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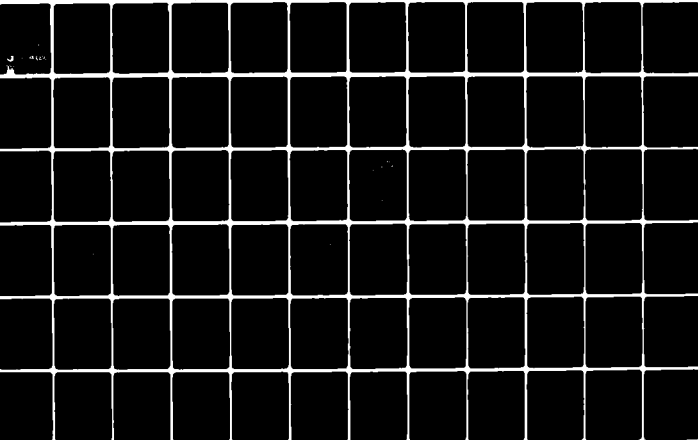
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AIR FORCE RUNOFF MODEL (AFRUM) USER MANUAL DOCUMENTATION.(U)
JUL 80 D E OVERTON, G W SCHLOSSNAGLE F08635-77-C-0254

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AIR FORCE RUNOFF MODEL (AFRUM) USER MANUAL DOCUMENTATION

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JULY 1980

FINAL REPORT

OCTOBER 1978 - JULY 1980

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Air Force Runoff Model (AFRUM) is a stormwater runoff simulation model designed to predict stormwater flow and quality resulting from real or design storms for small watersheds generally limited to 2,000 acres or less. The principal model inputs are watershed area, land use characteristics, percent forested, percent impervious, and percent denuded. The input will also include either an observed hydrograph or an estimated Soil Conservation Service Curve Number (CN). The model is based upon 410 storms in 36 watersheds. Output is both tabular and graphical and provides the watershed hydrograph, pollutograph,			

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20. ABSTRACT (Concluded).

- > and discussion of model assumptions. This report provides a background of the model, batch user instructions for CDC 6600 computers, and two example problems. The complete software package is provided in the Appendix.

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PREFACE

This report contains the Air Force Runoff Model (AFRUM) computer program user instructions and documentation developed during the period October 1978 - July 1980 under contract FO8635-77-C-0254 with the University of Tennessee, Knoxville, Tennessee 37916. Captain George W. Schlossnagle managed the project and modified the final product with the assistance of Sgt Mike Siebert to improve the user orientation.

A special thanks is given to the Grissom AFB civil engineers, civil engineering personnel and weather personnel, and the 6th Weather Squadron personnel of Tinker AFB for their excellent support of the project's data collection phase.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

The Air Force Runoff Model (AFRUM) for simulating storm hydrographs and pollutant yields was developed for the U.S. Air Force by the Department of Civil Engineering at the University of Tennessee, Knoxville. The results of three separate but complementary studies had the same fundamental objectives, i.e., to evaluate the effects of specialized land use on stormwater runoff and its associated quality. The three studies were funded by the following three Federal agencies and dealt with the land use indicated:

<u>Federal Agency</u>	<u>Contract-Grant No.</u>	<u>Study</u>	
		<u>Period</u>	<u>Land Use</u>
U.S. Department of Energy	EY-76-S-05-4946	1975-79	Coal Strip Mining
U.S. Department of Interior Office of Water Resources Technology	TENN-A-046	1976-78	Urbanization
U.S. Air Force	F08635-77-C-0254	1975-79	Air Force Bases

AFRUM was developed in the course of analyzing 410 storms observed on 36 watersheds. The storm sample included watersheds

in agricultural, urban, and 100 percent forested land use conditions as well as watersheds undergoing coal strip mining and three watersheds at Grissom AFB, Indiana. AFRUM was extensively modified by the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida to increase the user utility by modification of input and output formats and simplification of internal processes.

SECTION II

OBJECTIVE OF AFRUM

AFRUM was developed for the purpose of simulating stormwater hydrographs from a realtime or design storm rainfall distribution, land use and soil type of the watershed of interest. The watershed is considered to be a lumped system, and the required basin characteristics are percent of watershed that is forested (PF), percent that is impervious (PI), percent in strip mining or denuded (PS), and surface drainage area in square miles (SQMI).

Runoff volume and the associated rainfall excess time distribution are simulated from the input rainfall using the U.S. Soil Conservation Service Curve Number Model (Reference 1). If a runoff hydrograph (stormwater flow rates out of the basin) is read into the program associated with a rainfall hyetograph (rainfall distribution), the program will compute a Curve Number (CN) from this information. Otherwise, a CN must be read into the computer and would be simulated using the procedures specified in Reference 1.

AFRUM makes provision for simulating a unit hydrograph or unit response function (URF), which is convoluted with the rainfall excess hyetograph. This computer program is an adaptation of the simulation phase of the TVA double triangle model reported by Ardis (Reference 2) and later modified by Betson (Reference 3).

A more detailed description of the development of AFRUM has been reported by Overton, Troxler and Crosby (Reference 4), Overton and Crosby (Reference 5), and CEEDO-TR-77-18.

AFRUM also simulates pollutant loads for the associated storm. This simulation is a function of the specified watershed and storm characteristics. Hence, additional parameters are not needed.

SECTION III

HARDWARE AND SOFTWARE REQUIREMENTS

The computer model described in this manual is written in Fortran IV and operates on CDC 6600 computers under the NOSBE operating system. The program requires approximately 56K bytes of usable core capacity and approximately 6CPU seconds to compile and execute. Input is accomplished by a card reader, and the output is accomplished by a 132 position line printer. The plot subroutine, HYPLOT, within this program utilizes a Calcomp Electromechanical Plotter.

1. Input Requirements

AFRUM accepts the following input:

- a. Accumulated storm rainfall at equal time intervals, DT.
- b. Stormwater discharge flow rates at equal time intervals, DT (this hydrograph may be used if available).
- c. Watershed characteristics
 - (1) Curve Number (CN) which can be estimated using Table 1. If the hydrograph is read in, CN is calculated.
 - (2) Drainage area in square miles (SQMI).
 - (3) Percent forest (PF).

TABLE 1. RUNOFF CURVE NUMBERS FOR URBAN AND SUBURBAN AREAS
(ANTECEDENT MOISTURE CONDITIONS II AND III; $I_a = 0.2S$)**

		Curve numbers by antecedent moisture conditions							
Zoning Classification	Percent Imperviousness	II				III			
		Hydrologic Soil*				Hydrologic Soil*			
		A	B	C	D	A	B	C	D
Business, industrial, or commercial	75	82	88	90	91	92	95	96	97
Apartment houses	65	78	85	88	90	90	94	95	96
Schools	45	68	78	84	87	84	90	93	95
Urban residential (Lots $\pm$ 10,000 ft ²)	40	65	77	83	86	82	89	93	94
Suburban residential (Lots $\pm$ 12,000 ft ²)	35	62	76	82	85	80	89	92	94
Suburban residential (Lots $\pm$ 17,000 ft ²)	30	60	74	81	84	78	88	92	93
Suburban residential	25	58	72	80	84	77	86	91	93
Parks and cemeteries	20	55	71	79	83	74	86	91	93
Unimproved areas	15	53	70	78	92	73	85	90	92
Lawns	0	45	65	75	80	66	82	88	91
Woods	0	36	60	73	79	-	-	-	-
Meadow (permanent)	0	30	58	71	78	-	-	-	-
Pasture or range	0	49	69	79	84	-	-	-	-

SCS National Engineering Handbook, Section 4, Table 15.1 "Percent of Imperviousness for Various Densities of Urban Occupancy."

*Soils are divided into four hydrologic soils groups: A, B, C, and D. Group A soils have a high infiltration rate even when thoroughly wet. When thoroughly wet, group B soils have a moderate infiltration rate, group C soils have a slow infiltration rate, and group D soils have a very slow infiltration rate. Table 7.1 of Reference 1 lists more than 9,000 soils and their hydrologic group.

**Antecedent Moisture Condition II is an average condition where III has the highest runoff potential. Condition II means soils in the watershed are practically saturated from antecedent rains.

- Data unavailable.

(4) Percent impervious (PI).

(5) Percent strip mined or denuded (PS).

2. Output provided

- a. Title banner page.
- b. Introduction to the model.
- c. Discussion of assumptions made by user.
- d. User input data.
- e. Adjusted model parameters.
- f. Simulated storm hydrograph (graphical and tabular).
- g. If read in, observed storm hydrograph (graphical and tabular).
- h. Suspended sediment storm load, Mn, Fe, Ca, Mg, SO_4 , and total alkalinity storm loads.

SECTION IV

DESCRIPTION OF AFRUM

1. Simulation of Direct Storm Runoff.

This program simulates direct runoff volume and rates using the Curve Number model of the U.S. Soil Conservation Service (Reference 1). All losses except evapotranspiration are lumped into a single initial abstraction. The model correlates the rainfall-direct runoff relations as a function of soil type, land use, and hydrologic condition.

For simple storms (high intensity and of short duration), the retention relative to the potential maximum retention S bears the following relation:

$$\frac{P - Q - I_a}{S} = \frac{Q}{P - I_a} \quad (1)$$

where P is storm rainfall in inches, Q is the direct storm runoff or effective rainfall in inches, and I_a is the initial abstraction in inches which is a measure of antecedent moisture. Initial abstraction includes surface storage, interception, and infiltration prior to runoff. The concept behind this method is for a given basin soil and land use condition, there is a maximum possible retention as storm rainfall increases, storm runoff will increase as defined by Equation (1). Storm runoff can be solved as follows:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \quad (2)$$

An empirical relation (Reference 6) for initial abstraction ($I_a = 0.2S$) is inserted and Equation (2) becomes

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \quad (3)$$

which is the relation used in the SCS method of estimating direct runoff from storm rainfall.

The runoff equation has been placed in graphical form with the main parameter being watershed retention, S , where S was related to the Curve Number, CN , as

$$S = \frac{1000}{CN} - 10 \quad (4)$$

Equations (2) and (4) show the interrelationships between CN , soils, land use, and hydrologic condition for average antecedent moisture conditions and are shown in the SCS Engineering Handbook (Reference 1) and summarized in Table 1.

Although Equation (3) was intended to simulate runoff volume it has been used extensively to simulate runoff rates by allowing P and Q in Equation (3) to represent accumulated storm rainfall and runoff volumes. Hence, incremental rainfall excess rates in each time period $i_e(j)$ are simulated as

$$i_e(j) = \frac{Q(j) - Q(j-1)}{DT}$$

where $Q(j)$ and $Q(j-1)$ are accumulated storm runoff volume at times $j \cdot DT$ and $(j-1) \cdot DT$, respectively, where j is the time increment number.

2. Simulation of Storm Hydrograph

a. Normalized Unit Response Function (NURF)

The Unit Response Function (URF) in AFRUM is based upon Ardis' (Reference 2) quadrilateral function. The URF was coupled with the CN model to form the TVA double triangle model. The shape of the URFs and associated CNs have been optimized on a total of 410 storms in 36 watersheds.

The quadrilateral URF is based on the concept that the initial response from a watershed comes from the riparian areas, and as other areas of the watershed become saturated, they too begin to contribute to runoff in the form of a delayed response. It is assumed that these two responses can be simulated by two separate triangle response functions as shown in Figure 1. When added together, these two triangles form the quadrilateral unit response function.

Symbols used in the figure are:

I = Precipitation excess intensity in inches per hour.
Since the volume of input is one basin-inch = $1/DT$.

DT = Time interval used in abstracting rainfall and discharge record in hours.

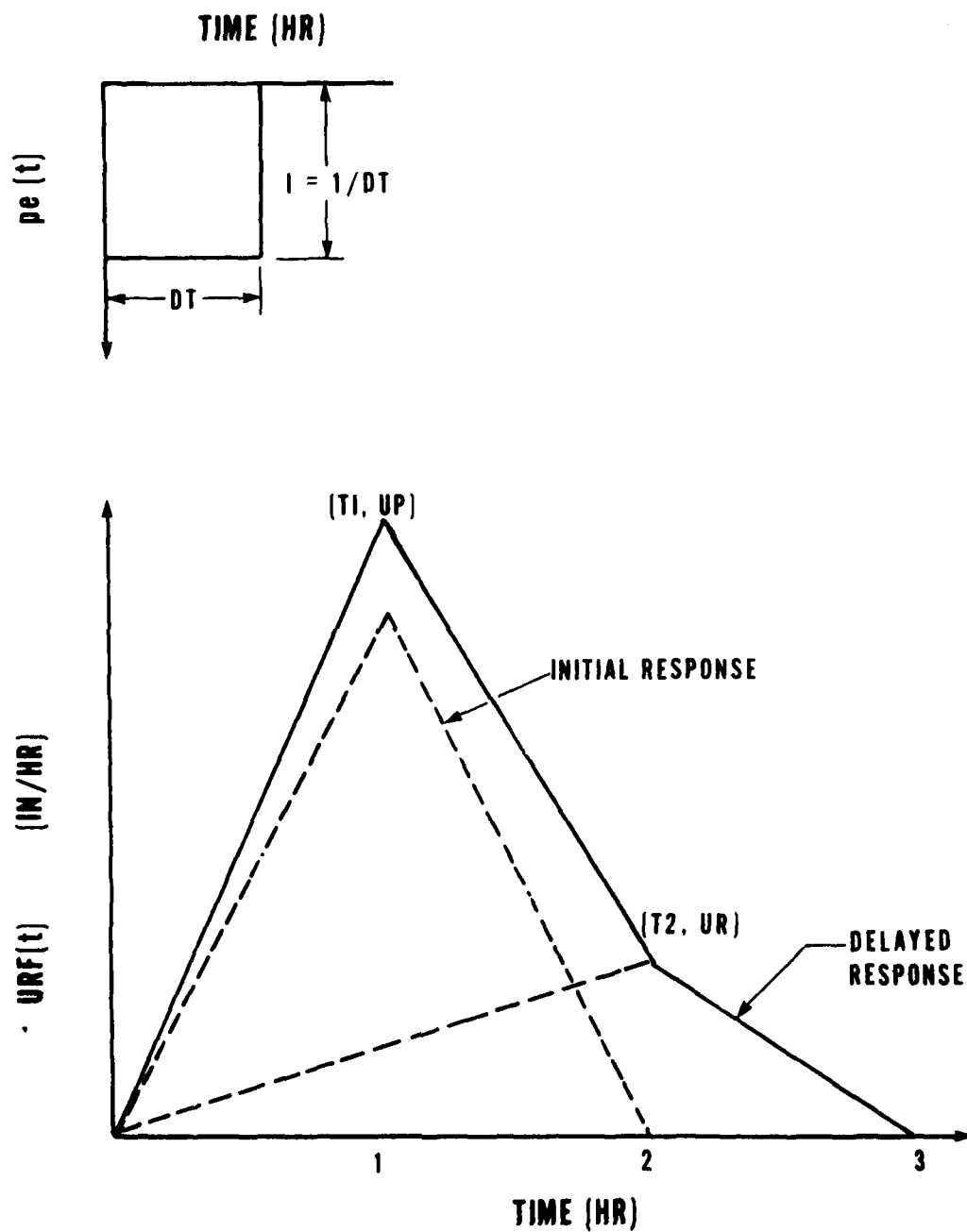


Figure 1. Double Triangle Model for Unit Response Function.

UP = Peak of unit response function at T1.

UR = Peak of delayed response at T2.

T1 = Time to peak of initial response, hours.

T2 = Time base of initial response and equal to the time of peak of delayed response, hours.

T3 = Time of end of delayed response, hours.

pe(t) = precipitation excess as a function of time, t, in inches per hour.

URF(t) = unit response function ordinate as a function of time, t, in inches per hour.

In deriving the URF, it is assumed that the peak of the delayed response (UR) occurs at the end of the initial response (T2), and the time bases of both responses and the time to peak of the initial response are integer multiples of DT. No assumption is made concerning the relative volumes contained in the initial and delayed responses or concerning the relative magnitudes of the peaks of the individual responses.

The double triangle URF is defined by the five parameters UP, UR, T1, T2, and T3. T3 is determined by:

$$T3 = (NOBS - NRAIN + 1) * DT$$

where NOBS = number of storm hydrograph ordinates in multiples of DT and NRAIN = number of rainfall increments in multiples of DT.

By maintaining a unit volume, UR is calculated from:

$$UR = (2 - [UP * T2] / [T3 - T1])$$

Therefore, defining a storm URF involves determining values of UP, T1, and T2.

The parameters UP, T1, and T2 are optimized using the pattern search technique. The objective function is the minimization of the sum of squares of errors between observed and simulated discharges. Since all five parameters describing the model are allowed to vary from storm to storm, the model is considered nonlinear. Rainfall excess is optimized using the SCS-Curve Number model after setting it equal to the observed direct runoff volume.

The variability of the URF from storm to storm within a watershed was explained by normalizing the time and discharge scale by the associated URF lag time, TL, where TL = time lapse between occurrences of 50 percent of the rainfall excess block and 50 percent of the URF volume. These normalized URFs are referred to as NURFs.

The NURF for each major land use category has been identified empirically, and are shown in Figure 2. The categories are: strip mined, 100 percent forest, urban without extensive storm sewers, urban with extensive storm sewers, and agricultural. As a matter of providing a reference, the NURF

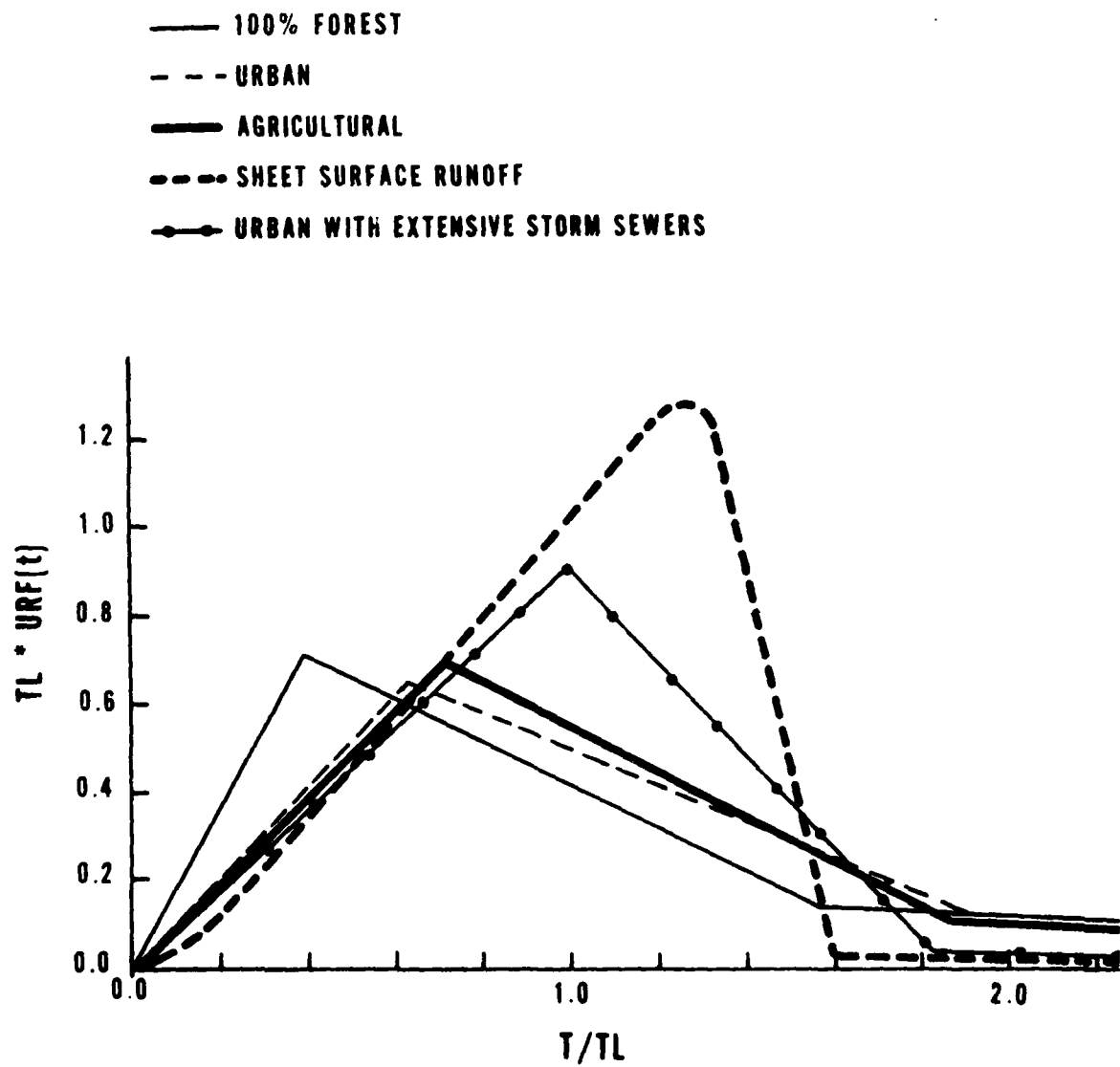


Figure 2. NURF for Various Land Use Conditions.

observed for sheet surface runoff from a plane (Reference 6) is shown. The strip mined watersheds were previously in 100 percent forested areas. Hence, a pattern is shown where the forested and strip mined watersheds have a small initial response whereas the urban and agricultural watersheds have a larger initial response. This implies that imperviousness and crop land produce much more surface runoff. The storm sewered NURF has an even higher initial response, which is generated by runoff collection systems. Sheet surface runoff has no delayed response.

b. Lag Time

Lag time, TL, for a storm is simulated in AFRUM using the concept that it varies inversely with the rainfall excess intensity. AFRUM uses a weighted rainfall excess intensity (WRE)

$$WRE = \frac{\sum_{j=1}^N i_e^2(j)}{\sum_{j=1}^N i_e(j)} \quad (8)$$

where N is the number of time intervals equal to DT. The weighted storm rainfall intensity is given the exponent 0.4 (References 4 and 5). The following equation is used to calculate the time lag

$$TL \text{ (min)} = \mu / WRE^{0.4} \quad (9)$$

where lag modulus, μ , is empirically related to watershed characteristics in the following manner:

(1) For rural watersheds

$$\mu(\text{hr}) = 0.060 * \text{SQMI} + 0.0203 * \text{PF} + 1.16 \quad (10)$$

(2) For urban watersheds

$$\mu(\text{hr}) = 3.24 (\text{SQMI}/\text{PI})^{0.6} \quad (11)$$

c. Convolution of URF

The final step in simulating a stormwater hydrograph is to convolute the storm URF with the rainfall excess time distribution. The URF is defined by simulating storm lag time from Equation (9) using with either Equation (10) or (11), depending on the watershed land use. WRE is calculated by Equation (8).

3. Simulation of Pollutant Yield

a. Load Modulus

AFRUM simulates storm pollutant yield using a load modulus (lb/acre-in of storm runoff) as a function of percent stripped or denuded (PS), lag modulus (μ), and percent forest or trees (PF), in the following form:

$$\mu_w = C_1 * \text{PS} - C_2 * \mu * \text{PF} + C_3 \quad (12)$$

The coefficients were optimized using stormwater quality data on a total of eleven watersheds; six of them were undergoing coal

strip mining and five were urbanized (Reference 5). Equation (12) was derived from a mass balance, and each of its terms represents a component of pollutant yield.

$C_1 * PS$ = source of pollutant or soil loss

$C_2 * \mu * PF$ = deposition between source and outfall, and

C_3 = storage in watershed picked up and redeposited.

The coefficients optimized for the coal strip mined and urbanized watersheds are shown in Table 2. The coefficients were previously presented in References 4 and 5.

b. Storm Load

Once load modulus for the watershed pollutant has been simulated, the storm pollutant yield, SPY, is simulated by

$$SPY = \mu_w * AREA * 640 * SRO \quad (13)$$

where SRO is the total storm runoff in surface inches, and AREA is in acres.

TABLE 2. COEFFICIENTS IN POLLUTANT YIELD MODEL

FOR EQUATION (12)

URBAN

Pollutant	Coefficients		
	Source C_1	Deposition C_2	Storage C_3
Suspended Solids	16.7	21.5	62.3
Fe	0.442	0.568	1.54
Mn	0.0072	0.0092	0.20
Ca	0.147	0.189	2.45
Mg	0.0597	0.113	0.0323
Sulfate	0.0719	0.0216	1.24
Total Alkalinity	0.319	0.128	6.71

COAL STRIP MINED (Active)

Suspended Solids	18.2	1.28	576.7
Fe	0.323	0	0.12
Mn	0.0161	0	0.002
Ca	0.131	0	0.38
Mg	0.133	0	0.40
Sulfate	1.39	0	2.45
Total Alkalinity	0.19	0	2.00

SECTION V

INSTRUCTIONS FOR DATA PREPARATION

The data cards should be prepared according to Figure 3 and Table 3. Figure 3 shows the layout of the data cards in the order in which they must be read into the computer. Table 3 shows how the data are to be punched and lists the description of variables used in the program.

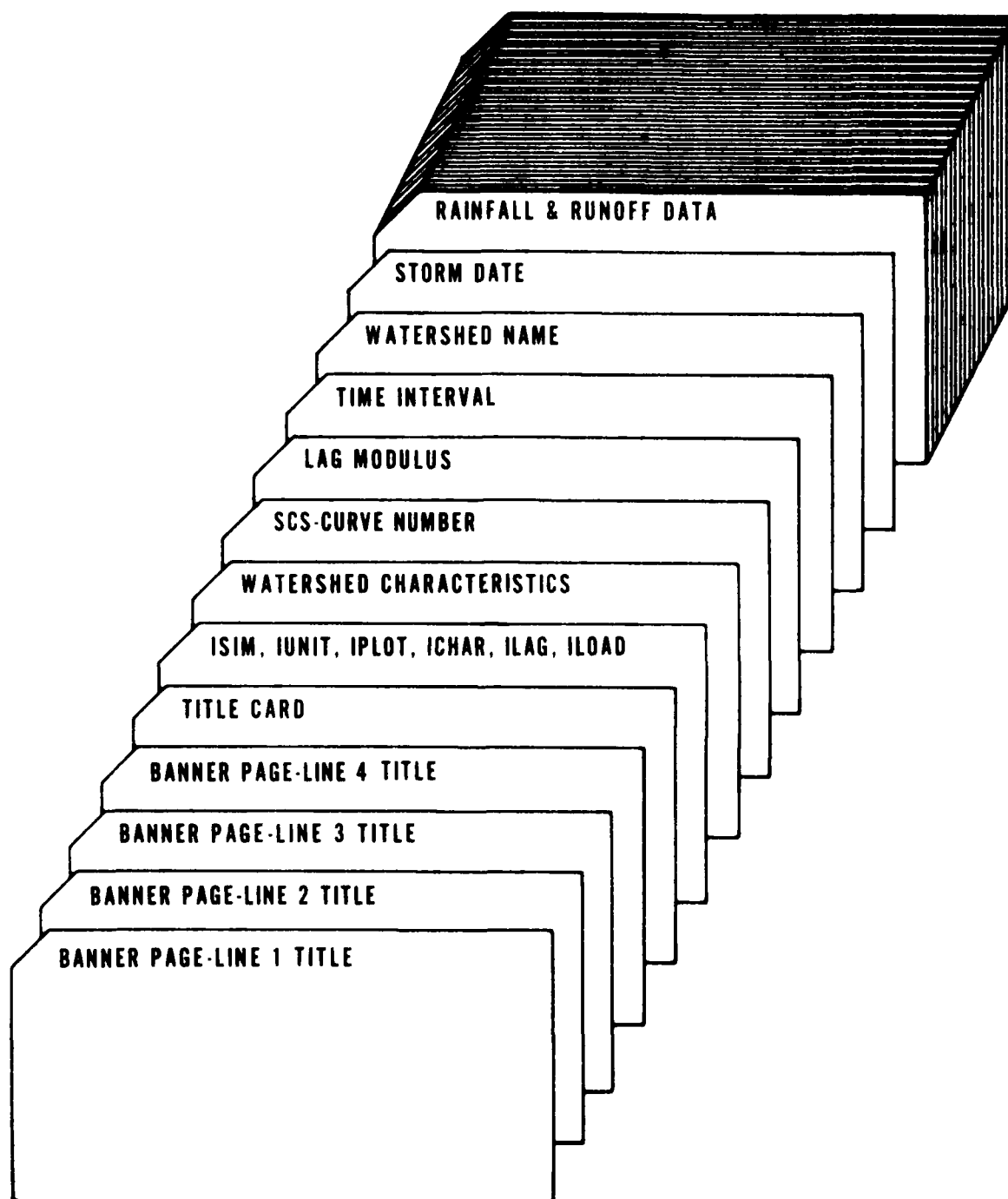


Figure 3. Data Deck for AFRUM

TABLE 3. AFRUM CARD DATA

U.S. AIR FORCE RUNOFF MODEL (AFRUM)

A STORM HYDROGRAPH SIMULATION MODEL DEVELOPED FOR THE AIR FORCE ENGINEERING SERVICES CENTER, TYNDALL AFB, FLORIDA BY DR DONALD OVERTON OF THE UNIVERSITY OF TENNESSEE, PRINCIPAL INVESTIGATOR AND GEORGE W. SCHLOSSNAGLE, CAPT USAF, BSC, PROJECT OFFICER

AFRUM		
CARD NO.	FORMAT/ COLUMNS	VARIABLE NAMES AND DESCRIPTION
1	(12A1)/ (1-12)	BANNER PAGE - 1ST LINE -- USER DESCRIPTION
2	(12A1)/ (1-12)	BANNER PAGE - 2ND LINE -- USER DESCRIPTION
3	(12A1)/ (1-12)	BANNER PAGE - 3RD LINE -- USER DESCRIPTION
4	(12A1)/ (1-12)	BANNER PAGE - 4TH LINE -- USER DESCRIPTION
5	(20A4)/ (1-80)	TITLE NAME AND LOCATION OF WATERSHED
6	(6I4)/ (1-4)	ISIM,IUNIT,IPL0T,ICHAR,ILAG,ILOAD ISIM-A CONTROL VARIABLE TO SPECIFY THE TYPE OF DATA SUPPLIED TO THE PROGRAM ISIM=1 ONLY RAINFALL DATA IS SUPPLIED AND AN ESTIMATE MUST BE MADE OF THE SCS CURVE NUMBER
	(5-8)	IUNIT-A CONTROL PARAMETER TO SPECIFY OUTPUT UNITS OF SIMULATED HYDROGRAPH IUNIT=0 UNITS ARE IN INCHES/HR IUNIT=1 UNITS ARE IN CFS
	(9-12)	IPL0T-A CONTROL PARAMETER TO DETERMINE IF OUTPUT IS PLOTTED IPL0T=0 NO PLOT IS PRODUCED IPL0T=1 A PLOT IS PRODUCED
	(13-16)	ICHAR-A CONTROL PARAMETER TO SPECIFY IF LAND USE IS URBAN (WITH OR WITHOUT EXTENSIVE STORM SEWERS), AGRICULTURAL, COAL STRIP MINED OR 100% FOREST ICHAR=0 URBAN WITHOUT STORM SEWERS ICHAR=1 URBAN WITH STORM SEWERS ICHAR=2 COAL STRIP MINED ICHAR=3 AGRICULTURAL ICHAR=4 FORESTED

TABLE 3. AFRUM CARD DATA (CONTINUED)

(17-20) ILAG-A CONTROL PARAMETER TO DETERMINE IF LAG
MODULUS IS READ IN OR SIMULATED FROM
WATERSHED CHARACTERISTICS
ILAG=0 LAG MODULUS IS READ IN
ILAG=1 LAG MODULUS IS SIMULATED FROM URBAN
WATERSHED CHARACTERISTICS (% IMPERVIOUS
AND AREA [SQMI])
ILAG=2 LAG MODULUS IS SIMULATED FROM RURAL
WATERSHED CHARACTERISTICS (% FOREST AND
AREA [SQMI])
(21-24) ILOAD-A CONTROL PARAMETER TO DETERMINE HOW
SUSPENDED SEDIMENT STORM LOAD IS TO BE
SIMULATED FROM % FOREST, % IMPERVIOUS,
% STRIPPED AND LAG MODULUS
ILOAD=1 URBAN WATERSHED
ILOAD=2 COAL STRIP MINED WATERSHED

WATERSHED CHARACTERISTICS: ID URBAN,PS=0; IF RURAL,PI=0
7 (4F8.0)/ SQMI,PF,PS,PI

(1-8) SQMI=WATERSHED AREA IN SQUARE MILES
(9-16) PF=PERCENT FOREST
(17-24) PS=PERCENT COAL STRIP MINED (OR DENUDED)

CARD A IS NOT REQUIRED IF ISIM=0 (CARD 5)

8 (F10.0)/ CN
(1-10) CN=SCS CURVE NUMBER FOR WATERSHED AT THE TIME
THE STORM OCCURED (VARIES WITH ANTECEDENT
MOISTURE)

CARD 9 IS NOT REQUIRED IF ILAG=1 or 2 (CARD 5)

9 (F10.0)/ U
(1-10) U=LAG MODULUS, HOURS
10 (F10.0)/ DT
(1-10)1 DT=TIME INTERVAL USED IN ABSTRACTING RAINFALL
(HRS)

CARD 11,12, and 13 MUST BE REPEATED FOR EACH STORM TO BE
SIMULATED

11 (8A4)/ BASIN
(1-32) BASIN=NAME OF WATERSHED

TABLE 3. AFRUM CARD DATA (CONCLUDED)

12	(2A4)/	BDATE BDATE=DATE OF STORM
13	(I1,9X, F10.3,30X, F10.3)/ (1)	ISTAGE,RAIN(I),SFLOW(I) ISTAGE-A CONTROL PARAMETER TO SIGNAL THE END OF A STORM DATA SET ISTAGE=0 SIGNALS CONTINUATION OF RAINFALL/ RUNOFF ISTAGE=1 SIGNALS LAST DATA CARD OF A STORM
	(2-10)	BLANK
	(11-20)	RAIN(I) RAIN(I)=CUMULATIVE STORM RAINFALL ABSTRACTED AT DT TIME INTERVALS. THE FIRST VALUE OF RAIN(I) MUST BE 0.0 AT TIME 0.0
	(21-50)	BLANK
	(51-60)	SFLOW(I) SFLOW(I)=STORMWATER DISCHARGED IN CFS, ABSTRACTED AT DT TIME INTERVALS, VALUES OF SFLOW(I) ARE NOT REQUIRED IF ISIM=1 (CARD 1). THE FIRST AND LAST VALUES OF SFLOW(I) MUST BE 0.0

NO. OF RAINFALL/RUNOFF CARDS MUST BE EQUAL TO NUMBER OF RAINFALL/
RUNOFF OBSERVATIONS
A MAXIMUM OF 500 RAINFALL/RUNOFF OBSERVATIONS MAY BE SUBMITTED

SECTION VI

EXAMPLE PROBLEMS

1. McDowell Ditch

An example application of AFRUM is provided for the McDowell Ditch watershed at Grissom Air Force Base, Indiana. The watershed is 276 acres in size, has 20 percent imperviousness, and essentially zero percent trees. The soils are classified in SCS group C and watershed land use is considered to be urban without extensive storm sewers.

The accumulated rainfall and hydrograph for the storm of November 14, 1978 was measured for the McDowell watershed. Since the runoff was available, the storm CN was calculated within AFRUM. However, using the SCS-CN method (see Table 3) the CN for the storm was estimated to be 83, whereas the calculated CN using storm rainfall and runoff was 81. This produced an error of 3.1 percent.

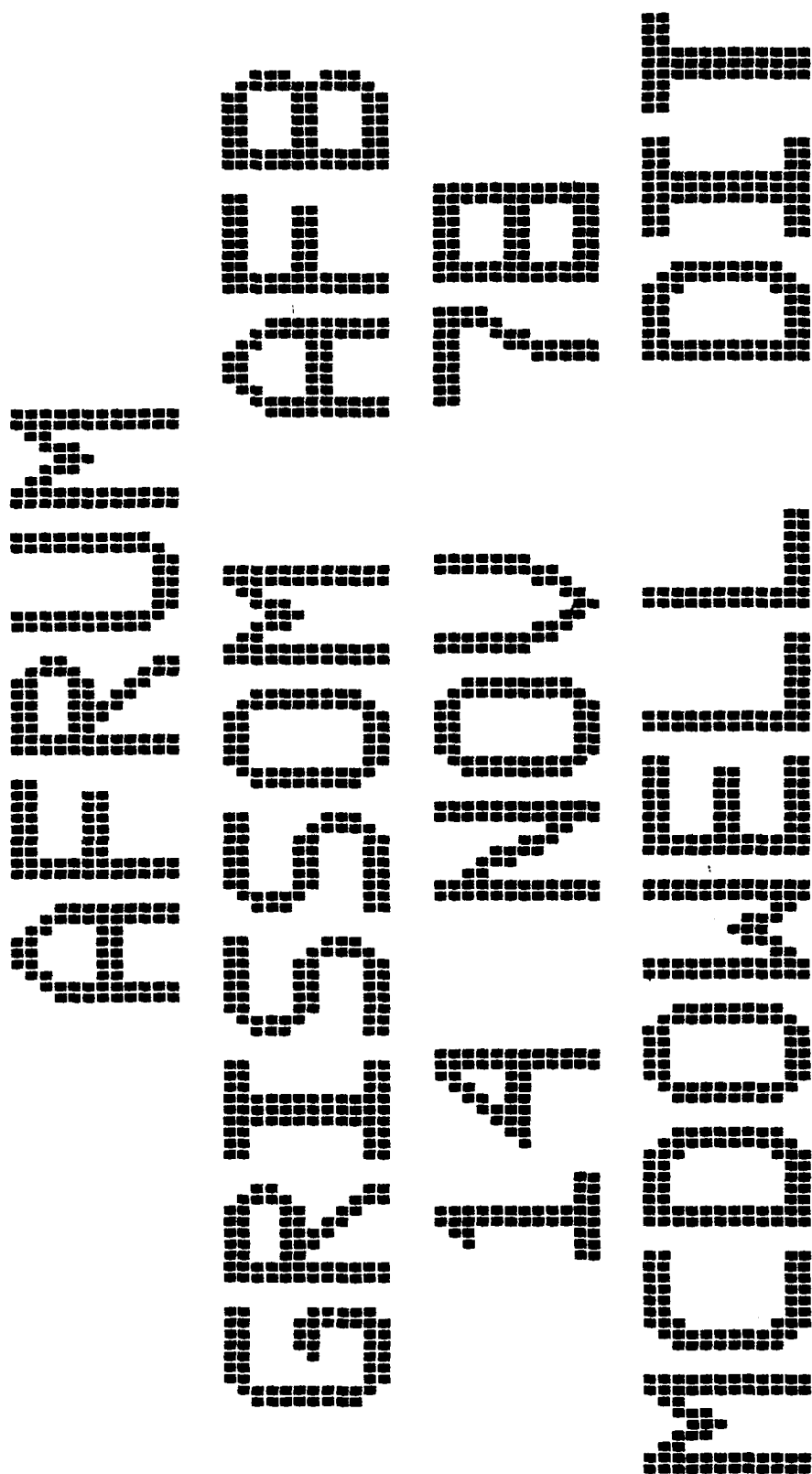
Hence, the data was punched onto the cards into the specified format and entered into the computer after the appropriate JCLs. A listing of the input and the program output follows.

AFRUM
 GRISSOM AFH
 14 NOV 78
 MCDOWELL DIT

0 1 1 0 1 1
 0.43 5.5 0.0 22.0
 0.25
 MCDOWELL DITCH
 11-14-78

0.0
 0.05
 0.10
 0.15
 0.20
 0.20
 0.20
 0.20
 0.20
 0.30
 0.31
 0.34
 0.35
 0.40
 0.43
 0.48
 0.55
 0.60
 0.70
 0.82
 0.92
 1.00
 1.08
 1.14
 1.21
 1.23
 1.24
 1.26
 1.27
 1.28
 1.29
 1.30
 1.30
 1.33
 1.36
 1.38
 1.38
 1.45
 1.46
 1.47
 1.47
 1.47
 1.48
 1.48
 1.49

0.006
 0.2
 0.3
 0.6
 1.1
 1.7
 2.5
 3.5
 4.6
 5.8
 6.5
 7.6
 8.5
 9.7
 10.8
 11.6
 12.1
 12.6
 13.0
 12.4
 11.6
 10.7
 9.9
 8.9
 7.9
 7.7
 7.5
 7.7
 7.9
 7.7
 7.5
 7.3
 7.1
 7.0
 6.7
 6.6
 6.4
 6.2
 5.0



INTRODUCTION

THE U.S. AIR FORCE RUNOFF MODEL (AFRUM) FOR SIMULATING STORM HYDROGRAPHS AND POLLUTANT YIELDS WAS DEVELOPED FOR THE AIR FORCE BY THE DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF TENNESSEE, KNOXVILLE AND THE RESEARCH AND DEVELOPMENT DIRECTORATE OF THE AIR FORCE ENGINEERING SERVICES CENTER (AFESC), TYNDALL AIR FORCE BASE, FLORIDA. DR. DONALD E. OVERTON OF THE UNIVERSITY OF TENNESSEE WAS THE PRINCIPAL INVESTIGATOR AND DR. GEORGE W. SCHLOSSNAGLE OF THE U.S. AIR FORCE WAS THE PROJECT OFFICER. THE RESULTS OF THREE SEPARATE BUT COMPLEMENTARY STUDIES WERE INCORPORATED INTO AFRUM. EACH OF THE THREE STUDIES HAD THE FUNDAMENTAL OBJECTIVE TO EVALUATE THE EFFECTS OF SPECIALIZED LAND USE ON STORMWATER RUNOFF AND ITS ASSOCIATED QUALITY. THE THREE STUDIES WERE FUNDED BY THE U.S. DEPARTMENT OF ENERGY, THE U.S. DEPARTMENT OF INTERIOR AND THE U.S. AIR FORCE. THE STUDY PERIOD WAS FROM 1975 THROUGH 1979. AFRUM WAS DEVELOPED IN THE COURSE OF ANALYZING 410 STORM EVENTS ON 36 WATERSHEDS, WHICH INCLUDED AGRICULTURAL, URBAN AND FORESTED LAND USE CONDITIONS AS WELL AS COAL STRIP MINING AND THREE WATERSHEDS ON A U.S. AIR FORCE BASE.

AFRUM WAS DEVELOPED FOR THE PURPOSE OF SIMULATING STORMWATER HYDROGRAPHS FROM ACTUAL OR DESIGN STORM RAINFALL DISTRIBUTIONS, LAND USE CHARACTERISTICS AND SOIL TYPE IN THE WATERSHED OF CONCERN. THE REQUIRED INPUT BASIN CHARACTERISTICS ARE:

1. PERCENT OF WATERSHED THAT IS FORESTED
2. PERCENT OF WATERSHED THAT IS IMPERVIOUS
3. PERCENT OF WATERSHED THAT IS DENUDED OR STRIP MINED
4. SURFACE DRAINAGE AREA

RUNOFF VOLUME AND THE ASSOCIATED RAINFALL EXCESS TIME DISTRIBUTION ARE SIMULATED FROM INPUT RAINFALL USING THE U.S. SOIL CONSERVATION SERVICE CURVE NUMBER. IF A RUNOFF HYDROGRAPH IS PROVIDED WITH THE ASSOCIATED RAINFALL HYETOGRAPH, AFRUM WILL COMPUTE THE CURVE NUMBER, CN; OTHERWISE CN MUST BE AN INPUT. CN IS SELECTED BY USING THE PROCEDURES PROVIDED IN THE NATIONAL ENGINEERING HANDBOOK, SECTION 4, U.S. SOIL CONSERVATION SERVICE.

AFRUM MAKES PROVISION FOR SIMULATING A UNIT HYDROGRAPH OR UNIT RESPONSE FUNCTION, WHICH IS CONVOLUTED WITH THE RAINFALL EXCESS HYETOGRAPH. AFRUM ALSO SIMULATES POLLUTANT LOADS FOR THE INPUTED STORM. THIS SIMULATION IS A FUNCTION OF THE SPECIFIED WATERSHED AND STORM CHARACTERISTICS.

GRISSOM AFB

THE WATERSHED NAME IS MCDOWELL DITCH
THE DATE OF THE RAINFALL EVENT IS 11-14-78
THE WATERSHED SIZE IN SQUARE MILES IS: SQMI= .43
THE PERCENT OF THE BASIN WHICH IS FOREST IS: PF= 5.50
THE PERCENT OF THE BASIN DENUDED IS: PS= 0.00
THE PERCENT OF THE BASIN WHICH IS IMPERVIOUS IS: PI= 22.00

BY SETTING ISIM = 0 YOU HAVE INDICATED THAT YOU PLAN
TO SUPPLY EITHER ACTUAL OR DESIGN RAINFALL AND RUNOFF
DATA; THEREFORE, THE SCS CURVE NUMBER, CN, WILL BE DE-
TERMINED BY SETTING RUNOFF EQUAL TO PRECIPITATION EXCESS.

OUTPUT UNITS OF THE SIMULATED HYDROGRAPH ARE HOURS
AND CUBIC FEET PER SECOND, CFS, AS SELECTED BY SETTING
IUNIT = 1.

YOU HAVE REQUESTED THAT THE HYDROGRAPH BE PLOTTED
BY SETTING IPLOT = 1.

THE WATERSHED IS ASSUMED TO BE URBAN WITHOUT
STORM SEWERS; ICHAR = 0.

YOU HAVE ELECTED TO SIMULATE LAG MODULUS IN
HOURS ASSUMING IT IS A FUNCTION OF THE WATERSHED AREA
AND PERCENT IMPERVIOUS AREA OF THE WATERSHED; ILAG = 1.

SEDIMENT LOAD HAS BEEN SIMULATED ASSUMING THE
WATERSHED IS RURAL OR URBAN WITHOUT MAJOR CONSTRUCTION;
ILOAD = 1.

TABLE I. USER INPUT

TIME (HR)	TOTAL RAIN (IN)	INCREMENTAL RAIN (IN)	OBSERVED FLOW (CFS)	DATA FLOW (IN/HR)
0.00	0.00	0.00	0.00	0.000000
0.25	0.05	0.05	0.00	0.000000
0.50	0.10	0.05	0.00	0.000000
0.75	0.15	0.05	0.00	0.000000
1.00	0.20	0.05	0.00	0.000000
1.25	0.200	0.000	0.00	0.000000
1.50	0.200	0.000	0.00	0.000000
1.75	0.200	0.000	0.00	0.000000
2.00	0.200	0.000	0.00	0.000000
2.25	0.30	0.10	0.00	0.000000
2.50	0.31	0.01	0.00	0.000000
2.75	0.34	0.03	0.00	0.000000
3.00	0.35	0.01	0.00	0.000000
3.25	0.40	0.05	0.00	0.000000
3.50	0.43	0.03	0.00	0.000000
3.75	0.48	0.05	0.00	0.000000
4.00	0.55	0.07	0.00	0.000000
4.25	0.60	0.05	0.00	0.000000
4.50	0.70	0.10	0.00	0.000000
4.75	0.82	0.12	0.00	0.000000
5.00	0.92	0.10	0.00	0.000000
5.25	1.000	0.08	0.00	0.000000
5.50	1.08	0.08	0.00	0.000000
5.75	1.14	0.06	0.00	0.000000
6.00	1.21	0.07	0.00	0.000000
6.25	1.23	0.02	0.01	0.00002
6.50	1.26	0.01	0.20	0.00072
6.75	1.26	0.02	0.30	0.00108
7.00	1.27	0.01	0.60	0.00216
7.25	1.28	0.01	1.10	0.00396
7.50	1.29	0.01	1.70	0.00613
7.75	1.30	0.01	2.50	0.00901
8.00	1.30	0.00	3.50	0.01261
8.25	1.33	0.03	4.60	0.01658
8.50	1.36	0.03	5.80	0.02090
8.75	1.38	0.02	6.50	0.02342
9.00	1.38	0.00	7.60	0.02739
9.25	1.45	0.07	8.50	0.03063
9.50	1.46	0.01	9.70	0.03496
9.75	1.47	0.01	10.80	0.03892
10.00	1.47	0.00	11.60	0.04180
10.25	1.47	0.00	12.10	0.04360
10.50	1.48	0.01	12.60	0.04541
10.75	1.48	0.00	13.00	0.04685
11.00	1.49	0.01	12.40	0.04469
11.25	0.00	0.00	11.60	0.04180
11.50	0.00	0.00	10.70	0.03856
11.75	0.00	0.00	9.90	0.03568
12.00	0.00	0.00	8.90	0.03207
12.25	0.00	0.00	7.90	0.02847
12.50	0.00	0.00	7.70	0.02775
12.75	0.00	0.00	7.50	0.02703
13.00	0.00	0.00	7.70	0.02775
13.25	0.00	0.00	7.90	0.02847
13.50	0.00	0.00	7.70	0.02775
13.75	0.00	0.00	7.50	0.02703
14.00	0.00	0.00	7.30	0.02631
14.25	0.00	0.00	7.10	0.02559
14.50	0.00	0.00	7.00	0.02523
14.75	0.00	0.00	6.70	0.02414
15.00	0.00	0.00	6.60	0.02378
15.25	0.00	0.00	6.40	0.02306
15.50	0.00	0.00	6.20	0.02234
15.75	0.00	0.00	5.00	0.01802

TABLE I. USER INPUT (CONTINUED)

16.00	0.00	0.00	4.70	.01694
16.25	0.00	0.00	4.40	.01586
16.50	0.00	0.00	4.20	.01514
16.75	0.00	0.00	4.10	.01478
17.00	0.00	0.00	3.80	.01369
17.25	0.00	0.00	3.50	.01261
17.50	0.00	0.00	3.20	.01153
17.75	0.00	0.00	2.90	.01045
18.00	0.00	0.00	2.90	.01045
18.25	0.00	0.00	2.90	.01045
18.50	0.00	0.00	2.90	.01045
18.75	0.00	0.00	2.90	.01045
19.00	0.00	0.00	2.90	.01045
19.25	0.00	0.00	2.40	.00865
19.50	0.00	0.00	2.10	.00757
19.75	0.00	0.00	1.90	.00685
20.00	0.00	0.00	1.80	.00649
20.25	0.00	0.00	1.80	.00649
20.50	0.00	0.00	1.60	.00577
20.75	0.00	0.00	1.50	.00541
21.00	0.00	0.00	1.40	.00505
21.25	0.00	0.00	1.30	.00468
21.50	0.00	0.00	1.20	.00432
21.75	0.00	0.00	1.10	.00396
22.00	0.00	0.00	1.00	.00360
22.25	0.00	0.00	.90	.00324
22.50	0.00	0.00	.80	.00288
22.75	0.00	0.00	.80	.00288
23.00	0.00	0.00	.80	.00288
23.25	0.00	0.00	.80	.00288
23.50	0.00	0.00	.80	.00288
23.75	0.00	0.00	.75	.00270
24.00	0.00	0.00	.71	.00256
24.25	0.00	0.00	.65	.00234
24.50	0.00	0.00	.61	.00220
24.75	0.00	0.00	.61	.00220
25.00	0.00	0.00	.60	.00216
25.25	0.00	0.00	.60	.00216
25.50	0.00	0.00	.55	.00198
25.75	0.00	0.00	.47	.00169
26.00	0.00	0.00	.47	.00169
26.25	0.00	0.00	.47	.00169
26.50	0.00	0.00	.47	.00169
26.75	0.00	0.00	.47	.00169
27.00	0.00	0.00	.47	.00169
27.25	0.00	0.00	.47	.00169
27.50	0.00	0.00	.47	.00169
27.75	0.00	0.00	.43	.00155
28.00	0.00	0.00	.40	.00144
28.25	0.00	0.00	.37	.00133
28.50	0.00	0.00	.33	.00119
28.75	0.00	0.00	.32	.00115
29.00	0.00	0.00	.30	.00108
29.25	0.00	0.00	.29	.00105
29.50	0.00	0.00	.28	.00101
29.75	0.00	0.00	.28	.00101
30.00	0.00	0.00	.27	.00097
30.25	0.00	0.00	.26	.00094
30.50	0.00	0.00	.24	.00086
30.75	0.00	0.00	.24	.00086
31.00	0.00	0.00	.24	.00086
31.25	0.00	0.00	.24	.00086
31.50	0.00	0.00	.24	.00086
31.75	0.00	0.00	.23	.00083
32.00	0.00	0.00	.23	.00083
32.25	0.00	0.00	.22	.00079

TABLE I. USER INPUT (CONCLUDED)

32.75	0.00	0.00	.22	.00079					
33.00	0.00	0.00	.10	.00036					
33.25	0.00	0.00	.05	.00018					
33.50	0.00	0.00	0.00	0.00000					
ADJUSTED HYDROGRAPH PARAMETERS									
RFI	U	N	TL	UP	UR	T1	T2	T3	AREA
.085	.306	.400	.820	.809	.146	.500	1.500	5.750	.991
UP	UR	T1	T2	T3	AREA				
.816	.148	.500	1.500	5.750	1.000				

TABLE II. HYDROGRAPH OUTPUT

OBSERVED FLOW OUT OF WATERSHED (CFS)	PREDICTED FLOW OUT OF WATERSHED (CFS)	TIME (HOURS)	SUSPENDED SOLIDS DISCHARGED FROM WATERSHED LBS/SEC
0.000	0.000	0.000	0.000
0.000	0.000	.250	0.000
0.000	0.000	.500	0.000
0.000	0.000	.750	0.000
0.000	0.000	1.000	0.000
0.000	0.000	1.250	0.000
0.000	0.000	1.500	0.000
0.000	0.000	1.750	0.000
0.000	0.000	2.000	0.000
0.000	0.000	2.250	0.000
0.000	0.000	2.500	0.000
0.000	0.000	2.750	0.000
0.000	0.000	3.000	0.000
0.000	0.000	3.250	0.000
0.000	0.000	3.500	0.000
0.000	0.000	3.750	0.000
0.000	.024	4.000	.000
0.000	.426	4.250	.003
0.000	1.332	4.500	.010
0.000	3.384	4.750	.024
0.000	7.657	5.000	.055
0.000	12.749	5.250	.092
0.000	16.618	5.500	.120
0.000	19.440	5.750	.140
0.000	20.970	6.000	.151
.006	21.832	6.250	.157
.200	21.066	6.500	.152
.300	17.345	6.750	.125
.600	14.395	7.000	.104
1.100	12.532	7.250	.090
1.700	10.795	7.500	.078
2.500	10.149	7.750	.073
3.500	9.684	8.000	.070
4.600	8.678	8.250	.063
5.800	8.924	8.500	.064
6.500	11.002	8.750	.079
7.600	12.134	9.000	.087
8.500	11.168	9.250	.080
9.700	12.830	9.500	.092
10.800	15.075	9.750	.109
11.600	12.920	10.000	.093
12.100	10.588	10.250	.076
12.600	7.895	10.500	.057
13.000	5.856	10.750	.042
12.400	5.430	11.000	.039
11.600	5.056	11.250	.036
10.700	4.980	11.500	.036
9.900	4.125	11.750	.030
8.900	3.342	12.000	.024
7.900	2.808	12.250	.020
7.700	2.284	12.500	.016
7.500	2.013	12.750	.015
7.700	1.752	13.000	.013
7.900	1.503	13.250	.011
7.700	1.264	13.500	.009
7.500	1.037	13.750	.007
7.300	.810	14.000	.006
7.100	.617	14.250	.004
7.000	.458	14.500	.003

TABLE II. HYDROGRAPH OUTPUT (CONTINUED)

6.700	.323	14.750	.002
6.600	.188	15.000	.001
6.400	.138	15.250	.001
6.200	.101	15.500	.001
5.000	.076	15.750	.001
4.700	.050	16.000	.000
4.400	.025	16.250	.000
4.200	.013	16.500	.000
4.100	0.000	16.750	0.000
3.800	0.000	17.000	0.000
3.500	0.000	17.250	0.000
3.200	0.000	17.500	0.000
3.000	0.000	17.750	0.000
2.900	0.000	18.000	0.000
2.800	0.000	18.250	0.000
2.700	0.000	18.500	0.000
2.600	0.000	18.750	0.000
2.400	0.000	19.000	0.000
2.300	0.000	19.250	0.000
2.200	0.000	19.500	0.000
2.100	0.000	19.750	0.000
2.000	0.000	20.000	0.000
1.800	0.000	20.250	0.000
1.600	0.000	20.500	0.000
1.400	0.000	20.750	0.000
1.300	0.000	21.000	0.000
1.200	0.000	21.250	0.000
1.100	0.000	21.500	0.000
1.000	0.000	21.750	0.000
.900	0.000	22.000	0.000
.800	0.000	22.250	0.000
.800	0.000	22.500	0.000
.800	0.000	22.750	0.000
.800	0.000	23.000	0.000
.800	0.000	23.250	0.000
.750	0.000	23.500	0.000
.710	0.000	23.750	0.000
.650	0.000	24.000	0.000
.610	0.000	24.250	0.000
.610	0.000	24.500	0.000
.600	0.000	24.750	0.000
.550	0.000	25.000	0.000
.470	0.000	25.250	0.000
.470	0.000	25.500	0.000
.470	0.000	25.750	0.000
.470	0.000	26.000	0.000
.470	0.000	26.250	0.000
.470	0.000	26.500	0.000
.470	0.000	26.750	0.000
.470	0.000	27.000	0.000
.470	0.000	27.250	0.000
.470	0.000	27.500	0.000
.430	0.000	27.750	0.000
.400	0.000	28.000	0.000
.370	0.000	28.250	0.000
.330	0.000	28.500	0.000
.320	0.000	28.750	0.000
.300	0.000	29.000	0.000
.290	0.000	29.250	0.000
.280	0.000	29.500	0.000
.280	0.000	29.750	0.000
.270	0.000	30.000	0.000
.260	0.000	30.250	0.000
.240	0.000	30.500	0.000
.240	0.000	30.750	0.000
.240	0.000	31.000	0.000
.240	0.000	31.250	0.000

TABLE II. HYDROGRAPH OUTPUT (CONCLUDED)

.240	0.000	31.500	0.000
.240	0.000	31.750	0.000
.230	0.000	32.000	0.000
.230	0.000	32.250	0.000
.220	0.000	32.500	0.000
.220	0.000	32.750	0.000
.100	0.000	33.000	0.000
.050	0.000	33.250	0.000
0.000	0.000	33.500	0.000

TOTAL SUSPENDED SOLIDS (LBS) DISCHARGED FROM WATERSHED
DURING STORM EVENT = 2308.209

FE CONC (PPM) 6.80680
FE LOAD (LBS) 135.87454

MN CONC (PPM) .88400
MN LOAD (LBS) 17.64604

CA CONC (PPM) 10.82900
CA LOAD (LBS) 216.16404

MG CONC (PPM) .14277
MG LOAD (LBS) 2.84984

SO4 CONC (PPM) 5.48080
SO4 LOAD (LBS) 109.40547

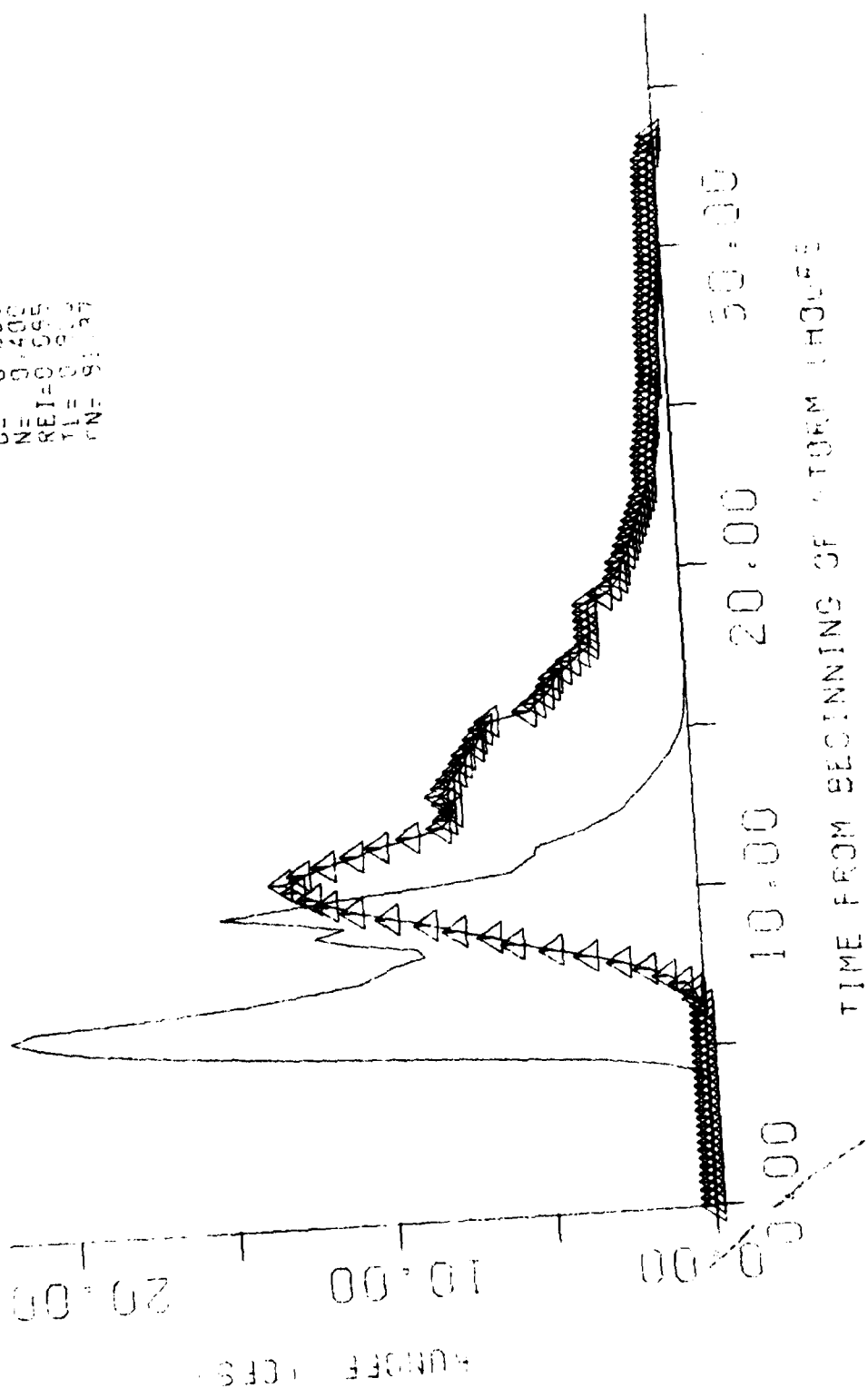
ALK CONC (PPM) 29.65820
ALK LOAD (LBS) 592.02478

KUP	KT1	KT2	KUR
.663	.632	1.880	.120
U	N	DT	
.306	.400	.25000	

SIMULATED LOAD MODULUS (LBS/AC-IN OF RUNOFF)
26.16

MCCORMICK
11-14-78

OBSERVED HYDROGRAPH
PREDICTED HYDROGRAPH
U= 0.305
N= 0.400
REI=0.505
YLE=0.000
CNE= 91.34



2. Capehart Marina

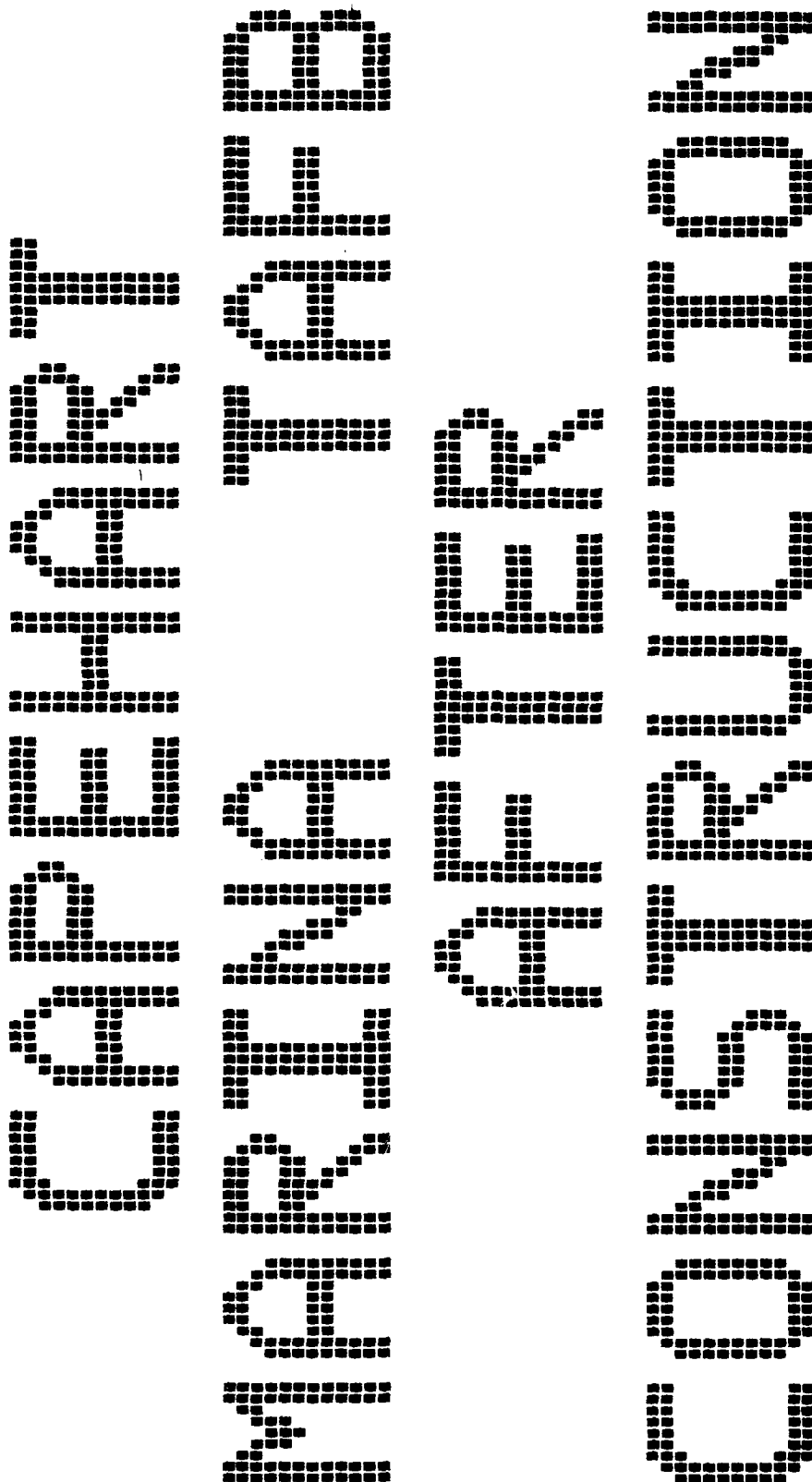
An example is provided for the Capehart Marina watershed at Tyndall AFB, Florida. No runoff data is available, and a design storm is supplied. The design storm of interest is 10 inches of rainfall in 12 hours read in at increments of one tenth of an hour. The watershed area is 0.17 square mile with 14.5 percent forest, 1 percent denuded area, and 15 percent impervious area. Curve number 58 was selected from Table 1. The watershed is urban with storm sewers.

A listing of the input and output follows.

CAPEHART
 MARINA, TAFB
 AFTER
 CONSTRUCTION
 CAPEHART MARINA AFTER CONSTRUCTION
 1 1 1 1 1 1
 .17 14.5 1. 15.
 58.
 1
 CAPEHART MARINA -(AFTER)
 04-22-80

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INTRODUCTION

THE U.S. AIR FORCE RUNOFF MODEL (AFRUM) FOR SIMULATING STORM HYDROGRAPHS AND POLLUTANT YIELDS WAS DEVELOPED FOR THE AIR FORCE BY THE DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF TENNESSEE, KNOXVILLE AND THE RESEARCH AND DEVELOPMENT DIRECTORATE OF THE AIR FORCE ENGINEERING SERVICES CENTER (AFESC), TYNDALL AIR FORCE BASE, FLORIDA. DR. DONALD E. OVERTON OF THE UNIVERSITY OF TENNESSEE WAS THE PRINCIPAL INVESTIGATOR AND DR. GEORGE W. SCHLOSSNAGLE OF THE U.S. AIR FORCE WAS THE PROJECT OFFICER. THE RESULTS OF THREE SEPARATE BUT COMPLIMENTARY STUDIES WERE INCORPORATED INTO AFRUM. EACH OF THE THREE STUDIES HAD THE FUNDAMENTAL OBJECTIVE TO EVALUATE THE EFFECTS OF SPECIALIZED LAND USE ON STORMWATER RUNOFF AND ITS ASSOCIATED QUALITY. THE THREE STUDIES WERE FUNDED BY THE U.S. DEPARTMENT OF ENERGY, THE U.S. DEPARTMENT OF INTERIOR AND THE U.S. AIR FORCE. THE STUDY PERIOD WAS FROM 1975 THROUGH 1979. AFRUM WAS DEVELOPED IN THE COURSE OF ANALYZING 410 STORM EVENTS ON 36 WATERSHEDS, WHICH INCLUDED AGRICULTURAL, URBAN AND FORESTED LAND USE CONDITIONS AS WELL AS COAL STRIP MINING AND THREE WATERSHEDS ON A U.S. AIR FORCE BASE.

AFRUM WAS DEVELOPED FOR THE PURPOSE OF SIMULATING STORMWATER HYDROGRAPHS FROM ACTUAL OR DESIGN STORM RAINFALL DISTRIBUTIONS, LAND USE CHARACTERISTICS AND SOIL TYPE IN THE WATERSHED OF CONCERN. THE REQUIRED INPUT BASIN CHARACTERISTICS ARE:

1. PERCENT OF WATERSHED THAT IS FORESTED
2. PERCENT OF WATERSHED THAT IS IMPERVIOUS
3. PERCENT OF WATERSHED THAT IS DENUDED OR STRIP MINED
4. SURFACE DRAINAGE AREA

RUNOFF VOLUME AND THE ASSOCIATED RAINFALL EXCESS TIME DISTRIBUTION ARE SIMULATED FROM INPUT RAINFALL USING THE U.S. SOIL CONSERVATION SERVICE CURVE NUMBER. IF A RUNOFF HYDROGRAPH IS PROVIDED WITH THE ASSOCIATED RAINFALL HYETOGRAPH, AFRUM WILL COMPUTE THE CURVE NUMBER, CN; OTHERWISE CN MUST BE AN INPUT. CN IS SELECTED BY USING THE PROCEDURES PROVIDED IN THE NATIONAL ENGINEERING HANDBOOK, SECTION 4, U.S. SOIL CONSERVATION SERVICE.

AFRUM MAKES PROVISION FOR SIMULATING A UNIT HYDROGRAPH OR UNIT RESPONSE FUNCTION, WHICH IS CONVOLUTED WITH THE RAINFALL EXCESS HYETOGRAPH. AFRUM ALSO SIMULATES POLLUTANT LOADS FOR THE INPUTED STORM. THIS SIMULATION IS A FUNCTION OF THE SPECIFIED WATERSHED AND STORM CHARACTERISTICS.

CAPEHART MARINA AFTER CONSTRUCTION

THE WATERSHED NAME IS CAPEHART MARINA -(AFTER)
THE DATE OF THE RAINFALL EVENT IS 04-22-80
THE WATERSHED SIZE IN SQUARE MILES IS: SQMI= .17
THE PERCENT OF THE BASIN WHICH IS FOREST IS: PF= 14.50
THE PERCENT OF THE BASIN DENUDED IS: PS= 1.00
THE PERCENT OF THE BASIN WHICH IS IMPERVIOUS IS: PI= 15.00

BY SETTING ISIM = 1 YOU HAVE INDICATED THAT YOU PLAN
TO SUPPLY ACTUAL OR DESIGN RAINFALL DATA; THEREFORE, AN
ESTIMATE OF THE SCS CURVE NUMBER, CN, MUST BE PROVIDED.

OUTPUT UNITS OF THE SIMULATED HYDROGRAPH ARE HOURS
AND CUBIC FEET PER SECOND, CFS, AS SELECTED BY SETTING
IUNIT = 1.

YOU HAVE REQUESTED THAT THE HYDROGRAPH BE PLOTTED
BY SETTING IPLOT = 1.

THE WATERSHED IS ASSUMED TO BE URBAN WITH STORM
SEWERS; ICHAR = 1.

YOU HAVE ELECTED TO SIMULATE LAG MODULUS IN
HOURS ASSUMING IT IS A FUNCTION OF THE WATERSHED AREA
AND PERCENT IMPERVIOUS AREA OF THE WATERSHED; ILAG = 1.

SEDIMENT LOAD HAS BEEN SIMULATED ASSUMING THE
WATERSHED IS RURAL OR URBAN WITHOUT MAJOR CONSTRUCTION;
ILOAD = 1.

TABLE I. USER INPUT

TIME (HR)	TOTAL RAIN (IN)	INCREMENTAL RAIN (IN)	OBSERVED FLOW (CFS)	DATA FLOW (IN/HR)
0.00	0.00	0.00	0.00	0.000000
.10	.05	.05	0.00	0.000000
.20	.10	.05	0.00	0.000000
.30	.15	.05	0.00	0.000000
.40	.20	.05	0.00	0.000000
.50	.25	.05	0.00	0.000000
.60	.30	.05	0.00	0.000000
.70	.35	.05	0.00	0.000000
.80	.40	.05	0.00	0.000000
.90	.50	.10	0.00	0.000000
1.00	.55	.05	0.00	0.000000
1.10	.60	.05	0.00	0.000000
1.20	.65	.05	0.00	0.000000
1.30	.70	.05	0.00	0.000000
1.40	.75	.05	0.00	0.000000
1.50	.80	.05	0.00	0.000000
1.60	.85	.05	0.00	0.000000
1.70	.90	.05	0.00	0.000000
1.80	.95	.05	0.00	0.000000
1.90	1.00	.05	0.00	0.000000
2.00	1.10	.10	0.00	0.000000
2.10	1.20	.10	0.00	0.000000
2.20	1.30	.10	0.00	0.000000
2.30	1.40	.10	0.00	0.000000
2.40	1.50	.10	0.00	0.000000
2.50	1.60	.10	0.00	0.000000
2.60	1.70	.10	0.00	0.000000
2.70	1.80	.10	0.00	0.000000
2.80	1.90	.10	0.00	0.000000
2.90	2.00	.10	0.00	0.000000
3.00	2.10	.10	0.00	0.000000
3.10	2.20	.10	0.00	0.000000
3.20	2.30	.10	0.00	0.000000
3.30	2.40	.10	0.00	0.000000
3.40	2.50	.10	0.00	0.000000
3.50	2.60	.10	0.00	0.000000
3.60	2.70	.10	0.00	0.000000
3.70	2.80	.10	0.00	0.000000
3.80	2.90	.10	0.00	0.000000
3.90	3.00	.10	0.00	0.000000
4.00	3.10	.10	0.00	0.000000
4.10	3.20	.10	0.00	0.000000
4.20	3.30	.10	0.00	0.000000
4.30	3.40	.10	0.00	0.000000
4.40	3.50	.10	0.00	0.000000
4.50	3.60	.10	0.00	0.000000
4.60	3.70	.10	0.00	0.000000
4.70	3.80	.10	0.00	0.000000
4.80	3.90	.10	0.00	0.000000
4.90	4.00	.10	0.00	0.000000
5.00	4.10	.10	0.00	0.000000
5.10	4.20	.10	0.00	0.000000
5.20	4.30	.10	0.00	0.000000
5.30	4.40	.10	0.00	0.000000
5.40	4.50	.10	0.00	0.000000
5.50	4.60	.10	0.00	0.000000
5.60	4.70	.10	0.00	0.000000
5.70	4.80	.10	0.00	0.000000
5.80	4.90	.10	0.00	0.000000
5.90	5.00	.10	0.00	0.000000

6.00	5.10	.10	0.00	0.000000
6.10	5.20	.10	0.00	0.000000
6.20	5.30	.10	0.00	0.000000
6.30	5.40	.10	0.00	0.000000
6.40	5.50	.10	0.00	0.000000
6.50	5.60	.10	0.00	0.000000
6.60	5.70	.10	0.00	0.000000
6.70	5.80	.10	0.00	0.000000
6.80	5.90	.10	0.00	0.000000
6.90	6.00	.10	0.00	0.000000
7.00	6.15	.15	0.00	0.000000
7.10	6.30	.15	0.00	0.000000
7.20	6.45	.15	0.00	0.000000
7.30	6.60	.15	0.00	0.000000
7.40	6.75	.15	0.00	0.000000
7.50	6.90	.15	0.00	0.000000
7.60	7.00	.10	0.00	0.000000
7.70	7.10	.10	0.00	0.000000
7.80	7.20	.10	0.00	0.000000
7.90	7.30	.10	0.00	0.000000
8.00	7.40	.10	0.00	0.000000
8.10	7.50	.10	0.00	0.000000
8.20	7.60	.10	0.00	0.000000
8.30	7.70	.10	0.00	0.000000
8.40	7.80	.10	0.00	0.000000
8.50	7.90	.10	0.00	0.000000
8.60	8.00	.10	0.00	0.000000
8.70	8.10	.10	0.00	0.000000
8.80	8.20	.10	0.00	0.000000
8.90	8.30	.10	0.00	0.000000
9.00	8.40	.10	0.00	0.000000
9.10	8.50	.10	0.00	0.000000
9.20	8.60	.10	0.00	0.000000
9.30	8.70	.10	0.00	0.000000
9.40	8.80	.10	0.00	0.000000
9.50	8.90	.10	0.00	0.000000
9.60	9.00	.10	0.00	0.000000
9.70	9.05	.05	0.00	0.000000
9.80	9.10	.05	0.00	0.000000
9.90	9.15	.05	0.00	0.000000
10.00	9.20	.05	0.00	0.000000
10.10	9.25	.05	0.00	0.000000
10.20	9.30	.05	0.00	0.000000
10.30	9.35	.05	0.00	0.000000
10.40	9.40	.05	0.00	0.000000
10.50	9.45	.05	0.00	0.000000
10.60	9.50	.05	0.00	0.000000
10.70	9.55	.05	0.00	0.000000
10.80	9.60	.05	0.00	0.000000
10.90	9.65	.05	0.00	0.000000
11.00	9.70	.05	0.00	0.000000
11.10	9.75	.05	0.00	0.000000
11.20	9.80	.05	0.00	0.000000
11.30	9.85	.05	0.00	0.000000
11.40	9.90	.05	0.00	0.000000
11.50	9.95	.05	0.00	0.000000
11.60	10.00	.05	0.00	0.000000

ESTIMATED CN= 58.00

RFI	U	N	TL	UP	UR	T1	T2	T3	AREA
.600	.220	.400	.270	3.330	.129	.300	.500	2.900	1.001

ADJUSTED HYDROGRAPH PARAMETERS

UP	UR	T1	T2	T3	AREA
3.327	.129	.300	.500	2.900	1.000

TABLE II. HYDROGRAPH OUTPUT

OBSERVED FLOW OUT OF WATERSHED (CFS)	PREDICTED FLOW OUT OF WATERSHED (CFS)	TIME (HOURS)	SUSPENDED SOLIDS DISCHARGED FROM WATERSHED LBS/SEC
0.000	0.000	0.000	0.000
0.000	0.000	.100	0.000
0.000	0.000	.200	0.000
0.000	0.000	.300	0.000
0.000	0.000	.400	0.000
0.000	0.000	.500	0.000
0.000	0.000	.600	0.000
0.000	0.000	.700	0.000
0.000	0.000	.800	0.000
0.000	0.000	.900	0.000
0.000	0.000	1.000	0.000
0.000	0.000	1.100	0.000
0.000	0.000	1.200	0.000
0.000	0.000	1.300	0.000
0.000	0.000	1.400	0.000
0.000	0.000	1.500	0.000
0.000	0.000	1.600	0.000
0.000	0.000	1.700	0.000
0.000	0.000	1.800	0.000
0.000	0.000	1.900	0.000
0.000	0.000	2.000	0.000
0.000	0.000	2.100	0.000
0.000	0.000	2.200	0.000
0.000	0.000	2.300	0.000
0.000	0.000	2.400	0.000
0.000	.045	2.500	.000
0.000	.423	2.600	.001
0.000	1.452	2.700	.004
0.000	3.326	2.800	.009
0.000	5.628	2.900	.016
0.000	7.932	3.000	.023
0.000	10.184	3.100	.029
0.000	12.384	3.200	.035
0.000	14.534	3.300	.041
0.000	16.636	3.400	.047
0.000	18.690	3.500	.053
0.000	20.698	3.600	.059
0.000	22.659	3.700	.064
0.000	24.576	3.800	.070
0.000	26.449	3.900	.075
0.000	28.278	4.000	.080
0.000	30.064	4.100	.085
0.000	31.807	4.200	.090
0.000	33.509	4.300	.095
0.000	35.169	4.400	.100
0.000	36.787	4.500	.104
0.000	38.365	4.600	.109
0.000	39.901	4.700	.113
0.000	41.398	4.800	.117
0.000	42.853	4.900	.122
0.000	44.269	5.000	.126
0.000	45.644	5.100	.129
0.000	46.980	5.200	.133
0.000	48.275	5.300	.137
0.000	49.531	5.400	.141
0.000	50.749	5.500	.144

0.0000	51.930	5.600	.147
0.0000	53.075	5.700	.151
0.0000	54.187	5.800	.154
0.0000	55.266	5.900	.157
0.0000	56.314	6.000	.160
0.0000	57.332	6.100	.163
0.0000	58.321	6.200	.165
0.0000	59.282	6.300	.168
0.0000	60.217	6.400	.171
0.0000	61.125	6.500	.173
0.0000	62.009	6.600	.176
0.0000	62.869	6.700	.178
0.0000	63.705	6.800	.181
0.0000	64.520	6.900	.183
0.0000	65.313	7.000	.185
0.0000	69.922	7.100	.198
0.0000	78.443	7.200	.223
0.0000	90.962	7.300	.258
0.0000	98.196	7.400	.279
0.0000	99.998	7.500	.284
0.0000	101.745	7.600	.289
0.0000	99.296	7.700	.282
0.0000	92.577	7.800	.263
0.0000	81.518	7.900	.231
0.0000	76.166	8.000	.216
0.0000	76.637	8.100	.217
0.0000	77.093	8.200	.219
0.0000	77.535	8.300	.220
0.0000	77.963	8.400	.221
0.0000	78.378	8.500	.222
0.0000	78.780	8.600	.224
0.0000	79.169	8.700	.225
0.0000	79.546	8.800	.226
0.0000	79.911	8.900	.227
0.0000	80.264	9.000	.228
0.0000	80.606	9.100	.229
0.0000	80.937	9.200	.230
0.0000	81.258	9.300	.231
0.0000	81.568	9.400	.231
0.0000	81.868	9.500	.232
0.0000	82.158	9.600	.233
0.0000	82.439	9.700	.234
0.0000	78.070	9.800	.221
0.0000	69.023	9.900	.196
0.0000	55.288	10.000	.157
0.0000	48.170	10.100	.137
0.0000	47.711	10.200	.135
0.0000	47.289	10.300	.134
0.0000	46.903	10.400	.133
0.0000	46.554	10.500	.132
0.0000	46.223	10.600	.131
0.0000	45.910	10.700	.130
0.0000	45.616	10.800	.129
0.0000	45.340	10.900	.129
0.0000	45.083	11.000	.128
0.0000	44.845	11.100	.127
0.0000	44.626	11.200	.127
0.0000	44.426	11.300	.126
0.0000	44.246	11.400	.126
0.0000	44.086	11.500	.125
0.0000	43.946	11.600	.125
0.0000	43.826	11.700	.124
0.0000	38.918	11.800	.110
0.0000	29.213	11.900	.083
0.0000	14.705	12.000	.042
0.0000	7.127	12.100	.020
0.0000	6.490	12.200	.018
0.0000	5.897	12.300	.017
0.0000	5.349	12.400	.015
0.0000	4.845	12.500	.014

0.000	4.387	12.600	.012
0.000	3.950	12.700	.011
0.000	3.537	12.800	.010
0.000	3.146	12.900	.009
0.000	2.777	13.000	.008
0.000	2.432	13.100	.007
0.000	2.109	13.200	.006
0.000	1.809	13.300	.005
0.000	1.531	13.400	.004
0.000	1.277	13.500	.004
0.000	1.045	13.600	.003
0.000	.837	13.700	.002
0.000	.651	13.800	.002
0.000	.489	13.900	.001
0.000	.349	14.000	.001
0.000	.233	14.100	.001
0.000	.140	14.200	.000
0.000	.070	14.300	.000
0.000	.023	14.400	.000
0.000	0.000	14.500	0.000

TOTAL SUSPENDED SOLIDS (LBS) DISCHARGED FROM WATERSHED
DURING STORM EVENT = 5188.523

FE CONC (PPM) 6.80680
FE LOAD (LBS) 775.87097

MN CONC (PPM) .88400
MN LOAD (LBS) 100.76246

CA CONC (PPM) 10.82900
CA LOAD (LBS) 1234.34018

MG CONC (PPM) .14277
MG LOAD (LBS) 16.27314

SO4 CONC (PPM) 5.48080
SO4 LOAD (LBS) 624.72727

ALK CONC (PPM) 29.65820
ALK LOAD (LBS) 3380.58065

OPTIMIZED CURVE NUMBER = 0.0

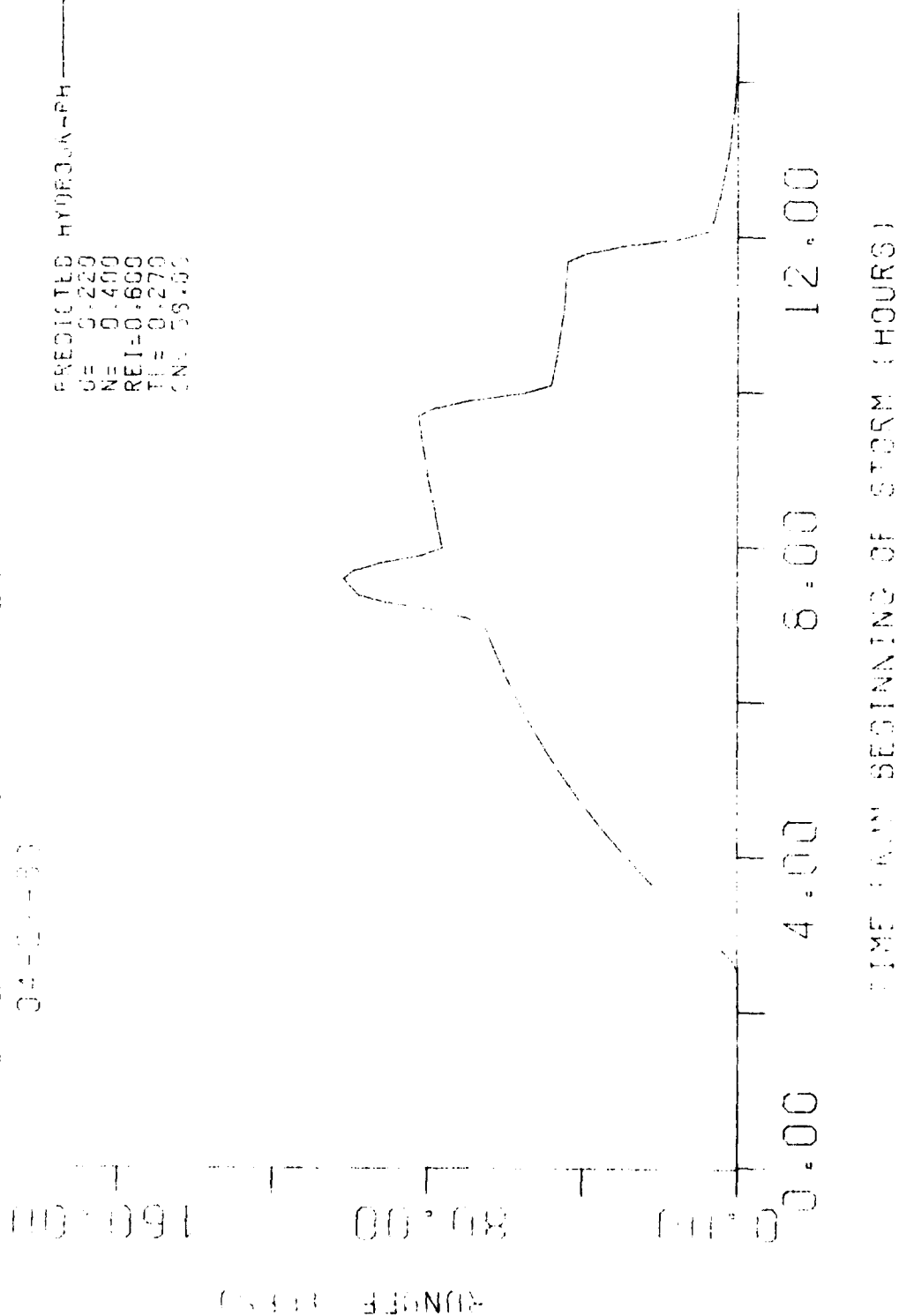
TOTAL RUNOFF= 4.6306INCHES

KUP	KT1	KT2	KUR
.900	.956	1.800	.035
U	N	DT	
.220	.400	.10000	

SIMULATED LOAD MODULUS (LBS/AC-IN OF RUNOFF)
10.30

COASTAL WINDING - AFTER
04-00-00

PREDICTED HYDROGRAPH
GE = 0.220
NE = 0.400
REI = 0.600
TE = 0.270
CN = 0.800



REFERENCES

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4. Overton, D.E., W.L. Troxler and E.C. Crosby, "Simulation of Effects of Urbanization of Stormwater Runoff and Quality," Univ. of Tennessee, Water Resource Center, Report No. 74, December 1979.
5. Overton, D.E., and E.C. Crosby, "Effects of Contour Coal Strip Mining on Stormwater Runoff and Quality - New River Basin, Tennessee," Department of Civil Engineering, The University of Tennessee, Knoxville, 1979.
6. Overton, D.E. and M.E. Meadows, Stormwater Modeling, Academic Press Inc., New York, 1976.

APPENDIX A
LISTING OF AFRUM


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135 CCCCCCCCCC
140 NO. OF RAINFALL/RUNOFF CARDS MUST BE EQUAL TO NUMBER OF RAINFALL/RUNOFF
    OBSERVATIONS
    A MAXIMUM OF 500 RAINFALL/RUNOFF OBSERVATIONS MAY BE SUBMITTED
    *****
145 REAL KT1,KT2,KUP,IMP,LOSS,KT23,KUR
    COMMON RUNOFF(800),HYDRO(800),RNOFF(500),RAIN(500),STAGE(500)
    >AREA(500),RF(500),PE(500),PE(500),SRO(500),BASIN(4),BDATE,
    >IAREA(664),PHI,DT,U,T1,T2,T3,UP,UR,REI,KT1,KT2,KUP,RN,ITOTAL,
    >ICHASH,IDMAX,NPRF,UMHYDRO(800),NPRO,CNOPT,NBIG,TL,KT23
    >,TIME(500),TFLOW(500),TFLOWI(500),SFLOW(500),BSFLOW(500)
    >DUMX(4),DUMY(4),BIGX,OBPEAK,PRPEAK,TP08,TPPR,ISIM
    >IPL0T,IUNIT,NPRF1,NPRF2,AREA,KUR
    >ITL(20),SQMI,SHAPE,SC,DD,SINU,CNA,SS,IMP,TLP
    <<LOAD,DL0AD
150
155 THE FOLLOWING DATA CARDS CONTAIN COEFFICIENTS FOR SIMULATING LAG MODULUS,
    UP, T1, T2, AND T3 US A FUNCTION OF WATERSHED CHARACTERISTICS.
    THESE REGIONALIZED COEFFICIENTS WERE DERIVED BY USING BMDP4R (LINEAR
    REGRESSION UPON PRINCIPAL COMPONENTS).
    THESE COEFFICIENTS ARE SUBJECT TO REVISION AS MORE DATA BECOMES AVAILABLE
    *****
160 DATA C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,-8.4076,0.0133,0.5126,0.0001,
    >-0.0635,7.2776,0.0333,0.0794,1.7401,-2.05101/
    >DATA C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,0.4466,0.0019,-0.015
    >1,-0.0001,0.0066,-0.0312,0.0007,0.00182,0.22134,0.07726/
    >DATA C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,0.2989,0.0066,-0.058
    >9,-0.0002,0.0157,-0.2129,-0.0031,0.00176,0.34552,-0.4254/
    >DATA C31,C32,C33,C34,C35,C36,C37,C38,C39,C40,0.7129,0.0063,-0.040
    >1,0.000,0.0264,0.3054,-0.0018,0.01398,-0.3646,-0.0733/
    >DATA C41,C42,C43,C44,C45,C46,C47,C48,C49,C50,-3.9713,-0.0208,.394
    >8,0.0,-0.0156,1.9912,0.0051,0.0284,2.7258,1.18497/
    CALL PLOT(0.0,1.5,-3)
170 CALL PLOT(0.0,1.5,-3)
    PRINTS BANNER ( FIRST 4 CRDS)
175 CALL LETTER
    CALL AESOP
180 IDMAX=MAXIMUM DIMENSION OF MATRIX HYDRO
    IDMAX=800
185 READ WATERSHED LOCATION AND NAME (CARD 1)
    READ(5,9) TITLE
    FORMAT(20A4)
    FORMAT (4A10)
190 READ PROGRAM CONTROL PARAMETERS (CARD 2)
    READ(5,12) ISIM,IUNIT,IPL0T,ICHAR,ILAG,ILOAD
    FORMAT(16I4)
195 READ WATERSHED PHYSICAL CHARACTERISTICS (CARD 3)
    READ(5,14) SQMI,PF,PS,PI
    IF (ISIM.EQ.2) GO TO 16
200 READ SCS CURVE NUMBER (CARD 4)
    READ(5,15) CN
    FORMAT(F10.0)
15

```

Line	Code	Statement
205	16	CONTINUE
	C	RN=.
	C	HEAD LAG MODULUS (CARD 5)
210	C	IF (LAG.GT. 0) GO TO 20
		READ(15,1) U
		GO TO 23
215	20	IF (LAG.EQ. 1) GO TO 22
		U=(0.660+SOMI) + (0.0203*PF) * 1.16
		IF (U.GE. 0.0) GO TO 23
220	520	WRITE(6,520)
		FORMAT(5X,"NEGATIVE VALUE OF LAGMODULUS SIMULATED,PROGRAM STOPPED
		>,"//)
		IQUIT=1
		GO TO 23
220	22	U=3.24*(SOMI/PI)**0.6
		IF (U.GE. 0.0) GO TO 23
225	21	WRITE(6,21)
		FORMAT(5X,"NEGATIVE VALUE OF LAGMODULUS SIMULATED,PROGRAM STOPPED
		>,"//)
		IQUIT=1
		CONTINUE
230	23	DEFINE NORMALIZED UNIT RESPONSE FUNCTION
	C	IF (ICHR .GT. 0) GO TO 24
		KUP=0.663
		KT1=0.632
		KT2=1.88
235		KUR=0.12
		GO TO 30
		IF (ICHR .GT. 1) GO TO 25
240	24	KUP=0.900
		KT1=0.956
		KT2=1.80
		KUR=0.035
		GO TO 30
		.GT. 2) GO TO 26
245	25	IF (ICHR
		KUP=0.253
		KT1=0.263
		KT2=1.085
		KUR=0.21
		GO TO 30
		IF (ICHR
		KUP=0.705
		KT1=0.695
		KT2=1.87
		KUR=0.13
		GO TO 30
255	27	KUP=0.716
		KT1=0.394
		KT2=1.57
		KUR=0.10
		CONTINUE
260	30	READ TIME INTERVAL (CARD 6)
	C	
	C	READ(15,15) DT
265		IF (ILOAD .EQ. 1) DLOAD=16.7*PS-21.5*U*PF+62.3
		IF (ILOAD .EQ. 2) DLOAD=18.17*PS-1.28*U*PF+52.7
		IF (DLOAD .GT. 0.0) GO TO 36
		DLOAD = 0.0
		WRITE (6,31)
		FORMAT (1H ,/,/,12X,"WARNING: EQUATIONS PREDICT MORE SEDIMENT CAN
	31	

270	C	* BE DEPOSITED"/,12X,"THAN CAN BE PICKED UP! THEREFORE, LOAD MODUL	AFRUM
270	C	* US IS SET EQUAL TO ZERO."/,///)	AFRUM
275	C	READ BASIN NAME (CARD 7)	AFRUM
275	36	READ(5,10) BASIN	AFRUM
275	C	READ(5,10) 480,35	AFRUM
275	35	CONTINUE	AFRUM
280	C	READ DATE OF STORM (CARD 8)	AFRUM
280	C	READ(5,37) 8DATE	AFRUM
280	37	FORMAT (A8)	AFRUM
285	C	WRITE (6,11) TITLE	AFRUM
285	11	FORMAT (15(/),46X,20A4,//)	AFRUM
285	C	CALL BASINA(SQMI,PF,PS,BDATE,BASIN,PI)	AFRUM
290	C	CALL ASSUME(IISIM,IPHI,IUNIT,IPILOT,ICHAR,ILAG,ILOAD)	AFRUM
290	50	IF (IQUIT .EQ. 1) GO TO 50	AFRUM
295	51	GO TO 51	AFRUM
295	C	CONTINUE	AFRUM
295	51	GO TO 480	AFRUM
295	C	CONTINUE	AFRUM
295	51	I=1	AFRUM
295	C	NPRO=0	AFRUM
295	C	NPRF=1	AFRUM
295	C	IPHI=0.0	AFRUM
295	C	IPHI=0	AFRUM
300	C	READ OBSERVED RAINFALL AND DISCHARGE (CARD 9)	AFRUM
300	C	READ(5,60) ISTATE,RAIN(I),SELOW(I)	AFRUM
300	55	FORMAT (11,9X,F10.3,F10.3)	AFRUM
305	60	TIME(I)=0.1-DT	AFRUM
305	C	IF (RAIN(I) .GT. RMAX) RMAX=RAIN(I)	AFRUM
305	C	RF(I)=0.0	AFRUM
305	C	GO TO 70	AFRUM
310	62	RF(I)=RAIN(I)-RAIN(I-1)	AFRUM
310	C	IF (RF(I) .LT. 0.0) RF(I)=0.0	AFRUM
310	70	CONTINUE	AFRUM
315	C	INCHES OF RNOFF=((FLOW(CFS)/AREA(FT**2))*3600SEC/HR*12.0IN/FT	AFRUM
315	C	IF (RAIN(I) .GT. 0.0) NPRF=NPRF+1	AFRUM
315	C	NPRO=NPRO+1	AFRUM
315	C	IF (ISTAGE .GE. 1) GO TO 100	AFRUM
315	C	I=I+1	AFRUM
320	100	GO TO 55	AFRUM
320	C	CONTINUE	AFRUM
320	103	WRITE (6,103)	AFRUM
325	105	FORMAT (1M,15X,"TABLE I. USER INPUT",///)	AFRUM
325	C	WRITE (6,105)	AFRUM
325	C	FORMAT (36X,"OBSERVED DATA"/5X,"TIME",6X,"TOTAL",2X,"INCREMENTAL",	AFRUM
325	C	2X,"FLOW",6X,"FLOW"/5X,"(HR)",6X,"RAIN",6X,"(CFS)",5X,	AFRUM
325	C	"(IN/HR)",15X,"(IN)",6X,"(IN)",///)	AFRUM
325	C	IF (ISLOW .EQ. 1) NPRO=0	AFRUM
330	108	IF (NPRF .GT. NDIM) NDIM=NPRF	AFRUM
330	C	IF (ISIM .EQ. 0) GO TO 1080	AFRUM
330	C	DO 1081 I=1,60	AFRUM
330	C	SFLOW(I)=0.0	AFRUM
330	C	RNOFF(I)=0.0	AFRUM
335	1080	CONTINUE	AFRUM
335	C	DO 115 I=1,NDIM	AFRUM
335	C	WRITE (6,110) TIME(I),RAIN(I),RF(I),SFLOW(I),RNOFF(I)	AFRUM
335	110	FORMAT (4F10.2,F10.5)	AFRUM
335	115	CONTINUE	AFRUM

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347 IF (ISIM .EQ. 1) PHI=0.0
348 IF (ISIM .EQ. 1) GO TO 290
349 DO 160 I=1,NPRO
350 TRUN=TRUN+RNOFF(I)
351 CONTINUE
352 IF (TRUN .LE. RAIN(NPRF)) GO TO 165
353 WRITE(6,162)
354 FORMAT(1X,"APPARENT ERROR IN DATA: RUNOFF EXCEEDS RAINFALL"/
355 >5X,"POSSIBLE CAUSE",25X,"CORRECTIVE ACTION"/
356 >1X,"(1)",2X,"NONUNIFORM RAINFALL DISTRIBUTION",7X,"DISCARD DATA"/
357 >1X,"(2)",2X,"ESTIMATE OF CN IS TOO LARGE",12X,"REDUCE INPUT CN"/)
358 GO TO 460
359 LOSS=RMAX-TRUN
360 RFINTR=MAX/(NPRF-1)*DT)
361 CNL=10.0
362 CNR=100.0
363 CNM=(CNL+CNR)/2.0
364 CALL SCS(CNL)
365 PRUNL=SRO(NPRF)
366 CALL SCS(CNR)
367 PRUNR=SRO(NPRF)
368 CALL SCS(CNM)
369 PRUNM=SRO(NPRF)
370 DP=PRUNM-TRUN
371 IF (DP<0.0) 240,270,220
372 CNR=CNM+DP
373 GO TO 160
374 CNL=CNM
375 GO TO 295
376 CNR=CNM
377 GO TO 295
378 CNL=CNM
379 GO TO 295
380 CNR=CNM
381 GO TO 295
382 CNL=CNM
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404 CNR=CNM
405 GO TO 295
406 CNL=CNM
407 GO TO 295
408 CNR=CNM
409 GO TO 295
410 CNL=CNM
411 GO TO 295

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410 CALL HYPLOT
411 CONTINUE
412 ISKIP=1
413 IF (ISKIP.EQ. 1) GO TO 460
414 WRITE(6,410)
415 FORMAT('H')
416 WRITE(7,420) BASIN, BDATE
417 FORMAT('8A4.2A4')
418 WRITE(7,440) RMAX, TIME INPRF) , TRUN, CN, OBPEAK, PRPEAK, TP08, TPRR
419 FORMAT('8F10.5')
420 WRITE(7,450) DP, UR, T1, T2, T3, REI
421 FORMAT('6F10.3')
422 CONTINUE
423 GO TO 36
424 CONTINUE
425 CALL PLOT(14.0,0.0,-3)
426 CALL PLOT(0.0,0.0,999)
427 STOP
428 END

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SUBROUTINE SCS	74/74	OPT=1	FTN 4.8*518	10/06/80	09.37.33
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963    C
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980    C
981    C
982    C
983    C
984    C
985    C
986    C
987    C
988    C
989    C
990    C
991    C
992    C
993    C
994    C
995    C
996    C
997    C
998    C
999    C
1000   C

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SUBROUTINE SIMLAT 74/74 OPT=1 FTM 4.8*518 10/06/80 09.37.33

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1      C
      C SUBROUTINE SIMLAT
5      C THIS SUBROUTINE IS A SIMULATION PROCEDURE FOR THE PARAMETERS
      C OF THE TVA DOUBLE TRIANGLE MODEL
      C
10     REAL KT1,KT2,KUP,IMP,LOSS,KT23,KUR
      COMMON RUNOFF(800),HYDRO(800),RNOFF(500),RAIN(500),STAGE(500)
      > AREA(664),PHI,DT,U,TL,T2,T3,UP,UR,REL,KTI,KT2,KUP,RN,ITOTAL,
      > ICRASH,IDMAX,NPRF,UYHYDRO(400),NPRO,CNOPT,NBIG,TL,KT23
      > TIME(500),TFLOW(500),TFLOWI(500),SFLOW(500),BSFLOW(500)
      > DUMX(4),DUMY(4),BIGX,OBPEAK,PRPEAK,TPOB,TPPR,ISIM
      > IPLOT,IUNIT,NPRF1,NPRF2,AREA,KUR
      > ITITLE(20),SQM1,SHAPE,SCADD,SINU,CNA,SS,IMP,TLF
      < ILOAD,DLOAD
      C ICRASH IS A CONTROL PARAMETER TO SIGNIFY THAT THE DATA IS INCOMPATIBLE
      C WITH THE MODEL BEING USED
      C ICRASH = 0
      C CALCULATE TL
      C TL = U/REL * RN
      C CALCULATE UP,T1,T2
      C UP = KTI * TL
      C T1 = KTI * TL
      C T2 = KTI * TL
      C CALL ADJUST(T1,DT)
      C CALL ADJUST(T2,DT)
      C IF (T2 LE T1) T2 = T1 + DT
      C CALCULATE UR AND T3
      C UR = KUR / TL
      C T3 = T1 + (T2 - T2 * UP) / UR
      C LIMIT T3 TO A REASONABLE VALUE
      C T1 = 15.0 * TL
      C IF (T3 LT T1) T3 = T1
      C T3 = T1
      C CALL ADJUST(T3,DT)
      C IF (T3 LE T2) T3 = T2 + DT
      C AREA = (0.5 * T1 * UP) + (0.5 * (UP * UR * (T2 - T1)) + (0.5 * UR * (T3 - T2)))
      C WRITE(6,360) REL,U,RN,TL,UP,UR,T1,T2,T3,AREA
      C360  FORMAT(6X,"REL",9X,"U",9X,"RN",9X,"TL",8X,"UP",8X,"UR",8X,"T1",8X,"
      > T2",8X,"T3",7X,"AREA"/10F10.3/)
      C UP = (1.0 / AREA) * UP
      C UR = (1.0 / AREA) * UR
      C AREA = (0.5 * T1 * UP) + (0.5 * (UP * UR * (T2 - T1)) + (0.5 * UR * (T3 - T2)))
      C WRITE(6,395)
      C395  FORMAT(10X,"ADJUSTED HYDROGRAPH PARAMETERS"/)
      C WRITE(6,400) UP,UR,T1,T2,T3,AREA
      C400  FORMAT(6X,"UP",8X,"UR",8X,"T1",8X,"T2",8X,"T3",6X,"AREA"/6F10.3///)
      > /
      C RETURN
      C430  END

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SUBROUTINE ADJUST	74/74	OPT=1	FTN 4.8*518	10/06/80	09.37.33
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1      C
      C SUBROUTINE ADJUST(T,DT)
5      C THIS SUBROUTINE ADJUSTS T1,T2,T3 TO THE NEAREST MULTIPLE OF DT
      C
10     FDELTA=DT
      DELTA=100.0*DT
      N=1
      ADT=N*DELTA
      IF (ADT .GE. T) GO TO 20
      N=N+1
      GO TO 10
15     IF (DELTA .GT. FDELTA) GO TO 30
      GO TO 50
30     DELTA=DELTA/10.0
      N=(N-1)/10
      GO TO 10
20     ADT=ADT - (FDELTA/2.0)
      IF (ADT .GT. T) GO TO 60
      GO TO 70
25     T=DELTA*(N-1)
      RETURN
      END

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SUBROUTINE CONVOL	74/74	OPT=1	FTN 4.8+518	10/06/80	09.37.33
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1	C	SUBROUTINE CONVOL	AFRUM 554
5	C	THIS SUBROUTINE CALCULATES THE ORIGINATES OF A CONVOLUTED HYDROGRAPH IF A	AFRUM 555
	C	UNIT HYDROGRAPH AND A PRECIPITATION EXCESS MATRIX ARE PROVIDED AS INPUT	AFRUM 556
10	C		AFRUM 557
	C		AFRUM 558
	C		AFRUM 559
	C		AFRUM 560
	C		AFRUM 561
15	C	REAL KT1,KT2,KUP,IMP,LOSS,KT23,KUR,LFE,LMN,LCA,LWG,LSO,LAL	AFRUM 562
	C	COMMON RUNOFF(800),HYDRO(800),RNOFF(500),RAIN(500),STAGE(500)	AFRUM 563
	C	>AREA(500),PE(500),PEI(500),PEI(500),SRO(500),BASIN(4),BOATE,	AFRUM 564
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 565
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 566
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 567
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 568
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 569
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 570
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 571
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 572
	C	>ICASH(604),PHI,DT,UA,IT,IT3,UP,UR,REL,KT1,KT2,KUP,RN,ITOTAL,	AFRUM 573
20	C	COMMON DUMPY,ICHAR,PE,PI,PS	AFRUM 574
	C	COMPUTE NUMBER OF INCREMENTS IN EACH LIMB OF HYDROGRAPH (RISING,FALLING,	AFRUM 575
	C	AND RECESSON)	AFRUM 576
	C	DELTA1=1/DT	AFRUM 577
	C	DELTA2=1/DT	AFRUM 578
	C	DELTA3=1/DT	AFRUM 579
25	C	INPUT DUMMY PARAMETER TO USE IN CONTROLLING OUTPUT	AFRUM 580
	C	ISXTP=1	AFRUM 581
	C	NPE=NPRF	AFRUM 582
30	C	COMPUTE NUMBER OF DT PERIODS IN EACH LIMB OF HYDROGRAPH (RISING,FALLING	AFRUM 583
	C	AND RECESSON	AFRUM 584
	C	N1=0	AFRUM 585
	C	IF (N1.GT. DELTA1*0.1) GO TO 100	AFRUM 586
	C	GO TO 90	AFRUM 587
35	C	N1=N1-1	AFRUM 588
	C	N2=0	AFRUM 589
	C	N2=N2+1	AFRUM 590
	C	IF (N2.GT. DELTA2*0.1) GO TO 120	AFRUM 591
	C	GO TO 110	AFRUM 592
40	C	N2=N2-1	AFRUM 593
	C	N3=0	AFRUM 594
	C	N3=N3+1	AFRUM 595
	C	IF (N3.GT. DELTA3*0.1) GO TO 140	AFRUM 596
	C	GO TO 130	AFRUM 597
45	C	N3=N3-1	AFRUM 598
	C	COMPUTE HYDROGRAPH ORIGINATES AT EACH DT	AFRUM 599
	C	S1=UP/T1	AFRUM 600
	C	S2=(UR-UP)/(T2-T1)	AFRUM 601
	C	S3=(0.0-UR)/(T3-T2)	AFRUM 602
50	C	HYDRO(I)=0.0	AFRUM 603
	C	N1=N1+1	AFRUM 604
	C	IF (N1.EQ.2) N1	AFRUM 605
	C	HYDRO(I)=HYDRO(I-1)+(S1*DT)	AFRUM 606
	C	CONTINUE	AFRUM 607
55	C	N1=N1+1	AFRUM 608
	C	N2=N2+1	AFRUM 609
	C	IF (N2.EQ.2) N2	AFRUM 610
	C	HYDRO(I)=HYDRO(I-1)+(S2*DT)	AFRUM 611
	C	CONTINUE	AFRUM 612
60	C	N2=N2+1	AFRUM 613
	C	N3=N3+1	AFRUM 614
	C	IF (N3.EQ.2) N3	AFRUM 615
	C	HYDRO(I)=HYDRO(I-1)+(S3*DT)	AFRUM 616
	C	CONTINUE	AFRUM 617

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65      170      CONTINUE
        185      HYDRO(N3)=0.0
        C        WRITE(6,185)
        C        FORMAT(////)
70      192      CONVOLUTE HYDROGRAPH WITH EXCESS RAINFALL
        193      ITOTAL=N3+NPRF-1
        194      IF (ITOTAL.LT. 800) GO TO 193
        195      WRITE(6,192)
        196      FORMAT(5X,"STORAGE SPACE EXCEEDED. KILL JOB")
        197      ICRASH=1
        198      GO TO 451
        199      DO 194 I=1,N3
        200      UHYDRO(I)=HYDRO(I)
        201      CONTINUE
        202      DO 195 I=1,IDMAX
        203      HYDRO(I)=0.0
        204      CONTINUE
        205      DO 196 I=1,IDMAX
        206      RUNOFF(I)=0.0
        207      CONTINUE
        208      DO 197 I=1,N3
        209      HYDRO(I)=UHYDRO(I)*PE(I)
        210      CONTINUE
        211      DO 300 J=2,NPRF
        212      JMIN=J-1
        213      JMAX=JMIN+N3
        214      DO 209 JJ=1,JMIN
        215      RUNOFF(JJ)=0.0
        216      CONTINUE
        217      K=J
        218      DO 210 JJ=K,JMAX
        219      RUNOFF(JJ)=UHYDRO(JJ-JMIN)*PE(K)
        220      CONTINUE
        221      DO 220 JJ=1,JMAX
        222      UHYDRO(JJ)=HYDRO(JJ)+RUNOFF(JJ)
        223      CONTINUE
        224      DO 221 JJ=1,JMAX
        225      CONTINUE
        226      NBIG=ITOTAL
        227      IF (NPRO.GT. NBIG) NBIG=NPRO
        228      BIGX=0.0
        229      OBPEAK=0.0
        230      PRPEAK=0.0
        231      TPOR=0.0
        232      TIME(I)=0.0
        233      HYDRO(I)=0.0
        234      RUNOFF(I)=0.0
        235      DO 340 I=2,NBIG
        236      TIME(I)=TIME(I-1)+DT
        237      CONTINUE
        238      IT1=ITOTAL+1
        239      DO 350 I=IT1,IDMAX
        240      HYDRO(I)=0.0
        241      CONTINUE
        242      NPRO=NPRO+1
        243      DO 360 I=NPRO1,IDMAX
        244      RUNOFF(I)=0.0
        245      CONTINUE
        246      IF (UNIT.EQ.0) GO TO 368
        247      CONVRT=(SQRT(40.*3560.))/(3600.*12.)
        248      DO 365 I=1,NBIG
        249      HYDRO(I)=HYDRO(I)*CONVRT
        250      RUNOFF(I)=RUNOFF(I)*CONVRT
        251      CONTINUE
        252      DO 410 I=1,NBIG
        253      UHYDRO(I)=HYDRO(I)
        254      GO TO 380
        255      PRPEAK=HYDRO(I)
        256      370

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AFRUM 687

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135      TPR=TIME(I)
136      CONTINUE
137      GO TO 385
140      OBPEAK=ROFF(I)
141      TPOB=TIME(I)
142      CONTINUE
143      IF (I1STM.EQ.1) OBPEAK=0.0
144      IF (I1STM.EQ.1) TPOB=0.0
145      IF (OBPEAK.GT.8IGY) 8IGY=OBPEAK
146      GO TO 430
150      CONTINUE
151      WRITE(6,411) TPOB,TPPR
152      FORMAT(4X,"OBSERVED",10X,"PREDICTED"/
153      >2X,"TIME TO PEAK",5X,"TIME TO PEAK"/
154      >4X,"HOURS",10X,"HOURS"/
155      >F10.3,F10.3)
156      IF (IUNIT.EQ.1) GO TO 420
157      WRITE(6,412) OBPEAK,PRPEAK
158      FORMAT(12X,"OBSERVED PEAK",5X,"PREDICTED PEAK"/
159      >5X,"(IN/HR)",11X,"(IN/HR)"/
160      >F11.5,F11.5)
161      GO TO 4519
162      WRITE(6,425) OBPEAK,PRPEAK
163      FORMAT(12X,"OBSERVED PEAK",5X,"PREDICTED PEAK"/
164      >6X,"(CFS)",12X,"(CFS)"/
165      >F11.5,F11.5)
166      GO TO 4519
167      8IGX=1ML/NBIG
168      DUMX(1)=0.0
169      DUMX(2)=8IGX
170      DUMX(3)=8IGY
171      DUMX(4)=8IGY
172      NPREF=NBIG+2
173      ARATE=MIN/HR
174      IF (IUNIT.NE.0) ARATE="(CFS)"
175      BRATE=7HLBS/HR
176      IF (IUNIT.NE.0) BRATE=7HLBS/SEC
177      WRITE(6,4300)
178      FORMAT(1M,18X,"TABLE I. HYDROGRAPH OUTPUT",///)
179      IF (ILOAD.NE.0) WRITE(6,434)
180      IF (ILOAD.NE.0) WRITE(6,434)
181      WRITE(6,436)
182      FORMAT(7X,"OBSERVED",6X,"PREDICTED")
183      IF (ILOAD.NE.0) WRITE(6,437)
184      IF (ILOAD.NE.0) WRITE(6,437)
185      WRITE(6,438)
186      FORMAT(8X,"FLOW OUT OF",3X,"FLOW OUT OF")
187      IF (ILOAD.NE.0) WRITE(6,439)
188      IF (ILOAD.NE.0) WRITE(6,439)
189      WRITE(6,4391)
190      FORMAT(6X,"WATERSHED",5X,"WATERSHED",8X,"TIME")
191      IF (ILOAD.NE.0) WRITE(6,4392)
192      IF (ILOAD.NE.0) WRITE(6,4392)
193      IF (ILOAD.NE.0) WRITE(6,4393)
194      IF (ILOAD.NE.0) WRITE(6,4393)
195      IF (ILOAD.NE.0) WRITE(6,4394)
196      IF (ILOAD.NE.0) WRITE(6,4394)
197      IF (ILOAD.NE.0) WRITE(6,4395)
198      IF (ILOAD.NE.0) WRITE(6,4395)
199      IF (ILOAD.NE.0) WRITE(6,4396)
200      IF (ILOAD.NE.0) WRITE(6,4396)
201      IF (ILOAD.NE.0) WRITE(6,4397)
202      IF (ILOAD.NE.0) WRITE(6,4397)
203      IF (ILOAD.NE.0) WRITE(6,4398)
204      IF (ILOAD.NE.0) WRITE(6,4398)
205      IF (ILOAD.NE.0) WRITE(6,4399)
206      IF (ILOAD.NE.0) WRITE(6,4399)
207      IF (ILOAD.NE.0) WRITE(6,4400)
208      IF (ILOAD.NE.0) WRITE(6,4400)
209      IF (ILOAD.NE.0) WRITE(6,4401)
210      IF (ILOAD.NE.0) WRITE(6,4401)
211      IF (ILOAD.NE.0) WRITE(6,4402)
212      IF (ILOAD.NE.0) WRITE(6,4402)
213      IF (ILOAD.NE.0) WRITE(6,4403)
214      IF (ILOAD.NE.0) WRITE(6,4403)
215      IF (ILOAD.NE.0) WRITE(6,4404)
216      IF (ILOAD.NE.0) WRITE(6,4404)
217      IF (ILOAD.NE.0) WRITE(6,4405)
218      IF (ILOAD.NE.0) WRITE(6,4405)
219      IF (ILOAD.NE.0) WRITE(6,4406)
220      IF (ILOAD.NE.0) WRITE(6,4406)
221      IF (ILOAD.NE.0) WRITE(6,4407)
222      IF (ILOAD.NE.0) WRITE(6,4407)
223      IF (ILOAD.NE.0) WRITE(6,4408)
224      IF (ILOAD.NE.0) WRITE(6,4408)
225      IF (ILOAD.NE.0) WRITE(6,4409)
226      IF (ILOAD.NE.0) WRITE(6,4409)
227      IF (ILOAD.NE.0) WRITE(6,4410)
228      IF (ILOAD.NE.0) WRITE(6,4410)
229      IF (ILOAD.NE.0) WRITE(6,4411)
230      IF (ILOAD.NE.0) WRITE(6,4411)
231      IF (ILOAD.NE.0) WRITE(6,4412)
232      IF (ILOAD.NE.0) WRITE(6,4412)
233      IF (ILOAD.NE.0) WRITE(6,4413)
234      IF (ILOAD.NE.0) WRITE(6,4413)
235      IF (ILOAD.NE.0) WRITE(6,4414)
236      IF (ILOAD.NE.0) WRITE(6,4414)
237      IF (ILOAD.NE.0) WRITE(6,4415)
238      IF (ILOAD.NE.0) WRITE(6,4415)
239      IF (ILOAD.NE.0) WRITE(6,4416)
240      IF (ILOAD.NE.0) WRITE(6,4416)
241      IF (ILOAD.NE.0) WRITE(6,4417)
242      IF (ILOAD.NE.0) WRITE(6,4417)
243      IF (ILOAD.NE.0) WRITE(6,4418)
244      IF (ILOAD.NE.0) WRITE(6,4418)
245      IF (ILOAD.NE.0) WRITE(6,4419)
246      IF (ILOAD.NE.0) WRITE(6,4419)
247      IF (ILOAD.NE.0) WRITE(6,4420)
248      IF (ILOAD.NE.0) WRITE(6,4420)
249      IF (ILOAD.NE.0) WRITE(6,4421)
250      IF (ILOAD.NE.0) WRITE(6,4421)
251      IF (ILOAD.NE.0) WRITE(6,4422)
252      IF (ILOAD.NE.0) WRITE(6,4422)
253      IF (ILOAD.NE.0) WRITE(6,4423)
254      IF (ILOAD.NE.0) WRITE(6,4423)
255      IF (ILOAD.NE.0) WRITE(6,4424)
256      IF (ILOAD.NE.0) WRITE(6,4424)
257      IF (ILOAD.NE.0) WRITE(6,4425)
258      IF (ILOAD.NE.0) WRITE(6,4425)
259      IF (ILOAD.NE.0) WRITE(6,4426)
260      IF (ILOAD.NE.0) WRITE(6,4426)
261      IF (ILOAD.NE.0) WRITE(6,4427)
262      IF (ILOAD.NE.0) WRITE(6,4427)
263      IF (ILOAD.NE.0) WRITE(6,4428)
264      IF (ILOAD.NE.0) WRITE(6,4428)
265      IF (ILOAD.NE.0) WRITE(6,4429)
266      IF (ILOAD.NE.0) WRITE(6,4429)
267      IF (ILOAD.NE.0) WRITE(6,4430)
268      IF (ILOAD.NE.0) WRITE(6,4430)
269      IF (ILOAD.NE.0) WRITE(6,4431)
270      IF (ILOAD.NE.0) WRITE(6,4431)
271      IF (ILOAD.NE.0) WRITE(6,4432)
272      IF (ILOAD.NE.0) WRITE(6,4432)
273      IF (ILOAD.NE.0) WRITE(6,4433)
274      IF (ILOAD.NE.0) WRITE(6,4433)
275      IF (ILOAD.NE.0) WRITE(6,4434)
276      IF (ILOAD.NE.0) WRITE(6,4434)
277      IF (ILOAD.NE.0) WRITE(6,4435)
278      IF (ILOAD.NE.0) WRITE(6,4435)
279      IF (ILOAD.NE.0) WRITE(6,4436)
280      IF (ILOAD.NE.0) WRITE(6,4436)
281      IF (ILOAD.NE.0) WRITE(6,4437)
282      IF (ILOAD.NE.0) WRITE(6,4437)
283      IF (ILOAD.NE.0) WRITE(6,4438)
284      IF (ILOAD.NE.0) WRITE(6,4438)
285      IF (ILOAD.NE.0) WRITE(6,4439)
286      IF (ILOAD.NE.0) WRITE(6,4439)
287      IF (ILOAD.NE.0) WRITE(6,4440)
288      IF (ILOAD.NE.0) WRITE(6,4440)
289      IF (ILOAD.NE.0) WRITE(6,4441)
290      IF (ILOAD.NE.0) WRITE(6,4441)
291      IF (ILOAD.NE.0) WRITE(6,4442)
292      IF (ILOAD.NE.0) WRITE(6,4442)
293      IF (ILOAD.NE.0) WRITE(6,4443)
294      IF (ILOAD.NE.0) WRITE(6,4443)
295      IF (ILOAD.NE.0) WRITE(6,4444)
296      IF (ILOAD.NE.0) WRITE(6,4444)
297      IF (ILOAD.NE.0) WRITE(6,4445)
298      IF (ILOAD.NE.0) WRITE(6,4445)
299      IF (ILOAD.NE.0) WRITE(6,4446)
300      IF (ILOAD.NE.0) WRITE(6,4446)
301      IF (ILOAD.NE.0) WRITE(6,4447)
302      IF (ILOAD.NE.0) WRITE(6,4447)
303      IF (ILOAD.NE.0) WRITE(6,4448)
304      IF (ILOAD.NE.0) WRITE(6,4448)
305      IF (ILOAD.NE.0) WRITE(6,4449)
306      IF (ILOAD.NE.0) WRITE(6,4449)
307      IF (ILOAD.NE.0) WRITE(6,4450)
308      IF (ILOAD.NE.0) WRITE(6,4450)
309      IF (ILOAD.NE.0) WRITE(6,4451)
310      IF (ILOAD.NE.0) WRITE(6,4451)
311      IF (ILOAD.NE.0) WRITE(6,4452)
312      IF (ILOAD.NE.0) WRITE(6,4452)
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320      IF (ILOAD.NE.0) WRITE(6,4456)
321      IF (ILOAD.NE.0) WRITE(6,4457)
322      IF (ILOAD.NE.0) WRITE(6,4457)
323      IF (ILOAD.NE.0) WRITE(6,4458)
324      IF (ILOAD.NE.0) WRITE(6,4458)
325      IF (ILOAD.NE.0) WRITE(6,4459)
326      IF (ILOAD.NE.0) WRITE(6,4459)
327      IF (ILOAD.NE.0) WRITE(6,4460)
328      IF (ILOAD.NE.0) WRITE(6,4460)
329      IF (I
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205      SUS=CONC*HYDRO(1)*DLOAD
206      PRAT=16.4411*SUS
207      IF (PRAT.LT.1E-6) SUS=15.3
208      SUS=5*SUS*SQRT(15.3)
209      CONTINUE
210      VRO=SUS/((CONC*DLOAD)
211      IF (VRO.LT.1E-6) RETURN
212      WRITE(6,460) SUS
213      FORMAT('//////,12X,"TOTAL SUSPENDED SOLIDS (LBS) DISCHARGED FROM WAT
214      ERSHEM",,12X,"DURING STORM EVENT ="*F15.3)
215      IF (VRO.LT.1E-6) GO TO 760
216      WRITE(6,4601)
217      FORMAT('IH ,',,12X)
218      GO TO 4109
219      CONTINUE
220      IF (VRO.LT.1E-6) GO TO 760
221      IF (VRO.LT.1E-6) RETURN
222      IF (VRO.LT.1E-6) RETURN
223      GO TO 760
224      CFE=4.42*ULFE
225      LFE=ULFE*SRO(NPRF)*SQMI*640
226      ULMN=0.0072*PI-0.0092*U*PF+0.20
227      CMN=4.42*ULMN
228      ULMN=ULMN*NPRF)*SQMI*640
229      LCM=ULMN*SRO(NPRF)*SQMI*640
230      ULCA=0.0072*PI-0.0092*U*PF+0.20
231      CMCA=4.42*ULCA
232      ULCA=ULCA*NPRF)*SQMI*640
233      LCA=ULCA*SRO(NPRF)*SQMI*640
234      ULMG=0.0072*PI-0.0092*U*PF+0.20
235      CMG=4.42*ULMG
236      ULMG=ULMG*SRO(NPRF)*SQMI*640
237      ULMO=0.0072*PI-0.0092*U*PF+0.20
238      CMO=4.42*ULMO
239      ULMO=ULMO*SRO(NPRF)*SQMI*640
240      LMO=ULMO*SRO(NPRF)*SQMI*640
241      ULAL=0.0072*PI-0.0092*U*PF+0.20
242      CAL=4.42*ULAL
243      ULAL=ULAL*SRO(NPRF)*SQMI*640
244      GO TO 790
245      LFE=0.0072*PI-0.0092*U*PF+0.20
246      CMFE=4.42*ULFE
247      LFE=ULFE*SRO(NPRF)*SQMI*640
248      ULMN=0.0072*PI-0.0092*U*PF+0.20
249      CMN=4.42*ULMN
250      ULMN=ULMN*NPRF)*SQMI*640
251      LCM=ULMN*SRO(NPRF)*SQMI*640
252      ULCA=0.0072*PI-0.0092*U*PF+0.20
253      CMCA=4.42*ULCA
254      ULCA=ULCA*NPRF)*SQMI*640
255      LCA=ULCA*SRO(NPRF)*SQMI*640
256      ULMG=0.0072*PI-0.0092*U*PF+0.20
257      CMG=4.42*ULMG
258      ULMG=ULMG*SRO(NPRF)*SQMI*640
259      ULMO=0.0072*PI-0.0092*U*PF+0.20
260      CMO=4.42*ULMO
261      ULMO=ULMO*SRO(NPRF)*SQMI*640
262      LMO=ULMO*SRO(NPRF)*SQMI*640
263      ULAL=0.0072*PI-0.0092*U*PF+0.20
264      CAL=4.42*ULAL
265      ULAL=ULAL*SRO(NPRF)*SQMI*640
266      GO TO 790
267      LFE=0.0072*PI-0.0092*U*PF+0.20
268      CMFE=4.42*ULFE
269      LFE=ULFE*SRO(NPRF)*SQMI*640
270      ULMN=0.0072*PI-0.0092*U*PF+0.20
271      CMN=4.42*ULMN
272      ULMN=ULMN*NPRF)*SQMI*640
273      LCM=ULMN*SRO(NPRF)*SQMI*640
274      ULCA=0.0072*PI-0.0092*U*PF+0.20
275      CMCA=4.42*ULCA
276      ULCA=ULCA*NPRF)*SQMI*640
277      LCA=ULCA*SRO(NPRF)*SQMI*640
278      ULMG=0.0072*PI-0.0092*U*PF+0.20
279      CMG=4.42*ULMG
280      ULMG=ULMG*SRO(NPRF)*SQMI*640
281      ULMO=0.0072*PI-0.0092*U*PF+0.20
282      CMO=4.42*ULMO
283      ULMO=ULMO*SRO(NPRF)*SQMI*640
284      LMO=ULMO*SRO(NPRF)*SQMI*640
285      ULAL=0.0072*PI-0.0092*U*PF+0.20
286      CAL=4.42*ULAL
287      ULAL=ULAL*SRO(NPRF)*SQMI*640
288      GO TO 790
289      LFE=0.0072*PI-0.0092*U*PF+0.20
290      CMFE=4.42*ULFE
291      LFE=ULFE*SRO(NPRF)*SQMI*640
292      ULMN=0.0072*PI-0.0092*U*PF+0.20
293      CMN=4.42*ULMN
294      ULMN=ULMN*NPRF)*SQMI*640
295      LCM=ULMN*SRO(NPRF)*SQMI*640
296      ULCA=0.0072*PI-0.0092*U*PF+0.20
297      CMCA=4.42*ULCA
298      ULCA=ULCA*NPRF)*SQMI*640
299      LCA=ULCA*SRO(NPRF)*SQMI*640
300      ULMG=0.0072*PI-0.0092*U*PF+0.20
301      CMG=4.42*ULMG
302      ULMG=ULMG*SRO(NPRF)*SQMI*640
303      ULMO=0.0072*PI-0.0092*U*PF+0.20
304      CMO=4.42*ULMO
305      ULMO=ULMO*SRO(NPRF)*SQMI*640
306      LMO=ULMO*SRO(NPRF)*SQMI*640
307      ULAL=0.0072*PI-0.0092*U*PF+0.20
308      CAL=4.42*ULAL
309      ULAL=ULAL*SRO(NPRF)*SQMI*640
310      GO TO 790
311      LFE=0.0072*PI-0.0092*U*PF+0.20
312      CMFE=4.42*ULFE
313      LFE=ULFE*SRO(NPRF)*SQMI*640
314      ULMN=0.0072*PI-0.0092*U*PF+0.20
315      CMN=4.42*ULMN
316      ULMN=ULMN*NPRF)*SQMI*640
317      LCM=ULMN*SRO(NPRF)*SQMI*640
318      ULCA=0.0072*PI-0.0092*U*PF+0.20
319      CMCA=4.42*ULCA
320      ULCA=ULCA*NPRF)*SQMI*640
321      LCA=ULCA*SRO(NPRF)*SQMI*640
322      ULMG=0.0072*PI-0.0092*U*PF+0.20
323      CMG=4.42*ULMG
324      ULMG=ULMG*SRO(NPRF)*SQMI*640
325      ULMO=0.0072*PI-0.0092*U*PF+0.20
326      CMO=4.42*ULMO
327      ULMO=ULMO*SRO(NPRF)*SQMI*640
328      LMO=ULMO*SRO(NPRF)*SQMI*640
329      ULAL=0.0072*PI-0.0092*U*PF+0.20
330      CAL=4.42*ULAL
331      ULAL=ULAL*SRO(NPRF)*SQMI*640
332      GO TO 790
333      LFE=0.0072*PI-0.0092*U*PF+0.20
334      CMFE=4.42*ULFE
335      LFE=ULFE*SRO(NPRF)*SQMI*640
336      ULMN=0.0072*PI-0.0092*U*PF+0.20
337      CMN=4.42*ULMN
338      ULMN=ULMN*NPRF)*SQMI*640
339      LCM=ULMN*SRO(NPRF)*SQMI*640
340      ULCA=0.0072*PI-0.0092*U*PF+0.20
341      CMCA=4.42*ULCA
342      ULCA=ULCA*NPRF)*SQMI*640
343      LCA=ULCA*SRO(NPRF)*SQMI*640
344      ULMG=0.0072*PI-0.0092*U*PF+0.20
345      CMG=4.42*ULMG
346      ULMG=ULMG*SRO(NPRF)*SQMI*640
347      ULMO=0.0072*PI-0.0092*U*PF+0.20
348      CMO=4.42*ULMO
349      ULMO=ULMO*SRO(NPRF)*SQMI*640
350      LMO=ULMO*SRO(NPRF)*SQMI*640
351      ULAL=0.0072*PI-0.0092*U*PF+0.20
352      CAL=4.42*ULAL
353      ULAL=ULAL*SRO(NPRF)*SQMI*640
354      GO TO 790
355      LFE=0.0072*PI-0.0092*U*PF+0.20
356      CMFE=4.42*ULFE
357      LFE=ULFE*SRO(NPRF)*SQMI*640
358      ULMN=0.0072*PI-0.0092*U*PF+0.20
359      CMN=4.42*ULMN
360      ULMN=ULMN*NPRF)*SQMI*640
361      LCM=ULMN*SRO(NPRF)*SQMI*640
362      ULCA=0.0072*PI-0.0092*U*PF+0.20
363      CMCA=4.42*ULCA
364      ULCA=ULCA*NPRF)*SQMI*640
365      LCA=ULCA*SRO(NPRF)*SQMI*640
366      ULMG=0.0072*PI-0.0092*U*PF+0.20
367      CMG=4.42*ULMG
368      ULMG=ULMG*SRO(NPRF)*SQMI*640
369      ULMO=0.0072*PI-0.0092*U*PF+0.20
370      CMO=4.42*ULMO
371      ULMO=ULMO*SRO(NPRF)*SQMI*640
372      LMO=ULMO*SRO(NPRF)*SQMI*640
373      ULAL=0.0072*PI-0.0092*U*PF+0.20
374      CAL=4.42*ULAL
375      ULAL=ULAL*SRO(NPRF)*SQMI*640
376      GO TO 790
377      LFE=0.0072*PI-0.0092*U*PF+0.20
378      CMFE=4.42*ULFE
379      LFE=ULFE*SRO(NPRF)*SQMI*640
380      ULMN=0.0072*PI-0.0092*U*PF+0.20
381      CMN=4.42*ULMN
382      ULMN=ULMN*NPRF)*SQMI*640
383      LCM=ULMN*SRO(NPRF)*SQMI*640
384      ULCA=0.0072*PI-0.0092*U*PF+0.20
385      CMCA=4.42*ULCA
386      ULCA=ULCA*NPRF)*SQMI*640
387      LCA=ULCA*SRO(NPRF)*SQMI*640
388      ULMG=0.0072*PI-0.0092*U*PF+0.20
389      CMG=4.42*ULMG
390      ULMG=ULMG*SRO(NPRF)*SQMI*640
391      ULMO=0.0072*PI-0.0092*U*PF+0.20
392      CMO=4.42*ULMO
393      ULMO=ULMO*SRO(NPRF)*SQMI*64
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SUBROUTINE BASINA	74/74	OPT=1	FTN 4.8.518	10/06/80	09.37.33
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1      C
      C
5      C
      C
      SUBROUTINE BASINA(SOMI,PF,PS,BDATE,BASIN,PI)
      DIMENSION BASIN(4)
      WRITE(6,10) BASIN,BDATE,SOMI,PF,PS,PI
10      FORMAT(46X,"THE WATERSHED NAME IS",A10,"/,"
      >36X,"THE DATE OF THE RAINFALL EVENT IS",A8,"/,"
      >36X,"THE WATERSHED SIZE IN SQUARE MILES IS",
      >36X,"THE PERCENT OF THE BASIN WHICH IS FOREST IS: ",
      >36X,"THE PERCENT OF THE BASIN DENUDED IS",
      >36X,"THE PERCENT OF THE BASIN WHICH IS IMPERVIOUS IS: PI= ",F8.2//
      RETURN
      END

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AFRUM 1067
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SUBROUTINE ASSUME 74/74 OPT=1 FTN 4.8+518 09.37.33
C
C SUBROUTINE ASSUME (ISIM,IPMT,IUNIT,IPILOT,ICHAR,ILAG,ILOAD)
C
5 IF (ISIM.EQ.1) GO TO 10
  WRITE (6,5)
  FORMAT (46X,
  *BY SETTING ISIM = 0 YOU HAVE INDICATED THAT YOU PLAN"/,
  *36X,"TO SUPPLY EITHER ACTUAL OR DESIGN RAINFALL AND RUNOFF"/,
  *36X,"DATA; THEREFORE, THE SCS CURVE NUMBER, CN, WILL BE DE-"/,
  *36X,"TERMINED BY SETTING RUNOFF EQUAL TO PRECIPITATION EXCESS."/)
  GO TO 12
10 WRITE (6,15)
15 FORMAT (46X,
  *BY SETTING ISIM = 1 YOU HAVE INDICATED THAT YOU PLAN"/,
  *36X,"TO SUPPLY ACTUAL OR DESIGN RAINFALL DATA; THEREFORE, AN"/,
  *36X,"ESTIMATE OF THE SCS CURVE NUMBER, CN, MUST BE PROVIDED."/)
12 CONTINUE
  IPIUNIT (EQ.1) GO TO 25
  IPIUNIT (EQ.2) GO TO 32
20 >36X,"AND INCHES AS SELECTED BY SETTING IUNIT = 0."/)
  GO TO 32
25 WRITE (6,30)
30 FORMAT (46X,"OUTPUT UNITS OF THE SIMULATED HYDROGRAPH ARE HOURS"/,
  *36X,"AND CUBIC FEET PER SECOND. CFS, AS SELECTED BY SETTING"/,
  *36X,"IUNIT = 1."/)
32 CONTINUE
  IF (IPILOT.EQ.1) GO TO 40
  WRITE (6,35)
35 FORMAT (46X,"NO PLOT HAS BEEN REQUESTED; IPILOT = 0."/)
  GO TO 47
40 WRITE (6,45)
45 FORMAT (46X,"YOU HAVE REQUESTED THAT THE HYDROGRAPH BE PLOTTED"/,
  *36X,"BY SETTING IPILOT = 1."/)
47 CONTINUE
  IPICHAR (GT.0) GO TO 55
  IPICHAR (EQ.0) GO TO 55
50 FORMAT (6X,"THE WATERSHED IS ASSUMED TO BE URBAN WITHOUT"/,
  *36X,"SEWERS; ICHAR = 0."/)
  GO TO 100
55 IF (IPICHAR.GT.1) GO TO 65
  WRITE (6,60)
60 FORMAT (46X,"THE WATERSHED IS ASSUMED TO BE URBAN WITH STORM"/,
  *36X,"SEWERS; ICHAR = 1."/)
  GO TO 100
65 IF (IPICHAR.GT.2) GO TO 75
  WRITE (6,70)
70 FORMAT (46X,"THE WATERSHED IS SIMILAR TO A COAL STRIP MINE"/,
  *36X,"AREA, OR DENuded FOREST AREA; ICHAR = 2."/)
  GO TO 100
75 IF (IPICHAR.GT.3) GO TO 85
  WRITE (6,80)
80 FORMAT (46X,"THE WATERSHED IS MOSTLY AGRICULTURAL; ICHAR = 3X"/)
  GO TO 100
85 IF (IPICHAR.GT.4) GO TO 95
  WRITE (6,90)
90 FORMAT (46X,"THE WATERSHED IS ASSUMED TO BE MOSTLY FORESTED"/,
  *36X,"YOU HAVE SET ICHAR = 4."/)
  GO TO 100
100 CONTINUE
  IF (ILAG.GT.0) GO TO 110
  WRITE (6,105)
105 FORMAT (46X,"YOU HAVE DECIDED TO SELECT A VALUE FOR LAG"/,
  *36X,"MODULUS IN HOURS; ILAG = 0."/)
  GO TO 110
110 CONTINUE

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[illegible]

3/06/80

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GO TO 110
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ROUTINE AS

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65      GO TO 130
110      IF (LAG.GT.1) GO TO 120
115      WRITE(6,115)
120      FORMAT(46X,"YOU HAVE ELECTED TO SIMULATE LAG MODULUS IN"/,
>36X,"HOURS ASSUMING IT IS A FUNCTION OF THE WATERSHED AREA",/,
>36X,"AND PERCENT IMPERVIOUS AREA OF THE WATERSHED", ILAG = 1.,//)
70      GO TO 130
120      WRITE(6,125)
125      FORMAT(46X,"YOU HAVE ELECTED TO SIMULATE LAG MODULUS IN"/,
>36X,"HOURS ASSUMING IT IS A FUNCTION OF THE RURAL WATERSHED"/,
>36X,"AREA AND THE PERCENT OF THE WATERSHED THAT IS FORESTED"/,
>36X,"LAG = 2.",//)
75      GO TO 130
130      CONTINUE
135      IF (LOAD.EQ.2) GO TO 140
140      WRITE(6,135)
145      FORMAT(46X,"SEDIMENT LOAD HAS BEEN SIMULATED ASSUMING THE"/,
>36X,"WATERSHED IS RURAL OR URBAN WITHOUT MAJOR CONSTRUCTION"/,
>36X,"LOAD = 1.",//)
80      GO TO 150
140      WRITE(6,145)
145      FORMAT(46X,"SEDIMENT LOAD HAS BEEN SIMULATED ASSUMING THE"/,
>36X,"WATERSHED IS A DENUDED FOREST AREA OR A COAL STRIP MINE"/,
>36X,"AREA LOAD = 2.",//)
85      GO TO 150
150      CONTINUE
160      WRITE(6,160)
160      RETURN
      END

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AFRUM 1133
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1      C
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10     C
15     C
20     C
25     C
30     C
35     C
40     C
45     C
50     C
55     C
60     C
65     C
70     C

SUBROUTINE AFSOP
  WRITE (6,1000)
  FORMAT (151,/,63X,"INTRODUCTION",/,/,35X,
  "THE U.S. AIR FORCE RUNOFF MODEL (AFRUM) FOR SIMULATING STORM",/,
  "35X,"HYDROGRAPHS AND POLLUTANT YIELDS WAS DEVELOPED FOR THE AIR F
  "ORCE",/,35X,
  "BY THE DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF TENNESSEE.",
  "35X,
  "KNOXVILLE AND THE RESEARCH AND DEVELOPMENT DIRECTORATE OF THE",
  "35X,
  "AIR FORCE ENGINEERING SERVICES CENTER (AFESC), TYNDALL AIR FORCE",
  "35X,
  "BASE, FLORIDA. DR. DONALD E. OVERTON OF THE UNIVERSITY OF TENNES
  "35X,"SEE WAS THE PRINCIPAL INVESTIGATOR AND DR. GEORGE W. SCH
  "LOSSNAGLE",/,35X,"OF THE U.S. AIR FORCE WAS THE PROJECT OFFICER.",
  "THE RESULTS OF THREE")
  WRITE (6,2000)
  FORMAT (11,34X,"SEPARATE BUT COMPLEMENTARY STUDIES WERE INCORPORAT
  "ED INTO AFRUM",/,35X,
  "EACH OF THE THREE STUDIES HAD THE FUNDAMENTAL OBJECTIVE TO EVALUA
  "TE",/,35X,"THE EFFECTS OF SPECIALIZED LAND USE ON STORMWATER RUNO
  "F AND 1130,/,35X,
  "ASSOCIATED QUALITY. THE THREE STUDIES WERE FUNDED BY THE U.S. DEP
  "ARTMENT OF ENERGY, THE U.S. DEPARTMENT OF INTERIOR AND THE U.S. AIR
  "FORCE",/,35X,
  "THIS STUDY PERIOD WAS FROM 1975 THROUGH 1979. AFRUM WAS DEVEL-",
  "OPED IN THE COURSE OF ANALYZING 410 STORM EVENTS ON 36 WATERSHEDS
  "35X,
  "MATCH INCLUDED AGRICULTURAL, URBAN AND FORESTED LAND USE CONDITI
  "IONS",/,35X,
  "AS WELL AS COAL STRIP MINING AND THREE WATERSHEDS ON A U.S. AIR F
  "ORCE",/,35X,"BASE.",/,/)
  WRITE (6,3000)
  FORMAT (11,34X,
  "AFRUM WAS DEVELOPED FOR THE PURPOSE OF SIMULATING STORMWATER",/,
  "35X,"HYDROGRAPHS FROM ACTUAL OR DESIGN STORM RAINFALL DISTRIBUTION
  "S",/,35X,
  "LAND USE CHARACTERISTICS AND SOIL TYPE IN THE WATERSHED OF CONCER
  "N",/,35X,
  "THE REQUIRED INPUT BASIN CHARACTERISTICS ARE:",/,
  "35X," 1. PERCENT OF WATERSHED THAT IS FORESTED",/,
  "35X," 2. PERCENT OF WATERSHED THAT IS IMPERVIOUS",/,
  "35X," 3. PERCENT OF WATERSHED THAT IS DENUDED OR STRIP MINED",
  "35X," 4. SURFACE DRAINAGE AREA",/,35X,
  "RUNOFF VOLUME AND THE ASSOCIATED RAINFALL EXCESS TIME DISTRIBUTIO
  "N",/,35X,
  "ARE SIMULATED FROM INPUT RAINFALL USING THE U.S. SOIL CONSERVATI
  "ON")
  WRITE (6,4000)
  FORMAT (11,34X,
  "SERVICE CURVE NUMBER. IF A RUNOFF HYDROGRAPH IS PROVIDED WITH TH
  "E",/,35X,
  "ASSOCIATED RAINFALL HYETOGRAPH, AFRUM WILL COMPUTE THE CURVE NUM-
  "BER, CN; OTHERWISE CN MUST BE AN INPUT. CN IS SELECTED BY USING
  "35X,
  "THE PROCEDURES PROVIDED IN THE NATIONAL ENGINEERING HANDBOOK",/,
  "35X,"SECTION 4.5. U.S. SOIL CONSERVATION SERVICE",/,
  "35X,"AFRUM MEETS PROVISION FOR SIMULATING A UNIT HYDROGRAPH OR",/,
  "35X,"UNIT RESPONSE FUNCTION, WHICH IS CONVOLUTED WITH THE RAINFALL
  "EXCESS HYETOGRAPH. AFRUM ALSO SIMULATES POLLUTANT LOADS FOR THE",/,
  "35X,
  "HYPOTHESED STORM. THIS SIMULATION IS A FUNCTION OF THE SPECIFIED",/,
  "35X,"WATERSHED AND STORM CHARACTERISTICS.",/,1H)
  RETURN
  END

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SUBROUTINE HYPLOT 74/74 OPT=1 FTM 4.8*518 10/06/80 09.37.33

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SUBROUTINE LETTER		74/74	OPT=1	FTN 4.8-518	10/06/80	09.37.33
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SUBROUTINE	CHARAC	74/74	OPT=1	FTN 4.8+518	10/06/80	09.37.33
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MAR(01,K)K=1,12),I
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406B,
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7774A(193068,K=1,12),I
7774A(194068,K=1,12),I
7774A(195068,K=1,12),I
7774A(196
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			01608
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65      3*1406B,2*0614B,0330B,6*0160B/
      DATA(CHAR(26,K),K=1,12)/
      2*1776B,0006B,0014B,0030B,0060B,0140B,0300B,0600B,1400B,2*1776B/
      DATA(CHAR(27,K),K=1,12)/
      12*0/
      DATA(CHAR(29,K),K=1,12)/
      2*1776B,8*1406B,2*1776B/
      DATA(CHAR(29,K),K=1,12)/
      0060R,0160R,0360B,7*0060B,2*0776B/
      DATA(CHAR(30,K),K=1,12)/
      2*1776B,3*0014B,0030B,0060B,0140B,0300B,0600B,2*1776B/
      DATA(CHAR(31,K),K=1,12)/
      2*1776B,3*0006B,2*0376B,3*0006B,2*1776B/
      DATA(CHAR(32,K),K=1,12)/
      0016B,0036B,0066B,0146B,0306B,0776B,1776B,5*0006B/
      DATA(CHAR(33,K),K=1,12)/
      2*1776B,2*1400B,2*1776B,4*0006B,2*1776B/
      DATA(CHAR(34,K),K=1,12)/
      2*1776B,3*1400B,2*1776B,3*1406B,2*1776B/
      DATA(CHAR(35,K),K=1,12)/
      2*1776B,2*0006B,0014B,2*0030B,5*0006B/
      DATA(CHAR(36,K),K=1,12)/
      2*1776B,3*1406B,2*1776B,3*1406B,2*1776B/
      DATA(CHAR(37,K),K=1,12)/
      2*1776B,3*1406B,2*1776B,3*0006B,2*1776B/
      DATA(CHAR(38,K),K=1,12)/
      1HM,1H0,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ,1H,1H0,1H1,
      1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
      DATA LINE1(135,1H/
      DATA MASK/2000B,1000B,400B,200B,100B,40B,20B,10B,4B,2B,1B/
      DO 150 IJ=1,12
      J=13-IJ
      IF(1776B(J).NE.1ALPHA(27)) GO TO 70
      150 CONTINUE
      70 CONTINUE
      NUMLET=J
      OFFSET=(12-NUMLET)*6
      ITEST=0
      IJ=1
      DO 250 IJ=1,12
      JK=13-IJ
      IF(1776B(JK).EQ.1ALPHA(JK)) ITEST=1
      IF(1776B(JK).EQ.0) GO TO 251
      GO TO 250
      251 CONTINUE
      250 CONTINUE
      DO 2000 LNCNT=1,12
      LPOS=1,12
      LPOS=(11-LPOS+1)* OFFSET
      LTEST=CHAR(10,LPOS)+ MAKEUP=1,11
      LTEST=CHAR(10,LPOS)+ LNCNT).AND.MASK(MAKEUP)
      IF(LTEST.EQ.0) GO TO 1200
      LINE1(LPOS+MAKEUP)=1H0
      1200 CONTINUE
      1000 CONTINUE
      WRITE(6,200)(LINE1(JQ),JQ=1,135)
      DO 600 IK=1,135
      IF(LINE1(IK).EQ.1H0) LINE1(IK)=1HX
      WRITE(6,201)(LINE1(JQ),JQ=1,135)
      DO 601 IK=1,135
      IF(LINE1(IK).EQ.1HX) LINE1(IK)=1HA
      WRITE(6,201)(LINE1(JQ),JQ=1,135)
      DO 602 IK=1,135
      IF(LINE1(IK).EQ.1HA) LINE1(IK)=1HV
      WRITE(6,201)(LINE1(JQ),JQ=1,135)
      201 FORMAT(1H+,135A1)
      DO 106 IJ=1,135
      LINE1(IJ)
      106 CONTINUE
      2000 CONTINUE
      RETURN
      END

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AFRUM 980
AFRUM 981
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AFRUM 1053

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USAFRCE/CR/DEEV	1
USAFRCE/ER/DEEV	1

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