N)+SEEPAGE/43560
 100      CONTINUE
 C
 C**** WRITE SEEPAGE IN EACH CELL IF DESIRED.
 C
        IF(KNLNUM(KAND(I),IC).GT.0)THEN
        IF(QLOSS(MO,KAND(I),IC).EQ.0.)GO TO 200
        WRITE(IDC(I),218)ICOL(KOUNT1),IROW(KOUNT1),WP,
      &                  DXLEN(KOUNT1),QCELL
 218    FORMAT(2X,I2,5X,I2,4X,F8.2,6X,I8,6X,F8.2)
        END IF
 200    CONTINUE
        RETURN
        END
 C
 C*****************************************************************************
        SUBROUTINE LATERAL(I,IC,CNLFLG)                                      **
 C*****************************************************************************
 C
 C**** COMPUTES SEEPAGE FOR LATERALS AND SMALL DITCHES, NO CELL LOCATIONS
 C**** USED, SEEPAGE ADDED INTO DEEP PERCOLATION.
 C
        INTEGER YR,BEGYR
        INTEGER EX,WYE
        CHARACTER CANALNAME*40
        COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
        COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
        COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
        COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
        COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
        COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
        COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
        COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
        COMMON /CELL/ IQ, EX,WYE,DELX,DELY
        COMMON /BLOCK/ T1(6),KT(6)
 C
 C**** LOOP THROUGH EACH CELL WITH CANAL.
 C
        DO 200 KOUNT1=1,KOUNT
        T=KT(I)-T1(I)
 C
 C**** CALCULATE WETTED PERIMETER FROM TOPWIDTH
 C**** FOUND WITH CALLIBRATED MICROSCOPE.
 C
        AVG=WID(KOUNT1)*25.
        IF(AVG.LE.12.5)THEN
        WP=AVG*1.3
        ELSE IF(AVG.LE.25)THEN
        WP = AVG*1.2
        ELSE IF(AVG.LE.200.)THEN
        WP=AVG*1.1
        ELSE
        WP =AVG*1.05
        END IF
        D2 = (3*AVG*WP-3*(AVG**2))/8
 C
 C**** SEEPAGE FACTOR
 C
        IF(TMPSC(MO,IC,I).GT.0.)THEN
        SC=TMPSC(MO,IC,I)
        ELSE
        SC=PERM(KAND(I),IC)
        END IF
 C
 C**** TOTAL LENGTH AND WETTED PERIMETER.
 C
        TOTWP(KAND(I),IC)=TOTWP(KAND(I),IC)+
       &WP*DXLEN(KOUNT1)/43560
        TOTLNGTH(KAND(I),IC)=TOTLNGTH(KAND(I),IC)+DXLEN(KOUNT1)/
       &5280
```

```
C
C**** MONTHLY OR DDAILY DIVERSIONS.
C
      IF(CNLFLG.EQ.1)THEN
      SLOSS=SC*DXLEN(KOUNT1)*WP*DAY(MO)
      ELSE
      SLOSS=SC*DXLEN(KOUNT1)*WP
      END IF
C
C**** DAILY OR MONTHLY LOOP.
C
        DO 100 K=1,NDAY
        IF(QD(KAND(I),K).EQ.0) GO TO 100
C
C****** ADJUSTMENT FACTOR FOR TIME OF YEAR.
C
        T=T+1
        IF(T.LT.40.)THEN
        ADJ=1/((40/T)**.35)
        ELSE IF(T.GE.40) THEN
        ADJ=2.5/(T**.25)
        END IF
C
C
C****** SEEPAGE FORMULA.
C
        QMIN=QMAX(I)*.20
        IF(QD(KAND(I),K).LE.QMIN)THEN
        SEEPAGE=0.5*SLOSS*ADJ
        ELSE
        SEEPAGE=0.5*SLOSS*(1+(QD(KAND(I),K)-QMIN)/(QMAX(I)-QMIN))
     &  *ADJ
        END IF
C
C****** TOTAL SEEPAGE FOR CANAL.
C
        QLOSS(MO,KAND(I),IC)=QLOSS(MO,KAND(I),IC)+SEEPAGE/43560
C
C****** CHECK IF CANAL INCLUDED IN CELL RECHARGE SUM.
C
        IF(INKLD(KAND(I),IC).EQ.0)GO TO 100
        LATLOSS(KAND(I))=LATLOSS(KAND(I))+SEEPAGE/43560
100     CONTINUE
200   CONTINUE
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE SEEPAGE2(I,IC,QSUM)                                        **
C*****************************************************************************
C
C**** COMPUTES SEEPAGE USING BI-MONTHLY DIVERSIONS.
C
C
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      CHARACTER CANALNAME*40
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /CELL/ CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /BLOCK/ T1(6),KT(6)
C
C**** WRITE HEADING FOR CELL SEEPAGE IF DESIRED.
C
```

```
      IF(KNLNUM(KAND(I),IC).GT.0)THEN
      IF(QSUM.EQ.0.)GO TO 10
      WRITE(IDC(I),6)CANALNAME(KAND(I),IC),YR,MO
 6    FORMAT(//15X,'Cell seepage for ',A40,/15X,'Year ',I4,/15X,'Month '
     &       ,I2,//13X,'Wetted Perimeter   Length       Seepage',/
     &       'Column  Row',5X,'  (feet)  ',6X,'(feet)',
     &       '    (Acre feet/month)',/)
      END IF
 10   CONTINUE
C
C**** LOOP THROUGH EACH CELL WITH CANALS.
C
      DO 200 KOUNT1=1,KOUNT
      QCELL=0
      T=0
C
C**** CALCULATE WETTED PERIMETER FROM TOPWIDTH
C**** FOUND WITH CALLIBRATED MICROSCOPE.
C
      AVG=WID(KOUNT1)*25.
      IF(AVG.LE.12.5)THEN
      WP=AVG*1.3
      ELSE IF(AVG.LE.25)THEN
      WP = AVG*1.2
      ELSE IF(AVG.LE.200.)THEN
      WP=AVG*1.1
      ELSE
      WP =AVG*1.05
      END IF
C
C**** TOTAL WETTED PERIMETER AND LENGTH FOR CANAL.
C
      TOTWP(KAND(I),IC)=TOTWP(KAND(I),IC)+
     &WP*DXLEN(KOUNT1)/43560
      TOTLNGTH(KAND(I),IC)=TOTLNGTH(KAND(I),IC)+DXLEN(KOUNT1)/
     &5280
      D2 = (3*AVG*WP-3*(AVG**2))/8
C
C**** SEEPAGE FACTOR
C
      IF(TMPSC(MO,IC,I).GT.0.)THEN
      SC=TMPSC(MO,IC,I)
      ELSE
      SC=PERM(KAND(I),IC)
      END IF
C
C****** BI-MONTHLY LOOP.
C
        DO 100 K=1,2
        IF(QBM(KAND(I),K).EQ.0)GOTO 100
C
C****** SEEPAGE ADJUSTMENT FACTOR FOR TIME OF YEAR.
C
        T=KT(I)-BDAY(KAND(I),K)+T1(I)
        IF(T.LT.40)THEN
        ADJ=1/((40/T)**.35)
        ELSE IF(T.GE.40) THEN
        ADJ=2.5/(T**.25)
        END IF
C
C
C****** SEEPAGE FORMULA.
C
        SLOSS=SC*DXLEN(KOUNT1)*WP*BDAY(KAND(I),K)
        QMIN=QMAX(I)*.20
        IF(QBM(KAND(I),K).LE.QMIN)THEN
        SEEPAGE=0.5*SLOSS*ADJ
        ELSE
        SEEPAGE=0.5*SLOSS*(1+(QBM(KAND(I),K)-QMIN)/(QMAX(I)-QMIN))
     &  *ADJ
```

```
        END IF
C
C****** SUM SEEPAGE FOR CANAL.
C
        QLOSS(MO,KAND(I),IC)=QLOSS(MO,KAND(I),IC)+SEEPAGE/43560
        SEEPSUM(KAND(I))=SEEPSUM(KAND(I))+(SEEPAGE)/43560
        QCELL=QCELL+SEEPAGE/43560
C
C****** CHECK IF CANAL INCLUDED IN CELL RECHARGE SUM.
C
        IF(INKLD(KAND(I),IC).EQ.0)GO TO 100
        N=EX*(IROW(KOUNT1)-1)+ICOL(KOUNT1)
        SEEPAG(N)=SEEPAG(N)+SEEPAGE/43560
100     CONTINUE
C
C**** WRITE SEEPAGE IN EACH CELL IF DESIRED.
C
      IF(KNLNUM(KAND(I),IC).GT.0)THEN
      IF(QLOSS(MO,KAND(I),IC).EQ.0.)GO TO 200
      WRITE(IDC(I),218)ICOL(KOUNT1),IROW(KOUNT1),WP,
     &                DXLEN(KOUNT1),QCELL
218   FORMAT(2X,I2,5X,I2,4X,F8.2,6X,I8,6X,F8.2)
      END IF
200   CONTINUE
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE LAKE(I,IC,CNLFLG,QSUM)                                        *
C*****************************************************************************
C
C**** COMPUTES SEEPAGE USING DAILY OR MONTHLY DIVERSIONS AND TOTAL WETTED
C**** IN EACH GRID CELL.
C
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      CHARACTER CANALNAME*40
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /BLOCK/ T1(6),KT(6)
C
C**** WRITE HEADING FOR CELL SEEPAGE IF DESIRED.
C
      IF(KNLNUM(KAND(I),IC).GT.0)THEN
      IF(QSUM.EQ.0.)GO TO 10
      WRITE(IDC(I),6)CANALNAME(KAND(I),IC),YR,MO
6     FORMAT(//15X,'Cell seepage for ',A40,/15X,'Year ',I4,/15X,'Month '
     &       ,I2,//13X,'Wetted Perimeter   Length        Seepage',/
     &       'Column  Row',5X,'(sq. feet)',6X,'(feet)',
     &       '    (Acre feet/month)',/)
      END IF
10    CONTINUE
C
C**** LOOP THROUGH EACH CELL.
C
      DO 200 KOUNT1=1,KOUNT
      T=KT(I)-T1(I)
      QCELL=0
C
C**** SEEPAGE FACTOR
C
      IF(TMPSC(MO,IC,I).GT.0.)THEN
      SC=TMPSC(MO,IC,I)
```

```
      ELSE
      SC=PERM(KAND(I),IC)
      END IF
C
C**** CHECK FOR DAILY OR MONTHLY SEEPAGE COMPUTATIONS
C
      IF(CNLFLG.EQ.1)THEN
      SLOSS=SC*WID(KOUNT1)*DAY(MO)
      ELSE
      SLOSS=SC*WID(KOUNT1)
      END IF
      QMIN=QMAX(I)*.20
C
C****** DAILY OR MONTHLY LOOP.
C
        DO 100 K=1,NDAY
        IF(QD(KAND(I),K).EQ.0) GO TO 100
C
C****** SEEPAGE ADJUSTMENT FACTOR FOR TIME OF YEAR.
C
        T=T+1
        IF(T.LT.40)THEN
        ADJ=1/((40/T)**.35)
        ELSE IF(T.GE.40) THEN
        ADJ=2.5/(T**.25)
        END IF
C
C****** TOTAL LENGTH AND WETTED PERIMETER.
C
        TOTWP(KAND(I),IC)=TOTWP(KAND(I),IC)+
     &  WID(KOUNT1)/43560
C
C****** CORRECT SEEPAGE FORMULA.
C
        IF(QD(KAND(I),K).LE.QMIN)THEN
        SEEPAGE=0.5*SLOSS*ADJ
        ELSE
        SEEPAGE=0.5*SLOSS*(1+(QD(KAND(I),K)-QMIN)/(QMAX(I)
     &          -QMIN))*ADJ
        END IF
C
C****** SUM SEEPAGE FOR LAKE OR CANAL.
C
        QLOSS(MO,KAND(I),IC)=QLOSS(MO,KAND(I),IC)+SEEPAGE/43560
        QCELL=QCELL+SEEPAGE/43560
C
C****** CHECK IF CANAL INCLUDED IN CELL RECHARGE SUM.
C
        IF(INKLD(KAND(I),IC).EQ.0)GO TO 100
        N=EX*(IROW(KOUNT1)-1)+ICOL(KOUNT1)
        SEEPAG(N)=SEEPAG(N)+SEEPAGE/43560
C
100     CONTINUE
C
C**** WRITE SEEPAGE IN EACH CELL IF DESIRED.
C
      IF(KNLNUM(KAND(I),IC).GT.0)THEN
      IF(QLOSS(MO,KAND(I),IC).EQ.0.)GO TO 200
      WRITE(IDC(I),218)ICOL(KOUNT1),IROW(KOUNT1),WID(KOUNT1),
     &                 QCELL
218   FORMAT(2X,I2,5X,I2,4X,I8,18X,F8.2)
C
      END IF
200   CONTINUE
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE RIVER                                                       *
C*****************************************************************************
```

```
C
C**** SUMS GAINS OR LOSSES FOR RIVER OR CREEK REACHES.
C
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /SEEPDAT/ CNLDFLG(5,6),NCL,NRCHS,LRCH(20),NNODES(20)
      COMMON /SEEPDAT/ IX(20,40),IY(20,40),DISCH(20,12),INDV,IND
      COMMON /CELL/ CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
C
      DO 60 I=1,NRCHS
      RCHSUM=0
      RLOSS=DISCH(I,MO)/LRCH(I)
      LNODE=LRCH(I)/NNODES(I)
        DO 50 J=1,NNODES(I)
        N=EX*(IY(I,J)-1)+IX(I,J)
        CREEK(N)=LNODE*RLOSS
        RCHSUM=RCHSUM+CREEK(N)
50      CONTINUE
        DISCH(I,MO)=RCHSUM
60    CONTINUE
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE SNOW                                                        *
C*****************************************************************************
C
C**** DETERMINES IF SNOW FALLS OR MELTS.  SNOMELT TEMPERATURE ASSUMED TO
C**** EQUAL 32 DEG. F.  SNOW WATER CONTENT ASSUMED AS .3*DEPTH.
C
      INTEGER YR,BEGYR
      COMMON /FREEZE/ SNOMLT(3),TMEAN(3),SNO(3)
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
C
      DO 60 I=1,3
      IF(KLIMAT(I).GT.0) THEN
      TMEAN(I)=TAVG(I,MO)
      GO TO 40
      END IF
      TMEAN(I)=(TMAX(I,32)+TMIN(I,32))/2
      TAVG(I,MO)=TMEAN(I)
40    CONTINUE
      IF(TMEAN(I).LE.26)THEN
      SNO(I)=SNO(I)+PTOT(I,MO)
      PTOT(I,MO)=0
      SNOMLT(I)=0
      ELSE IF (TMEAN(I).GT.26)THEN
      SNOMLT(I)=.3*SNO(I)
      SNO(I)=0
      END IF
60    CONTINUE
C
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE DDPTHSM                                                     *
C*****************************************************************************
C
C**** DETERMINES TOTAL AREA, EVAPOTRANSPIRATION
C**** AND PRECIPITATION FOR EACH IRRIGATED AREA
C
      INTEGER YR,BEGYR
      INTEGER EX,WYE
```

```
      CHARACTER INAME*40
      CHARACTER ICZNM*20
      CHARACTER CANALNAME*40
      DIMENSION WET(12)
      COMMON /DATES/ YR,MO,DAY(12),IYR,JYR,BEGYR
      COMMON /FREEZE/ SNOMLT(3),TMEAN(3),SNO(3)
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /CELL/ CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
      DATA WET /.3,.3,0.9,0,0.,0.,0.,0.,0.,0.,0.6,0.3/
C
C**** COMPUTE TOTALS
C
      DO 50 I=1,IQ
      IF(IZ(I).EQ.0.)GO TO 50
      J=CZ(I)
      IF(MO.EQ.1)CPAREA(J)=CPAREA(J)+AREA(I)*DELA(IZ(I))
      AREASM(IZ(I))=AREASM(IZ(I))+AREA(I)*DELA(IZ(I))
      TRAIN(IZ(I))=TRAIN(IZ(I))+((PTOT(IWST(J),MO)+SNOMLT(IWST(J)))
     &/12)*AREA(I)*DELA(IZ(I))
      ET2(IZ(I))=ET2(IZ(I))+(ETPCRP(J)+WET(MO))*AREA(I)*DELA(IZ(I))/12
50    CONTINUE
C
C**** CONVERT TOTALS TO DEPTHS
C
      DO 80 ID=1,NIDST
      TRAIN(ID)=TRAIN(ID)/AREASM(ID)
      ET2(ID)=ET2(ID)/AREASM(ID)
80    CONTINUE
C
      RETURN
      END
C
C
C*****************************************************************************
      SUBROUTINE IRRIGATION                                                 **
C*****************************************************************************
C                                                                           **
C**** COMPUTES APPLICATION RATES,                                           **
C**** SOIL MOISTURE, AND RECHARGE.                                          **
C                                                                           **
C*****************************************************************************
C
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      REAL KM
      REAL PSAT,LYRDP
      DIMENSION WI(7),RATIO(12)
      CHARACTER INAME*40
      CHARACTER ICZNM*20
      CHARACTER CANALNAME*40,IFMT*80,NAME1*60
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
```

```
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /SOILDAT/ SLNUM(10),LYRDP(10,6),WHC(10,6),BDLM(10,6)
      COMMON /SOILDAT/ THETR(10,6),PSAT(10,6),PDIS(10,6),NLYRS(10)
      COMMON /SOILDAT/ PHI(10,6),THETAWP(10,6)
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /FREEZE/ SNOMLT(3),TMEAN(3),SNO(3)
      COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
      COMMON /PTOPT/ NOPTN(4),IFMT,NAME1,IOUT
      DATA RATIO /0.,0.,0.,0.,.03,.17,.31,.25,.18,.06,0.,0./
      EXTRA = 0
C
C
C************************************************
C**** GET APPLICATION RATES IN EACH DISTRICT
C************************************************
C
      DO 40 ID=1,NIDST
      F1=FLAG(ID)
C
C**** IRRIGATION PROJECTS WITH RETURN FLOWS
C
      IF(F1.EQ.1.) THEN
      RNFF(ID)=RTNFL(MO,ID)*DIV(MO,ID)*(1-FARMWST(MO,ID))
      SUM2(MO,ID)=DIV(MO,ID)*RTNFL(MO,ID)*FARMWST(MO,ID)
      IF(SUM2(MO,ID).GE..2*DEL(MO,ID))SUM2(MO,ID)=0.
      D3=DEL(MO,ID)-SUM2(MO,ID)
      APPLRT(ID)=D3/AREASM(ID)
      IF(PUMPAGE(ID).EQ.0.)GO TO 30
        IF(PFLAG(ID).GT.0)THEN
        SUM9(MO,ID)=PUMPAGE(ID)*RATIO(MO)
        APPLRT(ID)=APPLRT(ID)+SUM9(MO,ID)/AREASM(ID)
        ELSE
        CALL PUMP(ID)
        END IF
C
C**** IRRIGATION PROJECTS WITH DIVERSIONS AND
C**** PROJECT AND FARM RUNOFF BUT NO DELIVERY RECORDS.
C
      ELSE IF(F1.EQ.-1.)THEN
      RNFF(ID)=RTNFL(MO,ID)*DIV(MO,ID)*(1-FARMWST(MO,ID))
      SUM2(MO,ID)=DIV(MO,ID)*RTNFL(MO,ID)*FARMWST(MO,ID)
      DEL(MO,ID)=DIV(MO,ID)-SEEPSUM(ID)-RNFF(ID)
      IF(SUM2(MO,ID).GE..2*DEL(MO,ID))SUM2(MO,ID)=0.
      IF(DEL(MO,ID).LT.0.)DEL(MO,ID)=ABS(DEL(MO,ID))
      D3=DEL(MO,ID)-SUM2(MO,ID)
      APPLRT(ID)=D3/AREASM(ID)
      IF(PUMPAGE(ID).EQ.0.)GO TO 30
        IF(PFLAG(ID).GT.0)THEN
        SUM9(MO,ID)=PUMPAGE(ID)*RATIO(MO)
        APPLRT(ID)=APPLRT(ID)+SUM9(MO,ID)/AREASM(ID)
        ELSE
        CALL PUMP(ID)
```

```
        END IF
C
C**** IRRIGATION PROJECTS WITH APPLICATION RATES
C
      ELSE IF(F1.EQ.6.)THEN
      APPLRT(ID)=DEL(MO,ID)
      DEL(MO,ID)=APPLRT(ID)*AREASM(ID)
      IF(PUMPAGE(ID).EQ.0.)GO TO 30
        IF(PFLAG(ID).GT.0)THEN
        SUM9(MO,ID)=PUMPAGE(ID)*RATIO(MO)
        APPLRT(ID)=APPLRT(ID)+SUM9(MO,ID)/AREASM(ID)
        ELSE
        CALL PUMP(ID)
        END IF
C
C**** IRRIGATION PROJECTS WITH NO RUNOFF AND/OR  GROUNDWATER PUMPAGE.
C
      ELSE IF(F1.EQ.2. .OR. F1.EQ.3. .OR. F1.EQ.5.)THEN
      APPLRT(ID)=DEL(MO,ID)/AREASM(ID)
      IF(PUMPAGE(ID).EQ.0.)GO TO 30
        IF(PFLAG(ID).GT.0)THEN
        SUM9(MO,ID)=PUMPAGE(ID)*RATIO(MO)
        APPLRT(ID)=APPLRT(ID)+SUM9(MO,ID)/AREASM(ID)
        ELSE
        CALL PUMP(ID)
        END IF
C
C**** IRRIGATION PROJECTS WITH NO DELIVERY RECORDS AND NO RETURN FLOW.
C
      ELSE IF(F1.EQ.-3.)THEN
      DEL(MO,ID)=DIV(MO,ID)-SEEPSUM(ID)
      IF(DEL(MO,ID).LT.0.)DEL(MO,ID)=ABS(DEL(MO,ID))
      APPLRT(ID)=DEL(MO,ID)/AREASM(ID)
      IF(PUMPAGE(ID).EQ.0.)GO TO 30
        IF(PFLAG(ID).GT.0)THEN
        SUM9(MO,ID)=PUMPAGE(ID)*RATIO(MO)
        APPLRT(ID)=APPLRT(ID)+SUM9(MO,ID)/AREASM(ID)
        ELSE
        CALL PUMP(ID)
        END IF
C
C**** IRRIGATION PROJECTS WITH NO RECORDS
C
      ELSE IF(F1.EQ.0.)THEN
      APPLRT(ID)=APPLRT(IDNO(ID))-SUM9(MO,IDNO(ID))/AREASM(IDNO(ID))
      DEL(MO,ID)=APPLRT(ID)*AREASM(ID)
      IF(PUMPAGE(ID).EQ.0.)GO TO 30
        IF(PFLAG(ID).GT.0)THEN
        SUM9(MO,ID)=PUMPAGE(ID)*RATIO(MO)
        APPLRT(ID)=APPLRT(ID)+SUM9(MO,ID)/AREASM(ID)
        ELSE
        CALL PUMP(ID)
        END IF
C
      END IF
C
30    CONTINUE
C
C**** FINISHED COMPUTING APPLICATION RATES
C
C**** INITIALIZE AVAILABLE SOIL MOISTURE
C
      AM(ID)=0
C
40    CONTINUE
C
C**** LOOP TO DETERMINE RECHARGE IN EACH CELL FROM IRRIGATION
C
      DO 400 N=1,IQ
      IF(IZ(N).EQ.0)GO TO 400
```

```
      DO 60 L=1,7
      WI(L)=0
60    CONTINUE
      J = CZ(N)
      JSZ=SZ(N)
C
C**** COMPUTE NUMBER OF 10 INCH SOIL LAYERS IN ROOT ZONE.
C
      IF(ETPCRP(J).EQ.0.)RTDPTH(J)=0.
      LAYERS=ANINT(1.5*RTDPTH(J)*1.2)
      IF(LAYERS.LT.1 .AND. RTDPTH(J).GT.0)LAYERS = 1
      IF(LAYERS.GT.NLYRS(JSZ))LAYERS=NLYRS(JSZ)
      IF(ET2(IZ(N)).GT.0. .AND. LAYERS.EQ.0)LAYERS=1
C
C**** COMPUTE WATER APPLIED TO EACH CELL
C
      WI(1)=APPLRT(IZ(N))*12+SNOMLT(IWST(J))+PTOT(IWST(J),MO)
      ET3=ET2(IZ(N))*12
      GO TO 160
C
C**** LOOP TO DETERMINE SOIL MOISTURE IN EACH 10 INCH SOIL LAYER
C
80    CONTINUE
C
C****PRINT SOIL MOISTURE LEVEL FOR THE CHOSEN CELL IF SPECIFIED.
C
      IF(NOPTN(2).EQ.N)THEN
      WRITE(61,81)MO,JSZ,N,IZ(N)
81    FORMAT(/7X,'Soil moisture content at beginning of month ',I2,
     & /7X,'Soil zone number ',I2,/7X,'Cell number ',I4,' in',
     & ' irrigation code no. ',I2//)
      END IF
      DO 100 L=1,NLYRS(JSZ)
C
C**** WRITE SOIL MOISTURE LEVEL IN CHOSEN CELL IF SPECIFIED.
C
      IF(NOPTN(2).EQ.N)THEN
      WRITE(61,83)L,THETA(N,L)
83    FORMAT(7X,'Layer',3X,'Moisture Content'/19X,'(in/in)',/
     & 8X,I2,8X,F5.3)
      END IF
      IF(WI(L).LE.0.) THEN
      WI(L+1)=0
      PERC=0
      GO TO 100
      END IF
C
C**** COMPUTE TOTAL DEPTH OF WATER THAT CAN BE ADDED TO SOIL LAYER.
C
      DPTH=(PHI(JSZ,L)-THETA(N,L))*10
C
C**** REDISTRIBUTE INFILTRATED WATER.
C
      IF(DPTH.LT.0.0)THEN
      THETA(N,L)=PHI(JSZ,L)
      PERC=ABS(DPTH)
      WI(L+1)=PERC+WI(L)
      GOTO 100
      ELSE IF(DPTH.GE.0.)THEN
        IF(DPTH.LE.WI(L))THEN
        DTHETA=PHI(JSZ,L)-THETA(N,L)
        WI(L)=WI(L)-(DTHETA)*10
        THETA(N,L)=THETA(N,L)+DTHETA
        WI(L+1)=WI(L)
        ELSE
        CALL UNSAT(WI(L),N,JSZ,J,L,PERC)
        WI(L+1)=PERC
        END IF
      END IF
100   CONTINUE
```

```
      RCHG(N)=WI(L)
      GO TO 300
C
C**** SATISFY EVAPOTRANSPIRATION WITH STORED SOIL MOISTURE.
C
160   CONTINUE
C
C**** COMPUTE TOTAL AVAILABLE MOISTURE IN ROOT ZONE.
C
      TAM=0
        DO 180 L=1,LAYERS
        TAM=TAM+(THETA(N,L)-THETAWP(JSZ,L))*10
        THETA(N,L)=THETAWP(JSZ,L)
180     CONTINUE
C
C**** DECREASE POTENTIAL ET (AC-FT/AC) AND GO TO NEXT CELL.
C
      IF(ET3.GT.TAM)THEN
      SOURCE(N)=(ET3-TAM)/12
      GO TO 80
C
C**** COMPUTE TOTAL LEFTOVER WATER AFTER ET.
C
      ELSE
      EXTRA=(TAM-ET3)
      END IF
C
C****** REFILL SOIL MOISTURE RESERVIOR OF EACH LAYER WITH ANY
C****** LEFTOVER WATER AFTER ET IS SUBTRACTED.
C
        DO 220 L=1,LAYERS
        THETA(N,L)=THETAWP(JSZ,L)+EXTRA/(10*LAYERS)
220     CONTINUE
C
C**** ALL THROUGH.  GO APPLY WATER TO CELL.
C
      GO TO 80
300   CONTINUE
C
C****** TOTAL AVAILABLE MOISTURE IN EACH IRRIGATION PROJECT OR AREA.
C
      DO 360 L=1,LAYERS
C      DEPLT=THETAWP(JSZ,L)+WHC(JSZ,L)
C      IF(THETA(N,L).GT.DEPLT)THEN
C      AM(IZ(N))=AM(IZ(N))+(WHC(JSZ,L))*AREA(N)*DELA(IZ(N))*10/12
C      ELSE
      AM(IZ(N))=AM(IZ(N))+(THETA(N,L)-THETAWP(JSZ,L))*AREA(N)
     &         *DELA(IZ(N))*10/12
C      END IF
360   CONTINUE
C
        DO 380 L=1,NLYRS(JSZ)
        TM1(IZ(N))=(((THETA(N,L)-THETAWP(JSZ,L))*10)/12)*AREA(N)
     &  *DELA(IZ(N)) +TM1(IZ(N))
380     CONTINUE
C
400   CONTINUE
C
      RETURN
      END
C
C***************************************************************************
      SUBROUTINE MASSBAL                                                  **
C***************************************************************************
C                                                                         **
C**** SUMS IRRIGATION PROJECT WATER BALANCE COMPONENTS,                   **
C**** ADJUSTS CANAL SEEPAGE IF BALANCE IS OFF, COMPUTES                   **
C**** CROP CONSUMPTIVE USE.                                               **
C                                                                         **
C***************************************************************************
```

```
C
      REAL PSAT,LYRDP
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      CHARACTER INAME*40
      CHARACTER STA*20
      CHARACTER ICZNM*20
      CHARACTER CANALNAME*40
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /SCNDPMT/ RHMIN(3,12),SOLAR(3,12),DWIND(3,12),SRTO(3,12)
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /CROPS/ NMCRP(15,6),PCTA(15,6),MPL(15,6),NDPL(15,6)
      COMMON /CROPS/ MEC(15,6),NDEC(15,6),MHV(15,6),NDHV(15,6)
      COMMON /CROPS/ NDCUT(4,15,6),MCUT(4,15,6),ET(12,15,6)
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /WEATHER/ STA(3),LAT(3),LON(3),ALTF(3),ARIDITY(3)
      COMMON /WEATHER/ NAOO(3)
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /CELL/ CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /SOILDAT/ SLNUM(10),LYRDP(10,6),WHC(10,6),BDLM(10,6)
      COMMON /SOILDAT/ THETR(10,6),PSAT(10,6),PDIS(10,6),NLYRS(10)
      COMMON /SOILDAT/ PHI(10,6),THETAWP(10,6)
      COMMON /FREEZE/ SNOMLT(3),TMEAN(3),SNO(3)
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
C
        DO 200 ID=1,NIDST
        ET2(ID)=ET2(ID)*AREASM(ID)
        IF(FLAG(ID).EQ.0 .OR. FLAG(ID).EQ.2 .OR. FLAG(ID).EQ.5 .OR.
     &  FLAG(ID).EQ.6) GOTO 200
C
C****** COMPUTE RESIDUAL FROM WATER BALANCE.
C
        S1=DIV(MO,ID)-DEL(MO,ID)-SEEPSUM(ID)-LATLOSS(ID)-RNFF(ID)
C
C******** WRITE WARNING IF WATER BALANCE DOESNT BALANCE
C
          IF(INT(S1).NE.0)THEN
          WRITE(1,35)S1,IDIST(ID),MO,YR
35        FORMAT(/'WARNING: Canal seepage to high (-) or low (+) by',I5,
     &          ' acre feet',/'in irrig. proj. code no.',I2,'.',/'Mont'
     &          'h is ',I2,', year is ',I4,'.',/'Program adjusted retu'
     &          ,'rn flows and/or seepage rates.',/)
          ELSE
          GO TO 200
          END IF
C
C******** CORRECT CANAL SEEPAGE...
C
          IF(FLAG(ID).EQ.1..OR.FLAG(ID).EQ.4 .OR. FLAG(ID).EQ.-1)THEN
            IF(S1.LT.0.)THEN
              DO 40 KOUNT2=1,300
              N=NSPND(ID,KOUNT2)
              IF(N.EQ.0)GOTO 40
```

```
              SEEPAG(N)=SEEPAG(N)+(SEEPAG(N)/SEEPSUM(ID))*S1
 40           CONTINUE
            SEEPSUM(ID)=SEEPSUM(ID)+S1
            ELSE
              IF(SEEPSUM(ID).EQ.0.)THEN
              SEEPSUM(ID)=SEEPSUM(ID)+S1
              LATLOSS(ID)=LATLOSS(ID)+S1
              GO TO 116
              END IF
            S2=S1*.50
            S1=S1-S2
            RNFF(ID)=RNFF(ID)+S2
              DO 60 KOUNT2=1,300
              N=NSPND(ID,KOUNT2)
              IF(N.EQ.0)GOTO 60
              SEEPAG(N)=SEEPAG(N)+(SEEPAG(N)/SEEPSUM(ID))*S1
 60           CONTINUE
            SEEPSUM(ID)=SEEPSUM(ID)+S1
            END IF
          ELSE IF(FLAG(ID).EQ.3. .OR. FLAG(ID).EQ.-3)THEN
            IF(SEEPSUM(ID).EQ.0.)THEN
            SEEPSUM(ID)=SEEPSUM(ID)+S1
            LATLOSS(ID)=LATLOSS(ID)+S1
            GO TO 116
            END IF
          DO 80 KOUNT2=1,300
          N=NSPND(ID,KOUNT2)
          IF(N.EQ.0)GOTO 80
          SEEPAG(N)=SEEPAG(N)+(SEEPAG(N)/SEEPSUM(ID))*S1
 80       CONTINUE
          SEEPSUM(ID)=SEEPSUM(ID)+S1
          END IF
         GO TO 100
C
C********** WRITE WARNING IF THERES EXCESS WATER AND NO CANAL SEEPAGE.
C
116     WRITE(1,*)'Warning:  canal diversion file contains zero',
     &            ' diversions this month but farm diversions',
     &            ' are not.  Change diversions.  Program added',
     &            ' water to deep-seepage.'
100     CONTINUE
        IF(LATLOSS(ID).EQ.0.0)THEN
        UNIFM(ID)=0.0
        GO TO 200
        END IF
        UNIFM(ID)=LATLOSS(ID)/AREASM(ID)
200     CONTINUE
C
C**** LOOP THROUGH CELLS TO OBTAIN RECHARGE AND IRRIGATED AREA
C**** WATER BALANCE COMPONENTS
C
      DO 300 N=1,IQ
C
C****** INCLUDE CREEK SEEPAGE IN CELL RECHARGE IF NOT IN IRRIGATION AREA
C
      IF(IZ(N).EQ.0)THEN
        IF(CREEK(N).GT.0.)THEN
        RCHG(N)=CREEK(N)
        END IF
        GOTO 300
      END IF
      J=CZ(N)
      JSZ=SZ(N)
C
C**** SUM TOTAL DEEP PERCOLATION FOR EACH IRRIGATED AREA
C
      DEEPERC(IZ(N))=DEEPERC(IZ(N))+RCHG(N)*AREA(N)*DELA(IZ(N))/12
C
C****  COMPUTE TOTAL RECHARGE IN EACH CELL FOR YEAR AND MONTH
C
```

```
      RCHG(N)=(RCHG(N)/12+UNIFM(IZ(N)))*AREA(N)*DELA(IZ(N))+CREEK(N)
     &+SEEPAG(N)
      SUM(N)=SUM(N)+RCHG(N)
C
C**** COMPUTE TOTAL CONSUMPTIVE USE FOR EACH AREA
C
      ET2(IZ(N))=ET2(IZ(N))-SOURCE(N)*AREA(N)*DELA(IZ(N))
      SUM10(MO,IZ(N))=SUM10(MO,IZ(N))+(ETPCRP(J)/12)*AREA(N)
     &*DELA(IZ(N))
300   CONTINUE
C
C**** COMPUTE CHANGE IN SOIL MOISTURE FOR EACH IRRIGATED AREA
C
      DO 400 ID=1,NIDST
      DTM=TM1(ID)-TM(ID)*DELA(ID)
C
C**** COMPUTE TOTAL PRECIPITATION IN EACH AREA
C
      TRAIN(ID)=TRAIN(ID)*AREASM(ID)
C
C**** ADJUST ET IF ITS LESS THAN 0, (ROUNDING ERROR)
C
      IF(ET2(ID).LT.0)ET2(ID)=0
C
C**** COMPUTE RESIDUAL FOR SOIL MOISTURE BALANCE.
C
      D3=APPLRT(ID)*AREASM(ID)
      S3=TRAIN(ID)+D3-DEEPERC(ID)-ET2(ID)-DTM
C
C**** WRITE WARNING WHEN SOIL-MOIST. BALANCE DOESNT BALANCE.
C
      IF(ABS(S3).GT.20.)THEN
      WRITE(1,336)S3,ID,MO
336   FORMAT(/'Warning:  soil moisture balance off by',I6,' acre feet',
     &       /'Irrigation code no.',I2,', month is ',I2,/'Programs no',
     &       't correcting it.'/)
      END IF
C
C**** WRITE WATERBALANCE INFORMATION INTO ARRAY FOR YEARLY OUTPUT
C
      SUM8(MO,ID)=DTM
      SUM7(MO,ID)=ET2(ID)
      SUM6(MO,ID)=DEEPERC(ID)
      SUM5(MO,ID)=SEEPSUM(ID)+LATLOSS(ID)
      SUM4(MO,ID)=TRAIN(ID)
      SUM3(MO,ID)=RNFF(ID)
C
C**** SOIL MOISTURE FOR NEXT MONTHS SIMULATION.
C
      TM(ID)=TM1(ID)/DELA(ID)
400   CONTINUE
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE OUTPUT                                                     *
C*****************************************************************************
C
      INTEGER EX,WYE
      INTEGER YR,BEGYR
      DIMENSION S(12),SY(12)
      CHARACTER INAME*40,ICZNM*20,NAMCR*16
      CHARACTER CANALNAME*40,IFMT*80,NAME1*60,STA*20
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
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      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /SEEPDAT/ CNLDFLG(5,6),NCL,NRCHS,LRCH(20),NNODES(20)
      COMMON /SEEPDAT/ IX(20,40),IY(20,40),DISCH(20,12),INDV,IND
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /CROPS/ NMCRP(15,6),PCTA(15,6),MPL(15,6),NDPL(15,6)
      COMMON /CROPS/ MEC(15,6),NDEC(15,6),MHV(15,6),NDHV(15,6)
      COMMON /CROPS/ NDCUT(4,15,6),MCUT(4,15,6),ET(12,15,6)
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /WEATHER/ STA(3),LAT(3),LON(3),ALTF(3),ARIDITY(3)
      COMMON /WEATHER/ NAOO(3)
      COMMON /SCNDPMT/ RHMIN(3,12),SOLAR(3,12),DWIND(3,12),SRTO(3,12)
      COMMON /PTOPT/ NOPTN(4),IFMT,NAME1,IOUT
      DIMENSION NAMCR(15)
      DATA NAMCR  /'ALFLAFA HAY','BEANS','CORN','GRASS PASTURE',
     &             'PEAS','POTATOES','SUGAR BEETS','SPRING GRAIN',
     &             'WINTER GRAIN','SWEET CORN','ALFALFA SEED',
     &             'FRUIT TREES','SMALL VEGETABLES','ONIONS','HOPS'/
C
C
C**** WRITE OUT MONTHLY RECHARGE IF SPECIFIED.
C
      IF(NOPTN(1).GT.0)THEN
      WRITE(19,9)MO,YR
9     FORMAT(I2,/I4)
      DO 20 J=1,WYE
      N=EX*(J-1)
      WRITE(19,IFMT)(RCHG(N+I),I=1,EX)
20    CONTINUE
      END IF
C
C**** WRITE YEARLY RESULTS.
C
      IF(MO.EQ.12)THEN
C
C**** WRITE YEARLY RECHARGE IF SPECIFIED.
C
      IF(NOPTN(4).GT.0)THEN
      DO 25 J=1,WYE
      N=EX*(J-1)
      WRITE(55,IFMT)(SUM(N+I),I=1,EX)
25    CONTINUE
      END IF
C**********************
C**** OUTPUT RESULTS **
C**********************
C
      WRITE(IOUT,32)NAME1,YR
32    FORMAT(1H1//30X,A60,/30X,'Summary for simulation year ',I4/)
C
C**** WEATHER SUMMARIES....
C
      DO 40 J=1,3
      WRITE(IOUT,33)STA(J),NAOO(J),LAT(J),ALTF(J),ARIDITY(J)
33    FORMAT(/30X,'Weather Station Monthly Summaries',/7X,'Station ',
     &     A20,3X,'NAOO No.',I7,4X,'Lat',I9,4X,'Elev.',I5,3X,'Aridity',
     &     '(%)',I4,/24X,'Jan',4X,'Feb',4X,'Mar',4x,'Apr',4x,'May',4X,
     &     'Jun',4X,'Jul',4X,'Aug',4X,'Sep',4X,'Oct',4X,'Nov',4X,'Dec')
```

```
      WRITE(IOUT,34)(TAVG(J,K),K=1,12),(PTOT(J,K),K=1,12),
     &              (RHMIN(J,K),K=1,12),(SOLAR(J,K),K=1,12),
     &              (DWIND(J,K),K=1,12),(SRTO(J,K),K=1,12)
 34   FORMAT(' Mean Temperature',4X,12(2X,F5.2),/' Precipitaion (in.)  '
     &      ,12(2X,F5.2),/' Min. Rel. Humidity',2X,12(2X,F5.2),/
     &      ' Solar Rad. (mm/day) ',12(2X,F5.2),/' Daily Wind (m/sec)',
     &      2X,12(2X,F5.2),/' Sunshine n/N',8X,12(2X,F5.3))
 40   CONTINUE
C
C**** CROP ET...
C
      WRITE(IOUT,41)
 41   FORMAT(1H1//30X,'MONTHLY POTENTIAL EVAPOTRRANSPIRATION'/40X,
     &      'Acre feet')
      DO 60 JKROP=1,NOAREAS
      J=JCPZN(JKROP)
      WRITE(IOUT,42)ICZNM(J),J,CPAREA(J),ELV(J),STA(IWST(J))
 42   FORMAT(/7X,'Area Name  ',A20,3X,'  Zone No.',I2,'  Acreage',I7,
     &      '    Elev.',I5,'    Weather Sta.  ',A20,/101X,'Month/day',/
     &      5X,'Crop Name',4X,'Area',4X,
     &      'Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep',
     &      '   Oct   Nov   Dec  Plant E.Cov  Hvst  Alfalfa Cuttings')
        DO 50 JC=1,NCRPS(J)
        CROPAREA=CPAREA(J)*PCTA(JC,J)/100
        IF(NMCRP(JC,J).EQ.1)THEN
        WRITE(IOUT,43)NAMCR(NMCRP(JC,J)),CROPAREA,(ET(K,JC,J),K=1,12),
     &                MPL(JC,J),NDPL(JC,J),MEC(JC,J),NDEC(JC,J),
     &                MHV(JC,J),NDHV(JC,J),(MCUT(I,JC,J),
     &                NDCUT(I,JC,J),I=1,3)
 43     FORMAT(1X,A16,I5,1X,12(1X,I5),2X,6(I2,'/',I2,1X))
        ELSE
        WRITE(IOUT,44)NAMCR(NMCRP(JC,J)),CROPAREA,(ET(K,JC,J),K=1,12),
     &                MPL(JC,J),NDPL(JC,J),MEC(JC,J),NDEC(JC,J),
     &                MHV(JC,J),NDHV(JC,J)
 44     FORMAT(1X,A16,I5,1X,12(1X,I5),2X,3(I2,'/',I2,1X))
        END IF
 50     CONTINUE
 60   CONTINUE
C
C**** SEASONAL WATER BALANCES FOR IRRIGATION DISTRICTS...
C
C
      WRITE(IOUT,95)
 95   FORMAT(1H1)
      PAG=0
      DO 200 ID=1,NIDST
      PAG=PAG+1
C
        DO 100 K=1,12
        S(K)=0
        SY(K)=0
 100    CONTINUE
C
 103  FORMAT(1H1)
      IF(PAG.EQ.4 .OR. PAG.EQ.7)WRITE(IOUT,103)
      WRITE(IOUT,110)YR,INAME(ID),AREASM(ID)
 110  FORMAT(/41X,I4,' Irrigated Area Water Balance  (Acre-feet)',/
     &41X,A40,/41X,'Irrigated Area  ',I6,' Acres',/33X,'Jan   Feb   Mar'
     &,'  Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec',
     &4X,'Season Total',/111X,'AF/Acre')
C
        DO 120 K=1,12
        S(2)=S(2)+SUM2(K,ID)
        S(3)=S(3)+SUM3(K,ID)
        S(4)=S(4)+SUM4(K,ID)
        S(5)=S(5)+SUM5(K,ID)
        S(6)=S(6)+SUM6(K,ID)
        S(7)=S(7)+SUM7(K,ID)
        S(8)=S(8)+SUM8(K,ID)
        S(9)=S(9)+SUM9(K,ID)
```

```
      S(10)=S(10)+SUM10(K,ID)
      S(11)=S(11)+DEL(K,ID)
      S(1)=S(1)+DIV(K,ID)
120   CONTINUE
C
        DO 140 K=1,12
        SY(K)=S(K)/AREASM(ID)
140     CONTINUE
C
      WRITE(IOUT,162)(DIV(K,ID),K=1,12),S(1),SY(1)
162   FORMAT(' River (Res.) Diversion',7X,12I6,I8,F8.5)
      WRITE(IOUT,163)(DEL(K,ID),K=1,12),S(11),SY(11)
163   FORMAT(' Farm Deliveries',14X,12I6,I8,F8.5)
      WRITE(IOUT,164)(SUM9(K,ID),K=1,12),S(9),SY(9)
164   FORMAT(' Groundwater pumpage',10X,12I6,I8,F8.5)
      WRITE(IOUT,165)(SUM7(K,ID),K=1,12),S(7),SY(7)
165   FORMAT(' Actual Evapotranspiration',4X,12I6,I8,F8.5)
      WRITE(IOUT,166)(SUM8(K,ID),K=1,12),S(8),SY(8)
166   FORMAT(' Soil Moisture Change',9X,12I6,I8,F8.5)
      WRITE(IOUT,167)(SUM6(K,ID),K=1,12),S(6),SY(6)
167   FORMAT(' Deep Percolation',13X,12I6,I8,F8.5)
      WRITE(IOUT,168)(SUM5(K,ID),K=1,12),S(5),SY(5)
168   FORMAT(' Seepage Losses',15X,12I6,I8,F8.5)
      WRITE(IOUT,169)(SUM3(K,ID),K=1,12),S(3),SY(3)
169   FORMAT(' Return Flows',17X,12I6,I8,F8.5)
      WRITE(IOUT,170)(SUM4(K,ID),K=1,12),S(4),SY(4)
170   FORMAT(' Total Precipitation',10X,12I6,I8,F8.5)
      WRITE(IOUT,171)(SUM2(K,ID),K=1,12),S(2),SY(2)
171   FORMAT(' Farm Runoff',18X,12I6,I8,F8.5)
      WRITE(IOUT,172)(SUM10(K,ID),K=1,12),S(10),SY(10)
172   FORMAT(' Crop Evapotranspiration',6X,12I6,I8,F8.5)
C
200   CONTINUE
C
C**** RIVER AND CREEK REACHES.
C
      WRITE(IOUT,206)
206   FORMAT(1H1,/30X,'River and Creek Losses (acre-feet)',
     &       //8X,'Length of'/' Reach  Reach (ft)',4X,
     &       'Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep',
     &       '   Oct   Nov   Dec')
      DO 210 I=1,NRCHS
      WRITE(IOUT,207)I,LRCH(I),(DISCH(I,K),K=1,12)
207   FORMAT(I5,4X,I6,5X,12(I5,1X))
210   CONTINUE
C
211   FORMAT(/20(I5),/)
212   FORMAT(/4X,20(I5),/)
C
C
C**** WRITE OUT RECHARGE MAP IF SPECIFIED.
C
213   FORMAT(/20X,A60,//20X,'Annual Recharge in Each Cell for ',I4,//)
      IF(NOPTN(3).GT.0)THEN
      WRITE(49,213)NAME1,YR
      WRITE(49,212)(KG,KG=1,20)
        DO 240 JG=1,65
        NM=80*(JG-1)
        WRITE(49,221)JG,(SUM(NM+KG),KG=1,20)
240     CONTINUE
      WRITE(49,212)(KG,KG=21,40)
        DO 241 JG=1,65
        NM=80*(JG-1)
        WRITE(49,221)JG,(SUM(NM+KG),KG=21,40)
241     CONTINUE
      WRITE(49,212)(KG,KG=41,60)
        DO 242 JG=1,65
        NM=80*(JG-1)
        WRITE(49,221)JG,(SUM(NM+KG),KG=41,60)
242     CONTINUE
```

```
      WRITE(49,212)(KG,KG=61,80)
        DO 243 JG=1,65
        NM=80*(JG-1)
        WRITE(49,221)JG,(SUM(NM+KG),KG=61,80)
243     CONTINUE
      END IF
C
221     FORMAT(I2,2X,20(I5))
220     FORMAT(20(I5))
C
      DO 380 I=1,NCL
      KD=KAND(I)
      IF(YR.EQ.BEGYR)THEN
        DO 360 IC=1,KCANL(KD)
        WRITE(IDC(I),300)CANALNAME(KD,IC),TOTLNGTH(KD,IC),TOTWP(KD,IC),
     &  PERM(KD,IC)
300     FORMAT(///A40,/'Length ',I3,' Miles',/ 'Total wetted perimeter',
     &  I8,' Acres',/'Seepage coefficient',F6.3,' feet/day',//)
360     CONTINUE
      END IF
C
      WRITE(IDC(I),365)YR
365   FORMAT(///40X,I4,'   Canal Seepage Losses  (Acre-feet)',//45X,
     &'April',7X,'May',6X,'June',6X,'July',5X,'August',3X,'September',
     &2X,'October'/)
C
        DO 370 IC=1,KCANL(KD)
        WRITE(IDC(I),367)CANALNAME(KD,IC),(QLOSS(K,KD,IC),K=4,10)
367     FORMAT(A40,7I10)
370     CONTINUE
380   CONTINUE
C
C**** CALL SUBROUTINE TO OUTPUT A PSUEDO PLOT FILE IF SPECIFIED.
C
      END IF
C
      RETURN
      END
C
C*******************************************
      SUBROUTINE ZERO1
C*******************************************
C
      REAL PSAT,LYRDP
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      INTEGER ROW, COL
      CHARACTER INAME*40
      CHARACTER CNLDTL*40
      CHARACTER TNAME*40,PNAME*40,STA*20,NAME*40
      CHARACTER ICZNM*20,CNLDVF*40
      CHARACTER CANALNAME*40
      COMMON /DATES/ YR,MO,DAY(12),IYR,JYR,BEGYR
      COMMON /SCNDPMT/ RHMIN(3,12),SOLAR(3,12),DWIND(3,12),SRTO(3,12)
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /CROPS/ NMCRP(15,6),PCTA(15,6),MPL(15,6),NDPL(15,6)
      COMMON /CROPS/ MEC(15,6),NDEC(15,6),MHV(15,6),NDHV(15,6)
      COMMON /CROPS/ NDCUT(4,15,6),MCUT(4,15,6),ET(12,15,6)
      COMMON /WEATHER/ STA(3),LAT(3),LON(3),ALTF(3),ARIDITY(3)
      COMMON /WEATHER/ NAOO(3)
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
```

```
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /SOILDAT/ SLNUM(10),LYRDP(10,6),WHC(10,6),BDLM(10,6)
      COMMON /SOILDAT/ THETR(10,6),PSAT(10,6),PDIS(10,6),NLYRS(10)
      COMMON /SOILDAT/ PHI(10,6),THETAWP(10,6)
      COMMON /SEEPDAT/ CNLDFLG(5,6),NCL,NRCHS,LRCH(20),NNODES(20)
      COMMON /SEEPDAT/ IX(20,40),IY(20,40),DISCH(20,12),INDV,IND
      COMMON /SEEPDAT/ CNLDTL(6),CNLDVF(6),IRCLDV(6),CNLFLG(6)
      COMMON /SEEPDAT/ TRBFL(8),TRBQFL(8),BGRC(6),JBGRC(9)
      COMMON /WEATHDAT/ INTN,TNAME,IRECT,INTX,PNAME,IRECP,NWST
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
      COMMON /FREEZE/ SNOMLT(3),TMEAN(3),SNO(3)
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /BLOCK/ T1(6),KT(6)
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
      DATA NSPND /1500*0/
C
      DO 95 N=1,IQ
      SUM(N)=0
95    CONTINUE
C
      DO 40 J=1,NOAREAS
      CPAREA(J)=0
40    CONTINUE
      DO 69 K=1,12
        DO 50 KD=1,5
          DO 65 IC=1,6
          TOTWP(KD,IC)=0
          TOTLNGTH(KD,IC)=0
          QLOSS(K,KD,IC)=0
65        CONTINUE
50      CONTINUE
        DO 68 ID=1,NIDST
        DEL(K,ID)=0
        DIV(K,ID)=0
        SUM2(K,ID)=0
        SUM3(K,ID)=0
        SUM4(K,ID)=0
        SUM5(K,ID)=0
        SUM6(K,ID)=0
        SUM7(K,ID)=0
        SUM8(K,ID)=0
        SUM9(K,ID)=0
        SUM10(K,ID)=0
        SUM11(K,ID)=0
68      CONTINUE
69    CONTINUE
C
      RETURN
      END
C
C*****************************************
      SUBROUTINE ZERO2
C*****************************************
C
      REAL PSAT,LYRDP
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      INTEGER ROW, COL
      CHARACTER INAME*40
      CHARACTER CNLDTL*40
      CHARACTER TNAME*40,PNAME*40,STA*20,NAME*40
      CHARACTER ICZNM*20,CNLDVF*40
      CHARACTER CANALNAME*40
```

```
      COMMON /DATES/ YR,MO,DAY(12),IYR,JYR,BEGYR
      COMMON /SCNDPMT/ RHMIN(3,12),SOLAR(3,12),DWIND(3,12),SRTO(3,12)
      COMMON /CROPZN/ NOAREAS,NCRPS(6),RTDPTH(6),ETPCRP(6),CPAREA(6)
      COMMON /CROPZN/ ICZNM(6),JCPZN(6),IWST(6),ELV(6)
      COMMON /CLIMATE/ TMAX(3,32),TMIN(3,32),PRECIP(3,31),JNDAY
      COMMON /CLIMATE/ TAVG(3,12), PTOT(3,12), KLIMAT(3),IR2(3),IR3(3)
      COMMON /CANAL/ KOUNT,IROW(210),ICOL(210),TMPSC(12,6,4)
      COMMON /CANAL/ WID(210),DXLEN(210),PERM(5,6),QLOSS(12,5,6)
      COMMON /CANAL/ KCANL(5),INKLD(5,6),CANALNAME(5,6),IDC(4)
      COMMON /CANAL/ TOTLNGTH(5,6),TOTWP(5,6),KNLNUM(5,6)
      COMMON /CANAL/ QM,QD(5,31),QBM(5,2),BDAY(5,2),NDAY,QMAX(4)
      COMMON /CANAL/ LATLOSS(9),SEEPAG(5200),SEEPSUM(9),KAND(5)
      COMMON /CROPS/ NMCRP(15,6),PCTA(15,6),MPL(15,6),NDPL(15,6)
      COMMON /CROPS/ MEC(15,6),NDEC(15,6),MHV(15,6),NDHV(15,6)
      COMMON /CROPS/ NDCUT(4,15,6),MCUT(4,15,6),ET(12,15,6)
      COMMON /WEATHER/ STA(3),LAT(3),LON(3),ALTF(3),ARIDITY(3)
      COMMON /WEATHER/ NAOO(3)
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /SOILDAT/ SLNUM(10),LYRDP(10,6),WHC(10,6),BDLM(10,6)
      COMMON /SOILDAT/ THETR(10,6),PSAT(10,6),PDIS(10,6),NLYRS(10)
      COMMON /SOILDAT/ PHI(10,6),THETAWP(10,6)
      COMMON /SEEPDAT/ CNLDFLG(5,6),NCL,NRCHS,LRCH(20),NNODES(20)
      COMMON /SEEPDAT/ IX(20,40),IY(20,40),DISCH(20,12),INDV,IND
      COMMON /SEEPDAT/ CNLDTL(6),CNLDVF(6),IRCLDV(6),CNLFLG(6)
      COMMON /SEEPDAT/ TRBFL(8),TRBQFL(8),BGRC(6),JBGRC(9)
      COMMON /WEATHDAT/ INTN,TNAME,IRECT,INTX,PNAME,IRECP,NWST
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
      COMMON /FREEZE/ SNOMLT(3),TMEAN(3),SNO(3)
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /BLOCK/ T1(6),KT(6)
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
C
      DO 60 N=1,IQ
      SEEPAG(N)=0
      SOURCE(N)=0
      RCHG(N)=0
      CREEK(N)=0

60    CONTINUE
C
      DO 65 ID=1,NIDST
      UNIFM(ID)=0
      TRAIN(ID)=0
      ET2(ID)=0
      APPLRT(ID)=0
      SEEPSUM(ID)=0
      TM1(ID)=0
      AREASM(ID)=0
      DEEPERC(ID)=0
      RNFF(ID)=0
      LATLOSS(ID)=0
65    CONTINUE
C
      DO 67 J=1,NOAREAS
      ETPCRP(J)=0
      RTDPTH(J)=.1
67    CONTINUE
C
      DO 100 KD=1,5
        DO 120 IC=1,6
        TOTLNGTH(KD,IC)=0
        TOTWP(KD,IC)=0
```

```
120     CONTINUE
100   CONTINUE
C
      RETURN
      END
C
C*****************************************************************************
      SUBROUTINE PUMP(ID)
C*****************************************************************************
C
C**** COMPUTES MONTHLY PUMPAGE.
C
C*****************************************************************************
C
C
      CHARACTER INAME*40
      COMMON /DATES/ YR,MO,DAY(12),IYR,JYR,BEGYR
      COMMON /BUDGET/ DEEPERC(9),AREASM(9),SUM(5200),AM(9)
      COMMON /BUDGET/ RNFF(9),TM(9),TM1(9),TRAIN(9),UNIFM(9)
      COMMON /TOTAL/ SUM2(12,9),SUM3(12,9),SUM4(12,9),SUM5(12,9)
      COMMON /TOTAL/ SUM6(12,9),SUM7(12,9),SUM8(12,9),SUM9(12,9)
      COMMON /TOTAL/ SUM10(12,9),SUM11(12,9)
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
C
C**** DONT USE PUMPING FOR WINTER ET.
C
      IF(MO.LE.3 .OR. MO.GE.11) GOTO 500
C
C**** USE UP EXCESS WATER, GO BACK
C
      IF(MO.EQ.10 .AND. PUMPING(ID).GT.0)THEN
      APPLRT(ID)=APPLRT(ID)+PUMPING(ID)/AREASM(ID)
      SUM9(MO,ID)=PUMPING(ID)
      PUMPING(ID)=0
      GO TO 500
      END IF
C
C**** GET WATER NEEDED; W2.
C
C      W2=ET2(ID)-APPLRT(ID)-TRAIN(ID)-AM(ID)/AREASM(ID)
      MDPLT=AM(ID)/AREASM(ID)+TRAIN(ID)-ET2(ID)
      IF(MDPLT.LT.0.)THEN
      W2=(AM(ID)/AREASM(ID))*1
      ELSE
      W2=(ET2(ID)-TRAIN(ID))*1
      END IF
C
C**** IF NO WATER NEEDED, USE EXCESS, GO BACK.
C
      IF(W2.LE.0.)GO TO 500
C
C**** IF NO WATER AVAIL., GO BACK.
C
      IF(PUMPING(ID).EQ.0.) GO TO 500
C
C****** COMPUTE PUMPAGE FOR MONTH.
C
      W4=PUMPING(ID)-W2*AREASM(ID)
      IF(W4.LT.0.0)THEN
      APPLRT(ID)=APPLRT(ID)+PUMPING(ID)/AREASM(ID)
      SUM9(MO,ID)=PUMPING(ID)
      PUMPING(ID)=0
      ELSE
      APPLRT(ID)=APPLRT(ID)+W2
      SUM9(MO,ID)=W2*AREASM(ID)
      PUMPING(ID)=PUMPING(ID)-W2*AREASM(ID)
      END IF
C
```

```
C**** GO BACK
C
500   RETURN
      END
C
C*******************************************************************************
      SUBROUTINE UNSAT(WATER,N,JSZ,JCP,L,PERC)                               **
C*******************************************************************************
C                                                       ****
C**** ESTIMATES BROOKS-COREY PARAMETERS FOR             ****
C**** INFILTRATION UNDER UNSATURATED CONDITIONS.        ****
C                                                       ****
C**********************************************************
C
      INTEGER YR,BEGYR
      INTEGER EX,WYE
      REAL KM
      REAL PSAT,LYRDP
      DIMENSION WI(7)
      CHARACTER INAME*40,NAME1*60,IFMT*80
      COMMON /SOILDAT/ SLNUM(10),LYRDP(10,6),WHC(10,6),BDLM(10,6)
      COMMON /SOILDAT/ THETR(10,6),PSAT(10,6),PDIS(10,6),NLYRS(10)
      COMMON /SOILDAT/ PHI(10,6),THETAWP(10,6)
      COMMON /DATES/ YR, MO, DAY(12),IYR,JYR,BEGYR
      COMMON /CELL/CZ(5200),IZ(5200),SZ(5200),AREA(5200)
      COMMON /CELL/ IQ, EX,WYE,DELX,DELY
      COMMON /IRRDIST/ IDIST(9),PUMPAGE(9),APPLRT(9),DEL(12,9),INAME(9)
      COMMON /IRRDIST/ DIV(12,9),FARMWST(12,9),RTNFL(12,9),FLAG(9)
      COMMON /IRRDIST/ NIDST, IDNO(9),PUMPING(9),ET2(9),DELA(9),PFLAG(9)
      COMMON /WATERBAL/ THETA(5200,6),RCHG(5200),SOURCE(5200)
      COMMON /WATERBAL/ CREEK(5200),NSPND(5,300)
      COMMON /PTOPT/ NOPTN(4),IFMT,NAME1,IOUT
C
      WI(L)=WATER
      IF(WI(L).LE.0.)WI(L+1)=0
C
C**** CAPILLARY PRESSURE AND HYDRAULIC CONDUCTIVITY
C
      SE=(THETA(N,L)-THETR(JSZ,L))/(PHI(JSZ,L)-THETR(JSZ,L))
      PCAP=(1/(SE**(1/BDLM(JSZ,L))))*PDIS(JSZ,L)
      IF(PCAP.LE.PDIS(JSZ,L)) PCAP=PDIS(JSZ,L)
      UNSTK=((PDIS(JSZ,L)/PCAP)**(2+3*BDLM(JSZ,L)))*PSAT(JSZ,L)
      TEST=WI(L)/(UNSTK*DAY(MO))
      IF(TEST.GT.1.0)THEN
      PERC=UNSTK*DAY(MO)
      THETA(N,L)=THETA(N,L)+(WI(L)-PERC)/10
      ELSE
      PERC=WI(L)
      END IF
C
C**** WRITE UNSAT CONDUCTIVITY FOR CELL IF SPECIFIED TO 'UNSAT_OUT'.
C
      IF(NOPTN(2).EQ.N)THEN
      PCFC=(THETA(N,L)/(THETAWP(JSZ,L)+WHC(JSZ,L)))*100
      SMC=THETA(N,L)
      SHC=PSAT(JSZ,L)*DAY(MO)
      USHC=UNSTK*DAY(MO)
      WRITE(61,46)JSZ
46    FORMAT(20X,'Unsaturated Flow Estimates',//20X,'Soil number ',I2//)
      WRITE(61,48)
48    FORMAT(17X,'Percent',2X,'Residual',47X,'Saturated',4X,'Unsaturate'
     &,'d',/6X,'Moisture',4X,'Field',3X,'Moisture',12X,'Capillary',2X,
     &'Displacement',12X,'Hydraulic',5X,'Hydraulic',3X,'Applied',/'Laye'
     &,'r  Content',2X,'Capacity',3X,'Content',2X,'Porosity',3X,'Pressu'
     &,'re',4X,'Pressure',4X,'Lambda',3X,'Conductivity',2X,'Conductivit'
     &,'y   Water')
      WRITE(61,49)
49    FORMAT(6X,'(in./in.)',5X,'(%)',3X,'(in./in.)',12X,'(inches)',4X,
     &'(inches)',14X,'(in./month)',3X,'(in./month)',2X,'(in./month)',//)
      WRITE(61,381)L,SMC,PCFC,THETR(JSZ,L),PHI(JSZ,L),PCAP,
```

```
     &PDIS(JSZ,L),BDLM(JSZ,L),SHC,USHC,WI(L)
381   FORMAT(2X,I2,4X,F5.3,5X,I4,6X,F5.3,5X,F5.3,4X,F8.3,5X,F6.3,
     &7X,F4.3,5X,F7.2,7X,F7.2,6X,F6.2)
      END IF
C
      RETURN
      END
```