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REVISED MODEL OF WATERSHED HYDROLOGY

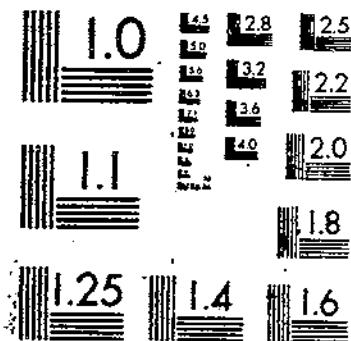
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# **TECHNICAL BULLETIN ON WATERSHED HYDROLOGY**

**A United States Contribution to the  
International Hydrological Decade**

**Technical Bulletin No. 1518**

**TECHNICAL BULLETIN ON WATERSHED HYDROLOGY**

# **USDAHL-74 REVISED MODEL OF WATERSHED HYDROLOGY**

## **A United States Contribution to the International Hydrological Decade**

**By H. N. Holtan, G. J. Stiltner,  
W. H. Henson, and N. C. Lopez**

**Technical Bulletin No. 1518**

*Hydrology Unit  
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The entire staff of the Hydrograph Laboratory, ARS, contributed to this revision of the original USDAHL-70 model through research of various components, through data searches and processing, through cartographic representation, and through programing and debugging of hydrologic concepts.

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## USDAHL-74 REVISED MODEL OF WATERSHED HYDROLOGY

### A United States Contribution to the International Hydrological Decade

By H. N. HOLTAN, *hydraulic engineer*, and G. J. STILTNER, W. H. HENSON, and N. C. LOPEZ,<sup>1</sup> *mathematicians*,  
*Hydrograph Laboratory, Northeastern Region, Agricultural Research Service*

In the Hydrograph Laboratory, watershed hydrology is organized on a multidisciplinary basis and includes (1) meteorology and climate, (2) soils and vegetation, (3) hydraulics, (4) hydrogeology, and (5) watershed hydrologic systems. Findings in the first four subject-matter areas are applied in their natural sequences of time and space in hydrologic systems analyses. Questions arising from trial applications in the last area serve as a guide and impetus to the basic studies.

The hydrologic model presented here is the second attempt to express watershed hydrology as a continuum. This revision of the model is the result of numerous improvements in the subroutines and increased output demands. The major change is in the method of computing evapotranspiration. Standard curves of crop growth were inadequate to reflect the extremes observed in annual evapotranspiration. In this revision the growth index is computed as a function of current temperatures and thereby is unique for each specific year.

Growing interest in potentials for water pollution by erosion or chemical transport is placing demands for greater detail in the program output. Subroutine POLLUT was added for optional use to print out or store the daily status of soil moisture and increments of water movements in each regime or layer of each zone. Hydrographs of overland flow are also output in MAINLINE for possible use in predicting erosion on each zone.

By frequent revisions and substitutions of parts of the model we hope to maintain a

sequence of the best methods currently developed. But perhaps the greatest contribution of any model lies in the questions it raises rather than in the methods it proposes. At least we can draw some encouragement from a statement by Conant (2): "...the success of natural scientists . . . is not due primarily to their methods but to the aim of their efforts. And curiously enough the aim is determined every few years by what has been the outcome of the experiments and observations of the preceding years . . . ."

The mathematical model of watershed hydrology under study in the Hydrograph Laboratory is designed to serve the purposes of agricultural watershed engineering. Our primary emphasis is on separating out the details of what actually happens during the runoff process as a basis for planning the engineering structures and procedures that will control the times, routes, and amounts of waterflow. In brief, we are trying to reduce the entire system of watershed hydrology to a predictable pattern of physical probabilities that will account for the dispersion of water and its subsequent concentration in channel systems.

The study is not finished. Our model is currently a series of empiricisms selected to provide a mathematical continuum from ridgeline to watershed outlet in terms of input information readily available to the analyst. Hopefully the model will help to bridge the gap between theory and practice by providing a framework in which new basic knowledge can be applied to watershed engineering. Hopefully also the

<sup>1</sup> Resigned January 1973.

<sup>2</sup> Italic numbers in parentheses refer to Literature Cited, p. 29.

empiricisms will be replaced by logical explanations of the physical process as the continuum is accepted and developed for practical use.

Just what this will ultimately become is unpredictable. Objectives in watershed engineering change with population increases and with our desire for a higher, more controlled standard of living. We depend on our watersheds for the necessities of life as well as for the enjoyment of our leisure. Our way of life demands a regulated environment protected against the extremes of nature. We want neither flood nor drought.

We are becoming concerned with the safe

disposition of sediments and waste materials from our watersheds (20). Dispersed wastes such as fumes, smoke, and other airborne pollutants from industry and inadvertent excesses of applied fertilizers, herbicides, and other pesticides in agriculture suggest the propriety of a dispersed system concept of watershed hydrology as a vehicle of disposal. Predictably then our interest is extending to smaller and smaller increments of the watershed with complete accounting for dispersion of precipitation to evapotranspiration, moisture storage, ground-water recharge, and surface and subsurface movements to streamflow.

## PRECIPITATION

Input precipitation to the model consists of a continuous record of rainfall or snowfall weighted to represent the watershed. Variation in areal distribution must be accepted as error or it must be reduced by dividing the watershed into small areas and applying the model to rainfall measurements on each small area independently. Rainfall amounts can be determined for regular periods of time or they can be tabulated at breakpoints in the mass curve. In either instance, all periods of time must be accounted for in this model. All computations start at the first date entered in the precipitation data and stop with the last date entered in the data set. Ideally, precipitation data should start with January 1 at 0001 hour and end on December 31 at 2400 hours each year so that blocks of record can be chosen at will. The slight discrepancy of 0001 hour in January is to avoid zero time increments in continuous records.

The model was applied to four ARS experimental watersheds representing a diversity of climate and physiography as listed in table 1. Snowfall was tabulated as water equivalent for the two northern watersheds. Significant errors resulted, particularly where heavy snow accumulations during extended cold periods were followed by a rapid thaw or rain. Sensible adjustments for major events at Coshocton, Ohio, were based on the U.S. Weather Bureau tem-

perature records and storm reports.<sup>3</sup> These

TABLE 1.—*Characteristics of 4 experimental agricultural watersheds*

Watershed No. <sup>1</sup>	Area	Physiography	slope	Land	annual
	Sq mi			pre-	ci-
				ci-	pa-
Little Mill Creek (W-97), Coshocton, Ohio.	26.26	7.16	Allegheny Plateau.	2-35	41
Beaver Creek (W-11), Hastings, Nebr.	44.4	3.45	Loess plains.	0-12+	24
Upper Taylor Creek (W-3), Ft. Lauderdale, Fla.	8.3	15.7	Flat woods of Coastal Plains.	0-2	48
Brushy Creek (W-G), Riesel, Tex.	42.4	6.84	Blacklands of Coastal Plains.	1-6	34

<sup>1</sup> Identification number in "Hydrologic Data for Experimental Agricultural Watersheds in the United States," compiled by Harold W. Hobbs, U.S. Dept. Agr. Misc. Pub. 1070, 447 pp. 1962.

<sup>2</sup> U.S. WEATHER BUREAU. CLIMATOLOGICAL DATA, CONTINUING SERIES BY STATES. U.S. Weather Bur., U.S. Dept. Com. 1957-64.

helped to reconcile computed runoff with observed data, but an automated system for computing snowmelt was needed.

In model USDAHL-74, input precipitation increments can be labeled "S" for snow and will be stored as "snow" subject to equation [1] for daily snowmelt on each zone:

$$MELT = 0.15 \cdot (T - THAW) \cdot (1.0 - 0.5 VEG) + 2P \quad [1]$$

where

*MELT* = potential snowmelt per day in zone surface inches

*T* = weekly average air temperature ( $^{\circ}$ F)

*THAW* = temperature at which snowmelt starts

*VEG* = weighted average vegetative density for zone

*P* = inches falling as rain that day

The insertion of the variable "*THAW*" permits adjustments for aspect, elevation, or other factors usually involved in relating snowmelt to a temperature record. This is particularly important when snowmelts at higher elevations are computed from temperatures observed at a lower elevation.

Equation [1] again helped results but serves more pointedly to illustrate the type of solution needed for snowmelt. It includes only temperature, shading, and rain on snow, but experience in the middle latitudes indicates that these are highly significant factors for runoff. Aspect and snow drifting are also recognized factors, but no solution has been attempted here.

## HYDROLOGIC GROUPING OF SOILS AND LAND USE

Soils on each watershed are grouped by land-capability classes, as illustrated for three of the watersheds in figure 1, to form hydrologic response zones for computing infiltration,

evapotranspiration, and overland flow. Zones indicated for each watershed typify the elevation sequence of uplands, hillsides, and bottom lands in these areas. Zones are always num-

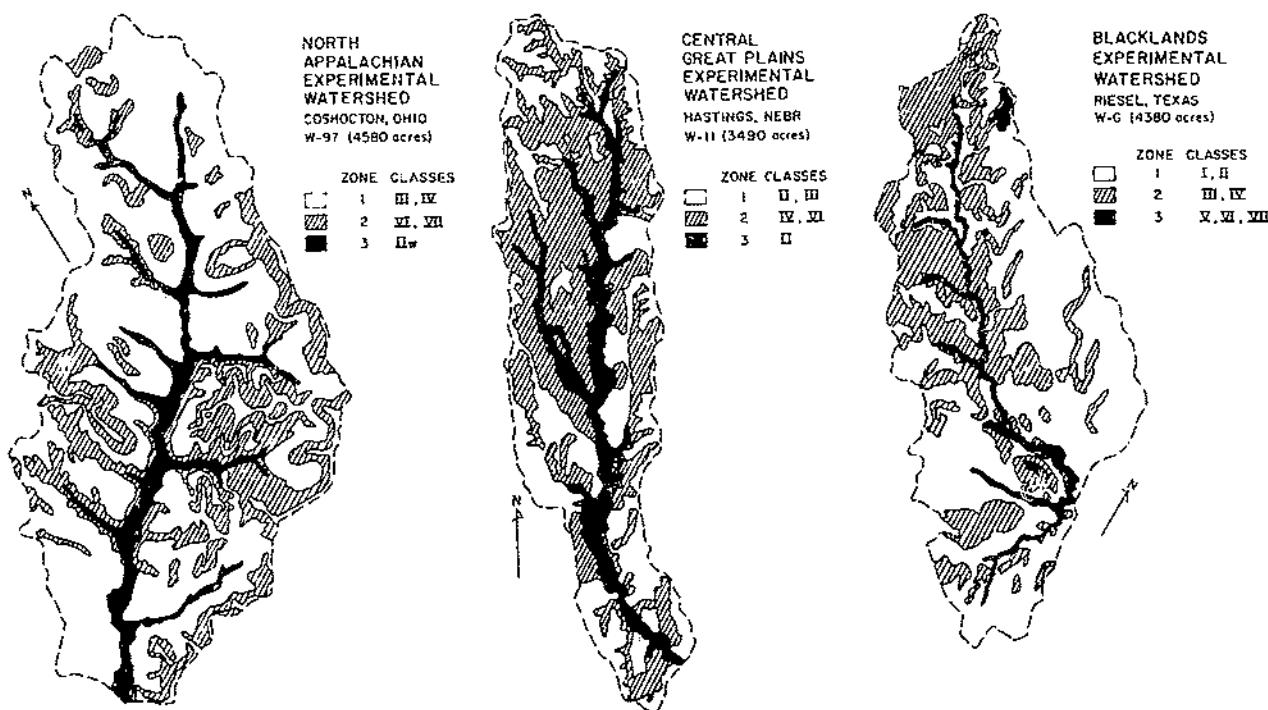


FIGURE 1.—Hydrologic zones of land-capability classes for three watersheds.

bered in a downslope order because some of the runoff will cascade over successive zones. For example, on the Coshocton watershed an estimated 80 percent of zone 1 runoff flows directly onto the alluviums of zone 3, and only 20 percent cascades to soils of zone 2.

In the watershed description data compiled by the Agricultural Research Service field stations (18), percentages are given of the area

of major soils and of land-capability classes. Moisture-tension data in table 2 reported by the Hydrograph Laboratory (9) and reports from the Soil Survey Laboratory<sup>1</sup> provide soil

<sup>1</sup> U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, SOIL SURVEY LABORATORY. DATA AND DESCRIPTION OF SOME SOILS OF . . . . Soil Survey Invest. Rpt., continuing series by States.

TABLE 2.—*Profile description and physical properties of Cecil gritty sandy loam*

Location: Blacksburg, Virginia; Brunswick County, Rocky Run Branch Watershed, located in pasture 75' SW of fence, 400 yds. W of county road #656.  
 Vegetation and land use: Pasture.  
 Topography: Gently sloping.  
 Drainage: Well-drained.  
 Parent material: Granite gneiss and schist.  
 Described and sampled by: K. Fussell, J. Williams, and J. B. Burford.

Horizon	Description	Available moisture	
		Per inch of soil	In horizon
		Inches	Inches
Ap.....	0 to 6 inches. Dark yellowish brown (10YR 4/4) gritty sandy loam; very friable; weak medium granular structure; many fine roots; medium acid; few small pedes of red (2.5YR 4/6) brought up from lower horizons by plowing; abrupt wavy boundary.	0.10	0.60
B22t.....	6 to 15 inches. Red (2.5YR 4/6) clay with few fine mottles of yellowish red (5YR 5/8); some ped faces are coated with yellowish red (5YR 4/8) clay, which is apparently result of root and worm action; firm; moderate medium subangular blocky structure; thin continuous clay films; few mica flakes; common fine roots; occasional quartz rock less than $\frac{1}{2}$ " in diameter; medium acid; clear wavy boundary.	.07	.63
B23t.....	15 to 31 inches. Red (2.5YR 4/6) clay loam with common fine faint mottles of yellowish red (5YR 5/8) and common fine distinct mottles of yellowish brown (10YR 5/8); moderate medium and fine subangular blocky structure; friable; thin clay film on most ped faces; common mica flakes; 10 percent grit by volume; few fine roots; strongly acid; clear wavy boundary.	.06	.96
B31.....	31 to 42 inches. Red (2.5YR 4/6) clay loam with many medium faint mottles of yellowish red (5YR 5/8) and few medium distinct mottles of strong brown (7.5YR 5/8) and reddish yellow (7.5YR 6/8); friable; moderate to weak medium and fine blocky and subangular blocky structure; patchy clay film; many mica flakes; 10 percent grit by volume; strongly acid; clear smooth boundary.	.13	1.43
B32.....	42 to 56 inches. Mottled colors of red (2.5YR 4/8), yellow red (5YR 5/8), reddish yellow (7.5YR 6/8), very pale brown (10YR 7/4) highly weathered granite gneiss and schist with few pockets of light clay loam; friable; weak fine and medium subangular blocky structure; many mica flakes; slimy and greasy to the feel; 10 percent grit by volume; few patchy clay films; very strongly acid; gradual wavy boundary.	.18	2.52
C.....	56 to 71 inches plus. Mottled colors of yellowish red (5YR 5/8), red (2.5YR 4/6), reddish yellow (5YR 6/8) and very pale brown (10YR 7/4) highly weathered granite gneiss and schist; silt loam with 10 percent grit by volume.	.18	-----

TABLE 2.—*Profile description and physical properties of Cecil gritty sandy loam—Con.*

Horizon	Depth	Bulk density	Moisture as percent of dry weight at respective atmospheres of tension				
			0.1	0.3	0.6	3	15
	Inches	G/cm³	Percent	Percent	Percent	Percent	Percent
Ap-	0-6	1.72	15.24	12.35	10.30	9.21	6.34
B22t	6-15	1.83	26.90	23.76	22.22	21.53	18.28
B23t	15-31	1.32	32.02	29.26	28.67	27.27	24.58
B31	31-42	1.41	29.89	28.02	25.87	21.68	18.62
B32	42-56	1.29	35.15	26.66	19.52	16.49	13.02
C	56-71+	1.29	36.36	24.46	26.29	15.78	10.69

profile descriptions for computing weighted averages of hydrologic capacities (4) of soils in each zone.

Specific gravity was estimated at 2.65 for all soils in computing total porosities. Moisture at 0.3 bar tension was used for field capacity in

dividing total storage capacities ( $S$ ) into moisture freely drained by gravity ( $G$ ) and moisture drained by vegetation ( $AWC$ ). The lower limit of  $AWC$  is assumed to be the moisture at 15 bars tension. Table 3 is a summary of many samples and gives  $S$ ,  $G$ , and  $AWC$  in

TABLE 3.—*Hydrologic capacities of soil texture classes<sup>1</sup>*

Texture class	<i>S</i>	<i>G</i>	<i>AWC</i>	<i>AWC/G</i>
	Percent	Percent	Percent	
Coarse sand	24.4	17.7	6.7	0.38
Coarse sandy loam	24.5	15.8	8.7	.55
Sand	32.3	19.0	13.3	.70
Loamy sand	37.0	26.9	10.1	.38
Loamy fine sand	32.6	27.2	5.4	.20
Sandy loam	30.9	18.6	12.3	.66
Fine sandy loam	36.6	23.5	13.1	.56
Very fine sandy loam	32.7	21.0	11.7	.56
Loam	30.0	14.4	15.6	1.08
Silt loam	31.3	11.4	19.9	1.74
Sandy clay loam	25.8	13.4	11.9	.89
Clay loam	25.7	13.0	12.7	.98
Silty clay loam	23.8	8.4	14.9	1.77
Sandy clay	19.4	11.6	7.8	.67
Silty clay	21.4	9.1	12.9	1.34
Clay	18.8	7.3	11.5	1.58

<sup>1</sup> Adapted from "Land Capability: A Hydrologic Response Unit in Agricultural Watersheds," by C. B. England, U.S. Dept. Agr. ARS 41-172, Sept. 1970.

$S$  = total porosity—15 bar moisture percent,  $G$  = total porosity—0.3 bar moisture percent, and  $AWC = S$  minus  $G$ .

percent volume of textural horizons. Figure 2 presents graphically the transitions of moisture capacities over the textural range from sands to clay. These can be used to compute  $S$ ,  $G$ , and

AWC as illustrated in table 4. The data in this table were computed from figure 2 by the equation:

$$\text{Percent volume} = \frac{100 \cdot \text{percent weight}}{37.7 + \text{percent weight at full saturation}}$$

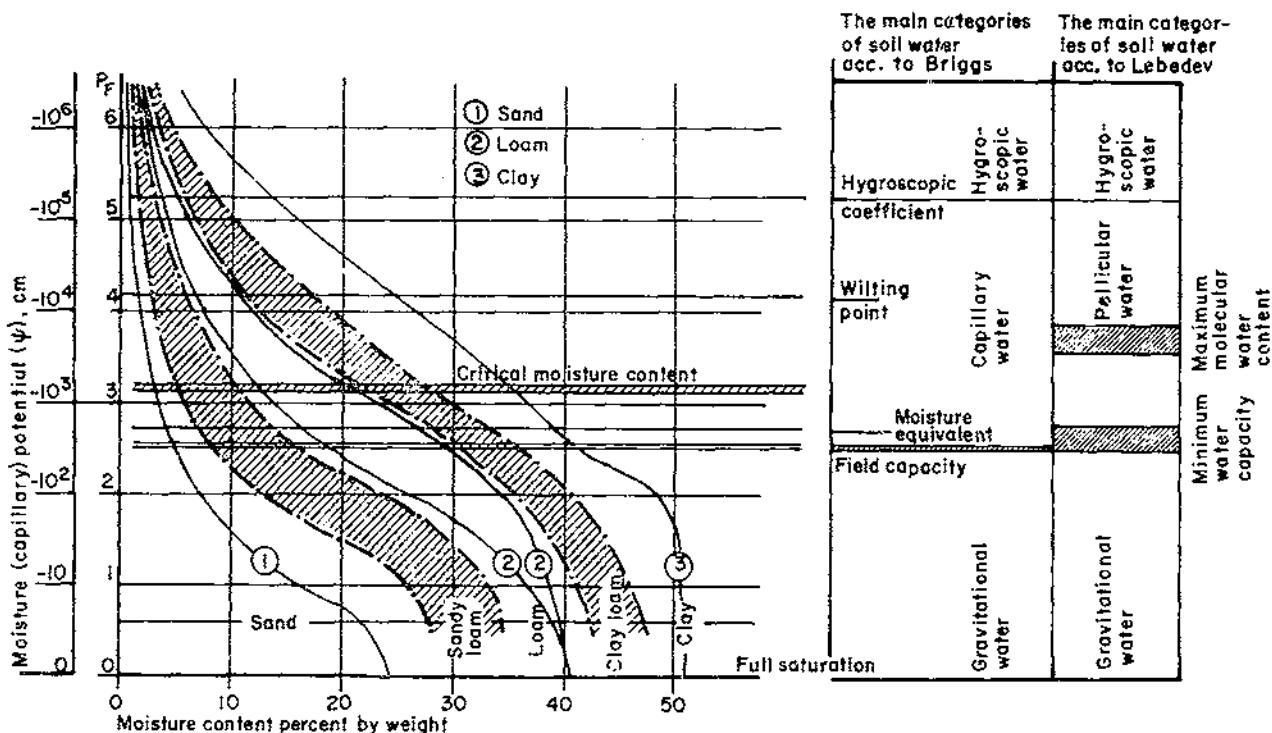


FIGURE 2.—Relationship between moisture potential and moisture content for soils of various textures. [From "Representative and Experimental Basins," edited by C. Toebe and V. Ouryvaev, published by UNESCO, 1970.]

TABLE 4.—Computations of hydrologic capacities from potential moisture-content relationships for soils of various textures

Texture	Wilting point		Field capacity		Saturation		Moisture freely drained by gravity (G), volume	Moisture drained by vegetation (AWC), volume	Total storage capacity (S), volume
	Weight	Volume	Weight	Volume	Weight	Volume	(G), volume	(AWC), volume	(S), volume
Sand.....	2	3.2	6	9.7	24	38.9	29.2	6.5	85.7
Loams.....	6	7.6	18	22.9	41	52.1	29.2	15.3	44.5
{ Loams.....	10	12.7	29	36.8	41	52.1	15.3	24.1	39.4
Clay.....	25	27.9	42	46.8	52	58.0	11.2	18.9	80.1

Percentages are applied to depths of "A" horizons or to plow depths in nonlayered soils and to depths of maximum root penetration as might be limited by hardpans, gravelly layers,

or other textures unsuited for root growth. The input format of the model accepts *G* and *AWC* in percent by volume and applies them to soil depths to compute volumes.

## EVAPOTRANSPIRATION

Evapotranspiration (*ET*) potentials are estimated by coefficients applied to published pan-evaporation data. The method is a combination of techniques developed by Mustonen and McGuiness (15), Jensen (11), and Pruitt (17). It is adapted for use with cardinal temperatures presented in table 5 in estimating plant growth. Figure 8 is a plotting of the potential growth index (*XGI*), which is the cardinal temperature functions, for alfalfa and

corn.<sup>5</sup> This index is the (current temperature—lower cardinal temperature)/(upper cardinal temperature—lower cardinal temperature). Cardinal temperatures are the upper or optimum and lower or minimum temperatures for crop growth. When the current temperature

<sup>5</sup> Although the data in some of the graphs were collected during 1956–60, the findings are still valid and useful as guidelines for estimating evapotranspiration by various plant species.

TABLE 5.—Cardinal temperatures for growth of some common crops

Crop	Cardinal temperatures (°F)			Reference
	Minimum	Optimum	Maximum	
Oats, rye, wheat, barley	32–41	77–87.8	87.8–98.6	Parker, N. W. 1946. Environment factors and their control in plant environments. <i>Soil Sci.</i> 62: 109–119.
Sorghum, melons	59–64.4	87.8–98.6	111.2–122	
Corn	50	-----	-----	Chang, J. H. 1968. Climate and agriculture: An ecological survey. 304 pp. Aldine Pub. Co., Chicago.
Peas	40	-----	-----	
Citrus fruit	55	-----	-----	Wiggans, S. C. 1936. The effect of seasonal temperatures. . . . <i>Agron. Jour.</i> 48: 21–25.
Oats	40	-----	-----	Meyer, B. S., and Anderson, D. B. 1939. Plant physiology. 696 pp. D. van Nostrand Co., New York.
Corn	50	86–95	113	Oosting, H. J. 1956. The study of plant communities. 440 pp. W. H. Freeman & Co., San Francisco.
Flax	35	70	82	Haberlandt, G. F. J. 1874. Cited by Richards, S. J., et al. 1952. Soil temperature and plant growth. <i>Amer. Soc. Agron. Monog.</i> II, pp. 360–363.
Peas, vetch, rye	33–34	-----	-----	Lehenbauer, P. A. 1914. Growth of maize. . . . <i>Physiol. Res.</i> 1: 247–288.
Corn, sorghum	46–50	-----	-----	Wang, J. Y. 1963. Agricultural meteorology. 693 pp. Pacemaker Press, Milwaukee.
Tobacco	55–57	-----	110	Rhykerd, C. L., et al. 1960. Sorghum grows best at warm temperatures. <i>Crops and Soils</i> 12: 24.
Corn	50	60–95	105	Martin, J. H. 1941. Climate and sorghum. In <i>Climate and Man</i> . U.S. Dept. Agr. Ybk. 1941: 348.
Sorghum	60	-----	-----	Doggett, H. 1970. Sorghum. 403 pp. Longmans, Green and Co., Ltd., London.
Tobacco	60	80	100	Garnett, W. W. 1946. The production of tobacco. 516 pp. Blakiston Co., Philadelphia.
Ryegrass	-----	60	-----	Weihing, R. N. 1963. Growth of ryegrass as influenced by temperature. . . . <i>Agron. Jour.</i> 55: 519–521.

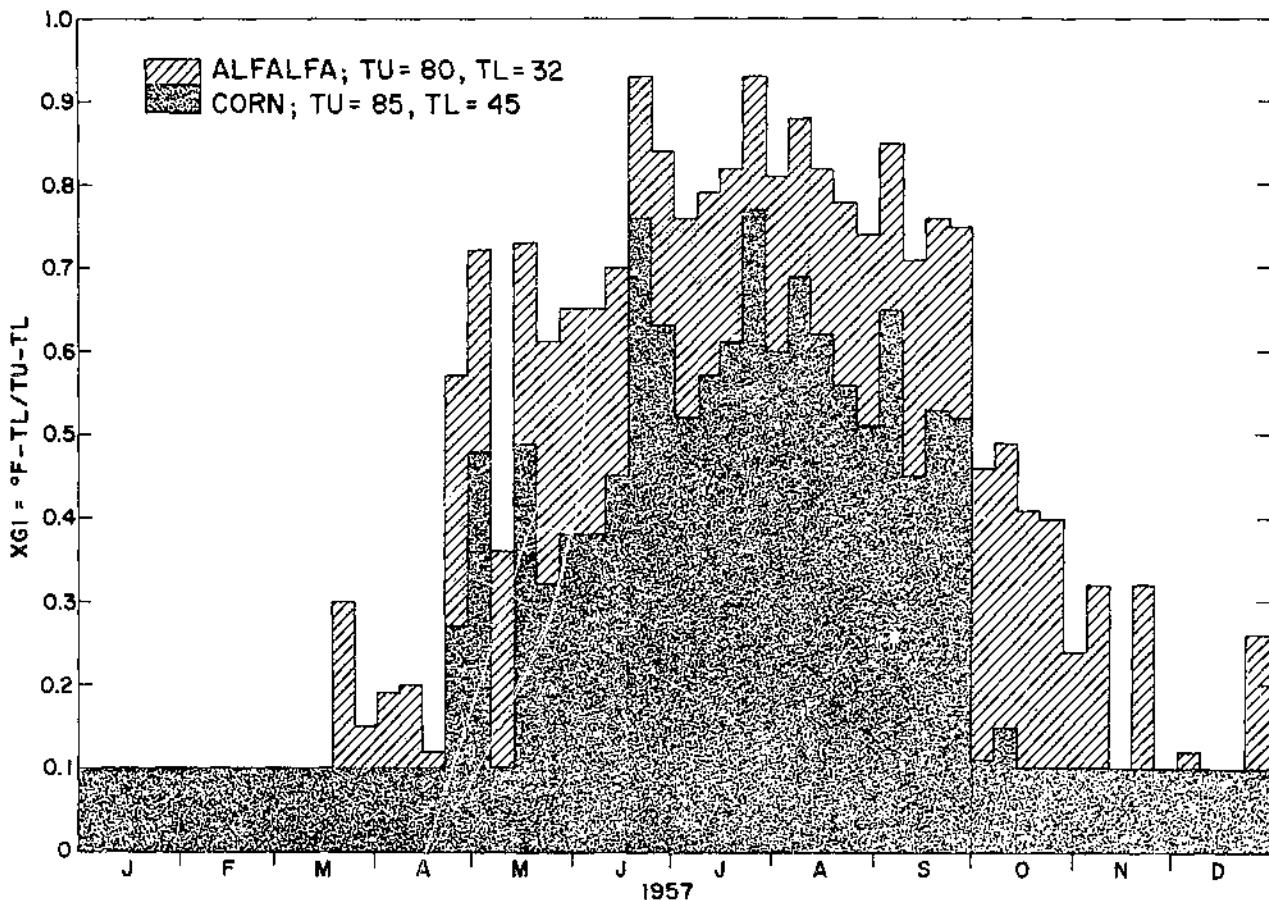


FIGURE 3.—Relative potential growth ( $XGI$ ) graphs for alfalfa and corn computed from upper and lower cardinal temperatures ( $TU$  and  $TL$ ).

exceeds the upper cardinal limit, the plant is assumed to suffer and the  $XGI$  function is set less than 1.0 by a function of the amount of exceedence. If the current temperature is equal to or less than the lower cardinal limit, the  $XGI$  is set equal to a fixed minimum.

The growth index ( $GI$ ) for a given crop is then computed from the  $XGI$  graph for that crop as illustrated in figure 4 for alfalfa and corn. The  $GI$  follows the  $XGI$  if no cultural practices intervene. However, since cultural practices that reduce the foliage also reduce evapotranspiration, the  $GI$  for the crop is reduced following plowing, planting, cultivating, or harvesting if vegetation is abolished or reduced by the operation. (This excludes *minimum tillage* practices.) After each practice the crop is assumed to recover in a specified

number of weeks at which time the  $GI$  graph rejoins the  $XGI$  graph. In the case of turn-plowing, when the soil is inverted and left in an aerated condition, the  $GI$  value is set at 1.0 and assumed to settle back to a bare fallow condition of low  $ET$  in 2 weeks where it remains a constant at 0.1 until planting of a crop.

Cardinal temperatures can be obtained from the literature for most crops. Table 5 is a compilation of minimum and optimum cardinal temperatures for some of the more common crops together with literature citations. Generally the local reputation of a crop for seasonal growth can be drawn upon to approximate the cardinal limits; e.g., if a grass is known to go dormant at midsummer, the associated temperatures indicate the upper limit. Winter

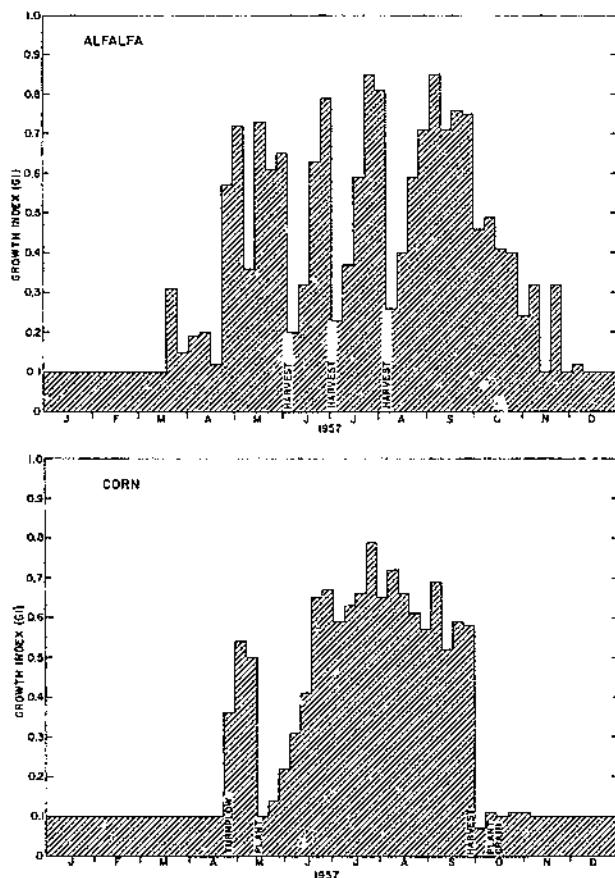


FIGURE 4.—Relative growth (GI) graphs: Above, for alfalfa as modified by cutting; below, for corn as modified by tillage.

wheat would be expected to have a lower limit near freezing. The evapotranspiration potential can then be estimated for any given days as:

$$ET = GI \cdot k \cdot E_p \cdot [(S - SA)/AWC]^z \quad [2]$$

where

- $ET$  = evapotranspiration potential in inches per day
- $GI$  = growth index of crop in percent of maturity
- $k$  = ratio of  $GI$  to pan evaporation, usually 1.0–1.2 for short grasses, 1.2–1.6 for crops up to shoulder height, and 1.6–2.0 for forest
- $E_p$  = pan evaporation in inches per day

- $S$  = total porosity
- $SA$  = available porosity
- $AWC$  = porosity drainable only by evapotranspiration
- $z$  = set equal to  $AWC/G$  ( $G$  = gravity or free water)

Input to the model now includes 52 weekly averages of air temperature in place of the  $GI$  graphs required for each crop in model USDAHL-70. The use of temperature is designed to individualize plant growth estimates for each year.

C. H. Wadleigh, in mathematical analyses of plant growth data (unpublished), demonstrated that free water above field capacity dampens and inhibits plant growth and subsequently  $ET$  by excluding oxygen needed for plant growth. As illustrated schematically in figure 5,  $ET$  decreases from optimum at field capacity to zero at soil saturation. Thus  $ET$  increases from wilting point to an optimum at field capacity and diminishes to zero at saturation. However, evaporation increases from zero at field capacity to a value equal to pan evaporation at soil saturation. This separation of evaporation and transpiration becomes important in chemical transport studies.

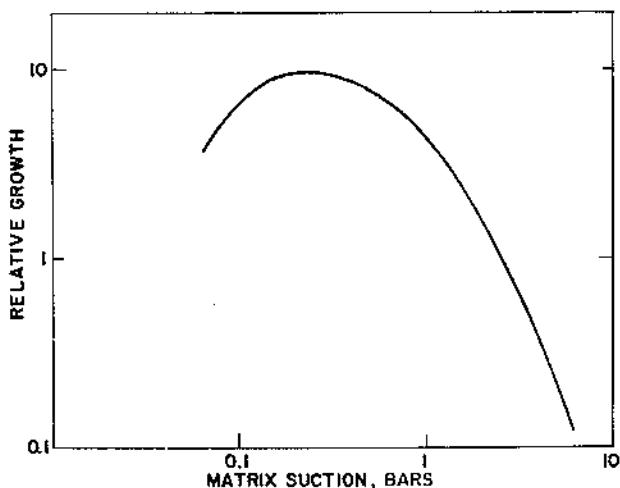


FIGURE 5.—Relative growth as modified by free water (matrix suction less than 0.25 bar) and moisture deficit (matrix suction greater than 0.25 bar). [After Wadleigh, unpub.]

## INFILTRATION

Infiltration capacity was expressed by Holtan (7, 8) as an exhaustion phenomenon convergent upon some constant rate:

$$f = a \cdot S_a^{1.4} + f_c \quad [3]$$

where

$f$  = infiltration capacity in inches per hour

$a$  = infiltration capacity in inches per hour per inch<sup>1.4</sup> of available storage (index of surface-connected porosity)

$S_a$  = available storage in surface layer ("A" horizon in agricultural soils) in inches water equivalent

$f_c$  = constant rate of infiltration after prolonged wetting (associated with capillary flow or with impeding stratum) in inches per hour

Gardner (5) found that water entering the soil under positive heads through larger pores spreads to the smaller pores both vertically and horizontally by capillary action. Equation [3] estimates this slow capillary movement as a constant ( $f_c$ ). The other right-hand term ( $a \cdot S_a^{1.4}$ ) is an empirically derived expression of flow rates due to positive heads. It represents the sum of products of velocities and cross sections in flow tubes.

True velocities cannot be determined from permeability tests because the cross-sectional

area of the stream tube cannot be determined. The hydraulic gradient likewise cannot be determined because the length of flow depends on the twisting and meandering of the tubes. The lengths of flow tubes increase as infiltration progresses, but no technique for measurement has yet been developed. If the direction of flow is generally vertical, the hydraulic gradient remains approximately equal to unity. Most of the variation in flow can therefore be attributable to changes in the cross sections of flow tubes.

Two premises appear feasible: First, only surface-connected porosity can be considered as part of the positive-head flow tube. This is illustrated schematically in figure 6. Pores near the soil surface have a greater probability of being surface connected than do pores at greater depths. Therefore the effective cross-sectional area of flow tubes diminishes as penetration of water fills available storage space from the surface downward. Gardner observed saturated flow in sand lenses that were connected directly to the soil surface, but he found that sand lenses isolated in finer textures did not fill during unsaturated flow around them, as illustrated in figure 7.

The second premise is that roots of growing plants shrink because of drying whenever evaporation from the plant exceeds osmotic entry of water to the roots (3). This adds to the effect of soil shrinkage in creating passages for air or water to reach pores intercepted by

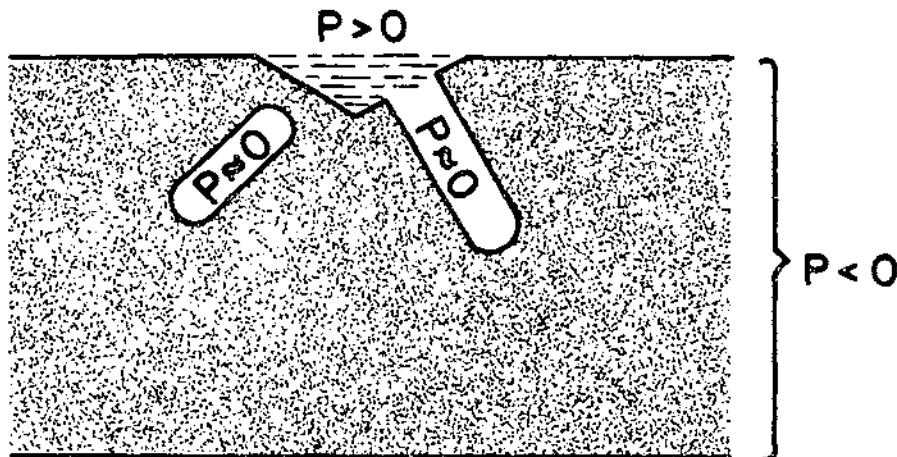


FIGURE 6.—Pressure potentials (P) at start of water application to soil.

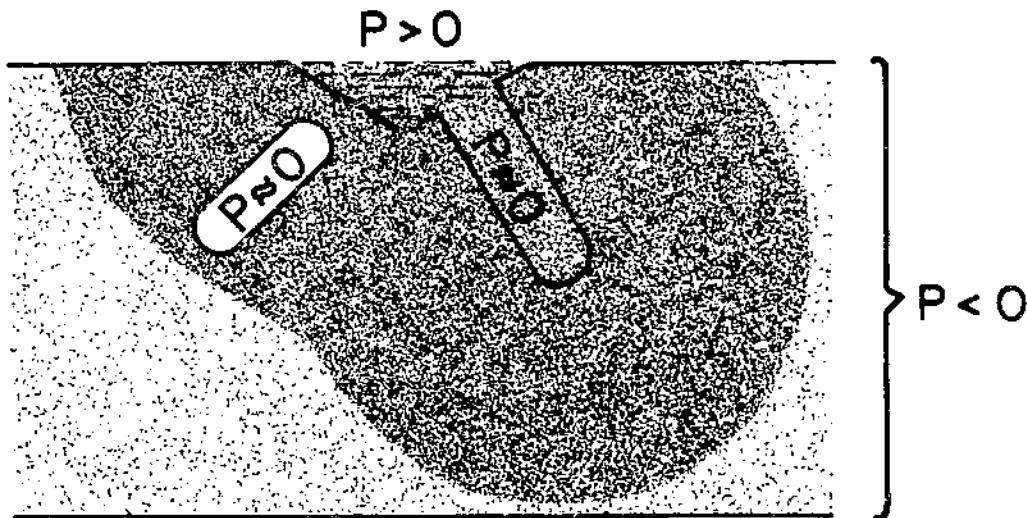


FIGURE 7.—Left, unsaturated flow; right, saturated flow in large pores in contact with surface only. [After Gardner (5).]

roots. The part of available storage that is thus connected to the surface depends on the density of plant roots and is estimated by the coefficient "a" of equation [3]. Logarithmic plottings of  $f$  versus  $S_e$  for numerous infiltrometer tests yielded this equation. Until a technique is developed for direct measurement of flow tubes, it is expedient to rely upon this estimate from previous records.

The  $GI$  of equation [2] is also used as a seasonal factor on the vegetation parameter "a" in the infiltration equation [3]:

$$f = GI \cdot a \cdot S_a^{1.4} + f_c \quad [4]$$

Infiltration and rainfall excess are computed for each soil zone by comparing observed rainfall to the infiltration capacities computed by equation [4]. In solutions of equation [4] the volume of infiltration cannot exceed the volume of water available at the soil surface including detentions of overland flow, nor can it exceed the product of the time increment ( $t$ ) and the average rate  $((f_1 + f_2) \cdot t/2)$ . Infiltration capacity depends on the amount of empty space with  $S_e$  diminished by infiltrated water but recovered by drainage or evaporation to the limit of  $G$ , and by  $ET$  to the additional limit of  $AWC$ .

Values of "a" are shown in table 6 for various types of vegetation. These were evaluated at plant maturity as the fraction of the ground-

surface area occupied by plant stems or root crowns. Stems and root crowns are assumed to reflect the fraction of porosity in the top layer that is surface connected by mature plant roots to form conduits for air or water. If surface continuity is achieved by incorporation or by mechanical means, the  $a$  value should be adjusted to represent it.

TABLE 6.—Tentative estimates of vegetative parameter "a" in infiltration equation<sup>1</sup>

Vegetation	Basal area rating a <sup>2</sup>	
	Poor condition	Good condition
Fallow	.10	.30
Row crops	.10	.20
Small grains	.20	.30
Hay:		
Legumes	.20	.40
Sod	.40	.60
Pasture:		
Bunchgrass	.20	.40
Temporary (sod)	.40	.60
Permanent (sod)	.80	1.00
Woods and forests	.80	1.00

<sup>1</sup>  $f = GI \cdot a \cdot S_a^{1.4} + f_c$  (see equations 3 and 4).

<sup>2</sup> Adjustments needed for weeds and grazing.

<sup>3</sup> After row crop.

<sup>4</sup> After sod.

Estimates of  $f_c$  were obtained from "Hydrology" (19), wherein major soils of the United States are grouped according to their rate of water intake after prolonged wetting. Soils are grouped in hydrologic classes A, B, C, and D. Musgrave (13) gave the associated rates of  $f_c$  in inches per hour as A = 0.45-0.30, B = 0.30-0.15, C = 0.15-0.05, and D = 0.05-0. The texture and density of the impeding layer give a clue to the selection of  $f_c$  within a group. If the impeding strata approach clay,  $f_c$  is near the lower limit of its group; for sand,  $f_c$  would be near the top; and for loams,  $f_c$  would be near the midpoint.

Depressions on the land surface act as reservoirs holding a volume ( $V_d$ ) of water until it is dissipated by infiltration. Although gen-

erally rather small in depth (about 0.05 inch for agricultural crops),  $V_d$  is drawn upon by infiltration and subsequently refilled by rainfall for each pause in rainfall intensity. Also, certain agricultural practices such as level terraces, contoured furrows, and listed crops may be designed to give  $V_d$  depths of several inches. Musgrave and Holtan (14) gave concepts and some estimates of depression storage in agriculture, but generally such estimates must be based on personal observations.

Certain soils such as the montmorillonitic clays form deep cracks on drying. Cracking is estimated for a given horizon from the ratio of bulk density at field capacity to bulk density when air-dry by the equation:

$$\text{Percent cracks} = 100 \left[ \left( \frac{BDW}{BDD} \right)^{1/3} - \frac{BDW}{BDD} \right] \quad [5]$$

where

$BDW$  = bulk density ( $\text{g/cm}^3$ ) at field capacity in percent volume

$BDD$  = bulk density ( $\text{g/cm}^3$ ) at air-dry in percent volume

This equation was developed from the work of Grossman et al. (6) considering a cube of soil and by deleting vertical shrinkage. Equa-

tion [5] is applied to layer thicknesses to compute maximum cracking volumes. The volume of cracks at any given time is computed as a linear function of soil moisture present and is limited to the plant available range (AWC). Cracks are therefore at maximum within the root depth at wilting point and disappear at field capacity.

## COEFFICIENTS FOR ROUTING FLOWS

Rainfall in excess of infiltration is routed across each soil zone of figure 1 and cascaded, subject to further infiltration, across designated subsequent soil zones en route to the channel. Overland flow is computed by an adaptation of the continuity equation:

$$Pe - Q_o = \Delta D \quad [6]$$

and

$$q_o = (ova) D^n \quad [7]$$

where

$Pe$  = volume of rainfall per unit of time in excess of infiltration and depression storage

$Q_o$  = volume of outflow per unit of time

$\Delta$  = increment

$D$  = average depth of flow in inches

$q_o$  = overland flow in inches per hour

$ova$  = coefficient dependent on roughness and length and degree of slope

$n$  = 3.0 for laminar and 1.67 for turbulent flow (fixed at 1.67 in this model)

The coefficient  $ova$  in equation [7] is determined from runoff recessions on rectangular plots as described by Musgrave and Holtan. It is the rate of flow produced by an average depth of 1.0 inch of water on the plot surface. In the flow data presented by Musgrave and Holtan,  $n$  equals 1.67 and  $ova$  can be estimated from vegetative density ( $a$ ), percent slope ( $S$ ), and feet length ( $L$ ) of flow path by the following equation:

$$ova = (150 - 125a) \cdot (12/\sqrt{1.5}) \cdot \sqrt{S/L} \quad [8]$$

For laminar flow,  $ova$  would vary linearly as  $S$  in equation [8] and the value of  $n$  must be set equal to 3.0 in equation [7].

Channel flows and subsurface return flows are routed by simultaneous solutions of the continuity equation and a storage function. Storage coefficients are obtained by integration of the flow recession curve for a given watershed. Techniques are under study in the Hydrograph Laboratory for the approximation of flow recession curves by linear segments to obtain the advantages of superposition in routing waterflows from different areas of the watershed. Flow from each unit is routed separately through watershed storage and all are summed to obtain watershed outflow.

Postrainfall recession curves are plotted on a semilogarithmic scale in figure 8 for Little Mill Creek Watershed (W-97) near Coshocton, Ohio. Evapotranspiration must be minimized if we are to obtain a true storage-flow relation-

ship. The March recession shows the least effect by  $ET$  and is used for analyses. The equation of the recession curve is:

$$qt = q_0 e^{-t/m} \quad [9]$$

where

- $q_t$  = rate of flow one time increment later in inches per hour
- $q_0$  = rate of flow at start of period in inches per hour
- $e$  = logarithmic base
- $t$  = time increment in hours
- $m$  = absolute value of  $t/\Delta \ln q$  and is constant for each straight-line segment of recession curve on semi-logarithmic scale

By integration of equation [9] the storage increment  $\Delta S$  within a linear segment of the recession curve is:

$$\Delta S = m' \Delta q \quad [10]$$

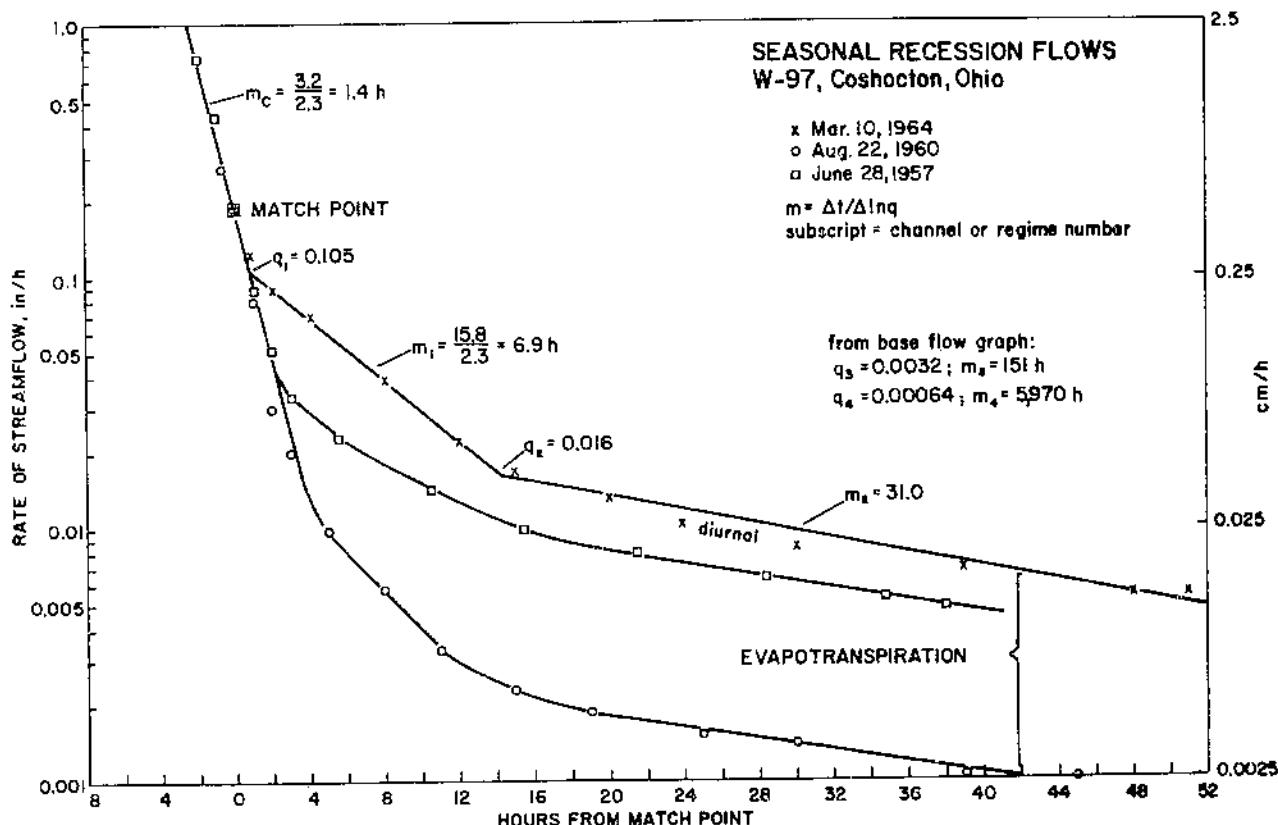


FIGURE 8.—Seasonal recession flows at W-97, Coshocton, Ohio.

Values of  $m$  derived for each linear segment of the semilogarithmic plotting are assumed to represent successive flow regimes (16), starting with  $m_c$  for channel flow and proceeding through a series— $m_1, m_2, m_3$ , and  $m_4$ —for successively deeper or more devous regimes of subsurface flow. Since some watersheds, such as the Beaver Creek watershed (W-11) at Hastings, Nebr., have no return flow, only  $m_c$  is defined.

On watershed W-97 it becomes necessary to separate flow regimes. The usual procedure has been to extend segments *backward* in time for subtraction from earlier regimes (1). In our experience and that of Kulandaiswamy and Seethorman (12), the adjusted points never plotted as a straight line and the resulting recession was too rapid. The authors prefer to use the same procedure as is generally used for separation of overlapping hydrographs of surface flows, i.e., extending the recession of the first storm *forward* in time for subtraction from subsequent flows.

Figure 9 illustrates the results of techniques suggested for separating flow regimes for input to this model. Each linear segment is extended toward zero and subtracted from subsequent flows to get the rising hydrograph of the succeeding regime. Now there is no question about maintaining logarithmic linearity within flow regimes. Also, the rising hydrograph fits better with the concept that return flows are less when flows in stream channels are at higher stages. The peak storage of the separated hydrograph can be computed for successive subsurface regimes by the equation:

$$S = q_b (m_L - m_{L-1}) \quad [11]$$

where

$S$  = peak storage of the difference hydrograph in inches

$q_b$  = rate at intersect with previous segment of recession

$m$  = absolute value of  $t/\ln (q_b/q_t)$

$L$  = flow regime number

$L-1$  =  $m$  of previous segment

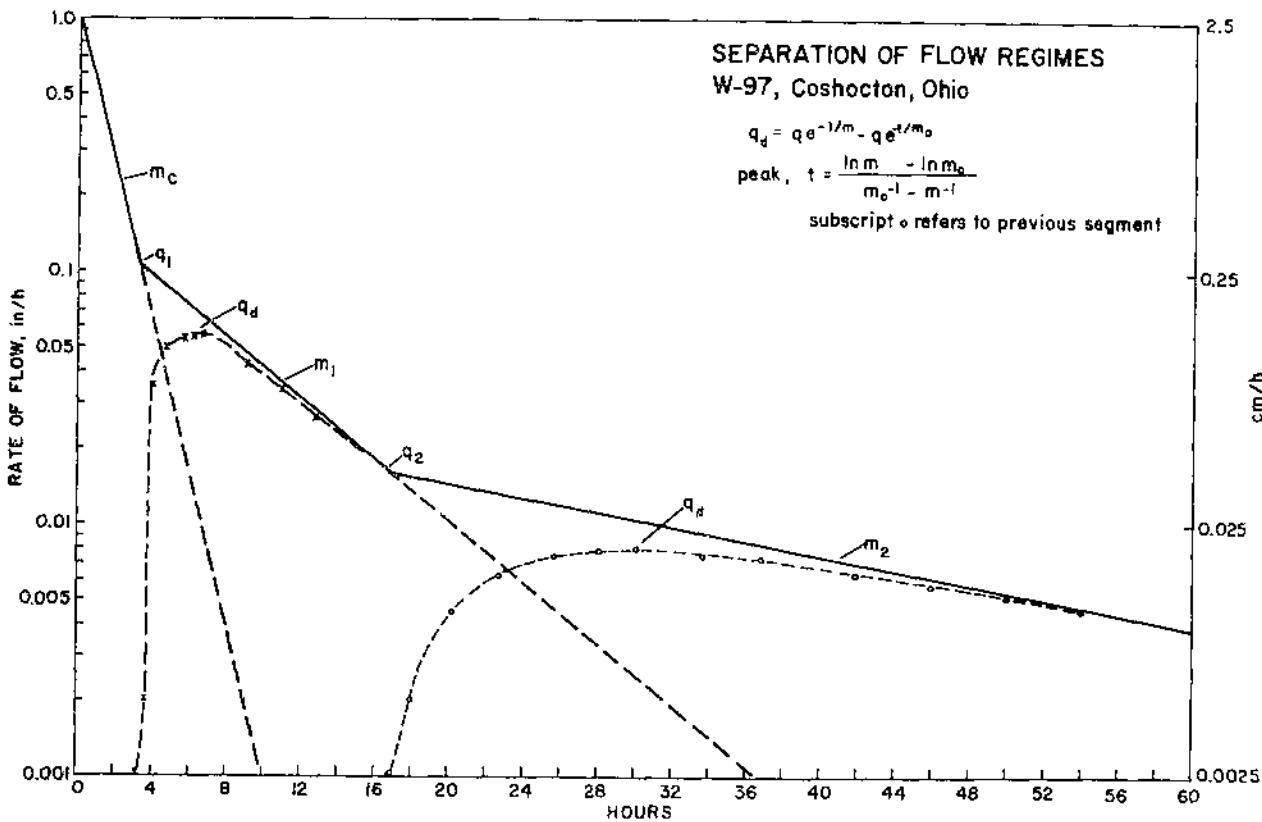


FIGURE 9.—Separation of flow regimes on W-97, Coshocton, Ohio.

Input to the model would then be  $m_c$ ,  $q_1$ ,  $m_1$ ,  $q_2$ ,  $m_2$ ,  $q_3$ ,  $m_3$ ,  $q_4$ , and  $m_4$  for those watersheds having four discernible regimes of subsurface flow. The value of  $m$  is readily determined as the number of hours required for the recession segment to cross one log cycle divided by 2.3, the natural logarithm of 10.0. Maximum free-water storage is assumed equal to the  $G$  value from the soil survey for regimes 1 and 2, but it is the storage under the hydrograph computed by equation [11] for the remaining flow regimes as in figures 8 and 9.

As determined from the watershed flow recessions,  $m_c$  includes detentions of overland flow. Since overland flow is routed in equation [7], the depth of overland flow must be subtracted from the  $\Delta S$  of equation [10]. At the peak, outflow is essentially equal to inflow and channel storage would be:

$$S = m_c \cdot q - (q/ova)^{0.6} \quad [12]$$

We can get an approximation of the corrected  $m_c$  ( $cm_c$  in the program) by solving for  $m$  at one unit of flow rate in equation [10]:

$$cm_c = m_c - ova^{-0.6} \quad [13]$$

Equation [13] is an approximation only and typifies an area of needed research.

Concern for the transport of agricultural chemicals has placed emphasis on the path of both surface and subsurface flows from relatively small upland areas well above the elevation of emerging subsurface return flow. As a result, USDAHL-70 was revised to permit inputs to table 9 (appendix) of  $m_1$  to  $m_4$  obtained from downstream gaging sites of an encompassing watershed together with an indication of the number of regimes, including  $m_c$ , which occur above the weir. Output includes "onsite" return flow of volumes that passed through the soils of one or more zones to become part of "runoff" at the weir. Output also lists "offsite" return flows for comparison with regional information downstream.

As the watershed size diminishes, the importance of detail increases. Therefore  $m_1$  and  $m_2$  are subscripted by zone and reevaluated

from soils information. Assumptions derived empirically were—

(1) Outflow is equal to permeability · width/length · gradient.

(2) Permeability varies as ratio of large pore diameters squared or as square of ratio of large pore volumes.

(3) Since  $f_c$  is permeability of layer 2, permeability of layer 1 is  $f_c \cdot (G_1/G_2)^2$ . Then since storage (*FREE WATER*) is equal to *DEPTH* ·  $G$  and since  $m = FREE/Q$ , we can derive  $mz_1$  and  $mz_2$  for each zone by equation [14]:

$$mz_L = depth_L \cdot G_2^2 \cdot ovl^2 \cdot (sl^2 + 1)^{0.5} / (f_c \cdot G_L \cdot \text{zone area} \cdot sl) \quad [14]$$

where

$mz$  = routing coefficient for zone

$G_2$  = gravity (free) water in regime 2

$ovl$  = length of land slope in feet

$sl$  = land slope in percent

$f_c$  = final rate of infiltration

$L$  = flow regime or layer

This is an area suggested for further research.

If the downstream flow record indicates that the hydrograph recession passes abruptly from the characteristic surface flow hydrograph to the low, sustained base flow without transitional slope breaks,  $m_1$  and  $m_2$  can be entered as zeros in table 9. The program will not compute flows in a regime whose  $m$  value is zero in table 9.

Equation [15] is a combination of the continuity equation and equation [10] used in computing outflow from each regime of each zone:

$$q_2 = \frac{2 \Delta I}{2m + \Delta t} + q_1 \frac{2m - \Delta t}{2m + \Delta t} \quad [15]$$

Equation [10] being linear forces the routed hydrograph from equation [15] to peak at its crossing with the inflow hydrograph, whereas channel flow responds nonlinearly to changes in inflow rate. Therefore nonlinearity was induced on the rising side of the streamflow routing by the techniques of Holtan and Overton (10) for successive routings through one-

half of the indicated storage using equation [16]:

$$q_2' = \frac{2 \Delta I}{m + \Delta t} + q_1' \frac{m - \Delta t}{m + \Delta t} \quad [16]$$

In the second application of equation [15] the quantity  $(q_1' + q_2') \Delta t/2$  is substituted for  $\Delta I$ . The symbols for equations [15] and [16] are—

$q$	= rate of outflow from storage in inches per hour
$q'$	= theoretical rate of outflow from each half of storage in inches per hour
$I$	= inflow volume in inches
$m$	= routing coefficient in hours
$\Delta t$	= time increment in hours
<sub>1</sub> and <sub>2</sub>	= beginning and end of $\Delta t$

## HYDROGEOLOGY

In the Hydrograph Laboratory's model, infiltrated water is proportioned to  $ET$ , or free-water evaporation, and to downward seepage or to lateral return flow in each flow regime. Since downward seepage and lateral flow are supplied by free water, estimates of maximum seepage rate ( $C$ ) and free-water capacity ( $G$ ), as well as the storage coefficient ( $m$ ), are needed in each flow regime.

Since subsurface flow regimes are considered sequential, seepage ( $C$ ) from a given regime is inflow to the next regime and must be adequate to supply the sum of the maximum flow rate ( $q_{L+1}$ ) experienced in the next regime and the rate of deep seepage ( $gr$ ):

$$C = q_{L+1} + gr \quad [17]$$

where

$L$  = regime number

$gr$  = maximum rate of ground-water recharge in inches per hour

Ground-water recharge from the ultimate return-flow regime is estimated on a regional basis. Average annual rainfall, average annual  $ET$ , and average annual streamflow yields in the vicinity can be used to derive an average annual ground-water recharge. This can be converted to inches per hour as an estimate of  $gr$ . At the Hastings, Nebr., watershed this value was estimated as equal to  $f_c$ , but the estimate at Coshocton, Ohio, watershed was 0.0006 inch per hour. At the Riesel, Tex., and Ft. Lauderdale, Fla., watersheds  $gr$  was estimated as zero.

Increments of downward seepage (subput) to the next regime are computed as a function of free or gravity water present:

$$\text{Subput}_{L+1} = \Delta t \cdot C \cdot (G - SA)/G \quad [18]$$

where

$\text{Subput}_{L+1}$	= water passing downward to next regime in inches
$\Delta t$	= time increment in hours
$C$	= rate of downward seepage in inches per hour
$G$	= free or gravity water in inches
$SA$	= air space in inches equivalent of water

The potential rate of outflow ( $q_p$ ) from a regime is derived by equation [15], but actual outflow from a regime is held equal to zero, as illustrated in figure 9, whenever summation outflow exceeds the value of intercept  $q_b$  for that regime. When summation outflow is less than  $q_b$ , a favorable gradient is assumed and outflow ( $q_L$ ) is computed by the following equation:

$$q_L = q_p (q_b - \Sigma q) / q_b \quad [19]$$

where

$q_p$  = potential regime outflow from equation [15]

$q_b$  = flow rate at intercept with previous segment

$\Sigma q$  = sum of all existing flow rates

An exception to equation [19] is made for frozen ground. If the average temperature of the air for 2 weeks is below 30° F, equation [19] is reduced for layer 1 by 0.1 inch per hour for each average °F below 30°, and below 20° flow is stopped. Thus it is assumed that highly permeable soils become impervious at lower temperatures.

The limits of free-water storage in the first two regimes are computed from soil survey data as the products of horizon thickness and percent freely drained porosity. The limits of free-water storage ( $G$ ) associated with subsequent flow regimes, i.e., regimes 3 and 4, are computed from the storage-flow relationship:

$$G_L = q_b \cdot (m_L - m_{L-1}) \quad [20]$$

where

$G$  = gravity or free water

$q_b$  = flow rate at breakpoint of recession curve

$m$  = routing coefficient

$L$  = regime number

Since there is no assurance that the flow recession analyzed represents a saturated A or B horizon, the  $G$  values determined from soil survey data for these two horizons take precedence in the model. Subsequently the  $q$  values and the  $G_L$  values of regimes 3 and 4 are apportioned to each zone of the watershed in proportion to the free-water limit ( $G_1$ ) of the topsoil:

$$G_L (\text{zone}) = m_L \cdot q_{max,L} \cdot G_1 (\text{zone}) / \bar{G}_1 \quad [21]$$

where

$G_L$  = gravity or free water of layer

$m_L$  = routing coefficient of layer

$q_{max,L}$  = maximum outflow of layer

$\bar{G}_1$  = areally weighted watershed average of layer 1 from soil survey

By this means the storage indicated by the lower flow recession is dispersed over the watershed in proportion to the depth of the topsoil horizon in each zone or hydrologic response unit. Routing coefficients ( $m_s$  and  $m_i$ ) remain unchanged for each regime, but the storage potentials ( $G$ ) and the maximum outflows ( $q_{max}$ ) are unique for each zone.

$$q_{max} = G/m \quad [22]$$

Evapotranspiration is drawn from both  $G$  and  $AWC$  when roots are present. Geologic research is needed to develop concepts of flow regimes associated with specific depths in the profile. In the meantime we are relying heavily on soil surveys for storage of regimes 1 and 2 and depend on the recession curve

analyses for storage values of subsequent regimes. Roots are arbitrarily designated as drawing water from the first two regimes, often creating a deficit in  $AWC$  to be satisfied before accruals to subsequent regimes can occur. Therefore  $AWC_1$  and  $AWC_2$  are required input.  $AWC_1$  is obtained from the moisture tension data of the first layer.  $AWC_2$  is estimated from the moisture tension data below the first layer to the depth of suitable habitat for roots as indicated in the soil profile description. Moisture deficits are computed only in the depth indicated for root habitat. Presently there is no basis for distributing any part of  $AWC$  to subsequent regimes except in a few places like Florida, where records of wells over impervious rock at very shallow depths may permit some speculations.

Evaporation from free water in the soil is treated as a function separate from evapotranspiration. It is extracted from depression storage ( $Vd$ ) or from the sum of free water in regimes 1 and 2 as the product of pan evaporation. The fraction total large pores ( $G_1$  and  $G_2$ ) occupied by free water are raised to a power of 1 for sands and a power of 2 for clays, i.e., if the ratio  $AWC/G$  is equal to or less than 0.7, the texture is considered sand and the exponent is taken as 1.0; if the ratio is greater than 0.7, the texture is considered to be fine and the exponent set at 2.0. These exponents are tentative and suggested for further research.

A percentage of overland flow from each zone is designated to cascade across the subsequent soil zone, with the remainder, if any, allocated to the alluviums or directly to channel inflow. Allocation is a matter of judgment based on the nearness of a zone to alluviums or on the presence or absence of diversions, graded terraces, listed furrows, or other interceptors leading directly to a stream channel. Infiltration in excess of  $AWC$  in the root zone is routed through storage of subsequent regimes by equation [14] and accumulated as run-on to the alluvium or as direct inflow to the stream channel if so designated by input. The total of all inflows to the channel is routed, using the channel storage coefficient  $m_c$  in equation [16] to obtain the outflow hydrograph for the watershed.

## RESULTS

The mathematical model programed in FORTRAN, as discussed in the appendix, was applied to the four widely separated and widely diversified ARS experimental watersheds listed in table 1. Water yields were computed on a continuing basis (table 7), and monthly and annual yields were used to test the results statistically. Runoff computed by the model is compared graphically with runoff computed from correlation with precipitation in figures 10-13 and statistically in table 8.

The regression of observed runoff on precipitation assumed the relationship  $y = a + bx$ . However, since the regression of observed runoff on values computed by USDAHL-74 assumed  $a = 0$  and  $b = 1.0$ , the estimate of  $S_e$  for the latter was computed as indicated in the footnote of table 8. The resulting  $r^2$  values

are estimates of the variance in observed runoff reflected by the respective predictor, precipitation or USDAHL-74. The coefficient of correlation ( $r$ ) is a measure of the goodness of fit, approaching 1.0 for a perfect fit.

Additional information can be printed out from computations within the sequence of the model. The moisture regimes of figure 14, the overland flows of figure 15, and the evapotranspiration on each soil zone in figure 16 are examples. However, the testing and development of these dispersed segments have just begun through application of the model to lysimeters, plots, and small watersheds of the Agricultural Research Service.

Awareness of such possibilities may stimulate speculation in regard to engineering applications. Overland flows, evapotranspiration,

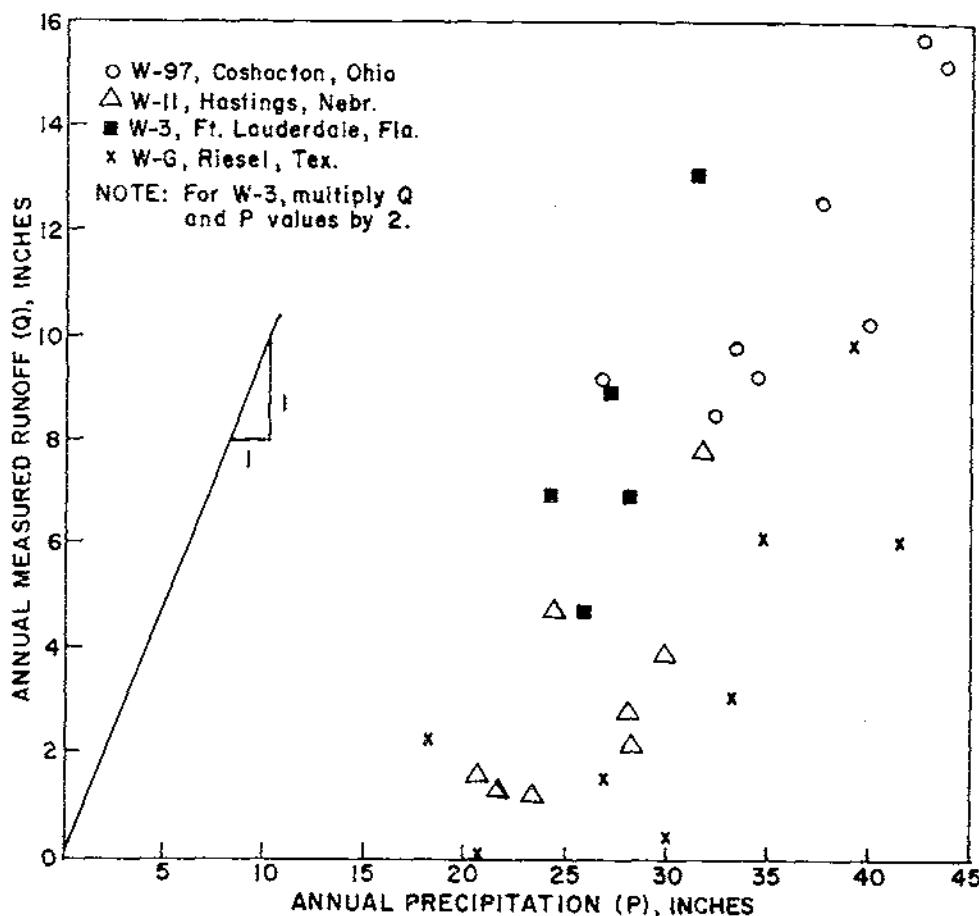


FIGURE 10.—Precipitation-runoff relationships for annual runoff at four watersheds.

TABLE 7.—Precipitation, observed runoff, and runoff as computed by USDAHL-74 model for 4 watersheds<sup>1</sup>

Year and month	W-97, Coshocton, Ohio			W-11, Hastings, Nebr.			W-3, Ft. Lauderdale, Fla.			W-G, Riesel, Tex.		
	Precipitation	Observed runoff	Computed runoff	Precipitation	Observed runoff	Computed runoff	Precipitation	Observed runoff	Computed runoff	Precipitation	Observed runoff	Computed runoff
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1956												
Jan.							0.39	0.04	0.14			
Feb.							1.04	.02	.02			
Mar.							1.11	.01	.01			
Apr.							6.20	.16	.58			
May							3.91	1.14	2.07			
June							4.77	.04	.34			
July							2.72	.05	.04			
Aug.							6.63	.09	.09			
Sept.							8.28	3.30	1.60			
Oct.							13.50	9.19	9.10			
Nov.							.12	.08	.12			
Dec.							.11	.02	0			
Total							48.78	14.14	14.11			
1957												
Jan.	1.80	1.12	1.19	0.16	0	0	1.41	.04	.07			
Feb.	1.38	.84	.79	.06	0	0	2.90	.04	.02			
Mar.	1.91	1.02	1.00	1.92	0	0	6.27	.55	1.40			
Apr.	5.30	4.16	3.81	3.02	.19	.34	5.95	.85	1.31			
May	3.89	.94	.55	6.35	1.39	1.45	6.45	.78	.97			
June	10.08	4.03	3.84	11.74	5.22	5.57	3.70	.90	.98			
July	2.96	.73	.24	.28	0	0	7.05	1.12	.84	0.02	0	0
Aug.	2.13	.08	.18	5.48	1.19	.89	8.53	3.43	3.43	.56	0	0
Sept.	3.69	.12	.64	.46	0	0	8.56	5.45	3.36	4.29	0	0
Oct.	1.52	.07	.15	1.25	0	0	1.64	.95	.97	8.18	1.64	2.93
Nov.	2.70	.35	1.13	.59	0	0	.26	.01	.03	4.56	.70	.50
Dec.	4.61	2.51	2.37	.01	0	0	3.67	.16	.28	.84	0	.01
Total	41.97	15.97	15.84	31.32	7.99	8.25	56.39	14.28	13.66	18.45	2.34	3.44
1958												
Jan.	1.62	.92	.86	.32	0	0	5.88	2.27	1.62	1.94	.06	.18
Feb.	.71	.52	.30	1.19	0	0	1.23	.29	.71	3.30	.65	.62
Mar.	1.00	.79	.55	2.70	.25	0	6.39	2.10	.84	1.37	.02	.06

See footnote at end of table.

TABLE 7.—*Precipitation, observed runoff, and runoff as computed by USDAHL-74 model for 4 watersheds<sup>1</sup>—Con.*

Year and month	W-97, Coshocton, Ohio			W-11, Hastings, Nebr.			W-3, Ft. Lauderdale, Fla.			W-G, Riesel, Tex.		
	Precipitation	Observed runoff	Computed runoff	Precipitation	Observed runoff	Computed runoff	Precipitation	Observed runoff	Computed runoff	Precipitation	Observed runoff	Computed runoff
1958—Con.	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
Apr.	3.80	1.47	1.12	1.82	.09	.07	2.71	.62	.66	3.12	.02	.30
May	3.06	2.07	1.37	1.46	0	0	3.40	.17	.46	2.04	.43	.50
June	4.19	.27	.43	8.35	.26	.67	7.34	.08	.28	2.12	0	0
July	10.08	2.57	3.02	4.78	.33	.30	5.74	1.59	2.21	1.10	0	0
Aug.	2.68	.75	.26	3.72	.36	.13	7.26	.85	1.02	6.50	.55	.90
Sept.	2.79	.24	.15	1.79	.07	0	4.68	.76	1.11	5.95	1.29	.57
Oct.	.38	.09	.01	.13	0	0	3.53	.59	.82	2.89	.22	.16
Nov.	1.53	.11	.14	.50	0	0	.58	.06	.11	1.47	0	.07
Dec.	0	.19	.09	.05	0	0	2.49	.07	.15	1.33	0	.05
Total	81.84	9.99	8.80	21.81	1.38	1.17	51.23	9.45	9.99	33.13	3.24	3.86
1959												
Jan.	7.30	4.52	3.02	.30	0	0	3.37	.48	.57	.36	0	0
Feb.	3.55	2.65	3.80	.34	.01	0	1.11	.17	.55	3.38	.42	.57
Mar.	2.55	1.33	1.52	3.67	.13	0	7.36	3.35	2.98	1.04	.02	.06
Apr.	4.47	1.81	1.42	.89	.03	0	1.78	.17	.37	3.93	.51	.38
May	2.88	.85	.13	6.52	.80	.55	5.41	.45	.42	3.77	.14	.21
June	4.81	.68	.69	4.90	.86	.87	9.21	5.28	4.96	7.97	2.24	1.75
July	2.97	.20	.01	2.98	1.26	1.66	3.46	.16	.59	3.94	.05	.06
Aug.	2.10	.21	.25	3.61	.23	.10	4.47	.39	.54	3.22	0	.6
Sept.	3.47	.05	.15	4.59	.59	.58	4.56	.41	.54	2.09	0	0
Oct.	5.46	.50	1.98	2.01	.09	.02	9.13	6.10	4.67	6.70	1.63	1.41
Nov.	2.76	.90	1.11	0	0	0	2.64	.59	.89	1.96	.53	.44
Dec.	2.22	1.71	1.14	.07	0	0	1.85	.44	.52	3.78	.83	.72
Total	44.54	15.41	15.22	29.88	4.00	3.78	54.35	17.99	17.60	42.14	6.37	5.60
1960												
Jan.	3.00	2.29	1.50	0	0	0	.37	.10	.19	2.13	1.17	.38
Feb.	3.42	1.40	1.62	0	0	0	4.28	.98	.72	2.20	.29	.19
Mar.	1.06	1.57	.29	3.04	1.43	.16	5.68	3.56	2.68	1.61	.23	.12
Apr.	1.68	.91	1.49	2.08	.68	.16	1.87	.08	.15	1.49	0	0
May	3.30	.63	.51	5.67	1.73	2.11	1.90	.01	.01	1.56	.27	0
June	5.66	1.02	1.34	5.16	.94	.59	11.59	2.69	4.30	4.89	0	.01
July	3.24	.17	.06	2.02	.01	0	11.15	4.56	4.34	.94	0	0

Aug.....	7.17	1.05	1.95	1.80	0	.01	5.41	1.93	2.13	3.74	.09	0
Sept.....	.85	.08	.01	3.07	.09	.03	16.47	10.99	11.24	.52	0	0
Oct.....	1.81	.05	0	1.04	0	0	1.97	1.54	1.00	5.83	.28	.01
Nov.....	1.82	.11	.42	.48	0	0	.77	.11	.18	2.24	.11	.26
Dec.....	1.60	.06	0	.02	0	0	.53	.03	0	7.34	3.88	4.32
Total.....	34.11	9.34	9.19	24.38	4.88	3.06	61.99	26.58	26.94	34.49	6.32	5.29
<i>1961</i>												
Jan.....	.91	.30	0	.06	0	0	-----	-----	-----	5.16	3.67	2.92
Feb.....	3.88	1.70	2.67	.23	0	0	-----	-----	-----	5.02	3.07	2.77
Mar.....	3.54	3.14	1.58	2.33	0	.16	-----	-----	-----	2.21	.10	.26
Apr.....	6.37	4.93	4.48	1.40	0	0	-----	-----	-----	.63	0	.01
May.....	2.65	.95	.55	7.06	.86	.68	-----	-----	-----	2.05	0	0
June.....	2.97	.51	.52	4.77	.95	1.32	-----	-----	-----	7.91	1.86	2.62
July.....	5.64	.39	.75	2.70	.01	.04	-----	-----	-----	4.69	.69	1.03
Aug.....	2.17	.14	.02	3.40	.24	.04	-----	-----	-----	.23	0	0
Sept.....	.95	.03	.01	3.83	.15	0	-----	-----	-----	4.73	.48	.26
Oct.....	2.27	.04	0	.51	0	0	-----	-----	-----	2.49	.12	0
Nov.....	3.31	.20	1.14	1.19	0	0	-----	-----	-----	1.99	0	0
Dec.....	2.51	.40	.80	0	0	0	-----	-----	-----	1.89	.10	.14
Total.....	37.17	12.73	12.52	27.48	2.21	2.24	-----	-----	-----	39.00	10.09	10.01
<i>1962</i>												
Jan.....	3.18	1.53	1.87	1.04	.21	0	-----	-----	-----	1.25	.02	.05
Feb.....	3.50	2.22	1.25	.28	0	.02	-----	-----	-----	1.57	.05	.13
Mar.....	3.32	2.47	2.63	2.51	.52	.05	-----	-----	-----	1.20	.08	.11
Apr.....	1.06	1.12	.51	.42	0	0	-----	-----	-----	3.74	.39	.16
May.....	2.47	.24	.01	2.96	0	.01	-----	-----	-----	2.56	.14	0
June.....	1.98	.07	.01	4.78	.21	.12	-----	-----	-----	6.29	1.05	.89
July.....	2.48	.03	.03	5.46	.48	.41	-----	-----	-----	.35	.02	0
Aug.....	1.61	.01	.01	5.11	.81	.50	-----	-----	-----	.10	0	0
Sept.....	5.65	.10	.84	3.39	.41	.14	-----	-----	-----	2.71	0	0
Oct.....	1.92	.08	.33	2.19	.25	.48	-----	-----	-----	2.22	0	0
Nov.....	3.03	.54	1.44	.16	0	0	-----	-----	-----	3.68	.01	0
Dec.....	2.06	.28	.56	.39	0	0	-----	-----	-----	1.25	0	0
Total.....	32.26	8.69	9.49	28.69	2.89	1.73	-----	-----	-----	26.92	1.76	1.34
<i>1963</i>												
Jan.....	.51	.48	.44	.44	.01	0	-----	-----	-----	.52	-----	0
Feb.....	1.70	.34	.67	0	.04	0	-----	-----	-----	1.29	-----	0
Mar.....	7.06	6.30	4.92	1.71	.08	0	-----	-----	-----	.99	-----	.05
Apr.....	3.02	1.24	.61	1.20	0	0	-----	-----	-----	2.06	-----	.07
May.....	1.97	.32	.07	.87	0	.01	-----	-----	-----	2.75	-----	0

See footnote at end of table.

TABLE 7.—*Precipitation, observed runoff, and runoff as computed by USDAHL-74 model for 4 watersheds<sup>1</sup>—Con.*

Year and month	W-97, Coshocton, Ohio			W-11, Hastings, Nebr.			W-5, Ft. Lauderdale, Fla.			W-G, Riesel, Tex.		
	Precipi-tation	Observed runoff	Computed runoff	Precipi-tation	Observed runoff	Computed runoff	Precipi-tation	Observed runoff	Computed runoff	Precipi-tation	Observed runoff	Computed runoff
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1963—Con.												
June	3.23	.59	.85	4.29	.15	.01	—	—	—	3.37	—	0
July	2.68	.04	.01	2.20	0	0	—	—	—	.34	—	0
Aug	2.84	.05	.10	2.24	0	0	—	—	—	.82	—	0
Sept	.25	0	0	8.92	1.08	1.36	—	—	—	1.10	—	0
Oct	.25	0	0	1.11	.02	.08	—	—	—	1.62	—	0
Nov	1.59	.01	0	.29	0	0	—	—	—	3.91	—	.23
Dec	1.48	.01	.15	.15	0	0	—	—	—	1.82	—	.16
Total	26.58	9.38	7.22	23.42	1.38	1.46	—	—	—	20.59	0	.51
1964												
Jan	2.71	.19	1.35	0	0	0	—	—	—	3.28	.05	.67
Feb	.50	.09	.83	.43	0	0	—	—	—	2.02	.01	0
Mar	8.84	5.15	3.80	1.19	0	0	—	—	—	2.05	.02	.27
Apr	5.76	3.03	2.41	1.16	0	0	—	—	—	4.18	.32	.61
May	3.54	.86	.44	.98	0	0	—	—	—	.59	0	0
June	3.30	.18	.01	5.78	.93	.92	—	—	—	1.87	0	0
July	3.42	.07	.01	3.40	.11	.01	—	—	—	0	0	0
Aug	3.90	.17	.37	5.61	.52	.08	—	—	—	6.24	.10	0
Sept	.66	0	0	1.68	.08	.23	—	—	—	4.26	.01	0
Oct	.84	.01	0	.11	0	0	—	—	—	.99	0	0
Nov	1.77	.04	.14	.52	0	0	—	—	—	3.45	.07	0
Dec	4.42	.61	2.15	0	0	0	—	—	—	1.06	0	0
Total	39.66	10.40	11.51	20.86	1.64	1.24	—	—	—	29.99	.58	1.55

<sup>1</sup> Precipitation adjusted for snowmelt estimates.

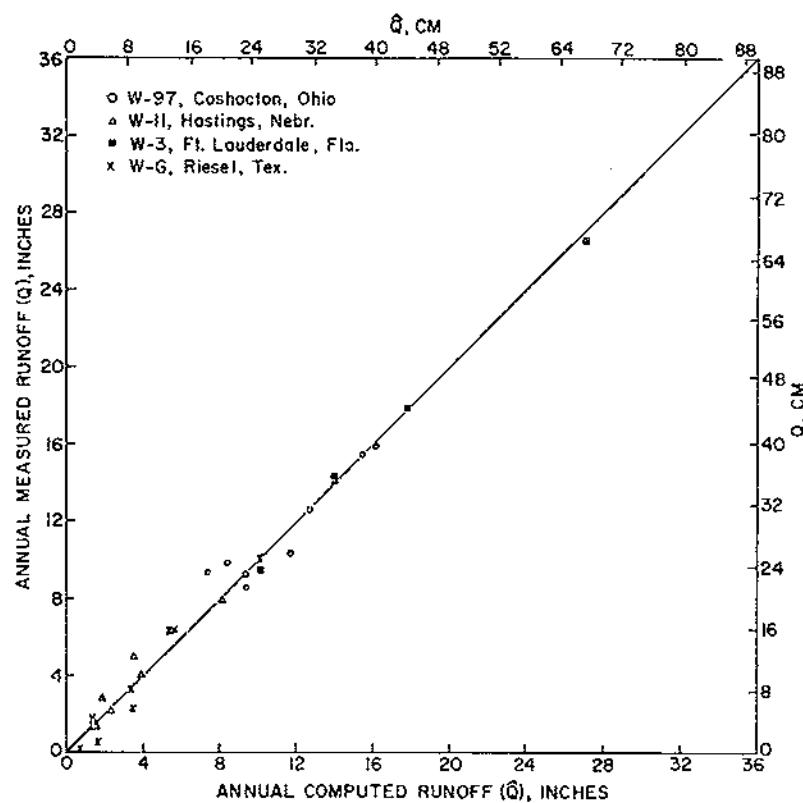


FIGURE 11.—Chart showing accuracy of USDAHL-74 model for estimating annual computed runoff as compared with annual measured runoff at four watersheds.

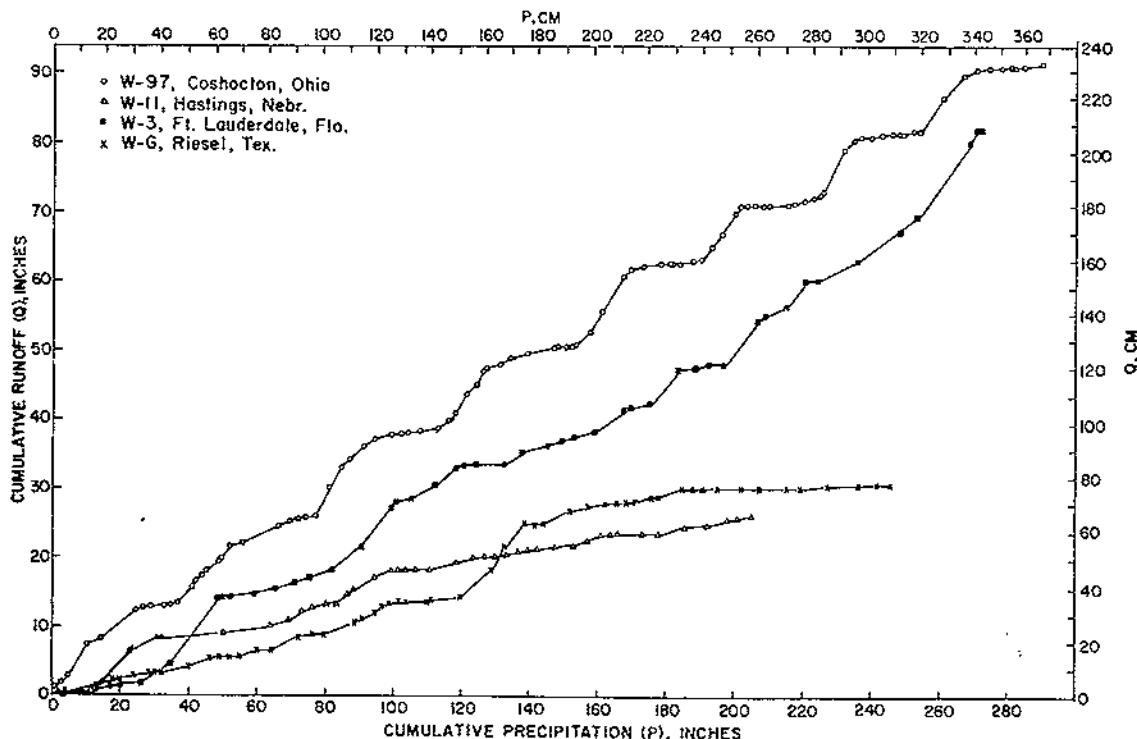


FIGURE 12.—Precipitation-runoff relationships for cumulative runoff at four watersheds.

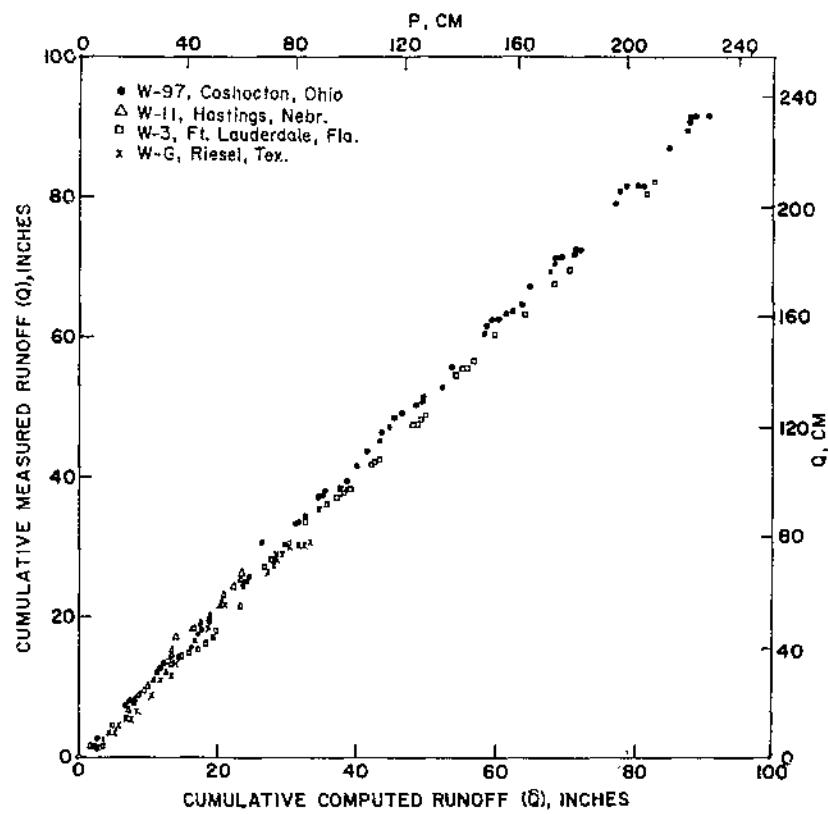


FIGURE 13.—Chart showing accuracy of USDAHL-74 model for estimating cumulative computed runoff as compared with cumulative measured runoff at four watersheds.

TABLE 8.—Correlation of observed runoff with observed precipitation and with runoff computed by USDAHL-74 model based on 1-month runoff period for 4 watersheds

Watershed and independent variable <sup>1</sup>	<i>a</i> <sup>2</sup>	<i>b</i> <sup>2</sup>	<i>S<sub>e</sub></i>	<i>r</i>	Observed runoff (from 0 to—)	<i>N</i>
W-97, Coshocton, Ohio:						
Observed precipitation	-0.33	0.43	0.95	0.67	6.30	{96}
Computed runoff	0	1.00	.57	.89		
W-11, Hastings, Nebr.:						
Observed precipitation	.20	.22	.41	.77	5.22	{96}
Computed runoff	0	1.00	.21	.95		
W-3, Ft. Lauderdale, Fla.:						
Observed precipitation	-1.01	.52	1.24	.87	10.99	{60}
Computed runoff	0	1.00	.57	.97		
W-G, Riesel, Tex.:						
Observed precipitation	-.33	.25	.57	.65	3.88	{90}
Computed runoff	0	1.00	.26	.94		
All watersheds, computed	0	1.00	.42	.95	10.99	342

<sup>1</sup> Runoff as computed by USDAHL-74 model; *r* is for unbiased fit of computed vs. observed, where

$$r = \sqrt{1 - S_e^2 / S_y^2}$$

$$S_e^2 = \sum (\text{observed} - \text{computed})^2 / (N-2)$$

$$S_y^2 = [(\sum (\text{observed})^2) - (\text{observed})^2 / N] / (N-1). \text{ Precipitation adjusted for snow and snowmelt.}$$

*N* = number of observations.

<sup>2</sup> Correlation equation:  $y = a + bx$ .

and moisture regimes are already a concern in the design of level terraces, in contour strip-cropping, in terrace benching (21), where an upslope strip of land is steepened to provide runoff water for crop production on a lower, leveled bench of land, and in many other designs for agronomic practices to conserve soil and water. The status and movement of free water in each soil zone could be printed out since they are important factors in interceptor ditching, tiling, and other solutions for drainage problems. Incorporation of these segments into the systems analyses of the watershed is essential if we are to achieve comprehensive planning.

Flood hydrographs continue to be of interest to watershed engineers. Figure 17 pre-

sents a computation of the annual hydrograph of average daily flows for W-3, Ft. Lauderdale, Fla., for 1956-60. Similar hydrographs of instantaneous rates can be printed out for any watershed by changing the print statements and the involved storages in the computer program.

Sensitivity of the model involves permutations of so many conditions and characteristics that a concise summary is not yet feasible. In general, the parameters affecting water yield are soil depths, root depths, evaporation rates, and the annual distribution of rainfall, whereas flood peaks and recession flows are most sensitive to rainfall intensities and the storage coefficients used in routing surface and subsurface flows.

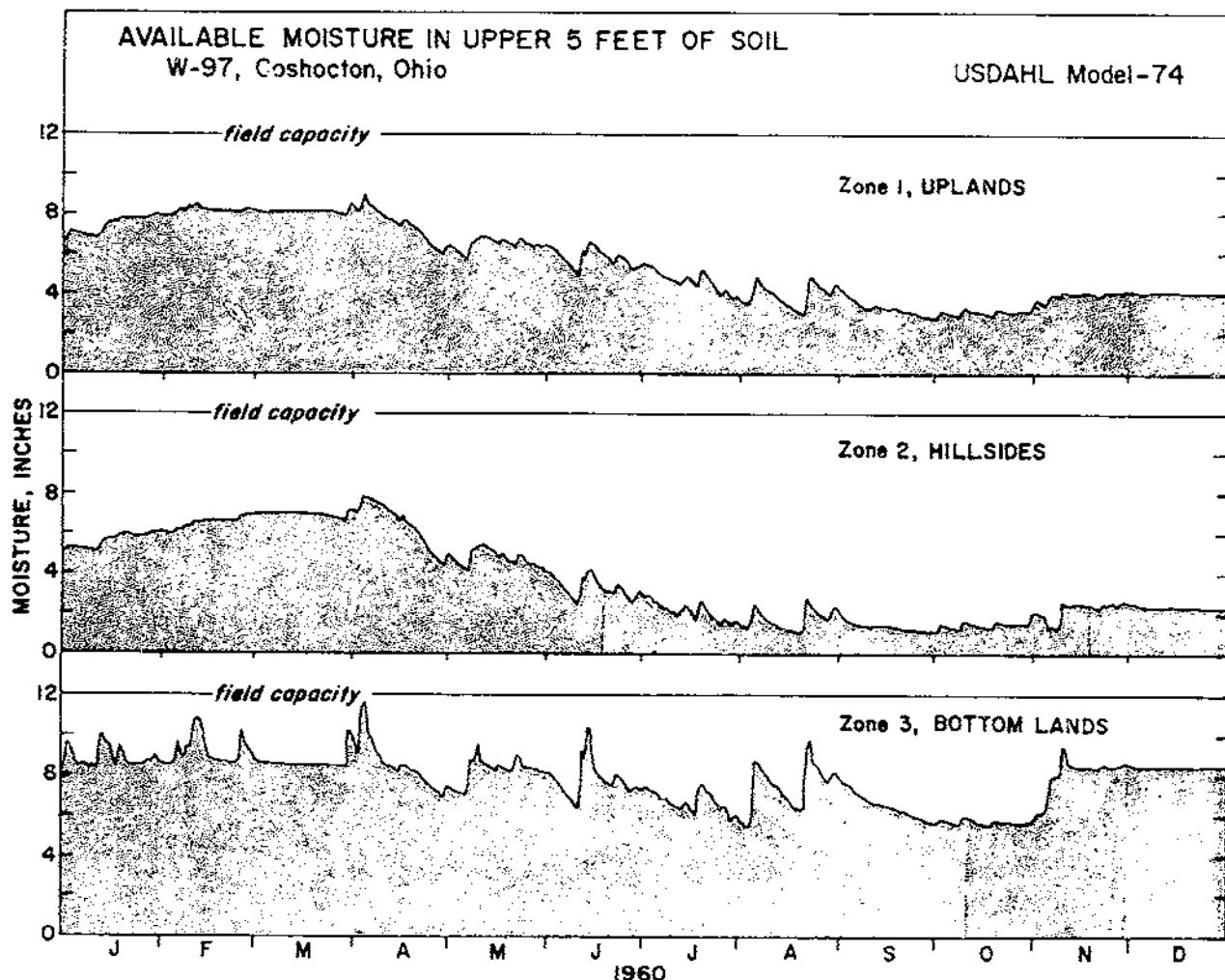


FIGURE 14.—Available moisture in upper 5 feet of soil or soil moisture regimes at W-97, Coshocton, Ohio, as computed by USDAHL-74 model.

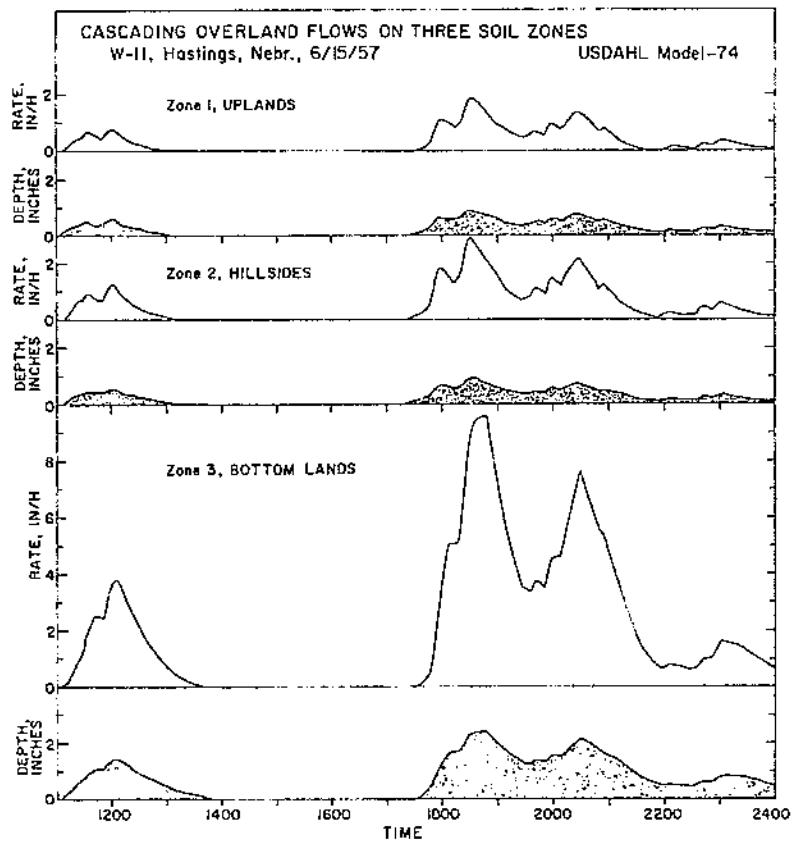


FIGURE 15.—Depth and rate of cascading overland flows on three successive soil zones of W-II, Hastings, Nebr., June 15, 1957, as computed by USDAHL-74 model.

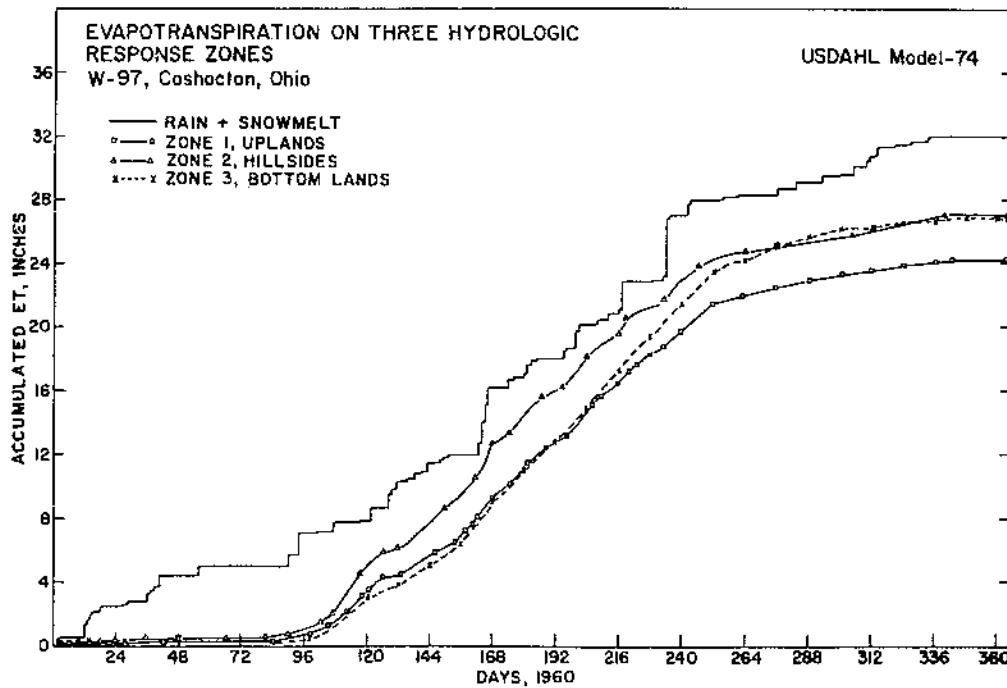


FIGURE 16.—Evapotranspiration on three hydrologic response zones of W-97, Coshocton, Ohio, as computed by USDAHL-74 model.

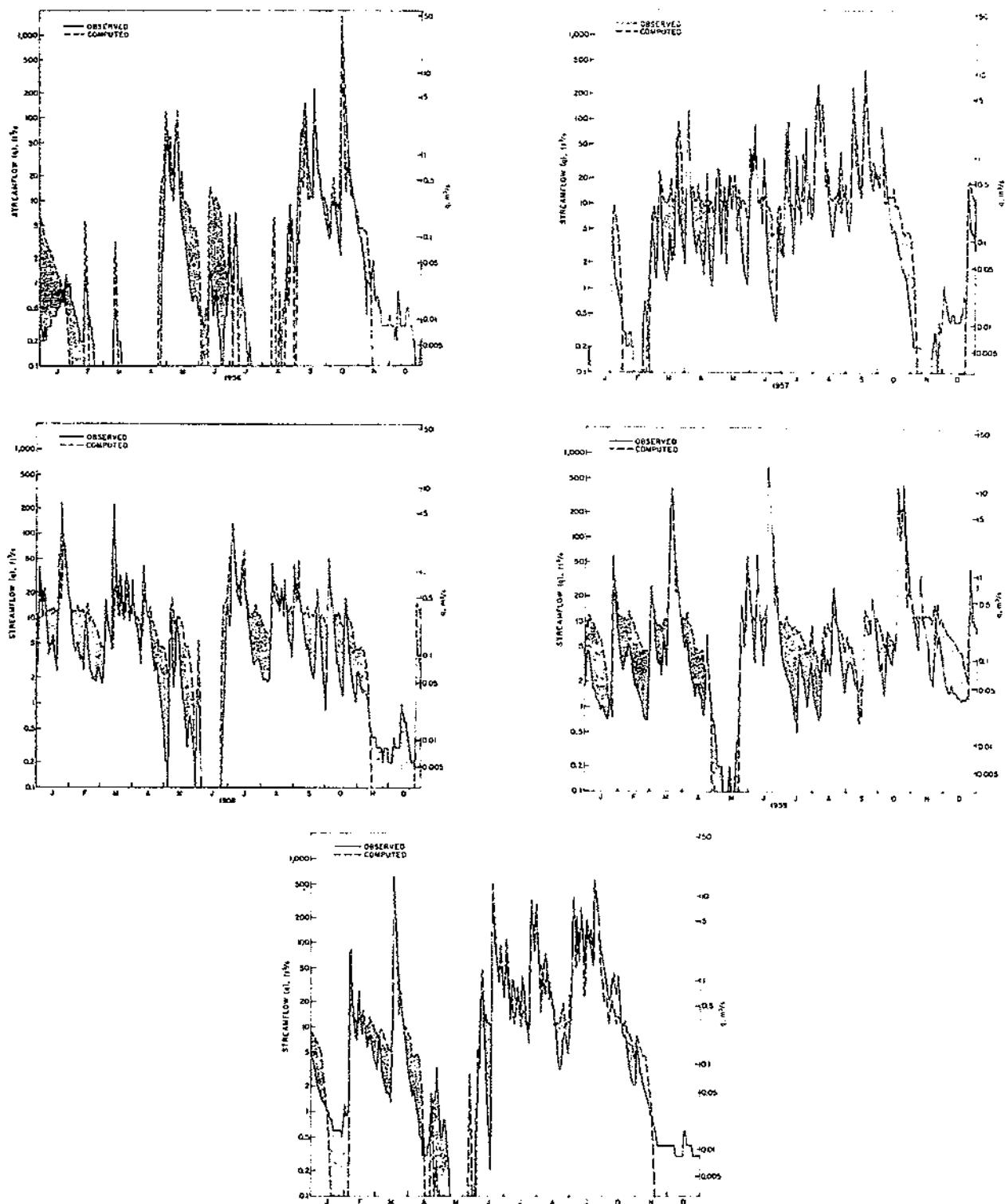


FIGURE 17.—Annual hydrographs of average daily streamflow in watershed W-3 (10,050 acres or 4,070 ha), Ft. Lauderdale, Fla., comparing observed data with data computed by USDAHL-74 model for 1956-60.

## FUTURE RESEARCH

Trial applications of the USDAHL-74 model indicated several critical needs for greater emphasis in the research program. They include (1) snow deposit and snowmelt prediction on agricultural watersheds in moderate climates, (2) root depth and moisture extraction patterns in layered soils, (3) geologic and geomorphic dimensioning throughout the watershed, and (4) practical dynamic approaches for routing flows through porous media.

The Hydrograph Laboratory plans to continue application of the model to watersheds, plots, and lysimeters at other locations to have a better representation of the national spec-

trum of climate and agriculture. We hope to begin more of this research in cooperation with ARS field projects. At this stage of development the model puts into a formal order all presently available subroutines that are adopted tentatively to permit progress in the overall study of watershed engineering. The model routines are divided so that as better subroutines are developed for each part of the process they can be inserted into the model without interfering with other routines in the sequence. Thus a sequence of best estimates will be maintained while research continues to improve each component.

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## APPENDIX

The original USDAHL-70 model program was written with two major objectives—*clarity and versatility*. The program is constructed in distinct subroutines so that as new concepts are evolved in a particular study area, the program will be relatively easy to update. Since modifications might have to be made because of differences in available equipment, particularly in core size, the model is programmed to simplify overlaying procedures. Many variables are kept in storage and are not printed out in the standard output. For a particular research interest they are readily available.

The program was developed on an IBM 360-65 computer operating under OS with HASP. The programming language is level G FORTRAN. Approximately 98K bytes of storage are required to run unoverlaid, and compilation cpu time using the level G compiler is approximately 1.55 minutes. Execution time for breakpoint rainfall on a three-zone watershed with subsurface flow is about 1 cpu minute per year.

The model has also been run on a Univac 1108 using the Exec 8 Control Language. Under this system 19K words of storage are needed, compilation time is 2.5 minutes, and, using the same watershed previously described, the run time is 28 cpu seconds per year.

The program is composed of 14 subroutines in addition to the MAIN, and it contains numerous comments that can be referred to for specific information. All the variables, which are in COMMON, are defined in comments at the beginning of MAIN. The model has two input and five output files. The data set reference variables are defined in the first executable statements in MAIN.

The model uses English units of measure. In general, volumes are in surface inches, lengths are in inches, and rates are in inches per hour. A metric version is also available.

Program decks and sample data can be obtained by writing to the Hydrograph Laboratory. Please indicate the kind of computer on which the program will be run and whether

a magnetic tape or card deck is desired. The sample program contains about 3,000 records 80 characters long.

### Input Parameters

Input parameters to the program describe the following: (1) *Watershed*, (2) *zones*, (3) *soils*, (4) *routing* (*channel and subsurface*), (5) *cascading*, and (6) *land use*. Table 9 gives the format for the input parameters. A sample program printout of input parameters appears in tables 12 and 13. The maximum "q's" and the recession coefficients under SUBSURFACE PARAMS and the soil parameters in inches shown in table 12 are calculated by the program from inputs in table 9. All the parameters are read using data set reference variable IREAD.

Input data to the program include temperature, percent grazing (GZ), tillage practice, percent land use by zones, pan evaporation, and rainfall. See table 10 for the format for all the input data except rainfall. Table 10 data are read on data set reference variable IREAD.

Input temperature data to the model are entered as 52 weekly averages of daily means. Data for 1 year are entered on 13 cards with 4 values per card.

Tillage practice information is entered on a separate card for each crop. The information can be read either once at the beginning of execution or yearly depending on whether "Does tillage change?" in table 9 is answered "Yes" or "No." Codes for different tillage or cultural practices are (1) turnplow (PLO), (2) plant (PLA), (3) harvest (HAR), and (4) cultivation (CUL). If there are not seven tillage operations for any crop in table 10, unused columns should be left blank.

The percent zone in each land-use crop is entered the first year and thereafter when land use changes. A card must be entered the first year for each zone in the watershed. The percent crops must be indicated for the zone in the same order as listed under land use in table 9. A blank record must be entered between the land-use percents and the pan data. If "Does land use change?" in table 9 was answered "Yes," then at least one card must be present each year. If no change occurred for a given

year, enter a blank card. If that question was answered "No," no cards are submitted for this section after the first year.

The pan-evaporation data are entered for each year of record as weekly averages of daily inches. The 52 values are entered on 13 cards. Pan data are read in subroutine LANUSE, and the data set reference variable is IREAD.

The items in table 10 are repeated yearly if the data are available. Temperature and pan-evaporation data must be read in for every year of calculation. If a partial year is calculated, blank cards may be inserted for the weeks not included in the calculation, but 13 cards must be submitted.

A more detailed description of the parameters requested in table 9 follows.

(Items (1) through (32) are read in subroutine PARAMS.)

(1) Comments .....	Watershed identity, rain gage, period of record, and other information that will identify run.
(2) Dates for storm hydrograph output.	Dates for which detailed routing information is to be saved.
(3) W/S, acres	Watershed acreage.
(4) Number of zones .....	Number of hydrologic response units. See figure 1.
(5) Routing coefficients:	
Total .....	Total number of segments in recession curve (see figs. 8-9) at some downstream point in encompassing watershed or region.
Above weir .....	Total number of segments in observed recession at outlet of watershed considered.
(6) Number of crops .....	Total number of crops or land-use practices (i.e., drilled and straight-row corn might be two crops).
(7) Deep ground-water recharge, in/h.	Deep percolation rate that does not show up in recession curve. See Hydrogeology section in text.
(8) Does land use change? Yes/No.	If any crop distribution percents within zones change during period of run, answer "Yes."

(9) Does tillage change?	Is the tillage practice available yearly for each crop? (If "No," only include practice for first year of calculation for every crop. Answer "No" even if practice is available for some but not all crops.)	(25) Initial, in/h	Rate of channel flow at beginning of calculation period.
(10) Z number	Zone number. "1" is upland.	(26) Initial snow	Water equivalent of amount of snow covering ground at beginning of calculation period.
(11) %W/S	Percent areal distribution of soil zones in watershed.	(27) THAW	Temperature at which snowmelt starts. May vary owing to differences in elevation or aspect at temperature station and major part of watershed.
(12) Length, ft	Average length of flow on zone.	(28) $q_1$ to $q_n$ , in/h	Maximum rates of flow associated with each linear segment of recession curve except channel flow segment. If recession has only a channel flow segment, this card is deleted. Fields not pertaining to watershed may be left blank. ( $q_1$ is largest rate, $q_n$ is smallest.)
(13) % slope	Slope of zone.	(29) $m_1$ to $m_n$ , h	Routing coefficients of segments, not including channel. ( $m_1$ is smallest coefficient, $m_n$ is largest.)
(14) $F_e$ , in/h	Final rate of infiltration after prolonged wetting. See Literature Cited (18).	(30) % subflow diverted to channel	Percent subsurface flow from zones above alluvium that does not cascade alluvium but goes directly to channel. See figure 1.
(15) Topsoil, in	Depth in inches of A horizon or topsoil. See table 2.	(31) $\% z_n$ cascading	Percent overland flow that cascades succeeding zone. See figure 1.
(16) Total soil, in	Depth in inches of aerated, well-drained soil including topsoil. See table 2.	(32) Remainder	Flow that does not cascade sequentially but goes to either channel or alluvium but not both.
(17) Z number	Zone number.	(Items (33) through (47) are read in subroutine LANUSE.)	
(18) % $G_1$	Percent of topsoil depth drained by gravity. 0-0.8 bar. See table 4.	(33) Crop name	Name of each crop (not more than eight letters per crop starting in column 1).
(19) % $AWC_1$	Percent of topsoil depth drained by plants. 0.8-15 bar. See table 4.	(34) $a$ values	Basal area of vegetation used as index of surface-connected porosity. See table 6.
(20) % $ASM_1$	Percent of topsoil depth holding water at beginning of calculation period. This total cannot exceed percent $G_1$ + percent $AWC_1$ .	(35) $Vd$ , in	Volume of depressions that would store rainfall until it infiltrated.
(21) % cracking	Percent of topsoil depth subject to cracking. See equation 4.		
(22) % $G_n$ , % $AWC_n$ , % $ASM_n$ , % cracking	Same as previously except they refer to soil profile below topsoil.		
(23) $\Delta t$ , h	Calculation interval desired for channel routing. Must divide evenly into 24.0 and should be less than or equal to one-fifth of channel routing coefficient.		
(24) $m_c$ , h	Channel routing coefficient. See figures 8 and 9.		

- (36) *ET/EP* ----- Ratio of maximum evapo-transpiration amount to maximum pan evaporation for a year. See "k" value in equation 2.
- (37) Root depth, in ----- Root depth. See table 2.
- (38) *TU* ----- Temperature ( $^{\circ}$ F) above which crop's *ET* is impaired.
- (39) *TL* ----- Temperature ( $^{\circ}$ F) below which crop's *ET* does not function.
- (45) *Z* number ----- Zone number.
- (46) % crop ----- Percent of zone in crop. Sum of percents for a given zone must equal 100.
- (47) *EP*, in/d ----- Consecutive weekly averages of daily pan evaporation.

If the watershed has fewer than four zones, omit the additional cards in the Zone and Soils sections of table 9.

A more detailed description of the data requested in table 10 follows.

- (40) Temperatures ----- Consecutive weekly averages of daily mean temperatures ( $^{\circ}$ F). Average temperature for first week begins in column 49 of card 1; temperature for 52d week begins in column 73 of card 13.
- (41) Crop name ----- This name must match exactly the name given in item 33. Delete unused cards.
- (42) *GZ* ----- Percent reduction in evapo-transpiration attributable to grazing. This figure is average for year.
- (43) *TIL* ----- One of four tillage codes.
- (44) MMDDYY ----- Date of tillage practice. Two dates for same crop may not be in same week. Month, day, year.

The input precipitation can be breakpoint or standard time intervals. Each observation must contain the date, military time, and amount of precipitation in inches since the previous reading. Time between two observations cannot be zero. The time increment *should not exceed 24 hours* for any precipitation period. (Note: This limit is occasioned by the storage allotted to the DELT array in COMMON and by the program division of all rain increments greater than 0.5 hour.) During extended periods of no precipitation,  $\Delta t$  should not exceed 2 months. A trailer card with 80 columns of "9's" indicates the end of the data and stops execution of the program as of the last input date and time. A calculation can begin and end at any time during a year. When continuous years of data are run, each year must end with a 1231YR 2400  $\Delta P$  reading. Computations will start at 0000 (military time) on the day of the first observation and will end as of the last observation. Any precipitation known to be snow should be marked by placing an *S* after the amount of precipitation. Precipitation is read in subroutine DATA. The data set reference variable is ITAPE, and it is unique to the precipitation data. The input precipitation format is shown in table 11.

TABLE 9.—Format for input parameters to USDAHL-74 model

USDA HYDROGRAPH LABORATORY 1974 MODEL OF WATERSHED HYDROLOGY - PARAMETERS

\* Total soil inches are determined as depth of aerated soil; may be limited by water table, but must exceed topsoil by at least 1 inch to avoid error checks.

**OPTIONAL**

\*\*\* INIT. SNOW is in water equivalent; THAW is temperature at which snowmelt starts.

TABLE 10.—Format for input data to USDAHL-74 model

USDA HYDROGRAPH LABORATORY 1974 MODEL OF WATERSHED HYDROLOGY—DATA

1	2	3	4	5	6	7	8	9	10	11	12	13
CROPS (% CROP AREA)												
1	2	3	4	5	6	7	8	9	10	11	12	13
BLANK CARD** IDENTIFICATION AND YEAR												
1	2	3	4	5	6	7	8	9	10	11	12	13
CULTURE												
1	2	3	4	5	6	7	8	9	10	11	12	13
14	15	16	17	18	19	20	21	22	23	24	25	26

\* If "TILLAGE CHANGE" is answered "Yes" in table 9, enter cards each year. If answered "No," enter no cards after first year. First year TIL symbols: GZ = % reduction by grazing or damage; PLO = turnplow; PLA = plant; HAR = harvest; CUL = cultivate.

\*\* If "LAND USE CHANGE" is answered "Yes" in table 9, (1) blank card follows "% crop" cards each year or (2) blank card only if no change. If answered "No" in table 9, blank card follows "% crop" cards first year only.

TABLE 11.—Card format for input precipitation to USDAHL-74 model

USDA HYDROGRAPH LABORATORY 1974 MODEL OF WATERSHED HYDROLOGY - RAINFALL

<sup>1</sup>MMDDYY = month, day, year. <sup>2</sup>Time in hours and minutes (military). <sup>3</sup>Precipitation increment in inches.

### Output Files

Five output files are produced by the model. Each file will be discussed separately. IPRIN is the standard printer file, and its unit is six. All input parameters and input annual data

are printed to this file. See tables 12-14. Parameter values in tables 12 and 13 are printed once at the beginning of execution. Annual data in tables 13 and 14 are printed when the year changes.

TABLE 12.—*Sample program printout of various input parameters to USDAHL-74 model*

#### USDAHL '74 MODEL OF WATERSHED HYDROLOGY

EXAMPLE: OUTPUT FOR ONLY 3 OF 5 COEFFICIENTS "ABOVE WEIR". SURFACE FLOW = "RUNOFF" AND BASE FLOW BELOW THE WEIR="OFFSITE"

STORM HYDROGRAPHS WILL BE PRINTED FOR THE FOLLOWING DATES:

NO DAY (JULIAN)	YR	6 28	179 57	6 29	180 57	6 30	181 57	1 21	21 59
1 22		22	59	1 23	23 59	1 24	24 59		

#### WATERSHED PARAMETERS

ACRES= 1000.0 NUMBER OF ZONES= 3.0 RTG COEFF: TOTAL= 5.0 ABOVE WEIR= 3.0 NUMBER OF CROPS= 7.0  
DEEP GROUND WATER RECHARGE= 0.00120 DOES LAND USE CHANGE? YES DOES YEARLY TILLAGE CHANGE? NO

#### GENERAL ZONE PARAMETERS

ZONE	% R/S	LENGTH	SLCFF	PC	DEPTH TOP	AERATED DEPTH
1	68.0	5385.	12.00	0.150	9.0	60.0
2	24.0	1900.	25.00	0.300	8.0	60.0
3	8.0	634.	4.00	0.150	16.0	60.0

#### SOIL PARAMETERS

ZONE	% G1	% AWI1	% ASH1	% CRAK1	% G2	% AWI2	% ASH2	% CRAK2
1	11.4	19.9	14.0	0.0	9.1	12.3	12.3	0.0
2	11.4	19.9	14.0	0.0	9.1	12.3	12.3	0.0
3	11.4	19.9	14.0	0.0	9.1	12.3	12.3	0.0

#### ROUTING PARAMETERS

CHANNEL ROUTING DELT T= 0.250 CHANNEL COEFFICIENT= 1.40 INITIAL STREAM FLO= 0.00250 INITIAL SNOW COVER= 0.0

#### SUBSURFACE PARAMS

REGIME	Q-MAX	COEFFICIENT
1	0.10500	6.90
2	0.01600	31.00
3	0.00320	151.00
4	0.00064	5970.00

#### COEFFICIENTS AND MAXIMUM Q'S PROPORTIONED TO ZONES ACCORDING TO SOIL DEPTH

REGIME	R 23	Q 21	R 22	Q 22	R 23	Q 23
1	0.982	0.131216	0.60	1.514544	4.88	0.373591
2	55.51	0.083617	4.90	0.965062	16.82	0.238051
3	151.00	0.003090	151.00	0.002747	151.00	0.005494
4	5970.00	0.000618	5970.00	0.000549	5970.00	0.001099

#### CASCADING PARAMETERS

ZONE % TO NEXT ZONE REST GOES TO?

3 20.0 ALLUVIUM  
2 20.0 CHANNEL  
(100% OF ALLUVIUM (ZONE 3) FLC GOES TO CHANNEL)  
(%BASEFLO DIVERTED FROM ALLUVIUM= 0.0)

#### THE SOIL PARAMETERS IN INCHES FOLLOW.

ZONE	LAYER	G	AWC	SA	CRACKING	C (IN/HR)	TOPD	SOILD
1	1	1.026	1.791	1.557	0.0	0.0848	9.00	60.00
	2	4.641	6.273	4.641	0.0	0.0043		
	3	0.467	0.0	0.467	0.0	0.0018		
	4	3.690	0.0	3.690	0.0	0.0012		
2	1	0.912	1.592	1.384	0.0	0.3683	8.00	60.00
	2	4.732	6.396	4.732	0.0	0.0039		
	3	0.415	0.0	0.415	0.0	0.0017		
	4	3.280	0.0	3.280	0.0	0.0012		
3	1	1.824	3.184	1.671	0.0	0.2393	16.00	60.00
	2	4.904	5.412	3.478	0.0	0.0067		
	3	0.830	0.0	0.0	0.0	0.0023		
	4	6.559	0.0	0.0	0.0	0.0012		

TABLE 18.—*Sample program printout of input land-use parameters to USDAHL-74 model and computed GI curves*

## LAND USE PARAMETERS

A VALUES	GRNHAY	PASTRE	CORNGR	WOODS	HAY2	IDLE	MISCEL
CROP YD	0.30	0.30	0.20	1.00	0.60	0.50	0.40
PTPP	0.05	0.05	0.05	0.05	0.05	0.05	0.02
ROOT DEPTH	1.20	1.00	1.50	2.00	1.20	1.00	1.00
UPPER TEMP	24.00	36.00	24.00	60.00	30.00	15.00	2.00
LOWER TEMP	80.00	80.00	85.00	80.00	80.00	80.00	80.00
	32.00	32.00	45.00	35.00	32.00	35.00	32.00

TILLAGE PRACTICE IS NOT AVAILABLE FOR YEARLY INPUT. THE TILLAGE PRACTICE FOR THE FIRST YEAR OF CALCULATION WILL BE USED FOR ALL OF THE YEARS.

CROP	% GRAZING	TILLAGE PRACTICES									
		CCBNR	0	PL0	43057	PLA	5 957	HAR	92657	PLA	101157
GRNHAY	0			HAR	72057						
HAY2	0			HAR	53057	HAR	62557	HAR	8 157		
PASTRE	0			NONE							
WOODS	0			NONE							
IDLE	0			NONE							
MISCEL	0			NONE							

## GI CURVES

WEEK	TEMP	GRNHAY	PASTRE	CORNGR	WOODS	HAY2	IDLE	MISCEL
1	23.79	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2	22.00	0.30	0.30	0.30	0.30	0.30	0.30	0.30
3	18.36	0.30	0.30	0.30	0.30	0.30	0.30	0.30
4	29.00	0.30	0.30	0.30	0.30	0.30	0.30	0.30
5	27.07	0.30	0.30	0.30	0.30	0.30	0.30	0.30
6	34.00	0.30	0.30	0.30	0.30	0.30	0.30	0.30
7	28.64	0.30	0.30	0.30	0.30	0.30	0.30	0.30
8	36.79	0.30	0.30	0.30	0.30	0.30	0.30	0.30
9	29.79	0.30	0.30	0.30	0.30	0.30	0.30	0.30
10	34.36	0.30	0.30	0.30	0.30	0.30	0.30	0.30
11	46.64	0.31	0.31	0.30	0.30	0.31	0.30	0.31
12	39.43	0.30	0.30	0.30	0.30	0.30	0.30	0.30
13	41.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30
14	41.79	0.30	0.30	0.30	0.30	0.30	0.30	0.30
15	37.71	0.30	0.30	0.30	0.30	0.30	0.30	0.30
16	59.52	0.57	0.57	0.36	0.55	0.57	0.55	0.57
17	66.64	0.72	0.72	0.54	0.70	0.72	0.70	0.72
18	69.07	0.36	0.36	1.00	0.31	0.36	0.37	0.36
19	67.00	0.73	0.73	0.10	0.71	0.73	0.71	0.73
20	61.14	0.61	0.61	0.14	0.58	0.61	0.58	0.61
21	63.36	0.65	0.65	0.22	0.63	0.65	0.63	0.65
22	63.43	0.65	0.65	0.31	0.63	0.20	0.63	0.65
23	65.78	0.70	0.70	0.41	0.68	0.32	0.68	0.70
24	76.71	0.93	0.93	0.65	0.93	0.63	0.93	0.93
25	72.21	0.84	0.84	0.67	0.83	0.79	0.83	0.84
26	68.25	0.76	0.76	0.59	0.74	0.45	0.74	0.76
27	70.00	0.79	0.79	0.63	0.78	0.50	0.78	0.79
28	71.43	0.82	0.82	0.66	0.81	0.68	0.81	0.82
29	76.79	0.28	0.93	0.79	0.93	0.87	0.93	0.93
30	70.86	0.41	0.81	0.65	0.80	0.81	0.80	0.81
31	74.00	0.68	0.88	0.72	0.87	0.52	0.87	0.88
32	71.57	0.78	0.82	0.66	0.81	0.60	0.81	0.82
33	69.57	0.78	0.78	0.61	0.77	0.69	0.77	0.78
34	67.79	0.75	0.75	0.57	0.73	0.73	0.73	0.75
35	72.79	0.85	0.85	0.69	0.84	0.65	0.84	0.85
36	65.86	0.71	0.71	0.52	0.69	0.71	0.69	0.71
37	68.64	0.76	0.76	0.59	0.75	0.76	0.75	0.76
38	68.14	0.75	0.75	0.58	0.74	0.75	0.74	0.75
39	53.86	0.46	0.46	0.09	0.42	0.46	0.42	0.46
40	55.29	0.49	0.49	0.14	0.45	0.49	0.45	0.49
41	51.50	0.41	0.41	0.10	0.37	0.41	0.37	0.41
42	51.29	0.40	0.40	0.13	0.36	0.40	0.36	0.40
43	43.57	0.30	0.30	0.17	0.30	0.30	0.30	0.30
44	47.57	0.32	0.32	0.22	0.30	0.32	0.30	0.32
45	35.86	0.30	0.30	0.26	0.30	0.30	0.30	0.30
46	47.29	0.32	0.32	0.28	0.30	0.32	0.30	0.32
47	36.21	0.30	0.30	0.30	0.30	0.30	0.30	0.30
48	37.79	0.30	0.30	0.30	0.30	0.30	0.30	0.30
49	31.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30
50	29.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30
51	44.29	0.30	0.30	0.30	0.30	0.30	0.30	0.30
52	35.44	0.30	0.30	0.30	0.30	0.30	0.30	0.30

LAND USE FOR YEAR 1957 FOLLOWS. IF A ZONE IS NOT MENTIONED, VALUES OF PREVIOUS YEAR ARE ASSUMED.

ZONE 1	GRNHAY= 13.0%	PASTRE= 22.0%	CORNGR= 13.0%	WOODS= 10.0%	HAY2= 31.0%	IDLE= 7.0%
ZONE 2	GRNHAY= 0.0%	PASTRE= 0.0%	CORNGR= 0.0%	WOODS= 96.0%	HAY2= 0.0%	IDLE= 0.0%
ZONE 3	GRNHAY= 0.0%	PASTRE= 96.0%	CORNGR= 0.0%	WOODS= 0.0%	HAY2= 0.0%	IDLE= 0.0%

TABLE 14.—*Sample program printout of input pan-evaporation data to USDAHL-74 model*

PAN EVAPORATION FOR YEAR 1957 FOLLOWS.

WEEK 1	0.040	0.030	0.020	0.020
WEEK 5	0.030	0.020	0.050	0.070
WEEK 9	0.050	0.060	0.150	0.080
WEEK 13	0.080	0.050	0.220	0.070
WEEK 17	0.140	0.200	0.260	0.200
WEEK 21	0.190	0.190	0.150	0.170
WEEK 25	0.230	0.190	0.210	0.180
WEEK 29	0.230	0.250	0.240	0.220
WEEK 33	0.230	0.200	0.150	0.160
WEEK 37	0.120	0.090	0.140	0.150
WEEK 41	0.080	0.100	0.080	0.080
WEEK 45	0.050	0.060	0.060	0.020
WEEK 49	0.020	0.050	0.050	0.040

IDALY is the daily output file. Daily summaries are shown in table 15. They are printed as of 2400 hours. Monthly and annual sum-

maries are shown in table 16. They are printed as of the year's end or the end of data.

TABLE 15.—*Sample program printout of various output daily summaries from USDAHL-74 model<sup>1</sup>*

DAILY SUMMARIES FOR YEAR 1957															
RUNOFF															
DAY	RAIN INCHES	CFS	ZONE 1			ZONE 2			ZONE 3						
			QO	ET:E	GR	SM1:2	QO	ET:E	GR	SM1:1	QO	ET:E	GR	SM1:2	
163	2.54	1.339	257.597	1.15	0.16	0.000	2.11	1.10	0.25	0.000	1.54	12.82	0.16	0.015	4.47
			0.00			5.31		0.00		3.22		0.0			6.36
164	0.32	0.176	33.878	0.00	0.17	0.000	1.79	0.00	0.30	0.000	1.48	0.00	0.17	0.015	3.48
			0.00			5.62		0.00		3.26		0.01			6.76
165	0.04	0.106	20.320	0.0	0.17	0.000	1.65	0.0	0.29	0.000	1.25	0.0	0.16	0.015	3.11
			0.00			5.62		0.0		3.25		0.01			5.69
166	0.0	0.018	3.555	0.0	0.17	0.000	1.51	0.0	0.24	0.000	1.06	0.0	0.16	0.015	2.96
			0.0			5.60		0.0		3.20		0.00			5.45
167	0.02	0.003	0.569	0.0	0.16	0.000	1.40	0.0	0.21	0.000	0.93	0.0	0.16	0.015	2.84
			0.0			5.56		0.0		3.14		0.00			5.41
168	0.0	0.002	0.316	0.0	0.16	0.000	1.29	0.0	0.19	0.000	0.81	0.0	0.16	0.015	2.72
			0.0			5.51		0.0		3.07		0.0			5.38
169	0.0	0.002	0.294	0.0	0.21	0.000	1.16	0.0	0.21	0.000	0.70	0.0	0.19	0.015	2.57
			0.0			5.43		0.0		2.97		0.0			5.34
170	0.02	0.001	0.276	0.0	0.21	0.000	1.08	0.0	0.19	0.000	0.63	0.0	0.19	0.015	2.46
			0.0			5.33		0.0		2.87		0.0			5.28
171	0.0	0.001	0.261	0.0	0.20	0.000	0.98	0.0	0.17	0.000	0.56	0.0	0.19	0.015	2.34
			0.0			5.22		0.0		2.77		0.0			5.21
172	0.0	0.001	0.250	0.0	0.20	0.000	0.90	0.0	0.16	0.000	0.50	0.0	0.19	0.015	2.23
			0.0			5.11		0.0		2.67		0.0			5.13
173	0.0	0.001	0.240	0.0	0.19	0.000	0.83	0.0	0.15	0.000	0.45	0.0	0.19	0.015	2.13
			0.0			4.98		0.0		2.57		0.0			5.05
174	0.10	0.001	0.232	0.0	0.19	0.000	0.86	0.0	0.15	0.000	0.49	0.0	0.18	0.015	2.13
			0.0			4.87		0.0		2.48		0.0			4.97
175	2.24	0.400	76.892	0.01	0.21	0.000	1.90	0.00	0.30	0.000	1.52	1.47	0.20	0.014	3.95
			0.00			5.23		0.00		2.81		0.00			6.95
176	0.0	0.080	15.424	0.0	0.15	0.000	1.75	0.0	0.26	0.000	1.27	0.0	0.16	0.015	3.18
			0.0			5.23		0.0		2.80		0.03			6.48
177	0.0	0.058	11.130	0.0	0.15	0.000	1.61	0.0	0.21	0.000	1.08	0.0	0.14	0.014	3.04
			0.0			5.23		0.0		2.77		0.01			5.71
178	0.0	0.017	3.275	0.0	0.15	0.000	1.48	0.0	0.18	0.000	0.94	0.0	0.14	0.014	2.91
			0.0			5.21		0.0		2.73		0.00			5.48
179	3.40	1.339	257.711	1.03	0.14	0.000	2.65	0.32	0.22	0.000	1.59	14.33	0.15	0.014	4.42
			0.00			5.81		0.00		3.67		0.00			6.85
180	0.0	0.133	25.642	0.0	0.14	0.000	1.79	0.0	0.27	0.000	1.31	0.39	0.17	0.014	4.34
			0.00			6.34		0.0		3.67		0.03			6.92
181	0.0	0.123	23.666	0.0	0.15	0.000	1.64	0.0	0.23	0.000	1.12	0.0	0.17	0.014	3.73
			0.00			6.27		0.0		3.63		0.03			6.23
182	0.0	0.089	17.139	0.0	0.15	0.000	1.51	0.0	0.21	0.000	0.97	0.0	0.15	0.015	3.19
			0.0			6.25		0.0		3.57		0.01			5.46
183	0.0	0.006	1.166	0.0	0.18	0.000	1.38	0.0	0.22	0.000	0.83	0.0	0.17	0.015	3.03
			0.0			6.20		0.0		3.49		0.00			5.41
184	0.0	0.003	0.599	0.0	0.18	0.000	1.26	0.0	0.20	0.000	0.73	0.0	0.17	0.015	2.88
			0.0			6.14		0.0		3.39		0.0			5.40
185	0.21	0.003	0.499	0.0	0.18	0.000	1.36	0.0	0.20	0.000	0.83	0.0	0.17	0.015	2.95
			0.0			6.07		0.0		3.30		0.0			5.38
186	0.02	0.002	0.410	0.0	0.18	0.000	1.26	0.0	0.19	0.000	0.75	0.0	0.17	0.015	2.82
			0.0			6.01		0.0		3.22		0.0			5.36
187	0.54	0.005	1.019	0.00	0.18	0.000	1.68	0.00	0.19	0.000	1.17	0.00	0.17	0.014	3.18
			0.0			5.94		0.0		3.13		0.00			5.35
188	0.0	0.002	0.334	0.0	0.18	0.000	1.52	0.0	0.24	0.000	0.98	0.0	0.17	0.014	3.01
			0.0			5.93		0.0		3.08		0.0			5.35
189	0.60	0.057	11.064	0.00	0.18	0.000	1.80	0.00	0.25	0.000	1.38	0.00	0.17	0.014	3.24
			0.00			5.97		0.0		3.04		0.00			5.67

<sup>1</sup> Definitions of headings:

- DAY Julian day of the year.  
 RAIN Inches of rain.  
 RUNOFF Inches of total watershed runoff.  
 CFS Mean daily cubic feet/second.  
 QO Inches of overland flow.  
 ET:E Upper value, ET, is zone inches of evapotranspiration;  
       lower value E is zone inches of direct evaporation from soil-free water.  
 GR Zone inches of deep ground-water contribution, i.e., downward seepage from last layer.  
 SM1:2 Inches of soil moisture in layer 1 (upper value) and layer 2 (lower value) in the zone  
       at 2400 of the DAY.  
 ZONE Homogeneous soil/cover complex.

TABLE 16.—*Sample program printout of various output monthly and annual summaries from USDAHL-74 model*

THE FOLLOWING IS A MONTHLY SUMMARY OF WATER YIELDS 1957:

MONTH	RAIN+	FT	EVAP	RUNOFF	RETURN FLOW		
					ONSITE	OFFSITE	GR
1	1.800	0.049	0.006	1.031	0.998	0.724	0.002
2	1.400	0.395	0.001	0.824	0.824	0.083	0.000
3	1.890	0.987	0.006	1.045	1.045	0.091	0.000
4	5.300	2.048	0.362	3.101	2.051	0.679	0.000
5	3.890	4.475	0.011	0.468	0.467	0.017	0.000
6	10.080	4.614	0.170	2.377	0.710	0.099	0.000
7	2.850	5.720	0.059	0.745	0.738	0.152	0.000
8	2.130	3.242	0.012	0.093	0.092	0.001	0.000
9	3.690	1.986	0.011	0.451	0.446	0.018	0.000
10	1.520	1.053	0.001	0.137	0.137	0.005	0.000
11	2.700	0.574	0.006	1.007	0.995	0.044	0.000
12	4.610	0.420	0.018	2.425	2.374	0.187	0.000
TOT AL	41.859	25.523	0.672	13.705	10.877	2.100	0.003

## ZONE 1

## ZONE 2

## ZONE 3

MO	00	RETURN FLOW			00	RETURN FLOW			00	RETURN FLOW		
		ONSITE	OFFSITE	GR		ONSITE	OFFSITE	GR		ONSITE	OFFSITE	GR
1	0.01	1.06	0.07	0.00	0.0	1.24	0.03	0.00	0.43	12.47	8.39	0.03
2	0.0	0.86	0.05	0.00	0.0	0.82	0.00	0.00	0.0	10.29	0.62	0.00
3	0.0	1.15	0.04	0.00	0.0	0.83	0.00	0.00	0.01	13.06	0.76	0.00
4	0.00	3.78	0.56	0.00	0.0	3.61	0.20	0.00	13.11	25.64	3.12	0.00
5	0.00	0.64	0.00	0.00	0.00	0.27	0.0	0.0	0.00	5.84	0.17	0.00
6	2.11	1.00	0.06	0.00	2.38	1.77	0.01	0.00	20.89	8.88	0.66	0.00
7	0.00	0.79	0.08	0.00	0.0	0.0	0.06	0.00	0.04	9.22	1.04	0.00
8	0.00	0.24	0.00	0.00	0.0	0.33	0.00	0.00	0.00	1.16	0.00	0.00
9	0.02	0.60	0.00	0.20	0.00	0.52	0.00	0.00	0.07	5.57	0.22	0.00
10	0.0	0.22	0.00	0.00	0.0	0.11	0.00	0.00	0.0	1.72	0.05	0.00
11	0.01	0.99	0.00	0.00	0.00	0.98	0.00	0.00	0.15	12.44	0.54	0.00
12	0.04	2.57	0.06	0.00	0.00	2.14	0.00	0.00	0.63	29.67	1.79	0.00
TOTAL	2.19	13.40	0.94	0.00	2.39	12.54	0.31	0.00	35.34	135.97	17.37	0.03

THE FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABOVE SUMMARY HAS PRINTED:

ZONEF=	1	1.0497	3.8905	0.4546	3.6896
ZDNF=	2	0.9675	2.9157	0.4145	3.2795
ZDNF=	3	1.7040	3.6779	0.8295	6.5593

THE FOLLOWING ARE RE-START VALUES TO APPROXIMATE WATERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY HAS PRINTED:

INITIAL STREAM FLO=	0.00138							
ZONF	# ASM1							
1	29.587							
2	29.156							
3	30.600							
RAIN -	FT -	RUNOFF -	E -	CN -	SOIL -	CHANNEL -	DEPRESSIONS-OVERLAND-OFFSITE =	-0.005
41.859	25.523	13.705	0.672	0.003	-0.138	0.0	0.0	2.100
SNOW=	0.0							

IHYD is the variable name for watershed storm hydrograph output given in table 17. This file is written to every routing delta time

on dates chosen by the user in the input parameter.

TABLE 17.—*Sample program printout of output streamflow data from USDAHL-74 model for one of storm dates in table 9<sup>1</sup>*

STORM HYDROGRAPH FOR YEAR 1957, DAY 179							Avg CFS		
TIME	RAIN VOL (INCHES)	RUNOFF VOL (INCHES)	CHAN	SUB	TOT	RUNOFF RATES (AVG IN/HR)	Avg CFS		
						CHAN	SUB	TOT	TOT
0.25	0.0	0.0	0.00	0.00	0.0	0.00099	0.00099	4.56	
0.50	0.0	0.0	0.00	0.00	0.0	0.00028	0.00028	1.30	
0.75	0.0	0.0	0.00	0.00	0.0	0.00028	0.00028	1.30	
1.00	0.0	0.0	0.00	0.00	0.0	0.00028	0.00028	1.30	
1.25	0.0	0.0	0.00	0.00	0.0	0.00028	0.00028	1.30	
12.75	0.26	0.0	0.00	0.00	0.0	0.00017	0.00017	0.77	
13.00	0.26	0.0	0.00	0.00	0.0	0.00017	0.00017	0.77	
13.25	0.64	0.00	0.00	0.00	0.00162	0.00070	0.00232	10.73	
13.50	0.65	0.00	0.00	0.01	0.00273	0.00272	0.00545	25.17	
13.75	0.65	0.00	0.01	0.01	0.0	0.00762	0.00762	35.17	
14.00	0.65	0.00	0.01	0.01	0.0	0.00690	0.00690	31.85	
14.25	1.02	0.00	0.01	0.01	0.00430	0.00781	0.01212	55.95	
14.50	1.03	0.01	0.01	0.02	0.01518	0.00889	0.02407	111.15	
14.75	1.04	0.01	0.02	0.03	0.02583	0.01189	0.03772	174.20	
15.00	1.17	0.02	0.02	0.04	0.03306	0.01212	0.04518	208.62	
15.25	1.18	0.03	0.02	0.05	0.04248	0.01425	0.05673	261.98	
15.50	1.18	0.04	0.03	0.07	0.04549	0.01428	0.05977	276.03	
15.75	1.19	0.05	0.03	0.08	0.03950	0.01482	0.05432	250.85	
16.00	1.20	0.06	0.03	0.09	0.03087	0.01271	0.04358	201.26	
16.25	1.23	0.07	0.04	0.10	0.02784	0.01802	0.04587	211.81	
16.50	1.25	0.07	0.04	0.11	0.02183	0.01195	0.03378	156.01	
16.75	1.41	0.08	0.05	0.13	0.02853	0.02253	0.05106	235.81	
17.00	1.46	0.09	0.05	0.14	0.04829	0.01768	0.06597	304.66	
17.25	1.55	0.11	0.05	0.16	0.06174	0.01703	0.07877	363.76	
17.50	1.70	0.13	0.06	0.18	0.07509	0.01687	0.09197	424.70	
17.75	1.83	0.15	0.06	0.21	0.09281	0.01645	0.10927	504.59	
18.00	1.96	0.18	0.07	0.24	0.11482	0.01598	0.13080	604.03	
18.25	2.18	0.21	0.07	0.28	0.14350	0.01539	0.15889	733.74	
18.50	2.38	0.26	0.07	0.34	0.18996	0.01381	0.20377	941.01	
18.75	2.76	0.32	0.08	0.40	0.24594	0.01278	0.25872	1194.78	
19.00	2.99	0.41	0.08	0.49	0.33835	0.01020	0.34655	1609.59	
19.25	3.18	0.52	0.08	0.60	0.45053	0.00560	0.45612	2106.38	
19.50	3.27	0.64	0.08	0.72	0.48939	0.00310	0.49248	2274.30	
19.75	3.33	0.75	0.08	0.84	0.44622	0.00169	0.44792	2068.48	
20.00	3.37	0.85	0.08	0.93	0.38434	0.00251	0.38685	1786.47	
20.25	3.39	0.93	0.08	1.02	0.32605	0.00481	0.33086	1527.90	
20.50	3.40	1.00	0.09	1.09	0.27170	0.00728	0.27298	1288.31	
20.75	3.40	1.06	0.09	1.14	0.22127	0.01007	0.23134	1068.35	
21.00	3.40	1.09	0.09	1.19	0.15935	0.01244	0.17179	793.32	
21.25	3.40	1.12	0.09	1.21	0.10150	0.01324	0.11474	529.88	
21.50	3.40	1.14	0.10	1.23	0.05974	0.01348	0.07322	338.13	
21.75	3.40	1.14	0.10	1.25	0.03877	0.01348	0.05226	241.32	
22.00	3.40	1.15	0.11	1.26	0.03389	0.01649	0.05037	232.63	
22.25	3.40	1.16	0.11	1.27	0.02293	0.01385	0.03678	169.87	
22.50	3.40	1.16	0.11	1.28	0.01686	0.01385	0.03071	141.82	
22.75	3.40	1.17	0.12	1.28	0.01686	0.01385	0.03071	141.82	
23.00	3.40	1.17	0.12	1.30	0.02664	0.02653	0.05317	245.54	
23.25	3.40	1.18	0.13	1.31	0.03078	0.01628	0.04706	217.35	
23.50	3.40	1.19	0.13	1.32	0.02514	0.01628	0.04142	191.28	
23.75	3.40	1.19	0.13	1.33	0.02514	0.01628	0.04142	191.28	
24.00	3.40	1.20	0.14	1.34	0.02514	0.01628	0.04142	191.28	

<sup>1</sup> Definitions of headings:

TIME \_\_\_\_\_ Accumulated military time of day.  
 CHAN \_\_\_\_\_ Channel flow.  
 SUB \_\_\_\_\_ Subsurface outflow.  
 TOT \_\_\_\_\_ Sum of CHAN and SUB.

Table 18 lists the overland flow zone hydrograph output and is printed on the same dates as IHYD for every rainfall breakpoint time interval on file IOVER.

TABLE 18.—*Sample program printout of output overland flow data by zones from USDAHL-74 model for storm dates in table 9<sup>1</sup>*

OVERLAND FLOW HYDROGRAPH FOR YEAR 1957 DAY 179

TIME	RAINT	Q0 Z1	D1 Z1	SE Z1	Q0 Z2	D1 Z2	SE Z2	Q0 Z3	D1 Z3	SE Z3
3.333	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00018
3.667	0.1800	0.0	0.0	0.06000	0.0	0.0	0.06000	0.0	0.0	0.06020
3.917	0.0400	0.0	0.0	0.07000	0.0	0.0	0.07000	0.0	0.0	0.07021
4.017	0.0	0.0	0.0	0.07000	0.0	0.0	0.07000	0.0	0.0	0.07022
4.317	0.0	0.0	0.0	0.07C00	0.0	0.0	0.07000	0.0	0.0	0.07C23
4.917	0.0	0.0	0.0	0.07000	0.0	0.0	0.07000	0.0	0.0	0.07027
5.917	0.0	0.0	0.0	0.07000	0.0	0.0	0.07000	0.0	0.0	0.07032
6.083	0.0	0.0	0.0	0.07000	0.0	0.0	0.07000	0.0	0.0	0.07033
6.250	0.3600	0.0	0.0	0.13000	0.0	0.0	0.13000	0.0	0.0	0.13034
6.500	0.1200	0.0	0.0	0.16000	0.0	0.0	0.16000	0.0	0.0	0.16035
6.667	0.0600	0.0	0.0	0.17000	0.0	0.0	0.17000	0.0	0.0	0.17C36
6.717	0.4000	0.0	0.0	0.19000	0.0	0.0	0.19000	0.0	0.0	0.19037
6.967	0.0400	0.0	0.0	0.20000	0.0	0.0	0.20000	0.0	0.0	0.20038
7.067	0.0	0.0	0.0	0.20000	0.0	0.0	0.20000	0.0	0.0	0.20039
7.367	0.0	0.0	0.0	0.20000	0.0	0.0	0.20000	0.0	0.0	0.20040
7.417	0.0	0.0	0.0	0.20000	0.0	0.0	0.20000	0.0	0.0	0.20041
7.708	0.0514	0.0	0.0	0.21500	0.0	0.0	0.21500	0.0	0.0	0.21542
8.000	0.0514	0.0	0.0	0.23000	0.0	0.0	0.23000	0.0	0.0	0.23044
8.100	0.0	0.0	0.0	0.23000	0.0	0.0	0.23000	0.0	0.0	0.23045
8.400	0.0	0.0	0.0	0.23000	0.0	0.0	0.23000	0.0	0.0	0.23046
8.867	0.0	0.0	0.0	0.23000	0.0	0.0	0.23000	0.0	0.0	0.23C49
9.000	0.2250	0.0	0.0	0.26000	0.0	0.0	0.26000	0.0	0.0	0.26050
9.100	0.0	0.0	0.0	0.26000	0.0	0.0	0.26000	0.0	0.0	0.26050
9.400	0.0	0.0	0.0	0.26000	0.0	0.0	0.26000	0.0	0.0	0.26052
10.000	0.0	0.0	0.0	0.26000	0.0	0.0	0.26000	0.0	0.0	0.26055
11.000	0.0	0.0	0.0	0.26000	0.0	0.0	0.26000	0.0	0.0	0.26061
13.000	0.0	0.0	0.0	0.26000	0.0	0.0	0.26000	0.0	0.0	0.26C71
13.050	0.0	0.0	0.0	0.26000	0.0	0.0	0.26000	0.0	0.0	0.26072
13.083	3.9000	0.00728	0.06691	0.27429	0.01000	0.04377	0.29743	0.01659	0.04505	0.29687
13.167	3.0000	0.07643	0.27354	0.31691	0.12150	0.19515	0.39549	0.19297	0.19575	0.39241
13.417	0.0400	0.02652	0.14512	0.44446	0.0	0.0	0.64907	0.0	0.0	0.65160
13.517	0.0	0.01413	0.09954	0.48819	0.0	0.0	0.65450	0.0	0.0	0.71900
13.817	0.0	0.0	0.0	0.61455	0.0	0.0	0.65450	0.0	0.0	0.77168
14.000	0.0	0.0	0.0	0.63398	0.0	0.0	0.65450	0.0	0.0	0.81899
14.133	0.9750	0.00205	0.03135	0.68383	0.0	0.0	0.76647	0.00242	0.01421	0.92796
14.167	6.0001	0.05440	0.22315	0.69182	0.07538	0.14666	0.78894	0.22337	0.21367	0.95028
14.250	0.4800	0.05249	0.23304	0.71922	0.05473	0.12108	0.85240	0.30391	0.25693	1.01315
14.500	0.0400	0.02752	0.14838	0.80525	0.0	0.0	1.03060	0.27188	0.24035	1.19388
14.600	0.0	0.01836	0.11644	0.83529	0.0	0.0	1.03605	0.39012	0.29837	1.25659
14.667	0.0	0.01372	0.09780	0.85297	0.0	0.0	1.03640	0.48497	0.33990	1.29799
14.967	0.1000	0.00204	0.03121	0.94592	0.0	0.0	1.06756	0.43582	0.31883	1.47953
15.000	3.3000	0.02373	0.13577	0.95115	0.00848	0.03964	0.108914	0.65895	0.42305	1.49385
15.250	0.0400	0.00747	0.06796	1.02467	0.0	0.0	1.18844	0.55219	0.36737	1.62781
15.350	0.0	0.00350	0.04314	1.04859	0.0	0.0	1.18865	0.55780	0.36960	1.67799
15.650	0.0	0.0	0.0	1.12598	0.0	0.0	1.18865	0.52517	0.35650	1.82597
15.667	0.0	0.0	0.0	1.12598	0.0	0.0	1.18865	0.52902	0.35806	1.82917
16.167	0.0800	0.0	0.0	1.17622	0.0	0.0	1.22865	0.22148	0.21258	2.06164
16.500	0.1200	0.0	0.0	1.21622	0.0	0.0	1.26665	0.24827	0.22763	2.20760
16.550	2.0005	0.00347	0.04298	1.22448	0.00178	0.01557	1.30428	0.48177	0.33855	2.22466
16.833	0.2471	0.00349	0.04307	1.29236	0.0	0.0	1.43800	0.64636	0.40369	2.34360
17.000	0.1800	0.00235	0.03395	1.33028	0.0	0.0	1.46817	0.78540	0.45365	2.40578
17.333	0.3600	0.00900	0.07600	1.40612	0.0	0.0	1.58839	1.00090	0.52454	2.54700
17.500	0.7200	0.03112	0.15972	1.44076	0.0	0.0	1.70381	1.13145	0.56450	2.61086
17.833	0.5100	0.06286	0.24333	1.51020	0.0	0.0	1.88632	1.53808	0.67843	2.74354
18.033	0.5500	0.08993	0.30153	1.54967	0.0	0.0	2.00272	1.79353	0.74382	2.82112
18.167	0.8251	0.13020	0.37631	1.57318	0.0	0.0	2.09348	2.16929	0.83355	2.87225
18.283	1.1144	0.18781	0.46862	1.59266	0.00841	0.03944	2.17030	2.62912	0.93525	2.91566
18.416	0.4500	0.19742	0.48284	1.61522	0.00299	0.02125	2.26025	2.55121	0.91855	2.96602
18.666	1.2000	0.34170	0.67051	1.66146	0.10924	0.18314	2.42381	3.42297	1.09533	3.05876
18.750	2.1600	0.46820	0.80980	1.67259	0.26377	0.31046	2.47822	4.31333	1.25797	3.08673
18.950	0.3500	0.41933	0.75807	1.70644	0.19017	0.25525	2.61061	4.50608	1.29134	3.15900
19.016	3.1502	0.59132	0.93131	1.71387	0.44069	0.42220	2.65353	5.47881	1.45168	3.17955
19.083	0.6000	0.58873	0.92886	1.72126	0.42587	0.41364	2.69685	5.57275	1.46653	3.19598

<sup>1</sup> Definitions of headings:

- TIME Increment of time.
- RAINT Rainfall intensity, in/h.
- Q0 Z Overland flow, in/h, from each zone.
- D1 Depth of overland flow.
- SF Volume of infiltration from each zone.

The daily volumes of moisture movements and the midnight status of soil moisture given

in table 19 are for possible use in computations of chemical transports printed on file IPOL.

TABLE 19.—*Sample program printout of output daily summaries for input to pollution subroutines from USDAHL-74 model for use in studies of moisture movement or chemical transports<sup>1</sup>*

DAILY SUMMARIES FOR INPUT TO POLLUTION																					
YRDAY	TEMP	ET	EV	QL				CN				GR	DQO	RUNON	QOPK	SM	L1				
				L1	L2	L3	L4	L1	L2	L3	L4						L1	L2	L3	L4	
57163	76.7	21	0.128	0.031	0.000	0.0	0.354	0.0	0.000	0.000	0.432	0.0	0.000	0.000	1.149	0.0	0.792	2.106	5.306	0.000	0.044
57163	76.7	22	0.216	0.031	0.000	0.0	1.028	0.0	0.000	0.000	0.432	0.0	0.000	0.000	1.099	0.651	1.183	3.536	3.223	0.000	0.002
57163	76.7	23	0.128	0.033	0.0	0.0	1.293	0.083	0.000	0.009	1.327	0.007	0.000	0.015	12.823	14.561	6.525	4.474	6.362	0.007	3.502
57164	76.7	21	0.154	0.012	0.000	0.0	0.146	0.0	0.000	0.000	0.328	0.0	0.000	0.000	0.002	0.0	0.039	1.791	5.621	0.000	0.044
57164	76.7	22	0.239	0.006	0.000	0.0	0.031	0.0	0.000	0.000	0.045	0.0	0.000	0.000	0.002	0.001	0.040	3.483	3.262	0.000	0.002
57164	76.7	23	0.097	0.077	0.014	0.0	0.603	1.489	0.0	0.0	2.041	0.077	0.004	0.015	0.003	1.348	0.066	3.476	6.759	0.080	3.491
57165	76.7	21	0.169	0.001	0.000	0.0	0.006	0.0	0.000	0.000	0.003	0.0	0.000	0.000	0.0	0.0	0.0	1.652	5.624	0.000	0.043
57165	76.7	22	0.269	0.016	0.000	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	1.254	3.246	0.000	0.002
57165	76.7	23	0.157	0.001	0.002	0.005	0.184	1.137	0.0	0.0	0.119	0.046	0.008	0.015	0.0	0.056	0.0	3.109	5.686	0.118	3.483
57166	76.7	21	0.144	0.022	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	1.506	5.602	0.000	0.043
57166	76.7	22	0.195	0.045	0.0	0.0	0.0	0.0	0.003	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	1.059	3.201	0.000	0.002
57166	76.7	23	0.153	0.009	0.0	0.000	0.0	0.220	0.003	0.0	0.0	0.009	0.008	0.015	0.0	0.001	0.0	2.961	5.451	0.115	3.476
57167	76.7	21	0.125	0.038	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	1.403	5.564	0.000	0.042
57167	76.7	22	0.156	0.062	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.929	3.139	0.000	0.002
57167	76.7	23	0.139	0.019	0.0	0.000	0.0	0.019	0.014	0.003	0.0	0.001	0.007	0.015	0.0	0.001	0.0	2.843	5.412	0.095	3.466
57168	76.7	21	0.109	0.052	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	1.294	5.512	0.000	0.042
57168	76.7	22	0.117	0.073	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.812	3.065	0.000	0.002
57168	76.7	23	0.128	0.030	0.0	0.0	0.0	0.0	0.013	0.007	0.0	0.0	0.006	0.015	0.0	0.001	0.0	2.716	5.382	0.075	3.450
57169	72.2	21	0.130	0.083	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	1.164	5.429	0.000	0.041
57169	72.2	22	0.115	0.095	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.697	2.970	0.000	0.002
57169	72.2	23	0.146	0.046	0.0	0.0	0.0	0.0	0.011	0.008	0.0	0.0	0.005	0.015	0.0	0.001	0.0	2.571	5.336	0.059	3.431
57170	72.2	21	0.108	0.099	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	1.076	5.330	0.000	0.041
57170	72.2	22	0.089	0.100	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.628	2.870	0.000	0.002
57170	72.2	23	0.132	0.059	0.0	0.0	0.0	0.0	0.008	0.009	0.0	0.0	0.004	0.015	0.0	0.001	0.0	2.460	5.277	0.047	3.410
57171	72.2	21	0.092	0.109	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.984	5.221	0.000	0.040
57171	72.2	22	0.071	0.101	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.556	2.769	0.000	0.002
57171	72.2	23	0.121	0.069	0.0	0.0	0.0	0.0	0.007	0.010	0.0	0.0	0.003	0.015	0.0	0.001	0.0	2.340	5.208	0.031	3.388
57172	72.2	21	0.080	0.116	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.904	5.105	0.000	0.040
57172	72.2	22	0.060	0.101	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.497	2.668	0.000	0.002
57172	72.2	23	0.113	0.076	0.0	0.0	0.0	0.0	0.005	0.011	0.0	0.0	0.002	0.015	0.0	0.001	0.0	2.229	5.132	0.030	3.365
57173	72.2	21	0.069	0.121	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.834	4.984	0.000	0.039
57173	72.2	22	0.049	0.099	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.448	2.568	0.000	0.002
57173	72.2	23	0.103	0.083	0.0	0.0	0.0	0.0	0.004	0.011	0.0	0.0	0.002	0.015	0.0	0.001	0.0	2.127	5.049	0.023	3.341
57174	72.2	21	0.070	0.116	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.865	4.665	0.000	0.039
57174	72.2	22	0.054	0.092	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.000	0.0	0.0	0.0	0.494	2.477	0.000	0.002
57174	72.2	23	0.100	0.084	0.0	0.0	0.0	0.0	0.003	0.012	0.0	0.0	0.001	0.015	0.0	0.001	0.0	2.126	4.955	0.019	3.316
57175	72.2	21	0.137	0.052	0.000	0.0	0.592	0.0	0.000	0.000	0.418	0.0	0.000	0.000	0.015	0.0	0.055	1.900	5.235	0.000	0.038
57175	72.2	22	0.268	0.029	0.000	0.0	0.581	0.0	0.000	0.000	0.362	0.0	0.000	0.000	0.004	0.000	0.025	1.522	2.605	0.000	0.002
57175	72.2	23	0.108	0.002	0.0	0.0	3.355	0.204	0.001	0.004	2.253	0.017	0.001	0.015	1.465	6.884	0.521	3.949	6.947	0.034	3.299

<sup>1</sup> Definitions of headings:

- YRDAY Year and Julian day.  
 TEMP Average weekly temperature.  
 ET Evapotranspiration from layers L1 and L2, in inches.  
 EV Evaporation from layers L1 and L2, in inches.  
 QL Lateral outflow from layers L1, L2, L3, and L4, in inches.  
 CN Flow downward out of layers L1, L2, L3, and L4, in inches.  
 GR Ground-water recharge, i.e., CN from last layer.  
 DQO Overland flow from zone, in inches.  
 RUNON Overland flow cascading from other zones, in inches.  
 QOPK Peak rate of overland flow, in/h.  
 SM Soil moisture in layers L1, L2, L3, and L4, in inches.  
 L Flow regime.  
 Z Zones Z1, Z2, and Z3.

If output of one or more files is not wanted, the individual files can be deleted by not requesting that file through the JOB CONTROL LANGUAGE.

### Flow Charts and Printouts for Routines of Model

Flow charts (figs. 18-29) are included for all the routines except INIT, DAYS, and POLLUT. INIT is the initialization subroutine, and it is called from MAIN right after subroutine PARAMS. Subroutine DAYS calculates the number of days between two dates in the 20th century, and it checks for errors in dates. DAYS is called from subroutine DATA. Subroutine POLLUT (12) is added to the model to get detailed daily printout (table 19) for use in predicting chemical transports.

If overlaying is necessary, a few suggestions may be helpful.

(1) INIT and PARAMS are called only once.

(2) ETCALC, EVAP, SUBSUR, INFIL, and PEROUT are called for every increment of time for every zone and should be kept together.

(3) ROUTE is called every routing delta time.

(4) OUTPUT and POLLUT are called once a day.

(5) SUMRY and LANUSE are called once a year.

(6) DATA and DAYS are not called on a predictable basis since these subroutines are called as a function of input precipitation.

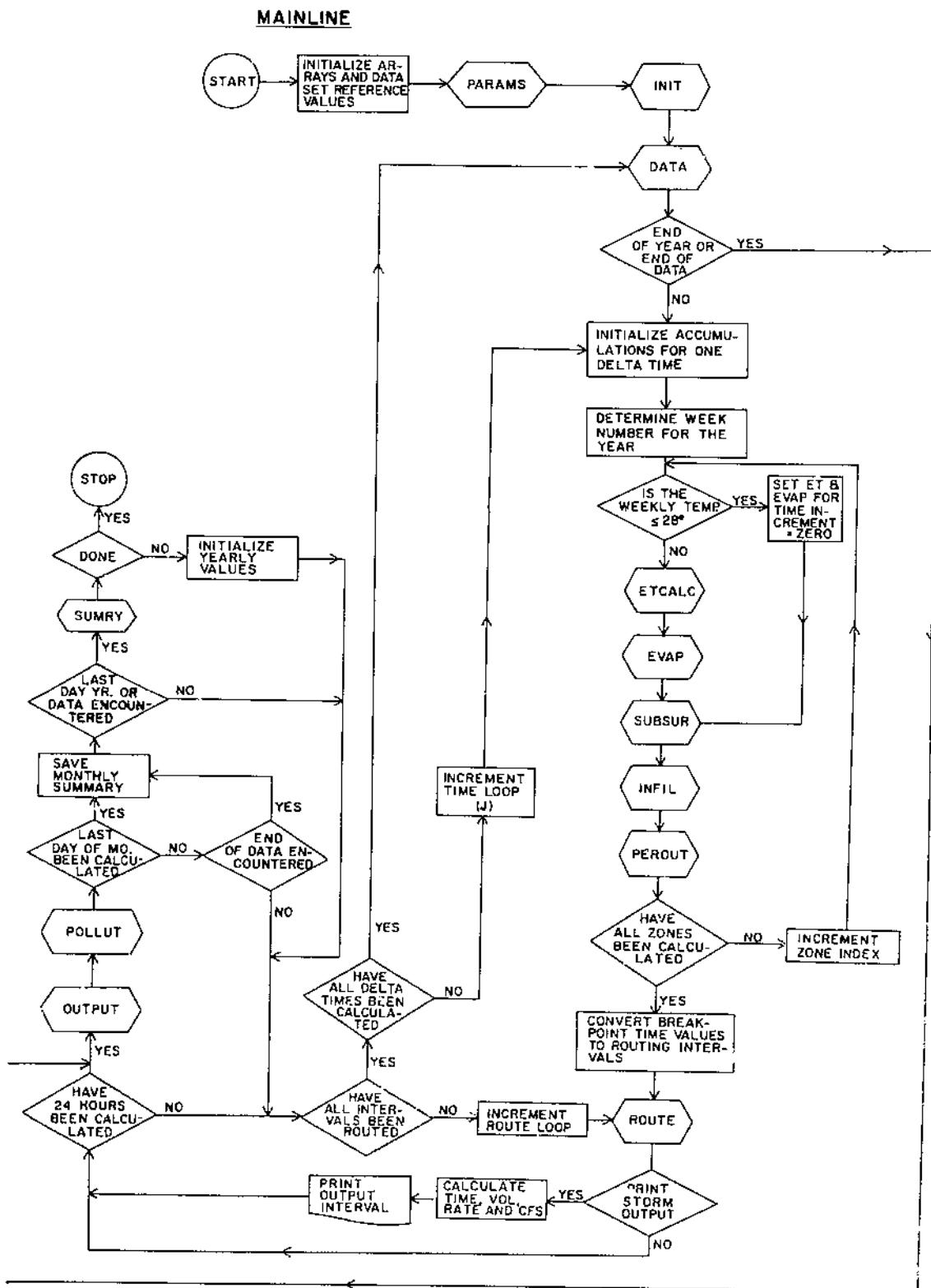


FIGURE 18.—Flow chart of USDAHL-74 mainline.

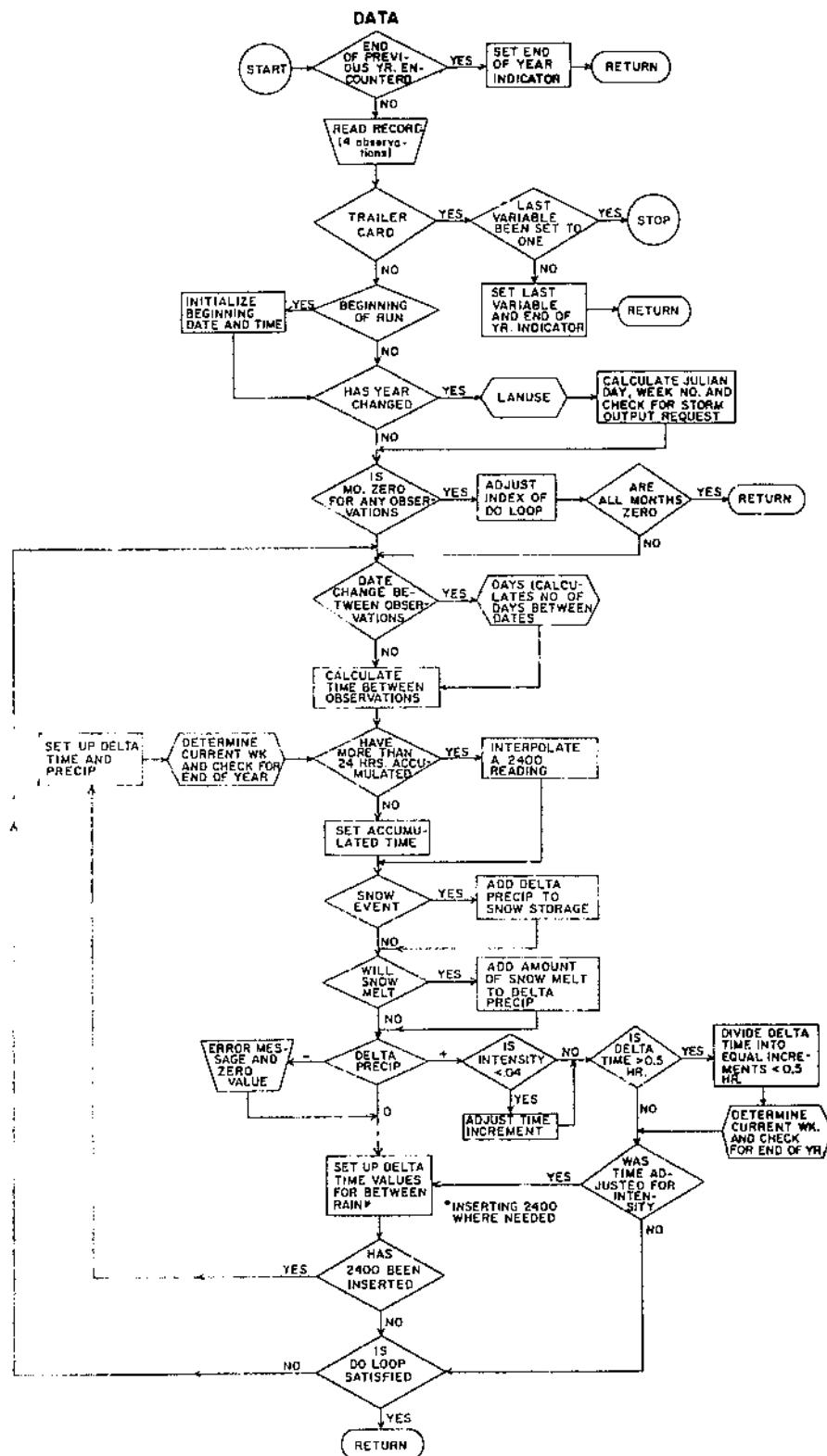


FIGURE 19.—Flow chart of USDAHL-74 data.

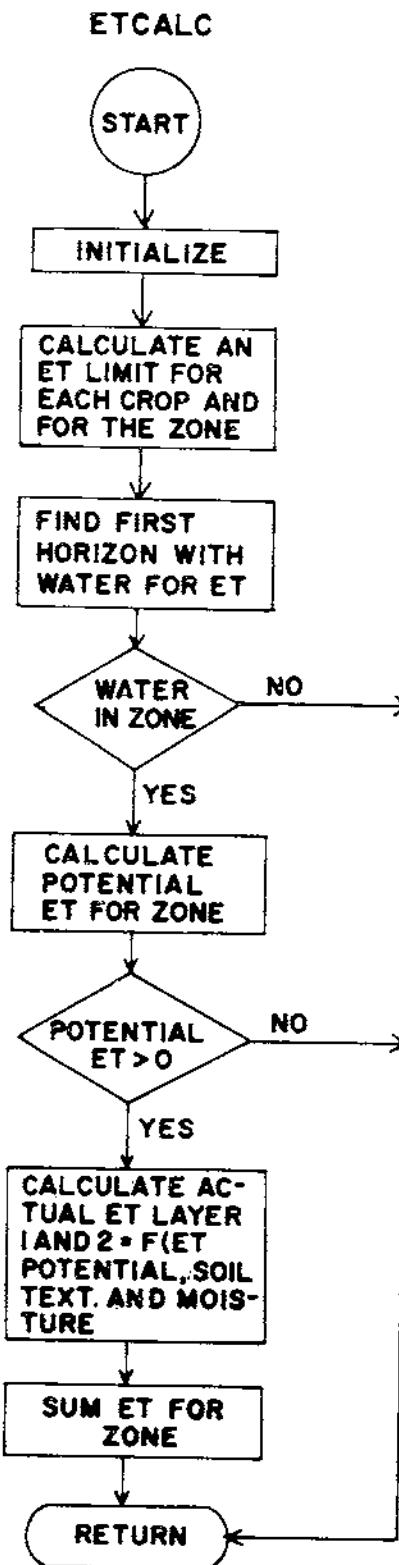


FIGURE 20.—Flow chart of USDAHL-74 evapotranspiration.

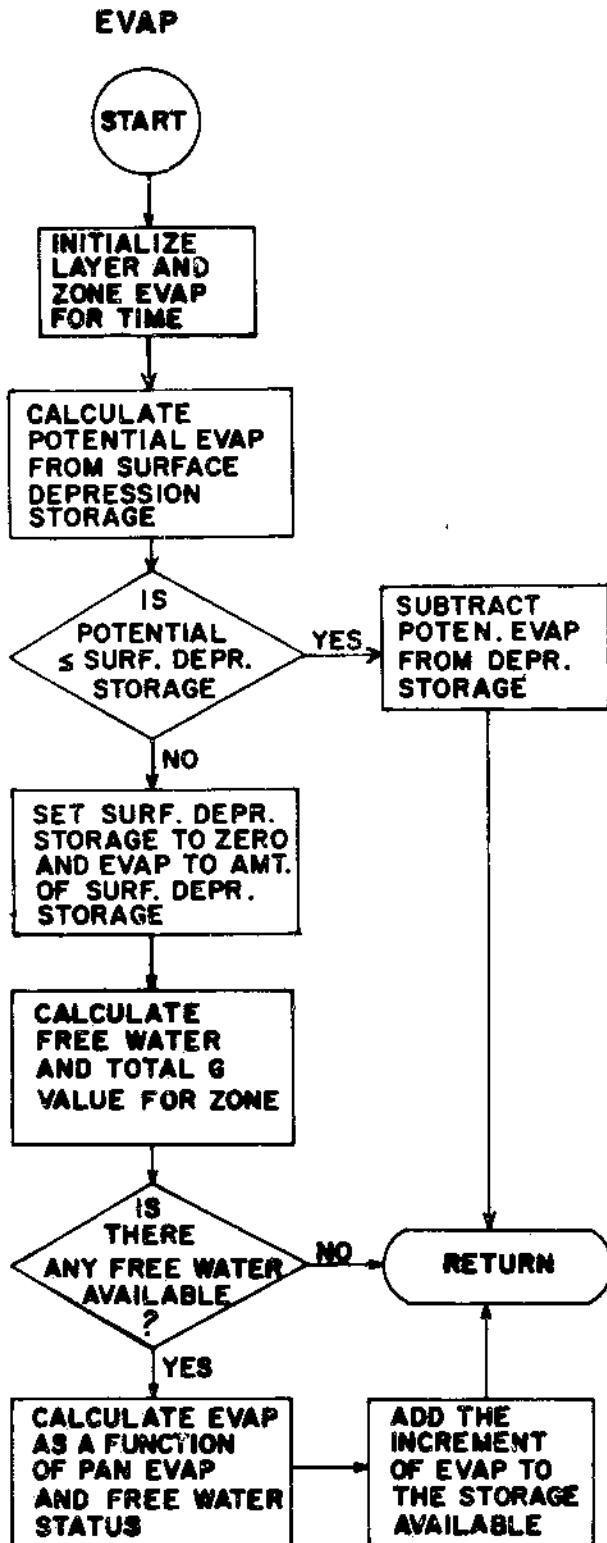


FIGURE 21.—Flow chart of USDAHL-74 evaporation.

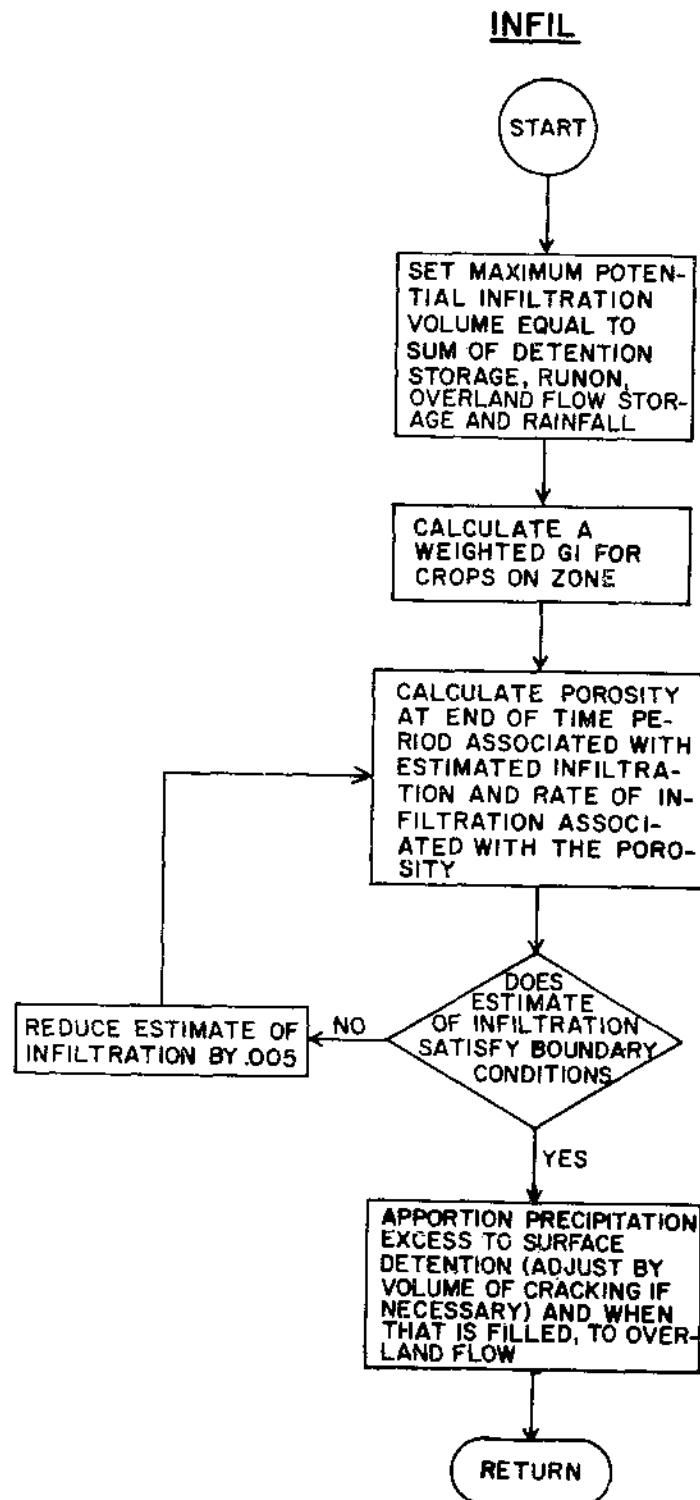


FIGURE 22.—Flow chart of USDAHL-74 infiltration.

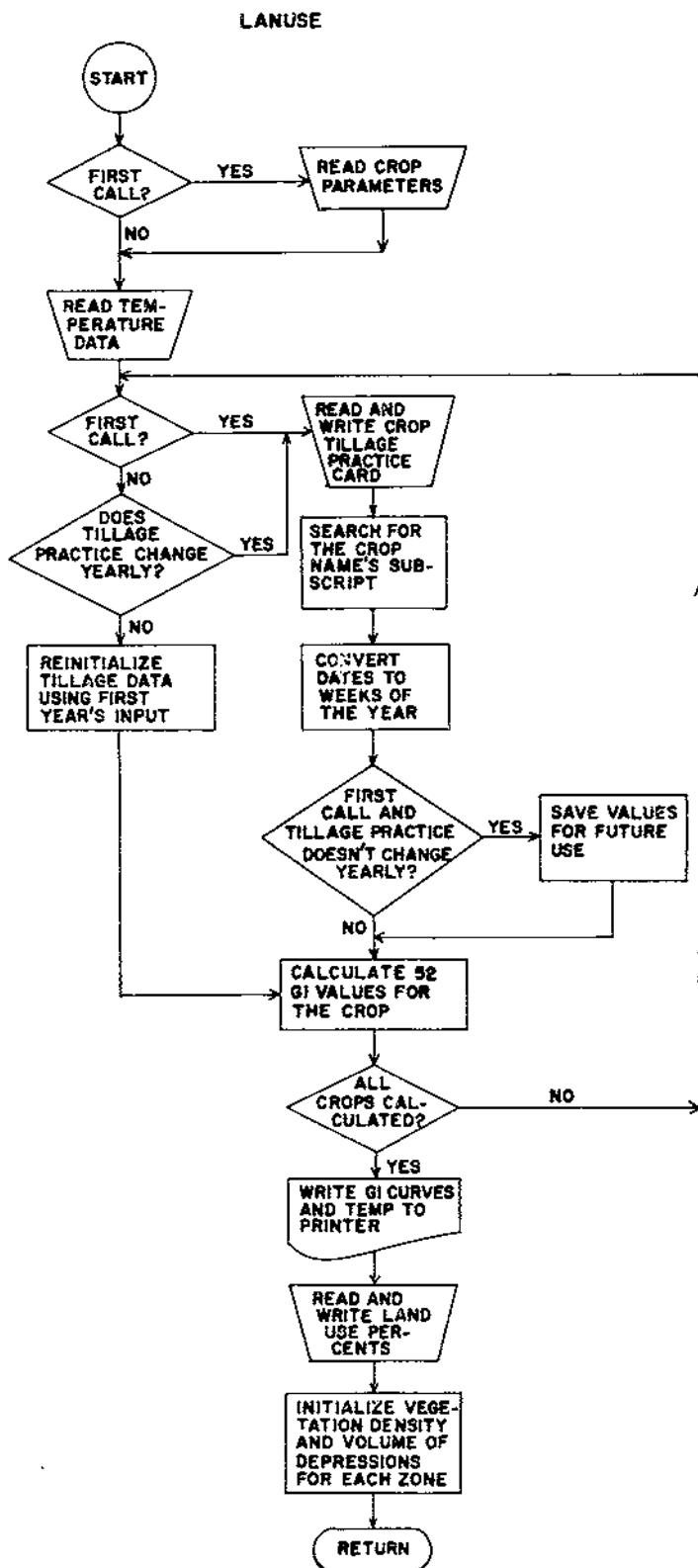


FIGURE 23.—Flow chart of USDAHL-74 land use.

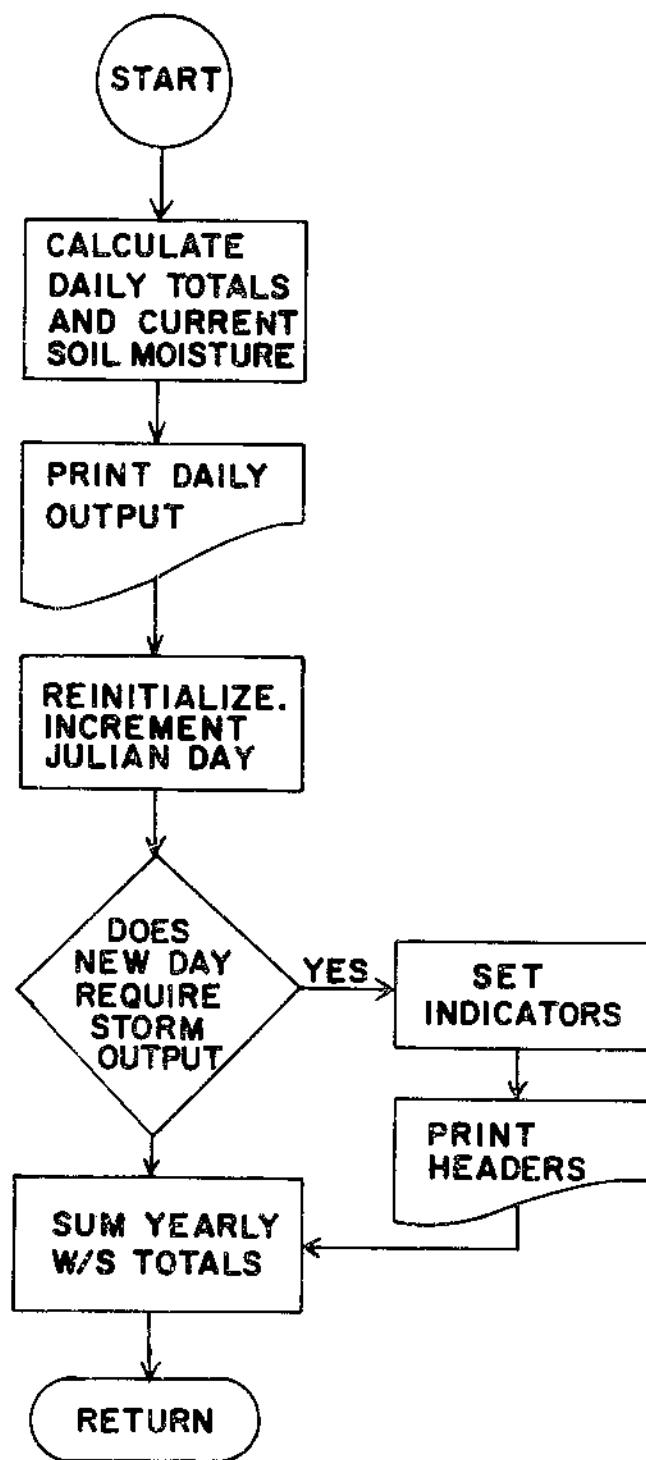
**OUTPUT**

FIGURE 24.—Flow chart of USDAHL-74 output.

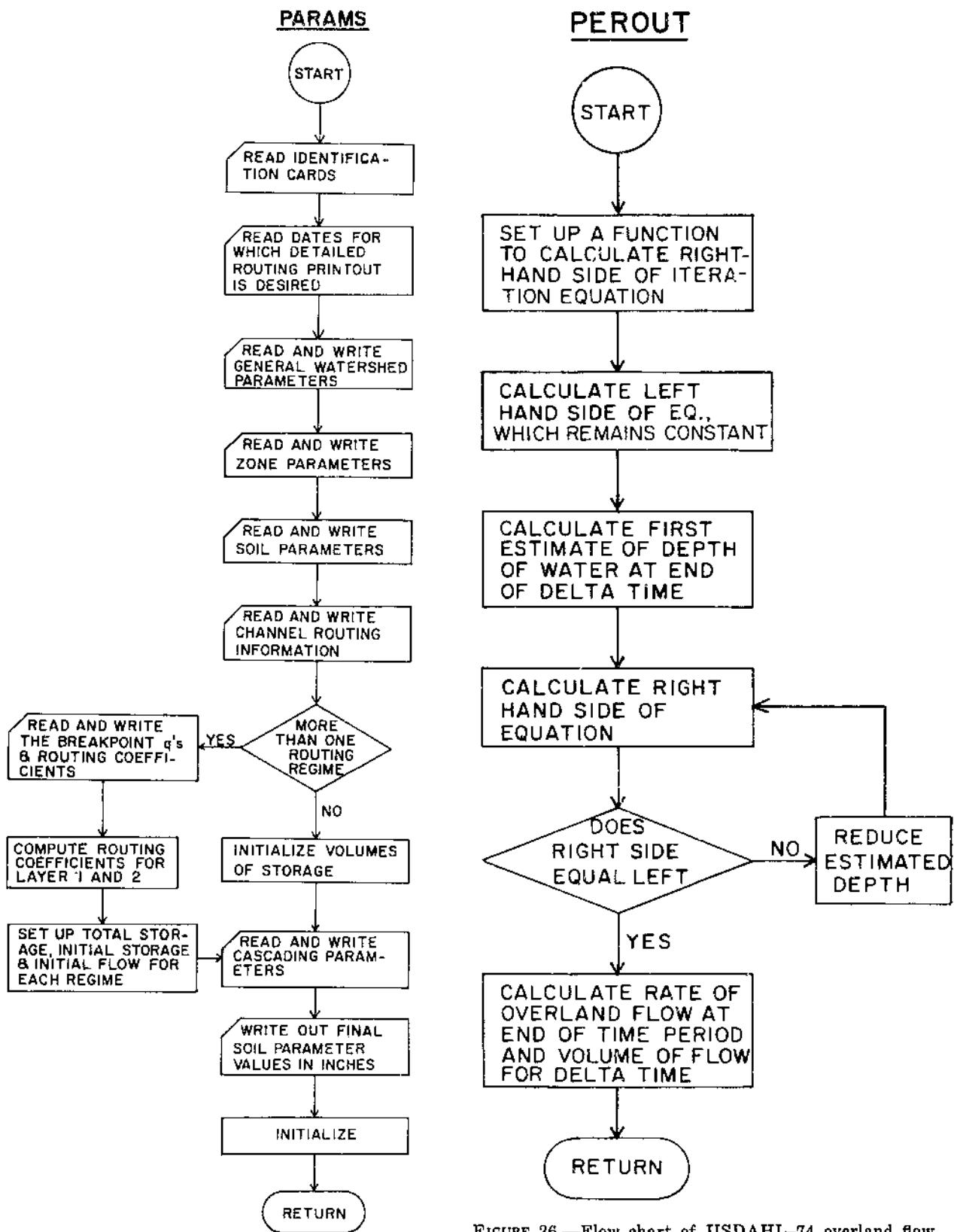


FIGURE 26.—Flow chart of USDAHL-74 overland flow.

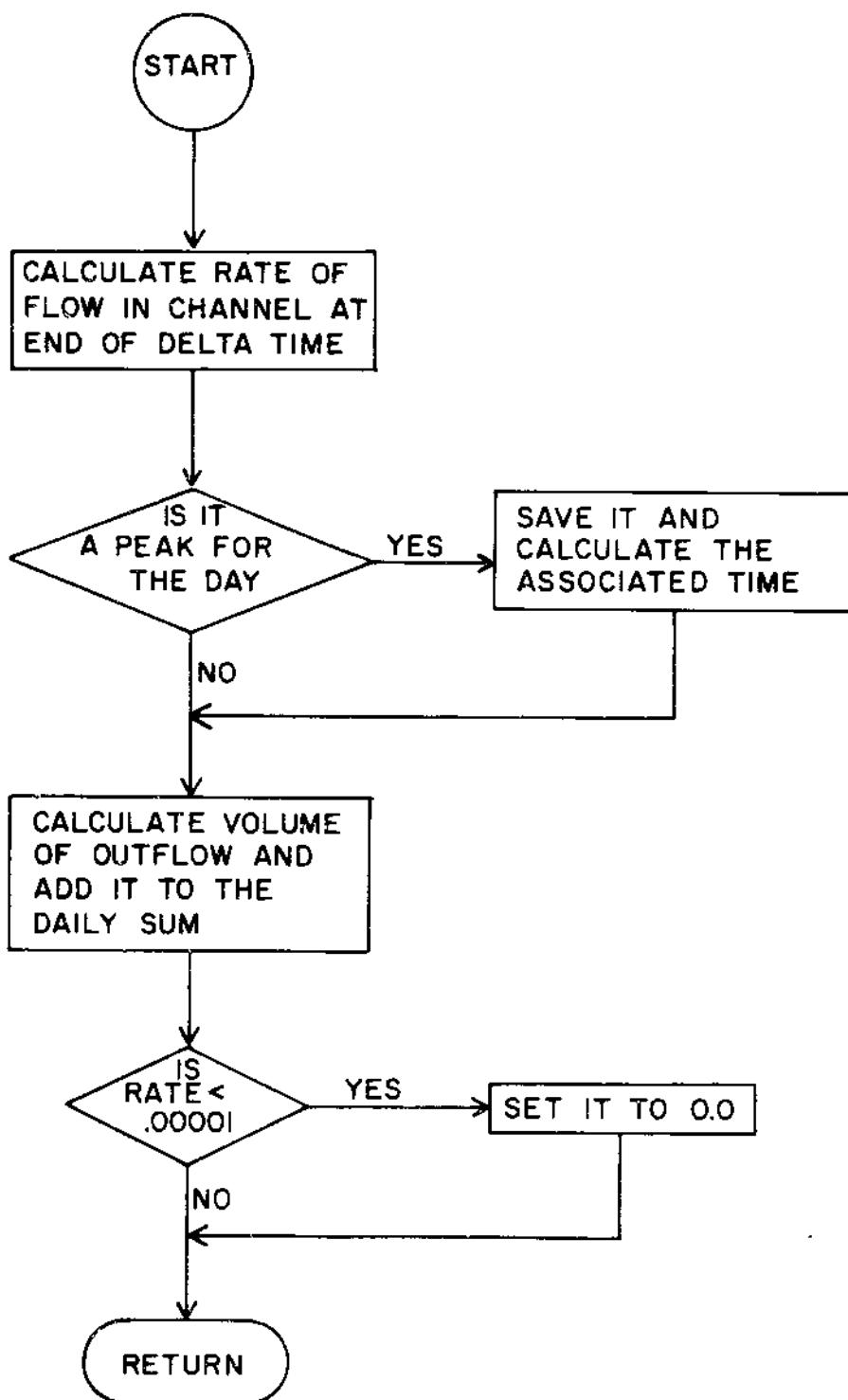
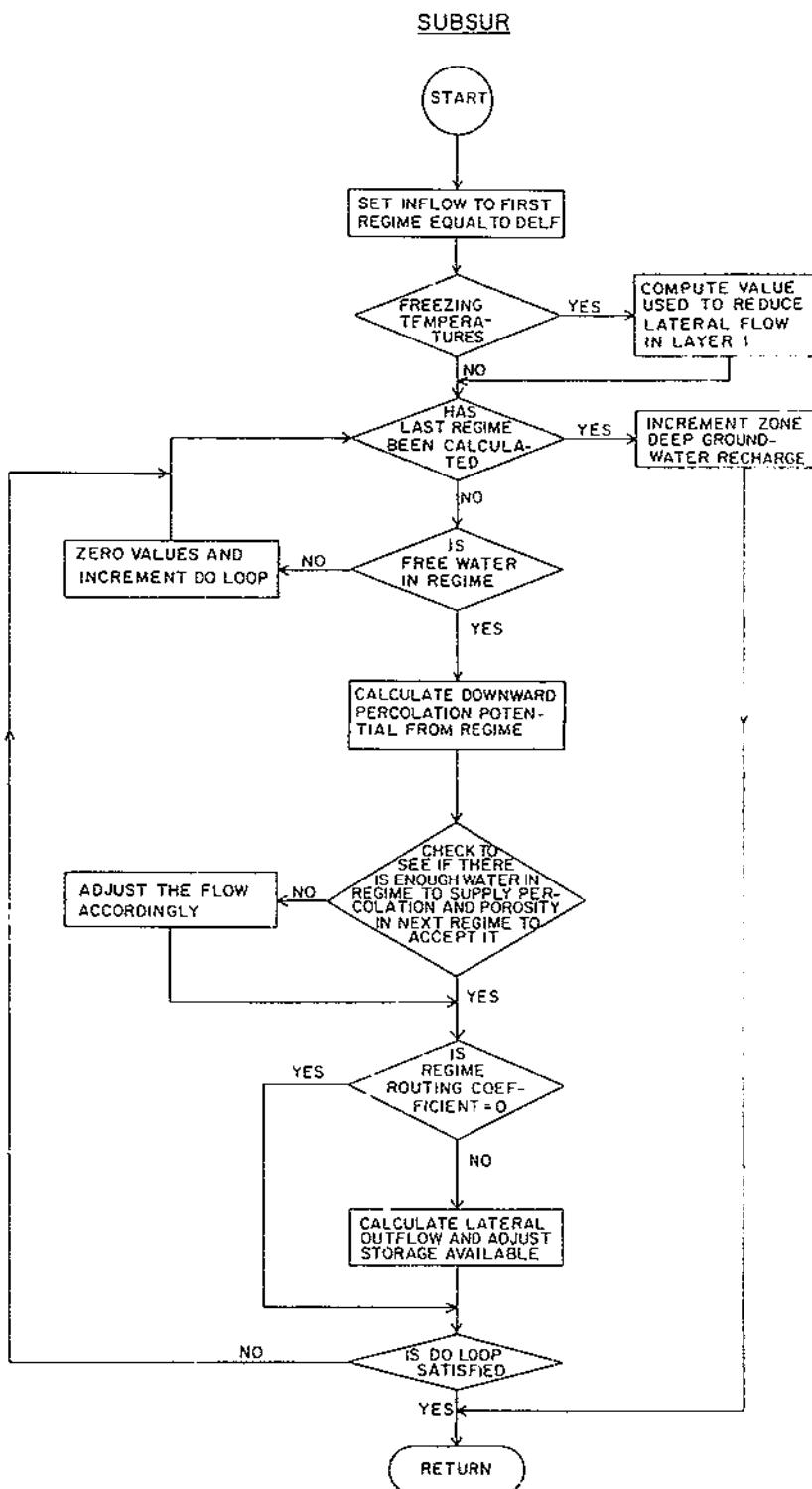
ROUTE

FIGURE 27.—Flow chart of USDAHL-74 channel flow.



$$\text{Inflow} - \text{Outflow} = \text{change in storage}$$

$$\text{and} \quad S = mq$$

FIGURE 28.—Flow chart of USDAHL-74 subsurface flow.

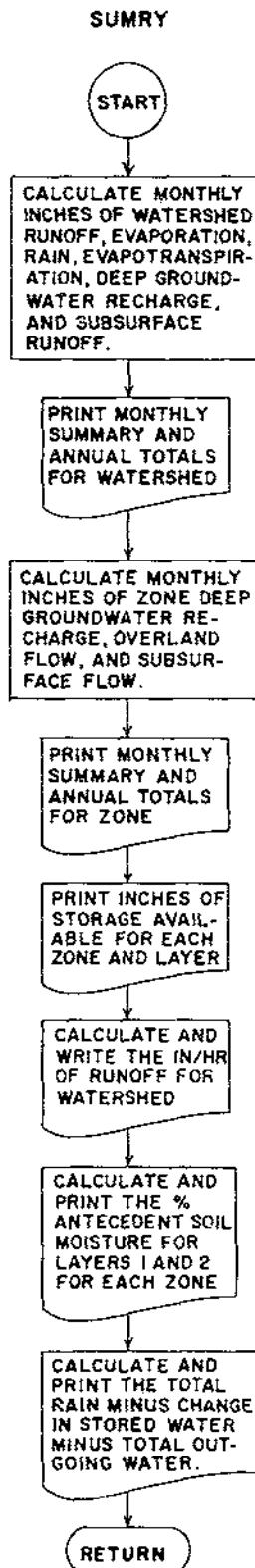


FIGURE 29.—Flow chart of USDAHL-74 annual summaries.

C	U.S. DEPARTMENT OF AGRICULTURE HYDROGRAPH LABORATORY	I	10
C	USDAHL-74 MODEL OF WATERSHED HYDROLOGY	I	20
C	VARIABLES IN COMMON	I	40
C	VARIABLE	DEFINITION	I 50
C	A	BASAL AREA OF VEGETATION (USED AS AN INDEX OF SURFACE CONNECTED POROSITY.	I 60
C	ACRES	NUMBER OF ACRES IN THE WATERSHED.	I 70
C	AWC	STORAGE DRAINED BY EVAPOTRANSPIRATION.	I 80
C	BOL	WATER STORED IN OVERLAND FLOW AT BEGINNING OF YEAR OR RUN.	I 90
C	RVD	WATER STORED IN VOLUME OF DEPRESSIONS AT BEGINNING OF YEAR OR RUN.	I 100
C	C	DOWNDRAIN SEEPAGE FROM A LAYER.	I 110
C	CASC	INDICATES WHETHER THE PERCENT OF OVERLAND FLOW WHICH DOES NOT CASCADE THE SUCCEEDING ZONE (I.E. 1-PCASI GOES TO CHANNEL OR THE ALLUVIUM.	I 120
C	COPT	SOIL LAYERS IN ZONE IN WHICH CRACKING OCCURS.	I 130
C	CHIN	INCHES OF INFLOW TO THE CHANNEL FOR ONE ROUTING INTERVAL.	I 140
C	CM	CHANNEL ROUTING COEFFICIENT.	I 150
C	CON1 AND CON2	CHANNEL ROUTING CONSTANTS WHICH ARE FUNCTIONS OF CM AND RDELT.	I 160
C	CROPS	LITERAL ARRAY OF CROP NAMES.	I 170
C	CRPV0	VOLUME OF DEPRESSIONS ASSOCIATED WITH A CROP.	I 180
C	CVOL	MAXIMUM VOLUME OF CRACKING FOR A ZONE LAYER.	I 190
C	D1	AVERAGE DEPTH OF OVERLAND FLOW ON ZONE.	I 200
C	DAILY	WATERSHED INCHES OF CHANNEL OUTFLOW.	I 210
C	DAMO	ACCUMULATION OF DAYS IN A YEAR AT END OF MONTHS.	I 220
C	DELE	INCREMENT OF SOIL EVAPORATION FOR THE DELTA TIME.	I 230
C	DELET	INCREMENT OF EVAPOTRANSPIRATION FROM THE WATERSHED FOR DELTA TIME.	I 240
C	DELF	VOLUME OF INFILTRATION INTO A ZONE DURING DELTA TIME.	I 250
C	DELP	INCREMENT OF RAINFALL FOR THE DELTA TIME.	I 260
C	DELO	VOLUME OF LATERAL FLOW FROM A ZONE FLOW REGIME FOR A DELTA TIME. (INCHES)	I 270
C	DEL02	INCREMENT OF LATERAL FLOW FROM ZONE,	I 280
C	DELT	DELTA TIME ARRAY SET UP IN DATA.	I 290
C	DELT.F	MAXIMUM DELTA TIME FOR CALCULATIONS DURING STORMS.	I 300
C	DET	VOLUME OF EVAPOTRANSPIRATION CALCULATED DURING THE DELTA TIME FOR THE ZONE. (INCHES)	I 310
C	DPE	INCREMENT OF PRECIPITATION EXCESS. INPUT TO OVERLAND FLOW.	I 320
C	DQO	ZONE INCHES OF OVERLAND FLOW FOR THE DELTA TIME.	I 330
C	F	EVAPORATION FROM THE SOIL FREE WATER.	I 340
C	FL	EVAPORATION FROM SOIL FREE WATER FROM A ZONE LAYER FOR DELTA TIME.	I 350
C	EP	PAN EVAPORATION FOR CURRENT WEEK.	I 360
C	ESTEP	RATIO OF MAXIMUM FT TO MAXIMUM EP FOR A CROP.	I 370
C	FTL	EVAPOTRANSPIRATION FROM A ZONE LAYER FOR DELTA TIME.	I 380
C	FC	FINAL RATE OF INFILTRATION AFTER PROLONGED WETTING.	I 390
C	FIL	RATE OF INFILTRATION AT THE END OF DELTA TIME.	I 400
C	G	STORAGE DRAINED BY GRAVITY.	I 410
C	GAZ	PERCENT REDUCTION OF GI FOR GRAZING EFFECTS.	I 420
C	GI	GROWTH INDEX CURVE FOR A GIVEN CROP.	I 430
C	IBEG	INDICATES THE FIRST PASS THROUGH THE PROGRAM.	I 440
C	IDALY	DATA SET REFERENCE VARIABLE FOR DAILY OUTPUT.	I 450
C	IHYD	DATA SET REFERENCE VARIABLE FOR STORM HYDROGRAPH OUTPUT.	I 460
C	TOVER	DATA SET REFERENCE VARIABLE FOR OVERLAND FLOW HYDROGRAPH OUTPUT.	I 470
C	TPRIN	DATA SET REFERENCE VARIABLE FOR OUTPUT.	I 480
C	TREAD	DATA SET REFERENCE VARIABLE FOR PARAMETER INPUT AND PAN EVAPORATION INPUT DATA.	I 490
C	IROTA	INDICATES WHETHER LAND USE PERCENTS CHANGE DURING THE RUN.	I 500

C	ITAPE	DATA SET REFERENCE VARIABLE FOR RAINFALL INPUT.	I	730
C	ITIL	INDICATES WHETHER TILLAGE PRACTICES WILL BE INPUT YEARLY OR THE FIRST YEAR ONLY.	I	740
C	TYDAY	JULIAN DAY OF THE YEAR.	I	750
C	TYR	YEAR ASSOCIATED WITH MONTHLY SUMMARY OUTPUT AT THE END OF A YEAR.	I	760
C	IYRI	YEAR OF PREVIOUS PAINFALL OBSERVATION.	I	780
C	JUL	DATES FOR WHICH DETAILED ROUTING IS REQUESTED.	I	800
C	KCUL	SAVES TILLAGE PRACTICE CODES WHEN ONLY THE FIRST YEAR IS ENTERED.	I	810
C	KDATE	SAVES TILLAGE DATES WHEN ONLY FIRST YEAR IS ENTERED.	I	820
C	KNO	SAVES THE NUMBER OF TILLAGE EVENTS WHEN ONLY THE FIRST YEAR IS ENTERED.	I	830
C	KONT	SUMS NUMBER OF PONTING DELTAS CALCULATED TO INDICATE 24 HRS.	I	840
C	M	FLOW REGIME ROUTING COEFFICIENT.	I	850
C	MIST	FIRST MONTH OF PAINFALL INPUT DATA.	I	860
C	MDY	DAY OF PAINFALL OBSERVATION.	I	880
C	MHR	MILITARY HOUR FOR INPUT.	I	910
C	MIN	MINUTFS PAST HOUR. FOR INPUT.	I	920
C	MO	MONTH OF RAINFALL OBSERVATION.	I	930
C	MSTOR	INDICATES WHETHER DETAILED ROUTING VALUES ARE TO BE SAVED FOR THE CURRENT DATE (IYDAY).	I	940
C	MYR	YEAR ARRAY FROM RAINFALL RECORD.	I	950
C	MZ	FLOW REGIME ROUTING COEFFICIENT FOR A ZONF.	I	960
C	NCHFK	PREVIOUS WEEK OF THE YEAR.	I	970
C	NE	TOTAL NUMBER OF ELEMENTS IN DELTA TIME ARRAY SET UP IN SUBROUTINE DATA.	I	1000
C	NKROP	TOTAL NUMBER OF CROPS IN THE WATERSHED.	I	1010
C	NST	TOTAL NUMBER OF DATES REQUESTED FOR DETAILED ROUTING PRINT OUT.	I	1020
C	NUML	TOTAL NUMBER OF SUBSURFACE FLOW REGIMES IN WATERSHED.	I	1030
C	NUMZ	TOTAL NUMBER OF ZONES IN WATERSHED.	I	1040
C	NWEEK	WEEK OF THE YEAR.	I	1050
C	OLDGI	WEIGHTED GI FOR A ZONE FOR THE PREVIOUS WEEK.	I	1060
C	OVA	OVERLAND FLOW FACTOR FOR A ZONF.	I	1070
C	OWL	LFNGTH OF FLOW FOR A ZONE IN FEET.	I	1080
C	PAGE	COUNTER TO SPACE OUTPUT ON A PAGE.	I	1090
C	PAN	WEEKLY AVERAGES OF DAILY VOLUMES OF PAN EVAPORATION. (INCHES).	I	1100
C	PCAS	PERCENT OF OVERLAND FLOW WHICH CASCADFS THE SUCCEEDING ZONE.	I	1110
C	PCKROP	PERCENT OF A CROP IN A ZONE.	I	1120
C	PCZON	PERCENT OF THE WATERSHED IN A GIVEN ZONE.	I	1130
C	PEAK	DAILY MAXIMUM RATE OF CHANNEL FLOW IN IN/HR.	I	1140
C	PRECIP	SUCCEEDING INCREMENTS IN THE DFLP ARRAY.	I	1150
C	OI	RATE OF LATERAL FLOW OUT OF A SUBSURFACE REGIME.	I	1160
C	OLI	RATE OF LATERAL FLOW OUT OF A REGIME AT THE BEGINNING OF A TIME INCREMENT.	I	1170
C	QMAX	MAXIMUM RATE OF LATERAL OUTFLOW FROM A ZONE FLOW REGIME.	I	1180
C	ODI	ZONF RATE OF OVERLAND FLOW.	I	1190
C	OPPK	ZONE PEAK OF THE RUNOFF HYDROGRAPH FOR EACH DAY.	I	1200
C	OZ	SUM OF LATERAL FLOW RATES FROM A ZONF.	I	1210
C	R1	RATE OF FLOW IN THE CHANNEL.	I	1220
C	ROELT	ROUTING DELTA TIME. THIS VALUE SHOULD DIVIDE INTO 24 WITH NO REMAINDER.	I	1230
C	ROOTD	DEPTH OF ROOTS FOR A CROP IN INCHES.	I	1240
C	RUNON	WEIGHTED INFLOW TO A ZONE WHICH IS ADDED TO RAINFALL WHEN CALCULATING INFILTRATION.	I	1250
C	SA1	CURRENT STORAGE AVAILABLE IN A ZONE LAYER.	I	1260
C	SCN	DAILY VOLUMES OF VERTICAL PERCOLATION FROM A ZONE LAYER. (INCHES).	I	1270
C	SDQO	DAILY VOLUME OF OVERLAND FLOW FROM A ZONE. (IN.)	I	1280
C	SEL	DAILY VOLUME OF EL.	I	1290
C	SETL	DAILY VOLUME OF ETL.	I	1300
C	SG1	WEIGHTED SUM OF TOP SOIL G VALUES IN THE WATERSHED.	I	1310
C	SGR	DAILY VOLUME OF SCN FROM LAST LAYER TO GROUND WATER. (INCHES).	I	1320

C	SL	SLOPE OF A ZONE IN PERCENT.	I	1450
C	SMAX	MAXIMUM STORAGE (G+AWC).	I	1460
C	SOILD	DEPTH OF AERATED SOIL. (INCHES).	I	1470
C	SOL	DAILY VOLUME OF LATERAL FLOW FROM A ZONE LAYER.	I	1480
C	SRUNON	DAILY SUM OF RUNON TO A ZONE. (INCHES).	I	1490
C	SUBPUT	WATER MOVING INTO A LAYER DURING DELTA TIME.	I	1500
C		SURPUT() IS INFILTRATION, SURPUT(NUML+1) IS INPUT TO SUMCN. (INCHES). (SURPUT(L)=CN(L-1)).	I	1510
C	SUMCN	ACCUMULATED AMOUNT OF DEEP SEEPAGE WITHIN A ZONE THIS WATER DOES NOT CONTRIBUTE TO STREAM FLOW.	I	1520
C	SUMET	ACCUMULATED INCHES OF EVAPOTRANSPIRATION IN A ZONE.	I	1530
C	TEMP	WEEKLY AVERAGES OF MEAN DAILY AIR TEMPERATURES. DEGREES F.	I	1540
C	THAW	TEMPERATURE AT WHICH SNOWMELT STARTS. DEGREES F	I	1550
C	TIM	ARRAY OF DELTA TIMES TO BE USED WHEN DELTA PRECIPITATION IS ZERO.	I	1560
C	TIME	INCREMENT OF TIME IN HOURS.	I	1570
C	TL	TEMP BELOW WHICH CROP'S ET DOES NOT FUNCTION.	I	1580
C	TOPD	DEPTH OF TOP SOIL. (INCHES).	I	1590
C	TP	TIME OF DAILY MAXIMUM FLOW IN MILITARY HOURS.	I	1600
C	TU	TEMP ABOVE WHICH CROP'S ET IS IMPAIRED.	I	1610
C	VD	CURRENT VOLUME OF WATER IN DEPRESSION STORAGE.	I	1620
C	VDMAX	MAXIMUM VOLUME OF DEPRESSION STORAGE FOR A ZONE.	I	1630
C	VEG	WEIGHTED VEGETATION FACTOR FOR INFILTRATION FOR A ZONE.	I	1640
C	VOL	VOLUME OF CHANNEL RUNOFF FOR A ROUTING DELTA TIME.	I	1650
C	WPP1 AND WPP2	WILTING POINT OF LAYER 1 AND LAYER 2, RESPECTIVELY.	I	1660
C	ZGI	WEIGHTED GI VALUE FOR A ZONE.	I	1670
C	ZONE	INDEX CONTROLLING ZONE UNDER CONSIDERATION.	I	1680
C		COMMON A(10),ACRES+AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN, 1CM,CON1,CON2,CROPS(2,10),CRPVDI(10),CVOL(4,4),D1(4),DAILY,DAMO(1P), 2DELF,DFLET,DELF(4),DELP(300),DFLR(4),DELQZ(4),DELT(300),DELTF,DET, 3DPE(4),DQO(4),E,FL(4,2),FP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4), 4GA7(10),GT(10),GTG(10,52),IREG,IDL,IHYD,IOVER,IPRIN,IREAD,IPOTA COMMON ITAPF,ITTL,ITYDAY,IYR,IYI,JUL(50),KCHL(10,10),KDATE(10,10), 1KNO(10),KONT,M(4),MDY(15),MHR(5),MIN(5),MIST,M0(5),MSTOR,MYR(5), PNCHK,NE,NKROP,NST,NUML,NUM7,NWFEK,OLDGT(4),OVA(4),OVL(4), 3PAGF,PAN(52),PCAS(4),PKROP(4,10),PCZON(5),PEAK,PRFCIP,D1(4,4), 4QL1(4,4),QMAX(4,5),QO1(4),QOPK(4),QZ(4),R1,PDELT,R00TD(10) COMMON PUNON(5),SA1(4,4),SCN(4,4),SD00(4),SFL(4,2),SETL(4,2)+SG1, 1SGP(4),SL(4),SMAX(4,4),SOLID(4),SQL(4,4),SRUNON(4),SURPUT(5), 2SUMFT(4),SIHCN(4),TEMP(52),TIM(5),TIME+TL(10),TOPD(4),TP,TU(10), 3VD(4)+VDMAX(4),VEG(4),VOL,ZGI(4),ZONE,WPP1(4),WPP2(4) DIMENSTN RAMO(12),BASE(4),CRAK(4),DAYCN(4),DAYET(4),EMO(1P), 1ETHO(12),H7(4,4),NUMRS(4),OFFSIT(4),OFSTMO(12),ONSTMO(12), 2RAMO(12)+RUNMO(12),SF(4),SNO(4),SUMRA(4)+SUMO(12)+SUMPE(4), 3TOTCN(4),TOTFT(4),ZRAM(4,12),ZCM(4,12),ZFST(4,12),?PEM(4,12) INTEGEP ZONE REAL M,MELK(4,4),MZ RHO=1./24.	I	1690
C		DATA SET REFERENCE VARIABLES REFER TO THE FOLLOWING FILES: IDAY= DAILY OUTPUT. IHYD= STORM HYDROGRAPH OUTPUT. IOVER= OVERLAND FLOW HYDROGRAPH. IPRIN= ALL OUTPUT (INCLUDING ERROR MESSAGES) EXCEPT HYDROGRAPHS. IREAD= INPUT PARAMETERS, LAND USE DATA, PAN EVAPORATION DATA. ITAPF= INPUT RAINFALL DATA.	I	1700
C	IDAY=13		I	1710
C	IHYD=10		I	1720
C	IOVER=11		I	1730
C	IPRIN=6		I	1740
C	IREAD=5		I	1750
C	ITAPF=3		I	1760
C		TPOL = 9=DAILY OUTPUT IN SUBROUTINE POLLUT	I	1770
C			I	1780
C			I	1790
C			I	1800
C			I	1810
C			I	1820
C			I	1830
C			I	1840
C			I	1850
C			I	1860
C			I	1870
C			I	1880
C			I	1890
C			I	1900
C			I	1910
C			I	1920
C			I	1930
C			I	1940
C			I	1950
C			I	1960
C			I	1970
C			I	1980
C			I	1990
C			I	2000
C			I	2010
C			I	2020
C			I	2030
C			I	2040
C			I	2050
C			I	2060
C			I	2070
C			I	2080
C			I	2090
C			I	2100
C			I	2110
C			I	2120
C			I	2130
C			I	2140
C			I	2150

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C      IPAGE=10                                1 2160
C      IBEG=0       INITIALIZE VALUE TO INDICATE BEGINNING. 1 2170
C      IREG1=0
C      L=0
C      LAST=0
C      ST=0.
C      DELTF=0.50
C      JUL(1)=0       INITIALIZE VALUES OF MONTHLY ACCUMULA- 1 2240
C      JS=1           TIONS FOR DAYS OF THE YEAR. 1 2250
C      MSTDR=0
C      STIM=0.
C      DAMO(1)=31. 1 2260
C      DAMO(2)=59. 1 2270
C      DAMO(3)=90. 1 2280
C      DAMO(4)=120. 1 2290
C      DAMO(5)=151. 1 2300
C      DAMO(6)=181. 1 2310
C      DAMO(7)=212. 1 2320
C      DAMO(8)=243. 1 2330
C      DAMO(9)=273. 1 2340
C      DAMO(10)=304. 1 2350
C      DAMO(11)=334. 1 2360
C      DAMO(12)=365. 1 2370
C      READ IN PARAMETERS FOR THE RUN. 1 2380
C      CALL PARAMS (MZ,NREG,PBAS,SNO,THAW) 1 2390
C      NX=NRFG-1 1 2400
C      INITAILIZE VALUES. 1 2410
C      TRWS=0.0 1 2420
C      BACC=0.0 1 2430
C      BAYR=0.0 1 2440
C      RACC=0. 1 2450
C      TRA= 0. 1 2460
C      WRASE=0.0 1 2470
C      RDLT=1./RDFLT 1 2480
C      CALL INIT (ACC,BAMO,BEGPI,BEGSA,CRAK,DAYCN,DAYET,EACC,EMO,ETAC, 1 2490
C      IETMO,ETYR,FYR,ICNT,JCODE,LST,OFFSIT,OFSTM0,ONSTMO,RAIN,PAMO,PP1, 1 2500
C      PRUNMO,SF,SUMRA,SUMO,SUMPF,TACC,TE,TFT,TOTCN,TOTET,TPAN,YEARLY, 1 2510
C      3ZBAM,ZCM,ZDFST,ZPEM,RDLT) 1 2520
C      READ A PAINFALL INPUT RECORD OF FOUR 1 2530
C      OBSERVATIONS. 1 2540
100 CALL DATA (JCODE,JS,LAST,LST,MELK,NUMBS,SF,SNO,ST,TRA,THAW) 1 2550
C      MCOUNT=1 1 2560
C      IF(JCODE-11120,120,110 1 2570
110 L=1 1 2580
C      BA=0. 1 2590
C      CH=0. 1 2600
C      ETT=0. 1 2610
C      EV=0. 1 2620
C      RI=0. 1 2630
C      NROT= 1 2640
C      DO LOOP THAT CONTROLS THE DELTA TIMES 1 2650
C      ARPAY. THE ENTIRE MOISTURE ACCOUNTING 1 2660
C      IS CALCULATED FOR EACH DELTA TIME. 1 2670
C      1 2680
120 DO 610 J=1,NE 1 2690
C      IF(L>12)1P1,390 1 2700
121 PRECIP=DELP(J) 1 2710
C      TIME=DELT(.1) 1 2720
C      RTIM=1./TIME 1 2730
C      ST=ST+TIME 1 2740
C      DFLE=0. 1 2750
C      DELET=0. 1 2760
C      RAIN=RAIN+PRECIP 1 2770
C      BASR=0.0 1 2780
C      DO 130 ZONE=1,NUMZ 1 2790
C      RUNON(ZONE)=0.0 1 2800
C      QZ(ZDNF)=0.0 1 2810
130 BASF(ZONE)=0.0 1 2820
C      SUBSCRIPT 'NUMZ+1' INDICATES THE CHANNEL. 1 2830
C      RUNON(NUMZ+1)=0.0 1 2840
C      NWEEK=IYDAY/7.+99 1 2850
C      1 2860
C      1 2870
C      1 2880

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      IF(NWEEK=5) 142,142,141          1 2890
141 NWEEK=52                         1 2900
142 IF(NWEEK-NCHFK) 143,145,143     1 2910
143 DO 144 KROP = 1..NKROP          1 2920
144 GI(KROP)=GTG(KROP,NWEEK)
      EP=PAN(NWEEK)                  1 2930
      145 DO 280 ZONEF=1,NUMZ          1 2940
         IF(TMP(NWEEK)-28.) 152,152,157 1 2950
152 DET=0.0                           1 2960
      ETL(ZONF+1)=0.0                1 2970
      ETL(ZONE+2)=0.0                1 2980
      E=0.0                            1 2990
      EL(ZONE+1)=0.0                1 3000
      EL(ZONE+2)=0.0                1 3010
      GO TO 160                      1 3020
      C                               THE EVAPOTRANSPIRATION SURROUTINE RE-
      C                               COVRS AVAILABLE STORAGE (POROSITY) BY
      C                               PLANT USE.                      1 3030
      157 CALL ETCALC
      DFLET=DELET+DET*PCZON(ZONE)    1 3040
      C                               THE EVAPORATION SURPOUTINE RECOVERS
      C                               AVAILARLE STOPAGE BY DIRECT EVAPDATION
      C                               FROM THE SOIL FREEWATER.        1 3050
      CALL EVAP (CRAK,RHD)
      DELE=DELE+F*PCZON(ZONE)        1 3060
      C                               THE SUBSURFACE FLOW SURROUTINE ROUTES
      C                               FREEWATER AS A STORAGE FUNCTION TO
      C                               DOWNWARD PERCOLATION OR LATRAL OUTFLOW,
      C                               INPUT TO THE FIRST REGIME (A HORIZON)
      C                               IS DELTA INFILTRATION; AND TNPUT TO
      C                               OTHER REGIMES IS PERCOLATION FROM ITS
      C                               PRECEDING REGIME.          1 3070
      160 CALL SUBSUR (MZ,V)           1 3080
         IF(NX) 211-211,170          1 3090
211  WBASE=0.0                        1 3100
      BASB=0.0                         1 3110
      GO TO 189                      1 3120
170  DO 185 LAYFR=1,NX              1 3130
         IF(M(LAYER)) 185-185,180  1 3140
180  BASF(ZONE)=BASE(ZONE)+DELO(LAYER) 1 3150
185  CONTINUF                      1 3160
189  IF(NUML-NX) 190,190,186        1 3170
186  DO 188 LAYFR=NREG,NUML
         IF(M(LAYER)) 188-188,187  1 3180
187  OFFSIT(ZONF)=OFFSIT(ZONE)+DFLG(LAYER) 1 3190
188  CONTINUF                      1 3200
190  IF(ZONE-NUMZ) 210,200,200  1 3210
200  WBASE=BASF(NUMZ)*PCZON(NUMZ)+BASB*PRAS
      RUNON(NUMZ)=RUNON(NUMZ)+BASB*(1.-PRAS)/PCZON(NUMZ) 1 3220
      GO TO 220                      1 3230
210  BASB=BASB+BASE(ZONE)*PCZON(ZONE) 1 3240
      C                               THE INFILTRATION SURROUTINE DECREASES
      C                               AVAILABLE STORAGE DURING PERIODS OF
      C                               PAINFALL AND ALSO WHEN THERE IS WATER
      C                               IN SURFACE DETENTION OR OVERLAND FLOW
      C                               STOPAGE.                      1 3250
      220 IF(NUMRS(MCOUNT),NE,J) GO TO 225
      MCOUNT=MCOUNT+1
      C                               TPRECP IS TOTAL PRECIP (RAIN PLUS
      C                               SNOWMELT WEIGHTED FOR A ZONE.)
      225 TPRECP=PRFCIP*MELK(ZONE,MCOUNT) 1 3260
      CALL INFIL (CRAK,M7,TPRECP)
      C                               THE OVERLAND FLOW SURROUTINE ROUTES
      C                               WATER IN EXCESS OF INFILTRATION TO
      C                               SURFACE DETENTION OR OVERLAND FLOW. 1 3270
      CALL PEROUT (RTIM)
      RUNON(ZONE+1)=RUNON(ZONE+1)+DOO(ZONF)*PCAS(ZONE)*PCZON(ZONF)/
      1 PCZON(ZONF+1)                  1 3280
      IF(GASC(ZONF)) 240,236,240    1 3290

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230 RUNON(NUMZ+1)=RUNON(NUMZ+1)+(1.-PCAS(ZONE))*DQO(ZONE)*PCZON(ZONE)    I 3620
      GO TO 250
240 RUNON(NUMZ)=RUNON(NUMZ)+(1.-PCAS(ZONE))*DQO(ZONE)*PCZON(ZONE)/    I 3630
      (PCZON(NUMZ))
250 SUMBA(ZONE)=SUMBA(ZONE)+RASF(ZONE)
      SUMPE(ZONE)=SUMPE(ZONE)+DQO(ZONE)
C          SUM VALUES FOR DAILY PRINTOUT OF POLLUTION    I 3640
C          VALUES.                                         I 3650
C          QOPK = PEAK OF THE RUNOFF HYDROGRAPH    I 3660
C          FOR EACH DAY.                                I 3670
C          SCN = DAILY SUM OF DOWNWARD PERCOLATION    I 3680
C          OUT OF LAYFRS 1, NUML.                      I 3690
C          SDQO = DAILY SUM OF OVERLAND FLOW FOR    I 3700
C          A ZONE.                                     I 3710
C          SEL = DAILY SUM OF EV FOR EACH ZONE AND    I 3720
C          LAYFRS 1 AND 2.                            I 3730
C          SETL = DAILY SUM OF ET FOR EACH ZONE AND    I 3740
C          LAYFRS 1 AND 2.                            I 3750
C          SGR = SCN (NUML).                           I 3760
C          SQL = DAILY SUM OF SUBSURFACE FLOW FOR    I 3770
C          EACH ZONE AND EACH LAYER.                  I 3780
C          SRUNON= DAILY SUM OF RUNON.                 I 3790
C          I 3800
C          DO 260 LAYER=1,2
C          SFTL(ZONE,LAYER)=ETL(ZONE,LAYER)+SETL(ZONE,LAYER)    I 3810
260 SFL(ZONE,I,AYER)=SEL(ZONE,LAYER)+EL(ZONE,LAYER)    I 3820
      DO 270 LAYER=1,NUML
      SOL(ZONE,LAYER)=SOL(ZONE,LAYER)+DELO(LAYER)    I 3830
270 SCN(ZONE,LAYER)=SCN(ZONE,LAYER)+SUBPUT(LAYER+1)    I 3840
      SGR(ZONE)=SCN(ZONE,NUML)
      IF (001(ZONE)-QOPK(ZONE)) 271,271,272    I 3850
271 QOPK(ZONE)=001(ZONE)
272 SDQO(ZONE)=SDQO(ZONE)+DQO(ZONE)
      SRUNON(ZONE)=SRUNON(ZONE)+RUNON(ZONE)
      SF(ZONE)=SF(ZONE)+DELF(ZONE)
280 CONTINU
C          PRINT OVERLAND FLOW HYDROGRAPH IF    I 3860
C          REQUESTED.                                I 3870
C          IF (MSTOR1300+310,300    I 3880
300 RAINTE=PRECIP*PTIM
      WRITE(10VFR,11ST,PAINT,(001(ZONE),01(ZONE),SF(ZONE),ZONF=1,NUMZ)    I 3890
      1 FORMAT(*,F6.3,F10.4,4(1X,F9.5))
310 TREG=
C          TOTAL VOLUME OF FLOW INTO THE CHANNEL IS    I 3900
C          THE SUM OF OVERLAND FLOW FROM THE ALLUVI-    I 3910
C          UM AND FLOW SENT DIRECTLY TO THE CHANNEL    I 3920
C          RATHER THAN CASCADED SEQUENTIALLY.        I 3930
C          I 3940
C          FL02= RUNON(NUMZ+1)
C          IF (FL02-0.0000001) 320,320+330
320 FL02=0.0
C          INTERPOLATION TO STANDARD DELTA TIME    I 3950
C          FOR ROUTING. DEFINITION OF VARIABLES:    I 3960
C          ACC = ACCUMULATED RUNOFF.                I 3970
C          BACC= ACCUMULATED BASE FLOW.             I 3980
C          FACC= ACCUMULATED EVAPORATION.           I 3990
C          FTAC= ACCUMULATED EVAPOTRANSPIRATION.   I 4000
C          PAE = INCREMENT OF E.                   I 4010
C          PAET= INCREMENT OF FT.                  I 4020
C          PARA= INCREMENT OF PAIN.                I 4030
C          PAPO= INCREMENT OF PUNOFF.              I 4040
C          PACC= ACCUMULATED RAIN.                 I 4050
C          TACC= ACCUMULATED TIME FROM LAST    I 4060
C          BREAKPOINT.                            I 4070
C          I 4080
C          330 TEST=(TACC+TIME)*RDLT-0.999
C          IF (TEST) 340,350,350
340 TACC=TACC+TIME
      BACC=BACC+WBASF
      RACC=RACC+PPFCIP
      ACC= ACC+FL02
      ETAC=ETAC+DELET
      EACC=EACC+DELE
      NROT=0
      I 4090
      I 4100
      I 4110
      I 4120
      I 4130
      I 4140
      I 4150
      I 4160
      I 4170
      I 4180
      I 4190
      I 4200
      I 4210
      I 4220
      I 4230
      I 4240
      I 4250
      I 4260
      I 4270
      I 4280
      I 4290
      I 4300
      I 4310
      I 4320
  
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GO TO 380
350 PART=RDFLT-TACC          1 4330
PARO=FLO2*PART*RTIM         1 4340
PARA=WBASF*PART*RTIM        1 4350
PAET=DELET*PART*RTIM        1 4360
PAE=DELE*PART*RTIM          1 4370
PARP=PRECIP*PART*RTIM       1 4380
TIME= TIME*PART             1 4390
WBASF=WBASF-PARA            1 4400
DELET=DELET-PAET             1 4410
DELE=DELE-PAE                1 4420
PRECIP=PRECIP-PARA           1 4430
FLO2=FLO2-PARO              1 4440
CH=ACC+PARO                 1 4450
ETAC=ETAC+PAFT              1 4460
BA=RACC+PARA                 1 4470
RI=RACC+PARA                 1 4480
EV=FACC+PAF                  1 4490
NROT=1                        1 4500
TEST=TIME*RDLT-0.999          1 4510
IF(TEST>1360.370+370        1 4520
360 TACC=TIME               1 4530
RACC=PRECIP                  1 4540
ACC= FLO2                     1 4550
ETAC= DELET                   1 4560
EACC=DELE                     1 4570
BACC=WBASF                    1 4580
GO TO 380                     1 4590
370 NROT=TIME*RDLT+0.001      1 4600
ROT=NROT*RNFILT*RTIM         1 4610
PARA=WBASF*ROT               1 4620
FARO=FLO2*ROT                1 4630
PAET=DELET*ROT               1 4640
PAE=DELE*ROT                 1 4650
PARP=PRECIP*ROT               1 4660
ACC=FLO2-PARO                 1 4670
BACC=WBASF-PARA               1 4680
ETAC=DELET-PAET               1 4690
EACC=DELE-PAE                 1 4700
TACC=TIME-NROT*ROELT         1 4710
IF(TACC)>371,372-372         1 4720
371 TACC=0.0                   1 4730
372 RACC=PRECIP-PARA          1 4740
RNROT=1./FLOAT(NROT)          1 4750
BIN=PARA*RNROT               1 4760
RIN=PARA*RNROT               1 4770
CHT=PARO*RNROT               1 4780
ETIM=PAET*RNROT              1 4790
ETN=PAE*RNROT                1 4800
NROT=NROT+1                   1 4810
380 IF(NROT)>610,610,390      1 4820
390 DO 600 I=1,NROT           1 4830
IF(I-1)>400,400,410          1 4840
400 CHIN=CH                   1 4850
IF(BA.LT.0.0) RA=0.0          1 4860
AVGB=BA*RDLT                  1 4870
TBWS=TBWS+RA                  1 4880
TET=TET+TET                   1 4890
TE=EV*TF                      1 4900
TRA=TRA+RT                     1 4910
GO TO 420                     1 4920
410 CHIN=CHI                  1 4930
TBWS=TBWS+AIN                  1 4940
AVGR=BIN*RDLT                  1 4950
TET=TET+ETIN                   1 4960
TE=TE+EIN                      1 4970
TRA=TRA+RIN                     1 4980
C                                     1 4990
C                                     1 5000
C                                     1 5010
C                                     1 5020
C                                     1 5030
C                                     1 5040
C                                     1 5050
C                                     1 5060
C                                     1 5070
THE CHANNEL ROUTING SUBROUTINE IS CALLED
FOR EACH POUTING DELTA TIME (AN INPUT
PARAMETER) THAT IS CALCULATED UNLESS
TINFLOW AND PREVIOUS OUTFLOW ARE BOTH
ZERO. WHEN 24 HOURS OF ROUTING DELTAS
HAVE BEEN CALCULATED, DAILY ACCUMU-
LATIONS ARE PRINTED AND CHECKS FOR END
OF MONTH AND YEAR ARE REGUN.

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420 IF(CHIN)440,430,440                                1 5080
430 IF(R1)440,450,440                                1 5090
440 CALL ROUTE (CMC,IBFG1,RPI,CHIN1,RDLT)             1 5100
C          PRINT STORM HYDROGRAPH IF REQUESTED.          1 5110
C          AVGB = AVERAGE WATERSHED SURFACE INCHES       1 5120
C          PER HOUR OF SUBSURFACE FLOW FOR              1 5130
C          THE ROUTING INTERVAL.                         1 5140
C          AVGR = AVERAGE WATERSHED SURFACE INCHES       1 5150
C          PER HOUR OF CHANNEL FLOW FOR THE             1 5160
C          ROUTING INTERVAL.                           1 5170
C          AVGT = SUM OF AVGR AND AVGB.                 1 5180
C          CFS = CUBIC FEET PER SECOND EQUIVALENT      1 5190
C          OF AVGT.                                 1 5200
C          DAILY= TOTAL WATERSHED SURFACE INCHES OF     1 5210
C          CHANNEL FLOW FOR STIM.                      1 5220
C          STIM = MILITARY TIME OF DAY.                1 5230
C          TBWS = TOTAL WATERSHED SURFACE INCHES OF     1 5240
C          SUBSURFACE FLOW FOR STIM.                  1 5250
C          TRA = TOTAL WATERSHED SURFACE INCHES OF      1 5260
C          PASTFALL FOR STIM.                          1 5270
C          VOLT = ACCUMULATED WATERSHED SURFACE        1 5280
C          INCHES OF THE SUM OF CHANNEL AND            1 5290
C          SUBSURFACE RUNOFF FOR STIM.                 1 5300
C
450 IF(MSTOR)441,442,441                                1 5310
441 STIM=(KONT+1)*RDELT                               1 5320
VOLT=DAILY+TBWS                                     1 5330
AVGR=VOL*ROLT                                      1 5340
AVGT=AVGB*AVGR                                     1 5350
CFS=AVGT*1.0083*ACRES                             1 5360
WRITE(IHYD,21STIM,TRA,DAILY,TBWS,VOLT,AVGR,AVGR,AVGT,CFS
2 FORMAT(1,*,F5.2,2X,F6.2,2X,3F7.2,3F11.5,F10.2)    1 5370
442 KONT=KONT+1                                     1 5380
IF(KONT-ICNT1600,460,460                                1 5390
460 CALL OUTPUT (BAYR,DAYCN,DAYET,ETYR,FYR,ICNT,JS,RAIN,SF,ST,
TBWS,TE,TET,TOTCN,TOTET,TRA,TRAN,YEARLY,XDAY,RHD)
CALL POLLUT (TPAGE,PAIN)
RAIN=0.0
KONT=0
C          CHECK FOR LEAP YEAR AND THEN SEE IF THE      1 5400
C          DAY OF THE YEAR IS THE LAST DAY OF A        1 5410
C          MONTH. IF A MONTH END IS ENCOUNTERED,      1 5420
C          SAVE MONTHLY SUMMARY INFORMATION.          1 5430
1 5440
1 5450
C
IF(IYR=4*(IYR/4))490,470,490                         1 5460
470 IF(XDAY=32) 490,490,480                           1 5470
480 XDAY=XDAY-1                                       1 5480
490 DO 510 MX=1,12                                     1 5490
IF(XDAY=DAYM(MX))510,500,510
500 MN=MX
GO TO 520
510 CONTINUE
GO TO 540
520 CN=0.
WOFST=0.
ONSIT=0.
DO 530 ZONF=1,NUMZ
ZCM(ZONE,MN)=SUMCN(ZONE)
ZPEM(ZONE,MN)=SUMPE(ZONE)
ZBAM(ZONE,MN)=SUMBA(ZONE)
ZOFST(ZONF,MN)=OFFSIT(ZONE)
IF(ZONE.EQ.NIUM7) GO TO 525
ONSIT=SUMBA(ZONE)*PCZON(ZONF)*PRAS+ONSIT
WOFST=OFFSIT(ZONE)*PCZON(ZONE)*PBAS+WOFST
GO TO 530
525 ONSIT=SUMBA(NUM7)*PCZON(NUM7)+ONSIT
WOFST=OFFSIT(NUM7)*PCZON(NUM7)+WOFST
530 CN=SUMCN(ZONF)*PCZON(ZONF) +CN
RUNMO(MN) =YEARLY
ETMO(MN)=ETYR
EMO(MN)=EYR
1 5500
1 5510
1 5520
1 5530
1 5540
1 5550
1 5560
1 5570
1 5580
1 5590
1 5600
1 5610
1 5620
1 5630
1 5640
1 5650
1 5660
1 5670
1 5680
1 5690
1 5700
1 5710
1 5720
1 5730
1 5740
1 5750
1 5760

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C SUMO(MN) =CN
C RAMD(MN)=TRAN
C BAMO(MN)=RAYR
C OFSTMO(MN)=WOFST
C ONSTM0(MN)=DNSIT
C IF THE END OF THE YEAR OR THE END OF THE
C DATA IS CALCULATED, PRINT OUT THE
C MONTHLY SUMMARIES, STORAGES AVAILABLE
C IN EACH REGIME, AND THE MOISTURE BALANCE
C FOR THE TIME PERIOD.
C
C 540 IF(MN=12)540,580,540
C 550 L=2
C DO 570 MX=1,12
C IF(XDAY-DAM0(MX))560,560,570
C 560 MN=MX
C GO TO 520
C 570 CONTINUE
C MN=12
C GO TO 520
C 580 CALL SUMRY (BAMO,BEGRI,BEGSA,CMC,CN,EMO,ETMO,ETYR,EYR,MN,OFSTMO,
C 1ONSTM0,RAMD,RUNMO,SUMD,TRAN,WDFST,YEARLY,ZBAM,ZCM,ZOFST,ZPEM)
C SNOW=0.
C DO 700 ZONE=1,NUMZ
C 700 SNOW=SNOW+SNO(ZONE)*PCZON(ZONE)
C WRITE(IPRIN,1000) SNOW
C 1000 FORMAT('OSNOW=*,F8.3')
C STOP THE CALCULATION AT THE LAST DATE AND
C TIME INDICATED IN DATA.
C
C 586 JCODE=0
C LAST=1
C REINITIALIZE YEARLY AND MONTHLY ACCUMU-
C C LATION VALUES.
C
C DO 583 MX=1,12
C RUNMO(MX)=0.
C ETMO(MX)=0.
C RAMD(MX)=0.
C EMO(MX)=0.
C ONSTM0(MX)=0.
C OFSTMO(MX)=0.
C 583 SUM0(MX)=0.
C DO 590 ZONE=1,NUMZ
C TOTCN(ZONE)=0.
C SUMPE(ZONE)=0.0
C SUMRA(ZONE)=0.0
C SUMCN(ZONE)=0.0
C OFFSIT(ZONE)=0.
C DO 590 MN=1,12
C ZCM(ZONE,MN)=0.0
C ZPEM(ZONE,MN)=0.0
C ZOFST(ZONE,MN)=0.0
C 590 ZBAM(ZONE,MN)=0.0
C EYR=0.0
C TRAN=0.0
C YEARLY=0.
C MIST=1
C IYR=IYR+1
C IYDAY=1
C BAYR=0.0
C ETYR=0.
C END OF THE CHANNEL ROUTING DO LOOP AND
C FIND OF THE PAINFALL INPUT DELTA TIMES
C ARRAY.
C
C 600 CONTINUE
C 610 CONTINUE
C L=0
C IF(JCODE-1)100,100,110
C 581 STOP
C END

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SUBROUTINE DATA (JCODE,JS,LAST,LST,HELK,NUMRS,SF,SNO,ST,TRA,THAW)    2  10
COMMON A(10),ACRES,AWC(4,4),BOL,BVD,C(4,4),CASC(4),COPT(4),CHIN,   2  20
1CM,CONI,CONP,CROPS(2+10),CRPVD(10),CVOL(4,4),D1(4),DAILY,DAMO(12), 2  30
2DELF,DELET,DELFL(4),DELP(300),DELQ(4),DELQ7(4),DELT(300),DELT,DET, 2  40
3DPE(4),DQO(4),E,EL(4,2),EP+ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4), 2  50
4GAZ(10),GI(10),GIG(10,52),IBEG,IHD,IOVER,IPRIN,IREAD,IROTA 2  60
COMMON ITAPE,ITIL,IYDAY,IYR,IYRI,JUL(50),KCUL(10,10),KOATE(10,10), 2  70
1KNO(10),KONT,M(4),MDY(5),MHP(5),MIN(5),MIST,MO(5),MSTOR,MYR(5), 2  80
2NCHEK+NE,NKROP,NST,NUML,NUMZ,NWEEK,OLDG1(4),OVA(4),OVL(4), 2  90
3PAGE,PAN(52),PCAS(4),PCKROP(4,10),PCZON(5),PEAK,PRECIP,Q1(4,4), 2 100
4QLI(4,4),GMAX(4,5),Q01(4),GOPK(4),QZ(4),R1,RDELT,ROOTD(10) 2 110
COMMON RUNON(5),SA1(4,4),SCN(4,4),SDQO(4),SEL(4,2),SETL(4,2),SG1, 2 120
1SGR(4),SL(4),SHAX(4,4),SOILD(4),SQL(4,4),SRUNON(4),SUBPUT(5), 2 130
2SUMET(4),SUMCN(4),TEMP(52),TIM(5),TIME,TL(10),TOPD(4),TP,TU(10), 2 140
3VD(4),VDMAX(4),VEG(4),VOL,ZGI(4),ZONE,WPP1(4),WPP2(4) 2 150
DIMFNSION DIVS(4),DP(4),DT(4),HMIN(5),HRS(5),ID(3,2),IDUM(4), 2 160
1IS(4),NUMRS(4),NUMDY(2),SF(4),SNO(4) 2 170
INTEGER ZONE 2 180
REAL M,MEL(4),HELK(4,4),MELT 2 190
DATA ISNOW,TDUM/1HS,4 * 2H / 2 200

C THIS PROGRAM PREPARES BREAKPOINT INPUT 2 210
C DATA FOR USE IN THE MODEL BY MELTING 2 220
C INCREMENTS LABELED S FOR SNOW AS FUNCTIONS 2 230
C OF TEMPERATURE, RAIN AND VEGETATION. 2 240
C THEN ASSURING THAT NO TIME INCREMENT 2 250
C DURING RAINFALL OR MELT IS GREATER THAN 2 260
C 0.5 HOURS AND WHEN PRECIP STOPS, TIME 2 270
C INCREMENTS ARE SET TO 0.1,0.3,0.6,1.0,2.0, 2 280
C AND 24.0 THEREAFTER, UNTIL THE NEXT RAIN. 2 290
C DURING PAINFALL, TIME INCREMENTS THAT ARE 2 300
C TOO LARGE ARE DIVIDED INTO EQUAL TIME 2 310
C INCREMENTS LESS THAN 0.5 HOURS. 2400 2 320
C READINGS ARE INSERTED IF THEY DO NOT 2 330
C APPEAR IN THE DATA. FOR THE PURPOSE OF 2 340
C DISCUSSION A RECORD CONSISTS OF 4 RAIN OR 2 350
C SNOW OBSERVATIONS THAT ARE BREAKPOINT 2 360
C TIME AND DELTA PRECIP AMOUNTS WITH THEIR 2 370
C CORRESPONDING DATES. 2 380
TSAV=0.0 2 390
PSAV=0. 2 400
IDJ=0 2 410
IDJS=0 2 420
C READ A RECORD. 2 430
IF(JCODE.EQ.1) GO TO 181 2 440
1I=2 2 450
READ(ITAPE,1,END=188)(MO(J),MDY(J),MYR(J),MHR(J),MIN(J),DP(J-1), 2 460
1IS(J-1),J=2,5) 2 470
1 FORMAT(10X, 3(3I2,1X,2I2+F4.2+A1+2X)+3I2,1X,2I2+F4.2,A1) 2 480
IF(MO(2)-99)100,188,100 2 490
188 IF(LAST)189,187,189 2 500
C STOP THE RUN IF A TRAILER (9+S) CARD OR AN 2 510
C END OF FILE ON PRECIP DATA HAS BEEN READ. 2 520
189 STOP 2 530
187 LAST=1 2 540
181 JCODE=2 2 550
RETURN 2 560
100 LAST=0 2 570
IF(TREG)115,110,115 2 580
110 MO()=MO(?) 2 590
MYR()=MYR(?) 2 600
MDY()=MDY(?) 2 610
IF(MHR(2))140,120,140 2 620
120 IF(MIN(2))140,130,140 2 630
130 MIN(2)=0 2 640
140 MIST=MO(1) 2 650
IYR=MYR(1) 2 660
115 IF(IYR).EQ.MYR(II-1) GO TO 190 2 670
CALL LANUSF 2 680
IYR)=IYR 2 690
MHR(II-1)=0 2 700
MIN(II-1)=0 2 710
TTIME=0. 2 720

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DTIME=0.
IF(MYR(II-1)-4*(MYR(II-1)/4),EQ.0) GO TO 118
INDYR=365
GO TO 119
118 INDYR=366
119 DO 150 K=1,2
  ID(1,K)=MDY(II-1)
  ID(2,K)=MO(II-1)
  ID(3,K)=MYR(II-1)
  CALL DAYS (ID,NDAYS,NUMDY,IPRIN)
  IYDAY=NUMDY(1)
  NW=IYDAY/7.+.99
  JULIAN=IYDAY
  TEST=IYDAY+1000*MYR(II-1)
  IF(TEST-JUL(1))190,160,190
C               IF FIRST DATE TO BE CALCULATED IS ALSO
C               REQUESTED FOR DETAILED ROUTING PRINTOUT.
C               INITIALIZE VALUES.
160 MSTOR=1
  TRA=0.
  JS=JS+1
  WRITE(IHYD,?)MYR(II-1),IYDAY
  ? FORMAT('0 STORM HYDROGRAPH FOR YEAR 19*,I2,', DAY ',I3 ')
  WRITE(IHYD,3)
  3 FORMAT(' TIME RAIN VOL   RUNOFF VOL (INCHES)      RUNOFF RATES(AVG
  1 IN/HR)    AVG CFS//' (INCHES)     CHAN   SUB   TOT      C
  2 PHAN      SUB      TOT      TOT//')
  WRITE(IOVER,4)MYR(II-1),IYDAY,(IDUM(ZONE),ZONE,ZONE,ZONE=1,
  1NUMZ)
  4 FORMAT('OVERLAND FLOW HYDROGRAPH FOR YEAR 19*,I2,', DAY ',I3,//'
  1TIME      RAINT//4(A2,' 00 Z//T//' 01 Z//I1,' SF Z//I1))
  ST=0.
  DO 165 ZONF=1,NUMZ
  165 SF(ZONE)=0.
C               INITIALIZE VALUES OF DIVS,NO,NB,AND NE.
  190 DO 200 J=1,4
  200 DIVS(J)=1.0
    NO=5
    NR=1
    NE=0
C               CHECK TO SEE IF RECORD HAS FOUR OBSFRVA-
C               TIONS AND ADJUST (NO) IF NECESSARY.
    DO 240 J=IT,5
    IF(MO(J)240,220,240
  220 NO=J-1
    IF(NO-1)250,230,250
  230 RETURN
  240 CONTINUE
C               FLOAT VALUES OF TIME OBSERVATIONS AND
C               CHANGE MINUTES TO HOURS.
  250 ITI=II-1
    DO 260 L=ITI+NO
    HRS(L)=MHR(L)
    HMIN(L)=MIN(L)
  260 HMIN(L)=HMIN(L)/60.
C               BEGIN RIG LOOP WHICH CALCULATES ADJUSTED
C               INCREMENTS OF TIME.
    DO 650 J=II,NO
    TIM(1)=.1
    TIM(2)=0.3
    TIM(3)=.6
    TIM(4)=1.0
    TIM(5)=2.0
    KBEG=1
C               CHECK FOR DATE CHANGE.
    IF(MDY(J-1)-MDY(J))290,290
  280 IF(MO(J-1)-MO(J))290,300,290
C               IF THE DATE IS DIFFERENT, SET UP ARRAY
C               FOR DAYS SUBROUTINE.
  290 ID(1,1)=MDY(J-1)
    ID(2,1)=MO(J-1)
    ID(3,1)=MYR(J-1)
C               2 730
C               2 740
C               2 750
C               2 760
C               2 770
C               2 780
C               2 790
C               2 800
C               2 810
C               2 820
C               2 830
C               2 840
C               2 850
C               2 860
C               2 870
C               2 880
C               2 890
C               2 900
C               2 910
C               2 920
C               2 930
C               2 940
C               2 950
C               2 960
C               2 970
C               2 980
C               2 990
C               2 1000
C               2 1010
C               2 1020
C               2 1030
C               2 1040
C               2 1050
C               2 1060
C               2 1070
C               2 1080
C               2 1090
C               2 1100
C               2 1110
C               2 1120
C               2 1130
C               2 1140
C               2 1150
C               2 1160
C               2 1170
C               2 1180
C               2 1190
C               2 1200
C               2 1210
C               2 1220
C               2 1230
C               2 1240
C               2 1250
C               2 1260
C               2 1270
C               2 1280
C               2 1290
C               2 1300
C               2 1310
C               2 1320
C               2 1330
C               2 1340
C               2 1350
C               2 1360
C               2 1370
C               2 1380
C               2 1390
C               2 1400
C               2 1410
C               2 1420
C               2 1430
C               2 1440

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C      ID(1,2)=MDY(J)
C      ID(2,2)=MD(J)
C      ID(3,2)=MYR(J)
C
C      CALCULATE THE DAYS BETWEEN THE TWO DATES.
C      CALL DAYS (ID+NDAYS,NUMDY,IPRIN)
C      GO TO 310
C
C      IF DATE IS SAME, DAYS BETWEEN EQUAL ZERO.
C
C      300 NDAYS=0
C      310 XDAYS=NDAYS
C
C      CALCULATE TIME IN HOURS BETWEEN TWO
C      OBSERVATIONS.
C
C      DT(J-1)=HRS(J)+HMIN(J)-HRS(J-1)-HMIN(J-1)+XDAYS*24.0
C      320 IF(TTIME-23.999)340+330+330
C      330 TTIME=0.
C      340 DTIME=TTIME
C      IF(TTIME+DT(J-1)-24.)360+330+350
C      350 TSAV=DT(J-1)
C      PSAV=DP(J-1)
C      DT(J-1)=24.-TTIME
C
C      WHEN PRECIP IS LESS THAN .25 INCHES, THE
C      ENTIRE QUANTITY IS USED IN FIRST DELTA.
C
C      IF(DP(J-1).LT.0.25) GO TO 355
C      DP(J-1)=DP(J-1)*DT(J-1)/TSAV
C      355 TSAV=TSAV-DT(J-1)
C      PSAV=PSAV-DP(J-1)
C      GO TO 370
C      360 TTIME=HRS(J)+HMIN(J)
C
C      IDENTIFIED SNOW IS STORED, THEN MELTED ON
C      EACH ZONE AS A FUNCTION OF TEMPERATURE,
C      VEGETATIVE DENSITY, AND PRECIP FALLING
C      AS RAIN AND ADDED BACK TO PRECIP AS
C      WATERSHED AVERAGE.
C
C      370 IF(IS(J-1).NE.ISNOW) GO TO 372
C      DO 371 ZONE=1,NUMZ
C      371 SNO(ZONE)=SNO(ZONE)+DP(J-1)
C      DP(J-1)=0.
C      372 MELT=0.
C      DO 375 ZONE=1,NUMZ
C      IF(TEMP(NW).LE.THAW) GO TO 379
C      MFL(ZONE)=0.
C      IF(SNO(ZONE).LE.0.) GO TO 379
C      MFL(ZONE)=(TEMP(NW)-THAW)*(1.-.5*VEG(ZONE))*15*DT(J-1)/24.
C      1+2.*DP(J-1)
C      IF(MFL(ZONE).GE.SNO(ZONE)) GO TO 374
C      SNO(ZONE)=SNO(ZONE)-MFL(ZONE)
C      MEL(ZONE)=MEL(ZONE)+DP(J-1)
C      GO TO 375
C      374 MEL(ZONE)=SNO(ZONE)+DP(J-1)
C      SNO(ZONE)=0.
C      375 MELT=MELT+MFL(ZONE)*PCZON(ZONE)
C      DP(J-1)=MELT
C      IF(MELT.LE.0.) GO TO 379
C      DO 376 ZONE=1,NUMZ
C
C      MFLK IS THE WEIGHTING FACTOR TO
C      DISTRIBUTE SNOWMELT ON THE ZONE.
C
C      376 MFLK(ZONE,J-1)=MEL(ZONE)/MELT
C
C      DAILY MELT IS ASSUMED TO OCCUR IN 4 HOURS.
C
C      IF(DT(J-1).LE.4.) GO TO 377
C      SDJ=DT(J-1)-4.0
C      DT(J-1)=4.0
C      IJS=1
C      GO TO 377
C
C      379 DO 373 ZONE=1,NUMZ
C      373 MFLK(ZONE,J-1)=1.
C
C      CHECK FOR DELTA PRECIP EQUAL ZERO.
C
C      377 IF(DP(J-1)>380.480+390
C      380 WRITE(IPRIN,5)
C      5 FORMAT(' ERROR DELTA PRECIP NEGATIVE VALUE SET TO ZERO')
C      GO TO 480
C
C      390 TEST=DP(J-1)/DT(J-1)-.0399
C      IF(TEST<400.410+410
C
C      400 ADJ=DT(J-1)-DP(J-1)/.04

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DT(J-1)=DP(J-1)/.04
IDJ=1
410 IF(DT(J-1)-DELTf)450,450,420
C                                     CHECK FOR DELTA TIME GREATER THAN DELTf
C                                     (USUALLY 0.5 HOURS).  IF IT IS
C                                     GREATER, INCREMENT DIVS. OTHER-
C                                     WISE ACCEPT THE VALUE.
420 TEST=DT(J-1)/DELTf
ITEST=TEST
TEST=TEST-ITEST
IF(TEST)430,430,440
430 DIVS(J-1)=ITEST
GO TO 450
440 DIVS(J-1)=ITEST+1
450 IDV=DIVS(J-1)
C                                     ADD THE NUMBER OF DIVISIONS FOR THE OB-
C                                     SERVATION TO THE CURRENT TOTAL FOR THE
C                                     RECORD.
NE=NE+IDV
C                                     INSERT THE ADJUSTED INCREMENTS FOR
C                                     THE OBSERVATION INTO THE ARRAY FOR THE
C                                     RECORD, WHICH WILL BE USED IN THE MAIN
C                                     PROGRAM.
DO 460 K=NR,NE
DELP(K)=DP(J-1)/DIVS(J-1)
DELT(K)=DT(J-1)/DIVS(J-1)
C                                     DETERMINE WEEK FOR MELT COMPUTATIONS.
C                                     WHEN 12/31 IS ENCOUNTERED SAVE REMAINING
C                                     RECORDS ON CARD AND RETURN TO MAIN TO
C                                     TO COMPLETE YEAR'S COMPUTATIONS.
460 DTIME=DTIME+DELT(K)
LCODE=1
660 IF(DTIME.LT.23.999) GO TO (465,560,560,575)+LCODE
DTIME=0.
IF(LST.GT.0) GO TO 730
JULTAN=JULTAN+1
NW=JULIAN/7.+.99
IF(NW.LE.52) GO TO (465,560,560,575)+LCODE
NW=52
IF(JULIAN-INDYR) 720,710,730
710 LST=1
720 GO TO (465,560,560,575)+LCODE
730 IF(J.EQ.ND) GO TO 760
IF(MYR(J+1).GT.MYR(J)) GO TO 742
II=J
GO TO 745
742 II=J+1
745 DP(II-1)=PSAV
750 JCONE=1
MYR(II-1)=MYR(1)+1
MO(II-1)=1
MDY(II-1)=1
LST=0
NUMRS(J-1)=NF+1
RTURN
C                                     SET UP SUBSCRIPT OF THE FIRST INCREMENT
C                                     OF THE NEXT OBSERVATION TO BE ENTERED
C                                     IN THE ADJUSTED ARRAY AND CONTINUE THE
C                                     BIG LOOP.
465 NB=NE+1
IF(INOJ)575,575,470
470 DP(J-1)=0.
DT(J-1)=ADJ
INJ=0
C                                     BEGINNING OF THE CALCULATION OF STANDARD
C                                     DELTA TIMES WHEN DELTA PRECIP EQUAL ZERO.
480 NE=NB
TIMF1=0.
490 DO 510 K=KAFG,S
KSAV=K
DELP(NE)=0.
TIME2=TIME1+TIM(K)

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      IF(DT(J-1)-TIMEF2=0.00001)570,570,500          2 2890
500 DFLT(NE)=TJM(K)                                2 2900
      TIMEF1=TIMEF2                                  2 2910
      DTIME=DTIMEF+DELT(NE)                          2 2920
      NE=NE+1                                         2 2930
510 CONTINUEF                                     2 2940
      KSAV=6                                         2 2950
520 DELP(NE)=0.                                     2 2960
      TIME2=TIME1+74.                               2 2970
      IF(DT(J-1)-TIMEF2)570,570,530                2 2980
530 TEST=24.-TTMF1                                 2 2990
      IF(TEST)550,550,540                           2 3000
540 DELT(NE)=TEST                                 2 3010
      TTMF1=24.                                     2 3020
      DTIME=DTIMEF+DELT(NE)                         2 3030
      LCODE=2                                       2 3040
      GO TO 660                                     2 3050
550 DELT(NE)=?4.                                   2 3060
      TTMF1=TIME?                                    2 3070
      DTIME=DTIMEF+DELT(NE)                         2 3080
      LCODE=3                                       2 3090
      GO TO 660                                     2 3100
560 NF=NE+1                                       2 3110
      GO TO 520                                     2 3120
570 DELT(NE)=DT(J-1)-TIME1                        2 3130
      NR=NE+1                                       2 3140
      DTIME=DTIMEF+DELT(NE)                         2 3150
      LCODE=4                                       2 3160
      GO TO 660                                     2 3170
575 IF(IDJS.LE.0) GO TO 580                      2 3180
      DP(J-1)=0.                                    2 3190
      DT(J-1)=SADJ                                2 3200
      IDJS=0                                       2 3210
      GO TO 480                                     2 3220
580 IF(TSAV=0.0001)650,650,590                  2 3230
590 DT(J-1)=TSAV                                 2 3240
      TSAV=0.                                       2 3250
      DP(J-1)=PSAV                                2 3260
      IF(DP(J-1))630,600,630                      2 3270
600 TTIMF=HRS(J)+HMIN(J)                         2 3280
      TIMF1=0.                                      2 3290
      NF=NB                                         2 3300
      IF(KSAV=5)610,610,520                        2 3310
610 TIM(KSAV)=TIM(KSAV)-DELT(NE-1)              2 3320
      IF(TIM(KSAV))620,620,640                  2 3330
620 KBEG=KSAV+1                                 2 3340
      IF(KREG=5)490,490,520                        2 3350
630 TTJME=0.                                     2 3360
      KAFG=1                                       2 3370
      GO TO 320                                     2 3380
640 KBEG=KSAV                                 2 3390
      GO TO 490                                     2 3400
650 NUMBS(J-1)=NE+1                            2 3410
C                                         SAVE THE LAST RECORD ON A CARD. 2 3420
      MYR(II-1)=MYR(NO)                           2 3430
      MO(II-1)=MO(NO)                            2 3440
      MDY(II-1)=MDY(NO)                           2 3450
      MHR(II-1)=MHR(NO)                           2 3460
      MTN(II-1)=MTN(NO)                           2 3470
      RETURN                                         2 3480
      END                                           2 3490

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C      SUBROUTINE DAYS (OBTAINED FROM DSA)          3   10
C      STEVEN SCHLESINGER    JDR 1433             3   20
C      THIS SUBROUTINE CALCULATES THE NUMBER OF DAYS 3   30
C      FROM ONE DATE TO A SECOND DATE FOR ANY        3   40
C      TWO DATES FROM JANUARY 1, 1900 TO DECEMBER 31, 1999 3   50
C      SUBROUTINE AS FOLLOWS -                      3   60
C      ID(1,1) = THE DAY IN THE MONTH OF THE BEGINNING DATE 3   70
C      ID(1,2) = THE DAY IN THE MONTH OF THE ENDING DATE 3   80
C      ID(2,1) = THE MONTH OF THE BEGINNING DATE       3   90
C      ID(2,2) = THE MONTH OF THE ENDING DATE         3  100
C      ID(3,1) = LAST TWO DIGITS OF THE YEAR OF THE BEGINNING DATE 3  110
C      ID(3,2) = LAST TWO DIGITS OF THE YEAR OF THE ENDING DATE 3  120
C      IF THERE IS AN ERROR IN EITHER OF THE DATES, NDAYS IS SET EQUAL 3  130
C      TO ZERO AND THE SUBROUTINE RETURNS TO THE MAINLINE PROGRAM 3  140
C      THE TWO DATES MUST BE ENTERED AS A 3 BY 2 ARRAY INTO THE 3  150
C      SUBROUTINE DAYS (ID,NDAYS,NUMDY,IPRIN)           3  160
C      DIMENSION IA(12),ID(3,2),NUMDC(2),NUMDY(2)        3  170
C      DO 250 J=1,2                                     3  180
C      IN = ID(2,J)                                    3  190
C      IF (IN) 110,110,100                            3  200
100 IF (IN-12) 120,120,110                         3  210
110 WRITE(IPRIN,1)                                 3  220
1   FORMAT (1H0MONTH NUMBER ZERO OR GREATER THAN TWELVE) 3  230
GO TO 270                                         3  240
120 IF (ID(1,J)) 180,180,130                     3  250
130 GO TO (140,160,140,150,140,150,140,140,150,140,150,140) . IN 3  260
140 IF (ID(1,J)-31) 190,190,180                  3  270
150 IF (ID(1,J)-30) 190,190,180                  3  280
160 IF (ID(1,J)-29) 190,170,180                  3  290
170 IF (ID(3,J)-4*(ID(3,J)/4)) 180,190,180      3  300
180 WRITE(IPRIN,2)                                 3  310
2   FORMAT (45H0DAY NUMBER TOO LARGE FOR GIVEN MONTH OR ZERO) 3  320
GO TO 270                                         3  330
190 IA(01) = 000                                   3  340
IA(02) = 031                                   3  350
IA(03) = 059                                   3  360
IA(04) = 090                                   3  370
IA(05) = 120                                   3  380
IA(06) = 151                                   3  390
IA(07) = 181                                   3  400
IA(08) = 212                                   3  410
IA(09) = 243                                   3  420
IA(10) = 273                                   3  430
IA(11) = 304                                   3  440
IA(12) = 334                                   3  450
NUMDY(J) = IA(IN) + ID(1,J)                      3  460
IF (ID(3,J)) 200,230,200                         3  470
200 IF (ID(3,J)-4*(ID(3,J)/4)) 240,210,240      3  480
210 IF (ID(2,J)-2) 240,240,220                  3  490
220 NUMDY(J)=NUMDY(J)+1                          3  500
GO TO 240                                         3  510
230 NUMDC(J) = NUMDY(J)                          3  520
GO TO 250                                         3  530
240 NUMDC(J)=NUMDY(J)+365*ID(3,J)+(ID(3,J)-1)/4 3  540
250 CONTINUE                                       3  550
NDAYS = NUMDC(2) - NUMDC(1)                      3  560
IF (NDAYS) 260,280,280                         3  570
260 WRITE(IPRIN,3)                                3  580
3   FORMAT (51H0NEGATIVE NUMBER OF DAYS - SECOND DATE BEFORE FIRST) 3  590
270 NDAYS = 0                                      3  600
280 RETURN                                         3  610
END                                              3  620

```

```

SUBROUTINE FTCALC
C THIS SUBPROGRAM CALCULATES EVAPOTRANSPI- 4 10
C RATION USING THE EQUA- 4 20
C TION ET=GI*K*EP FOR POTENTIAL ZONE ET. 4 30
C THEN THE POTENTIAL IS USED TO CALCULATE 4 40
C ACTUAL ET AS AN EXPONENTIAL FUNCTION OF 4 50
C SOIL MOISTURE. 4 60
C 4 70
COMMON A(10),ACRES,ANC(4,4),BOL,BVD,C(4+4),CASC(4),CDPT(4),CHIN, 4 80
1CM,CON1,CON2,CROPS(2+10),CRPVD(10),CVOL(4+4),D(1)(4),DAILY,DAMO(12)+ 4 90
2DFLE,DELET,DELF(4),DELP(300),DELO(4),DELOZ(4),DELT(300),DELT,DET, 4 100
3DPE(4),DDO(4),E,EL(4,2),FP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4+4)+ 4 110
4GAZ(10),GI(10),GIG(10+52),IBEG,IDLAY,IHYD,IOVER,IPRIN,IREAD,IROTA 4 120
COMMON ITAPE,ITIL,IYDAY,IYR,IYR1,JUL(10),KCUL(10,10),KDATE(10+10)+ 4 130
1KNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),MIST,MO(5),MSTOR,MYR(5)+ 4 140
2NCHEK,NE,NKROP,NST,NUML,NUMZ,NWEEK,OLDG(4),OVA(4),OVL(4), 4 150
3PAGF,PAN(52),PCAS(4),PCKROP(4+10),PCZON(5),PEAK,PRECIP,QI(4+4), 4 160
4QL1(4,4),QMAX(4,5),QOI(4),QOPK(4),QZ(4)+R1,RDELT,ROOTD(10) 4 170
COMMON RUNDN(5),SAI(4,4)+SCN(4,4),SDQD(4),SFL(4,2)+SETL(4,2),SG1, 4 180
1SGR(4),SL(4),SMAX(4,4),SOILD(4),SQL(4,4)+SRUNDN(4)+SUBPUT(5), 4 190
2SUMFT(4),SUMCN(4),TEMP(52),TIM(5),TIME,TL(10),TOPD(4)+TP,TU(10), 4 200
3V(4),VDMAX(4),VEG(4)+VOL,ZGI(4)+ZONE+WPP1(4)+WPP2(4) 4 210
DIMENSION ETLIM(10)+FREE(2),XXX(2) 4 220
INTEGER ZONEF 4 230
REAL M 4 240
C FT IS OPTIMUM AT FIELD CAPACITY. DIMI- 4 250
C NISHING WITH MOISTURE CONTENT BELOW FIELD 4 260
C CAPACITY AND DIMINISHING WITH AIR AS 4 270
C EXCLUDED BY FREE WATER ABOVE FIELD 4 280
C CAPACITY. 4 290
ROT=1. 4 300
DET=0. 4 310
DDET=0. 4 320
ETL(ZONE+1)=0.0 4 330
ETL(ZONF,2)=0.0 4 340
PROT=1.0 4 350
C CALCULATE THE MAXIMUM VOLUME OF STORAGE 4 360
C PENETRATED BY PLANT ROOTS FOR EACH CROP. 4 370
C ZLIM=0. 4 380
DO 170 KROP=1,NKROP 4 390
IF(PCKROP(ZONE,KROP))130,130,105 4 400
105 IF(ROOTD(KROP)-SOILD(ZONE))120+110+110 4 410
110 ETLIM(KROP1=SMAX(ZONE+2)) 4 420
GO TO 150 4 430
120 IF(ROOTD(KROP)-TOPD(ZONE))130,130+140 4 440
130 ETLIM(KROP1=0) 4 450
GO TO 170 4 460
140 ROT=(ROOTD(KROP)-TOPD(ZONE))/(SOILD(ZONE)-TOPD(ZONE)) 4 470
ETLIM(KROP)= ANC(ZONE+2)* ROT +G(ZONE+2) 4 480
150 IF(ZLIM-ETLIM(KROP))160+170+170 4 490
160 ZLIM=ETLIM(KROP) 4 500
PROT=ROT 4 510
170 CONTINUE 4 520
DO 220 LAYER=1,2 4 530
L=LAYER 4 540
IF(LAYER-1)115,115,116 4 550
115 TFST=SMAX(ZONE,1)-SAI(ZONE+1) 4 560
GO TO 117 4 570
116 TEST=ZLIM-SAI(ZONE+2) 4 580
117 IF(TEST)220,220+230 4 590
220 CONTINUE 4 600
GO TO 400 4 610
C CALCULATE DELT ET FOR EACH CROP. 4 620
230 DO 270 KROP=1,NKROP 4 630
IF(L-2)260,250+250 4 640
C CHECK TO SEE IF CROP'S FT LIMIT HAS BEEN 4 650
C EXCEEDED. 4 660
250 TEST=SAI(ZONE+2)- ETLIM(KROP) 4 670
IF(TEST)260,270+270 4 680
260 ET=GI(KROP)*EP=PCKROP(ZONE,KROP)*ETEP(KROP)*TIME/24. 4 690
C CALCULATE POTENTIAL DELTA ET FOR THE ZONE. 4 700
DET=DET+ET 4 710
270 CONTINUE 4 720

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C           ADJUST THE STORAGE AVAILABLE IN THE      4 730
C           HORIZON BY THE ACTUAL ET FOR THE ZONE.   4 740
C
IF (DET)>280,400,290                                4 750
280 WPRINT(IPRIN,1)7ZONE,DET                      4 760
 1 FORMAT('IERROR IN ETCALC -- DELTA ET FOR CROPS IN ZONE*,I2,* IS NE 4 770
 1GATIVE (*,FR.2,*.*)
  STOP                                                 4 780
290 LAYER=L
  FREE(1)=G(ZONE,1)-SA1(ZONE,1)                   4 810
  FREE(2)=G(ZONE+2)*PROT-SA1(ZONE,2)             4 820
  DO 600 K=1,2                                     4 830
  IF(FREE(K))601,293,293                         4 840
601 FREE(K)=0.0                                    4 850
293 XXX(K)=AWC(ZONF,K)/G(ZONF,K)                 4 860
600 CONTINUE
  IF(LAYER-1)297,297,298                         4 870
298 ALEFT=DET
  GO TO 340                                       4 880
297 IF(FREE(1))591,591,592                         4 890
592 X=1.-(FREE(1)/G(ZONE,1))*XXX(1)              4 900
  GO TO 593                                       4 910
591 X=(1.-(SA1(ZONE,1)-G(ZONE,1))/AWC(ZONF,1))*XXX(1) 4 920
593 TEST=SA1(ZONE+1)+DET*X-SMAX(ZONE,1)          4 930
  IF (TEST)310,310,300                            4 940
300 DDET=SMAX(ZONE+1)-SA1(ZONE+1)
  SA1(ZONF,LAYER)=SMAX(ZONE,LAYER)               4 950
  GO TO 320                                       4 960
310 SA1(ZONE,LAYER)=SA1(ZONE,LAYER)+DET*X
  DDET=DET*X                                      4 970
320 ALEFT=DFT-DDET
  ETL(ZONE,LAYER)=DDET                           4 980
340 IF(FREE(2))342,342,341                         4 990
341 X=(1.-(FREE(2)/(G(ZONE+2)*PROT)))*XXX(2)
  ALEFT=ALEFT*X
  GO TO 380                                       4 1000
342 TEST=ZLIM-SA1(ZONE+2)                         4 1010
  IF (TEST)350,350,360                            4 1020
350 DET=DDET
  GO TO 390                                       4 1030
360 ALEFT=ALEFT*(1.-(SA1(ZONF,2)-G(ZONE+2))/(ZLIM-G(ZONE+2)))*XXX(2)
  X=SA1(ZONF,2)+ALEFT-ZLIM
  IF (Y)380,380,370                            4 1040
370 DET=DDET+ZLIM-SA1(ZONE+2)
  ETL(ZONE,P)=ZLIM-SA1(ZONF,2)
  SA1(ZONE+2)=ZLIM
  GO TO 390                                       4 1050
380 DET=DDET+ALEFT
  ETL(ZONE,P)=ALEFT
  SA1(ZONE+2)=SA1(ZONF,2)+ALEFT
390 SUMET(ZONE)=SUMET(ZONE)+DET
400 RETURN
END

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SUBROUTINE EVAP (CRAK,RHD)      5 10
COMMON A(10),ACRES,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN, 5 20
1CM,CON1,CON2,CPOPS(2+10),CRPWD(10),CVOL(4,4),D1(4),DAILY,DAMO(12), 5 30
2DELE,DELET,DELF(4),DELP(300),DELQ(4),DELQZ(4),DELT(300),DELT,DET, 5 40
3DPE(4),DQQ(4),E,EL(4,2),EP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4), 5 50
4GAZ(10),GI(10),GIG(10,52),IREG,IDALEY,IHYD,IOVER,IPRIN,IREAD,IROTA 5 60
COMMON ITAPF,ITIL,IYDAY,IYR,IYR1,JUL(10),KCUL(10,10),KDATE(10,10), 5 70
1KNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),MIST,MO(5),MSTOR,MYR(5), 5 80
2NCHEK,NE,NKROP,NST,NUML,NUMZ,NWEEK,OLOGT(4),OVA(4),OVL(4), 5 90
3PAGE,PAN(52),PCAS(4),PCKROP(4+10),PCZON(5),PEAK,PRECIP,Q1(4,4), 5 100
4QL1(4,4),QMAX(4,5),Q01(4),QOPK(4),Q7(4),R1,RDELT,R00TD(10) 5 110
COMMON RUNON(5),SA1(4,4),SCN(4,4),SDQO(4),SEL(4,2),SETL(4,2),SG1, 5 120
1SAR(4),SL(4),SMAX(4,4),SOILD(4),SQL(4,4),SRUNON(4),SUBPUT(5), 5 130
2SUMET(4),SUMCN(4),TEMP(52),TIM(5),TIME TL(10),TOPD(4),TP,TU(10), 5 140
3VD(4),VDMAX(4),VEG(4)+VOL+ZGI(4)+ZONE,WPP1(4)+WPP2(4) 5 150
DIMENSION CRAK(4),TEST(2)
INTEGER ZONE
REAL M
C
      THIS SUBROUTINE CALCULATES EVAPORATION      5 190
      DIRECTLY FROM THE FREE WATER AND ON SOIL.      5 200
      EL(ZONE+1)=0.0      5 210
      EL(ZONE+2)=0.0      5 220
      E=0.0      5 230
      VDEV=(1.-.6*VEG(ZONE))*EP*TIME*RHD      5 240
      IF(VDEV-(VD(ZONE)-CRAK(ZONE))>100)100,100,110
100  E=VDEV      5 260
      VD(ZONE)=VD(ZONE)-E      5 270
      GO TO 210      5 280
110  E=VD(ZONE)-CRAK(ZONE)      5 290
      IF(F)111+111,112      5 300
111  E=0.0      5 310
112  VD(ZONE)=VD(ZONE)-E      5 320
      FREE=0.      5 330
      GT=0.      5 340
      DO 150 L=1,2      5 350
      TEST(L)=G(ZONE,L)-SA1(ZONE,L)      5 360
      IF(TEST(L)>130)150,150,140
130  TEST(L)=0.      5 380
140  FREE=TEST(L)+FREE      5 390
150  GT=GT+G(ZONE,L)      5 400
      IF(FREE>210)210,210,160
160  IF(AWC(ZONE+1)/G(ZONE+1)-.7)161,161,162      5 420
161  XXX=1.0      5 430
      GO TO 163      5 440
162  XXX=2.0      5 450
163  EPOT=(FREE/GT)*XXX*(EP*TIME*RHD-F)
      DO 200 L=1,2      5 460
      IF(TEST(L)>200)200,200,170
170  IF(TEST(L)-FPOT)>190,180,180      5 490
180  SA1(ZONE,L)=SA1(ZONE,L)+FPOT      5 500
      E=E+EPOT      5 510
      EL(ZONE,L)=FPOT      5 520
      GO TO 210      5 530
190  E=E+TEST(L)      5 540
      SA1(ZONE,L)=G(ZONE,L)      5 550
      EPOT=EPOT-TEST(L)      5 560
      EL(ZONE,L)=TEST(L)      5 570
200  CONTINUE      5 580
210  RETURN      5 590
END      5 600

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SUBROUTINE INFIL (CPAK,MZ,TPREC)
COMMON A(10),ACRES,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN,
1CM,CON1,CON2,CPOPS(2,10),CRPWD(10),CVOL(4,4),D1(4),DAILY,DAMO(12),
2DELE,DELET,DELF(4),DELP(300),DELQ(4),DELQZ(4),DELT(300),DELTf,DET,
3DPE(4),DQO(4),E,EL(4,2),FP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4),
4GAZ(10),GI(10),GIG(10,52),IBEG,IDLH,IHYD,IOVER,IPRIN,IREAD,IROTA
COMMON ITAPE,ITIL,IYDAY,IYR,IYR1,JUL(50),KCUL(10,10),KDATE(10,10),
1KNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),M1ST,MO(5),MSTOR,MYR(5),
2NCHEK,NE,NKROP,NST,NUML,NUMZ,NWEEK,OLDGI(4),OVA(4),OVL(4),
3PAGE,PAN(5?),PCAS(4),PCKROP(4,10),PCZON(5),PEAK,PRECIP,V1(4,4),
4QL1(4,4),QMAX(4,5),Q01(4),QOPK(4),QZ(4),R1,RDELT,ROOTD(10)
COMMON RUNON(5),SA1(4,4),SCN(4,4),SDQO(4),SEL(4,2),SETL(4,2),SG1,
1SGR(4),SL(4),SMAX(4,4),SOILD(4),SQL(4,4),SRUNON(4),SUBPUT(5),
2SUMET(4),SUMCN(4),TEMP(52),TIM(5),TIME,TL(10),TOPD(4),TP,TU(10),
3VD(4),VDMAX(4),VEG(4),VOL,ZGI(4),ZONE,WPP1(4),WPP2(4)
DIMENSION CRAK(4),MZ(4,4),SA2(4)
INTEGER ZONE
REAL M,MZ
CRAK(ZONE)=0.0

C THIS SURROUTINE CALCULATES THE VOLUME
C OF INFILTRATION INTO A ZONE AND THE
C AMOUNT OF PRECIPITATION EXCESS ON THE
C SURFACE OF A ZONE FOR EACH INCREMENT OF
C PAINFALL IN THE ADJUSTED INPUT ARRAY.
C THE ROUTINE USES HOLTAN'S INFILTRATION
C CONCEPT. INITIALLY ESTIMATE DELTA INFIL-
C TRATION AS THE TOTAL WATER AVAILABLE TO
C INFILTRATE. I.E., DEPRESSION STORAGE.
C DELTA PRECIP., RUNON FROM ZONE UPSLOPE,
C AND DEPTH OF EXISTING OVERLAND FLOW.
C DELF(ZONE)=VD(ZONE)+TPREC+RUNON(ZONE)+D1(ZONE)
C CALCULATE WEIGHTED GROWTH INDEX FOR
C THE ZONE.
C IF(NWEEK-NCHEK) 10,20,10
10 NCHEK=NWEEK
DO 100 IZ=1,NUMZ
ZGI(IZ)=0.
DO 100 KROP=1,NKROP
100 ZGI(IZ)=ZGT(IZ)+GI(KROP)*PCKROP(ZONE,KROP)
20 GUES= TIME*(ZGI(ZONE)*VEG(ZONE)*SA1(ZONE+1)*1.4 +FC(ZONE))
TEST=GUES-DELF(ZONE)
IF(TEST)110,110,120
110 DELF(ZONE)=GUES

C CALCULATE THE AVAILABLE POROSITY TO
C RECEIVE THE ESTIMATED INFILTRATION AMOUNT
C AND CHECK FOR SATURATION.
120 SA2(1)=SA1(ZONE+1)-DELF(ZONF)
IF(SA2(1))170,170,130
C IF THE POROSITY IS > ZERO, COMPUTE RATE
C OF INFILTRATION AT THE END OF DELTA TIME.
130 F2=ZGI(ZONE)*VEG(ZONE)*SA2(1)*1.4+FC(ZONE)
C CALCULATE THE AVERAGE RATE AND COMPARE
C THE ESTIMATED AVERAGE WITH THE CALCULATED.
C 140 FAV=(FIL(ZONE)+F2)*.5
IF(DELF(ZONE)/TIME-FAV)200,200,150
C IF THE ESTIMATED AVERAGE IS THE LARGER,
C REDUCE THE ESTIMATED INFILTRATION AND
C CALCULATE THE ASSOCIATED POROSITY.
150 DELF(ZONE)=DELF(ZONE)-.005
IF(DELF(ZONF))160,120,120
160 DELF(ZONE)=0.0
GO TO 120

C IN CASES WHERE THE POROSITY BECOMES
C NEGATIVE AFTER THE ESTIMATED INFILTRA-
C TION IS SUBTRACTED, SET DELF EQUAL TO THE
C STORAGE LEFT AND SET THE RATE AT THE END
C OF DELTA TIME EQUAL TO THE MAXIMUM RATE
C OF OUTFLOW FROM THE LAYER.
170 DELF(ZONE)=SA1(ZONF,1)
SA2(1)=0.0
IF(MZ(ZONE,1))190,180,190

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180 F2=C(ZONE+1)          6 730
  GO TO 140               6 740
190 F2=C(ZONE+1)+G(ZONE,1)/M2(ZONE+1) 6 750
  GO TO 140               6 760
C                               ONCE DELTA INFILTRATION IS ESTABLISHED. 6 770
C                               CALCULATE THE EXCESS WATER THAT DID NOT 6 780
C                               INFILTRATE AND APPORTION IT TO SURFACE 6 790
C                               DETENTION OR INPUT FOR OVERLAND FLOW. 6 800
200 EX=RUNON(ZONE)+TPRECP-DELF(ZONE) +D1(ZONE) 6 810
  IF(EX)>210.220.230 6 820
C                               IF THE EXCESS IS NEGATIVE, SOME SURFACE 6 830
C                               DETENTION MUST HAVE BEEN TAKEN INTO THE 6 840
C                               SOIL. 6 850
210 DVD=EX          6 860
  VD(ZONE)=VD(ZONE)+DVD 6 870
  DPE(ZONE)=-D1(ZONE) 6 880
  GO TO 300               6 890
C                               IF THE EXCESS IS ZERO, BOTH THE CHANGE 6 900
C                               IN SURFACE DETENTION AND OVERLAND FLOW 6 910
C                               INPUT ARE ZERO. 6 920
220 DVD=0.          6 930
  DPE(ZONE)=-D1(ZONE) 6 940
  GO TO 300               6 950
C                               IF THE EXCESS IS POSITIVE, FILL SURFACE 6 960
C                               DETENTION AND THEN LEFT THE REST SUPPLY 6 970
C                               OVERLAND FLOW. 6 980
C                               THESE STATEMENTS HAVE BEEN INCLUDED TO 6 990
C                               INCORPORATE CRACKING SOILS IN THE MODEL. 6 1000
230 SAI1(ZONE+1)=SA1(1) 6 1010
  IEPTH=CDPT(ZONE) +.1 6 1020
  IF(IEPTH)>270.270.240 6 1030
240 DO 260 KLAY=1.IEPTH 6 1040
  TEST=SA1(ZONE,KLAY)-G(ZONE,KLAY) 6 1050
  IF(TEST)>260.260.250 6 1060
250 CRAK(ZONE)=CRAK(ZONE)+TEST/AWC(ZONE,KLAY)*CVOL(ZONE,KLAY) 6 1070
260 CONTINUE           6 1080
270 TEST=VD(ZONE)+EX-(VDMAX(ZONE)+CRAK(ZONE)) 6 1090
  IF(TEST)>210.210.290 6 1100
290 DVD=VDMAX(ZONE)+CRAK(ZONE)-VD(ZONE) 6 1110
  VD(ZONE)=VDMAX(ZONE)+CRAK(ZONE) 6 1120
  DPE(ZONE)=EX-DVD -D1(ZONE) 6 1130
300 SAI(ZONE+1)=SA1(1) 6 1140
  FIL(ZONE)=F? 6 1150
  RETURN           6 1160
  END             6 1170

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SUBROUTINE INIT (ACC,RAMO,BEGRI,BEGSA,CRAK,DAYCN,DAYET,EACC,EMO,
  1ETAC,ETMO,ETYR,EYR,ICNT,JCODE,LST,OFFSIT,OFSTM0,ONSTM0,RAIN,RAMO,
  2RP1,RUNMO,SF,SUMRA,SUMO,SUMPE,TACC,TE,TET,TOTCN,TOTET,TRAN,
  3YEARLY,ZBAM,ZCM,ZOFST,ZPFM,ROLT)
  COMMON A(10),ACRES,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN,
  1CM,CON1,CON2,CRDPS(2,10),CPPVD(10),CVOL(4,4),D1(4),DAILY,DAMO(12),
  2DELE,DELET,DELFL(4),DELP(300),DELO(4),DELQZ(4),DELT(300),DELTf,DET,
  3DPE(4),D00(4),E,EL(4,2),EP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4),
  4GAZ(10),GI(10),GIG(10,52),IBEG,IADY,IHYD,IOVER,IPRIN,IREAD,IROTA
  COMMON ITAPF,ITIL,IYDAY,IYR,IYR1,JUL(50),KCUL(10,10),KDATE(10,10),
  1KNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),MIST,MO(5),MSTOR,MYR(5),
  2NCHEK,NE,NKROP,NST,NUML,NUMZ,NWEEK,OLDGI(4),OVA(4),OVL(4),
  3PAGE,PAN(52),PCAS(4),PCKROP(4,10),PCZON(5),PEAK,PRECIP,Q1(4,4),
  4QL1(4,4),GMAX(4,5),Q01(4),QOPK(4),RZ(4),R1,ROELT,RODTD(10)
  COMMON RUNON(5),SA1(4,4),SCN(4,4),SD00(4),SEL(4,2),SETL(4,2),SG1,
  1SGR(4),SL(4),SMAX(4,4),SOILD(4),SQL(4,4),SRUNON(4),SUBPUT(5),
  2SUMFT(4),SUMCN(4),TEMP(52),TIM(5),TIME,TL(10),TOPD(4),TP,TU(10),
  3VD(4),VDMAX(4),VEG(4),VOL,ZGI(4),ZONE,WPP1(4),WPP2(4)
  DIMENSION RAMO(12),CRAK(4),DAYCN(4),DAYET(4),EMO(12),ETMO(12),
  1OFFSIT(4),OFSTM0(12),ONSTM0(12),RAMO(12),RUNMO(12),SF(4),SUMBA(4),
  2SUMO(12),SUMPE(4),TOTCN(4),TOTFT(4),ZBAM(4,12),ZCM(4,12),
  3ZOFST(4,12),ZPFM(4,12)
  INTEGER ZONE
  REAL M
C                               INITIALIZE VALUES.
  IYR1=0
  JCODE=0
  LST=0
  NWEEK=0
  NCHEK=0
  BVD=0.
  BOL=0.
  BEGSA=0.
  DO 110 ZONE=1,NUMZ
    CRAK(ZONE)=0.0
    DAYCN(ZONE)=0.0
    DAYET(ZONE)=0.
    DELF(ZONE)=0.0
    D1(ZONE)=0.0
    FIL(ZONE)=0.0
    OFFSIT(ZONE)=0.0
    OLDGI(ZONE)=0.
    Q01(ZONE)=0.0
    QOPK(ZONE)=0.0
    SD00(ZONE)=0.0
    SF(ZONE)=0.0
    SGR(ZONE)=0.0
    SRUNON(ZONE)=0.0
    SUMRA(ZONE)=0.0
    SUMET(ZONE)=0.0
    SUMCN(ZONE)=0.0
    SUMPE(ZONE)=0.0
    TOTCN(ZONE)=0.
    TOTFT(ZONE)=0.
    VO(ZONE)=0.0
    DO 100 LAYFR=1,2
      SETL(ZONE+LAYFR)=0.0
  100  SFL(ZONE+LAYER)=0.0
    DO 110 LAYFR=1,4
      SQL(ZONE+LAYFR)=0.0
      SCN(ZONE+LAYFR)=0.0
  110  BEGSA=BEGSA+SA1(ZONE+LAYFR)*PCZON(ZONE)
      PCZON(NUMZ+1)=1.0
      RAIN=0.
      IYDAY=0
      RP1=R1
      BEGPI=R1
      PAGE=28.
      VOL=0.0
      ACC=0.0
      ETAC=0.0
      TACC=0.0
      7   10
      7   20
      7   30
      7   40
      7   50
      7   60
      7   70
      7   80
      7   90
      7  100
      7  110
      7  120
      7  130
      7  140
      7  150
      7  160
      7  170
      7  180
      7  190
      7  200
      7  210
      7  220
      7  230
      7  240
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      7  270
      7  280
      7  290
      7  300
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      7  320
      7  330
      7  340
      7  350
      7  360
      7  370
      7  380
      7  390
      7  400
      7  410
      7  420
      7  430
      7  440
      7  450
      7  460
      7  470
      7  480
      7  490
      7  500
      7  510
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      7  600
      7  610
      7  620
      7  630
      7  640
      7  650
      7  660
      7  670
      7  680
      7  690
      7  700
      7  710
      7  720
  
```

EACC=0.0	7	730
ICNT=24.*RDL T+.001	7	740
KONT=0	7	750
TRAN=0.0	7	760
PEAK=0.	7	770
DAILY=0.	7	780
YFARLY=0.	7	790
TF=0.	7	800
TET=0.	7	810
ETYR=0.0	7	820
EYR=0.0	7	830
DO 150 MN=1.12	7	840
BAMO(MN)=0.0	7	850
OFSTMO(MN)=0.0	7	860
ONSTM0(MN)=0.0	7	870
ETMO(MN)=0.0	7	880
EMO(MN)=0.0	7	890
RAMO(MN)=0.0	7	900
SUMO(MN)=0.0	7	910
RUNMO(MN)=0.0	7	920
DO 150 ZONF=1,NUMZ	7	930
ZPEM(ZONE,MN)=0.0	7	940
ZRAM(ZONE,MN)=0.0	7	950
ZOFST(ZONE,MN)=0.0	7	960
150 ZCM (ZONE,MN)=0.0	7	970
RFTURN	7	980
END	7	990

```

SURROUNTING LANUSE          8 10
C                           8 20
C                           8 30
C                           8 40
C                           8 50
C                           8 60
C                           8 70
C                           8 80
C                           8 90
C                           8 100
C                           8 110
C                           8 120
C                           8 130
C                           8 140
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C                           8 370
C                           8 380
C                           8 390
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C                           8 490
C                           8 500
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C                           8 600
C                           8 610
C                           8 620
C                           8 630
C                           8 640
C                           8 650
C                           8 660
C                           8 670
C                           8 680
C                           8 690
C                           8 700
C                           8 710
C                           8 720
COMMON A(10),ACRES,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN,
1CM,CON1,CON2,CROPS(2+10),CRPVD(10),CVOL(4+4),D(4),DAILY,DAMO(12),
2DELE,DELET,DELFL(4),DELP(300),DELQ(4),DELQZ(4),DELT(300),DELT,F,DET,
3DPE(4),DQO(4),E,EL(4,2),EP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4),
4GAZ(10),GI(10),GIG(10,52),IREG,IDL,HYD,IOVER,IPRIN,IREAD,IROTA
COMMON ITAPE,ITIL,IYDAY,IYR,IYR1,JUL(50),KCUL(10+10),KDATE(10,10),
IKNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),MIST,MO(5),MSTOR,MYR(5),
PNCHKE,N,E,NKROP,NST,NUML,NUMZ,NWEEK,OLDGI(4),OVA(4),OVL(4),
3PAGE,PAN(52),PCAS(4),PCKROP(4+10),PCZON(5),PEAK,PRECIP,O(4,4),
4QL1(4,4),QMAX(4,5),QO(4),QOPK(4),QZ(4),R,RDLET,ROOTD(10)
COMMON RUNON(5),SAI(4,4),SCN(4,4),SD00(4),SEL(4,2),SETL(4,2),SG1,
1SGR(4),SL(4),SMAX(4,4),SOILD(4),SOL(4,4),SRUNON(4),SUBPUT(5),
PSUMET(4),SUMCN(4),TEMP(5?),TIM(5),TIME,TL(10),TOPD(4),TP,TU(10),
3VD(4),VDMAX(4),VEG(4),VOL,ZGI(4),ZONE,WPP1(4),WPP2(4)
DIMFNISION CNAME(2),CNO(10),CODE(4),CWK(52),IALPH(4),ICUL(10),
1ID(7),IDATE(10),IM(7),IY(7),ROP(10),XGI(52)
REAL M
INTEGER CNO,CODE,COND,CWK,WEEK,ZONE
DATA IALPH, CODE/3HPL0,3HPLA,3HHAR,3HCUL,4+5,6+7/
IF(IREG)140,100,140
100 WRITE(IPRIN,3)
      READ CROP PARAMETERS
      READ(IREAD,35) ((CROPS(KK,K),KK=1,2),K=1,NKROP)
35 FORMAT(18A4)
      READ(IREAD,20)(A(K),K=1,NKROP)
      READ(IREAD,20)(CRPVD(K),K=1,NKROP)
      READ(IREAD,20)(ETEP(K),K=1,NKROP)
      READ(IREAD,20)(ROOTD(K),K=1,NKROP)
      READ(IREAD,20)(TU(K),K=1,NKROP)
      READ(IREAD,20)(TL(K),K=1,NKROP)
20 FORMAT(10F8,3)
      PRINT CROP PARAMETERS.
      WRITE(IPRIN,5) ((CROPS(KK,K),KK=1,2),K=1,NKROP)
      WRITE(IPRIN,6)(A(K),K=1,NKROP)
      WRITE(IPRIN,9)(CRPVD(K),K=1,NKROP)
      WRITE(IPRIN,7)(ETEP(K),K=1,NKROP)
      WRITE(IPRIN,6)(ROOTD(K),K=1,NKROP)
      WRITE(IPRIN,1)(TU(K),K=1,NKROP)
      WRITE(IPRIN,2)(TL(K),K=1,NKROP)
1 FORMAT(5X,'UPPER TEMP*',10F10.2)
2 FORMAT(5X,'LOWER TEMP*',10F10.2)
3 FORMAT(*'LAND USE PARAMETERS'//)
5 FORMAT('0',17X,10(2X,2A4))
6 FORMAT(5X,'ROOT DEPTH*',10F10.2)
7 FORMAT(5X,'ETEP      ',10F10.2)
8 FORMAT(5X,'A VALUES   ',10F10.2)
9 FORMAT(5X,'CROP VD    ',10F10.2)
C                           CALCULATE GROWTH INDEX CURVES AS A
C                           FUNCTION OF TEMPERATURE AND TILLAGE
C                           PRACTICE FOR EACH CROP.
C                           IF(IYIL)120,110,120
110 WRITE(IPRIN,10)
GO TO 130
120 WRITE(IPRIN,11)
10 FORMAT(*'TILLAGE PRACTICE IS NOT AVAILABLE FOR YEARLY INPUT. THE
IYILLAGE PRACTICE FOR THE FIRST YEAR OF CALCULATION*' WILL BE USE
20 FOR ALL OF THE YEARS.')

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11 FORMAT('OTTILLAGE WILL BE READ YEARLY.')
130 WRITE(IPRIN,12)
12 FORMAT('*OCROP      * GRAZING*,10X,*TILLAGE PRACTICES')
C          READ TEMPERATURE DATA.
140 READ(IREAD,21,FND=880)(TFMP(K),K=1,52)          8 730
21 FORMAT(48X,4F8.3)                                8 740
DO 740 IC=1,NKROP                                  8 750
IF (IBEG)>180,180,150                               8 760
150 IF (ITTL)>160,160,180                           8 770
C          REINITIALIZE TILLAGE PRACTICES FOR THE
C          CASE WHEN TILLAGE IS NOT AVAILABLE FOR
C          EVERY YEAR OF CALCULATION.                 8 780
160 KROP=IC                                         8 790
  GAZ=GAZ(KROP)                                     8 800
  NO=KNO(KROP)                                     8 810
  DO 170 K=1,NO                                     8 820
    ICUL(K)=KCUL(KROP,K)                           8 830
170 IDATE(K)=KDATE(KROP,K)                         8 840
  GO TO 390                                         8 850
C          READ THE CROP TILLAGE PRACTICE CARD.
C          PLO = TURN PLOW (4)                        8 860
C          PLA = PLANT      (5)                        8 870
C          HAR = HARVEST    (6)                        8 880
C          CUL = CULTIVATION   (7)                      8 890
180 READ(IREAD,22) CNAME,IGR,(ICUL(K),IM(K),ID(K),IY(K),K=1,7) 8 900
  GAZ=1,-IGR*.01                                    8 910
C          FIND THE CROP'S SUBSCRIPT NUMBER.          8 920
  DO 210 K=1,NKROP                                 8 930
    IF (CROPS(1,K)=CNAME(1))P10,190,P10           8 940
  190 IF (CROPS(2,K)=CNAME(2))P10,200,P10           8 950
  200 KROP=K                                         8 960
    GAZ(KROP)=GAZ
    GO TO 220                                         8 970
  210 CONTINUE                                       8 980
    WRITE(IPRIN,23) CNAME
    STOP                                              8 990
  220 DO 240 K=1,7
    IF (IM(K))240,230,240
C          NO = NUMBER OF CULTIVATION PRACTICES.     8 1000
  230 NO=K-1                                         8 1010
    GO TO 250                                         8 1020
  240 CONTINUE                                       8 1030
    NO=7                                           8 1040
  250 IF (NO)270,260,270                            8 1050
  260 WRITE(IPRIN,13) CNAME,IGR
    13 FORMAT('0',2A4,6X,I3,13X,*NONE*)
    GO TO 350                                         8 1060
  270 WRITE(IPRIN,14) CNAME,IGR,(ICUL(K),IM(K),ID(K),IY(K),K=1,NO) 8 1070
    14 FORMAT('0',2A4,6X,I3,13X,7(A3,IX,3I2,3X))
C          CALCULATE THE WEEK OF THE YEAR ASSOCIATED
C          WITH EACH CULTIVATION DATE.                8 1080
  280 DO 330 K=1,NO
    IF (IM(K)-1)280,280,290
  290 IDATE(K)=ID(K)
    GO TO 330                                         8 1090
  290 KM=IM(K)
    IF (IY(K)-4*(IY(K)/4))320,300,320
  300 IF (IM(K)-2)320,320,310
  310 IDATE(K)=ID(K)+DAMO(KM-1)+1
    GO TO 330                                         8 1100
  320 IDATE(K)=ID(K)+DAMO(KM-1)
  330 IDATE(K)=IDATE(K)/7,+.99
    IF (IDATE(K)-52)350,350,340
  340 IDATE(K)=52
  350 IF (IBEG+ITTL)360,360,390
C          SAVE THE TILLAGE PRACTICES READ THE FIRST
C          YEAR FOR THE CASE WHEN TILLAGE IS NOT
C          AVAILABLE FOR EVERY YEAR OF CALCULATION. 8 1110
  360 GAZ(KROP)=GAZ
  KNO(KROP)=NO
  IF (NO)390,390,370
  370 DO 380 K=1,NO

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KDATE(KROP,K)=IDATE(K)
380 KCUL(KROP,K)=ICUL(K)
C TL = TEMPERATURE BELOW WHICH THE GROWTH
C INDEX FOR A PLANT IS CONSTANT.
C TU = TEMPERATURE AT WHICH POTENTIAL TRANS-
C PIRATION FOR A PLANT EQUALS PAN
C EVAPORATION.
C
390 XT=TU(KROP)-TL(KROP)
COND=1
ICON=1
WEEK=1
C XTP= RECOVERY PERIOD AFTER TURN PLOW,
C WEEKS REQUIRED FOR GI TO RETURN TO
C 0.1 UNTIL NEXT PRACTICE.
C
C XTP=2.0
XP = GROWTH PERIOD AFTER PLANTING. WEEKS
REQUIRED FOR GI TO REACH XGI.
C
C XH = RECOVERY PERIOD AFTER HARVEST.
C WEEKS REQUIRED FOR GI TO RETURN
C TO XGI.
C
C XH=4.0
XPH= A VARIABLE EQUAL TO XP OR XH
DEPENDING ON WHICH CULTURAL PRACTICE
IS IN FFECT.
C
C HNO=.3
DO 420 I=1,52
C XGI = GROWTH INDEX FOR ESTABLISHED
C VEGETATION WITH NO HINDERANCES SUCH
C AS DAMAGES OR CULTURAL PRACTICES.
C
C GIG = XGI MODIFIED BY DAMAGE OR CULTURAL
C PRACTICES FOR COMPARISON WITH
C MOISTURE EXTRACTION PATTERNS.
C
C XGI(I)=((TEMP(I)-TL(KROP))/XT)*GRAZ
IF TEMPERATURE EXCEEDS TU(KROP),
XGI IS REDUCED.
C
TEST=(XGI(I)/GRAZ-1.0)
IF (TEST) 402,402,401
401 XGI(I)=(1.0-TEST**1.5)*GRAZ
402 IF (XGI(I)=0.3) 410,420,420
C MINIMUM XGI=0.3 DOES NOT INCLUDE EVAP
C FROM FREEWATER.
C
410 XGI(I)=0.3
420 CONTINUE
IF (NO) 430,430,450
430 DO 440 WEEK=1,52
440 GIG(KROP,WEEK)=XGI(WEEK)
GO TO 740
450 IF (ICON=NO) 460,460,510
460 DO 480 K=1,4
IF (ICUL(ICON)=1ALPH(K)) 480,470,480
470 CNO(ICON)=CODE(K)
GO TO 490
480 CONTINUE
WRITE(IPRIN,24) ICUL(ICON)
STOP
490 CWK(ICON)=IDATE(ICON)
IF (WEEK-CWK(ICON)) 520,520,500
500 WRITE(IPRIN,15)
15 FORMAT(1H ,,RRRR--CULTIVATION DATES IN WRONG ORDER OR TWO IN THE
1 SAME WEEK,,)
GO TO 740
510 CWK(ICON)=53
520 IF (WEEK-CWK(ICON)) 530,630,530
530 GO TO (540,550,580,640,650,660,670),COND
COND = 1 FOR INITIAL CONDITION.
540 GIG(KROP,WEEK)=XGI(WEEK)
GO TO 710
C COND = ? FOR XPH EQUAL TO XP IF CURRENT
C WEEK IS GREATER THAN THE PLANT DATE
C OR LESS THAN PLANT DATE + XPH.
C

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C           COND = 2 FOR XPH EQUAL TO XH IF CURRENT      8 2160
C           WEEK IS GREATER THAN THE HARVEST DATE      8 2170
C           OR LESS THAN HARVEST DATE + XPH.            8 2180
C
C 550 IF(WEEK-(CWK(ICON-1)+XPH))570,560,560          8 2190
C 560 COND=1                                         8 2200
C   GO TO 530                                         8 2210
C 570 GIG(KROP,WEEK)=GIG(KROP,WEEK-1)+(XGI(WEEK)-GIG(KROP,WEEK-1))* 8 2220
C   1(WEEK-CWK(ICON-1))/XPH                           8 2230
C   GO TO 710                                         8 2240
C
C           COND = 3 IF CURRENT WEEK IS GREATER THAN      8 2250
C           TURN PLOW DATE OR LESS THAN                8 2260
C           TURN PLOW DATE + XTP.                      8 2270
C
C 580 IF(WEEK-(CWK(ICON-1)+XTP))600,590,590          8 2280
C 590 GIG(KROP,WEEK)=.1                             8 2290
C   COND=3                                         8 2300
C   GO TO 710                                         8 2310
C 600 GIG(KROP,WEEK)=1.0-.5*(WEEK-CWK(ICON-1))/XTP    8 2320
C   GO TO 710                                         8 2330
C 630 COND=CNO(ICON)                                8 2340
C   GO TO 530                                         8 2350
C
C           COND = 4 IF CURRENT WEEK IS EQUAL TO THE      8 2360
C           TURN PLOW DATE.                          8 2370
C
C 640 GIG(KROP,WEEK)=1.0                            8 2380
C   COND=3                                         8 2390
C   GO TO 710                                         8 2400
C
C           COND = 5 IF CURRENT WEEK IS EQUAL TO THE      8 2410
C           THE PLANT DATE.                         8 2420
C
C 650 GIG(KROP,WEEK)=0.1                            8 2430
C   COND=2                                         8 2440
C   XPH=XP                                         8 2450
C   GO TO 710                                         8 2460
C
C           COND = 6 IF CURRENT WEEK IS EQUAL TO THE      8 2470
C           HARVEST DATE.                         8 2480
C
C 660 GIG(KROP,WEEK)=HNO*XGI(WEEK)                  8 2490
C   HNO=.6                                         8 2500
C   XPH=XH                                         8 2510
C   COND=2                                         8 2520
C   GO TO 710                                         8 2530
C
C           COND = 7 IF CURRENT WEEK IS EQUAL TO THE      8 2540
C           CULTIVATION DATE. INSTANTANEOUS      8 2550
C           REDUCTION DUE TO CULTIVATION.        8 2560
C
C 670 GIG(KROP,WEEK)=0.9*XGI(WEEK)                  8 2570
C   COND=1                                         8 2580
C 710 IF(WEEK-CWK(ICON))730,720,730              8 2590
C 720 ICON=ICON+1                                    8 2600
C   WEEK=WEEK+1                                     8 2610
C   IF(WEEK-53)450,740,740                         8 2620
C 730 WEEK=WEEK+1                                    8 2630
C   IF(WEEK-53)520,740,740                         8 2640
C 740 CONTINUE                                       8 2650
C
C           PRINT THE GROWTH INDEX CURVES.             8 2660
C
C   WRITE(IPRIN,25) ((CPOPS(KK,K),KK=1,2),K=1,NKROP) 8 2670
C   DO 750 WEEK=1,52                                 8 2680
C 750 WRITE(IPRIN,26) WEEK, TEMP(WEEK), (GIG(KROP,WEEK),KROP=1,NKROP) 8 2690
C
C           READ LAND USE CHANGE FOR YEAR.          8 2700
C
C           THIS INFORMATION MUST BE ENTERED THE 1ST      8 2710
C           YEAR AND THEREAFTER WHEN LU CHANGES.       8 2720
C
C           THESE CARDS MUST BE FOLLOWED BY A BLANK      8 2730
C           TRAILER. IF LU DOESN'T CHANGE AFTER THE     8 2740
C           FIRST YEAR, BLANKS ARE NOT REQUIRED IN      8 2750
C           SUCCEEDING YEARS. IF LU CHANGES IN SOME      8 2760
C           YEARS, BUT NOT OTHERS, THE BLANK MUST BE      8 2770
C           INSERTED IN YEARS WITH NO CHANGE. CARDS      8 2780
C           NEED BE ENTERED ONLY FOR ZONES WITH LU      8 2790
C           CHANGING FROM THE PRECEDING YEAR. LU CARDS 8 2800
C           SHOULD BE INSERTED IN FRONT OF PAN EVAP-      8 2810
C           ORATION DATA FOR EACH YEAR.                 8 2820
C
C           IF(IBEG)760,770,760                         8 2830
C 760 IF(IROTA)860,860,770                         8 2840
C 770 Y=0.                                         8 2850
C 780 READ(IREAD,16) Z,( ROP(KK),KK=1,NKROP)        8 2860
C   16 FORMAT(10FA.?)                               8 2870
C   ZONE=Z                                         8 2880

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IF (ZONE) 800,800,790          8 2890
790 Y=Y+1                      8 2900
800 IF (Y-1) 820,830,810        8 2910
810 IF (Z) 860,860,840          8 2920
820 WRITE(IPRIN,17) IYR         8 2930
17 FORMAT('ILAND USE FOR THE YEAR 19*,I2,* IS THE SAME AS THE PREVIOUS
IS YEAR.')                      8 2940
   GO TO 860                      8 2950
830 WRITE(IPRIN,18) IYR         8 2970
18 FORMAT('ILAND USE FOR YEAR 19*,I2,* FOLLOWS. IF A ZONE IS NOT MENTIONED,
VALUES OF PREVIOUS YEAR ARE ASSUMED.') 8 2980
840 VEG(ZONE)=0.0                8 3000
  VDMAX(ZONE)=0.0                8 3010
  DO 850 KK=1,NKROP              8 3020
    PCKROP(70NF,KK)=ROP(KK)*.01
C                                     UPDATE THE MAXIMUM VOLUME OF DEPRESSIONS
C                                     AND VEGETATION PARAMETERS FOR THE INFIL-
C                                     TRATION SURROUNTING.                         8 3040
C                                     VDMAX(ZONE)=VDMAX(ZONE)+CRPVD( KK )*PCKROP(ZONE, KK ) 8 3050
C                                     850 VEG(ZONE)=VEG(ZONE)+A(KK)*PCKROP(ZONE,KK)           8 3060
C                                     WRITE(IPRIN,19) ZONE,((CROPS(KK,K),KK=1,2)*ROP(K),K=1,NKROP) 8 3070
19 FORMAT('OZONE',I2,6(3X,2A4,'='*F5.1,'%'))/7X,4(3X,2A4,'='*F5.1,
  1*''))                           8 3100
   Y=Y+1                            8 3110
   GO TO 780                          8 3120
22 FORMAT(2A4,I2,7(A3,3I2,1X))      8 3130
23 FORMAT('*IND MATCH FOR CROP NAME*',2A4,'* ON WATERSHED. (LANUSE)') 8 3140
24 FORMAT('*IND MATCH FOR OPERATION ',A3,'. (GIGEN)')                  8 3150
25 FORMAT('*1*,*GI CURVES*',//3X,*WEEK TEMP ',2X,10(2X,2A4))       8 3160
26 FORMAT(4X,I3,2X, F6.2, 10F10.2) 8 3170
860 WRITE(IPRIN,861) IYR           8 3180
861 FORMAT('*OPEN EVAPORATION FOR YEAR 19*,I2,* FOLLOWS.')            8 3190
C                                     READ PAN EVAPORATION DATA FOR THE YEAR. 8 3200
C                                     READ(IREAD,862)(PAN(L),L=1,52)          8 3210
862 FORMAT(48X,4F8.3)              8 3220
  DO 870 K=1,13                   8 3230
    KK=K*4-3                     8 3240
    KKK=K*4                     8 3250
    WRITE(IPRIN,863) KK,(PAN(L),L=KK,KKK)          8 3260
863 FORMAT('*WEEK ',I3,5X,4F15.3) 8 3270
870 CONTINUE                      8 3280
  PAGE=28.                      8 3290
  RETURN                         8 3300
880 STOP                           8 3310
END                                8 3320
                                     8 3330

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SUBROUTINE PARAMS (MZ,NPFG,PRAS,SNO,THAW)          10  10
C   THIS ROUTINE READS ALL OF THE INPUT             10  20
C   PARAMETERS AND INITIALIZES SOME VALUES.        10  30
COMMON A(10),ACRFS,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN,    10  40
1CM,CON1,CON2,CROPS(2,10),CRPWD(10),CVOL(4,4),D1(4),DAILY,DAMO(12), 10  50
2DELE,DELET,DELQ(4),DELT(300),DELQZ(4),DELT(300),DELT,DET, 10  60
3DPE(4),DQO(4),E,EL(4,2),EP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4), 10  70
4GAZ(10),GI(10),GIG(10,52),IBEG,(DALY,IHYD,IOVER,IPRIN,IREAD,IROTA 10  80
COMMON ITAPE,ITIL,IYDAY,IYR,IYR1,JUL(50),KCUL(10+10),KDATE(10+10), 10  90
1KNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),M1ST,MO(5),MSTOP,MYR(5), 10 100
2NCHEK,NE,NKROP,NST,NUML,NUMZ,NWEEK,OLDGI(4),OVA(4),OVL(4), 10 110
3PAGE,PAN(52),PCAS(4),PCKPROP(4,10),PCZON(5),PEAK,PRECIP,O1(4,4), 10 120
4QLI(4,4),QMAX(4,5),Q001(4),Q00PK(4),Q7(4),R1,ROELT,ROOTD(10) 10 130
COMMON RUNON(5),SA1(4,4),SCN(4,4),SDQO(4),SEL(4,2),SETL(4,2),SG1, 10 140
1SGR(4),SL(4),SMAX(4,4),SOILD(4),SQL(4,4),SPRUNON(4),SURPUT(5), 10 150
2SUMET(4),SUMCN(4),TEMP(52),TIME(5),TIME,TL(10),TOPD(4),TP+TU(10), 10 160
3VD(4),VDMAX(4),VEG(4),VOL,ZGI(4),ZONE,WPP1(4),WPP2(4) 10 170
DIMENSION COMENT(40),IDS(50),IDUM(4),IMS(50),IYS(50),LOC(2,4), 10 180
1LOCAT(2),M7(4,4),QMAXL(5),PERCT(4,4),RANG(4,4),SNO(4),XX(4) 10 190
INTEGER ALLU,CHAN,NO,YES,ZONE 10 200
REAL M,MZ 10 210
DATA YES,NO,CHAN,ALLU, 10 220
WRITE(IPRIN,10) 10 230
C   SET A TABLE OF ALPHA RESPONSES AND 10 240
C   THE ASSOCIATED CODES. 10 250
C   SET BLANKS TO BE USED IN FORMAT 10 260
C   CONTROL. 10 270
READ(IREAD,13) COMENT 10 280
WRITE(IPRIN,19) COMENT 10 290
C   READ DATES FOR WHICH DETAILED ROUTING IN- 10 300
C   FORMATION IS REQUESTED AND SET UP A JULIAN 10 310
C   DAY ARRAY FOR THOSE DATES. 10 320
DO 160 NN=1,5 10 330
IS2=NN+10 10 340
IS1=IS2-9 10 340
READ(IREAD,17)(IMS(K),IDS(K),IYS(K),K=IS1,IS2) 10 350
DO 160 KK=IS1,IS2 10 360
IF(IMS(KK)-1)100,110,120 10 370
100 NST=KK 10 380
JUL(KK)=0 10 390
GO TO 170 10 400
110 JUL(KK)=IDS(KK) 10 410
GO TO 160 10 420
120 KM=IMS(KK) 10 430
IF(IYS(KK)-4*(IYS(KK)/4))150,130,150 10 440
130 IF(IMS(KK)-2)150,150,140 10 450
140 JUL(KK)=IDS(KK)+DAMO(KM-1)+1 10 460
GO TO 160 10 470
150 JUL(KK)=IDS(KK)+DAMO(KM-1) 10 480
160 CONTINUE 10 490
NST=51 10 500
170 NN=NST-1 10 510
IF(NN)220,220,180 10 520
180 WRITE(IPRIN,2)(IMS(K),IDS(K)+JUL(K),IYS(K),K=1,NN) 10 530
2 FORMAT('0STORM HYDROGRAPHS WILL BE PRINTED FOR THE FOLLOWING DATES 10 540
1:10, //5X,' MO DAY (JULIAN) YR/4(5X,I3,IX,I3,4X,I3,2X,I3)) 10 550
DO 190 N=1,NN 10 560
190 JUL(N)=JUL(N)+1000 10 570
C   SORT DATE TO ASSURE CHRONOLOGICAL ORDER. 10 580
DO 210 N=1,NN 10 590
DO 210 J=N,NN 10 600
TFST=JUL(N)-JUL(J) 10 610
IF(TFST)210,210,200 10 620
200 X=JUL(N) 10 630
JUL(N)=JUL(J) 10 640
JUL(J)=X 10 650
210 CONTINUE 10 660
GO TO 230 10 670
220 NST=0 10 680
WRITE(IPRIN,3) 10 690
3 FORMAT('0NO STORM PRINT OUT IS REQUESTED.') 10 700
10 710

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C          READ THE GENERAL WATERSHED PARAMETERS.      10  720
230 READ(IREAD,14) ACRES,XZON,XLAY+REG,XKRP,GR,LOCAT,IHIST    10  730
        WRITE(IPRIN,21) ACRFS,XZON,XLAY,REG,XKRP,GR,LOCAT,IHIST    10  740
        NUMZ=XZON                                              10  750
        NUML=XLAY-1.                                            10  760
        NREG=REG                                              10  770
        NKROP=XKRP                                             10  780
C          CHECK THE INPUT TO SET UP THE LAND      10  790
C          USE CHANGE CODE (IROTA).                10  800
        IF(LOCAT(1).EQ.YES ) GO TO 231                  10  810
        IF(LOCAT(1).EQ.NO ) GO TO 234                  10  820
233 WRITE(IPRIN,237)
237 FORMAT(*'ALPHA INPUT DOES NOT MATCH ANY CORRECT RESPONSE')
        STOP                                              10  830
234 IROTA=0                                              10  840
        GO TO 232                                              10  850
231 IROTA=1                                              10  860
232 IF(IHIST.EQ.YES ) GO TO 235                  10  870
        IF(IHIST.EQ.NO ) GO TO 238                  10  880
        GO TO 233                                              10  890
238 ITIL=0                                              10  900
        GO TO 236                                              10  910
235 ITIL=1                                              10  920
236 WRITE(IPRIN,22)
C          READ THE ZONE PARAMETERS.            10  930
        DO 250 ZONF=1,NUMZ                               10  940
        READ(IREAD,15) XZON,PCZON(ZONE),OVL(ZONE),SL(ZONE),FC(ZONE),
        1TOPD(ZONE),SOILD(ZONE),WPP1(ZONE),WPP2(ZONF)      10  950
        CVOL(ZONE,3)=0.0                                10  960
        CVOL(ZONE,4)=0.0                                10  970
        IZON = XZON                                     10  980
        WRITE(IPRIN,23)IZON,PCZON(ZONE),OVL(ZONE),SL(ZONE),FC(ZONE),
        1TOPD(ZONE),SOILD(ZONE),WPP1(ZONE),WPP2(ZONE)      10  990
        WPP1(ZONE)=WPP1(ZONE)*TOPD(ZONE)*0.01           10 1000
        WPP2(ZONE)=WPP2(ZONE)*(SOILD(ZONE)-TOPD(ZONE))*0.01 10 1010
        DO 245 LAYER=3,4                                10 1020
        AWC(ZONE,LAYER)=0.0                            10 1030
        RANG(ZONE,LAYER)=1.0                           10 1040
245 PERCT(ZONE,LAYER)=0.0                           10 1050
        PCZON(ZONE)=PCZON(ZONE)*0.01                   10 1060
C          CHECK THE ORDER OF THE INPUT CARDS.       10 1070
        IF(ZONE-IZON)>240,250,240                   10 1080
250 CONTINUE                                         10 1090
        GO TO 255                                         10 1100
240 WRITE(IPRIN,20)
        STOP                                              10 1110
255 WRITE(IPRIN,24)
C          READ THE SOIL PARAMETERS.            10 1120
        DO 310 ZONF=1,NUMZ                               10 1130
C          SA1 IS TEMPORARILY REDEFINED HERE TO MEAN 10 1140
C          ANTECEDENT MOISTURE.                      10 1150
        READ(IREAD,15)XZON,G(ZONF,1),AWC(ZONE,1),SA1(ZONE,1),CVOL(ZONE,1),
        1G(ZONE,2),AWC(ZONE,2),SA1(ZONE,2),CVOL(ZONE,2) 10 1160
        SA1(ZONE,3)=0.0                                10 1170
        SA1(ZONE,4)=0.0                                10 1180
        IZON=XZON                                     10 1190
        WRITE(IPRIN,25)IZON,G(ZONF,1),AWC(ZONF,1),SA1(ZONE,1),CVOL(ZONF,1),
        1,G(ZONE,2),AWC(ZONE,2),SA1(ZONE,2),CVOL(ZONF,2) 10 1200
        DO 300 LAYER=1,2                                10 1210
        TEST = SA1(ZONE,LAYER)-G(ZONE,LAYER)-AWC(ZONE,LAYER) -0.000001 10 1220
        IF(TEST)>270,270,260                         10 1230
260 SA1(ZONE,LAYER)=G(ZONE,LAYER)+AWC(ZONE,LAYER) 10 1240
270 TEST= SA1(ZONE,LAYER)-AWC(ZONE,LAYER)          10 1250
        IF(TEST)>280,280,290                         10 1260
280 RANG(ZONE,LAYER)=0.                            10 1270
        PERCT(ZONE,LAYER)=1.-SA1(ZONE,LAYER)/AWC(ZONE,LAYER) 10 1280
        GO TO 300                                         10 1290
290 RANG(ZONE,LAYER)=1.0                           10 1300
300 SA1(ZONE,LAYER)=SA1(ZONE,LAYER)/(G(ZONE,LAYER)+AWC(ZONE,LAYER)) 10 1310
        IF(ZONE-XZON)>240,310,240                   10 1320
310 CONTINUE                                         10 1330
C          READ ROUTING PARAMETERS, CHANNEL VALUES. 10 1340
C          INITIAL SNOW COVER AND THAW.             10 1350

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READ(IREAD,15)RDELT,CM,P1,BSNOW,THAW
WRITE(IPRIN,26)RDELT,CM,P1,BSNOW
DO 315 ZONE=1,NUMZ
SNO(ZONE)=RSNOW
DO 315 LAYFR=1,4
315 MZ(ZONE,LAYFR)=0.0
IF (NUML) 320,320,350
320 M(1)=0.
M(2)=0.
QMAXL(1)=0.0
DO 340 ZONF=1,NUMZ
QMAX(ZONE+1)=0.0000001
QMAX(ZONE+2)=0.0000001
GZONE,1)=TOPD(ZONE)*G(ZONE,1)*0.01
AWC(ZONE+1)=AWC(ZONE+1)*TOPD(ZONE)*0.01
X=SOILD(ZONF)-TOPD(ZONE)
AWC(ZONE,2)=AWC(ZONE+2)*X*0.01
G(ZONE,2)=G(ZONE,2)*X*0.01
C          INITIALIZE STARTING POROSITY.
DO 330 L=1,2
C          SAI INITIALLY READ AS % ASM: IF NO RETURN
C          FLOW, CONVERT SAI TO AIR SPACE.
330 SAI(ZONF,L)=(1.-SAI(ZONF,L))*(AWC(ZONE+L)+G(ZONF,L))
C(ZONE,1)=FC(ZONE)
340 C(ZONE,2)=GR
GO TO 500
C          READ THF RECEDITION BREAKPOINTS FOR
C          SUBSURFACE RETURN FLOW ROUTING.
350 READ(IREAD,31) (QMAXL(L),M(L),L=1,NUML)
WRITE(IPRIN,27) (L,QMAXL(L),M(L),L=1,NUML)
QMAXL(NUML+1)=0.0
C          COMPUTE M1 AND M2 FOR EACH ZONE.
C          ASSUMPTIONS: (DERIVED EMPIRICALLY
C          PENDING FURTHER RESEARCH)
C          QMAX=FC*(G(L)/G(2))**2*(W/L RATIO OF
C          ZONE1*GRADIENT OF ZONE
C          M(L)=FREEWATER AT SATURATION/QMAX
C          M(L)=DEPTHRG(2)**2*DVL**2*(SL**2+1)**0.5/
C          (FC*G(L)*PARFA*SL)
DO 364 ZONE=1,NUMZ
CONST=G(ZONF,2)**2.*DVL(ZONF)**2.*((SL(ZONE)**0.01)**2.+1.0)**0.5/
1(FC(ZONE)*SL(ZONE)*ACRES*43560.*PPCZON(ZONE))
IF (M(1)) 359,359,360
      IF M FOR THF LAYER IS KNOWN TO BE ZERO,
      LEAVE IT.
359 MZ(ZONE,1)=0.
GO TO 361
360 MZ(ZONE+1)=CONST*TOPD(ZONE)/G(ZONE,1)
361 IF (M(2)) 363,363,362
363 MZ(ZONF,2)=0.
GO TO 364
362 MZ(ZONE,2)=CONST*(SOILD(ZONE)-TOPD(ZONE))/G(ZONE,2)
364 CONTINUE
C          IF RETURN FLOW OCCURS IN WATERSHED. DIS-
C          TRIBUTE STORAGE OF RECEDITION FLOW REGIMES
C          3 AND 4 IN PROPORTION TO
C          TOP SOIL G VALUES OF ZONFS.
390 SG1=0.0
DO 400 ZONF=1,NUMZ
G(ZONE,1)=TOPD(ZONE)*G(ZONE,1)*0.01
AWC(ZONE,1)=AWC(ZONE,1)*TOPD(ZONE)*0.01
X=SOILD(ZONF)-TOPD(ZONE)
G(ZONE,2)=G(ZONE,2)*X*0.01
AWC(ZONE,2)=AWC(ZONE,2)*X*0.01
400 SG1=SG1+ G(ZONE,1)*PPCZON(ZONE)
DO 480 ZONF=1,NUMZ
QMAX(ZONE,NUML+1)=GR
XX(ZONE)=G(ZONE,1)*PPCZON(ZONE)/SG1
IF (NUML-2) 440,450,420
420 DO 430 LAYFR=3,NUML
MZ(ZONE,LAYFR)=M(LAYER)
      10 1450
      10 1460
      10 1470
      10 1480
      10 1490
      10 1500
      10 1510
      10 1520
      10 1530
      10 1540
      10 1550
      10 1560
      10 1570
      10 1580
      10 1590
      10 1600
      10 1610
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      10 2080
      10 2090
      10 2100
      10 2110
      10 2120
      10 2130
      10 2140
      10 2150

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430 G(ZONE,LAYFR)=M(LAYER)*QMAXL(LAYER)*XX(ZONE)/PCZON(ZONE)      10 2160
   GO TO 450
440 MZ(ZONE,2)=0.0                                              10 2170
   QMAX(ZONE,2)=FC(ZONE)
C   IF ONLY ONE LAYER OF RETURN FLOW, CONVFR 10 2200
C   SAI TO AIR SPACE.                                              10 2210
C   SA1(ZONE,2)=(1.-SA1(ZONE,2))*(AWC(ZONE,2)*X*.01+G(ZONE,2)) 10 2220
C   C(ZONE,2)=GR                                              10 2230
C   C(ZONE,1)=FC(ZONE)                                              10 2240
   GO TO 470
450 KNUM=NUML-1                                              10 2250
   DO 461 LAYER=1,KNUM
   IF(M(LAYER)) 459,459,460
459 QMAX(ZONE,LAYER)=0.0                                              10 2260
   C(ZONE,LAYER)=FC(ZONE)                                              10 2270
   GO TO 461
460 QMAX(ZONE,LAYER)=G(ZONE,LAYER)/MZ(ZONE,LAYER)      10 2280
   C(ZONE,LAYER)=G(ZONE,LAYER+1)/MZ(ZONE,LAYER+1)+GR 10 2290
461 CONTINUE
C   C(ZONE,NUML)=GR                                              10 2300
470 QMAX(ZONE,NUML)=G(ZONE,NUML)/MZ(ZONE,NUML)      10 2310
480 CONTINUE
   WRITE(IPRIN,41)(IDUM(ZONE),ZONE,ZONE,ZONE=1,NUMZ)      10 2320
4 FORMATT('0',1)COEFFICIENTS AND MAXIMUM Q1'S PROPORTIONED TO ZONES AC 10 2330
1CORDING TO TOPSOIL DEPTH//2X,'REGIME',4(A2,RX,'M Z',I1,5X,'Q Z' 10 2340
2I1,2X)
   DO 490 LAYER=1,NUML
490 WRITE(IPRIN,5) LAYER,(MZ(ZONE,LAYER),QMAX(ZONE,LAYER),ZONE=1,NUMZ) 10 2350
5 FORMAT(' ',2X,I2,9X,A(F9,2,4,X,F8,6,5X))
500 IF(NUMZ-1)690,690,700
500 IF(NUMZ-1)690,690,700
690 PBAS=0.
   IF(NUML-1) 620,520,520
700 NMZ=NUMZ-1
C   READ CASCADE PARAMETERS.                                              10 2360
   READ(IREAD,16)PBAS,(PCAS(ZONE),(LOC(K,ZONE),K=1,2),ZONE=1,NMZ) 10 2370
   WRITE(IPRIN,28)(ZONE,PCAS(ZONE),(LOC(K,ZONE),K=1,2),ZONE=1,NMZ) 10 2380
   WRITE(IPRIN,29) NUMZ
   WRITE(IPRIN,30) PBAS
   PBAS=PBAS*0.01
   IF(NUML-1) 620,520,520
520 DO 610 ZONE=1,NUMZ
C   INITIALIZE STORAGES AND RATES IN SURFACE FLOW REGIMES. SAI STILL = ASM 10 2390
C   DO 610 LAYER=1,NUML
   IF(MZ(ZONE,LAYER))550,550,521
521 X=QMAX(ZONE,LAYER)
   IF(ZONE-NUMZ) 524,522,522
522 X1=P1*(1.-PRAS)/PCZON(NUMZ)
   GO TO 523
523 IF(X1-X)530,590,590
530 IF (X1)550,550,540
C   CONVERT SAI TO AIR.                                              10 2400
540 SA1(ZONE,LAYER)=(1.0-X1/X1*G(ZONE,LAYER)          10 2410
   Q1(ZONE,LAYER)=(G(ZONE,LAYER)-SA1(ZONE,LAYER))/MZ(ZONE,LAYER) 10 2420
   GO TO 600
550 IF(PANG(ZONE,LAYER))570,570,560
560 SA1(ZONE,LAYER)= G(ZONE,LAYER)          10 2430
   GO TO 580
570 SA1(ZONE,LAYER)=G(ZONE,LAYER)+PERCT(ZONE,LAYER)*AWC(ZONE,LAYER) 10 2440
580 Q1(ZONE,LAYER)=0.0          10 2450
   GO TO 600
590 SA1(ZONE,LAYER)=0.0          10 2460
   Q1(ZONE,LAYER)=QMAX(ZONE,LAYER)          10 2470
600 QL1(ZONE,LAYER)=0.0          10 2480
610 CONTINUE
620 DO 670 ZONE=1,NUMZ
   CVOL(ZONE,1)=CVOL(ZONE,1)*TOPD(ZONE)*0.01          10 2490
   X=SOILD(ZONE)-TOPD(ZONE)          10 2500
   CVOL(ZONE,2)=CVOL(ZONE,2)*X*0.01          10 2510
   IF(CVOL(ZONE,1))630,630,540          10 2520
630 CPDT(ZONE)=0.0          10 2530
   GO TO 670

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640 IF(CVOL(ZONE,2)>1650.650,660
650 COPT(ZONE)=1.0
660 GO TO 670
670 CONTINUE
671 IF(NUML>1,670)
672 DO 730 ZONE=1,NUMZ
673 IF(PCAS(ZONE)-100.1710.720,710
674 IF((LOC(1,ZONE),EQ,CHAN) GO TO 721
675 IF((LOC(1,ZONE),EQ,ALLU) GO TO 724
676 GO TO 233
677 CASC(ZONE)=1.0
678 GO TO 730
679 CASC(ZONE)=0.0
680 GO TO 730
681 CASC(ZONE)=-1.
682 CONTINUE
683 PCAS(NUMZ)=100.0
684 CASC(NUMZ)=0.0
685 RI=0.0
686 IF(NUML-1)780,780,790
687 NUML=2
688 DO 830 ZONE=1,NUMZ
689 PCAS(ZONE)=PCAS(ZONE)+0.01
690 VOMAX(ZONE)=0.0
691 DO 820 LAYFR=1,NUML
692 IF(LAYER>1)800,800,820
693 C          CHECK INITIALIZED STORAGE VALUES.
694 TFST=CVOL(ZONE,LAYER)-AWC(ZONE,LAYER)
695 IF(TEST180,820,810
696 CVOL(ZONE+1,LAYER)=AWC(ZONE+1,LAYER)
697 SMAX(ZONE+1,LAYER)=G(ZONE+1,LAYER)+AWC(ZONE+1,LAYER)
698 CONTINUE
699 WRITE(IPRIN,6)
700 FORMAT('0THF SOIL PARAMETERS IN INCHES FOLLOW.
701 1//1 ZONE LAYFR      G      AWC      SA      CRACKING      C(IN/HR)
702 2      TOPD      SOILD1)
703 DO 860 ZONE=1,NUMZ
704 WRITE(IPRIN,7)ZONE,TOPD(ZONE),SOILD(ZONE)
705 7 FORMAT(1.15,5X,2F10.2)
706 DO R60 LAYFP=1,NUML
707 IF(LAYER-1)A40,B40,B50
708 WRITE(IPRIN,8)LAYER,G(ZONE,LAYER),AWC(ZONE,LAYER),SA(ZONE,LAYER),
709 1CVOL(ZONE,LAYER),C(ZONE,LAYER)
710 8 FORMAT(1.5X, 75.4F10.3,F10.4)
711 GO TO 860
712 850 WRITE(IPRIN,9)LAYER,G(ZONE,LAYER),AWC(ZONE,LAYER),SA(ZONE,LAYER),
713 1CVOL(ZONE,LAYER),C(ZONE,LAYER)
714 9 FORMAT(1.5X,15.3F10.3,F10.3,F10.4)
715 860 CONTINUE
716 RETURN
717 10 FORMAT('1',3BX,'USDAHL 74 MODEL OF WATERSHED HYDROLOGY',40X,
718 1'2-742961//')
719 13 FORMAT(20A4)
720 14 FORMAT(6F8.2+3A4)
721 15 FORMAT(10F9.2)
722 31 FORMAT(9FB.0)
723 16 FORMAT(F8.2+3(F8.2+2A4))
724 17 FORMAT(10(3I2,2X))
725 19 FORMAT(101,1,20A4)
726 20 FORMAT('0PARAMETER INPUT CARDS ARE OUT OF ORDER OR IMPROPERLY
727 1PUNCHED, EXECUTION WILL BE TERMINATED.')
728 21 FORMAT('0WATERSHED PARAMETERS',//5X,'ACRES=',F8.1,5X,'NUMAFL OF ZO
729 1NES=1',F4.1,5X,'RTG COEFF: TOTAL=',F4.1,3X,'ABOVE WEIR=',F4.1,5X,
730 2'NUMBER OF CROPS=',F4.1//5X,'DEEP GROUND WATER RECHARGE=',F8.5,5X,
731 3'DOFS LAND USE CHANGE?',1X,2A4,5X,'DOES YEARLY TILLAGE CHANGE?',1
732 41X,A4)
733 22 FORMAT('0GENERAL ZONE PARAMETERS',//5X,'ZONE      % W/S      LENGTH
734 1      SI DPF      FC      DPTH TOP      AERATED DPTH      WP1%
735 2      WP2%',1)
736 23 FORMAT(6X,I2,6X,F5.1,6X,F7.0,7X,F5.2,8X,F6.3,6X,F5.1,8X,F5.1+8X,
737 1F6.2,4X,F6.2)
738 24 FORMAT('0SOIL PARAMETERS',//,5X,'ZONE      % G1      % AWC1      % AS
739 1M1      % CRAK1      % G2      % AWC2      % ASM2      % CRAK2')
740 25 FORMAT(6X,I2,7X,F5.1,5X,F5.1,5X+F5.1,5X+F6.2+10X,F5.1,5X,F5.1,6X,
741 1F5.1,4X,F6.2)
742 26 FORMAT('0ROUTING PARAMETERS',//,5X,'CHANNEL POUTING DELT T=',F7.3,
743 1' CHANNEL COEFFICIENT=',F7.2,6X,'INITIAL STREAM FLOW=',F9.5,6X,
744 2'INITIAL SNOW COVER=',F6.2)
745 27 FORMAT('0SUBSURFACE PARAMS',//15X,'REGIME      Q-MAX
746 1 COEFFICIENT//(15X,I2+13X,F7.5,11X,F9.2))
747 28 FORMAT('0CASCADED PARAMETERS',//5X,'ZONE      % TO NEXT ZONE      R
748 1EST GOES TO?//(16X,I2,9X,F6.1,I2X,2A4))
749 29 FORMAT(5X,'100% OF ALLUVIUM (ZONE',I2,') FLD GOES TO CHANNEL'))'
750 30 FORMAT(5X,'(%BASEFLN DIVERTED FROM ALLUVIUM=',F6.1,')')
751 END

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SUBROUTINE PFRROUT(RTIM)                                11 10
COMMON A(10),ACRES,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN,    11 20
1CM,CONJ,CONP,CROPS(2,10),CRPVO(10),CVOL(4,4),DI(4),DAILY,DAMO(12), 11 30
2DFLE,DELET,DFLF(4),DELP(300),DFLQ(4),DELQ(4),DELT(300),DELT,DET, 11 40
3DPE(4),DQO(4),F,FL(4,2),FP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4), 11 50
4GAZ(10),GT(10),GIG(10,52),IREG,IDL,ITHD,IOVER,IPRIN,IREAD,IROTA 11 60
COMMON ITAPF,ITIL,ITYD,ITYR,IYR,JUL(50),KCUL(10,10),KOATE(10,10), 11 70
1KNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),MIST,MO(5),MSTOR,MYR(5), 11 80
2NCHEK,NE,NKROP,NST,NUML,NUMZ,NWEEK,OLDGI(4),OVA(4),OVL(4), 11 90
3PAGE,PAN(52),PCAS(4),PCKROP(4,10),PCZON(5),PEAK,PRECIP,QI(4,4), 11 100
4QL1(4,4),QMAX(4,5),QO1(4),QOPK(4),QZ(4),R1,RELT,ROOTD(10) 11 110
COMMON RUNON(5),SA1(4,4),SCN(4,4),SDQO(4),SFL(4,2),SETL(4,2),SG1, 11 120
1SGR(4),SL(4),SMAX(4,4),SOILD(4),SQL(4,4),SRUNON(4),SUBPUT(5), 11 130
2SUMFT(4),SUMCN(4),TFMP(52),TIM(5),TTIME,TL(10),TOPD(4),TP,TU(10), 11 140
3VD(4),VDMAX(4),VEG(4),VOL,ZGI(4),ZONE,WPP1(4),WPP2(4) 11 150
INTEGER ZONE
RFAL M
      SET UP A FUNCTION TO CALCULATE THE 11 160
      RIGHT-HAND SIDE OF THE EQUATION. 11 170
C FUNC(D,T,A)=P.+D*T+A*D**1.67 11 180
C      THIS SUBROUTINE ROUTES PRECIPITATION 11 190
C      EXCESS OVERLAND TO THE NEXT ZONE. THE 11 200
C      EQUATION OF OVERLAND FLOW IS: Q=OVA*D**N. 11 210
C      INFLOW TO THIS SYSTEM IS PRECIPITATION 11 220
C      EXCESS. THE PROGRAM USES THE FOLLOWING 11 230
C      FORM OF THE EQUATIONS. 2*DPE/TIME-Q1+2 11 240
C      *D1/TIME=OVA*D2**OVN+2*D2/TIME WHERE DPE 11 250
C      EQUALS CHANGE IN PRECIPITATION EXCESS. 11 260
C      TIME=DELTA TIME. Q1=RATE OF RUNOFF AT THE 11 270
C      BEGINNING OF TIME. D1=STORAGE AT THE 11 280
C      BEGINNING OF TIME. OVA=FUNCTION OF VEGE- 11 290
C      TATION, SLOPE, AND LENGTH. D2=ENDING 11 300
C      STORAGE. N=1.667 ASSUMING TURBULENT FLOW. 11 310
C      THE VALUE OF D2 IS ITERATED UNTIL THE TWO 11 320
C      SIDES OF THE EQUATION BALANCE WITHIN .01. 11 330
C      CALCULATE THE LEFT SIDE OF THE EQUATION. 11 340
C      XLEFT=2.*DPE(ZONE)*RTIM-Q01(ZONE)+2.*D1(ZONE)*RTIM 11 350
C      IF(XLEFT)]10,110,120 11 360
C          IF THE INPUT PLUS STORAGE WILL NOT SUPPORT 11 370
C          HALF THE RATE OF OUTFLOW AT THE BEGINNING 11 380
C          OF DELTA TIME, THEN ALL OF STORAGE AND 11 390
C          INFLOW WILL RUN OFF IN THE DELTA TIME. 11 400
C      110 D2=0.0 11 410
C          D00(ZONE)=D1(ZONE)+DPE(ZONE) 11 420
C          Q02=0.0 11 430
C          GO TO 250 11 440
C          STORAGE AT THE END OF DELTA TIME WILL 11 450
C          NOT BE LARGER THAN INFLOW PLUS PREVIOUS 11 460
C          STORAGE MINUS HALF THE OUTFLOW AT 11 470
C          THE BEGINNING RATE. 11 480
C      120 D2=XLEFT*TTIME*0.5 11 490
C          USE THE FIRST ESTIMATE OF STORAGE AT THE 11 500
C          END OF DELTA TIME TO CALCULATE THE 11 510
C          RIGHT-HAND. 11 520
C          IF(ZGI(ZONE)-OLDGI(ZONE))8,10,R 11 530
C          8 OVA(ZONE)=(1470.-1225.*ZGI(ZONE)*VEG(ZONE))*SL(ZONE)**5/OVL(ZONE) 11 540
C          OLDGI(ZONE)=ZGI(ZONE) 11 550
C          10 RIGHT=FUNC(D2,RTIM,OVA(ZONE)) 11 560
C          IF(RIGHT-XLEFT)240,240,130 11 570
C          IF THE RIGHT-HAND SIDE OF THE EQUATION 11 580
C          IS LARGER, REDUCE THE ESTIMATE OF ENDING 11 590
C          STORAGE AND CHECK TO SEE IF IT IS ZERO. 11 600
C      130 X=D2 11 610
C          D2=X-0.30 11 620
C          IF(D2)150,150,140 11 630
C          140 RIGHT=FUNC(D2,RTIM,OVA(ZONE)) 11 640
C          IF(RIGHT-XLEFT)150,240,130 11 650
C          150 D2=X-0.10 11 660
C          IF(D2)180,180,160 11 670
C          160 RIGHT=FUNC(D2,RTIM,OVA(ZONE)) 11 680
C          IF(RIGHT-XLEFT)180,240,170 11 690
C          170 X=D2 11 700
C          IF(RIGHT-XLEFT)180,240,170 11 710
C          170 X=D2 11 720

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```
      GO TO 150                                11  730
180 D2=X-0.01                                11  740
      IF(D2)>210,210+190                      11  750
190 RIGHT=FUNC(D2,RTIM,OVA(ZONE))            11  760
      IF(RIGHT-XLEFT)>210,240+200          11  770
200 X=D2                                      11  780
      GO TO 180                                11  790
210 D2=X-0.005                               11  800
      IF(D2)>110,110+220                      11  810
220 RIGHT=FUNC(D2,RTIM,OVA(ZONE))            11  820
      IF(RIGHT-XLEFT)>130,130+240          11  830
230 D2=X                                      11  840
C
C
C
C
      WHEN THE TWO SIDES OF THE EQUATION      11  850
      BALANCE, CALCULATE THE RATE ASSOCIATED    11  860
      WITH THE ITERATED STORAGE VALUE AND THE    11  870
      VOLUME OF OUTFLOW FOR DELTA TIME.        11  880
240 Q02=OVA(ZONE)*D2**1.67                  11  890
      D00(ZONE)=D1(ZONE)+DPE(ZONE)-D2        11  900
C
C
      SAVE THE VALUES OF STORAGE AND RATE FOR   11  910
      THE NEXT DELTA TIME.                   11  920
250 D1(ZONE)=D2                                11  930
      Q01(ZONE)=Q02                            11  940
      RRETURN                                    11  950
      END                                       11  960
```

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SUBROUTINE POLLUT (IPAGE,RAIN)
      BY GLORIA STILTNER TO PROVIDE OUTPUT
      FOR COMPUTATIONS OF SOIL EROSION AND
      CHEMICAL TRANSPORT.                                12  10
C      COMMON A(10),ACRES,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN,    12  20
C      1CM,CON1,CON2,CROPS(2,10),CRPVD(10),CVOL(4,4),DI(4),DAILY,DAMO(12),  12  30
C      2DELE,DELET,DELF(4),DELP(300),DELQ(4),DELQZ(4),DELT(300),DELT,DET,  12  40
C      3DPE(4),DQO(4),E,EL(4,2),EP,ETEP(10),ETL(4,2),FC(4),FIL(4),G(4,4),  12  50
C      4GAZ(10),GI(10),GIG(10,52),IREG,IDL,JDYD,IOVER,IPRIN,IPEAD,IROTA  12  60
C      COMMON ITAPE,ITIL,IYDAY,IYR,IYR1,JUL(50),KCUL(10,10),KDATE(10,10)- 12  70
C      1KNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),MIST,MO(5),MSTOR,MYR(5),   12  80
C      2NCHEK,NE,NKROP,NST,NUML,NUMZ+NWEEK,QLDGT(4),OVA(4),OVL(4),        12  90
C      3PAGE,PAN(152),PCAS(4),PCKROP(4,10),PCZON(5),PEAK,PRECIP,Q1(4,4)+ 12 100
C      4QL1(4,4),QMAX(4,5),Q001(4),QOPK(4),QZ(4),R1,PDELT,ROOTD(10)     12 110
C      COMMON RUNON(S),SA1(4,4),SCN(4,4),SDQO(4),SEL(4,2),SETL(4,2),SG1,  12 120
C      ISGR(4),SL(4),SMAX(4,4),SOILD(4),SQL(4,4),SRUNON(4),SUBPUT(5),    12 130
C      2SUMET(4),SUMCN(4),TEMP(52),TIM(5),TIME,TL(10)+TOPD(4),TP,TU(10)+ 12 140
C      3VD(4),VDMAX(4)+VEG(4),VOL,ZGI(4),ZONE,WPP1(4)+WPP2(4)          12 150
C      DIMENSION SM(4,4)
C      INTEGER ZONE
C      REAL M
C
C      IF OUTPUT FROM SUBROUTINE POLLUT IS NOT           12 160
C      WANTED, DUMMY THE WRITE ON DEVICE 9 BY           12 170
C      CHANGING THE DD CARD IN THE JCL TO             12 180
C      //J0BX.FT09001 DD DUMMY                         12 190
C
C      IPOL=9                                         12 200
C      IYDAYP=IYDAY-1                                 12 210
C      DO 142 ZONE=1,4                               12 220
C      DO 142 LAYER=1,4                             12 230
C      142 SM(ZONE,LAYER)=0.0                         12 240
C      DO 141 ZONF=1,NUMZ                           12 250
C      DO 141 LAYFR=1,NUML                          12 260
C      141 SM(ZONE,LAYER)=SMAX(ZONE,LAYER)-SA1(ZONE,LAYER) 12 270
C      IF(IPAGE-10)110,100,110                      12 280
C      100 IPAGE=1                                    12 290
C      WRITE(I,IPOL,1)                                12 300
C      1 FORMAT('1DAILY SUMMARIES FOR INPUT TO POLLUTION')
C      1' *.*YRDAY TEMP    FT      EV      QL
C      2 CN          GR      DQO      RUNON QOPK   SM*/ 12 310
C      3' *.*          L1      L2      L1      L2      L1      L2      L3      L4 12 320
C      4 L1      L2      L3      L4                  L1      L2      L3      L4 12 330
C      54*)                                              12 340
C      110 DO 120 ZONF=1,NUMZ                         12 350
C      WRITE(IPOL,2)IYP,IYDAYP,TEMP(NWEEK),ZONE,(SETL(ZONE,LAYER),LAYER= 12 360
C      11,2),(SEL(ZONE,LAYER),LAYER=1,2),(SOL(ZONE,LAYER),LAYER=1,4)+ 12 370
C      2(SCN(ZONE,LAYER),LAYER=1,4),SDQO(ZONE),SRUNON(ZONE),QOPK(ZONE), 12 380
C      3(SM(ZONE,LAYER),LAYER=1,4)                   12 390
C      2 FORMAT('1',I3,F5.1,1X,'Z',I1,15F6.3+4F7.3) 12 400
C      120 CONTINUE                                     12 410
C      WRITE(IPOL,3)                                12 420
C      3 FORMAT('0')
C      IPAGE=IPAGE+1                                12 430
C      DO 140 ZONF=1,NUMZ                           12 440
C      QOPK(ZONE)=0.0                                12 450
C      SDQO(ZONE)=0.0                                12 460
C      SGR(ZONE)=0.0                                12 470
C      SRUNON(ZONF)=0.0                            12 480
C      DO 130 LAYER=1,2                            12 490
C      SETL(ZONE,LAYER)=0.0                         12 500
C      130 SEL(ZONE,LAYER)=0.0                      12 510
C      DO 140 LAYFR=1,4                            12 520
C      SOL(ZONE,LAYER)=0.0                         12 530
C      140 SCN(ZONE,LAYER)=0.0                      12 540
C      RETURN                                         12 550
C      END                                            12 560
C

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TB-1518 (1975)

USDA

HOLTRAN, H. H.  
ET AL.

(1975)

REvised  
Model

OF WATERSHED HYDROLOGY

TECHNICAL BULLETINS

A UNITED STATES

2 OF 2

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SURROUTINF ROUTE (CMC,IREG1,RP1,CHINI,RDLT)           13 10
COMMON A(10),ACRFS,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN,   13 20
1CM,CON1,CON2,CROPS(2,10),CRPVDF(10),CVOL(4,4),D1(4),DAILY,DAMO(12), 13 30
2DELF,DELET,DELFL(4),DELFL(300),DELQ(4),DELQZ(4),DELFT(300),DELTF,DET, 13 40
3OPE(4),DOO(4),E,EL(4,2),FP,FTEP(10),ETL(4,2),FC(4),FIL(4),G(4,4), 13 50
4GAZ(10),GI(10),GIG(10,52),IREG,TDALY,IHYD,IOVER,IPRN,IREAD,IROTA 13 60
COMMON ITAPE+ITIL,IYDAY,IYR,IYR1,JUL(50),KCUL(10,10),KDATE(10,10), 13 70
1KNO(10),KONT,M(4),MDY(5),MHR(5),MIN(5),MIST,MO(5),MSTOR,MYR(5), 13 80
2NCHEK,NE,NKPOP,NST,NUML,NUMZ,NWEEK,QLDGI(4),QVA(4),OVL(4), 13 90
3PAGE,PAN(5P),PCAS(4),PCKPROP(4,10),PCZON(5),PEAK,PRECIP,O(4,4), 13 100
4QI(4,4),QMAX(4,5),Q01(4),QOPK(4),QZ(4),R1,PDELT,ROOTD(10) 13 110
COMMON RUNON(5),SA1(4,4),SCN(4,4),SD00(4),SFL(4,2),SETL(4,2),SG1, 13 120
1SGR(4),SL(4),SMAX(4,4),SOILD(4),SQL(4,4),SPUNON(4),SURPUT(5), 13 130
PSUMET(4),SUMCN(4),TEMP(52),TIM(5),TIME,TL(10),TOPD(4),TP,TU(10), 13 140
3VD(4),VDMAX(4),VFG(4),VOL,ZGI(4),ZONE,WPP1(4),WPP2(4) 13 150
DIMFNISN QVAZ(4) 13 160
INTFGER ZONE 13 170
RFAL M 13 180

C THIS IS THE CHANNEL ROUTING SUBROUTINE. 13 190
C IT CALCULATES USING A REGULAR TIME 13 200
C INCREMENT (RDELT). 13 210
C CALCULATE THE RATE OF FLOW AT THE END 13 220
C OF THE TIME PERIOD. 13 230
IF(IREG1)>0,10,30 13 240
10 IREG1=1 13 250
XXD=0. 13 260
CHINI=0. 13 270
DO 20 IZ=1,NUMZ 13 280
OVAZ(IZ)=(1470,-1225.*VFG(IZ))*SL(IZ)**.5/OVL(IZ) 13 290
20 XXD=XXD+(OVAZ(IZ)**(-0.6))*PCZON(IZ) 13 300
CMC=CM-XXD 13 310
CON1=2./(CMC+RDELT) 13 320
CON2=(CMC-RDELT)/(CMC+RDELT) 13 330
IF THE CHANNEL ROUTING COEFFICIENT IS LESS 13 340
C THAN THE ROUTING INTERVAL DO NOT ROUTE BUT 13 350
C ASSUME THAT CHIN-CHINI=(R2-R1)*RDELT 13 360
30 IF(CMC-RDELT)>0,40,50 13 370
40 R2=R1-(CHINI-CHIN)*RDLT 13 380
GO TO 60 13 390
50 RP2=CHIN*CON1+RP1*CON2 13 400
R2=(RP1+RP2)*RDELT*.5*CON1+R1*CON2 13 410
C CHECK FOR THE DAILY PEAK RATE. 13 420
60 IF(PEAK>R2)100,110,110 13 430
100 PFAK=R2 13 440
C CALCULATE THE TIME OF THE PEAK. 13 450
TP=KONT*RDELT 13 460
C CALCULATE THE VOLUME OF FLOW FOR THE 13 470
C TIME PERIOD AND ADD IT TO THE DAILY 13 480
C TOTAL. 13 490
110 VOL=(R2+R1)*0.5*RDELT 13 500
DAILY=DAILY+VOL 13 510
IF(RP2-.00001)>120,120,130 13 520
120 R2=0.0 13 530
RP2=0. 13 540
VOL=0. 13 550
130 R1=R2 13 560
CHINI=CHIN 13 570
RP1=RP2 13 580
RETURN 13 590
END 13 600

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SUBROUTINE SURSUR (MZ,V)
COMMON A(10),ACRES,AWC(4,4),BOL,BVD,C(4,4),CASC(4),CDPT(4),CHIN,
1CM,CON1,CONP,CROPS(2+10),CRPWD(10),CVOL(4,4),D1(4),DAILY,DAMO(12),
2DELE,DELET,DELFL(4),DELP(300),DFLQ(4),DELQZ(4),DELT(300),DELT,DET,
3DPE(4),DQD(4),E,EL(4+2),FP,FTEP(10),ETL(4+2),FC(4),FIL(4),G(4,4),
4GAZ(10),GI(10),GIB(10,52),IREG,IDLX,IHYD,IOVER,IPRIN,IREAD,IROTA
COMMON ITAPF,ITIL,IYDAY,IYR,IYR1,JUL(50),KCUL(10,10),KDATF(10,10),
1KNG(10),KONT,M(4),MDY(5),MHR(5),MIN(5),MIST,MO(5),MSTOR,MYP(5),
2NCHEK,NE,NKROP,NST,NUML,NUMZ,NWEEK,OLDGI(4),OVA(4),OVL(4),
3PAGF,PAN(52),PCAS(4),PCKPROP(4,10),PCZON(5),PEAK,PRECIP,Q(4,4),
4QL(4,4),QMAX(4,5),QD1(4),QDPK(4),QD7(4),R1,PODELT,ROOTD(10)
COMMON RUNON(5),SA1(4,4),SCN(4,4),SDQD(4),SEL(4+2),SETL(4+2),SG1,
1SGR(4),SL(4),SMAX(4,4),SOTLD(4),SOL(4,4),SRUNON(4),SURPUT(5),
2SUMET(4),SUMCN(4),TEMP(52),TIM(5),TIME,TL(10),TOPD(4),TP,TU(10),
3VD(4),VDMAX(4),VEG(4)+VOL,ZGI(4),ZONE,WPP1(4),WPP2(4)
DIMENSION FREE1(6,4),FREE2(4),MZ(4,4),Q2(4),QL2(4),SA2(4)
INTEGER ZONE
REAL M,MZ

THIS SUBROUTINE CALCULATES RECOVERY FROM
THE TOP SOIL BY LATERAL FLOW AND DOWN-
WARD SEEPAGE AND ROUTES SEEPAGE THROUGH
THE SERIES OF LAYERS CALCULATING LATEPAL
AND DOWNWARD FLOW FOR EACH LAYER.
SET DELTA INFILTRATION EQUAL TO FLOW
INTO THE FIRST LAYER.

SURPUT(1)=DELFL(ZONE)
LPLUS=NUML+1

IF AVERAGE TEMPERATURE FOR TWO WEEKS IS
LESS THAN 30. REDUCE LATERAL FLOW OF LAYER
1 AS A FUNCTION OF DEGREES BELOW 30. WHEN
TEMPERATURE IS BELOW 20 LATERAL FLOW IN
LAYER 1 STOPS.

IF(NWEEK-NCHEK)12,20,12
12 IF(TBEG)10,10,11
10 AVG=TEMP(NWEEK)
GO TO 14
11 AVG=(TEMP(NCHEK)+TEMP(NWEEK))*0.5
14 IF(AVG-30.)13,15,15
15 V=1.
GO TO 20
13 V=(AVG-20.)*0.1
IF(V.LT.0.)V=0.
20 DO 480 LAYER=1,LPLUS
IF(LAYER-1)110,100,110
100 SA2(1)=SA1(ZONF+1)
IF(C(ZONE+1))1150,150,140
C
CHECK TO SEE IF THE BOTTOM LAYER HAS
BEEN EXCEEDED. IF SO, JUST ADD THE
INFLOW TO THE DEEP GROUND WATER ACCUMU-
LATON AND LEAVE THE LOOP.
110 IF(LAYER-NIML)130,130,120
120 SUMCN(ZONE)=SUMCN(ZONE)+SURPUT(LAYER)
GO TO 480
C
SUBTRACT INFLOW TO THE LAYER FROM THE
AVAILABLE POROSITY.
130 SA2(LAYER)=SA1(ZONE+LAYFR)-SURPUT(LAYER)
C
CHECK FOR FREE WATER IN THE LAYER. IF
NONE, SET OUTFLOWS EQUAL TO ZERO AND
CONTINUE.
140 IF(G(ZONE+LAYER)-SA2(LAYFR))150,150,160
150 Q2(LAYER)=0.0
FREE2(LAYER)=0.0
SURPUT(LAYER+1)=0.0
DELQ(LAYER)=0.0
DL2(LAYER)=0.0
GO TO 460
C
CALCULATE CURRENT FREE WATER AMOUNT.
160 FREE1(ZONF+LAYFR)=G(ZONE+LAYER)-SA2(LAYFR)
IF(MZ(ZONF+LAYFR))180,180,170
170 Q1(ZONF+LAYFR)=FREE1(ZONF+LAYFR)/MZ(ZONE+LAYER)
180 SURPUT(LAYER+1)=C(ZONE+LAYER)*TIME*FREE1(ZONF+LAYFR)/G(ZONF+LAYER)
TEST=FREE1(ZONE+LAYFR)-SURPUT(LAYER+1)
14 10
14 20
14 30
14 40
14 50
14 60
14 70
14 80
14 90
14 100
14 110
14 120
14 130
14 140
14 150
14 160
14 170
14 180
14 190
14 200
14 210
14 220
14 230
14 240
14 250
14 260
14 270
14 280
14 290
14 300
14 310
14 320
14 330
14 340
14 350
14 360
14 370
14 380
14 390
14 400
14 410
14 420
14 430
14 440
14 450
14 460
14 470
14 480
14 490
14 500
14 510
14 520
14 530
14 540
14 550
14 560
14 570
14 580
14 590
14 600
14 610
14 620
14 630
14 640
14 650
14 660
14 670
14 680
14 690
14 700
14 710
14 720

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IF(TEST)190,200,200          14 730
190 SURPUT(LAYFR+1)=FREE1(ZONE,LAYER)      14 740
200 IF(LAYER=MUML)210,230,210          14 750
210 TEST=SA1(ZONE,LAYER+1)-SUBPUT(LAYER+1) 14 760
    IF(TEST)220,230,230          14 770
220 SURPUT(LAYER+1)=SA1(ZONE,LAYER+1)      14 780
230 SA2(LAYER)=SA2(LAYER)+SURPUT(LAYER+1) 14 790
    FREE1(ZONE,LAYER)=FREE1(ZONE,LAYER)-SURPUT(LAYER+1) 14 800
    IF(MZ(ZONE,LAYER))250,250,260          14 810
C                                     CALCULATE DOWNWARD PERCOLATION. 14 820
250 Q2(LAYER)=0.          14 830
    QL2(LAYER)=0.0          14 840
    DELQ(LAYER)=0.          14 850
    GO TO 460          14 860
C                                     CALCULATE OUTFLOW FROM THE PEGIME. 14 870
260 X=2*MZ(ZONE,LAYER)          14 880
    CHECK=QZ(ZONE)+R1          14 890
    IF(LAYER=1)310,300,310          14 900
300 B=G(ZONE,LAYER)/(MZ(ZONE+1)-CM)      14 910
    GO TO 321          14 920
310 B=G(ZONE,LAYER)/(MZ(ZONE,LAYER)-MZ(ZONE,LAYER-1)) 14 930
320 W=(R-CHECK)/R          14 940
    IF(W)330,330,340          14 950
330 IF(FREE1(ZONE,LAYER))340,340,350 14 960
340 FREE1(ZONE,LAYER)=0.0          14 970
350 Q2(LAYER)=FREE1(ZONE,LAYER)/MZ(ZONE,LAYER)      14 980
    DELQ(LAYER)=0.0          14 990
    QL2(LAYER)=0.0          14 1000
    GO TO 450          14 1010
360 TEST= 4.*TTMF-X          14 1020
    QO1=Q1(ZONE,LAYER)          14 1030
    IF(TEST)370,380,380 14 1040
370 NLOOP=1          14 1050
    Y=SURPUT(LAYER)-SUBPUT(LAYER+1) 14 1060
    GO TO 390          14 1070
380 SAVE=TIME          14 1080
    NLOOP=TIME*P./MZ(ZONE,LAYER)+0.5 14 1090
    TIME=TIME/NLOOP          14 1100
    Y=(SURPUT(LAYER)-SUBPUT(LAYER+1))/NLOOP 14 1110
390 Z=(X-TIME)/(X+TIME)          14 1120
    DO 400 KOUNT=1,NLOOP          14 1130
C                                     CALCULATE LATERAL OUTFLOW. 14 1140
    Q2(LAYER)=P.*Y/(X+TIME) + QO1*Z 14 1150
400 QO1=Q2(LAYER)          14 1160
    IF(NLOOP=1)420,420,410 14 1170
410 TTMF=SAVE          14 1180
420 IF(LAYER.GT.1) V=1.          14 1190
    QL2(LAYER)=Q2(LAYER)*W*V 14 1200
C                                     IF Q2 IS NEGATIVE. SET IT TO ZERO. 14 1210
    IF(Q2(LAYER)<-.0000001)430,430,440 14 1220
430 Q2(LAYER)=0.0          14 1230
    QL2(LAYER)=0.0          14 1240
    DELQ(LAYER)=FREE1(ZONE,LAYER)      14 1250
    FREE2(LAYER)=0.0          14 1260
    GO TO 460          14 1270
440 DELQ(LAYER)=(QL2(LAYER)+Q1(LAYER))/2.0*TIME 14 1280
450 X=FPEE1(ZONE,LAYER)-DELQ(LAYER)      14 1290
    IF(X)430,430,460          14 1300
C                                     SAVE VALUES AT END OF DELTA TIME FOR USE 14 1310
C                                     IN NEXT PASS AND CACULATE NEW POROSITY. 14 1320
460 Q1(ZONE,LAYER)=Q2(LAYER)          14 1330
    QL1(ZONE,LAYER)=QL2(LAYER)          14 1340
    QZ(ZONE)=QZ(ZONE)+QL2(LAYER)      14 1350
C                                     ADJUST THE STORAGE AVAILABLE BY THE 14 1360
C                                     VOLUME OF OUTFLOW. 14 1370
    SA1(ZONE,LAYER)=SA2(LAYER)+DELQ(LAYER) 14 1380
480 CONTINUE          14 1390
    RETURN          14 1400
    END          14 1410

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C           ZC= DEEP PERCOLATION LOSS.          15 730
C           ZP= OVERLAND FLOW.                 15 740
C
C DO 150 ZONF= 1,NUMZ                         15 750
C ZC(ZONE,MIST)=ZCM(ZONE,MIST)                15 760
C ZP(ZONE,MIST)=ZPEM(ZONE,MIST)                15 770
C ZB(ZONE,MIST)=ZBAM(ZONE,MIST)                15 780
C ZO(ZONE,MIST)=ZOFST(ZONE,MIST)               15 790
C IF(MN-MIST)>150,150,130                      15 800
C
C 130 MX=MIST+1                                15 810
C DO 140 MI=MX,MN                            15 820
C ZP(ZONE,MI)=ZPEM(ZONE,MI)-ZPEM(ZONE,MI-1)   15 830
C ZB(ZONE,MI)=ZBAM(ZONE,MI)-ZBAM(ZONE,MI-1)   15 840
C ZO(ZONE,MI)=ZOFST(ZONE,MI)-ZOFST(ZONE,MI-1)  15 850
C 140 ZC(ZONE,MI)=ZCM(ZONE,MI)-ZCM(ZONE,MI-1)  15 860
C 150 CONTINUE                                 15 870
C
C           WRITE ZONE MONTHLY SUMMARY.        15 880
C
C DO 160 MX=MIST,MN                          15 890
C 160 WRITE(IPRIN,6)MX,(ZP(ZONE,MX)+ZB(ZONE,MX)+ZO(ZONE,MX),ZC(ZONE,MX),+ 15 900
C 1ZONE=1,NUM7)
C 6 FORMAT(15.4(1X,F6.2,1X,F6.2+1X,F6.2,1X,F6.2,2X)) 15 920
C WRITE(IPRIN,7)(ZPEM(ZONE,MN)+ZRAM(ZONF,MN)+ZOFST(ZONE,MN)+ZCM(ZONE 15 930
C 1,MN),ZONE=1,NUM7)
C 7 FORMAT(*OTOTAL*,F6.2+3F7.2,2X,3(4F7.2,2X))
C WRITE(IPRIN,8)
C 8 FORMAT(*OTHF FOLLOWING ARE SA VALUES IN INCHES AT THE TIME THE ABO 15 970
C 1VE SUMMARY WAS PRINTED:*) 15 980
C
C           WRITE THE STORAGE AVAILABLE IN ZONE SUR- 15 990
C FACE INCHES FOR THE SOIL LAYERS.            15 1000
C
C DO 170 ZONF=1,NUMZ                         15 1010
C 170 WRITE(IPRIN,9)ZONE,(SA1(ZONE,LAYER),LAYER=1,NUML) 15 1020
C 9 FORMAT(* ZONF=*,1S,4F10.4)
C
C           WRITE RESTART ANTECEDENT SOIL MOISTURE 15 1040
C PERCENTS AND WATERSHED SURFACE INCHES PER 15 1050
C HOUR FOR THE RATE OF INITIAL FLOW. THESE 15 1060
C VALUES WILL GIVE STARTING VALUES IN CASE 15 1070
C THERE IS A FAILURE IN THE MIDDLE OF A 15 1080
C LONG RUN. THE VALUES ARE FOR DEC. 31 AT 15 1090
C 2400 OF THE YEAR BEING SUMMARIZED OR FOR 15 1100
C THE LAST INPUT RAINFALL OBSERVATION DATE 15 1110
C AND TIME.                                     15 1120
C
C RATE=R
C DO 180 ZONF=1,NUMZ                         15 1130
C 180 RATE=RATE+07(ZONF)*PCZON(ZONE)
C WRITE(IPRIN,10)
C 10 FORMAT(*OT///* THE FOLLOWING ARE RF-START VALUES TO APPROXIMATE WAT 15 1170
C 1ERSHED CONDITIONS AT THE TIME THE ABOVE SUMMARY WAS PRINTED:*) 15 1180
C WRITE(IPRIN,11)PATE
C 11 FORMAT(*N* INITIAL STREAM FLO=*,F10.5) 15 1200
C WRITE(IPRIN,12)
C 12 FORMAT(5X,*ZONE% ASM1      % ASM2*)
C           CALCULATE AND PRINT THE TOTAL BALANCE 15 1230
C FIGURE. THIS NUMBER SHOULD BE CLOSE TO 15 1240
C ZERO! LARGE VALUES INDICATE PROGRAM BUGS 15 1250
C OR BAD INPUT. NORMALLY THE FIGURE IS 15 1260
C LESS THAN 0.1.                                15 1270
C
C EVD=0.
C EOL=0.
C ENDSA=0.
C VDSTG=0.0
C DO 190 ZONF=1,NUMZ                         15 1280
C EVD=EVD+VD(ZONF)*PCZON(ZONE)                15 1290
C EOL=EOL+DL(ZONF)*PCZON(ZONE)                15 1300
C X1=(SMAX(ZONE+1)-SA1(ZONE+1))/TOPD(ZONE)*100. 15 1310
C X2=(SMAX(ZONE+2)-SA1(ZONE+2))/(SOILD(ZONE)-TOPD(ZONE))*100. 15 1320
C WRITE(IPRIN,13)ZONF,X1,X2
C 13 FORMAT(4X,1S,5X,2(F10.3,5X))
C DO 190 LAYER=1,NUML
C 190 ENDSA=ENDSA+SA1(ZONF,LAYER)*PCZON(ZONE) 15 1330
C VDSTG=EVD-PVD
C OLSTG=EOL-ROL
C DLTS=REGSA-ENDSA
C CSTG=CMC*(P1-BFGR1)
C

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```
BAL=TRAN-ETYR-YEARLY-EYR-DLTSACN-CSTG-VDSTG-OLSTG-WOFST      15 1450
BEGSA=ENDSA                                              15 1460
BVD=EVD                                              15 1470
BOL=EOL                                              15 1480
BFGRI=R1                                             15 1490
WRITE(IPRIN,14)RAL                                     15 1500
14 FORMAT(10 PAIN - ET - RUNOFF - E - CN - SOIL 15 1510
I - CHANNEL - DEPRESSIONS-OVERLAND-OFFSITE =*,F8.3) 15 1520
  WRITE(IPRIN,16)TRAN,ETYR,YEARLY,EYR,CN,DLTSACN,CSTG,VDSTG,OLSTG 15 1530
15 WOFST                                              15 1540
16 FORMAT(10F10.3)                                     15 1550
RETURN                                              15 1560
END                                                 15 1570
```

**END**