PB84-189786

URBAN HIGHWAY STORM DRAINAGE MODEL

VOL. 2 PRECIPITATION MODULE

U.S. Department of Transportation

Federal Highway Administration

Research, Development, and Technology

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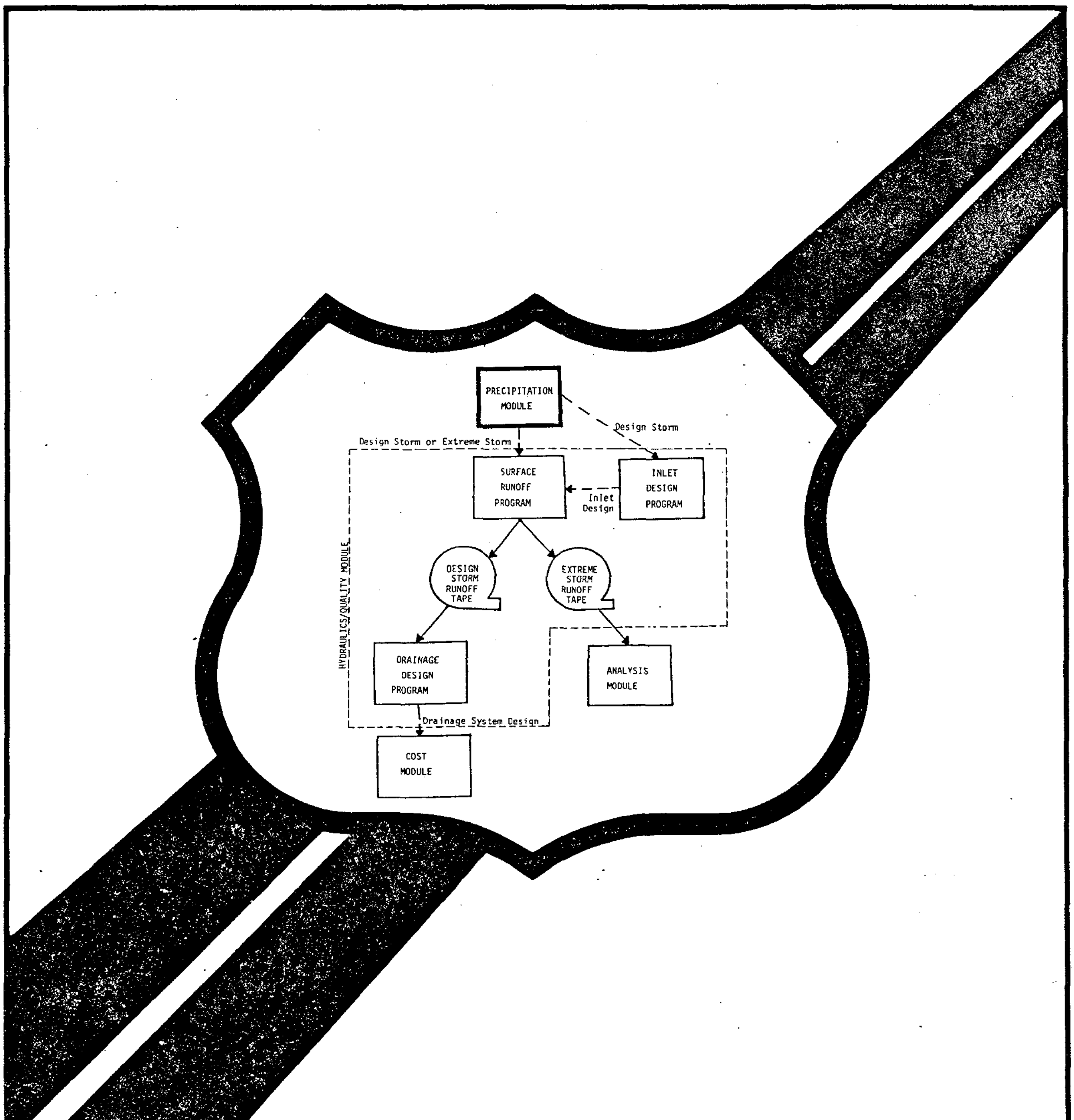
6300 Georgetown Pike
McLean, Virginia 22101

Report No.
FHWA/RD-83/042

Final Report

December 1983



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FOREWORD

This report documents the development and presents the user's manual for the Precipitation Module of this computer model. This module generates local design storm hyetographs of selected duration, frequency and rainfall skewness, and makes local dry period frequency analysis for the runoff quality investigation. Although this module is developed for use in this urban highway computer model to derive local storms, it can also be used in the design of small highway drainage structures in rural areas, such as culverts.

Research and development in urban and rural highway storm drainage is included in the Federally Coordinated Program of Highway Research, Development, and Technology Project 5H "Highway Drainage and Flood Protection." Dr. Roy E. Trent is the Project Manager and Dr. D. C. Woo is the Contracting Officer's Technical Representative for this study.

This report is being distributed on request only due to the specialized nature of the contents.

Richard E. Hay, Director
Office of Engineering
and Highway Operations
Research and Development
Federal Highway Administration

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Technical Report Documentation Page

1. Report No. FHWA/RD-83/042	2. Government Accession No.	3. Recipient's Catalog No. PB84 189786
4. Title and Subtitle Urban Highway Storm Drainage Model Vol. 2. Precipitation Module User's Manual and Documentation		5. Report Date December 1983 6. Performing Organization Code
7. Author(s) R. J. Dever, Jr. and R. J. Trotter		8. Performing Organization Report No.
9. Performing Organization Name and Address Camp Dresser and McKee Inc. 7630 Little River Turnpike, Suite 500 Annandale, Virginia 22003		10. Work Unit No. (TRAIS) 35H2-042 11. Contract or Grant No. DOT-FH-11-9162
12. Sponsoring Agency Name and Address Office of Engineering and Highway Operations R&D Federal Highway Administration 6300 Georgetown Pike McLean, VA 22101		13. Type of Report and Period Covered Final Report (September 1976 to March 1981) 14. Sponsoring Agency Code S01323

15. Supplementary Notes

FHWA Contracting Officer's Technical Representative: D. C. Woo (HNR-10)

16. Abstract

A package of six user-oriented computer programs has been developed and tested for the analysis and design of urban highway drainage systems and related non-point source pollution problems. These programs are organized into four related but independent Modules.

This report consists of the documentation and user's manual for the Precipitation Module. Hourly precipitation data can be statistically analyzed by this module to generate design storm hyetographs.

This report is the second in a series. The others in the series are:

Vol. No.	FHWA No.	Short Title
-	83/040	Executive Summary
1	83/041	Model Development and Test Applications
3	83/043	Inlet Design Program
4	83/044	Surface Runoff Program
5	83/045	Drainage Design Program
6	83/046	Analysis Module
7	83/047	Cost Estimation Module

17. Key Words Storm Drains-Highway, Computer Modeling, Synthetic Hyetographs, Rainfall, Statistical Model	18. Distribution Statement No restriction. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 207	22. Price

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CHAPTER I

OVERVIEW OF THE URBAN HIGHWAY STORM DRAINAGE MODEL

The Urban Highway Storm Drainage Model consists of four modules in six computer programs, developed for the Federal Highway Administration, U.S. Department of Transportation by the Water Resources Division of Camp Dresser & McKee Inc. The basic purpose of this package of programs is to provide the engineer with computational tools to assist in the analysis and design of highway drainage systems. Due to the nature of the problem, this model is not intended to fully automate the design process. Each module or program can be used separately to suit the designer's purpose.

The programs of the model are organized into four related but independent modules, as follows:

- Precipitation Module
- Hydraulics/Quality Module
  - Surface Runoff Program
  - Inlet Design Program
  - Drainage Design Program
- Analysis Module
- Cost Module

The Precipitation Module can perform a variety of statistical analyses on long-term hourly precipitation data and generate design storm hyetographs. The Hydraulics/Quality Module is the basic design tool in the package. This module simulates time-varying runoff quantity and quality, locates stormwater inlets and sizes the conduits of the major drainage system. The Analysis Module simulates unsteady gradually-varied flow in the drainage system and can be used to analyze complex hydraulic conditions, such as surcharge and backwater, that may be encountered during extreme storm events. The Cost Module can be used to estimate construction, operation and maintenance, and total annual costs associated with the drainage system.

The interrelationships among the computer programs are illustrated by Figure I-1. As can be seen from this figure, there are a variety of ways in which these programs can be used independently or in conjunction with each other. This flexibility should allow the engineer to apply one or more of these programs to a wide variety of common stormwater-related problems. The major features of each of the programs are summarized in Tables I-1 through I-4.

This chapter is intended only to give the reader a broad overview of the Urban Highway Storm Drainage Model. To gain an understanding of the potential applications, the capabilities and the limitations of a particular program in the package, the engineer will need to study the appropriate User's Manual and Documentation Report.

This report is the User's Manual and Documentation Report for the Precipitation Module. Chapter II of the report is an introduction to this program, describing the general approach used in the program and how the program fits into the drainage design process. The technical approach employed in the program is presented in some detail in Chapter III. Finally, Chapter IV is a complete user's manual for the program including input requirements, and a Fortran listing of the program.

The Urban Highway Storm Drainage Model is a storm event model. It starts with the derivation of the precipitation information. The basic approach is a statistical analysis of available data, either actual hourly precipitation data or some form of processed data.

This Precipitation Module consists of three program paths. Program Paths One and Two deal with the derivation of a single-peak design storm

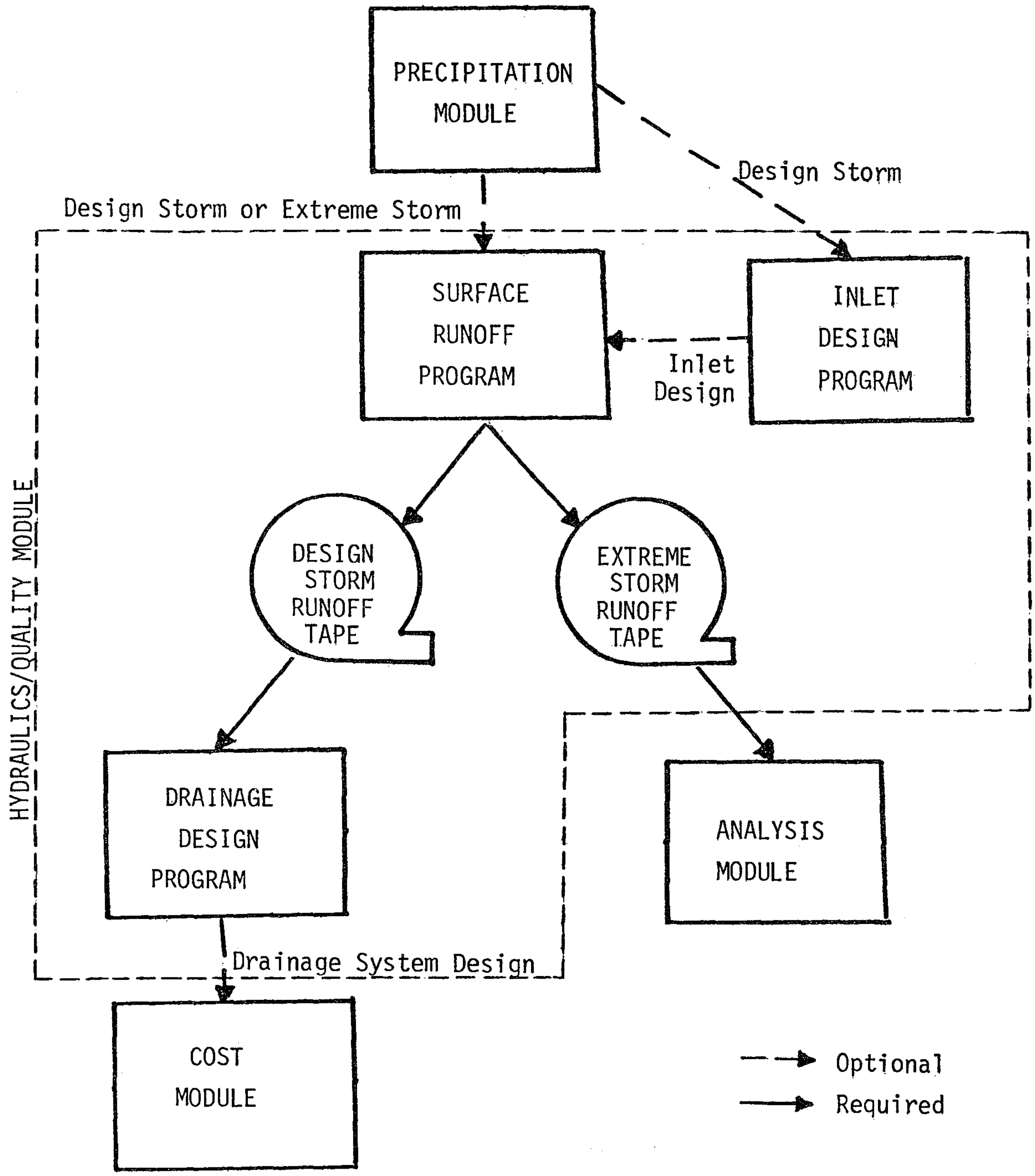

FIGURE I-1 Urban Highway Storm Drainage Model

TABLE I-1

MAJOR FEATURES OF THE PRECIPITATION MODULE

- Derivation of Hyetographs of Selected Return Frequency, Duration, and Skew
- Statistical Analysis of Hourly Rainfall Records to Generate Intensity-Duration-Frequency Curves
- Frequency of Occurrence Analysis of Hourly Rainfall Records for Peak Rainfall Intensity, Storm Duration, and Dry Period Duration
- Statistical Analysis of Hourly Rainfall Records for Storm Skew

TABLE I-2

MAJOR FEATURES OF HYDRAULICS/QUALITY MODULE PROGRAMS

INLET DESIGN PROGRAM (INLET)

- Simulation of Time-Varying Runoff and Gutter/Channel Flow
- Spacing of Fixed-Size Inlets in Gutters or Channels
- Prespecification of Inlet Locations if Required
- Simulation of Six Basic Inlet Types

SURFACE RUNOFF PROGRAM (SRO)

- Simulation of Time-Varying Runoff and Gutter/Channel Flow
- Simulation of Accumulation and Washoff of Suspended Solids and Associated Pollutants
- Simulation of All Inlet Types Considered in Inlet Design Program
- Simulation of Four Types of Gutters/Channels
- Generation of Runoff Tape (Inlet Hydrographs and Pollutographs)

DRAINAGE DESIGN PROGRAM (DRAIN)

- Standard Pipe Sizing
- Sizing of Trapezoidal Open Channels
- Routing of Pollutants Through Drainage System
- Simulation of Treatment at Outfalls (Suspended Solids Removal)

TABLE I-3

MAJOR FEATURES OF THE ANALYSIS MODULE

- Analysis of Extreme Storm Event Hydraulic Conditions in the Major Drainage System Such as Surcharge, Backwater, and Surface Flooding

- Simulation of Unsteady Gradually-Varied Flow in the Major Drainage System

- Simulation of Channels and Pipes of Five Different Cross-Sections

- Simulation of Pumping Station Operation

TABLE I-4

MAJOR FEATURES OF THE COST ESTIMATION MODULE

- Calculation of Capital Costs for Construction of Major Drainage Systems
- Calculation of Operation and Maintenance Costs and Total Annual Costs for Major Drainage Systems
- Estimation of Excavation and Backfill Volumes Associated with Construction of Major Drainage Systems

hyetograph of selected duration, frequency, and rainfall skewness factor from National Weather Service publications on rainfall frequency information (2) (4) (5) (6). For cities having rainfall intensity-duration-frequency curves available, Program Path Two can be used; otherwise, Program Path One should be used. Program Path Three deals with the derivation of the design storm hyetograph from local hourly precipitation data. It can also be used to derive only the local rainfall skewness factor for use in Program Path One or Two, if the user so desires. In addition, Program Path Three makes local dry periods frequency analysis which is critically needed in the runoff quality analysis in the Surface Runoff Program of this Model.

Results of a previously Federal Highway Administration sponsored study (1) are used extensively in the development of this Module.

CHAPTER II

INTRODUCTION TO THE PRECIPITATION MODULE

Any design of storm drainage facilities or analysis of stormwater problems must begin with identification of the precipitation information that will serve as the basis of the design or analysis. This information may consist of a design storm or storms of specified duration and return frequency, historical precipitation data for the study area, or some combination of these.

The Precipitation Module of the Urban Highway Storm Drainage Model is intended to help the engineer in analyzing available precipitation data and in deriving the design storms that he may require. The Module can be used to analyze long-term precipitation records for a variety of informative statistical properties. Given this statistical information or local precipitation statistics from other sources, the Module can derive hyetographs for design storms of selected duration and frequency.

It is the purpose of this report to describe the technical capabilities of the Precipitation Module and to provide the user with the information he needs to apply the Module.

GENERAL APPROACH

The Precipitation Module represents a completely independent part of the Urban Highway Storm Drainage Model. Its primary function is to facilitate the analysis of commonly available rainfall information and ultimately provide the user with the synthetic hyetographs needed as input to the Hydraulics/Quality Module of the Drainage Model.

Internally, the module is constructed to follow one of three Program Paths. The Program Path is selected by the user. Program Path One generates a single-peaked hyetograph for a given return frequency with the general shape shown in Figure II-1. Data requirements are minimal. They include a rainfall skewness factor, an event duration, an event frequency, and the 10-year, 1-hour; the 10-year, 24-hour; and the 100-year, 1-hour rainfall values.

Program Path Two is a variation of the first Program Path. It also calculates a synthetic design hyetograph of a given return frequency, but it uses local intensity-duration-frequency data. Data requirements include pattern skewness, event duration, event frequency, and intensity-duration data for the design frequency.

Program Path Three is quite different. While Program Paths One and Two are directly oriented to the development of a design hyetograph, Program Path Three is oriented toward analyzing local rainfall data. Program Path Three requires hourly precipitation data as input and it can generate as many or as few of the following analyses as the user desires:

- An annual series analysis for selected event durations,
- A partial duration series analysis for selected event durations,
- A frequency analysis of major precipitation events of record,
- A frequency analysis of dry periods, and
- A rainfall pattern skew analysis.

The analyses can be performed on both a yearly and seasonal basis.

The output from Program Path Three allows the design engineer to derive local estimates of each of the inputs required in Program Paths One and Two. Thus, if Program Path Three is run prior to Program Paths One or Two, the design engineer can develop a design hyetograph that reflects local meteorological conditions.

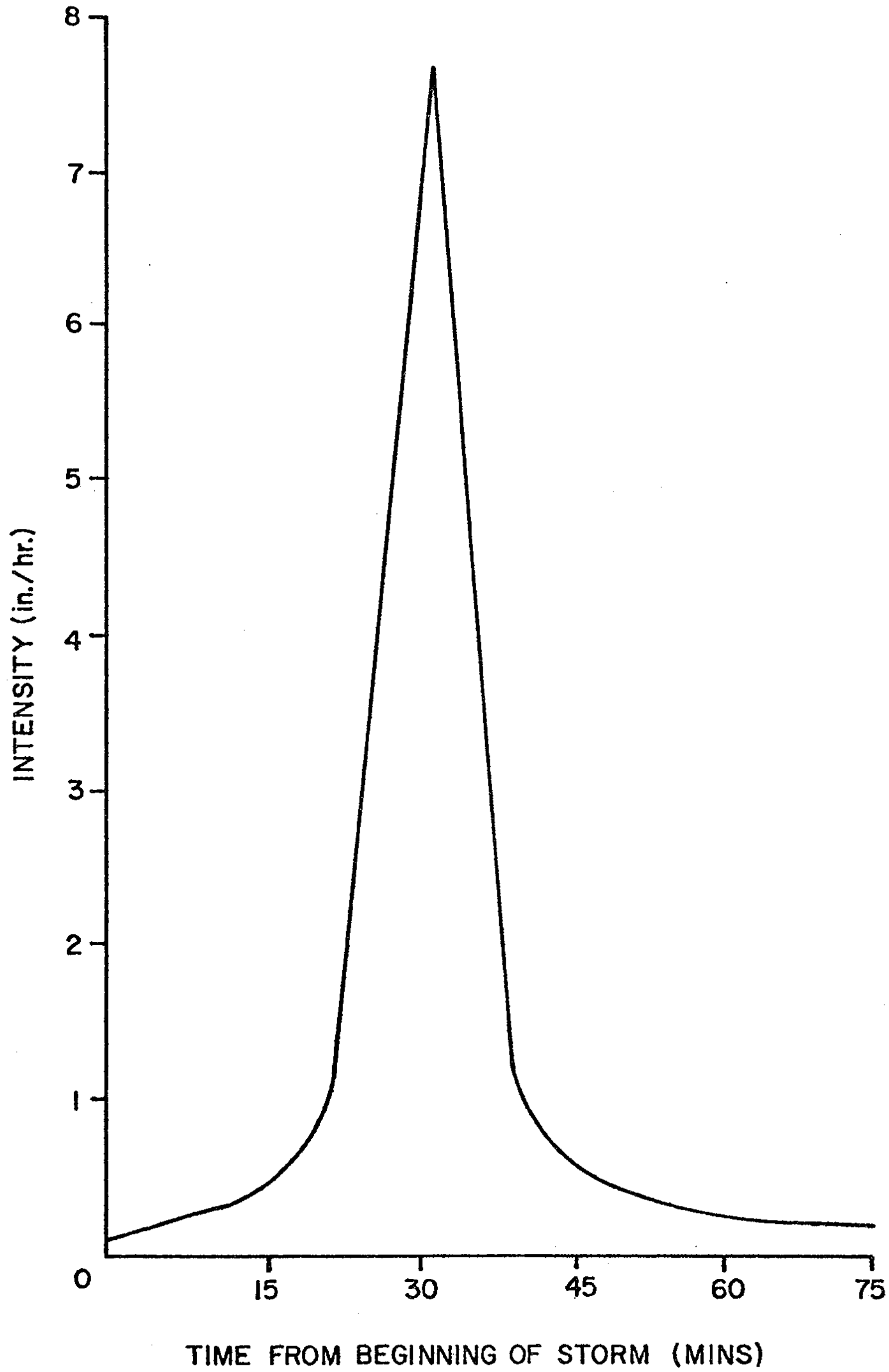

FIGURE II-1

A SYNTHETIC RAINFALL HYETOGRAPH

CAPABILITIES AND LIMITATIONS

The Precipitation Module is a very versatile computer model. The Module has several capabilities. These capabilities, by program path, are:

1. Program Path 1
   - Calculates the a, b, and c storm constants using a methodology developed by Chen (1). This methodology does not require intensity-duration-frequency data;
   - Generates a single peak synthetic hyetograph using equations developed by Chen (1); and
   - Plots the synthetic hyetograph.
2. Program Path 2
   - Calculates the a, b, and c storm constants using intensity-duration-frequency data and the "complex method of box";
   - Generates a single-peak synthetic hyetograph using equations developed by Chen (1); and
   - Plots the synthetic hyetograph.
3. Program Path 3
   - Performs a yearly and seasonal annual series analysis;
   - Plots annual series analysis frequency curves;
   - Performs a yearly and seasonal partial duration series analysis;
   - Generates and plots intensity-duration-frequency curves based on the partial duration series analysis;

- Performs a yearly and seasonal frequency of occurrence analysis on event length, peak hourly rainfall, and total event volume;

- Performs a yearly and seasonal frequency of occurrence analysis on the number of dry hours between wet hours;

- Plots the frequency of occurrence versus the units in each frequency analysis; and

- Performs a yearly and seasonal rainfall pattern skew analysis.

The Precipitation Module has several limitations that have been imposed upon it during the program's development. These limitations by program path are:

1. Program Path 1
   - The synthetic hyetograph is constructed of a maximum of 100 points.

2. Program Path 2
   - The synthetic hyetograph is constructed of a maximum of 100 points.

3. Program Path 3
   - A seasonal analysis cannot be performed without a yearly analysis;

   - A maximum of 50 calendar years of hourly rainfall data can be analyzed;

   - A maximum of 10 different durations can be handled in the annual and partial duration series analyses;

   - In every event frequency analysis, event length must be analyzed, i.e., the peak hourly rainfall and total event volume cannot be analyzed alone;

- The dry hour frequency analysis cannot be performed without the event frequency analysis; and

- A maximum of 50 storms can be analyzed in the rainfall pattern skew analysis.

COMPUTER REQUIREMENTS

The Precipitation Module has been developed on a CDC 6600/6700 shared system at the Naval Ship Research and Development Center (NSRDC) in Carderock, Maryland. The Module requires approximately 225,000 octal words of core to load the entire program.

To execute Program Path 1 of the Precipitation Module, approximately 2 seconds of computer time are required. This time requirement does not vary due to the fixed amount of input data.

A normal run of Program Path 2 requires from 6.0 to 25.0 seconds of execution time. This time varies according to the number of intensity-duration data points the user inputs to define the local intensity-duration-frequency curve, i.e., the more data points, the more time.

The largest portion of the Precipitation Module, Program Path 3, requires varying amounts of execution time. This time variance is based on two things--the analyses chosen and the length of the rainfall record. With all the analyses selected, approximately 30 seconds of execution time is required per year of rainfall record.

CHAPTER III

TECHNICAL APPROACH

INTRODUCTION

This chapter describes the mathematical formulation used and the assumptions made in the development of the Precipitation Module. Descriptions are presented in the following order:

1. Synthetic Hyetograph Formulation
   - a, b and c Storm Constant Development in Program Path 1
   - a, b and c Storm Constant Development in Program Path 2
2. Program Path 3
   - Series Analysis
   - Frequency Analysis
   - Rainfall Pattern Skew Analysis
3. Simplifying Assumptions

SYNTHETIC HYETOGRAPH FORMULATION

In Program Paths 1 and 2 of the Precipitation Module, a single-peak synthetic hyetograph for a user-specified return frequency is generated using a set of hyetograph equations developed by Chen (1). These equations were generated for three different types of storm patterns (i.e., γ (skew) = 0, $\gamma = 1$, $0 < \gamma < 1$). Each pattern takes one of two forms depending on the value of the parameter b (i.e., positive or negative). The equations are given in Table III-1.

Given the equations of Table III-1, the generation of the synthetic hyetograph in Program Paths 1 and 2 is straight forward. In both program paths, once the values of γ, t_d, a, b, and c have been determined, either as input or through calculation, a simple time step solution is carried out. The time variable t is increased incrementally from 0 to the time of duration and at each increment, the appropriate equation is solved to find r.

TABLE III-1
SYNTHETIC HYETOGRAPH EQUATIONS FOR
VARIOUS VALUES OF γ and b

For $\gamma = 0$ and a positive b

$$r = \frac{a\,[(1-c)\,t+b]}{(t+b)^{1+c}} \qquad \text{(III-1)}$$

For $\gamma = 1$ and a positive b

$$r = \frac{a\,[(1-c)(t_d-t)+b]}{[(t_d-t)+b]^{1+c}} \qquad 0 \le t \le t_d \qquad \text{(III-2)}$$

For $0<\gamma<1$ and a positive b

$$r = \frac{a\,[(1-c)(t_d-t/\gamma)+b]}{[(t_d-t/\gamma)+b]^{1+c}} \qquad 0 \le t \le \gamma t_d \qquad \text{(III-3)}$$

$$r = \frac{a\,[(1-c)(t-\gamma t_d)/(1-\gamma)+b]}{[(t-\gamma t_d)/(1-\gamma)+b]^{1+c}} \qquad \gamma t_d \le t \le t_d \qquad \text{(III-4)}$$

For $\gamma = 0$ and a negative b

$$r = \frac{a}{|b|^c}\left(\frac{1-c}{1+c}\right)^c \qquad t \le \frac{2|b|}{1-c} \qquad \text{(III-5)}$$

$$r = \frac{a\,[(1-c)\,t-|b|]}{(t-|b|)^{1+c}} \qquad t \ge \frac{2|b|}{1-c} \qquad \text{(III-6)}$$

For $\gamma = 1$ and a negative b

$$r = \frac{a\,[(1-c)(t_d-t) - |b|]}{[(t_d-t) - |b|]^{1+c}} \qquad 0 \le t \le t_d - \frac{2|b|}{1-c} \qquad \text{(III-7)}$$

$$r = \frac{a}{|b|^c}\left(\frac{1-c}{1+c}\right)^c \qquad t_d - \frac{2|b|}{1-c} \le t \le t_d \qquad \text{(III-8)}$$

For $0<\gamma<1$ and a negative b

$$r = \frac{a\,[(1-c)(t_d-t/\gamma) - |b|]}{[(t_d-t/\gamma) - |b|]^{1+c}} \qquad 0 \le t \le \gamma t_d - \frac{2|b|\gamma}{1-c} \qquad \text{(III-9)}$$

$$r = \frac{a}{|b|^c}\left(\frac{1-c}{1+c}\right)^c \quad \gamma t_d - \frac{2|b|\gamma}{1-c} \qquad \gamma t_d - \frac{2|b|\gamma}{1-c} \le t \le \gamma t_d + \frac{2|b|(1-\gamma)}{1-c} \qquad \text{(III-10)}$$

$$r = \frac{a\,[(1-c)(t-\gamma t_d)/(1-\gamma) - |b|]}{[(t-\gamma t_d)/(1-\gamma) - |b|]^{1+c}} \qquad \gamma t_d + \frac{2|b|(1-\gamma)}{1-c} \le t \le t_d \qquad \text{(III-11)}$$

where,

r = the rainfall intensity in inches per hour at any time point in the synthetic storm;

a,b and c = storm parameters based on meteorological localities;

t_d = the time of rainfall duration;

γ = the storm pattern skewness factor (i.e., the ratio of time to peak to the total duration of the storm); and

t = any time point in the storm in minutes.

A detailed discussion of Chen's derivation of the above equations can be found in his original work (1). It should be pointed out, however, that Chen's work is predicated on the fact that any intensity-duration-frequency curve, as shown in Figure III-1, can be approximated by the following equation:

$$r_{av} = \frac{a}{(t_d \pm b)^c} \tag{III-12}$$

where,

r_{av} = the average rainfall intensity in inches per hour;

t_d = the time duration of rainfall in minutes; and

a,b, and c = storm constants, the values of which depend on meteorological localities.

The next two sections of this chapter describe how the a, b, and c storm parameters needed for the hyetograph formulation are determined in Program Paths 1 and 2.

Development of Storm Constants a, b and c in Program Path One

In Program Path 1, the a, b, and c storm constants are calculated using the methodology developed by Chen (1). Figure III-2 has been digitized and selected values of a_1, b, and c are stored internally with their respective 10-year, 1-hour to 10-year, 24-hour ratio. The b and c parameters from Figure II-2 are the storm constants b and c, and the parameter a_1 can be related to the storm constant a by the following equation:

$$a = a_1 \; r_{av}^{(10,1)} \; \log_{10}((10^{2-x})(T^{x-1})) \tag{III-13}$$

where,

$r_{av}^{(10,1)}$ = the 10-year, 1-hour total rainfall in inches;

T = the frequency of return period in years;

x = the ratio of the 100-year to 10-year, 1-hour rainfalls; and

a_1 = the storm parameter from Figure III-2.

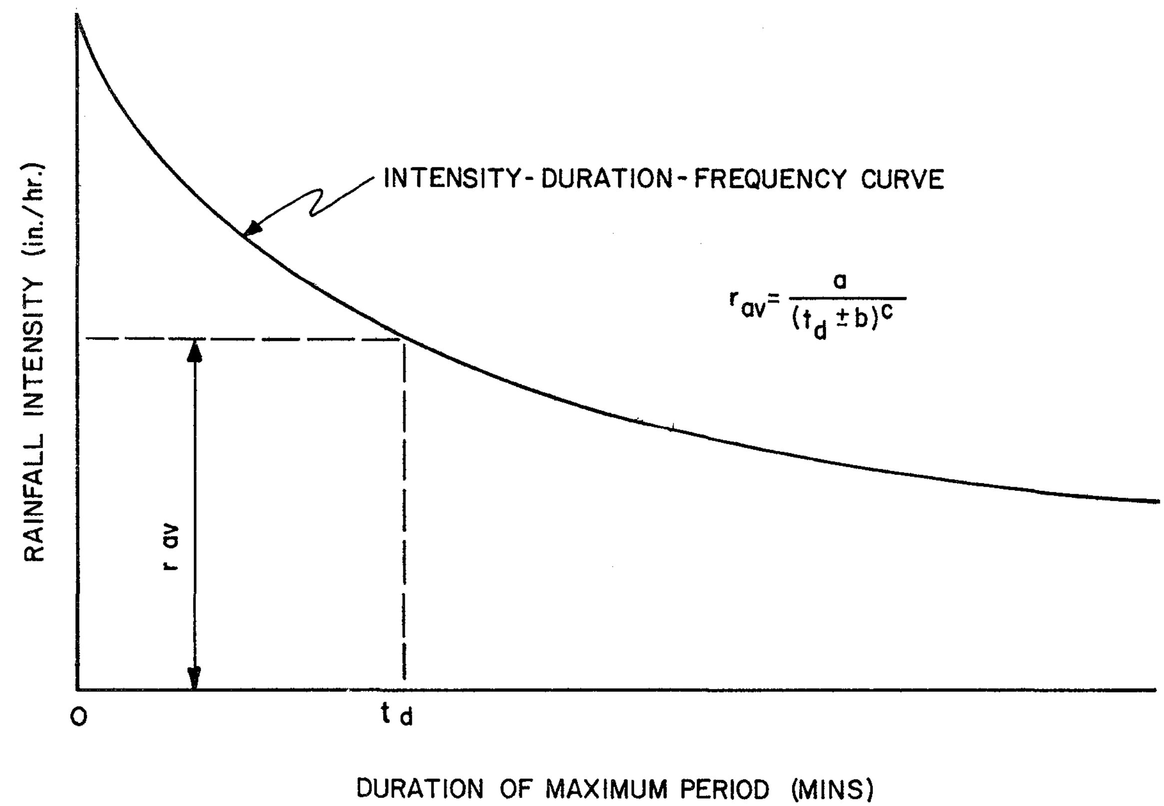

FIGURE III-1
INTENSITY-DURATION-FREQUENCY CURVE

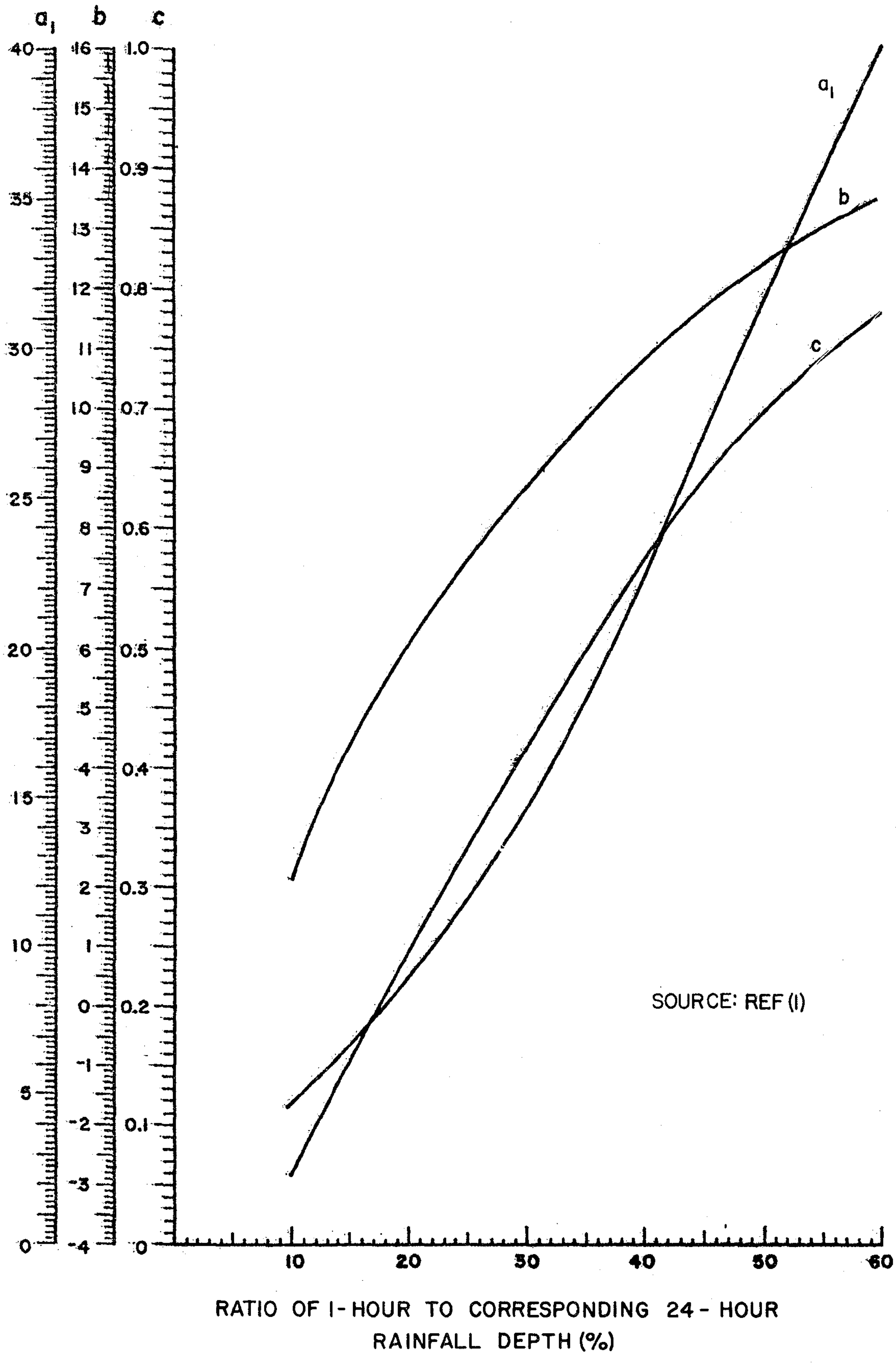

FIGURE III-2. RELATIONSHIP BETWEEN STORM CONSTANTS AND THE RATIO OF 1-HOUR TO CORRESPONDING 24-HOUR RAINFALL DEPTH

Subsequently, in Program Path 1, the user provides the return period (years) of the storm that he desires to simulate and the 10-year, 1-hour; 10-year, 24-hour; and 100-year, 1-hour total rainfalls (in or mm). Each of these rainfall values can be obtained from isopluvial maps like those shown in Figures III-3 through III-5, which are published by the U.S. Department of Commerce in Technical Paper 40(2), and from the later revised maps of 10-year, 24-hours (5), and of 100-year, 1-hour (6). The program calculates the needed ratios, linearly interpolates a_1, b, and c using the internally stored values, and calculates a using Equation III-13.

Development of Storm Constants a, b and c in Program Path Two

In Program Path 2, the design engineer supplies, as input, sets of rainfall intensity and time of duration that define the local intensity-duration curve for the design frequency. The program calculates values for the a, b and c storm constants that minimize the error function:

$$PI(a,b,c) = \sum_{t=0}^{tmax} \left(\log \frac{a}{(t+b)^c} - \log r_{av}\right) \qquad \text{(III-14)}$$

where,

PI = the error function of Performance Index for a set of a,b, and c;

a,b and c = the storm constants;

t = a user supplied time of duration; and

r_{av} = the user supplied average rainfall intensity (in./hr.) at time t.

An optimization technique known as the "Complex Method of Box" is employed to find the minimum value of PI. The method is presented below.

The first step in the Complex Method of Box is to construct a six-vertex, three-dimensional polygon like the one shown in Figure III-6. Each

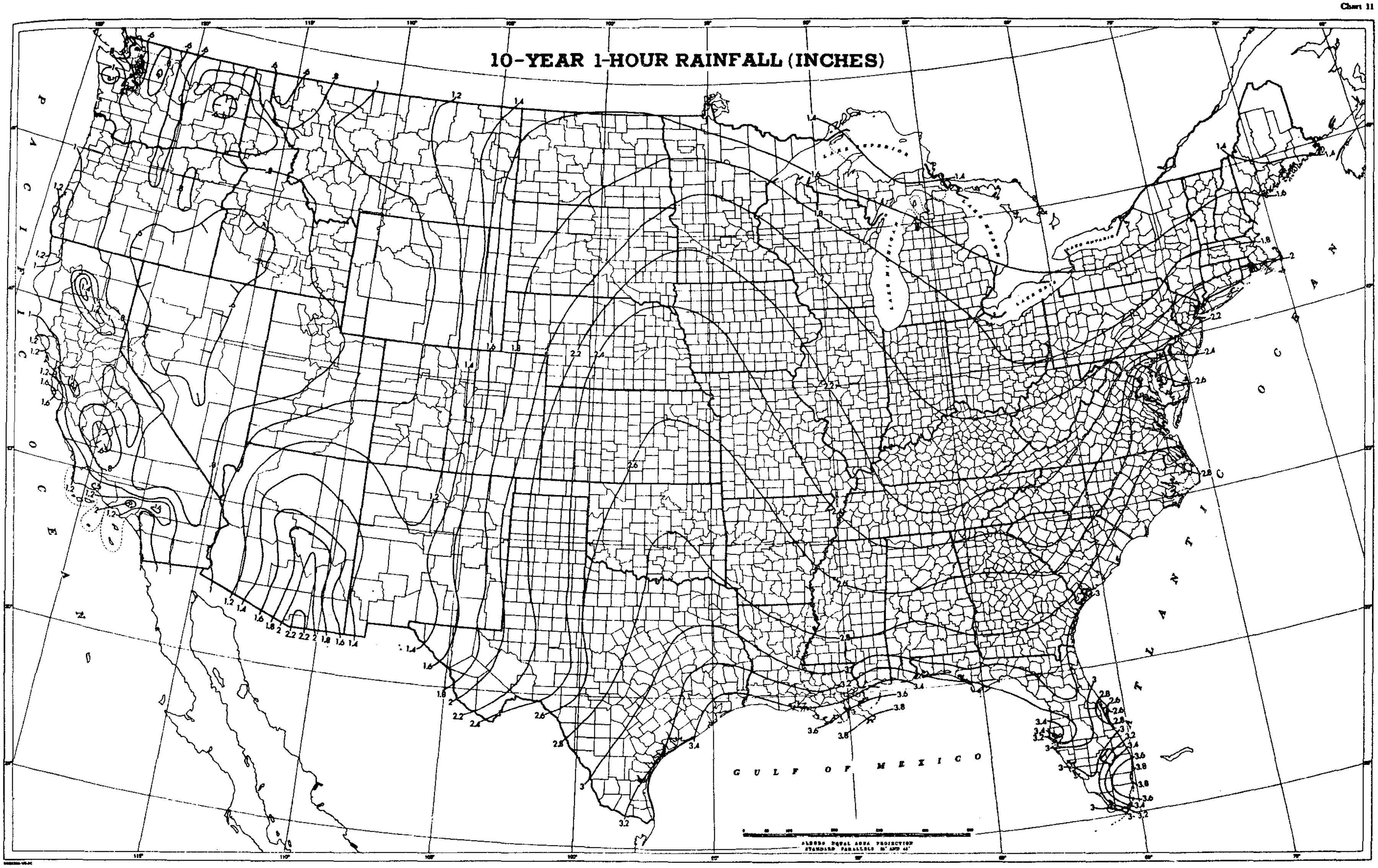

FIGURE III-3. TEN-YEAR ONE-HOUR RAINFALL MAP

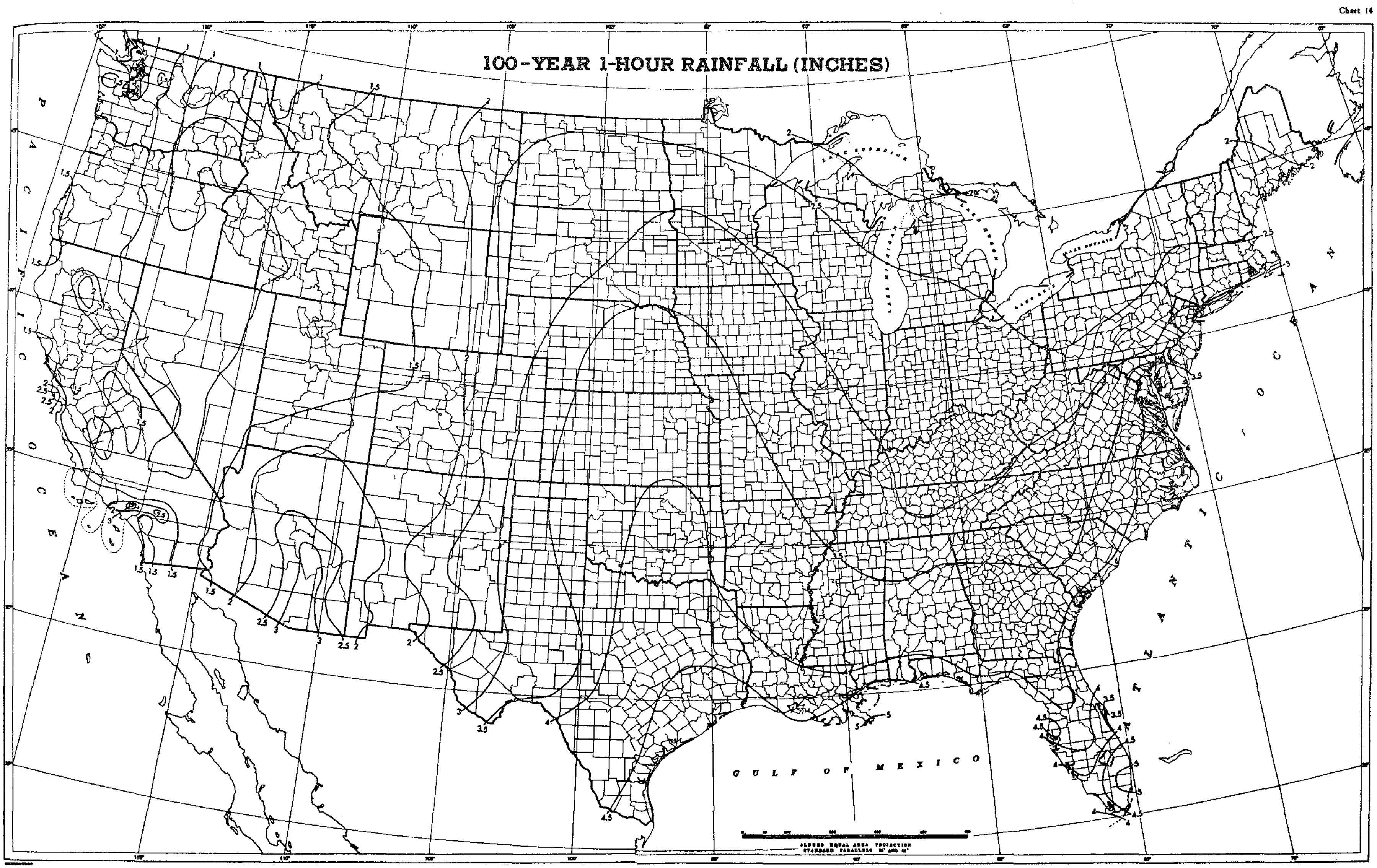

FIGURE III-4 ONE HUNDRED-YEAR ONE-HOUR RAINFALL MAP

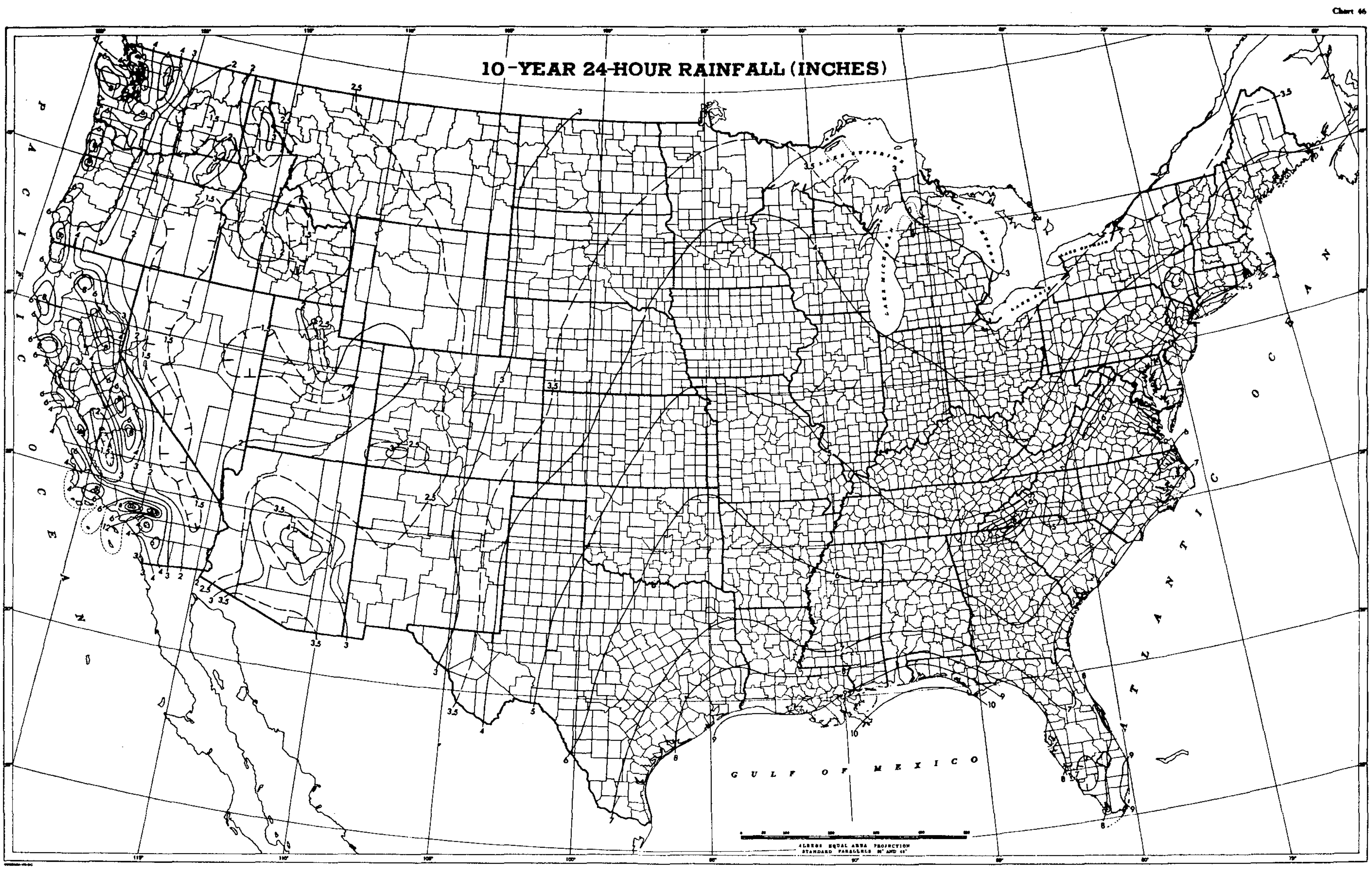

FIGURE III-5. TEN-YEAR 24-HOUR RAINFALL MAP

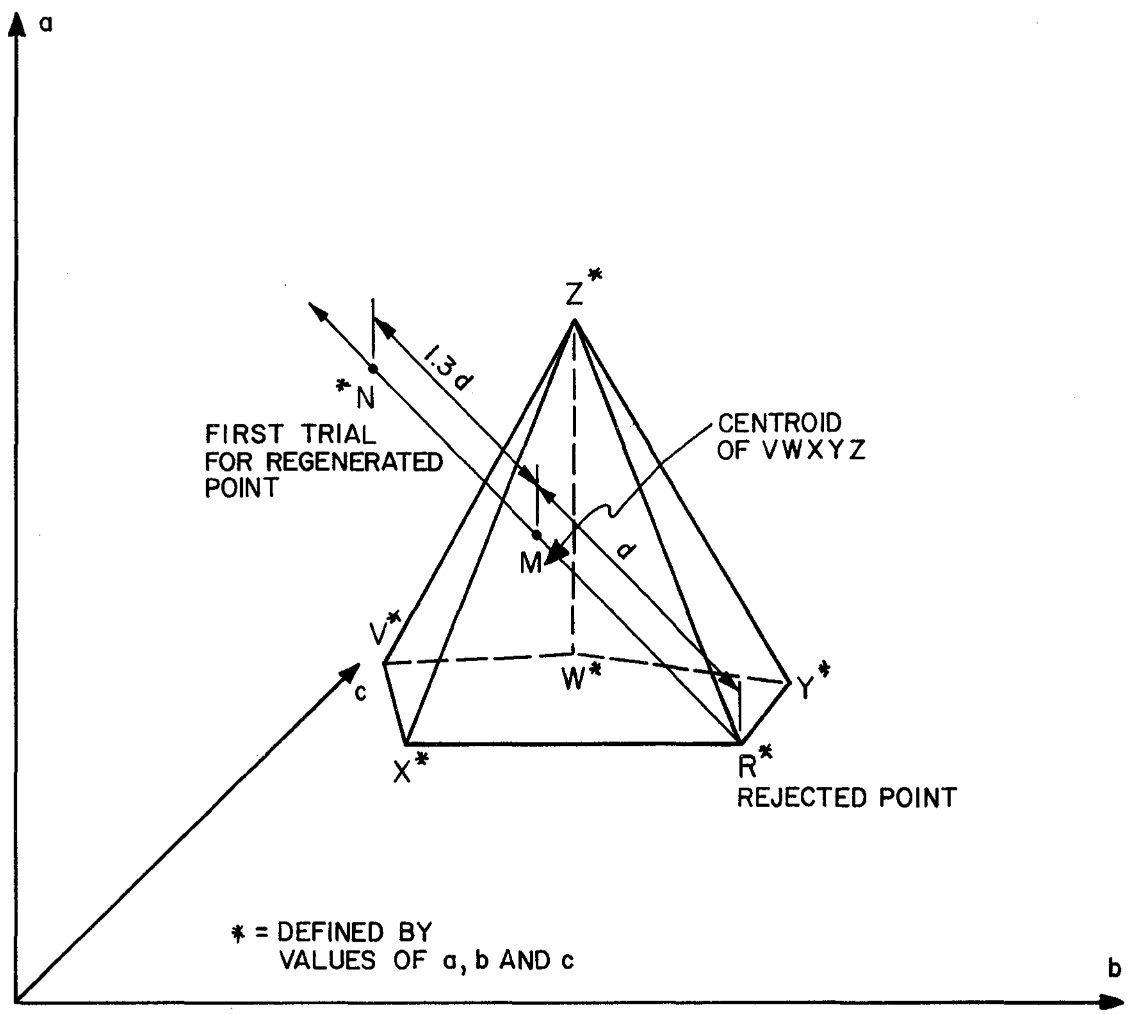

FIGURE III-6

A "COMPLEX" OF THE METHOD OF BOX

vertex in the polygon is defined by a set of a, b and c. The first vertex is an arbitrarily assigned set of a, b and c that meets the following implicit constraint:

$$\frac{a}{(t+b)^c} \leq 16 \qquad \text{(III-15)}$$

where

t = time which may vary from 5 to 145 minutes.

The value 16 represents the maximum expected average rainfall intensity in the United States. In the Precipitation Module, the first point has been hard coded in the program as a = 60.53, b = 7.85, c = 0.75.

The values of a, b and c at the other five verticies in the polygon are then computed using the following equation:

$$NV_i = LL_i + r(UL_i - LL_i) \qquad \text{(III-16)}$$

where,

NV_i = A new value of a, b or c (i.e., NV_a, NV_b, or NV_c);

r = a random number generated by the computer between 0 and 1;

LL_i = an internally stored lower limit placed on the storm constant in question (see Table III-2);

UL_i = an internally stored upper limit placed on the storm constant in question (see Table III-2).

The upper and lower limits placed on the a, b and c were derived based on Figure III-2.

TABLE III-2

EXPLICIT LIMITS PLACED ON THE
STORM PARAMETERS IN THE COMPLEX METHOD OF BOX

Storm Constant	Upper Limit	Lower Limit
a	150.0	0.0
b	16.0	-4.0
c	1.0	0.0

As each of the five sets of a, b and c are generated, the set (referred to hereafter as a point) is checked against the implicit constraint given in Equation III-15. If the point violates this constraint, it is moved halfway back toward the centroid of the points already determined and rechecked against the implicit constraint. This movement is accomplished by recalculating a, b and c using the following equation:

$$NV_i = \tfrac{1}{2}(NP_i + CP_i) \qquad \text{(III-17)}$$

where

NP_i = the value of a, b, or c at the point that violated the implicit constraint; and

CP_i = the value of a, b or c at the centroid given by:

$$CP_i = \frac{1}{K-1}(S_i - RP_i) \qquad \text{(III-18)}$$

where

K = the total number of points defining the figure;

S_i = the sum of all the a, b or c values at all the points in the figure but the rejected point; and

RP_i = the value of a, b or c at the rejected point.

Once an initial figure like the one depicted in Figure III-6 has been generated, the Performance Index at each of the six points defining the figure is calculated using Equation III-14. The point yielding the poorest (i.e., largest) PI is rejected and replaced by a new point. This new point is located on the opposite side of the centroid of the remaining five points, but at a distance 1.3 times the distance from the rejected point to the centroid. The direction of the new point is defined by the vector pointing from the rejected point to the centroid.

This procedure is illustrated in Figure III-6. The centroid of points *V, W, X, Y AND Z* is designated as *M*. If the distance between point *R* and the centroid *M* is *d*, the point *R* will be replaced by a point *N*, which is a distance 1.3d from the centroid *M*, in a direction defined by the line drawn from *R* through *M*. The values of a, b, and c at *N* are then given by:

$$NV_i = 2.3\ CP_i - 1.3\ (RP_i) \qquad \text{(III-19)}$$

where

i = a,b or c;

NV_i = the new value of a, b or c;

CP_i = the centroids value of a, b or c (equation II-18); and

RP_i = the rejected point value of a, b or c.

Once this new point is calculated, it is subjected to the following checks:

- The individual a, b and c values at the point are checked to see if they fall within the limits defined in Table III-2 and reset to the limit if necessary.

- The PI of the point is calculated using Equation III-14 and compared to the PI's of the other 5 points. If the new point has a PI that is still worse than that of the other five points in the new figure, its location is moved halfway back toward the previous centroid by recalculating a, b and c using Equation III-17.

- The point is checked to see if it violates the implicit constraint, Equation III-15. If it does, it is moved halfway back towards the previous centroid using Equation III-17.

At any point in this series of checks, if a violation does occur and the new point is corrected, the corrected point is resubmitted to the series of checks.

It is by using this method of point rejection and replacement that the final values of a, b and c are found. New points and thus new figures are generated using Equation III-19 until the PI's of the six points constructing the figure fall within plus or minus 0.0001 of each other. When this occurs, PI in Equation III-14 is said to be minimized and the a, b and c values at the point in the figure with the smallest PI are taken as the storm constants to be used in Chen's hyetograph equations.

PROGRAM PATH 3 STATISTICAL ANALYSES

Program Path 3 performs three major types of analyses:

- A Series Analysis;
- A Frequency Analysis; and
- A Rainfall Pattern Skew Analysis

The Program Path is designed to enable the engineer to analyze hourly rainfall data and derive local estimates of the various inputs required in Program Paths 1 and 2. Each of these three major types of analyses can be performed on both a yearly and seasonal basis. Details of these analyses are contained in the following paragraphs.

Series Analysis

The series analysis includes both an annual series analysis and a partial duration series analysis. The annual series analysis is carried out using an extreme value approach. An hourly record of precipitation over a specified number of years is searched. The maximum total rainfall (over specified durations) in hundredths of inches for each year or season is found. These rainfall amounts are ranked from largest to smallest, and the return period for each rainfall is calculated using the following standard equation:

$$T_r = \frac{n+1}{m} \tag{III-20}$$

where

T_r = the return period in years,

n = the number of years of record, and

m = the rank of the event (i.e., the largest storm has a rank of one, and the smallest storm has a rank of n).

Once the annual series analysis is complete, it is converted to a partial duration series analysis. The conversion is achieved by multiplying the return periods derived in the annual series analysis by the appropriate ratio of a partial duration to annual series return period from Table III-3. Table III-3 is stored internally, and the appropriate ratio for any annual series analysis return period is derived either by direct recall or linear interpolation.

In the annual and partial duration series analysis, some internal data manipulations are performed to adjust and expand the analyses. First, in both analyses, all the maximum one-hour duration total rainfalls are multiplied by 1.13, according to Technical Paper 40(2), to convert the clock hour rainfalls to 60-minute rainfalls. Secondly, in the partial duration series analysis, the 5, 10, 15 and 30-minute duration total rainfalls are estimated. These estimates are derived by multiplying the adjusted one-hour duration maximum rainfalls times the appropriate ratio given in Table III-4.

By including the 5, 10, 15 and 30-minute rainfalls in the partial duration series analysis, Program Path 3 has the capability of generating intensity-duration-frequency curves. The program simply divides the total rainfalls for a given return period by the appropriate durations to derive the average intensities for the different durations.

The annual and partial duration series analysis can be of great help to the design engineer. The output from these two analyses can provide local estimates of both the intensity-duration data required in Program Path 2 and the three rainfall values (10-year, 1-hour; 10-year, 24-hour; and 100-year, 1-hour) required in Program Path 1.

Frequency Analysis

The frequency analysis performed in Program Path 3 of the Precipitation Module is an extremely useful feature of the Module although not directly

TABLE III-3

PARTIAL DURATION SERIES ANALYSIS RATIOS

Annual Series Analysis Return Period (years)	Ratio of a Partial Duration to an Annual Series Analysis Return Period
1.16	0.431
1.58	0.633
2.00	0.725
2.54	0.787
5.52	0.906
10.50	0.952
>10.50	1.000

Source: Ref (3)

TABLE III-4

AVERAGE RELATIONSHIPS BETWEEN 60-MINUTE RAINFALL AND SHORTER DURATION RAINFALLS FOR THE SAME RETURN PERIOD

Duration (minutes)	Rainfall Depth Ratio
5	0.292
10	0.450
15	0.569
30	0.790

Source: This table was derived from two pieces of information in Reference (2). First, Table 3 gives the relationship between 30-minute rainfall and shorter duration rainfall. Second, the ratio of 30-minute rainfall to 60-minute rainfall was found to be 0.79 (Figure 5).

related to the generation of a design storm hyetograph. The frequency analysis can, however, be used to determine the best representative rainfall event and/or dry-hour period for a given location having hourly rain data.

A frequency analysis is done in Program Path 3 on the following:

- length of a precipitation event;
- peak hourly rainfall per event;
- total event rainfall; and
- dry period length.

The frequency of each occurrence is calculated by dividing the number of occurrences within a class interval by the total number of occurrences. The class interval is determined by dividing the user supplied maximum expected quantities for each analysis by either 100 or 50. Event length and dry-hour length are subdivided into 100 units, while the peak intensity and total volume are divided into 50 units. In the frequency curves the frequency of occurrence values are cumulative to show a continuous curve.

To define the rainfall event, the user must specify a fixed number of no-rain hours that must pass to signal the end of the rainfall event. When the number of successive hours of no rainfall equals or exceeds the specified number, the event is considered to be over. Any subsequent rainfall is considered to be a new event. The hours of no-rain occurring in the middle of the same event are added to the total time duration of the event.

An example showing the effect of the user-supplied event definition parameter is given below using the rainfall data shown in Table III-5, which spans a 48-hour period.

If the user defines for the event frequency analysis that four hours of no-rain must occur before an event is considered over, the rainfall trace in Table III-5 contains two rainfall events. The first event starts in day one,

TABLE III-5

EXAMPLE RAINFALL DATA TAPE
(Hundredths Inch)

Day \ Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	4	4	2	3	0	0	4	3	2	26
2	1	1	2	3	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0	0	0	12

lasts 15 hours, has a peak hourly rainfall of 0.04 inches, and ends in day two with a total event volume of 0.33 inches. The second event occurs entirely in day two, lasts three hours, and has a peak hourly and total volume of 0.03 and 0.05 inches, respectively.

However, if the user defines two hours as the amount of time required at zero rainfall to indicate the end of an event, the rainfall trace in Table III-5 is interpreted as follows:

No. of events:	3		
Day Occurring:	1,	1-2,	2
Duration:	6 hrs.,	7 hrs.,	3 hrs.
Peak Hourly Rainfall: (hundredths inch)	4,	4,	3
Total Volume: (hundredths inch)	17,	16,	5

For the dry-hour frequency analysis, the rainfall trace in Table III-5 will be interpreted as follows:

No. of dry periods:	4
Length of dry hours:	13, 2, 7, 10+

Note that the dry hours ending day two could continue over to day three.

The dry-hour frequency of occurrence analysis can be used to generate the number of no-rain hours required for event definition. For example, the number of dry hours which occurred 75 percent of the time or less might be used to define the rainfall event.

The frequency analysis for event length, peak hourly rainfall, total event volume, and dry hours can also be accomplished on a seasonal basis, if so desired.

Rainfall Pattern Skew Analysis

The skew analysis performed in Program Path 3 assumes that skew is independent of storm duration and frequency. An hourly precipitation record is searched for the N largest storms with durations greater than five hours.[1] If storms of lesser durations are included, skews of 0, 0.25, 0.5, 0.75, and 1 tend to dominate the analysis. A storm event is defined using the same procedure that was used to define an event in the frequency analysis (i.e., the user must stipulate the number of dry hours that must pass to indicate the end of an event).

As each of the N number of storms is found, its skew is calculated by dividing the time to peak (i.e., from the start of the storm to the peak hourly rainfall) by the total storm duration. This procedure is best illustrated by an example using the sample rainfall data in Table III-6.

On day 1, if the user has stipulated 2 hours must pass to indicate the end of a storm event, there is one 8-hour storm. This storm starts in hour 4, ends in hour 11, and has its peak intensity in hour 9, the sixth hour of the storm. The skew of this storm is thus 6/8 or 0.75.

The only time this procedure does not hold is when the peak intensity occurs in the first hour of a storm. When this occurs, the storm is said to have a skew of 0, not 1/8 or 0.125.

Once the skews of the storms are found, an estimate of the yearly skew is found by calculating the average (mean) skew of the storms. If an estimate of seasonal skew is requested, the storms are segregated by season and the average (mean) skew of the storms in each season is calculated. This final average skew can be used as the skew value required by Program Paths 1 and 2 to generate a design storm hyetograph representative of local meteorological conditions.

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[1] N is a user-supplied number between 1 and 50.

TABLE III-6

EXAMPLE RAINFALL DATA
(Hundredths of Inches)

Day \ Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
1	0	0	0	2	0	1	3	5	8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	20

SIMPLIFYING ASSUMPTIONS

Inherent in the formulation of the precipitation module were several assumptions. They were:

- The intensity-duration-frequency relationship can be approximated by Equation III-12 (i.e., $r_{av} = \frac{a}{(t_d+b)^c}$);
- A storm hyetograph is single peaked;
- Storm skew is independent of storm duration and frequency;
- The limits placed on the a, b and c storm constants in Table III-2 are valid;
- The constraint imposed on the a. b and c storm constants in Equation III-15 is valid (i.e., $\frac{a}{(t_d+b)^c} \leq 16$);
- A maximum 1-hour rainfall can be converted to a maximum 60-minute rainfall using a 1.13 conversion factor; and
- The 5, 10, 15 and 30-minute total rainfalls can be accurately estimated using the ratios in Table III-4.

CHAPTER IV

USER'S MANUAL

This chapter presents a discussion of the data required to apply the Precipitation Module. Preparation of the data cards for each program path and use of an hourly precipitation tape for Program Path Three are described in detail.

INPUT REQUIREMENTS - PROGRAM PATH ONE

As described in the previous chapters, Program Path One generates a synthetic hyetograph based on some commonly available rainfall statistics. In addition to the rainfall statistics, the return frequency, duration, and skew of the desired hyetograph must be supplied as input. The return frequency and storm duration should be selected by the user in accordance with the appropriate local criteria for drainage design or analysis. The storm skew can be selected based on the skew analysis of Program Path Three or the user's knowledge of local meteorological conditions.

The required rainfall statistics are the 10-year, 1-hour rainfall; the 10-year, 24-hour rainfall; and the 100-year, 1-hour rainfall. A recommended source of this information is the Weather Bureau's Technical Paper No. 40, "Rainfall Frequency Atlas of the United States" (2). The appropriate rainfall maps from TP-40 were reproduced earlier as Figures III-3 to III-5.

The format of the required input cards for Path One is given in Table IV-1 and described below.

Card Group One: Control Card

Card Group One consists of a single card that has the Program Path number (in this case, 1) punched in column 5. The units option is also selected with this card. British units are selected by setting IMET equal to zero; metric units are selected by setting IMET equal to one.

TABLE IV-1

PROGRAM PATH 1 DATA CARD FORMATS

Card Group	Format	Card Column	Description	Variable Name	Default Value
1			CONTROL CARD: One Card		
	2I5	5	Number of Program Path to be Followed (i.e., 1)	MOPT	None
		10	Units Option (IMET=0 - British units) (IMET=1 - metric units)	IMET	0
2			STORM CARD: One Card		
	F10.2	1-10	Ten-Year, One-Hour Rainfall (inches or millimeters)	R101	None
	F10.2	11-20	Ten-Year, Twenty-four-Hour Rainfall (inches or millimeters)	R1024	None
	F10.2	21-30	One-hundred-Year, One-Hour Rainfall (inches or millimeters)	R1001	None
	I5	31-35	Design Storm's Return Frequency (years)	IFREQ	None
	F5.2	36-40	Design Storm's Skew	SKEW	None
	I5	41-45	Design Storm's Duration (minutes)	DURA	None
3			TIME INCREMENT CARD		
	I4	1-4	Time Step Between Intensity Calculations (minutes; must be an even increment of the design storm's duration)	INCRE	None

Card Group Two: Storm Card

Card Group Two consists of a single card with the required rainfall values and the characteristics of the desired hyetograph. As explained above, the required rainfall statistics for the user's study area can be obtained from the Weather Bureau's Technical Paper No. 40 (2). The characteristics of the desired hyetograph must be selected according to local design criteria.

Card Group Three: Time Increment Card

Card Group Three also consists of a single card. The time increment between rainfall intensity calculations for the design hyetograph is specified on this card. The design storm duration divided by this time increment must yield an integer less than 101. For example, if the storm's duration given in Card Group 2 is 180 minutes, then 5 minutes is an acceptable time increment (180 divided by 5 is 36, an integer less than 101).

INPUT REQUIREMENTS - PROGRAM PATH TWO

Program Path Two also generates a synthetic hyetograph, but uses a rainfall intensity-duration-frequency curve as input. As with Program Path One, the return frequency and duration of the hyetograph to be generated must be specified by the user in accordance with local design criteria. The skew of the hyetograph may be selected from the Program Path Three skew analysis or from other information on local meteorology that may be available.

The required rainfall intensity-duration-frequency curve for the user's study area may be available from local sources. Alternately, this curve can be generated from hourly precipitation data using Program Path Three.

The data cards required for Program Path Two are described in Table IV-2 and the paragraphs that follow.

TABLE IV-2

PROGRAM PATH 2 DATA CARD FORMATS

Card Group	Format	Card Column	Description	Variable Name	Default Value
1			CONTROL CARD: One Card		
	2I5	5	Number of Program Path (2)	MOPT	None
		10	Units Option (IMET=0 - British units) (IMET=1 - Metric units)	IMET	0
2			STORM CARD: One Card		
	2I5	1-5	Design Storm's Return Frequency (Years)	IFREQ	None
		6-10	Design Storm's Duration (Minutes)	DURA	None
	F5.2	11-15	Design Storm's Skew	SKEW	None
	I5	16-20	Print control for intermediate points generated by Complex Method of Box	PRINTOP	0
3			DATA SET CONTROL CARD: One Card		
	I2	1-2	Number of Intensity-Duration Data Sets to be Input	MI	None
4			INTENSITY-DURATION-FREQUENCY CARDS: One to Ten Cards		
	4(I10, F10.2)	1-10	Duration, first (minutes)	DURAA(1)	None
		11-20	Average Rainfall Intensity, first (in./hr. or mm./hr.)	RAU(1)	None
		21-30	Duration, second (minutes)	DURAA(2)	None
		31-40	Average Rainfall Intensity, second (in./hr. or mm./hr.)	RAU(2)	None
		⋮		⋮	
5			INCREMENT CARD: One Card		
	I4	1-4	Time Step Between Intensity Calculations (minutes)	INCRE	None

Card Group One: Control Card

Card Group One is used to select the Program Path (in this case, 2) and the units option. British units are selected by setting IMET equal to zero, metric units by setting IMET equal to one.

Card Group Two: Storm Card

Card Group Two consists of a single card that specifies the design storm return frequency, duration, and skew. The frequency and duration should be selected according to local design criteria, the skew according to the Program Path Three analysis or other local information.

Intermediate results from the iterative routine that calculates the constants in the hyetograph equation can be printed out if PRINTOP is set equal to one on this card. This information may be of interest to some users but is generally superfluous. The user is therefore advised to set PRINTOP equal to zero on this card.

Card Group Three: Data Points Control Card

Card Group Three contains a single card that gives the number of rainfall intensity-duration data points (i.e., matching durations and rainfall intensities) to be input in Card Group Four. These data points define the rainfall intensity-duration-frequency curve required by Path Two. The user may supply as many as 40 data points, but 10 points have proven to be adequate.

Card Group Four: Intensity-Duration-Frequency Cards

Card Group Four defines the rainfall intensity-duration-frequency curve required by Program Path Two. One to ten cards may be supplied, each card with up to four data points on it (i.e., four matching sets of duration and rainfall intensity). Each card should be filled with data points before the next card is started. For example, if fourteen data sets are being supplied, four cards would be used - the first three cards with four sets of data on each, the fourth card with two sets of data on it.

The rainfall intensity-duration-frequency curve supplied should, of course, be for the same return frequency as the design hyetograph the user wants to generate. This intensity-duration-frequency curve may be available from local sources or can be obtained using Program Path Three.

Card Group Five: Time Increment Card

Card Group Five contains a single card defining the time increment between rainfall intensity calculations for the design hyetograph. When the storm duration supplied in Card Group Three is divided by this time increment, the result must be an integer less than 101.

INPUT REQUIREMENTS - PROGRAM PATH THREE

As described earlier, Program Path Three has the ability to perform several different statistical analyses on long-term hourly rainfall data for the user's study area. The input required basically consists of the rainfall data and a series of control cards for the various program options. The rainfall data file may be supplied on a magnetic storage device (tape or disk) or on cards.

Hourly precipitation records are maintained by the National Oceanic and Atmospheric Administration (NOAA) for numerous recording rain gages throughout the United States. Hourly rainfall data for a particular location may be obtained in the form of a magnetic tape from:

National Climatic Center
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Asheville, North Carolina 28801

The NOAA rainfall tapes are prepared in the format shown in Table IV-3.

TABLE IV-3

PRECIPITATION DATA TAPE FORMAT FOR 1 RAIN DAY

RECORD	FORMAT	COLUMNS	COLUMN DESCRIPTION	READ AS VARIABLE
1				
	I6	1-6	Rain Gage Identifier	Not Read
	3I2	7-8	The Year	IYR
		9-10	The Month	IMO
		11-12	The Day	IDY
	I1	13	The number 1 to indicate the 1st 12 hours of rainfall	Not Read
	12I3	14-16	First hour of rainfall (In/100)	RAIN1(1)
		17-19	Second hour of rainfall (In/100)	RAIN1(2)
		⋮		⋮
		47-49	Twelfth hour of rainfall (In/100)	RAIN1(12)
2				
	I6	1-6	Rain Gage Identifier	Not Read
	3I2	7-8	The Year	Not Read
		9-10	The Month	Not Read
		11-12	The Day	Not Read
	I1	13	The number 2 to indicate the 2nd 12 hours of rainfall	Not Read
	12I3	14-16	Thirteenth hour of rainfall (In/100)	RAIN1(13)
			Fourteenth hour of rainfall (In/100)	RAIN1(14)
		⋮		⋮
		47-49	Twenty-fourth hour of rainfall (In/100)	RAIN1(24)

The NOAA rainfall tapes only include data for days on which rainfall occurred and for the first and last day of each month. In order to properly perform the statistical analyses of Path Three, it is necessary to have a complete chronological record of both dry and wet hours for the period being analyzed. Path Three is designed to read a NOAA tape or other rainfall file in the format of Table IV-3, fill in the dry days, and perform the statistical analyses on the resulting complete record.

As indicated in Table IV-3, NOAA tapes contain rainfall data in units of hundredths of an inch. However, the user may choose to have the output from Path Three in either British units or metric units. All the options of Path Three are described in Table IV-4 and the paragraphs below, which give the format of the required input cards.

Following the paragraphs on the input cards, an additional discussion of possible problems with NOAA rainfall tapes is given, along with some guidance on how to resolve these problems.

Card Group One: Control Card

Card Group One contains a single card used to select the Program Path (in this case, 3) and the output units option. British units are selected by setting IMET equal to zero, metric units by setting IMET equal to one.

Card Group Two: Rainfall Data Processing Control Card

Card Group Two consists of a single card that controls the input of the hourly rainfall data.

The variable IOPT identifies which of three possible input sources are to be used - a complete chronological rainfall file (tape or disk) prepared by Path Three; a NOAA rainfall file (tape or disk); or data cards. If the input source is a complete rainfall file prepared by Path Three, IOPT should be set equal to an integer less than zero. If the input source is a NOAA rainfall file or cards, IOPT should be set equal to an integer greater than or equal to zero.

TABLE IV-4

PROGRAM PATH 3 DATA CARD FORMATS

Card Group	Format	Card Column	Description	Variable Name	Default Value
1			CONTROL CARD: One Card		
	2I5	5	Number of program path (3)	MOPT	None
		10	Output Units Option (IMET=0 - British Units) (IMET=1 - Metric Units)	IMET	0
2			RAINFALL DATA PROCESSING CONTROL CARD: One Card		
	3I8	1-8	Rainfall Data Processing Control Variable	IOPT	None
		9-16	Rainfall Data's Input Device Number	IN	None
		17-24	Subroutines RAINT's Processed Output Tape Device Number	IT	None
	4I2	27-28	Calendar Year of First Day of Rainfall Data to be Processed (i.e., 1975 = 75)	ISTART(1)	None
		29-30	Number of the Month in which First Day of Rainfall Data to be Processed Occurs	ISTART(2)	None
		31-32	Day of First Day of Rainfall Data to be Processed	ISTART(3)	None
		33-34	Rainfall Data Print Control	IPRINT	0
3			RAINFALL DATA CARDS: One Card for Each Day of Rainfall (NOTE: If IN ≠ 5, skip Card Group 3)		
	A2	1-2	Optional Data Card Label	ACHECK	None
	3I2	3-4	Year } Rainfall Day's Date	IYR	None
		5-6	Month } Rainfall Day's Date	IMO	None
		7-8	Day } Rainfall Day's Date	IDY	None
	24I3	9-11	First Hour's Rainfall (In/100)	RAIN1(1)	None
		12-14	Second Hour's Rainfall (In/100)	RAIN1(2)	None
		⋮		⋮	
		78-80	24th Hour's Rainfall (In/100)	RAIN1(24)	None

TABLE IV-4

PROGRAM PATH 3 DATA CARD FORMATS

(continued)

CARD GROUP	FORMAT	CARD COLUMN	DESCRIPTION	VARIABLE NAME	DEFAULT VALUE
			End this Card Group with one blank card.		
4			ANALYSIS OPTION CONTROL CARD: One Card		
	6I8	1-8	Annual Series Analysis Control Variable (NOTE: Columns 9-16 must equal 0 unless NSER = 1.)	NSER	0
		9-16	Partial Duration Series Analysis Control Variable	IPARTOP	0
		17-24	Seasonal Analysis Control Variable	INDSEA	0
		25-32	Storm Event Frequency Analysis Control Variable (NOTE: Columns 33-40 must equal 0 unless NEVNT = 1.)	NEVNT	0
		33-40	Dry Period Frequency Analysis Control Variable	IDRYOPT	0
		41-48	Rainfall Pattern Skew Analysis Control Variable	ISKEWOP	0
5			BEGINNING SEASON CARD: One Card (NOTE: If INDSEA = 0, skip Card Groups 6 and 7.)		
	25I3	1-3	Number of Seasons to be Analyzed	NOSEAS	None
		4-6	Number of the First Season's Beginning Month	MOSEAS(1)	None
		7-9	First Season's Beginning Day	MDAYBG(2)	None
		10-12	Number of Second Season's Beginning Month	MOSEAS(2)	None
		13-15	Second Season's Beginning Day	MDAYBG(2)	None
		⋮		⋮	

TABLE IV-4

PROGRAM PATH 3 DATA CARD FORMATS

(continued)

CARD GROUP	FORMAT	CARD COLUMN	DESCRIPTION	VARIABLE NAME	DEFAULT VALUE
6			ENDING SEASON CARD: One Card		
	24I3	1-3	Number of the First Season's Ending Month	MOSEND(1)	None
		4-6	First Season's Ending Day	MDAYEND(1)	None
		7-9	Number of the Second Season's Ending Month	MOSEND(2)	None
		10-12	Second Season's Ending Day	MDAYEND(2)	None
		⋮		⋮	
7			SERIES ANALYSIS CONTROL CARD: One Card (NOTE: If NSER = 0, skip Card Groups 7, 8, and 9.)		
	2I8	1-8	Number of Calendar Years of Rainfall Data in the Input File	NYR	None
		7-16	Number of Durations to be Analyzed	NDUR	None
8			DURATION CARD: One Card		
	10I8	1-8	First Duration (hours)	DURTN(1)	None
		9-16	Second Duration (hours)	DURTN(2)	None
		⋮		⋮	
9			PLOT CONTROL CARD: One Card		
	2I8	1-8	Annual Series Analysis Frequency Curve Plot Control Variable	IFRQPLT	0
		9-16	Partial Duration Series Analysis Intensity-Duration-Frequency Curve Plot Control Variable	IDFCPLT	0

TABLE IV-4

PROGRAM PATH 3 DATA CARD FORMATS

(continued)

CARD GROUP	FORMAT	CARD COLUMN	DESCRIPTION	VARIABLE NAME	DEFAULT VALUE
10			FREQUENCY ANALYSIS TITLE CARD: One Card (NOTE: If NEVNT = 0, skip Card Groups 10, 11, and 12.)		
	10A4	9-48	Alphanumeric Title Describing Frequency Analysis	NAME	None
11			DRY PERIOD CARD: One Card		
	I8	9-16	Number of Dry Hours That Must Elapse to Indicate the End of an Event	KDRY	None
12			FREQUENCY ANALYSIS CONTROL CARD: One Card		
	4F8.0	9-16	Maximum Event Duration to be Analyzed (hours)	EVNTMAX	None
		17-24	Maximum Peak Hourly Rainfall to be Analyzed (In./Hr.)	FMAX	None
		25-32	Maximum Total Event Rainfall Volume to be Analyzed (In.) (NOTE: Columns 33-40 are not required unless IDRYOPT = 1.)	FVOL	None
		33-40	Maximum Dry Period to be Analyzed (hours)	DRYMAX	None
13			RAINFALL PATTERN SKEW ANALYSIS CONTROL CARD: One Card (NOTE: If ISKEWOP = 0, skip Card Group 14.)		
	2I8	1-8	Number of Dry Hours That Must Elapse to Indicate the End of a Storm	ISTRMND	None
		9-16	Number of Storms to be Analyzed	NSTRM	None

The first input option above probably requires further explanation. As discussed earlier, Program Path Three will read a rainfall input file in the format of a NOAA rainfall tape and fill in the dry days required to make a complete chronological record. This complete record is written as a magnetic storage device file and used for the statistical analyses of Path Three. The user can save this complete chronological file and use it as input for subsequent runs of Path Three, thus eliminating the need to process the NOAA rainfall file on all but the first run.

The variable IN is used to define the rainfall data input device. When the data source is cards, IN must be set equal to 5 to indicate the card reader. When the data source is a file on tape or disk, IN must be set equal to the number of the peripheral unit containing the file.

The variable IT is used only if the rainfall data source is cards or a NOAA rainfall file. IT gives the number of the peripheral device on which the processed chronological rainfall file is to be written and saved.

The array ISTART (3) defines the date of the first day of rainfall that is to be analyzed. When the rainfall data source is cards or a NOAA file, ISTART should be the first day of rainfall that the user wants included in the complete chronological file. Program Path Three will then create a data file that covers the period from ISTART through and including the last rain day in the input data. When the data source is a Path Three-prepared rainfall file, ISTART should be the date for the first day of rainfall that appears on the file.

If the rainfall data source is cards or a NOAA file, the user can have a table of the rainfall data printed out by setting IPRINT equal to one. 45 rainfall days will be printed per page of output.

Card Group Three: Rainfall Data Cards

Card Group Three is supplied only if the hourly rainfall data file is supplied on cards. One card must be supplied for each rainfall day in the format shown in Table IV-4. A blank card must be supplied at the end of Card Group Three to terminate the rainfall record. If the rainfall data is not supplied on cards, Card Group Three should be omitted.

Card Group Four: Analysis Option Control Card

Card Group Four contains a single card with which the user selects the statistical analysis options to be performed. Each variable should be punched as zero or one; one means perform the analysis, zero means do not perform the analysis.

Note that the partial duration series analysis cannot be performed unless the annual series analysis is performed. Also note that the dry period frequency analysis cannot be performed unless the storm event frequency analysis is performed. If the seasonal analysis is selected, all the other analyses performed will be performed on a seasonal basis as well as an annual basis.

The user is referred to the example problem later in this chapter.

Card Groups Five and Six: Season Cards

If the seasonal analysis is selected, Card Groups Five and Six must be supplied; if the seasonal analysis is not selected, these Card Groups should be omitted.

Card Group 5 is a single card that defines the number of seasons to be analyzed and the beginning month and day of each season. Card Group Six is a single card that defines the corresponding ending month and day of each season.

The seasonal analysis can be performed on up to 12 seasons and on seasons that overlap calendar years (e.g., October to February). In each of these two Card Groups, the seasons must be defined from left to right in the order of their occurrence in a calendar year.

Card Groups Seven, Eight, and Nine: Series Analysis Cards

Card Groups Seven, Eight and Nine are included only if the annual series analysis is selected. Card Group Seven is a single card that defines the number of calendar years (full or partial) that appear in the hourly rainfall data file and the number of storm durations that are to be analyzed. A maximum of 50 calendar years and 10 durations can be specified.

Card Group Eight is a single card used to define the storm durations (in whole hours) that are to be analyzed. The selected durations must be specified from left to right in order of increasing length. If the partial duration series analysis has been selected, the one-hour duration must be specified.

Card Group Nine is a single card that controls whether or not annual series analysis frequency plots and partial duration series analysis intensity-duration-frequency curve plots are produced. The variable IFRQPLT controls the former, and the variable IDFCPLT controls the latter. Each variable must be set equal to either zero or one; one means produce the plots, and zero means do not produce the plots.

Card Groups Ten, Eleven and Twelve: Frequency Analysis Cards

Card Groups Ten, Eleven and Twelve are required only if the storm event frequency analysis option has been selected. If the storm event frequency analysis is not to be performed, these three Card Groups should be omitted.

Card Group Ten consists of a single card which contains an alphanumeric descriptive title of the event frequency analysis being performed.

Card Group Eleven is a single card which contains the number of dry hours used to define an event. The variable KDRY defines the number of whole hours that must elapse before an event is considered to be over.

The frequency analysis card is the only card in Card Group Twelve. This card contains four floating point variables which set the upper limits on the frequency analysis. A non-zero value for the maximum event duration to be considered in the frequency analysis must be entered as EVNTMAX.

If the user wants the frequency analysis of peak hourly rainfall per event and total event volume, then the maximum peak hourly rainfall to be analyzed (FMAX) and the maximum total event rainfall volume to be analyzed (FVOL) must be entered. These variables should be set equal to the upper limits expected during the analyses. If the limits are set too low, values will be lost from the analyses. FMAX and FVOL should be set equal to zero if these two analyses are not to be performed.

The fourth variable on Card Group Twelve is the maximum dry period to be analyzed, DRYMAX. A value should be supplied for DRYMAX if the dry period frequency analysis has been performed; otherwise, DRYMAX should be set equal to zero.

Card Group Thirteen: Rainfall Pattern Skew Analysis Control Card

Card Group Thirteen is a single card used to define the number of sequential dry hours that must pass before a storm event is considered to have ended and the number of storms to be analyzed in the skew analysis. This card group is included only if the rainfall pattern skew analysis option has been selected.

NOAA Rainfall Data Tapes

As explained earlier in this chapter, NOAA rainfall data tapes read by Program Path Three are prepared in the general format shown in Table IV-3. However, there are four additional features of the rainfall data format of which the user should be aware.

NOAA general data punching procedures are to include on a tape only the data for the first and last day of each month (regardless of whether rain fell or not) along with the data for each day when rain fell. All twenty-four hourly values are given for any day included on the tape, and the tape user is to assume that on any day not included on the tape, zero or only trace (non-recordable) amounts of rain fell. All rainfall amounts are recorded in three column fields (in hundredths of inches) with zero or trace amounts being recorded as a dash-blank-blank (-ƀƀ) rather than zero-zero-zero (ØØØ) or blank-blank-blank (ƀƀƀ). The dash-blank-blank (-ƀƀ) is not consistent with the format shown in Table IV-3 and should be replaced by the user with a zero-zero-zero (ØØØ) or a blank-blank-blank (ƀƀƀ) wherever it occurs. The user should process the tape in this manner before using it as input to the Program Path Three.

Second, when data are not recorded for a certain period of time (i.e., the data are missing), the data for the days covering the missing period are included on the tape, with the hourly values that were missing recorded as blank-blank-blank (ƀƀƀ). The user does not need to take any corrective action in this case; however, he should examine his NOAA tape and be aware of where data is missing. The user should consider limiting the statistical analysis to that part of the rainfall record in which no significant amounts of data are missing.

Third, when a timing instrument fails and an accumulative amount of rainfall is recorded (but not the hourly amounts in which it fell), the days covering the period of the timing instrument malfunction are also included on the tape. The accumulative rainfall amount is recorded in the last hour of instrument malfunction and all the other hours covering the period of accumulation are recorded as zero-dash-blank (Ø-ƀ) to indicate that the accumulative rainfall amount fell sometime within the indicated period. For both missing and accumulative periods covering more than two days, NOAA generally includes just the first and last day of the period rather than every day of the period. Therefore, where two non-consecutive days of missing or accumulative data appear back to back on the tape with the first day having a missing or accumulative punch in hour twenty-four and the latter having the same punch in hour one, all the days between the two are to be considered as having the same punch.

The user should correct the accumulated rainfall situation if it should occur on the NOAA tape that he is using. The accumulative rainfall amount should be distributed over the time period in question and the zero-dash-blank (Ø-ƀ) indicators replaced with the distributed rainfall values.

Fourth, the two twelve-hour records which make up each rainfall day are occasionally reversed in order or one of the records is missing. The user should examine the NOAA tape and put records in the proper order where required.

In general, it should be kept in mind that the hourly rainfall data file read by Path Three must conform to the format shown in Table IV-3.

PROGRAM DESCRIPTION

The Precipitation Module consists of one main program (PRECIP), 16 subroutines, and one block data routine. Figure IV-1 graphically illustrates the functional relationships between the main program, the 16 subroutines, and the three program paths. This chapter describes the main program and each of the three program paths by subroutine. Each program description includes:

- The calling program(s);
- Subroutine(s) called;
- Common Block(s) used;
- A brief written description of what the program does;
- A program flow chart;
- A table defining the key variables not held in Common; and
- A program listing.

Main Program PRECIP

- Common Blocks Used
  /CNTRL/
- Subroutines Called
  ABCCHE
  OPTIMI
  ANALYZ

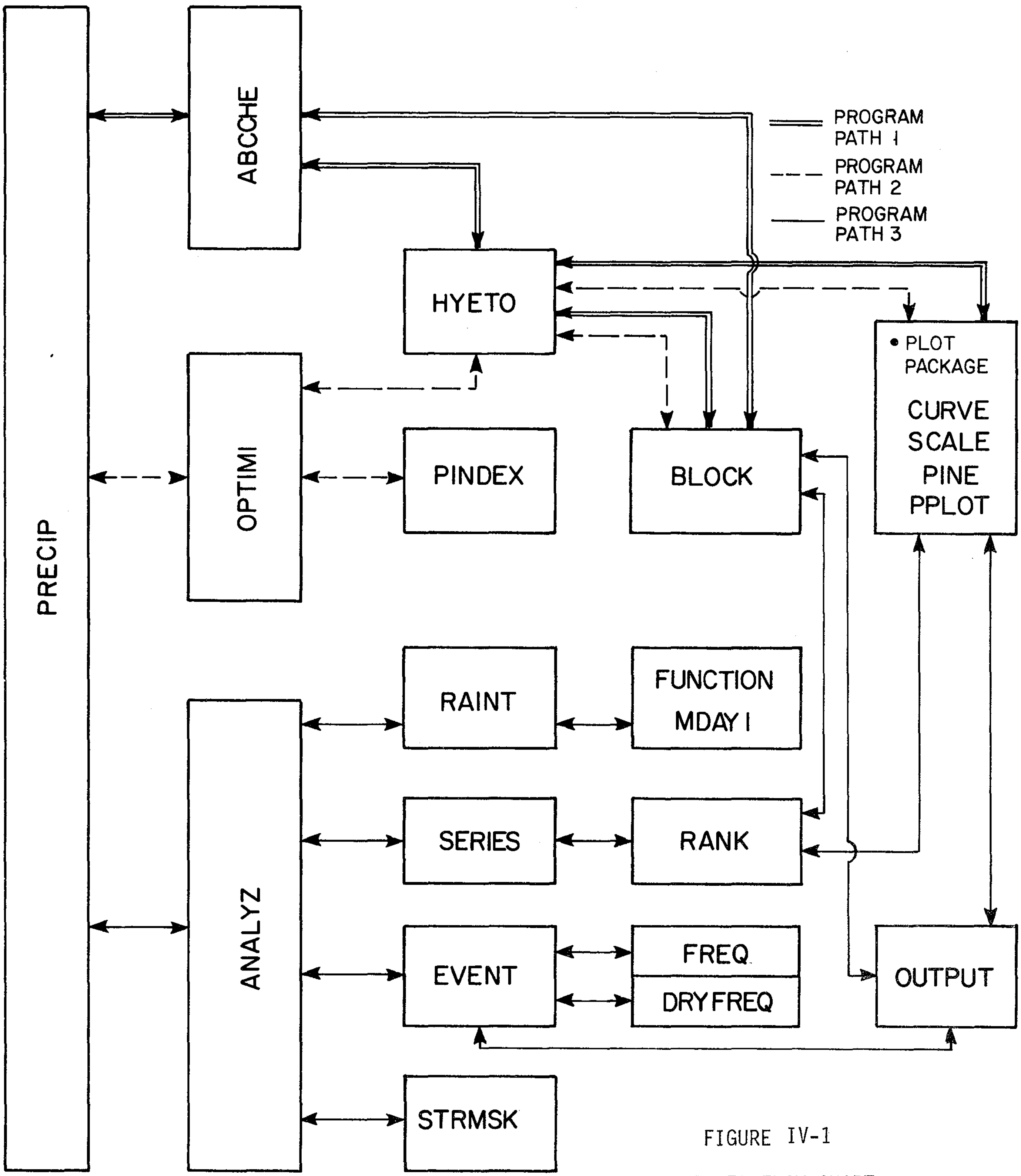

FIGURE IV-1

MASTER FLOW CHART
OF
PRECIPITATION MODULE SUBROUTINES

PRECIP is the main program of the Precipitation Module. Its sole function is to read the number of the program path the user wants the program to follow and to call the appropriate subprogram. Note that only one program path can be executed in a single run.

If Program Path 1 is requested, PRECIP calls subroutine ABCCHE. If Program Path 2 is requested, PRECIP calls subroutine OPTIMI, and if Program Path 3 is selected, PRECIP calls subroutine ANALYZ.

The flow chart for PRECIP is given in Figure IV-2 and is followed by a program listing. All program variables in COMMON are defined in a later section of this chapter.

Program Path One

Program Path 1 of the Precipitation Module consists of subroutines ABCCHE, HYETO, CURVE, SCALE, PINE, and PPLOT. When this Program Path is activated by the main program, PRECIP, a single-peak synthetic hyetograph is generated using the methodology developed by Chen.

Subroutine ABCCHE

- Called From
  PRECIP
- Common Blocks Used
  /CNTRL/
  /ABC/
  /A1BBCC/
- Subroutine Called
  HYETO

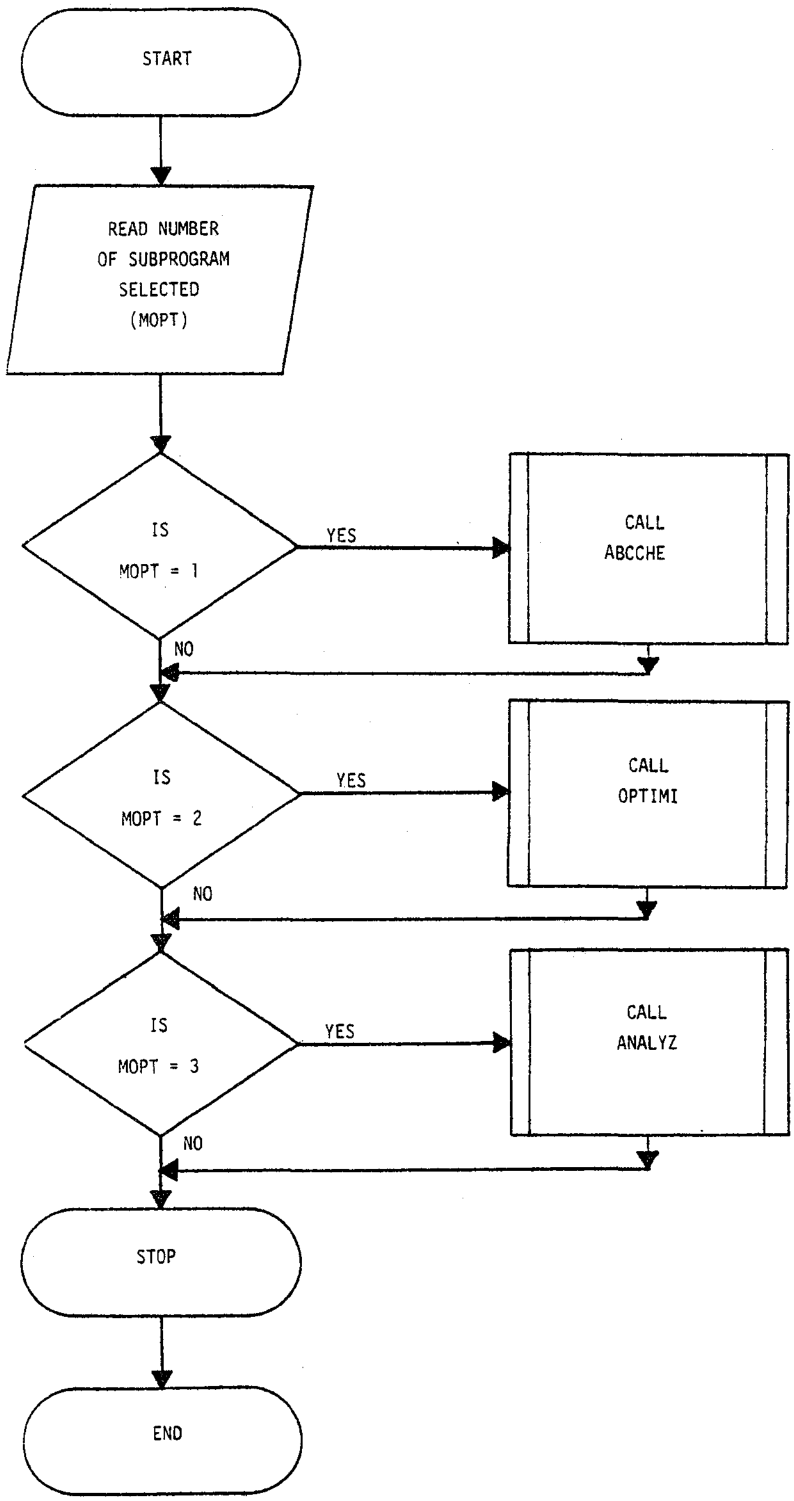

FIGURE IV-2

FLOW CHART FOR MAIN PROGRAM PRECIP

```
      PROGRAM PRECIP (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE10,
     2TAPE20,TAPE30)
C
C     ****************************************************************
C     **                                                            **
C     **              URBAN HIGHWAY STORM DRAINAGE MODEL            **
C     **                     PRECIPITATION MODULE                   **
C     **                                                            **
C     ****************************************************************
C
C     ****************************************************************
C     *
C     *      THIS IS THE MAIN PROGRAM FOR THE PRECIPITATION MODULE
C     *
C     *    IT CONTROLS WHICH OF THE THREE PROGRAM PATHS WILL BE RUN
C     *                (IE. PROGRAM PATHS 1, 2, OR 3)
C     *
C     ****************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
C
C******** N5 AND N6 ARE THE CARD READER AND PRINTER UNIT NUMBERS
C
      N5=5
      N6=6
C
C********  READ (MOPT) THE OPTION NUMBER SELECTED
C********  READ THE UNITS OPTION (IMET=0, ENGLISH)
C                                (IMET=1, METRIC )
C
      READ(N5,1000) MOPT,IMET
1000  FORMAT(2I5)
      WRITE(N6,2999)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
      WRITE(N6,20)
20    FORMAT(/////////* *,49H*****************************************
     2*****,* INPUT / OUTPUT INFORMATION *,49H************************
     3**********************)
      IF(MOPT.EQ.1) WRITE(N6,21)
      IF(MOPT.EQ.2) WRITE(N6,22)
      IF(MOPT.EQ.3) WRITE(N6,23)
      IF(IMET.EQ.0) WRITE(N6,24)
      IF(IMET.EQ.1) WRITE(N6,25)
21    FORMAT(////* *,43X,*THIS RUN DEVELOPS A SYNTHETIC HYETOGRAPH*/* *,
     248X,*USING THE METHODOLOGY OF CHEN*)
22    FORMAT(////* *,43X,*THIS RUN DEVELOPS A SYNTHETIC HYETOGRAPH*/* *,
     244X,*USING INTENSITY-DURATION-FREQUENCY DATA*)
23    FORMAT(////* *,48X,*THIS IS A RAINFALL ANALYSIS RUN*)
24    FORMAT(////* *,43X,*ENGLISH UNITS (FPS SYSTEM) ARE USED*)
25    FORMAT(////* *,48X,*SI UNITS (METRIC SYSTEM) ARE USED*)
```

```
      WRITE(N6,26) N5,N6
26    FORMAT(///////* *,55X,*GENERAL I/O INFO.*/* *,55X,17(*=*)///* *,50X
     2,*CARD READER UNIT NO. (N5)=*,I2//* *,52X,*PRINTER UNIT NO. (N6)=*
     3,I2)
      IF(MOPT.EQ.1) GO TO 2000
      IF(MOPT.EQ.2) GO TO 2001
      IF(MOPT.EQ.3) GO TO 2002
C
C********  RUN OPTION 1
C
2000  CALL  ABCCHE
      STOP
C
C********  RUN OPTION 2
C
2001  CALL  OPTIMI
      STOP
C
C********  RUN OPTION 3
C
2002  CALL  ANALYZ
      STOP
      END
```

Subroutine ABCCHE is the first subroutine called in Program Path 1. This subroutine reads the following information: the 10-year, 1-hour rainfall; the 10-year, 24-hour rainfall; the 100-year, 1-hour rainfall; the storm duration; the storm skew; and the storm frequency. It then calculates the a, b and c storm constants using Figure III-2 and Equation III-13 and calls Subroutine HYETO.

The flow chart for ABCCHE is given in Figure IV-3 and is followed by Table IV-5 identifying key variables not in COMMON and by a program listing. All program variables in COMMON are defined in a later section of this chapter.

Subroutine HYETO

- Called From
  - ABCCHE
  - OPTIMI
- Common Blocks Used
  - /LABE/
  - /ABC/
  - /LABELS/
- Subroutine Called
  - CURVE

Subroutine HYETO takes the a, b, and c storm constants that were calculated in subroutine ABCCHE (or OPTIMI) and calculates the rainfall intensities for the design hyetograph using Equations III-1 through III-13 and the methodology presented in Chapter III. It then calls the plotting package which is comprised of subroutines CURVE, SCALE, PINE, and PPLOT.

The program flow chart for HYETO is given in Figure IV-4 and is followed by Table IV-6 showing key variables not in COMMON and by a program listing. All program variables in COMMON are defined in a later section of this chapter.

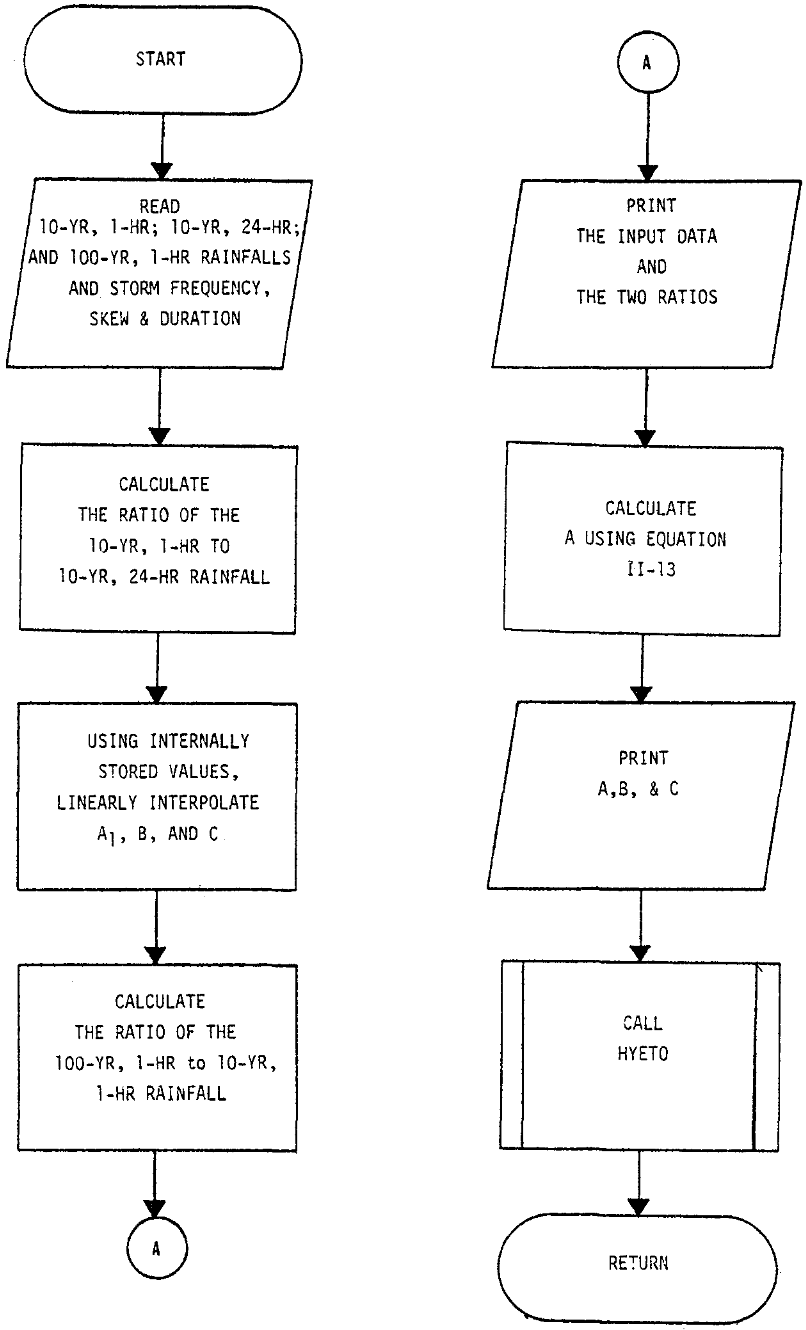

FIGURE IV-3

FLOW CHART FOR SUBROUTINE ABCCHE

TABLE IV-5

KEY VARIABLES NOT IN COMMON AND IN SUBROUTINE ABCCHE

VARIABLE NAME	DESCRIPTION	UNITS
R101	10-Yr, 1-Hr Rainfall	in. or mm.
R1024	10-Yr, 24-Hr Rainfall	in. or mm.
R1001	100-Yr, 1-Hr Rainfall	in. or mm.
R1 to 24	The ratio of the 10-yr, 1-hr to 10-yr, 24-hr rainfall	None
X	The ratio of the 100-yr, 1-hr to 10-yr, 1-hr rainfall	None
A_1	A_1 in Figure	None

```
      SUBROUTINE  ABCCHE
C
C
C     *****************************************************************
C     *
C     *   THIS SUBROUTINE CALCULATES THE A, B, AND C STORM CONSTANTS
C     *   USING INFORMATION FROM TECHNICAL PAPER 40 AND THE METHOD-
C     *   OLOGY AND CURVES DEVELOPED BY CHEN
C     *
C     *****************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON/ABC/ A,B,C,IFREQ,DURA,SKEW,DURAA(50),RAV(50),MI,PI
      COMMON/A1BBCC/AA1(11),BB(11),CC(11)
      INTEGER DURA
C
C********  READ THE 10-YR. 1-HR. RAINFALL (R101), THE 10-YR. 24-HR.
C********  RAINFALL (R1024), THE 100-YR. 1-HR. RAINFALL (R1001),
C********  THE STORM FREQUENCY (IFREQ), THE STORM SKEW (SKEW), AND THE
C********  STORM DURATION (DURA)
C
      READ(N5,1) R101,R1024,R1001,IFREQ,SKEW,DURA
1     FORMAT(3F10.2,I5,F5.2,I5)
C
C********  CALCULATE THE RATIO OF THE 10-YR. 1-HR. RAINFALL TO THE
C********  10-YR. 24-HR. RAINFALL (R1T024)
C
      R1T024=R101/R1024
C
C******* PRINT THE INPUT DATA
C
      WRITE(N6,2999)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
      WRITE(N6,200)
200   FORMAT  (////////////////* *,50X,*A B C PARAMETER ANALYSIS DATA*/*
     2*,31X,66(*=*))
C
      IF(IMET.EQ.0) GO TO 204
C
C******** METRIC OUTPUT
C
      WRITE(N6,201) IFREQ,R101,R1024,R1001
201   FORMAT(/* *,45X,*FREQUENCY ( RETURN PERIOD )=*,I5,* YEARS*/* *,45X
     2,*TEN-YEAR 1-HOUR RAINFALL=*,F6.2,* MILLIMETERS*/* *,45X,*TEN-YEAR
     3 24-HOUR RAINFALL=*,F6.2,* MILLIMETERS*/* *,41X,*ONE HUNDRED-YEAR
     41-HOUR RAINFALL=*,F6.2,* MILLIMETERS*)
C
C******** CONVERT TO FPS UNITS FOR SUBSEQUENT COMPUTATIONS
C
      R101=R101/25.40
```

```
      R1024=R1024/25.40
      R1001=R1001/25.40
      GO TO 101
C
C******** OUTPUT IN FPS UNITS
C
204   WRITE(N6,205) IFREQ,R101,R1024,R1001
205   FORMAT(/* *,45X,*FREQUENCY ( RETURN PERIOD )=*,I5,* YEARS*/* *,46X
     2,*TEN-YEAR 1-HOUR RAINFALL=*,F5.2,* INCHES*/* *,46X,*TEN-YEAR 24-H
     3OUR RAINFALL=*,F5.2,* INCHES*/* *,42X,*ONE HUNDRED-YEAR 1-HOUR RAI
     4NFALL=*,F5.2,* INCHES*)
C
C******** USING LINEAR INTERPOLATION, CALCULATE A1, B, AND C
C
101   IF((R1T024.LT.0.10).OR.(R1T024.GT.0.60)) GO TO 125
      BJ=0.10
      DO 10 I=1,11
      IF(R1T024.EQ.BJ) GO TO 100
10    BJ=BJ+0.05
      BJ=0.10
      DO 20 I=1,11
      IF((R1T024.GT.BJ).AND.(R1T024.LT.BJ+0.05)) GO TO 110
20    BJ=BJ+0.05
100   A1=AA1(I)
      B=BB(I)
      C=CC(I)
      GO TO 120
110   Z=R1T024-BJ
      ZZ=Z/0.05
      A1=AA1(I)+(ZZ*(AA1(I+1)-AA1(I)))
      B=BB(I)+(ZZ*(BB(I+1)-BB(I)))
      C=CC(I)+(ZZ*(CC(I+1)-CC(I)))
C
C********  CALCULATE THE RATIO OF THE 100-YR. 1-HR. RAINFALL TO THE
C********  10-YR. 1-HR. RAINFALL (X)
C
120   X=R1001/R101
C
C********  CALCULATE A
C
      A=A1*R101*ALOG10((10**(2-X))*(IFREQ**(X-1)))
C
C******** PRINT THE RATIOS CALCULATED AND A, B, AND C
C
      WRITE(N6,300) R1T024,X
300   FORMAT(/* *,39X,*RATIO OF TEN-YEAR 1-HOUR TO 24-HOUR RAINFALL=*,F5
     2.2/* *,31X,*RATIO OF ONE HUNDRED-YEAR 1-HOUR TO TEN-YEAR 1-HOUR RA
     3INFALL=*,F5.2)
      WRITE(N6,210) A,B,C
210   FORMAT(/////* *,55X,*FINAL A B C VALUES*/* *,55X,18(*=*)//* *,60X,
     2*A=*,F7.3/* *,60X,*B=*,F7.3/* *,60X,*C=*,F7.3)
      CALL HYETO
      GO TO 126
```

```
125   WRITE(N6,127)
127   FORMAT(* *,13H*** ERROR ***,* THE INPUT RAINFALL VALUES AND THEIR
     2CORRESPONDING RATIOS MAKE THE ANALYSIS IMPOSSIBLE-THE RUN IS ABORT
     3ED*)
126   RETURN
      END
```

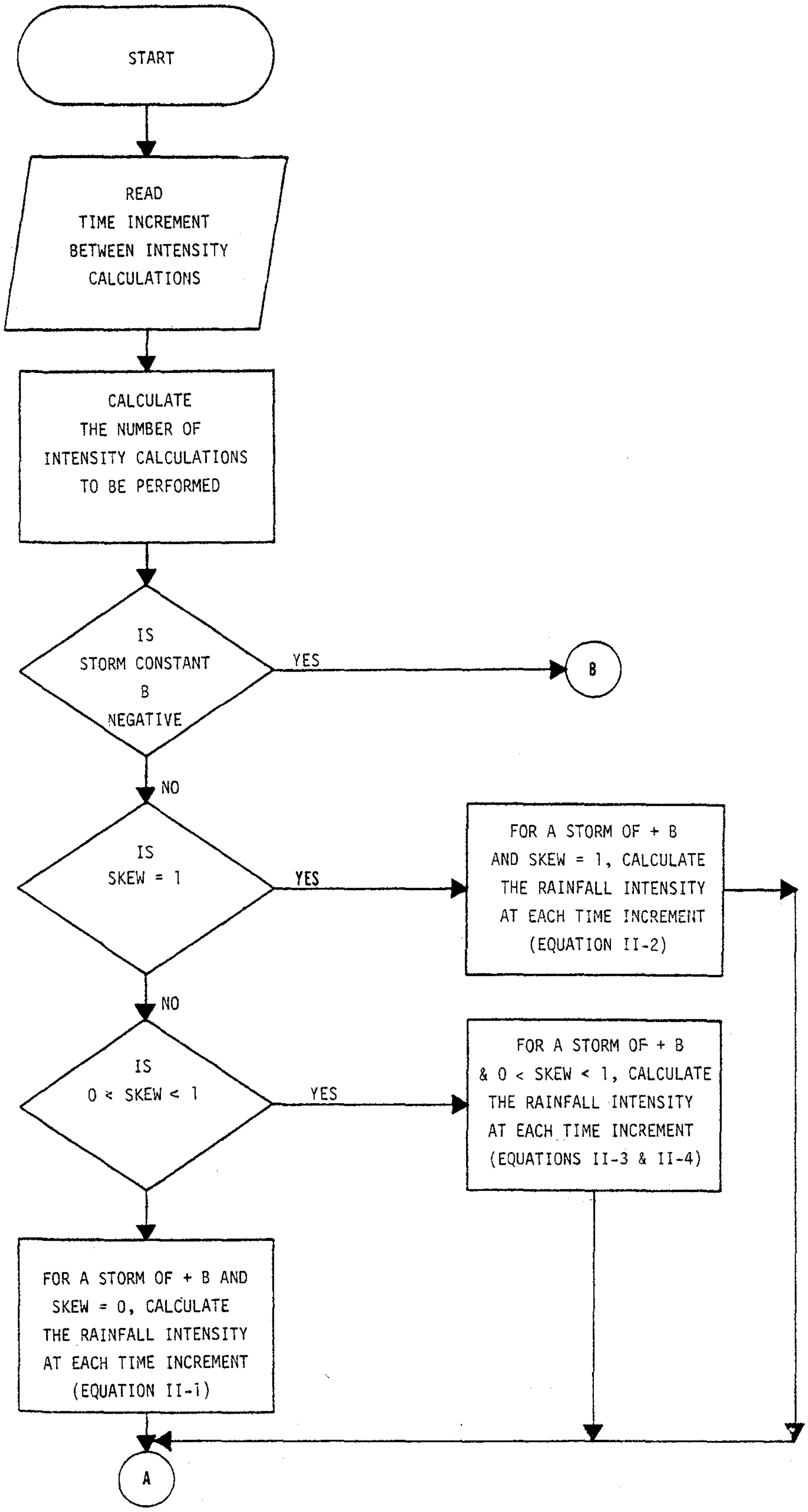

FIGURE IV-4

FLOW CHART FOR SUBROUTINE HYETO

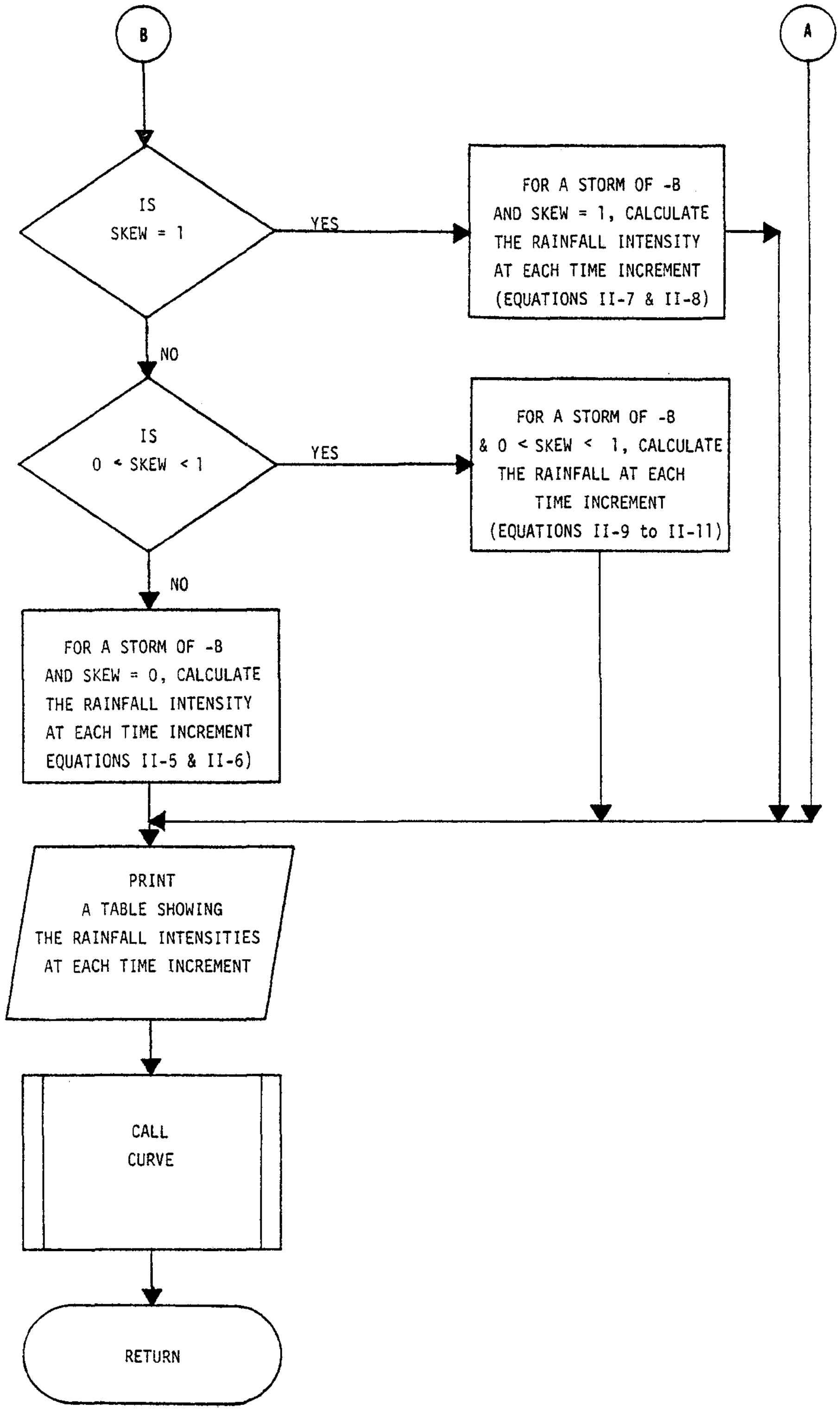

FIGURE IV-4

(continued)

TABLE IV-6

KEY VARIABLES NOT IN COMMON

AND IN SUBROUTINE HYETO

VARIABLE NAME	DESCRIPTION	UNITS
RINTEN (100)	Instantaneous Rainfall Intensity Array	in/hr or mm/hr
TIME (100)	Time Array	Minutes
INCRE	Time Between Intensity Calculations	Minutes
II	The Number of Intensity Calculations	None

```
      SUBROUTINE HYETO
C
C
C     ****************************************************************
C     *
C     *   THIS SUBROUTINE TAKES THE INFORMATION READ AND GENERATED
C     *   IN EITHER SUBROUTINE  ABCCHE OR SUBROUTINE  OPTIMI
C     *   AND DEVELOPS A SYNTHETIC DESIGN HYETOGRAPH USING EQUATIONS
C     *   DEVELOPED BY CHEN
C     *
C     ****************************************************************
C
C
      INTEGER DURA,TIME
      DIMENSION RINTEN(101),TIME(101),XX(101),Y(101)
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON/LABE/ TOPP(10),BOTT(10),SIDEE(50),SIDEM(50)
      COMMON/ABC/A,B,C,IFREQ,DURA,SKEW
      COMMON/LABELS/TOP(10),BOTTOM(10),SIDE(50)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
C
C********  READ INCRE, THE NORMAL TIME INCREMENT BETWEEN INTENSITY
C********  CALCULATIONS
C
      READ(N5,11) INCRE
11    FORMAT(I4)
C
C********  CALCULATE THE NUMBER OF INTENSITY CALCULATIONS TO BE
C********  PERFORMED
C
      II=DURA/INCRE+1
      IF(II.GT.101) GO TO 761
      GO TO 762
761   WRITE(N6,763)
763   FORMAT(* *,13H*** ERROR ***,* THE NO. OF TIME STEPS EXCEEDS THE PR
     2OGRAM CAPACITY - INCREASE THE VARIABLE INCRE.*)
      STOP
C
C********  IF STORM CONSTANT B IS NEGATIVE, GO TO THE NEGATIVE B
C********  SECTION OF THE PROGRAM
C
762   IF(B.LT.0) GO TO 140
C
C
C********  POSITIVE B SECTION OF THE PROGRAM
C
C
      IF(SKEW.EQ.1) GO TO 160
      IF((SKEW.GT.0).AND.(SKEW.LT.1)) GO TO 170
C
C********  FOR A STORM WITH A SKEW OF ZERO, CALCULATE THE INSTANTANEOUS
```

```
C********  RAINFALL INTENSITIES AT EACH TIME INCREMENT
C
      TIME(1)=0
      DO 30 I=1,II
      RINTEN(I)=(A*(((1-C)*TIME(I))+B))/((TIME(I)+B)**(1+C))
30    TIME(I+1)=TIME(I)+INCRE
      GO TO 180
C
C********  FOR A STORM WITH A SKEW OF ONE, CALCULATE THE INSTANTANEOUS
C********  RAINFALL INTENSITIES AT EACH TIME INCREMENT
C
160   TIME(1)=0
      DO 40 I=1,II
      RINTEN(I)=(A*(((1-C)*(DURA-TIME(I)))+B))/(((DURA-TIME(I))+B)**(1+C
     1))
40    TIME(I+1)=TIME(I)+INCRE
      GO TO 180
C
C********  FOR A STORM WITH A SKEW GREATER THAN 0 AND LESS THAN 1,
C********  CALCULATE THE INSTANTANEOUS RAINFALL INTENSITIES AT EACH TIME
C********  INCREMENT UP UNTIL THE TIME OF PEAK RAINFALL
C
170   TIME(1)=0
      DO 50 I=1,II
      RINTEN(I)=(A*(((1-C)*(DURA-(TIME(I)/SKEW)))+B))/(((DURA-(TIME(I)/
     1SKEW))+B)**(1+C))
      TIME(I+1)=TIME(I)+INCRE
      NN=0
      IF(TIME(I+1).EQ.(INT(SKEW*DURA+.5))) NN=1
      IF(TIME(I+1).EQ.(INT(SKEW*DURA+.5))) GO TO 190
C
C********  IF THE TIME OF PEAK RAINFALL DOES NOT FALL ON A NORMAL TIME
C********  INCREMENT, INCREASE THE NUMBER OF INTENSITY CALCULATIONS
C********  TO BE PERFORMED BY ONE
      IF(TIME(I+1).GT.(INT(SKEW*DURA+.5))) GO TO 191
50    CONTINUE
191   II=II+1
C
C********  SET THE FIRST TIME INCREMENT GREATER THAN OR EQUAL TO THE
C********  TIME OF PEAK RAINFALL EQUAL TO THE TIME OF PEAK
190   TIME(I+1)=(SKEW*DURA)
C
C********  FOR A STORM WITH A SKEW GREATER THAN 0 AND LESS THAN 1,
C********  CALCULATE THE INSTANTANEOUS PEAK RAINFALL INTENSITY
C
      RINTEN(I+1)=(A*(((1-C)*(DURA-(TIME(I+1)/SKEW)))+B))/(((DURA-(TIME(
     1I+1)/SKEW))+B)**(1+C))
      TIME(I+1)=INT(SKEW*DURA+0.5)
      I=I+2
C
C********  FOR A STORM WITH A SKEW GREATER THAN 0 AND LESS THAN 1,
C********  CALCULATE THE INSTANTANEOUS RAINFALL INTENSITIES AFTER THE
C********  TIME OF PEAK RAINFALL
C
      DO 60 J=I,II
C
C********  CHECK TO SEE IF THE PEAK RAINFALL INTENSITY FELL ON A NORMAL
```

```
C********  TIME INCREMENT
      IF(J.EQ.1) GO TO 500
      GO TO 510
C
C********  IF THE TIME OF PEAK RAINFALL INTENSITY FELL IN BETWEEN TWO
C********  NORMAL TIME INCREMENTS, MAKE SURE AN INTENSITY CALCULATION IS
C********  PERFORMED AT BOTH INCREMENTS
500   TIME(J)=TIME(J-2)+INCRE
      IF(NN.EQ.1) TIME(J)=TIME(J-1)+INCRE
      GO TO 60
510   TIME(J)=TIME(J-1)+INCRE
60    RINTEN(J)=(A*(((1-C)*(TIME(J)-(SKEW*DURA))/(1-SKEW))+B))/(((TIME(J
     1)-(SKEW*DURA))/(1-SKEW)+B)**(1+C))
      GO TO 180
C
C
C********  NEGATIVE B SECTION OF THE PROGRAM
C
C
140   B=B*(-1)
      IF(SKEW.EQ.1) GO TO 200
      IF((SKEW.GT.0).AND.(SKEW.LT.1)) GO TO 210
C
C********  FOR A STORM WITH A SKEW OF ZERO, CALCULATE THE INSTANTANEOUS
C********  RAINFALL INTENSITIES AT EACH TIME INCREMENT
C
      TIME(1)=0
      DO 300 I=1,II
C
C********  DETERMINE WHICH EQUATION IS APPLICABLE FOR THE TIME STEP
      IF(TIME(I).LE.(2*B/(1-C))) GO TO 220
      IF(TIME(I).GT.(2*B/(1-C))) GO TO 230
220   RINTEN(I)=(A/B**C)*((1-C)/(1+C))**C
      GO TO 300
230   RINTEN(I)=(A*(((1-C)*TIME(I))-B))/((TIME(I)-B)**(1+C))
300   TIME(I+1)=TIME(I)+INCRE
      GO TO 180
C
C********  FOR A STORM WITH A SKEW OF 1, CALCULATE THE INSTANTANEOUS
C********  RAINFALL INTENSITIES AT EACH TIME INCREMENT
C
200   TIME(1)=0
      DO 260 I=1,II
C
C********  DETERMINE WHICH EQUATION IS APPLICABLE FOR THE TIME STEP
      IF((TIME(I).GE.0).AND.(TIME(I).LE.(DURA-2*B/(1-C)))) GO TO 240
      IF(TIME(I).GT.(DURA-2*B/(1-C))) GO TO 250
240   RINTEN(I)=(A*(((1-C)*(DURA-TIME(I)))-B))/(((DURA-TIME(I))-B)**(1+C
     1))
      GO TO 260
250   RINTEN(I)=(A/B**C)*((1-C)/(1+C))**C
260   TIME(I+1)=TIME(I)+INCRE
      GO TO 180
```

```
C
C********  FOR A STORM WITH A SKEW GREATER THAN 0 AND LESS THAN 1,
C********  CALCULATE THE INSTANTANEOUS RAINFALL INTENSITIES AT EACH TIME
C********  INCREMENT
C
210   TIME(1)=0
      MM=0
      YY=0
C
C********  INCREASE THE NUMBER OF INTENSITY CALCULATIONS TO BE PERFORMED
C********  BY ONE (IN CASE THE PEAK RAINFALL DOES NOT FALL ON A NORMAL
C********  TIME INCREMENT)
      II=II+1
      DO 420 I=1,II
      GG=0
C
C********  IF THE TIME OF PEAK RAINFALL INTENSITY FALLS ON A NORMAL
C********  TIME INCREMENT, SET MM EQUAL TO ONE
      IF(TIME(I).EQ.(INT(SKEW*DURA+.5))) MM=1
C
C********  IF THE TIME INCREMENT IS THE FIRST ONE GREATER THAN OR EQUAL
C********  TO THE TIME OF PEAK RAINFALL INTENSITY, SET THE INCREMENT
C********  EQUAL TO THE TIME OF PEAK
      IF((TIME(I).GE.(INT(SKEW*DURA+.5))).AND.(YY.NE.1)) GO TO 600
      GO TO 610
600   TIME(I)=(SKEW*DURA)
      YY=1
      GG=1
C
C********  DETERMINE WHICH EQUATION IS APPLICABLE FOR THE TIME STEP
610   IF((TIME(I).GE.0).AND.(TIME(I).LE.(SKEW*DURA-2*B*SKEW/(1-C)))) GO
     1TO 280
      IF((TIME(I).GT.(SKEW*DURA-2*B*SKEW/(1-C))).AND.(TIME(I).LT.(SKEW*D
     1URA)+2*B*(1-SKEW)/(1-C))) GO TO 290
      IF(TIME(I).GE.(SKEW*DURA)+2*B*(1-SKEW)/(1-C)) GO TO 400
280   RINTEN(I)=(A*((1-C)*(DURA-TIME(I)/SKEW)-B))/(((DURA-TIME(I)/SKEW)-
     1B)**(1+C))
      GO TO 410
290   RINTEN(I)=(A/B**C)*((1-C)/(1+C))**C
      GO TO 410
400   RINTEN(I)=(A*((1-C)*(TIME(I)-SKEW*DURA)/(1-SKEW)-B))/(((TIME(I)-SK
     1EW*DURA)/(1-SKEW)-B)**(1+C))
C
C********  IF THE TIME OF PEAK RAINFALL INTENSITY FELL ON A NORMAL TIME
C********  INCREMENT (IE. MM=1), DECREASE THE NUMBER OF INTENSITY
C********  CALCULATIONS BY ONE
410   IF(TIME(I).EQ.SKEW*DURA) TIME(I)=INT(SKEW*DURA+0.5)
      IF((MM.EQ.1).AND.(I.EQ.II-1)) GO TO 180
      IF(MM.EQ.1) GO TO 431
C
C********  IF THE TIME OF PEAK RAINFALL INTENSITY FELL IN BETWEEN TWO
C********  NORMAL TIME INCREMENTS, MAKE SURE AN INTENSITY CALCULATION IS
C********  PERFORMED AT BOTH INCREMENTS
```

```
      IF((YY.EQ.1).AND.(GG.NE.0)) GO TO 430
431   TIME(I+1)=TIME(I)+INCRE
      GO TO 420
430   TIME(I+1)=TIME(I-1)+INCRE
420.  CONTINUE
C
C********  PRINT OUT A TABLE SHOWING THE CALCULATED INSTANTANEOUS
C********  RAINFALL INTENSITIES AT EACH TIME INCREMENT- THIS TABLE WILL
C********  INCLUDE THE PEAK RAINFALL INTENSITY
C
180   WRITE(N6,2999)
      WRITE(N6,6)
6     FORMAT(////* *,34X,*TABLE OF TIME AND RAINFALL INTENSITIES FOR DES
     2IGN HYETOGRAPH*)
      WRITE(N6,7)
7     FORMAT(* *,34X,60(*=*)//)
      IF(IMET.EQ.0) WRITE(N6,4)
      IF(IMET.EQ.1) WRITE(N6,45)
4     FORMAT(///* *,40X,*TIME (MINUTES)*,5X,*RAINFALL INTENSITY (IN./HR.
     2)*)
45    FORMAT(///* *,40X,*TIME (MINUTES)*,5X,*RAINFALL INTENSITY (MM./HR.
     2)*)
      WRITE(N6,5)
5     FORMAT(* *,40X,47(*-*)/)
      IF(MM.EQ.1) II=II-1
      IF(IMET.EQ.0) GO TO 75
C********                         * METRIC OUTPUT *
      DO 65 J=1,II
      RINTEN(J)=RINTEN(J)*25.40
65    WRITE(6,3) TIME(J),RINTEN(J)
      GO TO 90
C********                         * FPS OUTPUT *
75    DO 80 J=1,II
      ITIME=TIME(J)
80    WRITE(N6,3) ITIME,RINTEN(J)
3     FORMAT(* *,45X,I4,21X,F6.2)
C
90    WRITE(N6,9) IFREQ,DURA,SKEW
9     FORMAT(///* *,34X,*FREQUENCY=*,I3,* YEARS*,5X,*DURATION=*,I3,* MIN
     2UTES*,5X,*SKEW=*,F4.2)
C
C********  PLOT THE SYNTHETIC DESIGN HYETOGRAPH JUST DEVELOPED
C
      IF(IMET.EQ.0) GO TO 96
C********                    FILL ARRAYS FOR METRIC UNITS PLOT
      DO 95 M=1,II
      XX(M)=TIME(M)
95    Y(M)=RINTEN(M)
      GO TO 97
C********                    FILL ARRAYS FOR ENGLISH UNITS PLOT
96    DO 700 M=1,II
      XX(M)=TIME(M)
700   Y(M)=RINTEN(M)
C
```

```
97     NCV=1
       NPLOT=0
       IJOIN=1
       ITEL=0
       ISTAN=0
       DO 790 M=1,10
       TOP(M)=TOPP(M)
790    BOTTOM(M)=BOTT(M)
       IF(IMET.EQ.0) GO TO 7900
       DO 7800 M=1,50
7800   SIDE(M)=SIDEM(M)
       GO TO 800
7900   DO 791 M=1,50
791    SIDE(M)=SIDEE(M)
800    WRITE(N6,2999)
       CALL CURVE (XX,Y,II,NCV,NPLOT,IJOIN,ITEL,ISTAN)
       WRITE(N6,9) IFREQ,DURA,SKEW
       RETURN
       END
```

Subroutines CURVE, SCALE, PINE and PPLOT

In Program Path 1, the plotting routines are called to produce a plot of the synthetic hyetograph developed in subroutine HYETO. A brief discussion of the plotting routines and how they work is provided later in the section entitled "Plotting Subroutines."

Program Path Two

Program Path 2 of the Precipitation Module consists of subroutines OPTIMI, PINDEX, HYETO, CURVE, SCALE, PINE, AND PPLOT. When this program is activated by the main program, PRECIP, a single-peak synthetic hyetograph is generated with the use of intensity-duration-frequency data.

Subroutine OPTIMI

- Called From
  PRECIP
- Common Blocks Used
  /CNTRL/
  /ABC/
- Subroutines Called
  HYETO

Subroutine OPTIMI is the first subroutine called in Program Path 2. This subroutine reads intensity-duration data points that define the design intensity-duration-frequency curve and the storm skew, duration, and frequency. It then computes the a, b, and c storm constants that best define the input curve using the "Complex Method of Box." The performance index calculations necessary for the solution of the method are computed in subroutine PINDEX. When the final a, b and c values have been found, OPTIMI calls HYETO to compute the design hyetograph.

The flow chart for OPTIMI is given in Figure IV-5 and is followed by Table IV-7, showing the key variables not in COMMON, and by a program listing. All program variables in COMMON are defined in a later section of this chapter.

Subroutine PINDEX

- Called From
  OPTIMI
- Common Block Used
  /ABC/

Subroutine PINDEX is called by subroutine OPTIMI each time the PI for a new set of a, b and c is to be determined. PINDEX calculates the PI using Equation III-4. The flow chart for PINDEX is given in Figure IV-6 and a program listing follows.

Subroutines HYETO, CURVE, SCALE, PINE and PPLOT

In Program Path 2, subroutines HYETO, CURVE, SCALE, PINE, and PPLOT function in exactly the same manner as in Program Path 1.

Program Path Three

Program Path 3 of the Precipitation Module consists of subroutines ANALYZ, RAINT, SERIES, RANK, EVENT, FREQ, OUTPUT, STRMSKW, CURVE, SCALE, PINE, and PPLOT. When this program is activated by the main program, PRECIP, a complete hourly precipitation tape is prepared, an hourly rainfall analysis is executed, and one or more of the following analyses are performed:

1. SERIES ANALYSIS
   - An Annual Series Analysis
   - A Partial Duration Series Analysis

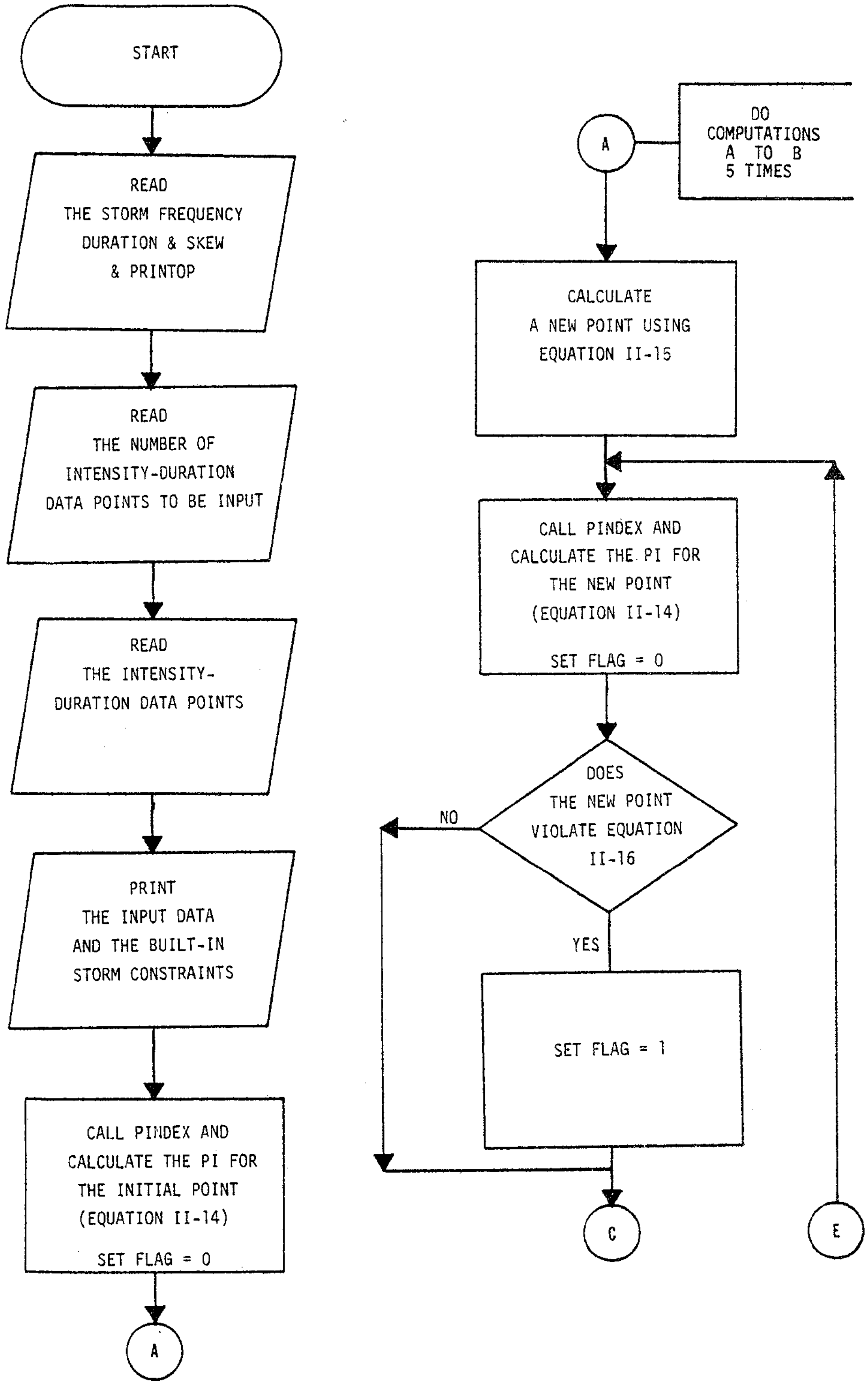

FIGURE IV-5

FLOW CHART FOR SUBROUTINE
OPTIMI

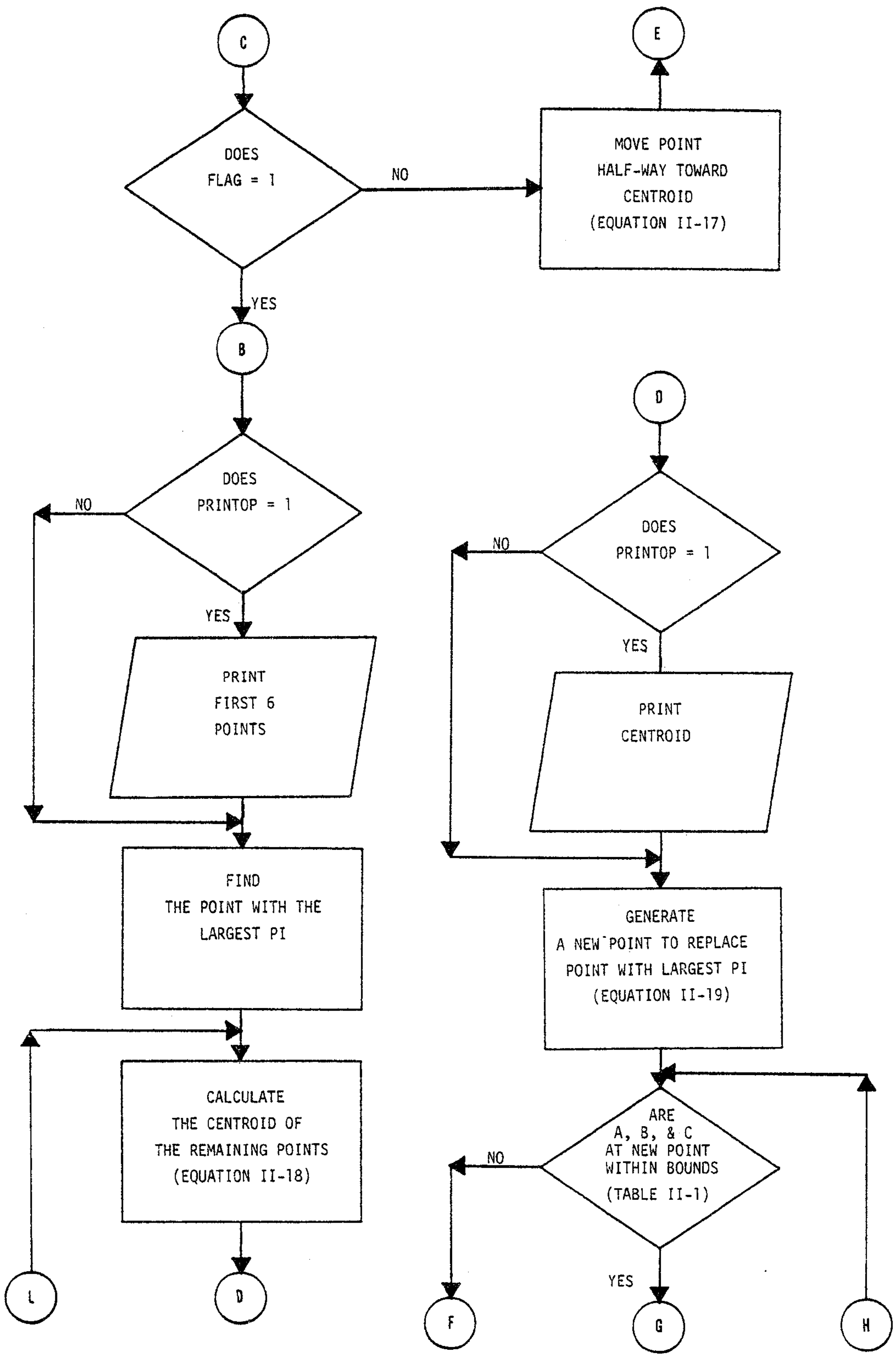

FIGURE IV-5

(continued)

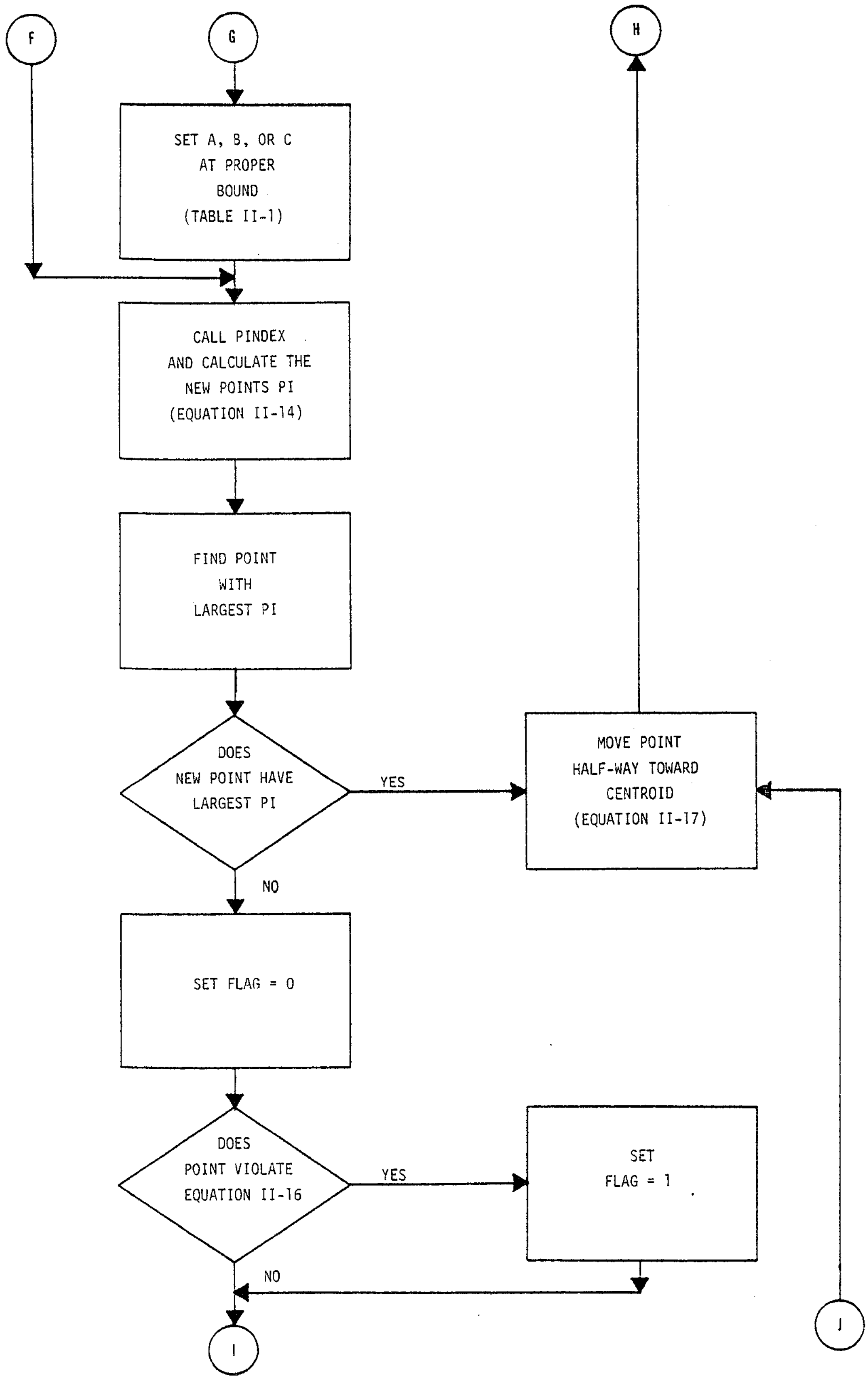

FIGURE IV-5
(continued)

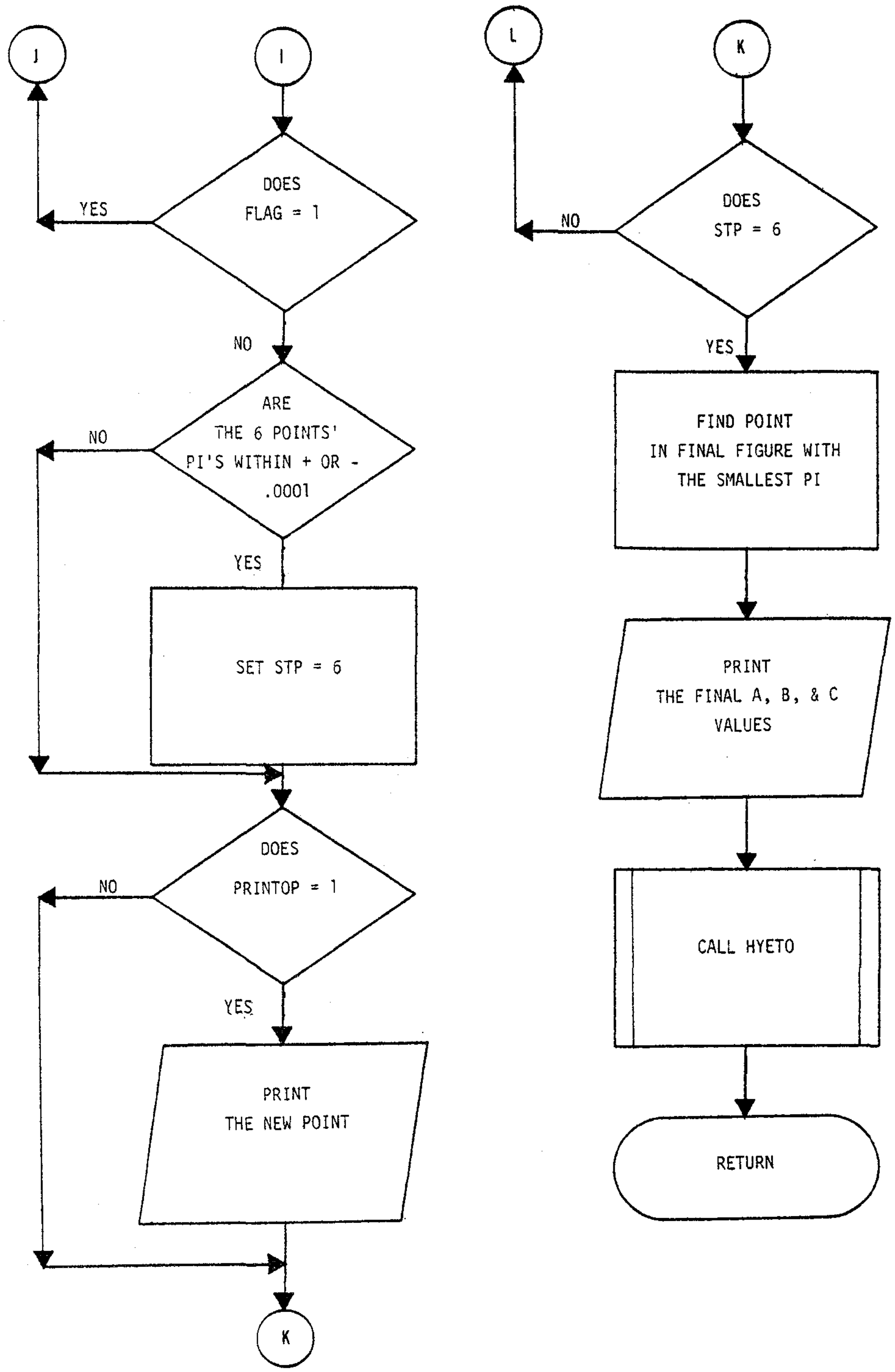

FIGURE IV-5

(continued)

TABLE IV-7

KEY VARIABLES NOT IN COMMON AND IN SUBROUTINE OPTIMI

VARIABLE NAME	DEFINITION	UNITS
PRINTOP	Controls whether or not intermediate points and centroid are printed	None
X(3,6)	Point Array (i.e., x(1,1) = a, x(2,1) = b, x(3,1) = c	None
PIV(6)	Performance index array	None
CU(3)	Storm constant upper limits	None
CL(3)	Storm constant lower limits	None
COUNT	Counts number of points generated	None
FLAG	Indicates whether or not equation was violated	None
RN	Random number between 0 and 1	None
XM(3)	Centroid Point	None

```
      SUBROUTINE  OPTIMI
C
C
C     ******************************************************************
C     *
C     *   THIS SUBROUTINE CALCULATES THE A, B, AND C STORM CONSTANTS
C     *   USING USER-SUPPLIED INTENSITY-DURATION DATA AND THE
C     *   COMPLEX METHOD OF BOX
C     *
C     ******************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON/ABC/ A,B,C,IFREQ,DURA,SKEW,DURAA(50),RAV(50),MI,PI
      INTEGER O,COUNT,OMIT,FLAG,STP,PRT
      INTEGER DURAA, PRINTO
      DIMENSION X(3,6),PIV(6),CU(3),CL(3),XM(3)
      DATA X,CU,CL
     1/60.53,7.85,0.75,15*0.0,150.0,16.0,1.0,0.0,-4.0,0.0/
      DATA J,K,N,AA,COUNT,OMIT,FLAG,STP,P,NV,EPS
     1/1,1,0,1.3,0,1,0,0,0.0,3,0.0001/
      WRITE(N6,2999)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
      NV2=2*NV
C
C********  READ THE INFORMATION NECESSARY TO DEVELOP A DESIGN HYETO-
C********  GRAPH ONCE THE STORM CONSTANTS ARE FOUND (THE STORM FREQUENCY
C********  (IFREQ), THE STORM DURATION (DURA), THE STORM SKEW (SKEW) )
C********  -ALSO READ THE STORM CONSTANT CALCULATION PRINT OPTION
C********  CONTROL VARIABLE
C
      READ(N5,120) IFREQ,DURA,SKEW, PRINTO
120   FORMAT(I5,I5,F5.2,I5)
C
C********  READ THE NUMBER OF INTENSITY-DURATION DATA POINTS TO BE
C********  INPUT
C
      READ(N5,101) MI
101   FORMAT(I2)
C
C********  READ THE INTENSITY-DURATION DATA POINTS THAT DEFINE THE
C********  INTENSITY DURATION FREQUENCY CURVE TO BE ESTIMATED
C
      READ(N5,100) (DURAA(I),RAV(I),I=1,MI)
100   FORMAT(4(I10,F10.2))
C
C********  ECHO PRINT THE INPUT DATA AND THE BUILT IN STORM CONSTANT
C********  CONSTRAINTS
```

```
C
      WRITE(N6,102)
102   FORMAT(//////* *,43X,*INPUT DURATIONS*,11X,*INPUT INTENSITIES*/* *
     2,43X,43(*=*)/)
C
      IF(IMET.EQ.0) GO TO 350
C
C********  METRIC UNITS OUTPUT
C********  CONVERT TO FPS UNITS FOR COMPUTATIONS
C
      DO 310 I=1,MI
      WRITE(N6,103) DURAA(I),RAV(I)
310   RAV(I)=RAV(I)/25.40
103   FORMAT(*0*,44X,I5,* MINUTES*,13X,F6.2,* MM./HR.*)
      GO TO 360
C
C********  FPS UNITS OUTPUT
C
350   DO 33 I=1,MI
      WRITE(N6,104) DURAA(I),RAV(I)
104   FORMAT(*0*,44X,I5,* MINUTES*,14X,F5.2,* IN./HR.*)
33    CONTINUE
C
360   WRITE(N6,110)
110   FORMAT(////* *,49X,*A B C VALUES ARE SUBJECT TO THE*/* *,49X,31(*=
     2*)/* *,54X,*FOLLOWING CONSTRAINTS*/* *,54X,21(*=*)/)
      WRITE(N6,111)
111   FORMAT(*0*,45X,*VARIABLE     UPPER LIMIT     LOWER LIMIT*/* *,45X,
     140(*-*))
      WRITE(N6,112) CU(1),CL(1)
      WRITE(N6,113) CU(2),CL(2)
      WRITE(N6,114) CU(3),CL(3)
112   FORMAT(* *,48X,*C*,11X,F5.1,11X,F5.1)
113   FORMAT(* *,48X,*B*,11X,F5.1,11X,F5.1)
114   FORMAT(* *,48X,*C*,11X,F5.1,11X,F5.1)
      WRITE(N6,115)
115   FORMAT(////* *,40X,17HA/(DURATION+B)**C,* MUST BE LESS THAN OR EQU
     2AL TO 16*)
      GO TO 500
501   IF(COUNT.GT.0) GO TO 1
      IF(COUNT.EQ.0) GO TO 700
    1 COUNT=COUNT+1
C
C********  SET FLAG EQUAL TO 1 IF THE POINT VIOLATES THE IMPLICIT
C********  CONSTRAINT
C
      JJ=5
      DO 32 NN=1,15
      IF(X(1,J)/(JJ+X(2,J))**X(3,J).GT.16.0) FLAG=1
32    JJ=JJ+10
      PIV(J)=PI
      GO TO (2,5,17),K
C
```

```
C********  CALCULATE ONE OF THE POINTS IN THE INITIAL FIGURE USING A
C********  RANDOM NUMBER GENERATOR
C
700   COUNT=COUNT+1
      PIV(J)=PI
    2 J=J+1
      DO 3 I=1,NV
      RN=RANF(1)
    3 X(I,J)=CL(I)+RN*(CU(I)-CL(I))
      K=2
      GO TO 500
C
C********  CHECK TO SEE IF FLAG EQUALS 1 (IE. IF THE POINT VIOLATES
C********  THE IMPLICIT CONSTRAINT)- IF FLAG EQUALS 1, GO TO 6 AND
C********  RECALCULATE THE POINT
C
    5 IF (FLAG.EQ.1) GO TO 6
C
C********  IF THE INITIAL FIGURE IS NOT COMPLETE, GO TO 2 AND GENERATE
C********  ANOTHER POINT
C
      IF (J.LT.NV2) GO TO 2
      IF( PRINTO.EQ.0) GO TO 9
C
C********  IF  PRINTO EQUALS 1, PRINT OUT THE INITIAL FIGURE OF POINTS
C********  AND THEIR PERFORMANCE INDEXES
C
      WRITE(N6,2999)
      WRITE(N6,1006)
      DO 1005 L=1,NV2
      WRITE(N6,1008) L,(X(I,L),I=1,NV),PIV(L)
 1005 CONTINUE
      WRITE(N6,2999)
      WRITE(N6,1012)
      GO TO 9
C
C********  IF THE POINT VIOLATES THE IMPLICIT CONSTRAINT, MOVE THE
C********  POINT HALF-WAY TOWARDS THE CENTROID OF THE POINTS ALREADY
C********  DETERMINED
C
    6 P=J-1
      DO 8 I=1,NV
      Z=0.0
      DO 7 L=1,J
    7 Z=Z+X(I,L)
    8 X(I,J)=0.5*((Z-X(I,J))/P+X(I,J))
      GO TO 500
C
C********  FIND THE POINT IN THE FIGURE WITH THE LARGEST (WORST)
C********  PERFORMANCE INDEX
C
    9 OMIT=1
```

```
      DO 10 L=2,NV2
      IF (PIV(OMIT).GT.PIV(L)) GO TO 10
      OMIT=L
   10 CONTINUE
      IF (N.EQ.0) GO TO 11
C
C********  IF THE NEWLY GENERATED POINT HAS THE LARGEST (WORST)
C********  PERFORMANCE INDEX, GO TO 19 AND RECALCULATE THE POINT
C
      IF (OMIT.EQ.J) GO TO 19
      GO TO 26
C
C********  CALCULATE THE CENTROID OF THE FIGURE FORMED BY ALL THE POINTS
C********  BUT THE ONE WITH THE LARGEST (WORST) PERFORMANCE INDEX
C
   11 O=NV2-1
      DO 13 I=1,NV
      Z=0.0
      DO 12 L=1,NV2
   12 Z=Z+X(I,L)
   13 XM(I)=(Z-X(I,OMIT))/O
      IF( PRINTO.EQ.0) GO TO 30
C
C********  IF  PRINTO EQUALS 1, PRINT OUT THE CENTROID
C
      WRITE(N6,1010) (XM(L),L=1,NV)
C
C********  GENERATE A NEW POINT TO REPLACE THE POINT WITH THE LARGEST
C********  (WORST) PERFORMANCE INDEX
C
30    DO 14 I=1,NV
14    X(I,OMIT)=(1.0+AA)*XM(I)-AA*X(I,OMIT)
C
C********  CHECK TO SEE IF THE NEWLY GENERATED POINT VIOLATES THE
C********  EXPLICIT CONSTRAINTS-IF THE POINT DOES VIOLATE A CONSTRAINT,
C********  SET THE POINT EQUAL TO THE CONSTRAINT
C
25    J=OMIT
      DO 16 I=1,NV
      IF (X(I,J).GT.CU(I)) X(I,J)=CU(I)
      IF (X(I,J).LT.CL(I)) X(I,J)=CL(I)
   16 CONTINUE
      N=1
C
C********  CALCULATE THE PERFORMANCE INDEX OF THE GENERATED POINT USING
C********  THE METHOD OF LEAST SQUARES
C
      A=X(1,J)
      B=X(2,J)
      C=X(3,J)
      CALL PINDEX
      PIV(J)=PI
      GO TO 9
```

```
26     K=3
       FLAG=0
       GO TO 501
C
C********  CHECK TO SEE IF FLAG EQUALS 1 (IE. IF THE POINT VIOLATES THE
C********  IMPLICIT CONSTRAINT)- IF FLAG EQUALS 1, GO TO 19 AND
C********  RECALCULATE THE POINT
C
   17 IF (FLAG.EQ.1) GO TO 19
C
C********  IF THE NEWLY GENERATED POINT SATISFIES ALL THE CONSTRAINTS,
C********  CHECK TO SEE IF THE METHOD HAS CONVERGED- IE. CHECK TO SEE
C********  IF ALL THE CURRENT POINTS PERFORMANCE INDEXES ARE WITHIN
C********  + OR - 0.0001 OF EACH OTHER
C
       DO 18 L=1,NV2
       IF (ABS(PIV(1)-PIV(L)).LE.EPS) STP=STP+1
   18 CONTINUE
       IF( PRINTO.EQ.0) GO TO 90
C
C********  IF  PRINTO EQUALS 1, PRINT OUT THE NEWLY GENERATED POINT AND
C********  ITS PERFORMANCE INDEX
       WRITE(N6,1002) J,(X(I,J),I=1,NV),PIV(J),COUNT
C
C********  IF THE METHOD HAS CONVERGED GO TO 21
90     IF(STP.GE.NV2) GO TO 21
C
C********  IF THE METHOD HAS NOT CONVERGED, GO TO 11, CALCULATE THE
C********  CENTROID, AND CONTINUE THROUGH THE CYCLE
       STP=0
       GO TO 11
C
C********  IF THE NEWLY GENERATED POINT HAS THE LARGEST (WORST)
C********  PERFORMANCE INDEX OR VIOLATES THE IMPLICIT CONSTRAINT, MOVE
C********  THE POINT HALF-WAY TOWARDS THE CENTROID OF THE OTHER POINTS
C
   19 DO 20 I=1,NV
   20 X(I,OMIT)=0.5*(X(I,OMIT)+XM(I))
       GO TO 25
C
C********  CALCULATE THE PERFORMANCE INDEX OF THE GENERATED POINT
C********  USING THE METHOD OF LEAST SQUARES
C
500    A=X(1,J)
       B=X(2,J)
       C=X(3,J)
       CALL PINDEX
       FLAG=0
       GO TO 501
C
C********  FIND THE SINGLE POINT IN THE FINAL CONVERGED FIGURE WITH THE
C********  SMALLEST (BEST) PERFORMANCE INDEX
C
```

```
   21 PRT=1
      DO 22 L=1,NV2
      IF (PIV(PRT).LE.PIV(L)) GO TO 22
      PRT=L
   22 CONTINUE
      J=PRT
C
C********  PRINT OUT THE FINAL  OPTIMIED VALUES OF THE STORM CONSTANTS
C
      WRITE(N6,2999)
      WRITE(N6,1014) (X(I,J),I=1,NV),PIV(J),COUNT
      A=X(1,J)
      B=X(2,J)
      C=X(3,J)
      CALL HYETO
1002  FORMAT(///* *,35X,*POINT *,I1,* =( A=*,E13.6,*, B=*,E13.6,*, C=*,E
     213.6,*)*/* *,35X,*PI=*,E13.6,5X,*NO. OF RUNS=*,I4)
1006  FORMAT(/////////////* *,57X,*INITIAL POINTS*/* *,57X,14(*=*))
1008  FORMAT(///* *,35X,*POINT *,I1,* =( A=*,E13.6,*, B=*,E13.6,*, C=*,E
     213.6,*)*/* *,35X,*PI=*,E13.6)
1010  FORMAT(///* *,35X,*CENTROID= ( A=*,E13.6,*, B=*,E13.6,*, C=*,E13.6
     2,*)*)
1012  FORMAT(////* *,55X,*REGENERATED POINTS*/* *,55X,18(*=*))
1014  FORMAT(///////////////////////* *,47X,*OPTIMIZED VALUES OF A, B AND
     2C ARE:*/* *,47X,35(*=*)/*0*,56X,*A=*,E13.6/*0*,56X,*B=*,E13.6/*0*,
     356X,*C=*,E13.6//*0*,49X,*PERFORMANCE INDEX=*,E13.6/*0*,52X,*NUMBER
     4 OF ITERATIONS=*,I4)
      RETURN
      END
```

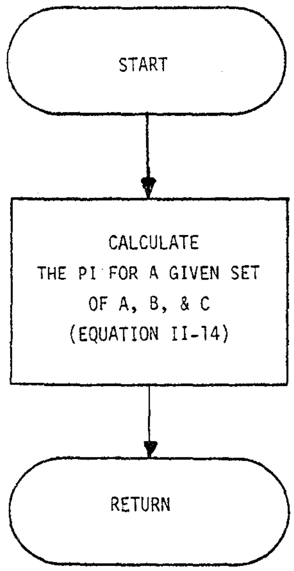

FIGURE IV-6

FLOW CHART FOR SUBROUTINE PINDEX

```
      SUBROUTINE PINDEX
C
C
C     ******************************************************************
C     *
C     *   THIS SUBROUTINE USES THE METHOD OF LEAST SQUARES AND
C     *   CALCULATES THE PERFORMANCE INDEX FOR THE DIFFERENT SETS
C     *   OF STORM CONSTANTS GENERATED IN SUBROUTINE  OPTIMI
C     *
C     ******************************************************************
C
C
      COMMON/ABC/ A,B,C,IFREQ,DURA,SKEW,DURAA(50),RAV(50),MI,PI
      INTEGER DURAA
      PI=0
      DO 2000 M=1,MI
      DD=(ALOG10(A)-C*ALOG10(DURAA(M)+B))-ALOG10(RAV(M))
      DD=DD*DD
2000  PI=PI+DD
      RETURN
      END
```

2. FREQUENCY ANALYSIS, and
   - An Event Frequency Analysis
   - A Dry Period Frequency Analysis
3. RAINFALL PATTERN SKEW ANALYSIS

Each of the above can be produced either on a yearly or a yearly and seasonal basis.

Subroutine ANALYZ

In Program Path 3, subroutine ANALYZ is the first subroutine called. This subroutine coordinates the entire rainfall analysis. It first reads a control card that defines the starting date and the source of the hourly precipitation data. The data source can be either 1) cards, 2) an unprocessed magnetic tape, or 3) a subroutine RAINT processed file. The rainfall analysis can only be performed on a RAINT processed file, so if the data source is either cards or an unprocessed magnetic tape, ANALYZ calls RAINT to prepare a proper rainfall data file.

Given that a RAINT processed rainfall tape is available, subroutine ANALYZ reads an analysis request card. On this card the user stipulates what analyses he wants executed. He may request:

- An annual series analysis,
- A partial duration series analysis,
- An event frequency analysis,
- A dry-period frequency analysis, and
- A skew analysis.

In addition, the user may request that all of the analyses selected be run on a seasonal basis as well as a yearly basis. The only restrictions placed on the user in terms of his selections are that he may not request a partial duration series analysis without an annual series analysis or a dry-period frequency analysis without an event frequency analysis.

Based upon the analysis request card, subroutine ANALYZ does the following:

- If a seasonal analysis is requested, it reads the seasonal information;
- If the annual series anlaysis is requested, it calls subroutine SERIES;
- If the event frequency analysis is requested, it calls subroutine EVENT; and
- If the rainfall pattern skew analysis is requested, it calls subroutine STRMSKW.

The flow chart for ANALYZ is given in Figure IV-7 and is followed by a program listing. All program variables in COMMON are defined in a later section of this chapter.

Subroutine RAINT

- Called From
  ANALYZ
- Common Block Used
  /CNTRL/

Subroutine RAINT prepares a complete, chronological, hourly precipitation tape for use in the rainfall analysis. Specifically, RAINT reads a user input, chronological, hourly rainfall file (either cards or magnetic tape) and calculates the century date[1] for each day of rainfall in the input file using Function MDAY1. On the basis of the century dates, RAINT then checks to see if any days are missing in the input file and writes a chronological hourly precipitation tape. This tape is written in blocks of 200 days and includes records for every day in the input file plus records for any missing days with the hourly rainfalls filled in with zeroes.

[1]The century date of a given date is the value assigned to the date when all days in the century are numbered consecutively from the first day in the century to the last.

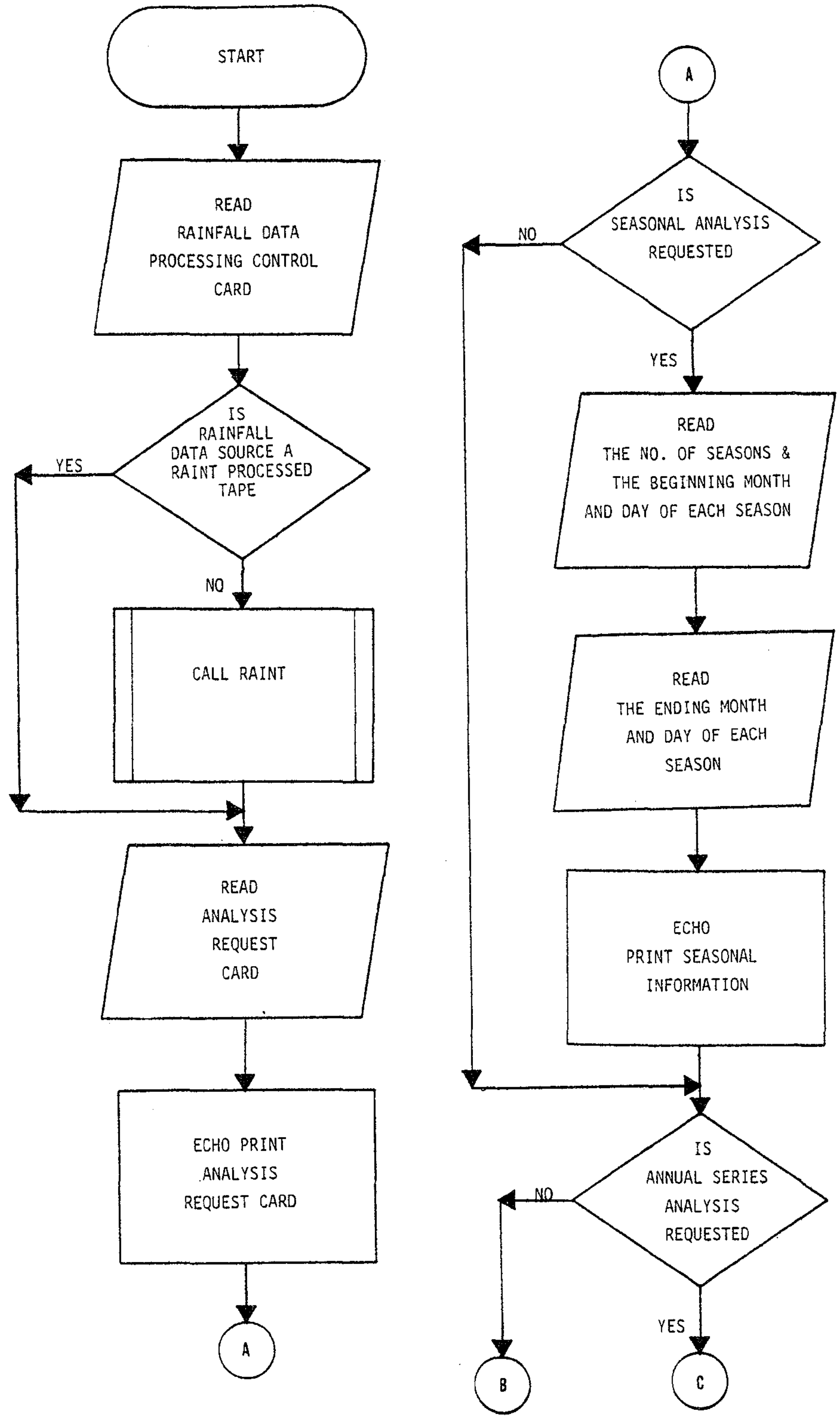

FIGURE IV-7

FLOW CHART FOR SUBROUTINE ANALYZ

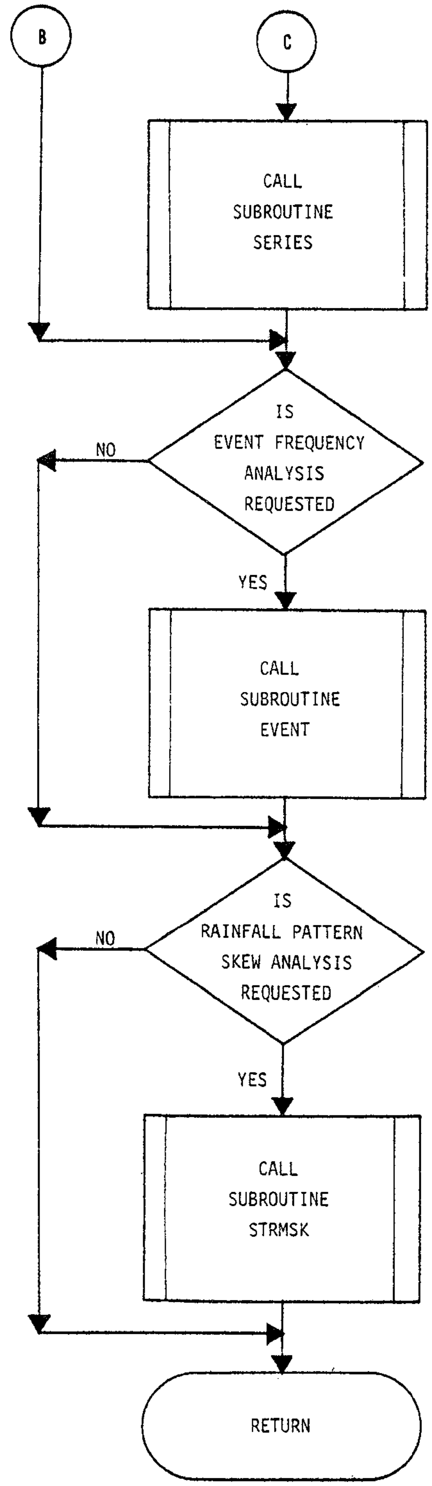

FIGURE IV-7

(continued)

```
      SUBROUTINE  ANALYZ
C
C
C     ******************************************************************
C     *                                                                *
C     * THIS SUBROUTINE READS THE OPTION CONTROL INFORMATION NECESSARY *
C     * FOR THE EXECUTION OF OPTION THREE AND CONTROLS THE EXECUTION   *
C     * OF THE ANALYSIS OPTIONS REQUESTED                              *
C     *                                                                *
C     *     IOPT...CONTROLS WHETHER OR NOT RAINT IS CALLED             *
C     *        - =DO NOT CALL RAINT-INPUT IS A RAINT OUTPUT TAPE       *
C     *        + OR 0 =CALL RAINT, PROCESS RAIN DATA AND STORE ON TAPE *
C     *     IN...RAINFALL DATA SOURCE CONTROL VARIABLE                 *
C     *        5 =CARD READER                                          *
C     *        ALL OTHER NO. =TAPE                                     *
C     *     IT...SUBROUTINE RAINTS PROCESSED TAPE NO.                  *
C     *     ISTART...STARTING DATE OF RAINFALL DATA                    *
C     *     IPRINT...CONTROLS PRINTING OF RAINFALL DATA                *
C     *        1 =PRINT                                                *
C     *        0 =DO NOT PRINT                                         *
C     *     NSER...SERIES OPTION CONTROL VARIABLE                      *
C     *        1 =EXECUTE SERIES                                       *
C     *        0 =DO NOT EXECUTE                                       *
C     *      IPARTO...PARTIAL DURATION SERIES CONTROL VARIABLE         *
C     *        1 =EXECUTE PARTIAL DURATION SERIES                      *
C     *        0 =DO NOT EXECUTE                                       *
C     *     INDSEA...SEASONAL ANALYSIS CONTROL VARIABLE                *
C     *        1 =EXECUTE ALL OPTIONS CALLED ON A SEASONAL BASIS       *
C     *        0 =DO NOT EXECUTE SEASONAL ANALYSES                     *
C     *     NEVNT...RAINFALL EVENT OPTION CONTROL VARIABLE             *
C     *        1 =EXECUTE EVENT                                        *
C     *        0 =DO NOT EXECUTE                                       *
C     *      IDRYOP...DRY PERIOD ANALYSIS CONTROL VARIABLE             *
C     *        1 =EXECUTE DRY PERIOD ANALYSIS                          *
C     *        0 =DO NOT EXECUTE                                       *
C     *      ISKEWO...SKEW ANALYSIS CONTROL VARIABLE                   *
C     *        1 =EXECUTE SKEW ANALYSIS                                *
C     *        0 =DO NOT EXECUTE                                       *
C     *     NOSEAS...NO. OF SEASONS TO BE  ANALYZD                     *
C     *     MOSEAS...BEGINING MONTHS OF SEASONS                        *
C     *     MDAYBG...BEGINING DAYS OF SEASONS                          *
C     *     MOSEND...ENDING MONTHS OF SEASONS                          *
C     *      MDAYEN...ENDING DAYS OF SEASONS                           *
C     *                                                                *
C     ******************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON /SEREES/ NYR,NDUR,DURTN(14),Y(744),MBG(12),MND(12),
     2MAXI(50,14),IDTI(50,10), MAXSEA(12,50,14),IDED(12,50,10),X(8784),
     3NOYRR,INDSEA,NOSEAS,INTYR,MOSEAS(12),MDAYBG(12),MOSEND(12),
     4 MDAYEN(12), IPARTO,M3
      INTEGER X,Y,DURTN
      DIMENSION INDOP(2),INDOP1(21),INDOP2(12)
      DATA INDOP
     1/4H NO ,4H YES/
```

```
      DATA INDOP1
     1/2HPR,2HOC,2HES,2HSE,2HD ,2HTA,2HPE,2H  ,2H N,2HWS,2H T,2HAP,2HE ,
     22H  ,2H  ,2H  ,2HCA,2HRD,2HS ,2H  ,2H  /
      DATA INDOP2
     1/4H  DO,4H NOT,4H PRI,4HNT R,4HAINF,4HALL ,4H    ,4H PRI,4HNT R,
     24HAINF,4HALL ,4H    /
C
C********  READ RAINFALL DATA PROCESSING INFORMATION
C
      READ(N5,710) IOPT,IN,IT,ISTART,IPRINT
710   FORMAT(3I8,2X,4I2)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
      WRITE(N6,25)
25    FORMAT(//////* *,49X,*RAINFALL PROCESSING I/O INFO.*/* *,49X,29(*=
     2*)/////)
      IF(IOPT.LT.0) GO TO 800
      IF(IN.EQ.5) GO TO 801
      LST=8
      LEND=14
      GO TO 802
800   LST=1
      LEND=7
      GO TO 802
801   LST=15
      LEND=21
802   IF(IPRINT.EQ.0) GO TO 803
      LST2=7
      LEND2=12
      GO TO 804
803   LST2=1
      LEND2=6
804   WRITE(N6,30) (INDOP1(JK),JK=LST,LEND),IN,IT,ISTART(2),ISTART(3),
     2ISTART(1),(INDOP2(JL),JL=LST2,LEND2)
30    FORMAT(* *,10X,*RAINFALL*,10X,*RAINFALL INPUT*,10X,*SUBROUTINE RAI
     2NT S*,10X,*STARTING DATE*,10X,*RAINT S PRECIP.*/* *,8X,*INPUT OPTI
     3ON*,11X,*UNIT NO.*,15X,*PROCESSED RAIN*,15X,*(ISTART)*,17X,*RECORD
     4*/* *,11X,*(IOPT)*,16X,*(IN)*,17X,*OUTPUT UNIT NO.*,35X,*PRINT CON
     5TROL*/* *,59X,*(IT)*,44X,*(IPRINT)*///* *,7X,7A2,11X,I4,22X,I4,20X
     6,I2,*/*,I2,*/*,I2,8X,6A4)
      IF(IOPT) 600,610,610
  610 CALL RAINT
      GO TO 605
600   IT=IN
605   WRITE(N6,2999)
C
C********  READ ANALYSIS OPTION CONTROL INFORMATION
C
      READ(N5,40)  NSER, IPARTO,INDSEA,NEVNT, IDRYOP, ISKEWO
40    FORMAT(6I8)
      WRITE(N6,900)
900   FORMAT(*0*,10X,*SUBROUTINE ANALYZ*)
      I1=NSER+1
```

```
      I2=IPARTO+1
      I3=INDSEA+1
      I4=NEVNT+1
      I5=IDRYOP+1
      I6=ISKEWO+1
      WRITE(N6,901) I1,I2,I3,I4,I5,I6
901   FORMAT(*0*,10X,6I10)
      WRITE(N6,45) INDOP(I1),INDOP(I2),INDOP(I3),INDOP(I4),INDOP(I5),IND
     2OP(I6)
45    FORMAT (*0*,9(/*0*),46X,*ANALYSIS OPTION CONTROL INFORMATION*/* *,
     246X,35(*=*)///* *,10X,*ANNUAL SERIES*,6X,*PARTIAL DURATION*,6X,*SE
     3ASONAL SERIES*,6X,*RAINSTORM*,8X,*DRY PERIOD*,6X,*SKEW ANALYSIS*/*
     4 *,12X,*ANALYSIS*,9X,*SERIES ANALYSIS*,10X,*ANALYSIS*,8X,*EVENT AN
     5ALYSIS*,6X,*ANALYSIS*,10X,*CONTROL*/* *,10X,*CONTROL OPTION*,6X,*C
     6ONTROL OPTION*,7X,*CONTROL OPTION*,5X,*CONTROL OPTION*,3X,*CONTROL
     7 OPTION*,7X,*OPTION*/* *,13X,*(NSER)*,14X,*(IPARTO)*, 13X,*(INDSEA
     8)*,11X,*(NEVNT)*,10X,*(IDRYOP)*,9X,*(ISKEWO)* ///* *,14X,1A4,16X,1
     9A4,18X,1A4,14X,1A4,13X,1A4,14X,1A4////)
      IF(INDSEA.EQ.0) GO TO 401
      WRITE(N6,2999)
C
C********  IF SEASONAL ANALYSIS IS SELECTED, READ SEASONAL INFORMATION
C
      READ(N5,55) NOSEAS,(MOSEAS(IM),MDAYBG(IM),IM=1,NOSEAS)
55    FORMAT(25I3)
      READ(N5,407) (MOSEND(IM), MDAYEN(IM),IM=1,NOSEAS)
407   FORMAT(24I3)
      WRITE(N6,60) NOSEAS
60    FORMAT(///////* *,45X,*SEASONAL ANLYSIS CONTROL INFORMATION */* *,
     245X,37(*=*)////* *,43X,*NO. OF SEASONS BEING ANALYZED (NOSEAS)=*,I
     33//////////)
      WRITE(N6,95)
95    FORMAT(* *,53X,*SEASONAL ORGANIZATION*/* *,53X,21(*=*)/)
      DO 120 J1=1,NOSEAS
120   WRITE(N6,125) J1,MOSEAS(J1),MDAYBG(J1),MOSEND(J1), MDAYEN(J1)
125   FORMAT(*0*,30X,*SEASON*,I3,* BEGINS IN MONTH*,I3,* ON DAY*,I3,* AN
     2D ENDS IN MONTH*,I3,* ON DAY*,I3)
      IF(NOSEAS.GT.12) WRITE(N6,700)
700   FORMAT(* *,13H*** ERROR ***,* THE NO. OF SEASONS SELECTED FOR ANAL
     2YSIS EXCEEDS THE PROGRAMS CAPACITY-THE MAXIMUM NO. OF SEASONS IS 1
     32-THE RUN IS ABORTED*)
      IF(NOSEAS.GT.12) STOP
      LG=0
      DO 701 LK=2,NOSEAS
701   IF(MOSEAS(LK).LT.MOSEAS(LK-1)) LG=1
      IF(LG.EQ.1) WRITE(N6,702)
702   FORMAT(* *,13H*** ERROR ***,* THE SEASONS ARE NOT IN CHRONOLOGICAL
     2 ORDER-THE RUN IS ABORTED*)
      IF(LG.EQ.1) STOP
C
C********  EXECUTE THE ANALYSIS OPTIONS REQUESTED
C
  401 IF(NSER.GT.0) CALL SERIES
      IF(NEVNT.GT.0) CALL EVENT
      IF( ISKEWO.GT.0) CALL  STRMSK
      RETURN
      END
```

The flow chart for RAINT is given in Figure IV-8 and is followed by Table IV-8 showing key variables not in COMMON and by a program listing. All program variable held in COMMON are defined in a later section of this chapter.

Subroutine SERIES

- Called From
  ANALYZ
- Common Blocks Used
  /CNTRL/
  /SERIES/
- Subroutine Called
  RANK

Subroutine SERIES performs a maximum storm analysis. Specifically, SERIES reads a card that specifies the durations (in hours) that the user wants analyzed.[1] It then searches the RAINT prepared rainfall tape, finds the maximum total rainfall for the specified durations in each year, and calls subroutine RANK. When control returns to SERIES, if a seasonal analysis is requested, SERIES rewinds the RAINT tape. It then searches the tape again, but finds the maximum total rainfalls in each season and calls RANK. In both the yearly and seasonal analyses, if a year of data is not complete, the year is deleted from the analysis.

The flow chart for SERIES is given in Figure IV-9 and is followed by a program listing. All program variables in COMMON are defined in a later section of this chapter.

[1]The user must always specify at least the one-hour duration.

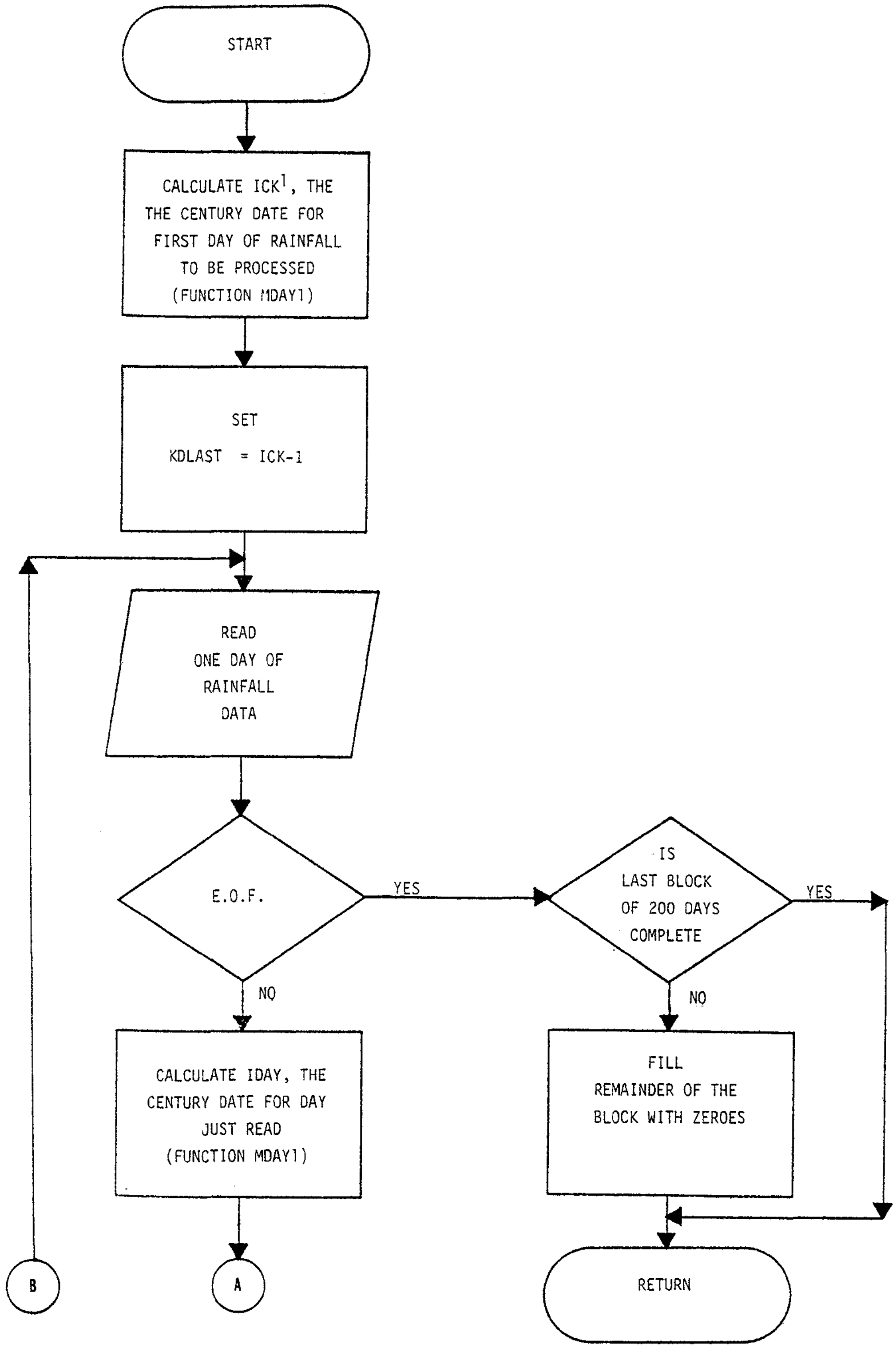

FIGURE IV-8

FLOW CHART FOR SUBROUTINE RAINT

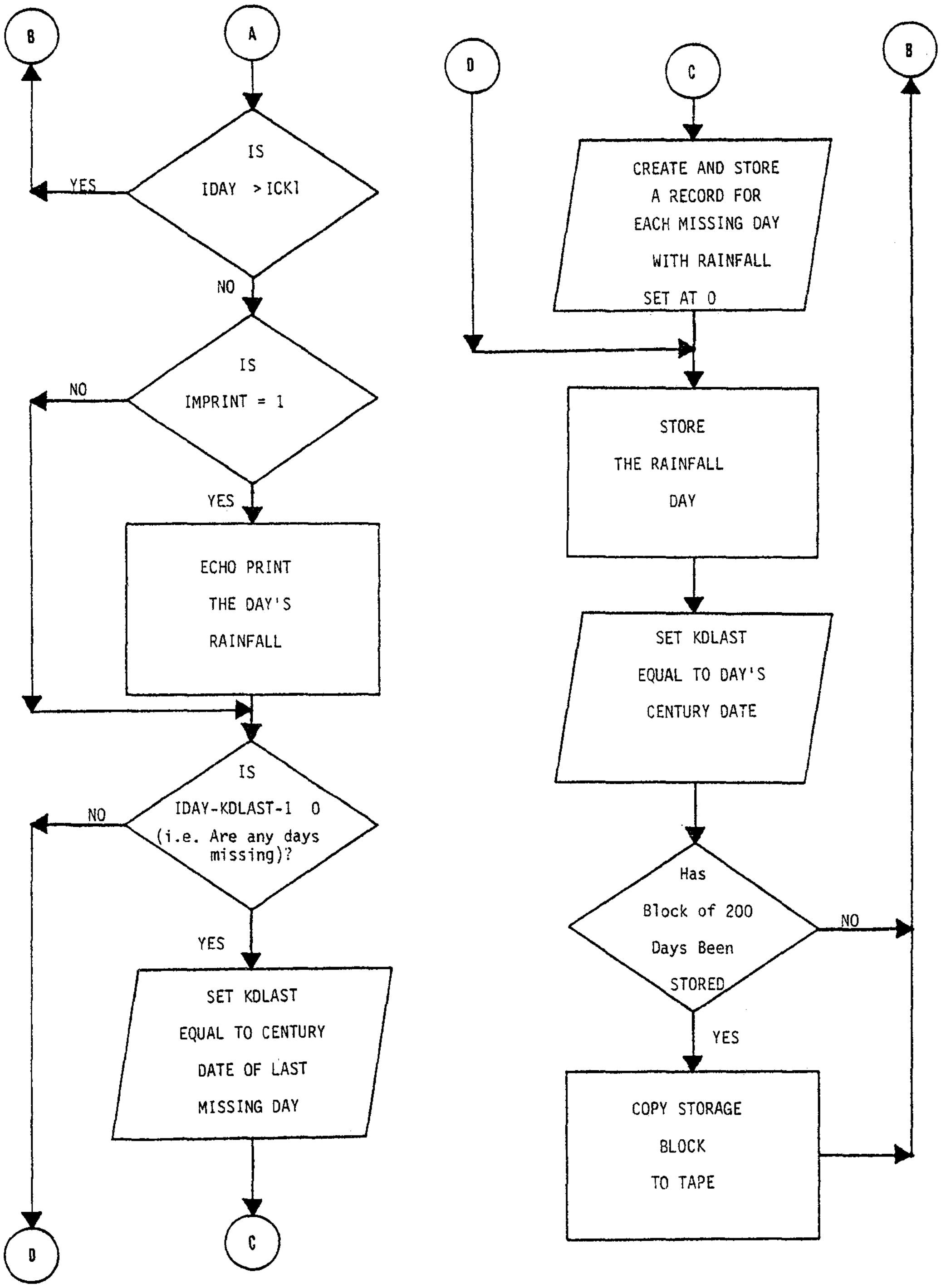

FIGURE IV-8

(continued)

TABLE IV-8

KEY VARIABLES NOT IN COMMON

AND IN SUBROUTINE RAINT

VARIABLE NAME	DESCRIPTION	UNITS
MONAT(12)	Defines number of days in each month	Days
KDAY(200)	Day of the month array	None
KYEAR(200)	Year Array	None
KMO(200)	Month Array	None
KDY(200)	Century Date Array	None
RAIN(200, 24)	Hourly Rainfall Array	In./100
RAIN(24)	Hourly Rainfall Array	In./100
TTL	Total Rainfall for 1 day	In./100
IMO	Month	None
IYR	Year	None
IDY	Day	None

```
      SUBROUTINE RAINT
C
C
C     ******************************************************************
C     *                                                                *
C     *   THIS SUBROUTINE PROCESSES EITHER A CARD IMAGE RAIN TAPE      *
C     *   OR RAINFALL DATA CARDS AND PROCESSES THEM INTO A BINARY      *
C     *   RAIN TAPE--WHEN IT PROCESSES THE RAINFALL DATA, IT INSERTS   *
C     *   ANY MISSING DAYS AND FILLS IN THE RAINFALL WITH ZEROES       *
C     *                                                                *
C     ******************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      INTEGER RAIN,RAIN1,TTL
      DIMENSION RAIN1(24)
      DIMENSION MONAT(12),KDAY(200),KYR(200),KMO(200),KDY(200),
     1RAIN(200,24)
C
C********  INITIALIZATION
C
      DO 300 I=1,12
 300  MONAT(I)=31
      MONAT(4)=30
      MONAT(6)=30
      MONAT(9)=30
      MONAT(11)=30
      MONAT(2)=28
      DO 310 I=1,200
      KDAY(I)=0
      KYR(I)=0
      KMO(I)=0
      KDY(I)=0
      DO 310 J=1,24
 310  RAIN(I,J)=0
C
C********  CALCULATE THE CENTURY DAY FOR THE FIRST DAY OF THE RAINFALL
C********  TO BE  ANALYZD
C
      ICK1=MDAY1(ISTART(1),ISTART(2),ISTART(3))
      KDLAST=ICK1-1
      KP=0
      NLINE=0
C
C********  READ THE CARD IMAGE RAINFALL FROM A TAPE OR CARDS
C
  100 IF(IN-5) 102,105,102
 102  READ(IN,810)IYR,IMO,IDY,(RAIN1(J),J=1,12)
 810  FORMAT(6X,3I2,1X,12I3)
      IF(EOF(IN)) 400,815
815   READ(IN,820) (RAIN1(J),J=13,24)
 820  FORMAT(13X,12I3)
      IF(EOF(IN)) 400,110
  105 READ(N5,830) ACHECK,IYR,IMO,IDY,(RAIN1(J),J=1,24)
  830 FORMAT(A2,3I2,24I3)
  110 IF(IYR) 400,400,120
```

```
C
C********  CALCULATE THE CENTURY DAY FOR THE DAY JUST READ
C
  120 IDAY=MDAY1(IYR,IMO,IDY)
C
C********  CONTINUE TO READ UNTIL THE FIRST DAY TO BE  ANALYZD IS
C********  REACHED
C

      IF(IDAY-ICK1) 100,130,130
  130 KP=KP+1
C
C********  IF IPRINT EQUALS ONE, ECHO PRINT THE RAINFALL DATA
C
      IF(IPRINT) 138,138,136
  136 KY=IYR+1900
      TTL=0
      DO 137 J=1,24
  137 TTL=TTL+RAIN1(J)
      NLINE=NLINE+1
      IF(MOD(NLINE,45)-1) 133,132,133
132   WRITE(N6,2999)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
      WRITE(N6,900) (L,L=1,24)
900   FORMAT(///* *,44X,*HOURLY RAINFALL IN HUNDREDTHS OF AN INCH*/* *,4
     24X,40(*=*)///* *,6X,*YEAR MO DAY*,2X,24I4,* TOTAL*/)
133   WRITE(N6,910) KY,IMO,IDY,(RAIN1(J),J=1,24),TTL
910   FORMAT(* *,5X,I5,I3,I4,2X,24I4,I6)
C
C********  CHECK TO SEE IF ANY DAYS ARE MISSING
C
  138 IBLANK=IDAY-KDLAST-1

      IF(IBLANK) 1000,240,140
C
C********  FILL IN RECORDS FOR THE MISSING DAYS
C
  140 K=MOD(KP-2,200)+1
      DO 200 I=1,IBLANK
      KI=MOD(K+I-1,200)+1
      KDAY(KI)=KDAY(K)+I
      KDY(KI)=KDY(K)+I
      KMO(KI)=KMO(K)
      KYR(KI)=KYR(K)
      DO 145 J=1,24
  145 RAIN(KI,J)=0.
      NMO=KMO(KI)
```

```
147    LLL=MONAT(NMO)
       IF((KYR(KI)/4*4).EQ.KYR(KI).AND.NMO.EQ.2) LLL=29
       IF(KDY(KI)-LLL)183,183,150
150    KDY(KI)=KDY(KI)-LLL
       KMO(KI)=KMO(KI)+1
  160 IF (KMO(KI)-12) 180,180,170
  170 KMO(KI)=1
      KYR(KI)=KYR(KI)+1
  180 NMO=MOD(NMO,12)+1
      GO TO 147
  183 IF (KI-200) 200,210,210
  200 CONTINUE
      GO TO 240
 210  DO 420 I1=1,200
      WRITE(IT)KDAY(I1),KYR(I1),KMO(I1),KDY(I1),(RAIN(I1,I2),I2=1,24)
 420  CONTINUE
      KDLAST=KDAY(200)
      KP=KP+I
      GO TO 138
C
C********  STORE THE RECORD FOR THE NEW RAIN DAY
C
  240 KP=KP+IBLANK
      K=MOD(KP-1,200)+1
      KDAY(K)=IDAY
      KYR(K)=IYR
      KMO(K)=IMO
      KDY(K)=IDY
      DO 250 J=1,24
 250  RAIN(K,J)=IABS(RAIN1(J))
      KDLAST=IDAY
C
C********  WRITE A BLOCK OF DATA FOR 200 DAYS ON THE STORAGE TAPE
C
      IF(K-200) 270,260,260
 260  DO 430 I1=1,200
      WRITE(IT)KDAY(I1),KYR(I1),KMO(I1),KDY(I1),(RAIN(I1,I2),I2=1,24)
 430  CONTINUE
C
C********  CONTINUE TO CYCLE THROUGH THE RAINFALL RECORD
C
  270 GO TO 100
C
C********  IF THE LAST BLOCK OF 200 DAYS IS NOT COMPLETE, FILL IN
C********  THE REMAINDER OF THE BLOCK WITH ZEROES
C
  400 KS=K+1
      DO 410 K=KS,200
      KDAY(K)=0.
      KYR(K)=0.
      KMO(K)=0.
      KDY(K)=0.
```

```
      DO 410 J=1,24
  410 RAIN(K,J)=0.
      DO 440 I1=1,200
      WRITE(IT)KDAY(I1),KYR(I1),KMO(I1),KDY(I1),(RAIN(I1,I2),I2=1,24)
 440  CONTINUE
      IN=IT
      GO TO 1001
1000  WRITE(N6,1002)
1002  FORMAT(* *,13H*** ERROR ***,* THE RAINFALL DATA IN THE INPUT FILE
     2IS NOT IN CHRONOLOGICAL ORDER-THE RUN IS ABORTED*)
      STOP
1001  REWIND IN
      RETURN
      END
```

```
      FUNCTION MDAY1(KYR,KMOX,KDY)
C
C
C     ****************************************************************
C     *                                                              *
C     *    THIS FUNCTION CALCULATES THE CENTURY DAY FOR ANY          *
C     *                     CALENDAR DATE                            *
C     *                                                              *
C     ****************************************************************
C
C
      MDAY1=0
      KMO=KMOX
      LEAP=0
C
C********  DETERMINE IF YEAR IS FULL CALENDAR YEAR (IE. 1975) OR IF
C********  YEAR IS ONLY TWO DIGITS (IE. 1975=75)
C
      IF (KYR .LT. 100) GO TO 2600
C
C********  IF YEAR IS FULL CALENDAR YEAR ADJUST IT TO TWO DIGITS
      KYR=MOD(KYR,100)
 2600 CONTINUE
C
C********  DETERMINE IF YEAR IS A LEAP YEAR
C
      IF (MOD(KYR,4) .EQ. 0) LEAP=1
C
C********  DETERMINE WHAT DAY OF THE YEAR THE DATE IS (IE.1-366)
C
      MDAY=KDY
      DO 2640 I=1,12
      IF (KMO .EQ. 1) GO TO 2650
      KMO=KMO-1
      MO=31
      IF (KMO .EQ. 2) GO TO 2620
      IF (KMO .EQ. 4) MO=30
      IF (KMO .EQ. 6) MO=30
      IF (KMO .EQ. 9) MO=30
      IF (KMO .EQ. 11) MO=30
      GO TO 2630
 2620 CONTINUE
      MO=28+LEAP
 2630 CONTINUE
      MDAY=MDAY+MO
 2640 CONTINUE
 2650 CONTINUE
```

```
C
C********  DETERMINE HOW MANY CENTURY DAYS PRECEED THE YEAR IN QUESTION
C
      IF (KYR .EQ. 0) GO TO 2660
      NYR=(KYR*365)+((KYR-1)/4)+1
C
C********  DETERMINE THE CENTURY DAY FOR THE DATE
C
      MDAY=MDAY+NYR
2660  MDAY1=MDAY
      RETURN
      END
```

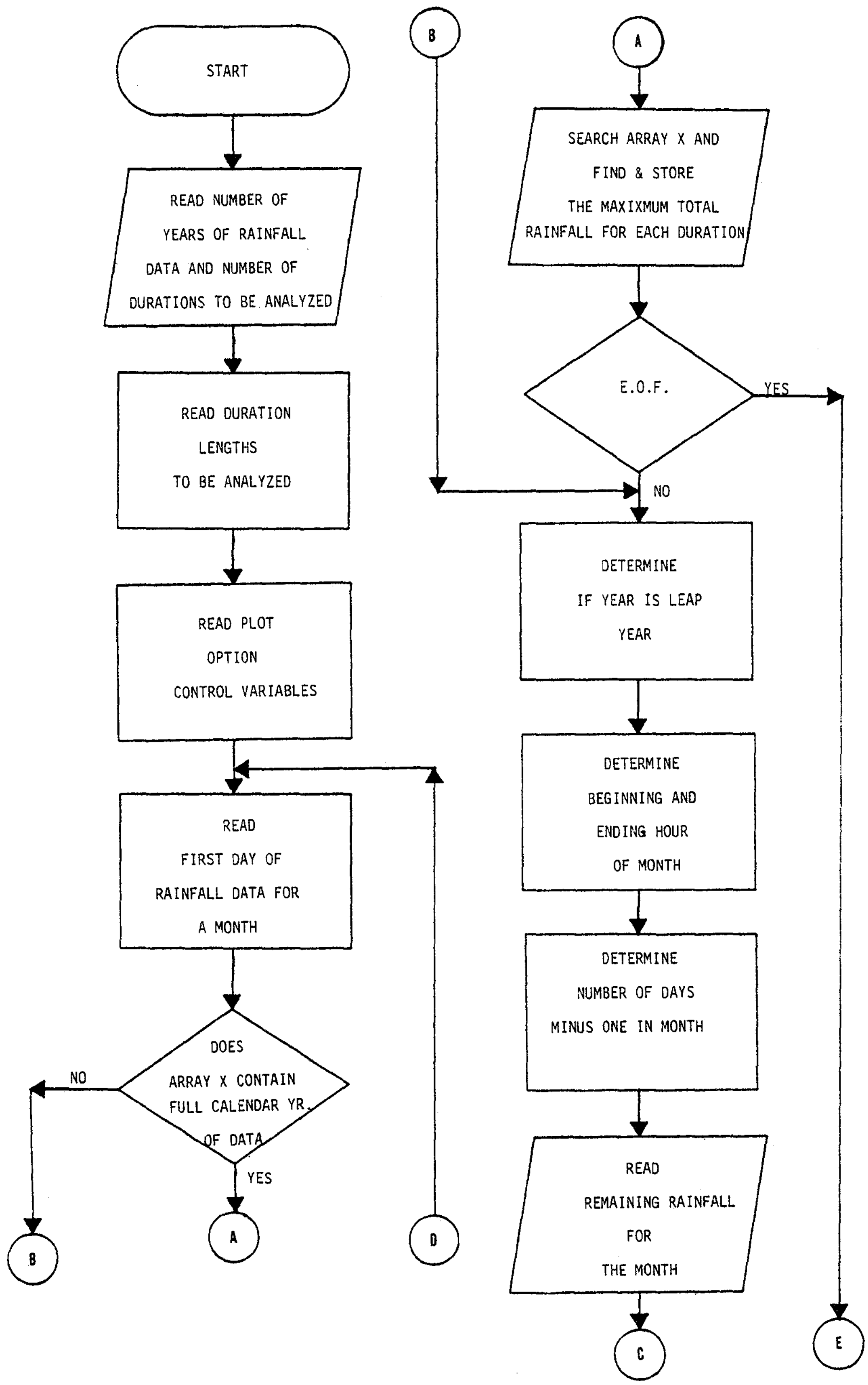

FIGURE IV-9

FLOW CHART FOR SUBROUTINE SERIES

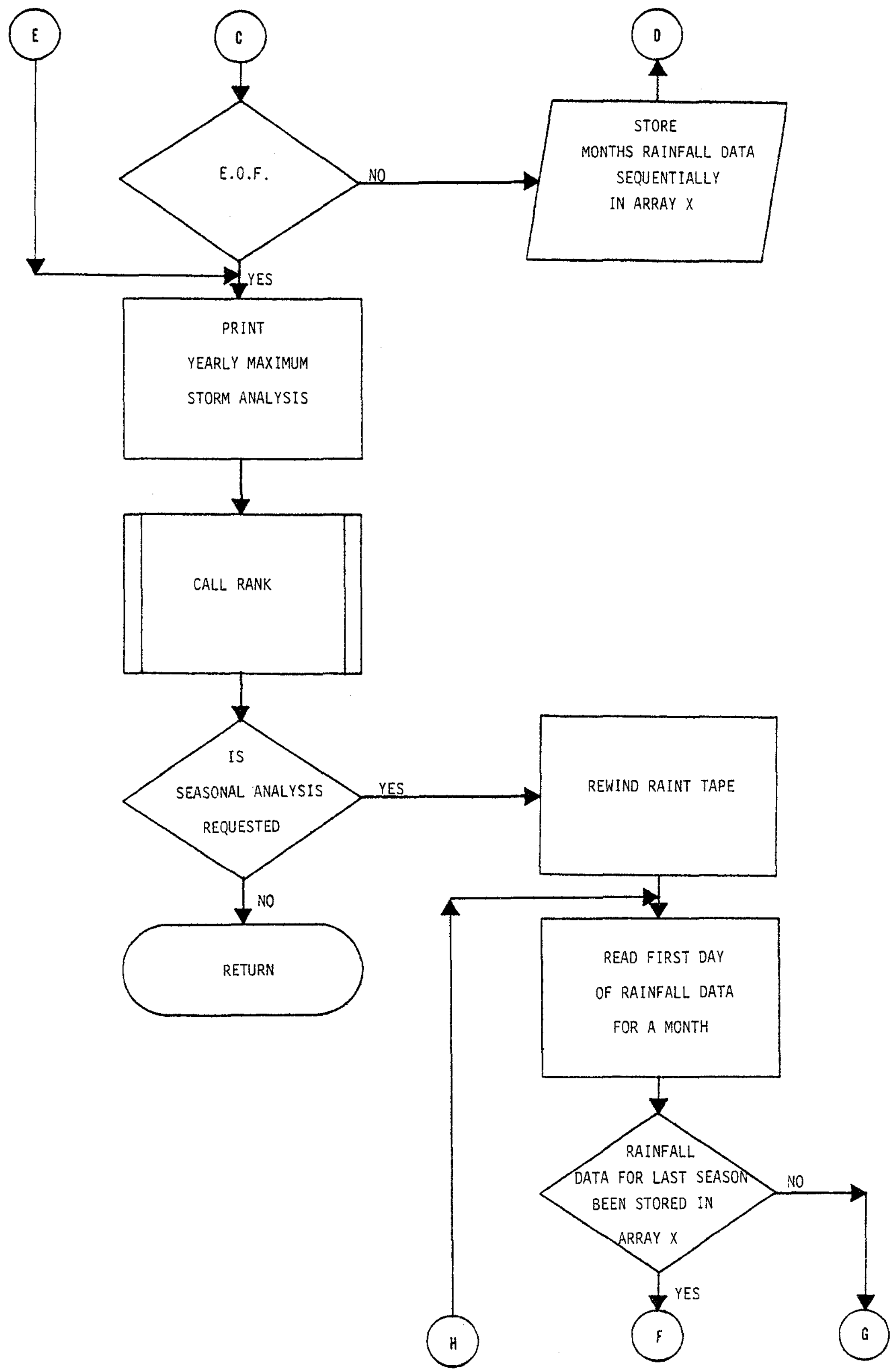

FIGURE IV-9

(continued)

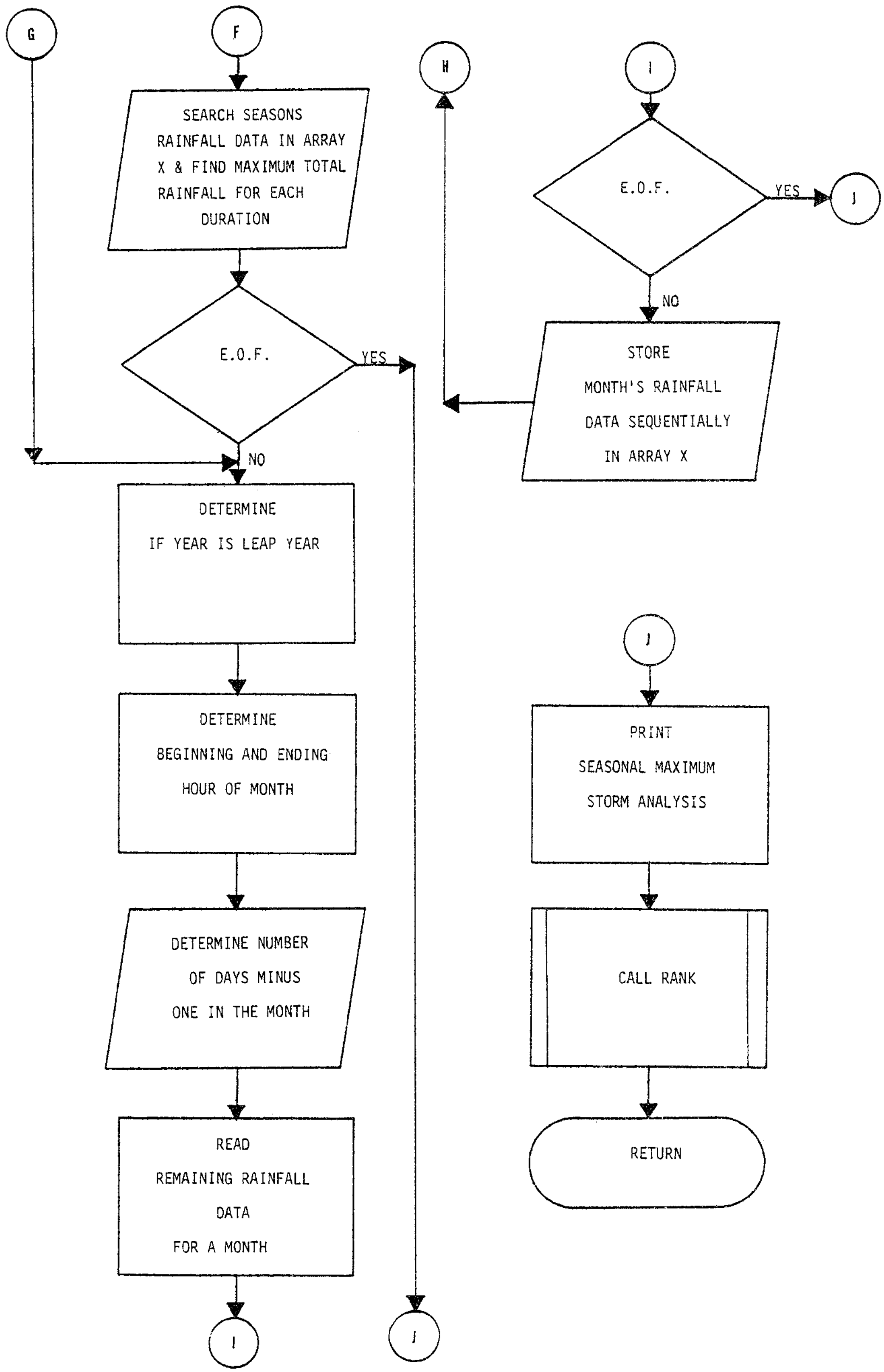

FIGURE IV-9

(continued)

```
      SUBROUTINE SERIES
C
C
C     *****************************************************************
C     *                                                               *
C     *  THIS SUBROUTINE PROCESSES RAINFALL DATA FROM RAINT AND SE-  *
C     *  LECTS THE MAXIMUM YEARLY OR SEASONAL STORMS FOR SPECIFIED    *
C     *  DURATIONS                                                    *
C     *                                                               *
C     *****************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON /SEREES/ NYR,NDUR,DURTN(14),Y(744),MBG(12),MND(12),
     2MAXI(50,14),IDTI(50,10), MAXSEA(12,50,14),IDED(12,50,10),X(8784),
     3NOYRR,INDSEA,NOSEAS,INTYR,MOSEAS(12),MDAYBG(12),MOSEND(12),
     4 MDAYEN(12), IPARTO,M3
      INTEGER X,TOT,Y,DURTN
      DATA MBG/1,745,1417,2161,2881,3625,4345,5089,5833,6553,7297,8017/
      DATA MND/744,1416,2160,2880,3624,4344,5088,5832,6552,7296,8016,876
     10/
C
C********  INITIALIZE VARIABLES
C
      JKL=0
       MAXSEA(1,1,1)=99999
      MOB=11
      NSTN=5
      DO 15 J1=1,8784
   15 X(J1)=999
      WRITE(N6,2999)
C
C********  READ NO. OF YEARS OF RAINFALL DATA AND NO. OF DURATIONS TO
C******** BE  ANALYZED
C
      READ(N5,70) NYR,NDUR
70    FORMAT(2I8)
      NOYRR=NYR
      NYRCK=NYR
      NOYRRC=NOYRR
      WRITE(N6,2005)
2005  FORMAT(//////////////* *,46X,*SERIES ANALYSIS CONTROL INFORMATION*/
     2* *,46X,35(*=*))
      WRITE(N6,75) NYR,NDUR
75    FORMAT(////              * *,45X,*NO. OF YEARS OF*,6X,*NO. OF DURATI
     2ONS*/* *,48X,*RAIN DATA*,10X,*BEING  ANALYZED*/* *,50X,*(NYR)*,16X
     3,*(NDUR)*///* *,51X,I2,20X,I2///)
      IF(NYR.GT.50) WRITE(N6,705)
705   FORMAT(* *,13H*** ERROR ***,* THE NO. OF YEARS OF DATA SELECTED FO
     2R ANALYSIS EXCEEDS THE PROGRAMS CAPACITY*/* *,14X,*-THE MAXIMUM NO
     3. OF YEARS POSSIBLE IS 50-THE RUN IS ABORTED*)
      IF(NYR.GT.50) STOP
      IF(NDUR.GT.10) WRITE(N6,706)
706   FORMAT(* *,13H*** ERROR ***,* THE NO. OF DURATIONS SELECTED FOR AN
     2ALYSIS EXCEEDS THE PROGRAMS CAPACITY*/* *,14X,*-THE MAXIMUM NO. OF
     3 DURATIONS POSSIBLE IS 10-THE RUN IS ABORTED*)
```

```
      IF(NDUR.GT.10) STOP
C
C********  READ DURATION LENGTHS TO BE  ANALYZED
C
      READ(N5,65) (DURTN(J),J=1,NDUR)
65    FORMAT(10I8)
      WRITE(N6,80)
80    FORMAT(* *,56X,*DURATION LENGTHS*/* *,57X,*BEING ANALYZED*/* *,60X
     2,*(DURTN)*//)
      DO 85 I=1,NDUR
85    WRITE(N6,91) DURTN(I)
91    FORMAT(* *,61X,I2,* HR.*)
      INTYR=ISTART(1)
C
C********  READ FREQUENCY CURVE AND INTENSITY DURATION FREQUENCY CURVE
C********  PLOT OPTION CONTROL VARIABLES
C
      READ(N5,2000)  IFRQPL, IDFCPL
2000  FORMAT(2I8)
C
C
C********  YEARLY PORTION OF PROGRAM
C
C
      DO 20 J1=1,NYR
      DO 20 K=1,NDUR
      MAXI(J1,K)=-999
20    IDTI(J1,K)=-999
      LEAP=24
      JYR=INTYR
      LDEC=0
C
C********  INPUT THE RAINFALL DATA
C********  READ FIRST RECORD FOR A MONTH
C
   90 READ(IT)A,IYR,MO,ID,(Y(I),I=1,24)
      IF(EOF(IT)) 1801,1802
1801  IF(MOB.NE.12) GO TO 1887
      JKL=1
      GO TO 120
1802  IF(MO.NE.1.AND.NSTN.EQ.5) GO TO 87
      IF(ID.NE.1.AND.NSTN.EQ.5) GO TO 87
      GO TO 88
87    IF(LDEC.EQ.1) GO TO 90
      LDEC=1
      INTYR=INTYR+1
      NYR=NYR-1
      GO TO 90
C
C********  IF END OF DATA, PRINT RESULTS OR PROCESS LAST YEARS DATA AND
C********  PRINT RESULTS
C
88    IF(IYR.EQ.0.AND.MOB.NE.12) GO TO 325
      IF(IYR.EQ.0) GO TO 120
      IF(NSTN.NE.0) GO TO 100
C
C********  IF END OF ONE YEARS DATA, PROCESS IT
```

```
C
      IF(IYR.NE.JYR) GO TO 120
      GO TO 110
C
C********  DETERMINE IF LEAP YEAR
C
  100 JYR=IYR
      MOB=MO
      IF((IYR/4*4).NE.IYR) GO TO 105
      NHR=8784
      LEAP=24
      GO TO 110
  105 NHR=8760
      LEAP=0
C
C********  DETERMINE BEGINNING HOUR AND ENDING HOUR FOR THE MONTH -
C********  HOUR 1 IS THE FIRST HOUR OF JANUARY
C
  110 NBG=MBG(MO)+LEAP
      NND=MND(MO)+LEAP
      MOB=MO
      IF(MO.EQ.1) NBG=MBG(MO)
      IF(MO.EQ.1) NND=MND(MO)
      IF(MO.EQ.2) NBG=MBG(MO)
      IF(MO.EQ.1) NHRM=744
      IF(MO.EQ.1) GO TO 95
C
C********  DETERMINE NUMBER OF DAYS MINUS ONE IN THE MONTH
C
      NHRM=MND(MO)-MND(MO-1)
      IF(MO.EQ.2) NHRM=NHRM+LEAP
  95  NHRM1=NHRM/24-1
      DO 650  II=1,NHRM1
      I3=II*24+1
      I4=I3+23
C
C********  READ THE REMAINING RAINFALL DATA FOR A MONTH
C
      READ(IT)A,IRY1,MO1,ID1,(Y(I),I=I3,I4)
      IF(EOF(IT)) 1887,1886
1886  IF(IRY1.EQ.0) GO TO 326
 650  CONTINUE
      LL=1
C
C********  STORE THE MONTHS RAINFALL DATA SEQUENTIALLY IN ARRAY X
C********  X(1) IS THE FIRST HOUR OF THE FIRST DAY OF THE YEAR
C
      DO 115 JQ=NBG,NND
      X(JQ)=Y(LL)
  115 LL=LL+1
      NSTN=0
      GO TO 90
C
C********  PROCESS ONE YEARS DATA
C
120   CONTINUE
C
```

```
C********  J IS AN INDICATOR OF THE YEAR UNDER CONSIDERATION
      J=JYR-INTYR+1
C
C********  SELECT MAXIMUM YEARLY STORM
C
      DO 190 I=1,NDUR
      II=DURTN(I)-1
      MHR=NHR-II
      DO 185 K=1,MHR
      IF(K.EQ.MHR) GO TO 845
      IF(X(K).EQ.0) GO TO 185
  845 TOT=X(K)
C
C********  ADJUST CLOCK HOUR RAINFALL TO 60 MINUTE RAINFALL FOR 1 HR.
C********  DURATIONS
      IF(DURTN(I).EQ.1) TOT=TOT*1.13
      IF(DURTN(I).EQ.1) GO TO 180
      DO 175 L=1,II
  175 TOT=TOT+X(K+L)
  180 IF(TOT.LT.MAXI(J,I)) GO TO 185
      MAXI(J,I)=TOT
      IDTI(J,I)=K
185   CONTINUE
190   CONTINUE
C
C********  IF ALL THE DATA HAS BEEN PROCESSED PRINT OUT RESULTS
C
      IF(IYR.EQ.0) GO TO 325
      IF(JKL.EQ.1) GO TO 325
      GO TO 100
C
C
C********  SEASONAL PORTION OF PROGRAM
C
C
999   REWIND IT
C
C********  INITIALIZE VARIABLES
C
      INTYR=ISTART(1)
      DO 900 I=1,NOSEAS
      DO 901 J=1,NOYRR
      DO 902 M=1,NDUR
       MAXSEA(I,J,M)=-999
      IDED(I,J,M)=-999
902   CONTINUE
901   CONTINUE
900   CONTINUE
      NSTNN=0
      NSTN=1
      MOBB=MOSEND(NOSEAS)
C
C********  INPUT RAINFALL DATA
C********  READ FIRST RECORD FOR A MONTH
C
      DO 903 J=1,NOYRR
      DO 904 I=1,NOSEAS
```

```
      IF(NSTNN.EQ.1) GO TO 806
905   READ(IT) A,IYR,MO,ID,(Y(II),II=1,24)
      IF(EOF(IT)) 1803,1804
1803  IF(I.LT.NOSEAS) GO TO 1999
      IF(MOBB.NE.MOSEND(NOSEAS)) GO TO 1999
      GO TO 327
1804  IF(MO.NE.MOSEAS(1).AND.NSTN.NE.0) GO TO 905
      IF(ID.NE.1.AND.NSTN.NE.0) GO TO 905
      IF(IYR.GT.INTYR.AND.NSTN.NE.0) NOYRR=NOYRR-(IYR-INTYR)
      IF(IYR.GT.INTYR.AND.NSTN.NE.0) INTYR=IYR
      IF(IYR.EQ.0.AND.I.LT.NOSEAS) GO TO 1999
      IF(IYR.EQ.0.AND.MOBB.NE.MOSEND(NOSEAS)) GO TO 1999
      IF(IYR.EQ.0) GO TO 327
      NSTN=0
C
C********  IF END OF ONE SEASONS DATA, PROCESS IT
C
      IF(MO.EQ.(MOSEND(I)+1)) GO TO 327
      IF(MO.EQ.1.AND.(MOSEND(I)+1).EQ.13) GO TO 327
C
C********  DETERMINE IF IYR IS LEAP YEAR
C
806   IF((IYR/4*4).NE.IYR) GO TO 805
      MOBB=MO
      NHRR=8784
      LEAP=24
      GO TO 800
805   NHRR=8760
      LEAP=0
      MOBB=MO
C
C********  DETERMINE BEGINNING AND ENDING HOUR OF THE MONTH
C
800   NBG=MBG(MO)+LEAP
      NND=MND(MO)+LEAP
      IF(MO.EQ.1) NBG=MBG(MO)
      IF(MO.EQ.1) NND=MND(MO)
      IF(MO.EQ.2) NBG=MBG(MO)
      IF(MO.EQ.1) NHRMM=744
      IF(MO.EQ.1) GO TO 811
C
C********  DETERMINE NUMBER OF DAYS MINUS 1 IN THE MONTH
C
      NHRMM=MND(MO)-MND(MO-1)
      IF(MO.EQ.2) NHRMM=NHRMM+LEAP
811   NHRMM1=NHRMM/24-1
      DO 812 II=1,NHRMM1
      I3=II*24+1
      I4=I3+23
C
C********  READ THE REMAINING RAINFALL DATA FOR A MONTH
C
      READ(IT) A,IRY1,MO1,ID1,(Y(IIM),IIM=I3,I4)
      IF(EOF(IT)) 1805,1806
1805  IF(I.LT.NOSEAS) GO TO 1999
      IF(I4.LE.( MDAYEN(NOSEAS)*24)) GO TO 1999
      GO TO 1888
```

```
1806  IF(IRY1.EQ.0.AND.I.LT.NOSEAS) GO TO 1999
      IF(IRY1.EQ.0.AND.I4.LE.( MDAYEN(NOSEAS)*24)) GO TO 1999
812•  CONTINUE
1888  JYRR=IRY1
      LL=1
C
C********  STORE THE MONTHS RAINFALL DATA SEQUENTIALLY IN ARRAY X
C********  X(1) IS THE FIRST HOUR OF THE FIRST DAY OF THE YEAR
C
      DO 813  JQ=NBG,NND
      X(JQ)=Y(LL)
813   LL=LL+1
      GO TO 905
C
C********  SELECT MAXIMUM SEASONAL STORM FOR INDEPENDENT DURATIONS
C
327   KK=MBG(MOSEAS(I))+((MDAYBG(I)-1)*24)+LEAP
      IF(MOSEAS(I).LE.2)KK=MBG(MOSEAS(I))+((MDAYBG(I)-1)*24)
      IF(MOSEND(I).EQ.1) GO TO 1003
      LL=MND(MOSEND(I)-1)+( MDAYEN(I)*24)+LEAP
      IF(MOSEND(I).EQ.2)  LL=MND(MOSEND(1))+( MDAYEN(I)*24)
      GO TO 1004
1003  LL= MDAYEN(I)*24
C
C********  DETERMINE IF SEASON OVERLAPS CALENDAR YEARS
1004  IF(MOSEND(I).LT.MOSEAS(I)) GO TO 1020
      DO 1005 M=1,NDUR
      III=DURTN(M)-1
      MMHR=LL-III
      DO 1006 N=KK,MMHR
      IF(N.EQ.MMHR) GO TO 1007
      IF(X(N).EQ.0) GO TO 1006
1007  TOT=X(N)
C
C********  ADJUST CLOCK HOUR RAINFALL TO 60 MINUTE RAINFALL FOR 1 HR.
C********  DURATIONS
      IF(DURTN(M).EQ.1) TOT=TOT*1.13
      IF(DURTN(M).EQ.1) GO TO 1009
      DO 1010 JJ=1,III
1010  TOT=TOT+X(N+JJ)
1009  IF(TOT.LT. MAXSEA(I,J,M)) GO TO 1006
       MAXSEA(I,J,M)=TOT
      IDED(I,J,M)=N
1006  CONTINUE
1005  CONTINUE
      NSTNN=1
      GO TO 904
C
C********  SELECT MAXIMUM STORM FOR INDEPENDENT DURATIONS FOR A SEASON
C********  THAT OVERLAPS CALENDAR YEARS
C
1020  DO 1021 M=1,NDUR
      LEAPYR=JYRR-1
      LEEP=0
      NHRR=8760
      IF((LEAPYR/4*4).EQ.LEAPYR) GO TO 81
      GO TO 82
```

```
81    NHRR=8784
      LEEP=24
82    KK=MBG(MOSEAS(I))+((MDAYBG(I)-1)*24)+LEEP
      IF(MOSEAS(I).LE.2) KK=MBG(MOSEAS(I))+((MDAYBG(I)-1)*24)
      III=DURTN(M)-1
      MMHR=NHRR-III
      DO 1022 N=KK,MMHR
      IF(N.EQ.MMHR) GO TO 1023
      IF(X(N).EQ.0) GO TO 1022
1023  TOT=X(N)
C
C********  ADJUST CLOCK HOUR RAINFALL TO 60 MINUTE RAINFALL FOR 1 HR.
C********  DURATIONS
      IF(DURTN(M).EQ.1) TOT=TOT*1.13
      IF(DURTN(M).EQ.1) GO TO 1025
      DO 1026  JJ=1,III
1026  TOT=TOT+X(N+JJ)
1025  IF(TOT.LT. MAXSEA(I,J,M)) GO TO 1022
       MAXSEA(I,J,M)=TOT
      IDED(I,J,M)=N
1022  CONTINUE
      IF(DURTN(M).EQ.1) GO TO 1034
      KM=1
      MMHR=MMHR+1
      DO 1030 N=MMHR,NHRR
      III=III-1
      IF(N.EQ.NHRR) GO TO 1031
      IF(X(N).EQ.0) GO TO 1030
1031  TOT=X(N)
      IF(III.EQ.0) GO TO 1035
      DO 1033 JJ=1,III
1033  TOT=TOT+X(N+JJ)
1035  DO 1039 JJ=1,KM
1039  TOT=TOT+X(JJ)
      IF(TOT.LT. MAXSEA(I,J,M)) GO TO 1030
       MAXSEA(I,J,M)=TOT
      IDED(I,J,M)=N
1030  KM=KM+1
1034  III=DURTN(M)-1
      MMHR=LL-III
      DO 1040 N=1,MMHR
      IF(N.EQ.MMHR) GO TO 1041
      IF(X(N).EQ.0) GO TO 1040
1041  TOT=X(N)
C
C********  ADJUST CLOCK HOUR RAINFALL TO 60 MINUTE RAINFALL FOR 1 HR.
C********  DURATIONS
      IF(DURTN(M).EQ.1) TOT=TOT*1.13
      IF(DURTN(M).EQ.1) GO TO 1042
      DO 1043  JJ=1,III
1043  TOT=TOT+X(N+JJ)
1042  IF(TOT.LT. MAXSEA(I,J,M)) GO TO 1040
       MAXSEA(I,J,M)=TOT
      IDED(I,J,M)=N
1040  CONTINUE
1021  CONTINUE
      NSTNN=1
```

```
904   CONTINUE
903   CONTINUE
      GO TO 328
C
C********  PRINT OUT YEARLY ANALYSIS
C
1887  NYR=NYR-1
326   MOB=0
325   IF(IYR.EQ.0.AND.MOB.NE.12) NYR=NYR-1
      IF(IRY1.EQ.0.AND.MOB.NE.12) NYR=NYR-1
      WRITE(N6,2999)
      WRITE(N6,700)
700   FORMAT(/////////////////////////////* *,48(*-*),* MAXIMUM STORM ANALY
     2SIS-BY YEAR *,48(*-*))
      WRITE(N6,4000)
4000  FORMAT(///* *,18X,12H*** NOTE ***,* RAINFALL VALUES GIVEN FOR 1 HR
     2. DURATIONS ARE 60 MINUTE NOT CLOCK HR. RAINFALLS*/* *,31X,*(IE. T
     3HE PRINTED VALUE = MAX. CLOCK HR. VALUE FROM INPUT X 1.13)*)
      IF(NYR.NE.NYRCK) WRITE(N6,701) NYRCK,NYR
701   FORMAT(///* *,22X,15H*** WARNING ***,* THE PERIOD OF RECORD ANALYZ
     2ED HAS BEEN REDUCED FROM*,I3,* TO*,I3,* YEARS*/* *,30X,*BECAUSE 1
     3OR MORE YEARS OF THE INPUT RAINFALL DATA WERE NOT COMPLETE*)
      DO 1080 J=1,NYR
      IYEAR=INTYR+J-1+1900
      IYEARR=INTYR+J-1
      LEAP=0
      IF((IYEARR/4*4).EQ.IYEARR) LEAP=24
      IF((J/2*2).NE.J) WRITE(N6,2999)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
      WRITE(N6,1081) IYEAR
1081  FORMAT(///* *,48X,*MAXIMUM STORM ANALYSIS FOR *,I4/* *,48X,31(*=*)
     2/)
      DO 1082 I=1,NDUR
      MKK=IDTI(J,I)
      DO 1084 N=1,12
      KMKK=MND(N)+LEAP
      IF(N.EQ.1)KMKK=MND(N)
      IF(MKK.GT.KMKK) GO TO 1084
      GO TO 1085
1084  CONTINUE
1085  MONTH=N
      IK=MBG(N)+LEAP
      IF(N.LE.2) IK=MBG(N)
      MMDAY=((MKK-IK)/24)+1
      MHOUR=MOD((MKK-IK),24)+1
      IF(IMET.EQ.0) GO TO 1185
      METMAX=MAXI(J,I)*25.4/100.
      WRITE(N6,1181) DURTN(I), METMAX, MONTH, MMDAY,IYEARR,MHOUR
1181  FORMAT(*0*,19X,*THE MAXIMUM*,I3,* HOUR STORM TOTALED*,I5,
     2* MILLIMETERS AND STARTED ON *,I2,*/*,I2,*/*,I2,* AT HOUR*,I3)
      GO TO 1082
1185  WRITE(N6,1086) DURTN(I),MAXI(J,I),MONTH,MMDAY,IYEARR,MHOUR
```

```
1086  FORMAT(*0*,19X,*THE MAXIMUM*,I3,* HOUR STORM TOTALED*,I5,* HUNDRED
     2THS INCHES AND STARTED ON *,I2,*/*,I2,*/*,I2,* AT HOUR*,I3)
1082  CONTINUE
1080  CONTINUE
      GO TO 1088
C
C********  PRINT OUT SEASONAL ANALYSIS
C
1999  NOYRR=NOYRR-1
328   WRITE(N6,2999)
      WRITE(N6,703)
703   FORMAT(///////////////////////////////* *,47(*-*),* MAXIMUM STORM ANALY
     2SIS-BY SEASON *,47(*-*))
      WRITE(N6,4000)
      IF(NOYRR.NE. NOYRRC) WRITE(N6,704)  NOYRRC,NOYRR
704   FORMAT(///* *,22X,15H*** WARNING ***,* THE PERIOD OF RECORD ANALYZ
     2ED HAS BEEN REDUCED FROM*,I3,* TO*,I3,* YEARS*/* *,29X,*BECAUSE 1
     3OR MORE SEASONS OF THE INPUT RAINFALL DATA WERE NOT COMPLETE*)
      DO 1051 I=1,NOSEAS
      JZIK=0
      WRITE(N6,2999)
      WRITE(N6,1064) I
1064  FORMAT(////* *,45X,*MAXIMUM STORM ANALYSIS FOR SEASON*,I4/* *,45X,
     237(*=*)/)
      DO 1052 J=1,NOYRR
      DO 1053 M=1,NDUR
      IYEAR=INTYR+J-1
      LEAP=0
      MK=IDED(I,J,M)
      IF((IYEAR/4*4).EQ.IYEAR) LEAP=24
      IF(MOSEND(I).LT.MOSEAS(I)) GO TO 1054
      GO TO 1060
1054  LEAPP=LEAP
      IF(MOSEAS(I).LE.2) LEAPP=0
      IF(MK.GE.(MBG(MOSEAS(I))+LEAPP).AND.MK.LE.(8760+LEAP)) GO TO 1060
      IYEAR=IYEAR+1
      LEAP=0
      IF((IYEAR/4*4).EQ.IYEAR) LEAP=24
1060  DO 1055 N=1,12
      KMK=MND(N)+LEAP
      IF(N.EQ.1)KMK=MND(N)
      IF(MK.GT.KMK) GO TO 1055
      GO TO 1056
1055  CONTINUE
1056  MONTH=N
      IK=MBG(N)+LEAP
      IF(N.LE.2) IK=MBG(N)
      MMDAY=((MK-IK)/24)+1
      MHOUR=MOD((MK-IK),24)+1
      IF(IMET.EQ.0) GO TO 1163
      METMAX=MAXSEA(I,J,M)*25.4/100.
      WRITE(N6,1161) J,DURTN(M),METMAX,MONTH,MMDAY,IYEAR,MHOUR
1161  FORMAT(*0*,15X,*THE NO.*,I3,* MAXIMUM*,I3,* HOUR STORM TOTALED*,I5
     2,* MILLIMETERS AND STARTED ON *,I2,*/*,I2,*/*,I2,* AT HOUR*,
     3I3)
      GO TO 1165
```

```
1163  WRITE(N6,1063) J,DURTN(M), MAXSEA(I,J,M),MONTH,MMDAY,IYEAR,MHOUR
1063  FORMAT(*0*,15X,*THE NO.*,I3,* MAXIMUM*,I3,* HOUR STORM TOTALED*,I5
     2,* HUNDREDTHS INCHES AND STARTED ON *,I2,*/*,I2,*/*,I2,* AT HOUR*,
     3I3)
1165  JZIK=JZIK+1
      IF(JZIK.EQ.24) GO TO 3000
      GO TO 1053
3000  JZIK=0
      WRITE(N6,2999)
      WRITE(N6,1064) I
1053  CONTINUE
1052  CONTINUE
1051  CONTINUE
      CALL RANK
      NOYRR=NOYRR+M3
      RETURN
1088  CALL RANK
      NYR=NYR+M3
      MOB=11
      NSTN=5
      DO 2001 J1=1,8784
2001  X(J1)=999
C
C********  IF SEASONAL ANALYSIS IS DESIRED, ACTIVATE SEASONAL PORTION
C********  OF PROGRAM
C
      IF(INDSEA.EQ.1) GO TO 999
      RETURN
      END
```

Subroutine RANK

- Called From
  SERIES
- Common Blocks Used
  /CNTRL/
  /SERIES/
  /LAB/
  /LABELS/
  /LABEE/
  /IDFC/
  /LABE/
- Subroutine Called
  CURVE

Subroutine RANK calculates the annual and partial duration series analyses on both a yearly and seasonal basis. Specifically, RANK takes the maximum total rainfalls that were calculated in subroutine SERIES, ranks them from largest to smallest, and calculates the annual series analysis return periods using Equation III-20. If a partial duration series analysis is requested, RANK next estimates the 5, 10, 15, and 30-minute duration total rainfalls using Table III-4. It then converts the annual series return periods to partial duration series return periods using Table III-3 and converts the total rainfall for each duration and return period to average rainfall intensities.

Two plotting options are available in subroutine RANK. The user may request an annual series analysis frequency plot (i.e., plots of total rainfall vs. return period for each duration) and/or an intensity-duration-frequency curve plot (i.e., plots of rainfall intensity vs. duration for each partial duration series analysis return period). Both plotting options are accomplished by subroutine CURVE.

The flow chart for RANK is given in Figure IV-10 and is followed by a program listing. All program variables in COMMON are defined in a later section of this chapter.

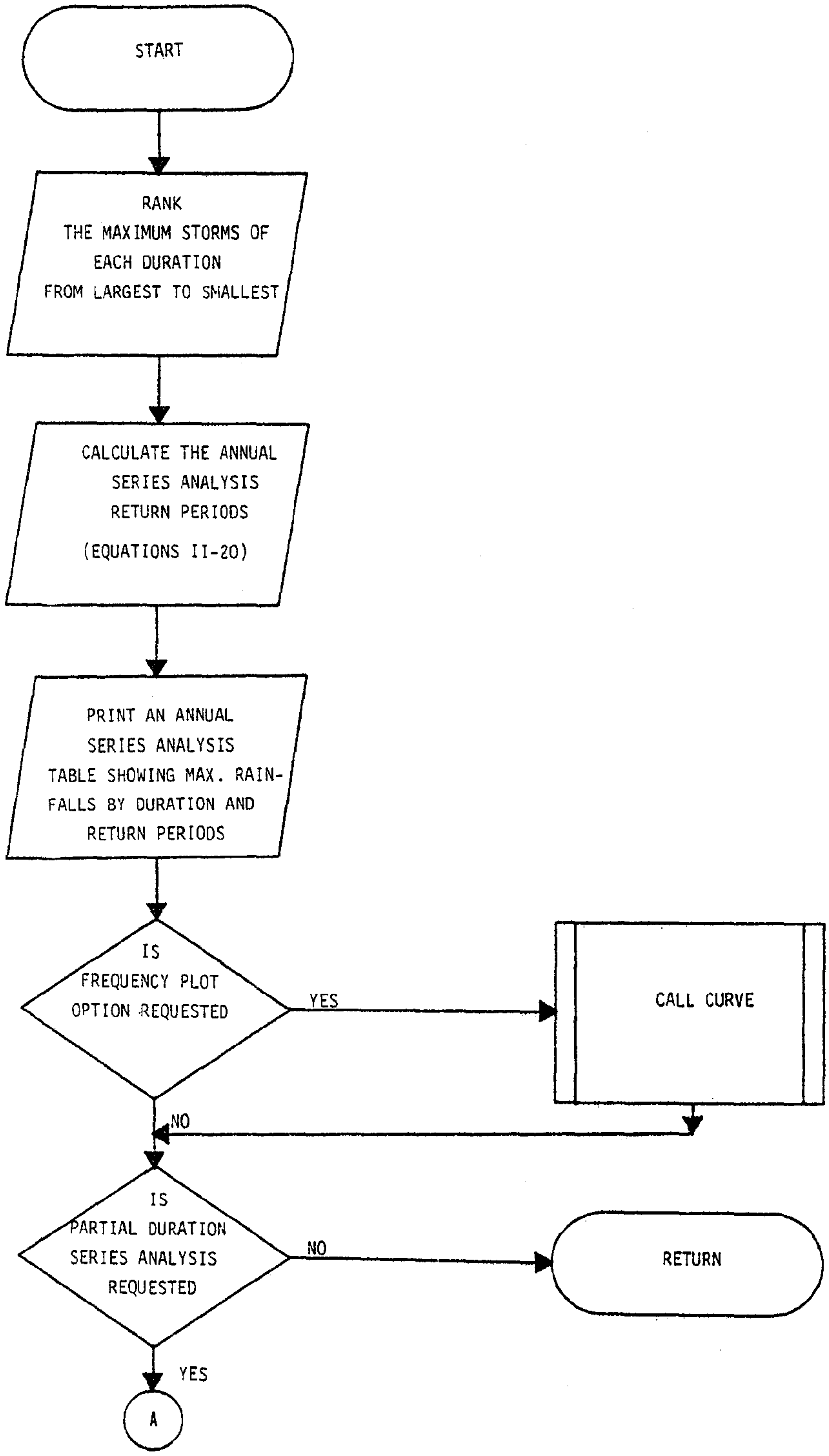

FIGURE IV-10

FLOW CHART FOR SUBROUTINE RANK

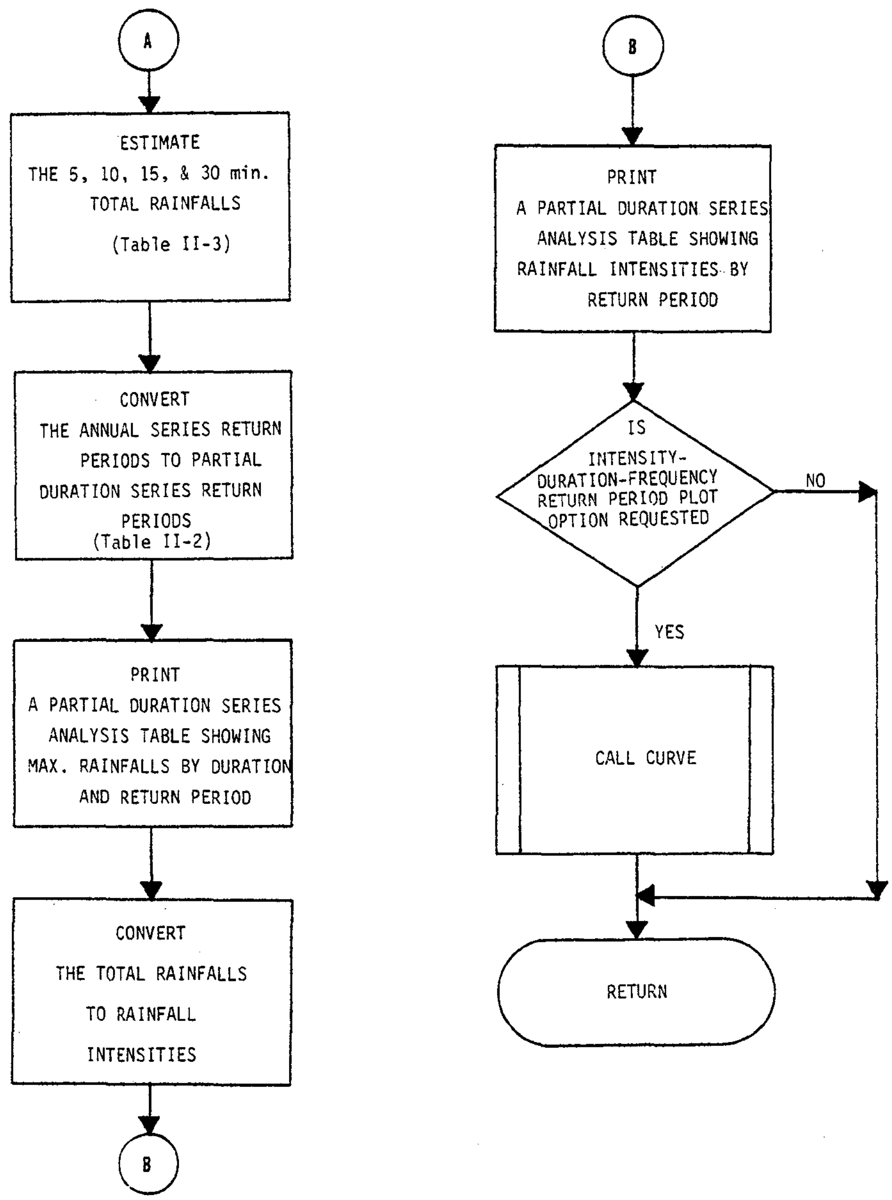

FIGURE IV-10

(continued)

```
      SUBROUTINE RANK
C
C
C     ****************************************************************
C     *                                                              *
C     *  THIS SUBROUTINE TAKES BOTH THE YEARLY AND SEASONAL OUTPUT    *
C     *  FROM SUBROUTINE SERIES AND PERFORMS BOTH AN ANNUAL AND PAR-  *
C     *  TIAL DURATION SERIES ANALYSIS ON IT                          *
C     *                                                              *
C     ****************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON /SEREES/ NYR,NDUR,DURTN(14),Y(744),MBG(12),MND(12),
     2MAXI(50,14),IDTI(50,10), MAXSEA(12,50,14),IDED(12,50,10),X(8784),
     3NOYRR,INDSEA,NOSEAS,INTYR,MOSEAS(12),MDAYBG(12),MOSEND(12),
     4 MDAYEN(12), IPARTO,M3
      COMMON /LAB/ TITLE(18),XLAB(11),YLAB(6),HORIZ(20),VERT(6)
      COMMON/LABELS/ TOP(10),BOTTOM(10),SIDE(50)
      COMMON/LABEE/ TPP(10),BTT(10),SIDD(50),SIDM(50)
      COMMON/IDFC/ BOTTO(10),TOPO(10)
      COMMON/LABE/ TOPP(10),BOTT(10),SIDEE(50),SIDEM(50)
      DIMENSION XX(102),YY(102),RETRN(50)
      INTEGER DURTN
      DIMENSION SYMB(85),LINE(85),ANN(8),RATIO(8)
      DIMENSION INDOP3(2),MTEMP(50,14),MTEMP2(12,50,14)
      DATA INDOP3
     1/4H NO ,4H YES/
      DATA ANN
     1/1.00,1.16,1.58,2.00,2.54,3.80,5.52,10.50/
      DATA RATIO
     1/0.300,0.431,0.633,0.725,0.787,0.870,0.906,0.952/
      DATA SYMB
     1/1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,
     21H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,
     31H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,
     41H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,
     51H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,
     61H-,1H-,1H-,1H-,1H-/
      DATA LINE
     1/1HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,1H ,1H ,
     21H ,1H ,1HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,
     31H ,1H ,1H ,1H ,1HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,1H ,1H ,1H ,1H ,
     41HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,1H ,1H ,
     51H ,1H ,1HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,1H ,1H ,1H ,1H ,1HI,1H ,
     61H ,1H ,1H ,1H ,1HI/
      MZIK=0
      NCV=1
      NPLOT=0
      IJOIN=1
      ITEL=0
      ISTAN=0
      IF( MAXSEA(1,1,1).EQ.99999) GO TO 701
      GO TO 700
C
C
```

```
C********  YEARLY ANNUAL AND PARTIAL DURATION SERIES ANALYSIS PORTION
C********  OF THE PROGRAM
C
C
C
C********  RANK THE YEARLY MAXIMUM STORMS FROM LARGEST TO SMALLEST IN
C********  TERMS OF TOTAL RAINFALL
C
701   DO 900 I=1,NDUR
      J=1
      LV=NYR-1
      DO 100 K=1,LV
  300 IF(MAXI(K,I)-MAXI(K+J,I)) 200,400,400
  200 MX=MAXI(K+J,I)
      MAXI(K+J,I)=MAXI(K,I)
      MAXI(K,I)=MX
  400 J=J+1
      IF(J+K.EQ.NYR+1) GO TO 500
      GO TO 300
  500 J=1
  100 CONTINUE
900   CONTINUE
C
C********  CHECK TO SEE IF ANY YEARS HAVE ZERO RAINFALL
C
      M3=0
      DO 723 M2=1,NYR
      IF(MAXI(M2,1).LE.0) M3=M3+1
723   CONTINUE
      NYR=NYR-M3
      WRITE(N6,2999)
      WRITE(N6,50) NYR
50    FORMAT(///////////////////////////* *,52(*-*),* ANNUAL SERIES ANALY
     2SIS *,52(*-*)////* *,28X,*THE SERIES ANALYSIS WAS PERFORMED ON*,I3
     3,* COMPLETE YEARS OF RAINFALL DATA*)
      WRITE(N6,8009) INDOP3(IFRQPL+1)
      IF(M3.GT.0) WRITE(N6,724) M3,M3
724   FORMAT(///* *,13X,38H*** NOTE *** THE PERIOD OF RECORD HAS ,
     2*BEEN REDUCED*,I3,* YEARS BECAUSE THE RAINFALL IN*,I3,
     3* YEARS TOTALED 0*)
      WRITE(N6,4000)
4000  FORMAT(///* *,18X,12H*** NOTE ***,* RAINFALL VALUES GIVEN FOR 1 HR
     2. DURATIONS ARE 60 MINUTE NOT CLOCK HR. RAINFALLS*/* *,31X,*(IE. T
     3HE PRINTED VALUE = MAX. CLOCK HR. VALUE FROM INPUT X 1.13)*)
C
C********  FOR THE YEARLY STORMS, CALCULATE THE ANNUAL SERIES ANALYSIS
C********  RETURN PERIODS
C
      DO 600 L=1,NYR
      X1=FLOAT(L)
      RETRN(L)=FLOAT(NYR+1)/X1
  600 CONTINUE
C
C********  PRINT OUT AN ANNUAL SERIES ANALYSIS TABLE SHOWING THE YEARLY
C********  TOTAL RAINFALLS BY DURATION AND RETURN PERIOD
C
      WRITE(N6,2999)
```

```
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
      WRITE(N6,90)
90    FORMAT(//* *,53X,*ANNUAL SERIES ANALYSIS*/* *,53X,22(*=*))
      IF(IMET.EQ.0) GO TO 87
      WRITE(N6,88)
88    FORMAT(////* *,45X,*TABLE OF TOTAL RAINFALLS IN MILLIMETERS*/
     2* *,40X,48(*-*)/*0*,49X,*BY DURATION AND RETURN PERIOD*/* *,49
     3X,29(*-*)//)
      DO 89 L=1,NYR
      DO 89 K=1,NDUR
      MTEMP(L,K)=MAXI(L,K)
89    MAXI(L,K)=MAXI(L,K)*(25.4/100.)
      GO TO 86
87    WRITE(N6,91)
91    FORMAT(////* *,40X,*TABLE OF TOTAL RAINFALLS IN HUNDREDTHS OF INCH
     2ES*/* *,40X,48(*-*)/*0*,49X,*BY DURATION AND RETURN PERIOD*/* *,49
     3X,29(*-*)//)
86    WRITE(N6,98)
98    FORMAT(* *,35X,*DURATIONS IN HOURS*/)
      WRITE(N6,92) (DURTN(JJ),JJ=1,NDUR)
92    FORMAT(* *,34X,I3,9(3X,I3))
      MK=NDUR*6+1
      WRITE(N6,93) (SYMB(KK),KK=1,MK)
93    FORMAT(*0*,14X,*RETURN*,13X,61A1)
      WRITE(N6,99) (LINE(JK),JK=1,MK)
99    FORMAT(* *,33X,61A1)
      WRITE(N6,94) RETRN(1),(MAXI(1,K),K=1,NDUR)
94    FORMAT(* *,14X,*PERIOD*,5X,F6.2,2X,*I*,10(I4,* I*))
      WRITE(N6,99) (LINE(JK),JK=1,MK)
      WRITE(N6,95) (SYMB(KK),KK=1,MK)
95    FORMAT(* *,14X,*(YRS.)*,13X,61A1)
      DO 80 L=2,NYR
      IF((L/9*9).EQ.L) GO TO 902
      GO TO 901
902   WRITE(N6,2999)
      WRITE(N6,90)
      WRITE(N6,91)
      WRITE(N6,98)
      WRITE(N6,92) (DURTN(JJ),JJ=1,NDUR)
      WRITE(N6,93) (SYMB(KK),KK=1,MK)
      WRITE(N6,99) (LINE(JK),JK=1,MK)
      WRITE(N6,94) RETRN(L),(MAXI(L,K),K=1,NDUR)
      WRITE(N6,99) (LINE(JK),JK=1,MK)
      WRITE(N6,95) (SYMB(KK),KK=1,MK)
      GO TO 80
901   WRITE(N6,99) (LINE(JK),JK=1,MK)
      WRITE(N6,96) RETRN(L),(MAXI(L,K),K=1,NDUR)
96    FORMAT(* *,25X,F6.2,2X,*I*,10(I4,* I*))
      WRITE(N6,99) (LINE(JK),JK=1,MK)
      WRITE(N6,97) (SYMB(KK),KK=1,MK)
97    FORMAT(* *,33X,61A1)
80    CONTINUE
```

```
82    CONTINUE
      IF( IFRQPL.EQ.0) GO TO 8021
C
C********  FOR THE YEARLY STORMS, IF  IFRQPL EQUALS 1, PLOT A FREQUENCY
C********  CURVE FOR EACH DURATION
C
      DO 65 I=1,NDUR
      JJJ=NYR
      DO 60 L=1,NYR
      XX(JJJ)=RETRN(L)
      YY(JJJ)=FLOAT(MAXI(L,I))
60    JJJ=JJJ-1
      IF(I.EQ.1) GO TO 44
      GO TO 48
44    DO 45 MM=1,10
      TOP(MM)=TPP(MM)
45    BOTTOM(MM)=BTT(MM)
      DO 47 MM=1,50
      IF(IMET.EQ.0) GO TO 46
      SIDE(MM)=SIDM(MM)
      GO TO 47
46    SIDE(MM)=SIDD(MM)
47    CONTINUE
48    WRITE(N6,2999)
      CALL CURVE(XX,YY,NYR,NCV,NPLOT,IJOIN,ITEL,ISTAN)
      WRITE(N6,41) DURTN(I)
41    FORMAT(/* *,48X,*THIS PLOT IS FOR*,I3,* HOUR DURATIONS*)
65    CONTINUE
C
C********  IF  IPARTO EQUALS 1, GO TO 2020 AND PERFORM A PARTIAL
C********  DURATION SERIES ANALYSIS ON THE YEARLY STORMS
C
8021  IF(IMET.EQ.0) GO TO 8011
      DO 81 L=1,NYR
      DO 81 K=1,NDUR
81    MAXI(L,K)=MTEMP(L,K)
8011  IF( IPARTO.GT.0) GO TO 2020
      GO TO 220
C
C
C********  SEASONAL ANNUAL AND PARTIAL DURATION SERIES ANALYSIS PORTION
C********  OF THE PROGRAM
C
C
C
C********  RANK EACH SEASONS MAXIMUM STORMS FROM LARGEST TO SMALLEST IN
C********  TERMS OF TOTAL RAINFALL
C
700   DO 230 I=1,NOSEAS
      DO 231 M=1,NDUR
      J=1
      LV=NOYRR-1
      DO 232 K=1,LV
233   IF( MAXSEA(I,K,M)- MAXSEA(I,K+J,M)) 234,235,235
234   MXX= MAXSEA(I,K+J,M)
       MAXSEA(I,K+J,M)= MAXSEA(I,K,M)
       MAXSEA(I,K,M)=MXX
```

```
235   J=J+1
      IF(J+K.EQ.NOYRR+1) GO TO 236
      GO TO 233
236   J=1
232   CONTINUE
231   CONTINUE
230   CONTINUE
C
C********  CHECK TO SEE IF ANY SEASONS HAVE ZERO RAINFALL
C
      M8=0
      M3=0
      DO 742 M6=1,NOSEAS
      DO 743 M7=1,NOYRR
      IF(MAXSEA(M6,M7,1).LE.0) M8=M8+1
743   CONTINUE
      IF(M8.GT.M3) M3=M8
      M8=0
742   CONTINUE
      NOYRR=NOYRR-M3
      WRITE(N6,2999)
      WRITE(N6,250) NOYRR
250   FORMAT(///////////////////////////* *,47(*-*),* SEASONAL ANNUAL SER
     2IES ANALYSIS *,48(*-*)////* *,28X,*THE SERIES ANALYSIS WAS PERFORM
     3ED ON*,I3,* COMPLETE YEARS OF RAINFALL DATA*)
      WRITE(N6,8009) INDOP3( IFRQPL+1)
8009  FORMAT(*0*,43X,*FREQUENCY CURVE PLOT OPTION ( IFRQPL)=*,1A4)
      IF(M3.GT.0) WRITE(N6,754) M3,M3
754   FORMAT(///* *,9X,38H*** NOTE *** THE PERIOD OF RECORD HAS ,
     2*BEEN REDUCED*,I3,* YEARS BECAUSE A SEASONS RAINFALL IN*,I3,
     3* YEARS TOTALED 0*)
      WRITE(N6,4000)
C
C********  FOR THE SEASONAL STORMS, CALCULATE THE ANNUAL SERIES ANALYSIS
C********  RETURN PERIODS
C
      DO 237 K=1,NOYRR
      X11=FLOAT(K)
237   RETRN(K)=FLOAT(NOYRR+1)/X11
      DO 259 I=1,NOSEAS
      WRITE(N6,2999)
      WRITE(N6,238)
238   FORMAT(//* *,48X,*SEASONAL ANNUAL SERIES ANALYSIS*/* *,48X,31(*=*)
     2)
C
C********  FOR EACH SEASON, PRINT OUT AN ANNUAL SERIES ANALYSIS
C********  TABLE SHOWING THE SEASONS TOTAL RAINFALLS BY DURATION AND
C********  RETURN PERIOD
C
      IF(IMET.EQ.0) GO TO 244
      WRITE(N6,245) I
245    FORMAT(////* *,45X,*TABLE OF TOTAL RAINFALLS IN MILLIMETERS*/
     2* *,40X,48(*-*)/*0*,42X,*FOR SEASON*,I3,* BY DURATION AND RETURN P
     3ERIOD*/* *,42X,43(*-*)//)
      DO 246 L=1,NOYRR
      DO 246 K=1,NDUR
      MTEMP2(I,L,K)=MAXSEA(I,L,K)
```

```
246    MAXSEA(I,L,K)=MAXSEA(I,L,K)*(25.4/100.)
       GO TO 247
244    WRITE(N6,239) I
239    FORMAT(////* *,40X,*TABLE OF TOTAL RAINFALLS IN HUNDREDTHS OF INCH
      2ES*/* *,40X,48(*-*)/*0*,42X,*FOR SEASON*,I3,* BY DURATION AND RETU
      3RN PERIOD*/* *,42X,43(*-*)//)
247    WRITE(N6,98)
       WRITE(N6,92) (DURTN(JJ),JJ=1,NDUR)
       MK=NDUR*6+1
       WRITE(N6,93) (SYMB(KK),KK=1,MK)
       WRITE(N6,99) (LINE(JK),JK=1,MK)
       WRITE(N6,94) RETRN(1),( MAXSEA(I,1,K),K=1,NDUR)
       WRITE(N6,99) (LINE(JK),JK=1,MK)
       WRITE(N6,95) (SYMB(KK),KK=1,MK)
       DO 240 L=2,NOYRR
       IF((L/9*9).EQ.L) GO TO 242
       GO TO 241
242    WRITE(N6,2999)
       WRITE(N6,238)
       WRITE(N6,239) I
       WRITE(N6,98)
       WRITE(N6,92) (DURTN(JJ),JJ=1,NDUR)
       WRITE(N6,93) (SYMB(KK),KK=1,MK)
       WRITE(N6,99) (LINE(JK),JK=1,MK)
       WRITE(N6,94) RETRN(L),( MAXSEA(I,L,K),K=1,NDUR)
       WRITE(N6,99) (LINE(JK),JK=1,MK)
       WRITE(N6,95) (SYMB(KK),KK=1,MK)
       GO TO 240
241    WRITE(N6,99) (LINE(JK),JK=1,MK)
       WRITE(N6,96) RETRN(L),( MAXSEA(I,L,K),K=1,NDUR)
       WRITE(N6,99) (LINE(JK),JK=1,MK)
       WRITE(N6,97) (SYMB(KK),KK=1,MK)
240    CONTINUE
259    CONTINUE
       IF( IFRQPL.EQ.0) GO TO 8020
C
C********  FOR THE SEASONAL STORMS, IF  IFRQPL EQUALS 1, PLOT A
C********  FREQUENCY CURVE FOR EACH DURATION IN EACH SEASON
C
       DO 260 I=1,NOSEAS
       DO 261 II=1,NDUR
       JJJ=NOYRR
       DO 262 L=1,NOYRR
       XX(JJJ)=RETRN(L)
       YY(JJJ)=FLOAT( MAXSEA(I,L,II))
262    JJJ=JJJ-1
       IF(I.EQ.1.AND.II.EQ.1) GO TO 263
       GO TO 264
263    DO 265 MM=1,10
       TOP(MM)=TPP(MM)
265    BOTTOM(MM)=BTT(MM)
       DO 268 MM=1,50
       IF(IMET.EQ.0) GO TO 266
       SIDE(MM)=SIDM(MM)
       GO TO 268
266    SIDE(MM)=SIDD(MM)
268    CONTINUE
```

```
264   WRITE(N6,2999)
      CALL CURVE (XX,YY,NOYRR,NCV,NPLOT,IJOIN,ITEL,ISTAN)
      WRITE(N6,267) DURTN(II),I
267   FORMAT(/* *,42X,*THIS PLOT IS FOR*,I3,* HOUR DURATIONS IN SEASON*,
     2I3)
261   CONTINUE
260   CONTINUE
C
C********  IF  IPARTO EQUALS 1, GO TO 3020 AND PERFORM A PARTIAL
C********  DURATION SERIES ANALYSIS ON THE SEASONAL STORMS
C
8020  IF(IMET.EQ.0) GO TO 8010
      DO 258 I=1,NOSEAS
      DO 258 L=1,NOYRR
      DO 258 K=1,NDUR
258   MAXSEA(I,L,K)=MTEMP2(I,L,K)
8010  IF( IPARTO.GT.0) GO TO 3020
      GO TO 220
C
C********  FOR THE YEARLY STORMS, FIND THE 5, 10, 15 AND 30 MINUTE
C********  DURATION TOTAL RAINFALLS
C
2020  DO 2021 J=1,NYR
      JI=NDUR
      DO 2022 M=1,NDUR
      MAXI(J,JI+4)=MAXI(J,JI)
2022  JI=JI-1
      MAXI(J,4)=MAXI(J,5)*0.790
      MAXI(J,3)=MAXI(J,5)*0.569
      MAXI(J,2)=MAXI(J,5)*0.450
      MAXI(J,1)=MAXI(J,5)*0.292
2021  CONTINUE
      GO TO 3066
C
C********  FOR THE SEASONAL STORMS, FIND THE 5, 10, 15 AND 30 MINUTE
C********  DURATION TOTAL RAINFALLS FOR EACH SEASON
C
3020  DO 3021 I=1,NOSEAS
      DO 3022 J=1,NOYRR
      JI=NDUR
      DO 3023 M=1,NDUR
       MAXSEA(I,J,JI+4)= MAXSEA(I,J,JI)
3023  JI=JI-1
       MAXSEA(I,J,4)= MAXSEA(I,J,5)*0.790
       MAXSEA(I,J,3)= MAXSEA(I,J,5)*0.569
       MAXSEA(I,J,2)= MAXSEA(I,J,5)*0.450
       MAXSEA(I,J,1)= MAXSEA(I,J,5)*0.292
3022  CONTINUE
3021  CONTINUE
      NYR=NOYRR
C
C********  FOR BOTH THE YEARLY AND SEASONAL STORMS, CALCULATE THE
C********  PARTIAL DURATION SERIES ANALYSIS RETURN PERIODS USING
C********  LINEAR INTERPOLATION
C
3066  DO 2023 J=1,NYR
      IF(RETRN(J).GT.10.5) GO TO 2023
```

```
      DO 2025 I=1,7
      IF(RETRN(J).GE.ANN(I).AND.RETRN(J).LE.ANN(I+1)) GO TO 2026
2025  CONTINUE
2026  IF(RETRN(J).EQ.ANN(I)) GO TO 3080

      IF(RETRN(J).EQ.ANN(I+1)) GO TO 3081
      GO TO 3082

3080  RETRN(J)=RETRN(J)*RATIO(I)
      GO TO 2023
3081  RETRN(J)=RETRN(J)*RATIO(I+1)
      GO TO 2023
3082  RD=RATIO(I+1)-RATIO(I)
      YD=ANN(I+1)-ANN(I)
      ZD=RETRN(J)-ANN(I)
      ZF=RATIO(I)+((ZD/YD)*RD)
      RETRN(J)=RETRN(J)*ZF
2023  CONTINUE
      KZZ=NDUR+4
      WRITE(N6,2999)
      IF( MAXSEA(1,1,1).NE.99999) GO TO 3024
C
C********  PRINT OUT TWO PARTIAL DURATION SERIES ANALYSIS TABLES- 1
C********  SHOWING YEARLY TOTAL RAINFALLS AND THE OTHER SHOWING YEARLY
C********  RAINFALL INTENSITIES- EACH BY DURATION AND RETURN PERIOD
C
      WRITE(N6,2040) NYR
2040  FORMAT(///////////////////////////* *,47(*-*),* PARTIAL DURATION SE
     2RIES ANALYSIS *,47(*-*)////* *,31X,*THE ANALYSIS WAS PERFORMED ON*
     3,I3,* COMPLETE YEARS OF RAINFALL DATA*)
      WRITE(N6,8008) INDOP3( IDFCPL+1)
8008  FORMAT(*0*,34X,*INTENSITY-DURATION-FREQUENCY CURVE PLOT OPTION (ID
     2FCPLT)=*,1A4)
      IF(M3.GT.0) WRITE(N6,724) M3,M3
      WRITE(N6,4000)
5002  WRITE(N6,2999)
      WRITE(N6,2041)
2041  FORMAT(//* *,48X,*PARTIAL DURATION SERIES ANALYSIS*/* *,48X,32(*=*
     2))
      IF(IMET.EQ.0) GO TO 5020
      DO 5025 L=1,NYR
      DO 5025 K=1,KZZ
      MTEMP(L,K)=MAXI(L,K)
5025  MAXI(L,K)=MAXI(L,K)*(25.4/100.)
      IF(MZIK.EQ.1) GO TO 5030
      WRITE(N6,88)
      GO TO 5004
5030  WRITE(N6,5035)
5035  FORMAT(////* *,38X,*TABLE OF RAINFALL INTENSITIES IN MILLIMETERS P
     2ER HOUR*/* *,33X,62(*-*)/*0*,49X,*BY DURATION AND RETURN PERIOD*/
     3* *,49X,29(*-*)//)
      GO TO 5004
5020  IF(MZIK.EQ.1) GO TO 5003
      WRITE(N6,91)
      GO TO 5004
5003  WRITE(N6,5005)
5005  FORMAT(////* *,33X,*TABLE OF RAINFALL INTENSITIES IN HUNDREDTHS OF
```

```
     2 INCHES PER HOUR*/* *,33X,62(*-*)/*0*,49X,*BY DURATION AND RETURN
     3PERIOD*/* *,49X,29(*-*)//)
5004  WRITE(N6,817)
  817 FORMAT(* *,23X,*DURATIONS IN HOURS*/)
      WRITE(N6,2042) (DURTN(JJ),JJ=1,NDUR)
2042  FORMAT(* *,22X,*1/12*,3X,*1/6*,3X,*1/4*,3X,*1/2*,2X,I3,9(3X,I3))
      MK=NDUR*6+25
      WRITE(N6,2043) (SYMB(KK),KK=1,MK)
2043  FORMAT(*0*,2X,*RETURN*,13X,85A1)
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
2049  FORMAT(* *,21X,85A1)
      WRITE(N6,2044)  RETRN(1),(MAXI(1,K),K=1,KZZ)
2044  FORMAT(* *,2X,*PERIOD*,5X,F6.2,2X,*I*,14(I4,* I*))
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2045) (SYMB(KK),KK=1,MK)
2045  FORMAT(* *,2X,*(YRS.)*,13X,85A1)
      DO 2050 L=2,NYR
      IF((L/9*9).EQ.L) GO TO 2052
      GO TO 2051
2052  WRITE(N6,2999)
      WRITE(N6,2041)
      IF(MZIK.EQ.1) GO TO 5010
      WRITE(N6,91)
      GO TO 5011
5010  WRITE(N6,5005)
5011  WRITE(N6,817)
      WRITE(N6,2042) (DURTN(JJ),JJ=1,NDUR)
      WRITE(N6,2043) (SYMB(KK),KK=1,MK)
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2044)  RETRN(L),(MAXI(L,K),K=1,KZZ)
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2045) (SYMB(KK),KK=1,MK)
      GO TO 2050
2051  WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2046) RETRN(L),(MAXI(L,K),K=1,KZZ)
2046  FORMAT(* *,13X,F6.2,2X,*I*,14(I4,* I*))
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2047) (SYMB(KK),KK=1,MK)
2047  FORMAT(* *,21X,85A1)
2050  CONTINUE
      IF(IMET.EQ.0) GO TO 2065
      DO 2060 L=1,NYR
      DO 2060 K=1,KZZ
2060  MAXI(L,K)=MTEMP(L,K)
2065  CONTINUE
      IF(MZIK.EQ.1) GO TO 5099
C
C********  CONVERT THE YEARLY TOTAL RAINFALLS TO RAINFALL INTENSITIES
C********  (IE. INCHES/HOUR)
C
      MZIK=1
      DO 6000 J=1,NYR
      DO 6001 M=5,KZZ
6001  MAXI(J,M)=MAXI(J,M)*1.000/DURTN(M-4)
      MAXI(J,1)=MAXI(J,1)*1.000/0.08333333
```

```
      MAXI(J,2)=MAXI(J,2)*1.000/0.16666667
      MAXI(J,3)=MAXI(J,3)*1.000/0.25
      MAXI(J,4)=MAXI(J,4)*1.000/0.50
6000  CONTINUE
      GO TO 5002
5099  IF( IDFCPL.EQ.0) GO TO 220
C
C********  FOR THE YEARLY STORMS, IF  IDFCPL EQUALS 1, PLOT AN
C********  INTENSITY DURATION FREQUENCY CURVE FOR EACH RETURN PERIOD
C
5000  DO 4020 IZ=1,10
      TOP(IZ)=TOPO(IZ)
4020  BOTTOM(IZ)=BOTTO(IZ)
      DO 4022 IZ=1,50
      IF(IMET.EQ.0) GO TO 4021
      SIDE(IZ)=SIDEM(IZ)
      GO TO 4022
4021  SIDE(IZ)=SIDEE(IZ)
4022  CONTINUE
      IF( MAXSEA(1,1,1).NE.99999) GO TO 8001
      DO 4010 J=1,NYR
      WRITE(N6,2999)
      JI=5
      DO 4011 M=1,NDUR
      XX(JI)=DURTN(M)*60.0
4011  JI=JI+1
      XX(1)=5.0
      XX(2)=10.0
      XX(3)=15.0
      XX(4)=30.0
      DO 4013 M=1,KZZ
      IF(IMET.EQ.0) GO TO 4012
      YY(M)=MAXI(J,M)*(25.4/100.)
      GO TO 4013
4012  YY(M)=MAXI(J,M)/100.0
4013  CONTINUE
      CALL CURVE (XX,YY,KZZ,NCV,NPLOT,IJOIN,ITEL,ISTAN)
      WRITE(N6,4015) RETRN(J)
4015  FORMAT(/* *,39X,*THIS PLOT IS FOR A RETURN FREQUENCY OF*,F6.2,* YE
     2ARS*)
4010  CONTINUE
      GO TO 220
C
C********  PRINT OUT TWO PARTIAL DURATION SERIES ANALYSIS TABLES FOR
C********  EACH SEASON- 1 SHOWING THE SEASONS TOTAL RAINFALL AND THE
C********  OTHER SHOWING THE SEASONS RAINFALL INTENSITIES- EACH BY
C********  DURATION AND RETURN PERIOD
C
3024  WRITE(N6,3040) NOYRR
3040  FORMAT(///////////////////////////* *,42(*-*),* SEASONAL PARTIAL DU
     2RATION SERIES ANALYSIS *,43(*-*)////* *,31X,*THE ANALYSIS WAS PERF
     3ORMED ON*,I3,* COMPLETE YEARS OF RAINFALL DATA*)
      WRITE(N6,8008) INDOP3( IDFCPL+1)
      IF(M3.GT.0) WRITE(N6,754) M3,M3
      WRITE(N6,4000)
7003  DO 3030 I=1,NOSEAS
      WRITE(N6,2999)
      WRITE(N6,3041)
```

```
3041  FORMAT(//* *,42X,*SEASONAL PARTIAL DURATION SERIES ANALYSIS*/* *,4
     22X,43(*=*))
      IF(IMET.EQ.0) GO TO 7020
      DO 7030 L=1,NOYRR
      DO 7030 K=1,KZZ
      MTEMP2(I,L,K)=MAXSEA(I,L,K)
7030  MAXSEA(I,L,K)=MAXSEA(I,L,K)*(25.4/100.)
      IF(MZIK.EQ.1) GO TO 7040
      WRITE(N6,245) I
      GO TO 7005
7040  WRITE(N6,7050) I
7050  FORMAT(////* *,38X,*TABLE OF RAINFALL INTENSITIES IN MILLIMETERS P
     2ER HOUR*/* *,33X,62(*-*)/*0*,42X,*FOR SEASON*,I3,* BY DURATION AND
     3 RETURN PERIOD*/* *,42X,43(*-*)//)
      GO TO 7005
7020  IF(MZIK.EQ.1) GO TO 7004
      WRITE(N6,239)I
      GO TO 7005
7004  WRITE(N6,7006) I
7006  FORMAT(////* *,33X,*TABLE OF RAINFALL INTENSITIES IN HUNDREDTHS OF
     2 INCHES PER HOUR*/* *,33X,62(*-*)/*0*,42X,*FOR SEASON*,I3,* BY DUR
     3ATION AND RETURN PERIOD*/* *,42X,43(*-*)//)
7005  WRITE(N6,817)
      MK=NDUR*6+25
      WRITE(N6,2042) (DURTN(JJ),JJ=1,NDUR)
      WRITE(N6,2043) (SYMB(KK),KK=1,MK)
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2044) RETRN(1),( MAXSEA(I,1,K),K=1,KZZ)
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2045) (SYMB(KK),KK=1,MK)
      DO 3050 L=2,NOYRR
      IF((L/9*9).EQ.L) GO TO 3052
      GO TO 3051
3052  WRITE(N6,2999)
      WRITE(N6,3041)
      IF(MZIK.EQ.1) GO TO 7007
      WRITE(N6,239)I
      GO TO 7008
7007  WRITE(N6,7006) I
7008  WRITE(N6,817)
      WRITE(N6,2042) (DURTN(JJ),JJ=1,NDUR)
      WRITE(N6,2043) (SYMB(KK),KK=1,MK)
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2044) RETRN(L),( MAXSEA(I,L,K),K=1,KZZ)
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2045) (SYMB(KK),KK=1,MK)
      GO TO 3050
3051  WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2046)  RETRN(L),( MAXSEA(I,L,K),K=1,KZZ)
      WRITE(N6,2049) (LINE(JK),JK=1,MK)
      WRITE(N6,2047) (SYMB(KK),KK=1,MK)
3050  CONTINUE
      IF(IMET.EQ.0) GO TO 3030
      DO 3060 L=1,NOYRR
      DO 3060 K=1,KZZ
 3060 MAXSEA(I,L,K)=MTEMP2(I,L,K)
```

```
3030  CONTINUE
      IF(MZIK.EQ.1) GO TO 8000
C
C********  CONVERT EACH SEASONS TOTAL RAINFALLS TO RAINFALL INTENSITIES
C********  (IE. INCHES/HOUR)
C
      MZIK=1
      DO 7000 I=1,NOSEAS
      DO 7001 J=1,NOYRR
      DO 7002 M=5,KZZ
7002   MAXSEA(I,J,M)= MAXSEA(I,J,M)*1.0/DURTN(M-4)
       MAXSEA(I,J,1)= MAXSEA(I,J,1)/0.08333333
       MAXSEA(I,J,2)= MAXSEA(I,J,2)/0.16666667
       MAXSEA(I,J,3)= MAXSEA(I,J,3)/0.25
       MAXSEA(I,J,4)= MAXSEA(I,J,4)/0.50
7001  CONTINUE
7000  CONTINUE
      GO TO 7003
8000  IF( IDFCPL.EQ.1) GO TO 5000
      GO TO 220
C
C********  IF  IDFCPL EQUALS 1, PLOT AN INTENSITY DURATION FREQUENCY
C********  CURVE FOR EACH RETURN PERIOD IN EACH SEASON
C
8001  DO 8002 I=1,NOSEAS
      DO 8003 J=1,NOYRR
      WRITE(N6,2999)
      JI=5
      DO 8004 M=1,NDUR
      XX(JI)=DURTN(M)*60.0
8004  JI=JI+1
      XX(1)=5.0
      XX(2)=10.0
      XX(3)=15.0
      XX(4)=30.0
      DO 8007 M=1,KZZ
      IF(IMET.EQ.0) GO TO 8005
      YY(M)=MAXSEA(I,J,M)*(25.4/100.)
      GO TO 8007
8005  YY(M)= MAXSEA(I,J,M)/100.0
8007  CONTINUE
      CALL CURVE(XX,YY,KZZ,NCV,NPLOT,IJOIN,ITEL,ISTAN)
      WRITE(N6,8006) I,RETRN(J)
8006  FORMAT(/* *,31X,*THIS PLOT IS FOR SEASON*,I3,* AND A RETURN FREQUE
     2NCY OF*,F6.2,* YEARS*)
8003  CONTINUE
8002  CONTINUE
220   RETURN
      END
```

Subroutine EVENT

- Called From
  - SERIES
- Common Blocks Used
  - /CNTRL/
  - /SERIES/
  - /RIDGWY/
  - /TREAD/
  - /BONA/
- Subroutines Called
  - FREQ
  - ENTRY DRYFREQ of FREQ
  - OUTPUT

Subroutine EVENT reads the input data required for the frequency analysis section of Program Path 3. Card input required consists of a title card, an event card, and a maximum expected frequency card. Subroutine EVENT also reads the RAINT processed rainfall tape.

An hourly loop is performed one day at a time on the hourly rainfall tape to determine the number of events and the length, peak hourly rainfall, and total volume of each rainfall event. Each time a storm event ends (i.e., each time a user-specified number of consecutive dry hours passes), subroutine FREQ is called.

When the dry-hour frequency option is selected, subroutine EVENT repeats the hourly loop to count the number of dry hours in the daily rainfall trace. Whenever the period of dry hours is interrupted by rainfall, subroutine FREQ is called via ENTRY DRYFREQ.

Subroutine EVENT continues reading the daily rainfall tape until an end-of-file is reached. At this point, subroutine OUTPUT is called.

The flow chart for EVENT is given in Figure IV-11 and is followed by Table IV-9 showing the key variables not in COMMON and by a program listing. All program variables in COMMON are defined in the last section of this chapter.

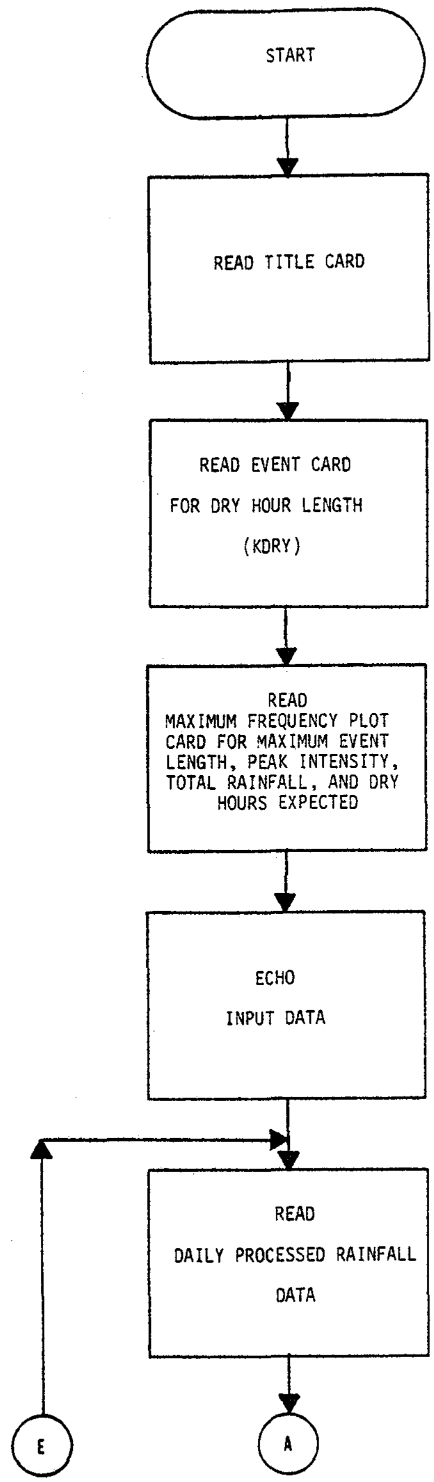

FIGURE IV-11

FLOW CHART FOR SUBROUTINE EVENT

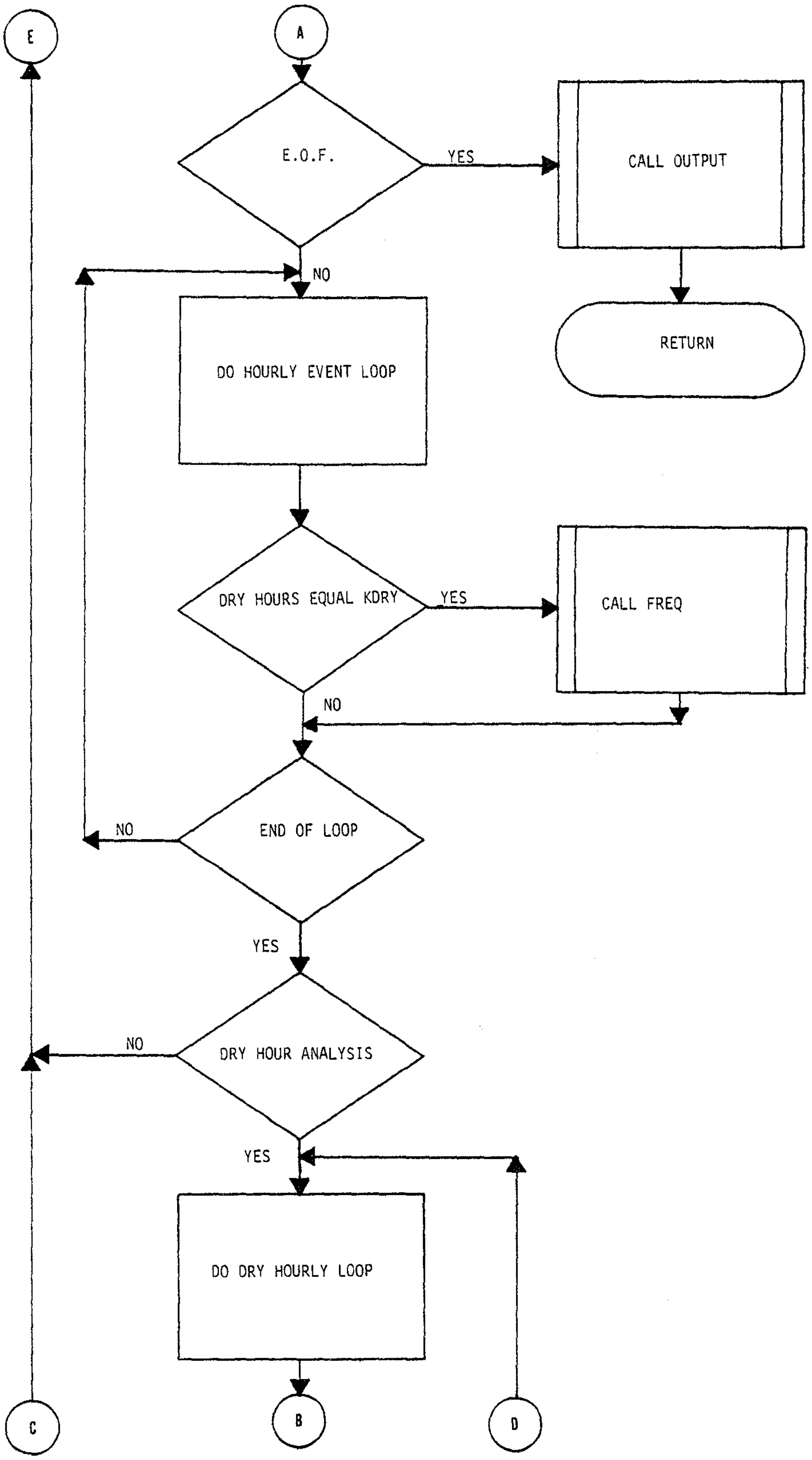

FIGURE IV-11 (Continued)

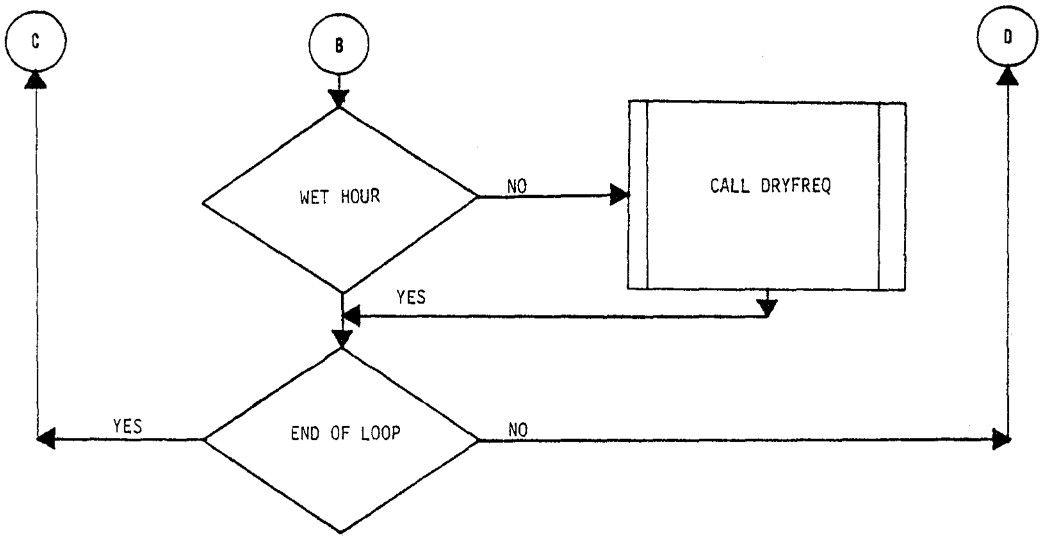

FIGURE IV-11

(continued)

TABLE IV-9

KEY VARIABLES NOT IN COMMON AND IN SUBROUTINE EVENT

FORTRAN VARIABLE	DEFINITION	UNITS
NAME [1]	Title of Current Simulation	None
IRAIN	Hourly Rainfall Data	Hundredths inches
KSTOP	Dry-Hour Counter	None

[1]Input Data

```
      SUBROUTINE EVENT
C
C
C     ******************************************************************
C     *                                                                *
C     *   EVENT SEARCHS A PROCESSED RAIN TAPE FROM SUBROUTINE RAINT    *
C     *   TO DETERMINE THE LENGTH OF EACH STORM EVENT, THE PEAK HOURLY *
C     *   RAINFALL PER STORM EVENT, THE TOTAL RAINFALL PER STORM EVENT *
C     *   AND THE NUMBER OF DRY HOURS BETWEEN WET HOURS. EVENT CALLS   *
C     *   SUBROUTINES FREQ AND OUTPUT.                                 *
C     *                                                                *
C     ******************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON /SEREES/ NYR,NDUR,DURTN(14),Y(744),MBG(12),MND(12),
     2MAXI(50,14),IDTI(50,10), MAXSEA(12,50,14),IDED(12,50,10),X(8784),
     3NOYRR,INDSEA,NOSEAS,INTYR,MOSEAS(12),MDAYBG(12),MOSEND(12),
     4 MDAYEN(12), IPARTO,M3
      COMMON/RIDGWY/SLEN(100,13),SMAX(100,13),SVOL(100,13),SDRY(100,13),
     1   FMAX,FVOL,DRYMAX,DRYLEN,KDRY,KLSS(5),K50,K100, EVNTMA
      COMMON /TREAD/ MDAY,MYR,MO,MDY,QDISCH(24)
      COMMON/BONA/ LEN,FAX,VOL,IEV,DRY
      DIMENSION NAME(10),IRAIN(24)
      INTEGER DRYLEN
      REWIND IT
C
C******** INITIALIZE VARIABLES
C
      DRYLEN=0
      DRY=0.
      IEV=0
      LEN=0
      FAX=0.
      VOL=0.
      DO 5 I=1,5
      KLSS(I)=0
    5 CONTINUE
      DO 8 I=1,100
      DO 8 J=1,13
      SLEN(I,J)=0.
      SDRY(I,J)=0.
    8 CONTINUE
      DO 9 I=1,50
      DO 9 J=1,13
      SMAX(I,J)=0.
      SVOL(I,J)=0.
    9 CONTINUE
      WRITE(N6,2999)
      WRITE(N6,2010)
 2010 FORMAT(//////////////////////////,1X,25(2H--),* EVENT FREQUENCY ANAL
     1YSIS *,25(2H--),///,54X,* LENGTH OF RAINFALL *,///,53X,* PEAK HOURLY
     2 RAINFALL *,///,52X,* TOTAL RAINFALL VOLUME *)
      K100=100
```

```
      K50=50
      WRITE(N6,2999)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL   ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
C
C******** READ TITLE CARD, EVENT CARD, AND MAX FREQUENCY PLOT CARD
C
      READ(N5,3000) NAME
 3000 FORMAT(8X,10A4)
      READ(N5,3020) KDRY
 3020 FORMAT(8X,I8)
      READ(N5,3050)  EVNTMA,FMAX,FVOL,DRYMAX
 3050 FORMAT(8X,4F8.0)
C
C******** ECHO INPUT DATA
C
      WRITE(N6,3005)
 3005 FORMAT(///,1X,23(2H**),*EVENT FREQUENCY ANALYSIS INFORMATION*,
     1   23(2H**))
      WRITE(N6,3010) NAME
 3010 FORMAT(////,54X,10A4)
      WRITE(N6,3040) KDRY
 3040 FORMAT(///,54X,*NUMBER OF DRY HOURS*,/,57X,*BETWEEN EVENTS*,/,
     1   63X,I3)
      IF(IMET.EQ.0) GO TO 3035
      FMAX=FMAX*2.54
      FVOL=FVOL*2.54
      WRITE(N6,3037)  EVNTMA,FMAX,FVOL,DRYMAX
 3037 FORMAT(///,30X,*   MAXIMUM   *,3X,*  MAXIMUM HOURLY  *,3X,
     1 *  MAXIMUM VOLUME *,3X,*  MAXIMUM DRY *,/,30X,*EVENT LENGTH*,3X,
     2 *RAINFALL PER EVENT*,3X,*OF RAIN PER EVENT*,3X,*HOURS EXPECTED*,
     3 /,30X,* ( EVNTMA)*,10X,*(FMAX)*,14X,*(FVOL)*,13X,*(DRYMAX)*,//,
     4  30X,F5.1,* HOURS*,6X,F5.2,* CENTIMETERS*,4X,F5.2,* CENTIMETERS*,
     5 2X,F5.1,* HOURS*)
      FMAX=FMAX/2.54
      FVOL=FVOL/2.54
      GO TO 3034
3035  WRITE(N6,3030)  EVNTMA,FMAX,FVOL,DRYMAX
3030  FORMAT(///,30X,*   MAXIMUM   *,3X,*  MAXIMUM HOURLY  *,3X,
     1 *  MAXIMUM VOLUME *,3X,*  MAXIMUM DRY *,/,30X,*EVENT LENGTH*,3X,
     2 *RAINFALL PER EVENT*,3X,*OF RAIN PER EVENT*,3X,*HOURS EXPECTED*,
     3 /,30X,* ( EVNTMA)*,10X,*(FMAX)*,14X,*(FVOL)*,13X,*(DRYMAX)*,//,
     4  30X,F5.1,* HOURS*,6X,F5.2,* INCHES*,9X,F5.2,* INCHES*,7X,F5.1,
     5 * HOURS*)
 3034 CONTINUE
C
C******** CHECK INPUT DATA VARIABLES KDRY,  EVNTMA AND DRYMAX
C
      IF(KDRY.GE.1) GO TO 410
      WRITE(N6,3021)
```

```
 3021 FORMAT(////,1X,13H*** ERROR ***,*VARIABLE KDRY = 0, SIMULATION END
     1ED*)
      STOP 100
  410 IF( EVNTMA.GE.1.0) GO TO 415
      WRITE(N6,3023)
 3023 FORMAT(////,1X,13H*** ERROR ***,*EVENT ANALYSIS CANNOT BE DONE (EV
     1NTMAX = 0) SIMULATION ENDED*)
      STOP200
  415 IF( IDRYOP.EQ.1.AND.DRYMAX.EQ.0.0) GO TO 420
      GO TO 421
  420 WRITE(N6,3025)
 3025 FORMAT(////,1X,13H*** ERROR ***,*DRY HOUR OPTION SELECTED AND VARI
     1ABLE DRYMAX = 0, SIMULATION ENDED*)
      STOP 300
  421 CONTINUE
       EVNTMA= EVNTMA/FLOAT(K100)
      IF(DRYMAX.EQ.0.0) GO TO 10
      DRYMAX=DRYMAX/FLOAT(K100)
   10 IF(FVOL.EQ.0.0) GO TO 20
      FVOL=FVOL/FLOAT(K50)
   20 IF(FMAX.EQ.0.0) GO TO 30
      FMAX=FMAX/FLOAT(K50)
   30 KSTOP=KDRY
   50 READ(IT) MDAY,MYR,MO,MDY,(IRAIN(I),I=1,24)
55    IF(MYR.EQ.0) GO TO 900
C
C******** SEARCH HOURLY RAIN DATA FOR STORM EVENTS
C
   95 DO 800 I=1,24
      QDISCH(I)=FLOAT(IRAIN(I))
      IF (QDISCH(I)) 100,100,150
  100 KSTOP=KSTOP+1
      IF(KSTOP-KDRY) 170,200,800
  150 KSTOP =0
C
C******** DETERMINE PEAK HOURLY RAINFALL
      FAX=AMAX1(FAX,QDISCH(I))
C
C******** DETERMINE TOTAL STORM VOLUME
      VOL=VOL+QDISCH(I)
C
C******** COUNT LENGTH OF STORM EVENT
  170 LEN=LEN+1
      GO TO 800
C
C******** END OF STORM EVENT
  200 CALL FREQ
  800 CONTINUE
      IF( IDRYOP.EQ.0) GO TO 50
C
C******** DETERMINE THE NUMBER OF DRY HOURS BETWEEN WET HOURS
C
      DO 1000 I=1,24
      IF(IRAIN(I).GT.0.AND.DRYLEN.GT.0) GO TO 310
```

```
      IF(IRAIN(I).GT.0.AND.DRYLEN.EQ.0) GO TO 1000
      DRYLEN=DRYLEN+1
      GO TO 1000
C
C******** END OF DRY HOUR PERIOD
  310 CALL  DRYFRE
      DRYLEN=0
 1000 CONTINUE
      GO TO 50
C
C******** END OF RAIN DATA PRINT OUT RESULTS
C
  900 CALL OUTPUT
      RETURN
      END
```

Subroutine FREQ

- Called From
  - EVENT
- Common Blocks Used
  - /CNTRL/
  - /SERIES/
  - /RIDGWY/
  - /TREAD/
  - /BONA/

Subroutine FREQ has two entry points--FREQ and DRYFREQ. ENTRY FREQ is called by subroutine EVENT at the end of a rainfall event. ENTRY DRYFREQ is called by subroutine EVENT at the end of a dry period.

Each time subroutine FREQ is called, a rainfall event or dry period is recorded. More specifically, in each frequency analysis, subroutine FREQ is called to record the occurrence of the parameter in the appropriate class intervals established by the user-supplied maximum expected values. For example, for each event length the class interval which contains the specific event length is recorded as having another occurrence. Any values not covered by a class interval are lost from the frequency analysis.

If a frequency analysis for the peak hourly rainfall is to be done, subroutine FREQ records the occurrences in their proper class interval. When the variable FMAX is entered in input as zero, this section of subroutine FREQ is skipped.

The next section of subroutine FREQ records the occurrences of total rainfall volume of the event if the user requests the analysis. If the variable FVOL is entered in input as zero, subroutine FREQ skips this step.

If the dry-hour frequency analysis is requested, then ENTRY DRYFREQ of subroutine FREQ is called by subroutine EVENT at the end of each dry period.

Based on the maximum expected dry-hour length input by the user, class intervals are established. Each time a dry period occurs, its occurrence is recorded in the appropriate class interval.

The flow chart for subroutine FREQ is given in Figure IV-12 and is followed by Table IV-10 showing the key variables not in COMMON and by a program listing. All program variables in COMMON are defined in a later section of this chapter.

Subroutine OUTPUT

- Called by
  EVENT
- Common Blocks Used
  /CNTRL/
  /SERIES/
  /RIDGWY/
  /TREAD/
  /BONA/
  /LAB/
  /LABELS/
  /NOLAB/
- Subroutine Called
  CURVE

Subroutine OUTPUT calculates the frequency of occurrence for each class interval established by subroutine FREQ. The number of occurrences found in each class interval are divided by the total number of occurrences to calculate the frequency of occurrence. Subroutine CURVE is called by subroutine OUTPUT after the frequency values for event length have been determined. The plots generated by subroutine CURVE are cumulative frequency plots.

If the peak hourly and total rainfall values for each rainfall event have been stored, the frequency of occurrence for each class interval is calculated. Subroutine CURVE is again called to plot the cumulative frequency curve.

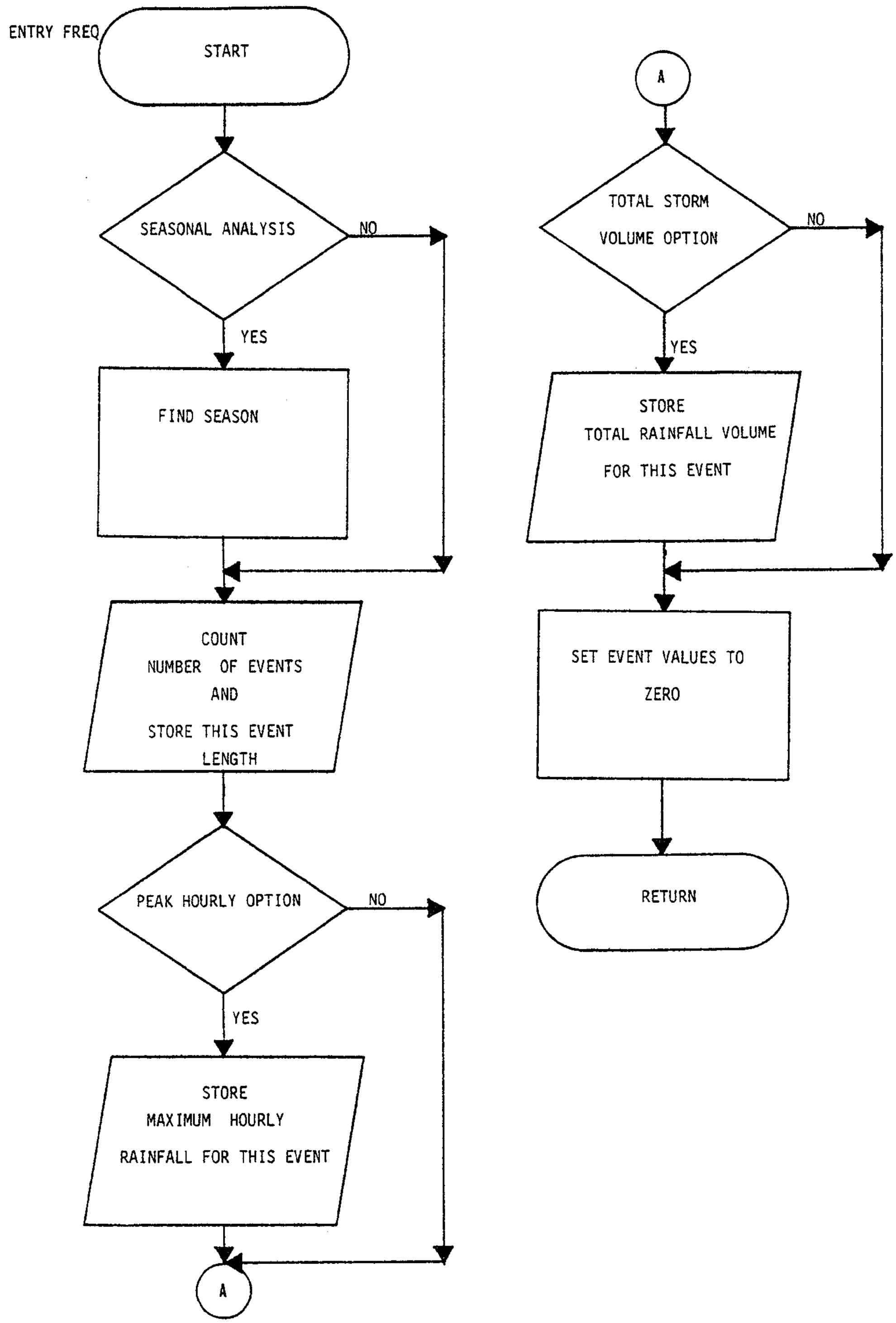

FIGURE IV-12

FLOW CHART FOR SUBROUTINE FREQ

ENTRY DRYFREQ

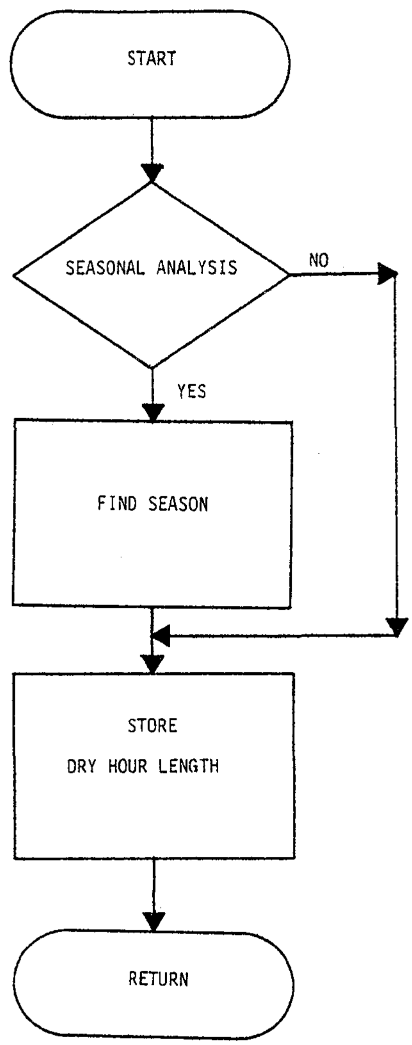

FIGURE IV-12

(continued)

TABLE IV-10

KEY VARIABLES FOR SUBROUTINE FREQ

FORTRAN VARIABLE	DEFINITION	UNITS
FINCR	Incremental Frequency Storage Counter	None
ISEAS	Event Seasonal Indicator	None
ISEASON	Dry-Hour Seasonal Indicator	None

```
      SUBROUTINE FREQ
C
C
C     ******************************************************************
C     *                                                                *
C     *   FREQ IS CALLED AT THE END OF A STORM EVENT AND CALCULATES    *
C     *   EXCEEDANCE FREQUENCIES FOR STORM LENGTH, PEAK HOURLY RAIN-   *
C     *   FALL, AND TOTAL STORM VOLUME ON AN ANNUAL AND SEASONAL BASIS.*
C     *   THE DRY HOUR FREQUENCY ANALYSIS ENTERS SUBROUTINE FREQ AT    *
C     *    DRYFRE                                                      *
C     *                                                                *
C     ******************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON /SEREES/ NYR,NDUR,DURTN(14),Y(744),MBG(12),MND(12),
     2MAXI(50,14),IDTI(50,10), MAXSEA(12,50,14),IDED(12,50,10),X(8784),
     3NOYRR,INDSEA,NOSEAS,INTYR,MOSEAS(12),MDAYBG(12),MOSEND(12),
     4 MDAYEN(12), IPARTO,M3
      COMMON/RIDGWY/SLEN(100,13),SMAX(100,13),SVOL(100,13),SDRY(100,13),
     1   FMAX,FVOL,DRYMAX,DRYLEN,KDRY,KLSS(5),K50,K100, EVNTMA
      COMMON /TREAD/ MDAY,MYR,MO,MDY,QDISCH(24)
      COMMON/BONA/ LEN,FAX,VOL,IEV,DRY
      INTEGER DRYLEN
C
C******** FIND SEASON IF INDSEA = 1
C
      IF(INDSEA.LE.0) GO TO 115
      ISEAS=0
  110 DO 100 I=1,NOSEAS
      IF(MOSEND(I).LT.MOSEAS(I)) GO TO 102
      IF(MO.GT.MOSEAS(I).AND.MO.LT.MOSEND(I)) ISEAS=I
      IF(MO.EQ.MOSEAS(I).AND.MDY.GE.MDAYBG(I)) ISEAS=I
      IF(MO.EQ.MOSEND(I).AND.MDY.LE. MDAYEN(I)) ISEAS=I
      IF(ISEAS.NE.0) GO TO 103
      GO TO 100
  102 IF(MO.GT.MOSEAS(I).AND.MO.LE.12) ISEAS=I
      IF(MOSEAS(I).EQ.MO) GO TO 104
      GO TO 105
  104 IF(MDY.GE.MDAYBG(I)) ISEAS=I
  105 IF(MO.GE.1.AND.MO.LT.MOSEND(I)) ISEAS=I
      IF(MO.EQ.MOSEND(I)) GO TO 106
      GO TO 107
  106 IF(MDY.LE. MDAYEN(I)) ISEAS=I
  107 IF(ISEAS.NE.0) GO TO 103
  100 CONTINUE
  103 IF(ISEAS.EQ.0) GO TO 110
      ISEAS=ISEAS+1
  115 CONTINUE
C
C******** COUNT THE NUMBER OF STORM EVENTS AND ADJUST THE LENGTH FOR
C******** THE DRY PERIOD (KDRY) FOLLOWING THE EVENT
```

```
C
      IEV=IEV+1
      LEN=LEN-KDRY+1
C
C******** STORE EVENT LENGTHS
C
      FINCR=0.
      DO 250 J=1,K100
      FINCR=FINCR+ EVNTMA
      TEMP2=FLOAT(LEN)
      IF(TEMP2-FINCR) 200,200,250
  250 CONTINUE
      KLSS(1)=KLSS(1)+1
      GO TO 300
  200 IF(INDSEA.EQ.0) GO TO 202
      SLEN(J,ISEAS)=SLEN(J,ISEAS)+1.
  202 SLEN(J,1)=SLEN(J,1)+1.
  300 FINCR=0.
      IF(FMAX.EQ.0.0) GO TO 550
C
C******** STORE MAXIMUM HOURLY RAINFALL
C
      FAX=FAX/100.
      DO 400 J=1,K50
      FINCR=FINCR+FMAX
      IF (FAX-FINCR) 500,500,400
  400 CONTINUE
      KLSS(2)=KLSS(2)+1
      GO TO 550
  500 IF(INDSEA.EQ.0) GO TO 502
      SMAX(J,ISEAS)=SMAX(J,ISEAS)+1.
  502 SMAX(J,1)=SMAX(J,1)+1.
  550 FINCR=0.
      IF(FVOL.EQ.0.0) GO TO 900
C
C******** STORE MAXIMUM RAIN VOLUME PER EVENT
C
      VOL=VOL/100.
      DO 600 J=1,K50
      FINCR=FINCR+FVOL
      IF (VOL-FINCR)650,650,600
  600 CONTINUE
      KLSS(3)=KLSS(3)+1
      GO TO 900
  650 IF(INDSEA.EQ.0) GO TO 652
      SVOL(J,ISEAS)=SVOL(J,ISEAS)+1.
  652 SVOL(J,1)=SVOL(J,1)+1.
C
C******** SET EVENT VALUES TO ZERO
C
  900 LEN=0
      FAX=0.
      VOL=0.
      RETURN
```

```
C
C******** FREQUENCY CACULATIONS FOR DRY HOURS ONLY
C
      ENTRY  DRYFRE
C
C******** FIND SEASON IF INDSEA = 1
C
      IF(INDSEA.LE.0) GO TO 815
       ISEASO=0
  810 DO 800 I=1,NOSEAS
      IF(MOSEND(I).LT.MOSEAS(I)) GO TO 802
      IF(MO.GT.MOSEAS(I).AND.MO.LT.MOSEND(I))  ISEASO=I
      IF(MO.EQ.MOSEAS(I).AND.MDY.GE.MDAYBG(I))  ISEASO=I
      IF(MO.EQ.MOSEND(I).AND.MDY.LE. MDAYEN(I))  ISEASO=I
      IF( ISEASO.NE.0) GO TO 803
      GO TO 800
  802 IF(MO.GT.MOSEAS(I).AND.MO.LE.12)  ISEASO=I
      IF(MOSEAS(I).EQ.MO) GO TO 804
      GO TO 805
  804 IF(MDY.GE.MDAYBG(I))  ISEASO=I
  805 IF(MO.GE.1.AND.MO.LT.MOSEND(I))  ISEASO=I
      IF(MO.EQ.MOSEND(I)) GO TO 806
      GO TO 807
  806 IF(MDY.LE. MDAYEN(I))  ISEASO=I
  807 IF( ISEASO.NE.0) GO TO 803
  800 CONTINUE
  803 IF( ISEASO.EQ.0) GO TO 810
       ISEASO= ISEASO+1
C
C******** STORE NUMBER OF DRY HOURS
C
  815 FINCR=0.
      DRY=DRY+1.
      TEMP3=FLOAT(DRYLEN)
      DO 750 J=1,K100
      FINCR=FINCR+DRYMAX
      IF(TEMP3-FINCR) 700,700,750
  750 CONTINUE
      KLSS(4)=KLSS(4)+1
      GO TO 710
  700 IF(INDSEA.EQ.0) GO TO 702
      SDRY(J, ISEASO)=SDRY(J, ISEASO)+1.
  702 SDRY(J,1)=SDRY(J,1)+1.
  710 CONTINUE
      RETURN
      END
```

If the user requests a dry-hour frequency analysis, the same procedure is followed to generate the frequency statistics and the cumulative frequency plot.

The flow chart for OUTPUT is presented in Figure IV-13 and is followed by Table IV-11 showing the key variables not in COMMON and by a program listing. All program variables in COMMON are defined in a later section of this chapter.

Subroutine STRMSK

- Called From
  ANALYZE
- Common Blocks Used
  /CNTRL/
  /SERIES/

Subroutine STRMSK performs the rainfall pattern skew analysis. Specifically, STRMSK searches the RAINT precipitation file and finds the largest storms. It then calculates the average skew for these storms and if a seasonal analysis is requested, segregates the storms into seasons and finds the average skew of the storms in each season.

The flow chart for STRMSK is given in Figure IV-14 and is followed by Table IV-12 showing the key variables not in COMMON and by a program listing. All program variables in COMMON are defined in a later section of this chapter.

Subroutine CURVE, SCALE, PINE and PPLOT

In Program Path 3, the plotting routines are called to produce the following:

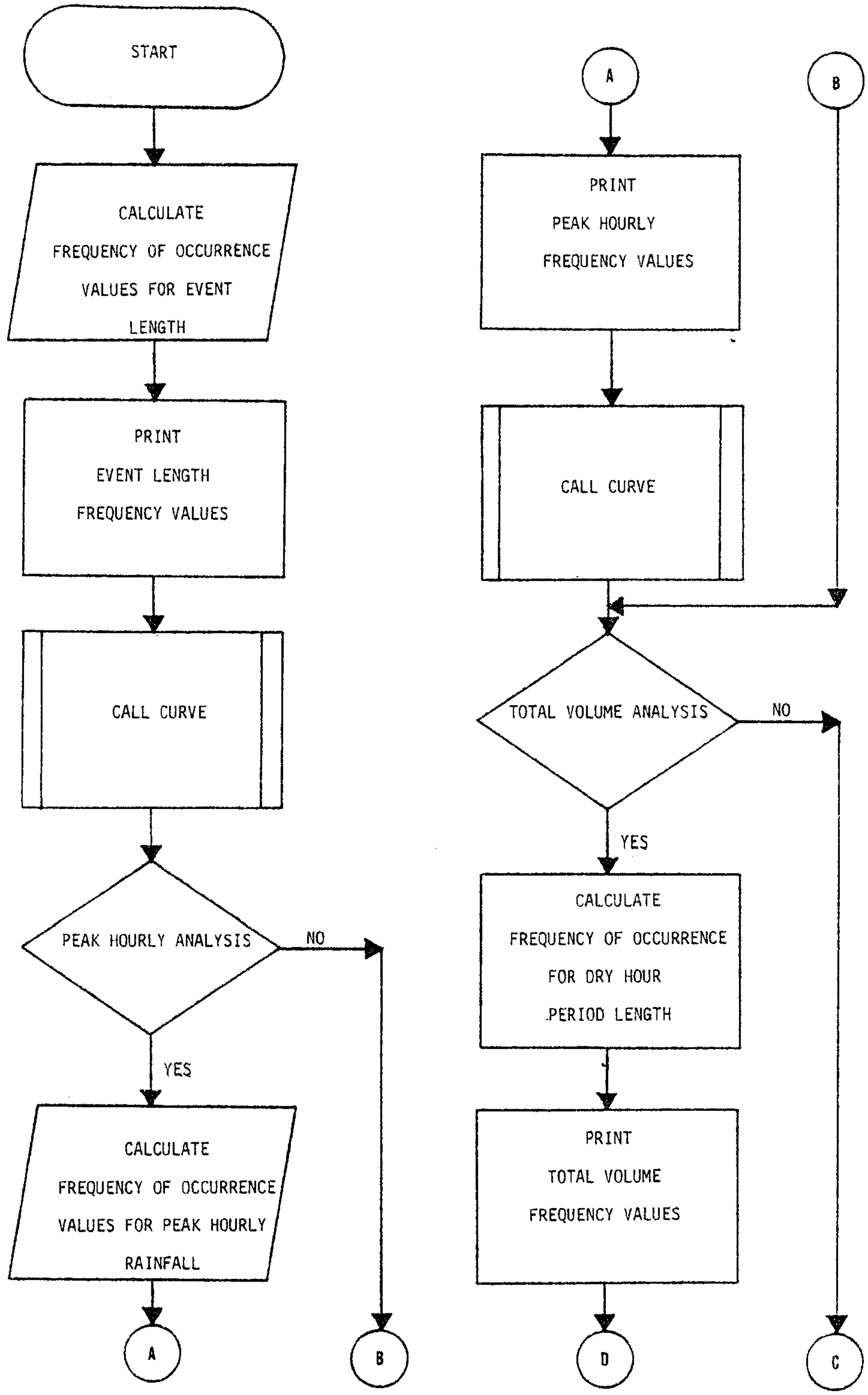

FIGURE IV-13

FLOW CHART FOR SUBROUTINE OUTPUT

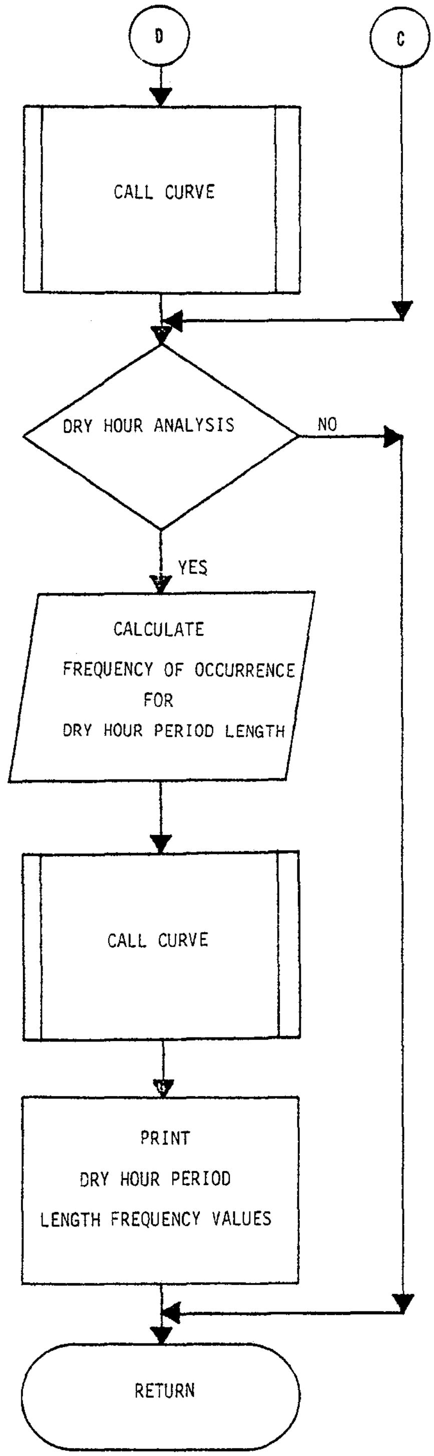

FIGURE IV-13

(continued)

TABLE IV-11

KEY VARIABLES NOT IN COMMON

AND IN SUBROUTINE OUTPUT

FORTRAN VARIABLE	DESCRIPTION	UNITS
FINCR	Incremental Storage Counter	None
NSPA	Counter for number of seasons plus annual	None

```
      SUBROUTINE OUTPUT
C
C
C     ******************************************************************
C     *                                                                *
C     *   OUTPUT IS CALLED AT THE END OF THE RAIN DATA AND PRINTS THE  *
C     *   STORM LENGTH, MAXIMUM HOURLY RAINFALL, TOTAL RAINFALL VOLUME *
C     *   AND THE DRY HOUR PERIODS IN TABULAR FORM. THE OUTPUT CAN BE  *
C     *   DONE ON AN ANNUAL AND SEASONAL BASIS. OUTPUT CALLS THE PLOT- *
C     *   TING ROUTINE CURVE.                                          *
C     *                                                                *
C     ******************************************************************
C
C
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON /SEREES/ NYR,NDUR,DURTN(14),Y(744),MBG(12),MND(12),
     2MAXI(50,14),IDTI(50,10), MAXSEA(12,50,14),IDED(12,50,10),X(8784),
     3NOYRR,INDSEA,NOSEAS,INTYR,MOSEAS(12),MDAYBG(12),MOSEND(12),
     4 MDAYEN(12), IPARTO,M3
      COMMON/RIDGWY/SLEN(100,13),SMAX(100,13),SVOL(100,13),SDRY(100,13),
     1   FMAX,FVOL,DRYMAX,DRYLEN,KDRY,KLSS(5),K50,K100, EVNTMA
      COMMON /TREAD/ MDAY,MYR,MO,MDY,QDISCH(24)
      COMMON/BONA/ LEN,FAX,VOL,IEV,DRY
      COMMON/LABELS/ TOP(10),BOTTOM(10),SIDE(50)
      COMMON/NOLAB/ TP1(10),SID1(50),BT1(10),BT2(10),BT3(10),BT4(10),
     1BT2M(10),BT3M(10)
      COMMON /LAB/ TITLE(18),XLAB(11),YLAB(6),HORIZ(20),VERT(6)
      INTEGER DRYLEN
      IF(INDSEA) 700,700,701
  701 NSPA=NOSEAS+1
      GO TO 705
  700 NSPA=1
  705 DO 200 J=1,NSPA
C
C******** OUTPUT LENGTHS OF STORMS
C
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
 1001 FORMAT(//,1X,20(2H* ),44H FREQUENCY ANALYSIS FOR LENGTH OF RAINFAL
     1L   ,21(2H* ))
 1000 FORMAT(//,3X,4(3X,4HTIME,6X,5HOCCUR,6X,4HFREQ,2X))
 1035 FORMAT(55X,*ANNUAL*)
 1036 FORMAT(55X,*SEASON*,I3)
      IS=0
      FINCR=0.
      DO 100 I=1,K100
      IS=IS+SLEN(I,J)
      X(I)=FLOAT(I)* EVNTMA
  100 CONTINUE
      IF(IS.LE.0) GO TO 200
```

```
      WRITE(N6,2999)
      WRITE(N6,1001)
      IF(J.EQ.1) WRITE(N6,1035)
      JJ=J-1
      IF(JJ.GE.1) WRITE(N6,1036)JJ
      WRITE(N6,1000)
      DO 110 I=1,K100
      Y(I)=SLEN(I,J)/FLOAT(IS)
  110 CONTINUE
      DO 120 I=1,K100,4
      K1=I
      K2=I+3
      IF (K2 . GT. K100)  K2=K100
      WRITE(N6,1020) (X(K),SLEN(K,J),Y(K),K=K1,K2)
 1020 FORMAT(1X,4(3F10.3))
  120 CONTINUE
      FINCR=0.
      DO 130 I=1,K100
      FINCR=Y(I)+FINCR
      Y(I)=FINCR
  130 CONTINUE
      IF(J.EQ.1) WRITE(N6,1030) IEV
 1030 FORMAT(///////////////,44X,*TOTAL NUMBER OF ANNUAL STORM EVENTS=*,
     1  I5)
C
C******** PREPARE FOR PLOTTING ROUTINES
C
      WRITE(N6,2999)
      WRITE(N6,1001)
      IF(J.EQ.1) WRITE(N6,1035)
      IF(JJ.GE.1) WRITE(N6,1036) JJ
      DO 150 L=1,10
      TOP(L)=TP1(L)
      BOTTOM(L)=BT1(L)
  150 CONTINUE
      DO 155 L=1,50
      SIDE(L)=SID1(L)
  155 CONTINUE
      CALL CURVE(X,Y,K100,1,0,1,0,2)
  200 CONTINUE
      IF(FMAX.EQ.0.0) GO TO 450
C
C******** OUTPUT PEAK RAINFALL PER EVENT
C
C******** SET OUTPUT METRIC OR ENGLISH UNITS FOR TABLES
      IF(IMET.GT.0) GO TO 170
      KUNIT1=5HIN/HR
      KUNIT2=3HIN.
      KUNIT3=4H(IN)
      GO TO 180
170   KUNIT1=5HMM/HR
      KUNIT2=3HMM.
      KUNIT3=4H(MM)
180   DO 400 J=1,NSPA
 1025 FORMAT(//,1X,20(2H* ),37HFREQUENCY ANALYSIS OF PEAK RAINFALL   ,1H(
     1,A5,1H),1X,20(2H* ))
```

```
 1026 FORMAT(//,1X,4(5X,A5,5X,5HOCCUR,6X,4HFREQ))
      IS=0
      FINCR=0.
      DO 300 I=1,K50
      IS=IS+SMAX(I,J)
      X(I)=FLOAT(I)*FMAX
  300 CONTINUE
      IF(IS.LE.0) GO TO 400
      WRITE(N6,2999)
      WRITE(N6,1025) KUNIT1
      IF(J.EQ.1) WRITE(N6,1035)
      JJ=J-1
      IF(JJ.GE.1) WRITE(N6,1036)JJ
      WRITE(N6,1026) KUNIT1
      DO 310 I=1,K50
      Y(I)=SMAX(I,J)/FLOAT(IS)
  310 CONTINUE
      DO 320 I=1,K50,4
      K1=I
      K2=I+3
      IF (K2 .GT. K50) K2=K50
      DO 315 K=K1,K2
      IF(IMET.GT.0) X(K)=X(K)*25.4
315   WRITE(N6,1020) (X(K),SMAX(K,J),Y(K))
  320 CONTINUE
      FINCR=0.
      DO 330 I=1,K50
      FINCR=FINCR+Y(I)
      Y(I)=FINCR
  330 CONTINUE
      IF(J.EQ.1) WRITE(N6,1030) IEV
C
C******** PREPARE FOR PLOTTING ROUTINES
C
      WRITE(N6,2999)
      WRITE(N6,1025) KUNIT1
      IF(J.EQ.1) WRITE(N6,1035)
      IF(JJ.GE.1) WRITE(N6,1036) JJ
      DO 350 L=1,10
      IF(IMET.EQ.0) GO TO 349
      BOTTOM(L)=BT2M(L)
      GO TO 350
349   BOTTOM(L)=BT2(L)
  350 CONTINUE
      CALL CURVE(X,Y,K50,1,0,1,0,2)
      IF(IMET.EQ.0) GO TO 352
      DO 351 K=K1,K2
  351 X(K)=X(K)/25.4
  352 CONTINUE
  400 CONTINUE
  450 IF(FVOL.EQ.0.0) GO TO 650
C
C******** OUTPUT TOTAL RAINFALL PER EVENT
C
      DO 600 J=1,NSPA
```

```
 1028 FORMAT(//,1X,20(2H* ),42H FREQUENCY ANALYSIS OF TOTAL RAIN VOLUME
     1 ,A4,1X,22(2H* ))
 1029 FORMAT(//,2X,4(5X,A3,5X,5HOCCUR,6X,4HFREQ,2X))
      IS=0
      FINCR=0.
      DO 500 I=1,K50
      IS =IS+SVOL(I,J)
      X(I)=FLOAT(I)*FVOL
  500 CONTINUE
      IF(IS.LE.0) GO TO 600
      WRITE(N6,2999)
      WRITE(N6,1028) KUNIT3
      IF(J.EQ.1) WRITE(N6,1035)
      JJ=J-1
      IF(JJ.GE.1) WRITE(N6,1036)JJ
      WRITE(N6,1029) KUNIT2
      DO 510 I=1,K50
      Y(I)=SVOL(I,J)/FLOAT(IS)
  510 CONTINUE
      DO 520 I=1,K50,4
      K1=I
      K2=I+3
      IF (K2 .GT. K50) K2=K50
      DO 525 K=K1,K2
      IF(IMET.GT.0) X(K)=X(K)*25.4
525   WRITE(N6,1020) (X(K),SVOL(K,J),Y(K))
  520 CONTINUE
      FINCR=0.
      DO 530 I=1,K50
      FINCR=FINCR+Y(I)
      Y(I)=FINCR
  530 CONTINUE
      IF(J.EQ.1) WRITE(N6,1030) IEV
C
C******** PREPARE FOR PLOTTING ROUTINES
C
      WRITE(N6,2999)
      WRITE(N6,1028) KUNIT3
      IF(J.EQ.1) WRITE(N6,1035)
      IF(JJ.GE.1) WRITE(N6,1036) JJ
      DO 550 L=1,10
      IF(IMET.EQ.0) GO TO 555
      BOTTOM(L)=BT3M(L)
      GO TO 550
555   BOTTOM(L)=BT3(L)
  550 CONTINUE
      CALL CURVE(X,Y,K50,1,0,1,0,2)
      IF(IMET.EQ.0) GO TO 602
      DO 601 K=K1,K2
  601 X(K)=X(K)/25.4
  602 CONTINUE
  600 CONTINUE
  650 IF( IDRYOP.EQ.0) GO TO 900
```

```
C
C******** OUTPUT DRY HOUR LENGTHS
C
      WRITE(N6,2999)
      WRITE(N6,2020)
 2020 FORMAT(///////////////////////////,1X,24(2H--),* DRY HOUR FREQUENCY
     1 ANALYSIS *,25(2H--))
      DO 220 J=1,NSPA
      IS=0
      FINCR=0.
      DO 210 I=1,K100
      IS=IS+SDRY(I,J)
      X(I)=FLOAT(I)*DRYMAX
  210 CONTINUE
      IF(IS.LE.0) GO TO 220
      WRITE(N6,2999)
      WRITE(N6,1002)
 1002 FORMAT(//,1X,20(2H* ),44H FREQUENCY ANALYSIS FOR LENGTH OF DRY HOU
     1RS ,21(2H* ))
      IF(J.EQ.1) WRITE(N6,1035)
      JJ=J-1
      IF(JJ.GE.1) WRITE(N6,1036)JJ
      WRITE(N6,1000)
      DO 230 I=1,K100
      Y(I)=SDRY(I,J)/FLOAT(IS)
  230 CONTINUE
      DO 240 I=1,K100,4
      K1=I
      K2=I+3
      IF(K2.GT.K100) K2=K100
      WRITE(N6,1003) (X(K),SDRY(K,J),Y(K),K=K1,K2)
 1003 FORMAT( 1X,4(3F10.3))
  240 CONTINUE
      FINCR=0.
      DO 250 I=1,K100
      FINCR=Y(I)+FINCR
      Y(I)=FINCR
  250 CONTINUE
      IF(J.EQ.1) WRITE(N6,1033) DRY
 1033 FORMAT(////////////////,38X,*TOTAL NUMBER OF ANNUAL DRY HOUR PERIOD
     1S=*,F5.0)
C
C******** PREPARE FOR PLOTTING ROUTINES
C
      WRITE(N6,2999)
      WRITE(N6,1002)
      IF(J.EQ.1) WRITE(N6,1035)
      IF(JJ.GE.1) WRITE(N6,1036) JJ
      DO 260 L=1,10
      BOTTOM(L)=BT4(L)
  260 CONTINUE
      CALL CURVE(X,Y,K100,1,0,1,0,2)
  220 CONTINUE
  900 CONTINUE
```

```
C
C******** CHECK FREQUENCY DATA FOR LOST VALUES
C
      WRITE(N6,2999)
      DO 800 I=1,5
      IF(KLSS(I).LE.0) GO TO 800
      GO TO (810,820,830,840,850), I
  810 WRITE(N6,815) KLSS(I)
  815 FORMAT(///,1X,15H*** WARNING ***,*FREQUENCY PLOT FOR EVENT LENGTH
     1HAS LOST*,I4,*VALUES, INCREASE VARIABLE  EVNTMA*)
      GO TO 800
  820 WRITE(N6,825) KLSS(I)
  825 FORMAT(///,1X,15H*** WARNING ***,*FREQUENCY PLOT FOR MAX HOURLY RA
     1INFALL HAS LOST*,I4,*VALUES, INCREASE VARIABLE FMAX*)
      GO TO 800
  830 WRITE(N6,835) KLSS(I)
  835 FORMAT(///,1X,15H*** WARNING ***,*FREQUENCY PLOT FOR MAX VOLUME OF
     1 RAIN HAS LOST*,I4,*VALUES, INCREASE VARIABLE FVOL*)
      GO TO 800
  840 WRITE(N6,845) KLSS(I)
  845 FORMAT(///,1X,15H*** WARNING ***,*FREQUENCY PLOT FOR MAX DRY HOURS
     1 EXPECTED HAS LOST*,I4,*VALUES, INCREASE VARIABLE DRYMAX*)
  850 GO TO 800
  800 CONTINUE
      RETURN
      END
```

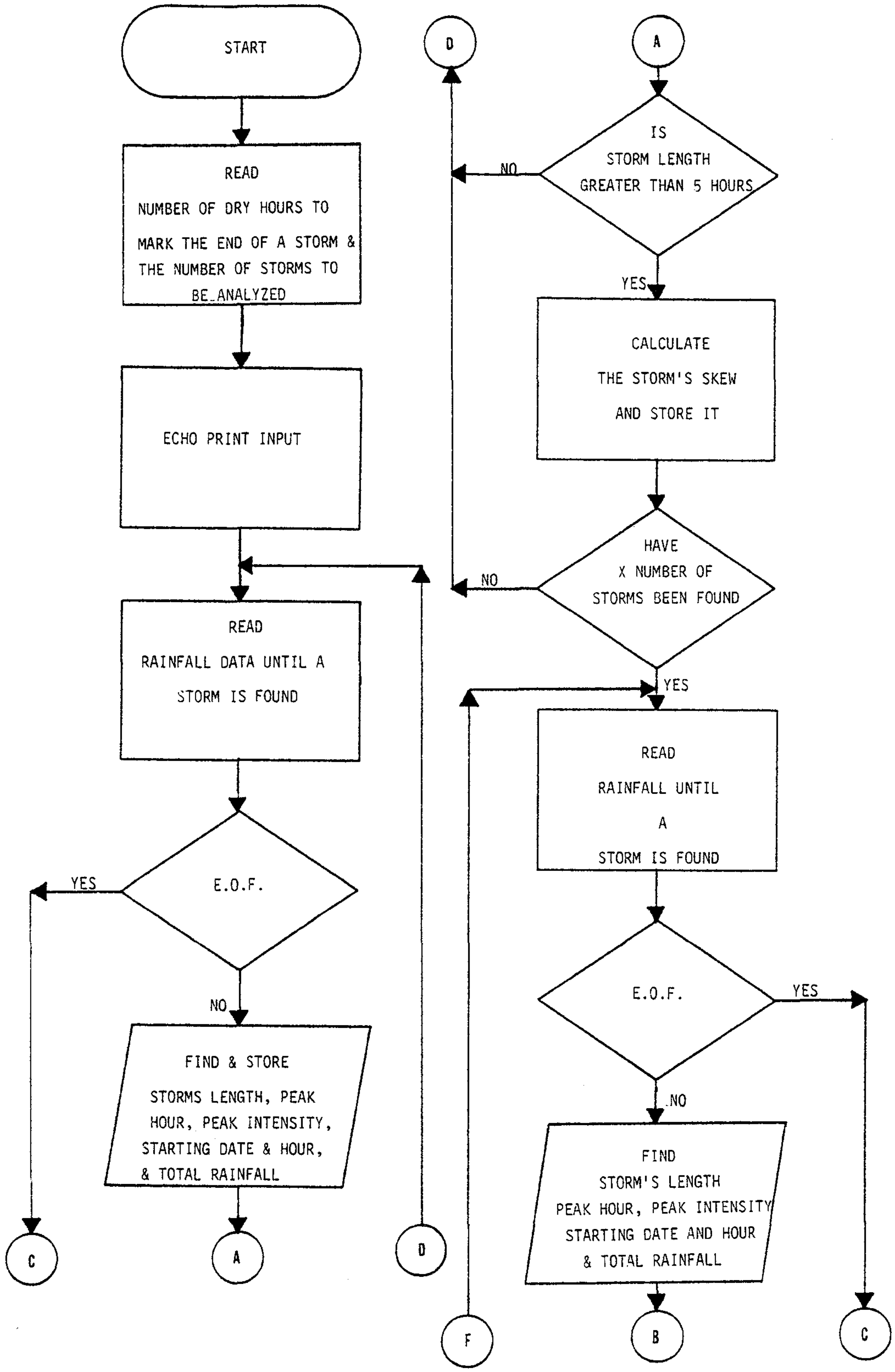

FIGURE IV-14

FLOW CHART FOR SUBROUTINE STRMSK

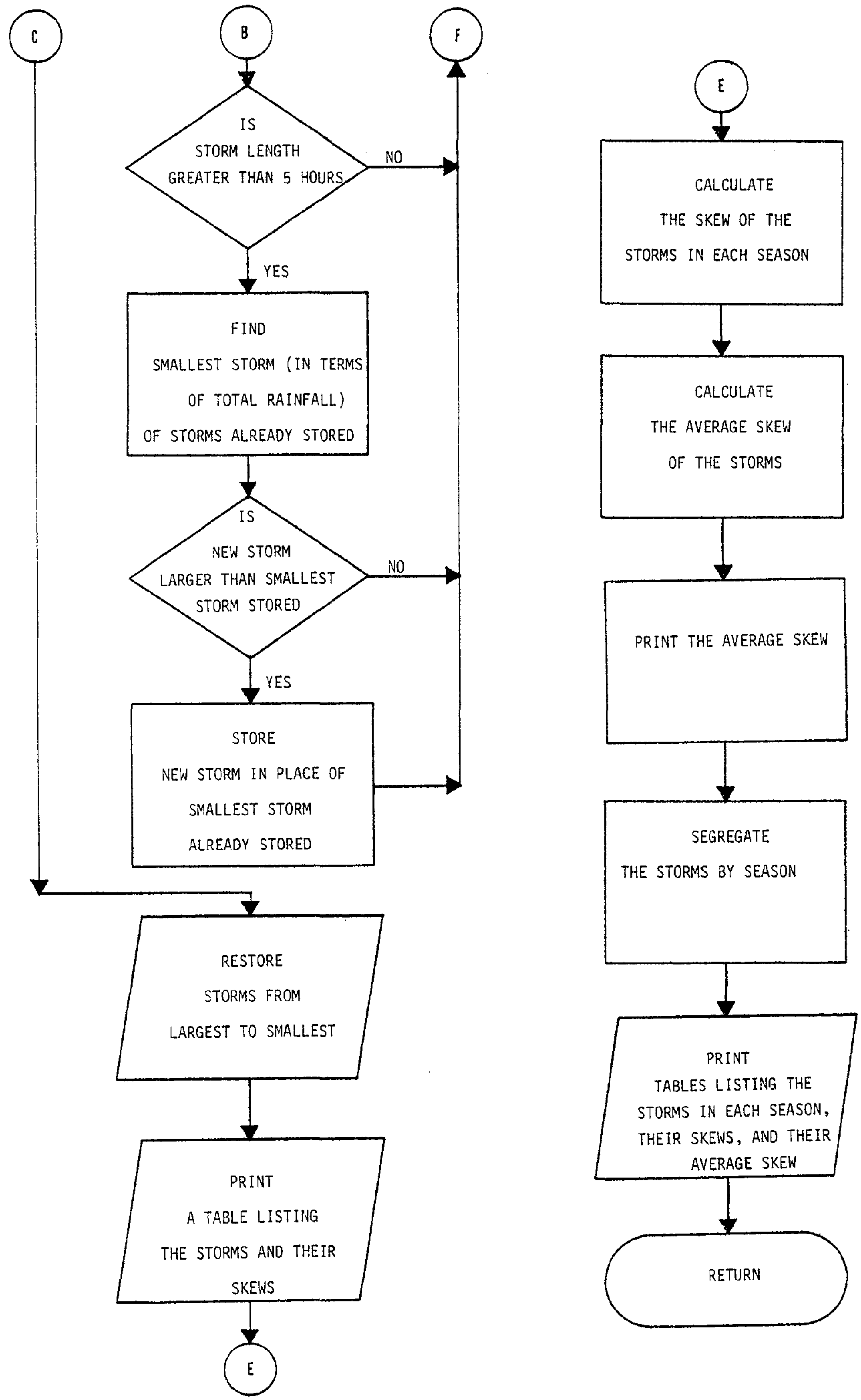

FIGURE IV-14

(continued)

TABLE IV-12

KEY VARIABLES NOT IN COMMON AND IN SUBROUTINE STRMSK

VARIABLE NAME	DESCRIPTION	UNITS
INSTRMND	No. of dry hours that must pass to indicate a storm is over	None
NSTRM	No. of storms to be analyzed	None
SKEW (50)	Skew storage array	None
IPEAK (50)	Peak intensity storage array	.01 In./Hr.
IPEKHR (50)	Peak hour storage array	None
MAXSTRM (50)	Total rainfall storage array	In./100
ILENGTH (50)	Storm duration array	Hours
IDATE (50,4)	Starting date and hour array	None
ISEASKW (12,50,8)	Seasonal storm parameter storage array	None
SEASKEW (12,50)	Seasonal storm skew storage array	None
NSTRMCT (12)	Seasonal storm counter array	None

```
      SUBROUTINE  STRMSK
C
C
C     ****************************************************************
C     *                                                              *
C     *   THIS SUBROUTINE TAKES A RAINFALL DATA TAPE PREPARED BY     *
C     *   SUBROUTINE RAINT, SELECTS THE LARGEST (IN TERMS OF TOTAL   *
C     *   RAINFALL) X NUMBER OF STORMS OF A DURATION GREATER THAN    *
C     *   OR EQUAL TO 5 HOURS, AND CALCULATES THEIR AVERAGE SKEW     *
C     *   - IF A SEASONAL ANALYSIS IS SELECTED, IT THEN SEGREGATES THE *
C     *   X NUMBER OF STORMS BY SEASON AND CALCULATES THE AVERAGE    *
C     *   SKEW OF THE STORMS IN EACH SEASON                          *
C     *                                                              *
C     ****************************************************************
C
C
      COMMON/CNTRL/N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL, IMET
      COMMON /SEREES/ NYR,NDUR,DURTN(14),Y(744),MBG(12),MND(12),
     2MAXI(50,14),IDTI(50,10), MAXSEA(12,50,14),IDED(12,50,10),X(8784),
     3NOYRR,INDSEA,NOSEAS,INTYR,MOSEAS(12),MDAYBG(12),MOSEND(12),
     4 MDAYEN(12), IPARTO,M3
      DIMENSION  MAXSTR(50),IPEAK(50), ILENGT(50),IPKHR(50),SKEW(50),
     2IDATE(50,4)
      DIMENSION  ISEASK(12,50,8), SEASKE(12,50), NSTRMC(12)
      INTEGER Y
      REWIND IT
C
C********  READ THE NUMBER OF DRY HOURS THAT INDICATE THE END OF A STORM
C********  ( ISTRMN) AND THE NUMBER OF STORMS TO BE  ANALYZD (NSTRM)
C
      READ(N5,1)  ISTRMN,NSTRM
1     FORMAT(2I8)
C
C********  ECHO PRINT THE INPUT DATA AND INITIALIZE VARIABLES
C
      WRITE(N6,2999)
2999  FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
     2**  URBAN HIGHWAY DRAINAGE MODEL  ****,8X,*WATER RESOURCES ENGINEE
     3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
     4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
     5****,6X,*PRECIPITATION MODULE*,6X,4H****,8X,*SPRINGFIELD, VIRGINIA
     6*)
      WRITE(N6,30)  ISTRMN,NSTRM
30    FORMAT(/////////////////////////////* *,56(*-*),* SKEW ANALYSIS *,57(
     2*-*)//* *,43X,*STORMS ARE DEFINED BY*,I3,* HOUR DRY PERIODS*//* *,
     341X,I3,* STORMS WERE SELECTED FOR THE SKEW ANALYSIS*)
      WRITE(N6,4000)
4000  FORMAT(///* *,31X,12H*** NOTE ***,* PEAK INTENSITIES EQUAL MAX. CL
     1OCK HR. IN STORM X 1.13*)
      IF( ISTRMN.LT.1) WRITE(N6,7000)
7000  FORMAT(//* *,13H*** ERROR ***,* THE NO. OF DRY HOURS SELECTED TO M
     2ARK THE END OF A STORM MAKES THE SKEW ANALYSIS IMPOSSIBLE*/* *,14X
     3,*-THE MINIMUM NO. OF DRY HOURS IS 1-THE RUN IS ABORTED*)
      IF( ISTRMN.LT.1) STOP
```

```
      IF(NSTRM.GT.50) WRITE(N6,7001)
7001  FORMAT(//* *,13H*** ERROR ***,* THE NO. OF STORMS SELECTED FOR ANA
     2LYSIS EXCEEDS THE PROGRAMS CAPACITY*/* *,14X,*-THE MAXIMUM NO. OF
     3STORMS IN THE SKEW ANALYSIS IS 50-THE RUN IS ABORTED*)
      IF(NSTRM.GT.50) STOP
      SKEW(1)=0.0
      IPEAK(1)=-999
      IPKHR(1)=0
       MAXSTR(1)=0
       ILENGT(1)=0
C
C********  K IS THE STORM COUNTER
      K=1
C
C********  M IS THE DRY HOUR COUNTER
      M=0
C
C********  J IS THE STORM HOUR COUNTER
      J=0
C
C
C********  FIND THE FIRST X NO. OF STORMS AND STORE THEM
C
C
3     READ(IT) A,IYR,MO,IDAY,(Y(I),I=1,24)
      IF(EOF(IT)) 42,41
41    IF(IYR.EQ.0) GO TO 42
C
C********  EXAMINE EACH HOUR OF RAINFALL DATA
C
      DO 4 I=1,24
      IF(Y(I).EQ.0.AND.J.EQ.0) GO TO 4
      IF(Y(I).EQ.0) GO TO 5
      IF(J.EQ.0) GO TO 6
      GO TO 7
C
C********  IF THE HOUR IS THE FIRST HOUR IN A STORM, STORE THE DATE
C********  AND HOUR
6     IDATE(K,1)=IYR
      IDATE(K,2)=MO
      IDATE(K,3)=IDAY
      IDATE(K,4)=I
C
C********  FOR HOURS WITH RAINFALL, CHECK TO SEE IF THE HOURS RAINFALL
C********  IS THE PEAK IN A STORM
7     J=J+1
      IF(IPEAK(K).LT.(Y(I)*1.13)) GO TO 11
      GO TO 12
C
C********  CONVERT THE PEAK CLOCK HOUR RAINFALL TO THE PEAK 60 MINUTE
C********  RAINFALL AND STORE IT ALONG WITH THE NO. OF THE HOUR IN WHICH
C********  IT OCCURED
11    IPEAK(K)=Y(I)*1.13
      IPKHR(K)=J
C
```

```
C********  ADD THE HOURS RAINFALL TO A STORMS TOTAL RAINFALL AND STORE
C********  THE TOTAL RAINFALL
12      MAXSTR(K)= MAXSTR(K)+Y(I)
C
C********  RESET THE DRY HOUR COUNTER TO ZERO
      M=0
      GO TO 4
C
C********  FOR HOURS WITH 0 RAINFALL, INCREASE THE STORM HOUR AND DRY
C********  HOUR COUNTERS BY ONE
5     M=M+1
      J=J+1
C  '
C********  IF THE DRY HOUR COUNTER EQUALS  ISTRMN GO TO 8
      IF(M.GE. ISTRMN) GO TO 8
      GO TO 4
C
C********  DETERMINE A STORMS DURATION AND STORE IT
8       ILENGT(K)=J- ISTRMN
C
C********  IF A STORM IS LESS THAN 5 HOURS IN DURATION, LOOK FOR THE
C********  NEXT STORM
      IF( ILENGT(K).LT.5) GO TO 10
C
C********  CALCULATE A STORMS SKEW AND STORE IT
      SKEW(K)=IPKHR(K)*1.0/ ILENGT(K)
      IF(IPKHR(K).EQ.1) SKEW(K)=0.0
      K=K+1
C
C********  IF THE FIRST X NO. OF STORMS HAS BEEN FOUND, GO TO 20
C
      IF(K.GT.NSTRM) GO TO 20
10    J=0
      M=0
       MAXSTR(K)=0
      IPEAK(K)=-999
      IPKHR(K)=0
       ILENGT(K)=0
      SKEW(K)=0.0
4     CONTINUE
      GO TO 3
C
C
C********  FINISH SEARCHING THE RAINFALL RECORD FOR STORMS- IF ANY OF
C********  THE STORMS FOUND IS LARGER THAN THE SMALLEST OF THE X NO.
C********  OF STORMS ALREADY STORED, STORE THE LARGER STORM IN PLACE
C********  OF THE SMALLER STORM
C
C
20      MINSTR=9999
      I=I+1
      J=0
      M=0
      IPK=-999
      MMAX=0
```

```
      MPKHR=0
      SKEWW=0.0
      LENGTH=0
      IF(I.EQ.25) GO TO 200
      GO TO 201
202   I=1
C
C********  FIND AND CHARACTERIZE THE NEXT STORM
C
201   DO 104 N=I,24
      IF(Y(N).EQ.0.AND.J.EQ.0) GO TO 104
      IF(Y(N).EQ.0) GO TO 105
      IF(J.EQ.0) GO TO 106
      GO TO 107
106   IYEAR=IYR
      MONTH=MO
      IDAE=IDAY
      IHOUR=N
107   J=J+1
      IF(IPK.LT.(Y(N)*1.13)) GO TO 111
      GO TO 112
111   IPK=Y(N)*1.13
      MPKHR=J
112   MMAX=MMAX+Y(N)
      M=0
      GO TO 104
105   M=M+1
      J=J+1
      IF(M.GE. ISTRMN) GO TO 108
      GO TO 104
108   LENGTH=J- ISTRMN
      IF(LENGTH.LT.5) GO TO 99
      SKEWW=MPKHR*1.0/LENGTH
      IF(MPKHR.EQ.1) SKEWW=0.0
      IF( MINSTR.NE.9999) GO TO 302
C
C********  FIND THE SMALLEST STORM OF THE STORMS ALREADY STORED
C
      DO 300 K=1,NSTRM
      IF( MAXSTR(K).LT. MINSTR) GO TO 301
      GO TO 300
301    MINSTR= MAXSTR(K)
      JK=K
300   CONTINUE
C
C********  IF THE STORM JUST FOUND IS SMALLER THAN THE SMALLEST STORM
C******** ALREADY STORED, LOOK FOR THE NEXT STORM
C
302   IF( MINSTR.GT.MMAX) GO TO 99
C
C********  IF THE STORM JUST FOUND IS LARGER THAN THE SMALLEST STORM
C********  ALREADY STORED, STORE THE NEW STORM IN THE PLACE OF THE
C********  SMALLEST STORM
C
```

```
       MAXSTR(JK)=MMAX
      IPKHR(JK)=MPKHR
      IPEAK(JK)=IPK
       ILENGT(JK)=LENGTH
      SKEW(JK)=SKEWW
      IDATE(JK,1)=IYEAR
      IDATE(JK,2)=MONTH
      IDATE(JK,3)=IDAE
      IDATE(JK,4)=IHOUR
       MINSTR=9999
99    M=0
      J=0
      MMAX=0
      MPKHR=0
      IPK=-999
      LENGTH=0
      SKEWW=0.0
104   CONTINUE
200   READ(IT) A,IYR,MO,IDAY,(Y(II),II=1,24)
      IF(EOF(IT)) 40,203
203   IF(IYR.EQ.0) GO TO 40
      GO TO 202
42    NSTRM=K-1
      WRITE(N6,50) NSTRM
50    FORMAT(/* *,25X,*THE RAINFALL DATA MADE IT NECESSARY TO ADJUST THE
     2 NO. OF STORMS  ANALYZD TO*,I3)
C
C********  WHEN THE ENTIRE RAINFALL RECORD HAS BEEN SEARCHED, REARRANGE
C********  THE X NO. OF STORMS AND THEIR DESCRIPTION PARAMETERS FROM
C********  LARGEST TO SMALLEST IN THE APPROPRIATE ARRAYS
C
40    MN=1
      LV=NSTRM-1
      DO 500 K=1,LV
501   IF( MAXSTR(K)- MAXSTR(K+MN)) 502,503,503
502   MX1= MAXSTR(K+MN)
      SX2=SKEW(K+MN)
      MX3=IPKHR(K+MN)
      MX4= ILENGT(K+MN)
      MX5=IPEAK(K+MN)
      MX6=IDATE(K+MN,1)
      MX7=IDATE(K+MN,2)
      MX8=IDATE(K+MN,3)
      MX9=IDATE(K+MN,4)
       MAXSTR(K+MN)= MAXSTR(K)
      SKEW(K+MN)=SKEW(K)
      IPKHR(K+MN)=IPKHR(K)
       ILENGT(K+MN)= ILENGT(K)
      IPEAK(K+MN)=IPEAK(K)
      IDATE(K+MN,1)=IDATE(K,1)
      IDATE(K+MN,2)=IDATE(K,2)
      IDATE(K+MN,3)=IDATE(K,3)
      IDATE(K+MN,4)=IDATE(K,4)
       MAXSTR(K)=MX1
```

```
      SKEW(K)=SX2
      IPKHR(K)=MX3
       ILENGT(K)=MX4
      IPEAK(K)=MX5
      IDATE(K,1)=MX6
      IDATE(K,2)=MX7
      IDATE(K,3)=MX8
      IDATE(K,4)=MX9
503   MN=MN+1
      IF(MN+K.EQ.NSTRM+1) GO TO 504
      GO TO 501
504   MN=1
500   CONTINUE
C
C********  PRINT OUT THE TOP X NO. OF STORMS AND THEIR DESCRIPTION
C
      DO 505 K=1,NSTRM
      IF(K.EQ.1.OR.K.EQ.21.OR.K.EQ.41) GO TO 506
      GO TO 67
506   WRITE(N6,2999)
      WRITE(N6,51)
51    FORMAT(/* *,43X,*THE STORMS USED IN THE SKEW ANALYSIS WERE:*/* *,4
     23X,42(*=*))
      IF(IMET.EQ.0) GO TO 60
      WRITE(N6,65)
65    FORMAT(//* *,18X,*STORM*,5X,*TOTAL RAINFALL*,5X,*STARTING TIME*,5X
     2,*DURATION*,5X,*PEAK*,5X,*PEAK INTENSITY*/* *,19X,*NO.*,6X,13H(MIL
     3LIMETERS),6X,*(DATE + HR.)*,6X,*(HOURS)*,6X,*HR.*,6X,*(MILLIMETERS
     4/HR.)*,4X,*SKEW*/* *,18X,5(*-*),5X,14(*-*),5X,13(*-*),5X,8(*-*),5X
     5,4(*-*),4X,17(*-*),3X,4(*-*)/)
   67 IF(IMET.EQ.0) GO TO 507
C********  INTRODUCE TEMPORARY VARIABLES FOR METRIC OUTPUT
      MTEMP1=MAXSTR(K)*25.4/100.
      MTEMP2 = IPEAK(K)*25.4
      WRITE(N6,53) K, MTEMP1 , (IDATE(K,L),L=2,3),IDATE(K,1),IDATE(K,4)
     1, ILENGT(K),IPKHR(K), MTEMP2, SKEW(K)
      GO TO 505
60    WRITE(N6,52)
52    FORMAT(//* *,18X,*STORM*,5X,*TOTAL RAINFALL*,5X,*STARTING TIME*,5X
     2,*DURATION*,5X,*PEAK*,5X,*PEAK INTENSITY*/* *,19X,*NO.*,7X,12H(INC
     3HES*100),6X,*(DATE + HR.)*,6X,*(HOURS)*,6X,*HR.*,7X,*(INCHES/HR.)*
     4,6X,*SKEW*/* *,18X,5(*-*),5X,14(*-*),5X,13(*-*),5X,8(*-*),5X,4(*-*
     5),5X,14(*-*),5X,4(*-*)/)
507   WRITE(N6,53) K, MAXSTR(K),(IDATE(K,L),L=2,3),IDATE(K,1),IDATE(K,4)
     2, ILENGT(K),IPKHR(K),IPEAK(K),SKEW(K)
53    FORMAT(*0*,19X,I2,12X,I4,10X,I2,*/*,I2,*/*,I2,3X,I2,8X,I2,9X,I2,10
     2X,I6,9X,F4.2)
505   CONTINUE
       SKEWTO=0
C
C********  CALCULATE AND PRINT OUT THE AVERAGE SKEW OF THE X NO. OF
C********  STORMS
C
```

```
      DO 510 K=1,NSTRM
510    SKEWTO= SKEWTO+SKEW(K)
       AVGSKE= SKEWTO/NSTRM
      WRITE(N6,54)  AVGSKE
54    FORMAT(///* *,42X,*THE AVERAGE SKEW OF THE ABOVE STORMS IS *,F4.2)
C
C********  IF A SEASONAL ANALYSIS IS NOT SELECTED, STOP
C
      IF(INDSEA.EQ.0) GO TO 803
      DO 710 M=1,12
710    NSTRMC(M)=0
      WRITE(N6,2999)
      WRITE(N6,57)
57    FORMAT(///////////////////////////* *,39(*-*),* SKEW ANALYSIS OF TH
     2E PRECEEDING STORMS BY SEASON *,39(*-*))
      WRITE(N6,4000)
C
C********  IF INDSEA EQUALS 1, SEGREGATE THE TOP X NO. OF STORMS BY
C********  SEASON
C
      DO 700 K=1,NSTRM
      M=0
      DO 701 I=1,NOSEAS
      IF(MOSEND(I).LT.MOSEAS(I)) GO TO 702
      IF(IDATE(K,2).GT.MOSEAS(I).AND.IDATE(K,2).LT.MOSEND(I)) M=I
      IF(IDATE(K,2).EQ.MOSEAS(I).AND.IDATE(K,3).GE.MDAYBG(I)) M=I
      IF(IDATE(K,2).EQ.MOSEND(I).AND.IDATE(K,3).LE. MDAYEN(I)) M=I
      IF(M.NE.0) GO TO 703
      GO TO 701
702   IF(IDATE(K,2).GT.MOSEAS(I).AND.IDATE(K,2).LE.12) M=I
      IF(MOSEAS(I).EQ.IDATE(K,2)) GO TO 704
      GO TO 705
704   IF(IDATE(K,3).GE.MDAYBG(I)) M=I
705   IF(IDATE(K,2).GE.1.AND.IDATE(K,2).LT.MOSEND(I)) M=I
      IF(IDATE(K,2).EQ.MOSEND(I)) GO TO 706
      GO TO 707
706   IF(IDATE(K,3).LE. MDAYEN(I)) M=I
707   IF(M.NE.0) GO TO 703
701   CONTINUE
703   IF(M.EQ.0) GO TO 700
       NSTRMC(M)= NSTRMC(M)+1
      N= NSTRMC(M)
       ISEASK(M,N,1)= MAXSTR(K)
       ISEASK(M,N,2)=IDATE(K,2)
       ISEASK(M,N,3)=IDATE(K,3)
       ISEASK(M,N,4)=IDATE(K,1)
       ISEASK(M,N,5)=IDATE(K,4)
       ISEASK(M,N,6)= ILENGT(K)
       ISEASK(M,N,7)=IPKHR(K)
       ISEASK(M,N,8)=IPEAK(K)
       SEASKE(M,N)=SKEW(K)
700   CONTINUE
```

```
C
C********  PRINT OUT THE STORMS IN EACH SEASON AND THEIR DESCRIPTION
C
      DO 708 I=1,NOSEAS
      M= NSTRMC(I)
      IF(M.EQ.0) GO TO 708
      DO 709 J=1,M
      IF(J.EQ.1.OR.J.EQ.21.OR.J.EQ.41) GO TO 800
      GO TO 795
800   WRITE(N6,2999)
      WRITE(N6,55) I
55    FORMAT(/* *,38X,*THE SEASON*,I3,* STORMS USED IN THE SKEW ANALYSIS
     2 WERE:*/* *,38X,52(*=*))
      IF(IMET.EQ.0) GO TO 790
      WRITE(N6,65)
  795 IF(IMET.EQ.0) GO TO 801
C********  INTRODUCE TEMPORARY VARIABLES FOR METRIC OUTPUT
      MTEMP1= ISEASK(I,J,1)*25.4/100.
      MTEMP2=ISEASK(I,J,8)*25.4
      WRITE(N6,53) J,MTEMP1,(ISEASK(I,J,L),L=2,7),MTEMP2,SEASKE(I,J)
      GO TO 709
  790 WRITE(N6,52)
801   WRITE(N6,53) J,( ISEASK(I,J,L),L=1,8), SEASKE(I,J)
709   CONTINUE
       SKEWTO=0
C
C********  CALCULATE AND PRINT OUT THE AVERAGE SKEW OF THE STORMS
C********  IN EACH SEASON
      DO 711 K=1,M
711    SKEWTO= SKEWTO+ SEASKE(I,K)
       AVGSKE= SKEWTO/M
      WRITE(N6,56) I, AVGSKE
56    FORMAT(///* *,41X,*THE AVERAGE SKEW OF THE SEASON*,I3,* STORMS=*,F
     24.2)
708   CONTINUE
803   RETURN
      END
```

- Annual series analysis frequency plots;
- Partial duration series analysis intensity-duration-frequency curve plots;
- An event length frequency plot;
- A peak hourly frequency plot;
- A total event volume frequency plot; and
- A dry period frequency plot.

A brief description of the plotting routines and how they work is given below.

Plotting Subroutines

The Precipitation Module uses four subroutines as its standard plotting package. These subroutines are CURVE, SCALE, PINE, and PPLOT. The three latter subroutines are coordinated by subroutine CURVE.

Subroutine CURVE is called several times in the Precipitation Module depending on the options chosen. Subroutines HYETO, RANK, and OUTPUT call the plotting routines.

Subroutine CURVE performs the following operations:

- Determines maximum and minimum of arrays to be plotted;
- Calculates the range of values and selects appropriate scale intervals;
- Computes horizontal and vertical axis labels based on calculated scale; and
- Calls the other subroutines.

Subroutine SCALE calculates the range of the X and Y coordinate system, the rate of change of the values in relation to the size of the plot, and provides the capability of plotting negative values. Subroutine PINE joins two coordinate locations with appropriate characters in the output array A of subroutine PPLOT. Subroutine PPLOT initializes the plotting array; stores individual locations; prints the top, side, and bottom labels; and outputs the final plot with scales. A program listing of subroutines CURVE, SCALE, PINE and PPLOT follow.

Block Data

In the Precipitation Module, the block data routine is used to store the digitized values taken from Figure III-12 and the alphanumeric labels for the various plots. The program listing of the block data follows.

Variables in Common

Tables IV-13 through IV-25 define all the variables in the Precipitation Module that are in COMMON. A separate table has been prepared for each labeled Common Block. The tables contain a list of the FORTRAN variables, a description of each variable, its units, and whether or not the variable is read as input.

```
      SUBROUTINE CURVE(X,Y,NPT,NCV,NPLOT,IJOIN,ITEL,ISTAN)
      DIMENSION X(203,1),Y(203,1),NPT(1)
      COMMON/STND/JSTAN,YSTAN
      COMMON/LAB/ TITLE(18),XLAB(11),YLAB(6)
     1,HORIZ(20),VERT(6)
      COMMON/AXES/XAXIS,YAXIS
      COMMON/LABELS/TOP(10),BOTTOM(10),SIDE(50)
      JSTAN=ISTAN
C ******* CURVE IS THE ENTRY TO A GENERALIZED PRINTER PLOT ROUTINE. THE
C         ROUTINE PLOTS SEQUENTIALLY PAIRED VALUES TAKEN FROM THE X AND
C         Y ARRAYS. THE SCALING VALUES FOR BOTH ARRAYS ARE STORED IN THE
C         LAST TWO ARRAY LOCATIONS IN THE SAME MANNER AS CALCOMP SCALING
C
C         THE ARGUEMENTS IN THE CALLING SEQUENCE ARE DEFINED BELOW...
C
C                  X...THE ARRAY CONTAINING THE X AXIS COORDINATES OF TH
C                      POINTS TO BE PLOTTED.
C
C                  Y...THE ARRAY CONTAINING THE Y AXIS COORDINATES OF TH
C                      POINTS TO BE PLOTTED.
C
C                NPT...THE NUMBER OF POINTS TO BE PLOTTED.
C
C                NCV...THIS VALUE IS ALWAYS ONE (1).
C
C              NPLOT...USED FOR PLOT IDENTIFICATION, THIS VALUE IS
C                      PRINTED ABOVE EACH PLOT FOR EACH CALL TO CURVE...
C               IJOIN...FLAG FOR JOINING OR NO JOINING OF DATA POINTS
C                ITEL...FLAG FOR GRID SIZE
C
C SET SPECIAL GRID SIZE IF DESIRED
C
      IF(ITEL-1) 1000,1010,1020
 1010 XAXIS=60.
      YAXIS=40.
      GO TO 1000
 1020 XAXIS=100.
      YAXIS=50.
1000  XAXIS=100
      YAXIS=40
      NPTS=NPT(1)*NCV
C
C                                                 SET UP X AND Y SCALES
C
      IXAX=XAXIS/10.
      IYAX=YAXIS/10.
      IXAX1=IXAX+1
      IYAX1=IYAX+1
      AXLEN=IXAX
      CALL SCALE(X,AXLEN,NPTS,1)
      AXLEN=IYAX
      IF(ISTAN.EQ.2) GO TO 100
```

```
      CALL SCALE(Y,AXLEN,NPTS,1)
C
C                                                 FORM X LABELS AND FACTORS
C
  100 XMIN=X(NPTS+1,1)
      DELTX=X(NPTS+2,1)
      XLAB(1)=XMIN
      DO 260 I=1,IXAX
  260 XLAB(I+1)=XLAB(I)+DELTX
      XSCAL=XAXIS/(XLAB(IXAX1)-XMIN)
C
C                                                 FORM Y LABELS AND FACTORS
C
      IF(ISTAN.EQ.2) GO TO 110
      YMIN=Y(NPTS+1,1)
      DELTY=Y(NPTS+2,1)
      GO TO 120
  110 YMIN=0.
      DELTY=0.25
  120 YLAB(IYAX1)=YMIN
      DO 270 I=1,IYAX
  270 YLAB(IYAX1-I)=YLAB(IYAX1+1-I)+DELTY
      YSCAL=YAXIS/(YLAB(1)-YMIN)
C
C                                                 INITIALIZE PLOT OUTLINE
C
      NCD=100
      IF(JSTAN.EQ.0) GO TO 2000
      YSTAN=YSCAL*(6.0-YMIN)
 2000 CALL PPLOT(0,0,NCD,NPLOT)
      K = 1
      IF(IJOIN.EQ.0) GO TO 500
C
C                                                 DRAW IN EACH CURVE
C
      DO 450 L=1,NCV
       IF(NPT(L).EQ.0) GO TO 440
C
C                                                 JOINING XO YO AND XT YT
C
      XO=XSCAL*(X(1,L)-XMIN)
      YO=YSCAL*(Y(1,L)-YMIN)
      NPOINT = NPT(L)
      DO 400 N = 2,NPOINT
      XT = XSCAL*(X(N,L) - XMIN)
      YT = YSCAL*(Y(N,L) - YMIN)
      IF(XT.LT.XO) GO TO 400
      CALL PINE(XO,YO,XT,YT,K,NPLOT)
      XO = XT
      YO = YT
  400 CONTINUE
  420 CONTINUE
  440 K = K + 1
```

```
  450 CONTINUE
      GO TO 550
C
C PLOT WITHOUT JOINING POINTS
C
  500 NPOINT=NPT(1)
      DO 510 N=1,NPOINT
      XT=XSCAL*(X(N,1)-XMIN)
      YT=YSCAL*(Y(N,1)-YMIN)
      IXT=XT+.5
      IYT=YT+.5
      CALL PPLOT(IXT,IYT,1,1)
  510 CONTINUE
C
C                                        OUTPUT FINAL PLOT
C
  550 NC=99
      CALL PPLOT(0,0,NC,NPLOT)
      RETURN
      END
```

```
      SUBROUTINE PINE(X1,Y1,X2,Y2,NSYM,NCT)
      COMMON/AXES/XAXIS,YAXIS
      JXAX=XAXIS
      JYAX=YAXIS
      AXA=X1
      AXB=X2
      AYA=Y1
      AYB=Y2
      N=1
      IF(ABS(AXB-AXA).LT.ABS(AYB-AYA)) GO TO 290
C
C     SET PARAMETERS FOR X DIRECTION
C
      IF(AXB.GT.AXA) GO TO 245
      AXA=X2
      AXB=X1
      AYA=Y2
      AYB=Y1
  245 CONTINUE
      IXA=AXA+.5
      IXB=AXB+.5
      IYA=AYA+.5
      IYB=AYB+.5
  250 CONTINUE
      IF(IXA.LT.0.OR.IXA.GT.JXAX) GO TO 260
      IF(IYA.LT.0.OR.IYA.GT.JYAX) GO TO 260
      CALL PPLOT(IXA,IYA,NSYM,NCT)
  260 CONTINUE
      IXA=IXA+1
      YA=(N*(AYB-AYA))/(AXB-AXA)
      IYA=AYA+YA+0.5
      N=N+1
      IF(IXA.LE.IXB) GO TO 250
      GO TO 400
C
C     SET PARAMETERS FOR Y DIRECTION
C
  290 CONTINUE
      IF(AYB.GT.AYA)   GO TO 295
      AYB=Y1
      AXB=X1
      AYA=Y2
      AXA=X2
  295 CONTINUE
      IXA=AXA+.5
      IXB=AXB+.5
      IYA=AYA+.5
      IYB=AYB+.5
  300 CONTINUE
      IF(IXA.LT.0.OR.IXA.GT.JXAX) GO TO 310
      IF(IYA.LT.0.OR.IYA.GT.JYAX) GO TO 310
      CALL PPLOT(IXA,IYA,NSYM,NCT)
  310 CONTINUE
      IYA=IYA+1
```

```
      XA=(N*(AXB-AXA))/(AYB-AYA)
      IXA=XA+AXA+0.5
      N=N+1
      IF(IYA-IYB) 300,320,400
  320 IXA = IXB
      GO TO 300
  400 RETURN
      END
```

```
      SUBROUTINE PPLOT(IX,IY,K,NCT)
      DIMENSION A(51,101),SYM(9)
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL
      COMMON/STND/JSTAN,YSTAN
      COMMON/AXES/XAXIS,YAXIS
      COMMON/LABELS/TOP(10),BOTTOM(10),SIDE(50)
      COMMON /LAB/ TITLE(18),XLAB(11),YLAB(6)
     1,HORIZ(20),VERT(6)
      DATA SYM / 4H****,4H++++, 4H    , 4HXXXX, 4H...., 4H2222,
     1 4H    , 4HIIII, 4H---- /
      IXAX1=XAXIS+1.
      IYAX1=YAXIS+1.
      JXAX1=XAXIS/10.+1.
      JYAX1=YAXIS/10.+1.
      IF(K-99) 200,220,230
  200 A(IYAX1-IY,IX+1)=SYM(K)
      RETURN
  220 CONTINUE
      I=0
      WRITE(N6,300) TOP
 300  FORMAT(////* *,20X,10A4/1H0)
      DO 225 II=1,JYAX1
      I=I+1
      WRITE(N6,310) SIDE(I),YLAB(II),(A(I,J),J=1,IXAX1)
  310 FORMAT(1H ,A1,F7.2,101A1)
      IF(II.EQ.JYAX1) GO TO 228
      DO 224 JJ=1,9
      I=I+1
      IF(I.GT.50) GO TO 500
  223 WRITE(N6,320) SIDE(I),(A(I,J),J=1,IXAX1)
  320 FORMAT(1H ,A1,7X,101A1)
      GO TO 224
  500 WRITE(N6,510) (A(I,J),J=1,IXAX1)
  510 FORMAT(1H ,8X,101A1)
  224 CONTINUE
  225 CONTINUE
  228 CONTINUE
      WRITE(N6,102) (XLAB(I),I=1,JXAX1)
      WRITE(N6,330) BOTTOM
  330 FORMAT(//,20X,10A4)
  102 FORMAT(1H ,11F10.1)
      RETURN
  230 IYAX=YAXIS
      DO 250 I=1,IYAX
      DO 240 J=1,IXAX1
  240 A(I,J)=SYM(7)
      A(I,1)=SYM(8)
  250 CONTINUE
      DO 260 J=1,IXAX1
  260 A(IYAX1,J)=SYM(9)
      DO 270  I=1,IXAX1,10
```

```
 270 A(IYAX1,I)=SYM(8)
     IYJ=IYAX1-10
     DO 290 I=11,IYJ,10
     A(I,1)=SYM(9)
 290 CONTINUE
     IF(JSTAN.EQ.0) RETURN
     IY=YSTAN
     IF((IYAX1-IY).LE.0) RETURN
     IF(IY.LE.0) RETURN
     DO 1000 J=2,IXAX1
     A(IYAX1-IY,J)=SYM(9)
1000 CONTINUE
     RETURN
     END
```

```
      SUBROUTINE SCALE (ARRAY,AXLEN,NPTS,INC)
      COMMON /CNTRL/ N5,N6,IN,IT,ISTART(3),IPRINT,NSER,NEVNT, IDRYOP,
     2 ISKEWO, IFRQPL, IDFCPL
      COMMON/AXES/XAXIS,YAXIS
      DIMENSION ARRAY(NPTS),INT(5)
      DATA INT/2,4,5,8,10/
      INCT=IABS(INC)
C
C                                         SCAN FOR MAX AND MIN
C
      AMAX=ARRAY(1)
      AMIN=ARRAY(1)
      DO 250 N=1,NPTS,INCT
      IF(AMAX.LT.ARRAY(N)) AMAX=ARRAY(N)
      IF(AMIN.GT.ARRAY(N)) AMIN=ARRAY(N)
  250 CONTINUE
      IF( AMAX - AMIN ) 275,255,275
C
C                                         RESET MAX AND MIN FOR ZERO RANGE
C
  255 IF( AMIN ) 265, 400, 260
  260 AMIN = 0.0
      AMAX = 2.0 * AMAX
      GO TO 275
  265 AMAX = 0.0
      AMIN = 2.0 * AMIN
  275 CONTINUE
C
C                                         COMPUTE UNITS/INCH
C
      RATE=(AMAX-AMIN)/AXLEN
C
C                                                   SCALE INTERVAL TO
C                                                   LESS THAN 10
      A=ALOG10(RATE)
      N=A
      IF(A.LT.0) N=A-0.9999
      RATE=RATE/(10.**N)
      L=RATE+1.00
C
C                                         FIND NEXT HIGHER INTERVAL
C
  280 DO 300 I=1,5
      IF(L-INT(I)) 320,320,300
  300 CONTINUE
C
C                                         L IS NEXT HIGHER INTERVAL
C                                         RANGE IS SCALED BACK TO FULL SET
C
  320 L=INT(I)
      RANGE=FLOAT(L)*10.**N
      IF(INC.LT.0) GO TO 350
```

```
C
C                                            SET UP POSITIVE STEPS
C
      K=AMIN/RANGE
      IF(AMIN.LT.0.) K=K-1
C
C                                            CHECK FOR MAX VALUE IN RANGE
C
      IF(AMAX.GT.(K+AXLEN)*RANGE) GO TO 330
      I=NPTS*INCT+1
      ARRAY(I)=K*RANGE
      I=I+INCT
      ARRAY(I)=RANGE
      RETURN
C
C                                            IF OUTSIDE RANGE RESET L AND N
C
  330 L=L+1
      IF(L.LT.11) GO TO 280
      L=2
      N=N+1
  340 GO TO 280
C
C                                            SET UP NEGATIVE STEPS
C
  350 K=AMAX/RANGE
      IF(AMAX.GT.0.) K=K+1
      IF(AMIN.LT.(K+AXLEN)*RANGE) GO TO 330
      I=INCT*NPTS+1
      ARRAY(I)=K*RANGE
      I=I+INCT
      ARRAY(I)=-RANGE
      RETURN
  400 WRITE(N6,100)
  100 FORMAT( // 10X, *RANGE AND SCALE ARE ZERO ON PLOT ATTEMPT*  )
      RETURN
      END
```

```
 BLOCK DATA
 COMMON/LABE/ TOPP(10),BOTT(10),SIDEE(50),SIDEM(50)
 COMMON/A1BBCC/ AA1(11),BB(11),CC(11)
 COMMON/LABEE/ TPP(10),BTT(10),SIDD(50),SIDM(50)
 COMMON/IDFC/ BOTTO(10),TOPO(10)
 COMMON/NOLAB/ TP1(10),SID1(50),BT1(10),BT2(10),BT3(10),BT4(10),
1BT2M(10),BT3M(10)
 DATA AA1
1/4.80,6.80,9.00,11.60,14.69,18.29,22.45,27.30,31.80,36.20,40.00/
 DATA BB
1/-2.75,-0.87,0.97,2.70,4.47,6.02,7.50,8.89,9.96,10.85,11.55/
 DATA CC
1/0.309,0.423,0.507,0.578,0.637,0.692,0.741,0.783,0.822,0.850,
1 0.874/
 DATA TOPP
1/4HSYNT,4HHETI,4HC DE,4HSIGN,4H HYE,4HTOGR,4HAPH ,4H    ,4H    ,4H
1    /
 DATA SIDEE
1/1HR,1HA,1HI,1HN,1HF,1HA,1HL,1HL,1H ,1HI,1HN,1HT,1HE,1HN,1HS,1HI,1
1HT,1HY,1H ,1HI,1HN,1H ,1HI,1HN,1HC,1HH,1HE,1HS,1H ,1HP,1HE,1HR,1H
1,1HH,1HO,1HU,1HR,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1
1H /
 DATA SIDEM
1/1HR,1HA,1HI,1HN,1HF,1HA,1HL,1HL,1H ,1HI,1HN,1HT,1HE,1HN,1HS,1HI,1
2HT,1HY,1H ,1HM,1HI,1HL,1HL,1HI,1HM,1HE,1HT,1HE,1HR,1HS,1H ,1HP,1HE
3,1HR,1H ,1HH,1HO,1HU,1HR,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1
4H /
 DATA BOTT
1/4H    ,4H    ,4H    ,4HTIME,4H IN ,4HMINU,4HTES ,4H    ,4H    ,4H
1    /
 DATA TPP
1/4HPLOT,4H OF ,4HTOTA,4HL RA,4HINFA,4HLL V,4HS. R,4HETUR,4HN PE,
14HRIOD/
 DATA BTT
1/4H    ,4H    ,4H RET,4HURN ,4HPERI,4HOD I,4HN YE,4HARS ,4H    ,
14H    /
 DATA SIDD
1/1H ,1HT,1HO,1HT,1HA,1HL,1H ,1HR,1HA,1HI,1HN,1HF,1HA,1HL,1HL,1H ,
21HI,1HN,1H ,1HH,1HU,1HN,1HD,1HR,1HE,1HD,1HT,1HH,1HS,1H ,1HO,1HF,
31H ,1HI,1HN,1HC,1HH,1HE,1HS,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,
41H ,1H /
 DATA SIDM
1/1H ,1H ,1H ,1H ,1HT,1HO,1HT,1HA,1HL,1H ,1HR,1HA,1HI,1HN,1HF,1HA,
21HL,1HL,1H ,1HI,1HN,1H ,1HM,1HI,1HL,1HL,1HI,1HM,1HE,1HT,1HE,1HR,
31HS,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,
41H ,1H /
 DATA BOTTO
1/4H    ,4H   S,4HTORM,4H DUR,4HATIO,4HN IN,4H MIN,4HUTES,4H    ,
24H    /
 DATA TOPO
1/4H   I,4HNTEN,4HSITY,4H DUR,4HATIO,4HN FR,4HEQUE,4HNCY ,4HCURV,
24HE   /
```

```
      DATA TP1
     1/4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,
     24H    /
      DATA SID1
     1/1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1HF,1HR,1HE,1HQ,1HU,1HE,1HN,1HC,
     21HY,1H ,1HO,1HF,1H ,1HO,1HC,1HC,1HU,1HR,1HR,1HE,1HN,1HC,1HE,1H ,
     31H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,1H ,
     41H ,1H /
      DATA BT1
     1/4H    ,4H    ,4H    ,4H    ,4HRAIN,4HFALL,4H LEN,4HGTH ,4H(HOU,
     24HRS) /
      DATA BT2
     1/4H    ,4H    ,4H    ,4H    ,4HPEAK,4H RAI,4HNFAL,4HL (I,4HN./H,
     24HR.) /
      DATA BT2M
     1/4H    ,4H    ,4H    ,4HPEAK,4H RAI,4HNFAL,4HL (M,4HM./H,4HR.) ,
     24H    /
      DATA BT3
     1/4H    ,4H    ,4H    ,4H  TO,4HTAL ,4HEVEN,4HT RA,4HINFA,4HLL (,
     24HIN.)/
      DATA BT3M
     1/4H    ,4H    ,4H    ,4H  TO,4HTAL ,4HEVEN,4HT RA,4HINFA,4HLL (,
     24HMM.)/
      DATA BT4
     1/4H    ,4H    ,4H    ,4H    ,4H DRY,4H HOU,4HR LE,4HNGTH,4H (HO,
     24HURS)/
      END
```

TABLE IV-13

KEY VARIABLES IN COMMON BLOCK ABC

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
A	Storm constant a	None	No
B	Storm constant b	None	No
C	Storm constant c	None	No
IREQ	Design storm frequency	Years	Yes
DURA	Design storm duration	Minutes	Yes
SKEW	Design storm skew	None	Yes
DURAA (50)	Storm duration	Minutes	Yes
RUU (50)	Average storm intensity	In./Hr.	Yes
MI	No. of storm durations and average storm intensities to be input	None	Yes
PI	Performance index	None	No

TABLE IV-14

KEY VARIABLES IN COMMON BLOCK A1BBCC

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
AA1 (11)	Values of A_1 from Figure II-3	None	No
BB (11)	Values of storm constant b from Figure II-3	None	No
CC (11)	Values of storm constant c from Figure II-3	None	No

TABLE IV-15

KEY VARIABLES IN COMMON BLOCK BONA

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
LEN	Rainfall event length	Hours	No
FAX	Peak hourly rainfall per event	In./Hr.	No
VOL	Total event rainfall volume	Inches	No
IEV	Total number of events per rainfall record	None	No
DRY	Total number of dry-hour periods per rainfall record	None	No

TABLE IV-16

KEY VARIABLES IN COMMON BLOCK CNTRL

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
N5	Card Input File Number	None	No
N6	Line Printer Output File Number	None	No
IN	Physical unit where input precipitation data is stored	None	Yes
IT	Physical unit where precipitation data is written after processing	None	Yes
ISTART (3)	Starting day of precipitation record	None	Yes
IPRINT	Indicator for printing input precipitation record	None	Yes
NSER	Indicator for calling annual series analyses (SR SERIES)	None	Yes
NEVNT	Indicator for calling Frequency Analyses (SR EVENT)	None	Yes
IDRYOP	Indicator for performing dry-hour frequency analysis	None	Yes
ISKEWO	Indicator for calling skew analysis (SR STRMSKW)	None	Yes
IFRQPL	Indicator for plotting annual series analysis frequency plots	None	Yes
IDFCPL	Indicator for plotting intensity-duration-frequency curves	None	Yes

TABLE IV-17

KEY VARIABLES IN COMMON BLOCK IDFC

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
BOTTO (10)	Alphanumeric label for bottom of intensity-duration-frequency curve plots	None	No
TOPO (10)	Alphanumeric label for top of intensity-duration-frequency curve plots	None	No

TABLE IV-18

KEY VARIABLES IN COMMON BLOCK LAB

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
TITLE (18)	Plotting alphanumeric descriptor	None	No
XLAB (11)	Graphical label x-axis	None	No
YLAB (6)	Graphical label y-axis	None	No
HORIZ (20)	Alphanumeric label x-axis	None	No
VERT (6)	Alphanumeric label y-axis	None	No

TABLE IV-19

KEY VARIABLES IN COMMON BLOCK LABE

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
TOPP (10)	Alphanumeric label for top of synthetic hyetograph plots	None	No
BOTT (10)	Alphanumeric label for bottom of synthetic hyetograph plots	None	No
SIDEE (50)	Alphanumeric label for side of synthetic hyetograph and intensity-duration-frequency curve plots	None	No

TABLE IV-20

KEY VARIABLES IN COMMON BLOCK LABEE

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
TPP (10)	Alphanumeric label for top of annual series analysis frequency plots	None	No
BTT (10)	Alphanumeric label for bottom of annual series analysis frequency plots	None	No
SIDD (50)	Alphanumeric label for side of annual series analysis frequency plots	None	No

TABLE IV-21

KEY VARIABLES IN COMMON BLOCK LABELS

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
TOP (10)	Alphanumeric label for top of all plots	None	No
BOTTOM (10)	Alphanumeric label for bottom of all plots	None	No
SIDE (50)	Alphanumeric label for side of all plots	None	No

TABLE IV-22

KEY VARIABLES IN COMMON BLOCK NOLAB

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
TP1 (10)	Alphanumeric label for top of frequency plots	None	No
SID1 (50)	Alphanumeric label for side of frequency plots	None	No
BT1 (10)	Alphanumeric label for bottom of event length frequency plot	None	No
BT2 (10)	Alphanumeric label for bottom of peak intensity frequency plot	None	No
BT3 (10)	Alphanumeric label for bottom of total event volume plot	None	No
BT4 (10)	Alphanumeric label for bottom of dry-hour frequency plot	None	No

TABLE IV-23

KEY VARIABLES IN COMMON BLOCK RIDGWY

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
SLEN (100,13)	Storage for event length for annual and by seasons	Hours	No
SMAX (100,13)	Storage for peak hourly rainfall per event for annual and by seasons	In./Hr	No
SVOL (100,13)	Storage for total event volume per event for annual and by seasons	Inches	No
SDRY (100,13)	Storage for dry hour length for annual and by seasons	Hours	No
FMAX	Maximum expected peak hourly rainfall	In./Hr	Yes
FVOL	Maximum expected total event volume	Inches	Yes
DRYMAX	Maximum expected dry-hour length	Hours	Yes
DRYLEN	Dry-hour period length	Hours	No
KDRY	Number of dry hours which defines an event length	Hours	Yes
KLSS (5)	Number of occurrences beyond maximums FMAX, FVOL, DRYMAX, and EVNTMAX	None	No
K50	Frequency counter storage units (=50)	None	No
K100	Frequency counter storage units (=100)		No
EVNTMA	Maximum expected event length	Hours	Yes

TABLE IV-24

KEY VARIABLES IN COMMON BLOCK SERIES

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
NYR	Number of calendar years of rainfall data to be analyzed in yearly series analyses	Years	Yes
NDUR	Number of duration lengths to be analyzed in series analyses	None	Yes
DURTN (14)	Duration lengths to be analyzed in series analyses	Hours	Yes
Y(744)	Hourly rainfall for one month	In./100	Yes
MBG (12)	Beginning hour of months	None	No
MND (12)	Ending hour of months	None	No
MAXI (50,14)	Storage for maximum yearly total rainfalls	In./100	No
IDTI (50,10)	Storage for starting hour of maximum yearly storms	None	No
MAXSEA (12, 50,14)	Storage for maximum seasonal total rainfalls	In./100	No
IDED (12,50, 10)	Storage for starting hour of maximum seasonal storms	None	No
X (8784)	Storage for 1 year's hourly rainfall	In./100	No
NOYRR	Number of calendar years of rainfall data to be analyzed in seasonal series analyses	None	No
INDSEA	Indicator for executing seasonal analyses	None	Yes
NOSEAS	Number of seasons to be analyzed	None	No

TABLE IV-24

KEY VARIABLES IN COMMON BLOCK SERIES
(continued)

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
INTYR	First calendar year of rainfall data to be analyzed in series analyses	None	No
MOSEAS (12)	Beginning months of seasons	None	Yes
MDAYBG (12)	Beginning days of seasons	None	Yes
MOSEND (12)	Ending months of seasons	None	Yes
MDAYEN (12)	Ending days of seasons	None	Yes
IPARTO	Indicator for executing partial duration series analysis	None	Yes

TABLE IV-25

KEY VARIABLES IN COMMON BLOCK TREAD

FORTRAN VARIABLE	DESCRIPTION	UNITS	INPUT DATA
MDAY	Century day of precipitation (YYMMDD)	None	No
MYR	Current simulation year	None	Yes
MO	Current simulation month	None	Yes
MDY	Current simulation day	None	Yes
QDISCH (24)	Hourly precipitation date floating point	Hundredths inch	Yes

CHAPTER V

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☆U.S. GOVERNMENT PRINTING OFFICE: 1984-421-428/3467

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The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

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1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.

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