MAGNITUDE AND FREQUENCY OF FLOOD VOLUMES FOR URBAN WATERSHEDS IN LEON COUNTY, FLORIDA

By Marvin A. Franklin

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CONTENTS

ILLUSTRATIONS

TABLES

ABBREVIATIONS AND CONVERSION FACTORS

Factors for converting inch-pound units to metric units and abbreviations of those units are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

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ABSTRACT

Techniques are provided for estimating storm runoff volume for urban watersheds in Leon County, Florida, for recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years. Synthetic storm runoff volumes were generated by using a calibrated lumped-parameter rainfall-runoff model, pan evaporation data from Milton, Florida, and long-term unit rainfall records from Thomasville-Coolidge, Georgia, and Pensacola, Florida. The synthetic storm runoff volumes were used to develop station runoff-frequency relations which were used in multiple linear regression analyses to derive regional equations relating storm runoff to basin characteristics. The significant basin characteristic was impervious area. The average standard error of regression was ±16 percent for all recurrence intervals except for the 2 year, ±18 percent, and the 500 year, ±17 percent.

INTRODUCTION

A knowledge of flood characteristics is essential for designing drainage structures and for using flood-prone land. A reliable estimate of flood-peak magnitude and frequency is necessary to design economical structures and prepare realistic zoning ordinances for a community. Recognizing the need for reliable flood data and improved techniques for estimating the frequency and magnitude of flooding, the U.S. Geological Survey and the Public Works Department of Leon County, Fla., began a cooperative investigation in 1978 to develop regression equations that could be used to estimate the magnitude and frequency of flood peaks in Leon County. The regression equations needed to estimate flood-peak magnitude for given recurrence-interval floods were reported earlier (Franklin and Losey, 1984). During that investigation, it became apparent that a method for estimating flood volumes was also needed. The volume of runoff can be used to evaluate and design drainage systems, especially where storage is a factor. Additionally, as basins develop, changes in runoff volumes can be estimated based on changes in the impervious area.

The data required to develop regression equations that can be used to estimate the volume and frequency of flood runoff in the urban parts of the county were published in Franklin and Losey (1984). The purpose of this report is to provide information on:

1. The statistical methods used in the analysis of the rainfall-runoff data and the results of the runoff volume analysis;

2. The regression equations needed to compute an estimate of the runoff volume for the desired recurrence-interval flood in Leon County, Fla.; and

3. A step-by-step example to illustrate the use of the regression equations for computing runoff volume.

More than 25 years of observed data are generally needed to make reliable estimates of the runoff volume of 50- and 100-year floods at a stream-gaging site. To reduce the time required for data collection, rainfall and runoff data collected in this investigation were used to calibrate a lumped-parameter, rainfall-runoff model (Franklin, 1982). Long-term rainfall records obtained from the National Weather Service (formerly U.S. Weather Bureau) were used to synthesize long-term runoff records for Leon County.

Log-Pearson type III frequency analysis was performed with this synthetic data base to generate runoff-frequency data for each gaging station. The majority of locations at which runoff-volume-frequency information is needed are ungaged; therefore, a multiple linear regression analysis was performed to develop the regional relation between runoff volume and selected basin characteristics.

DATA ACQUISITION

The data acquisition effort was divided into two phases. The first phase required the establishment of gaging stations for the collection of daily-rainfall, storm-rainfall, and flood-runoff data on streams in the study area.

The second phase required collection of independent basin characteristics for use in the multiple-regression analysis to define common parameters in each basin that could be related to flood magnitudes. More than 75 percent of the activity of the original project was directed toward the acquisition and processing of data.

Rainfall and Runoff

Rainfall-runoff data were collected at 15 rainfall, 2 daily streamflow, and 14 partial record streamflow sites for the period April 1979 through September 1982 with a total of 323 storm events being recorded. Figure 1 shows the location of the stations and table 1 gives the map location number, station identification number, and description of the location of each station. Each storm event consists of the total rainfall and the resulting runoff in each 5-minute time period from the start of the rainfall until the end of the storm runoff. A detailed description of the rainfall and runoff collection methods was given by Franklin and Losey (1984).

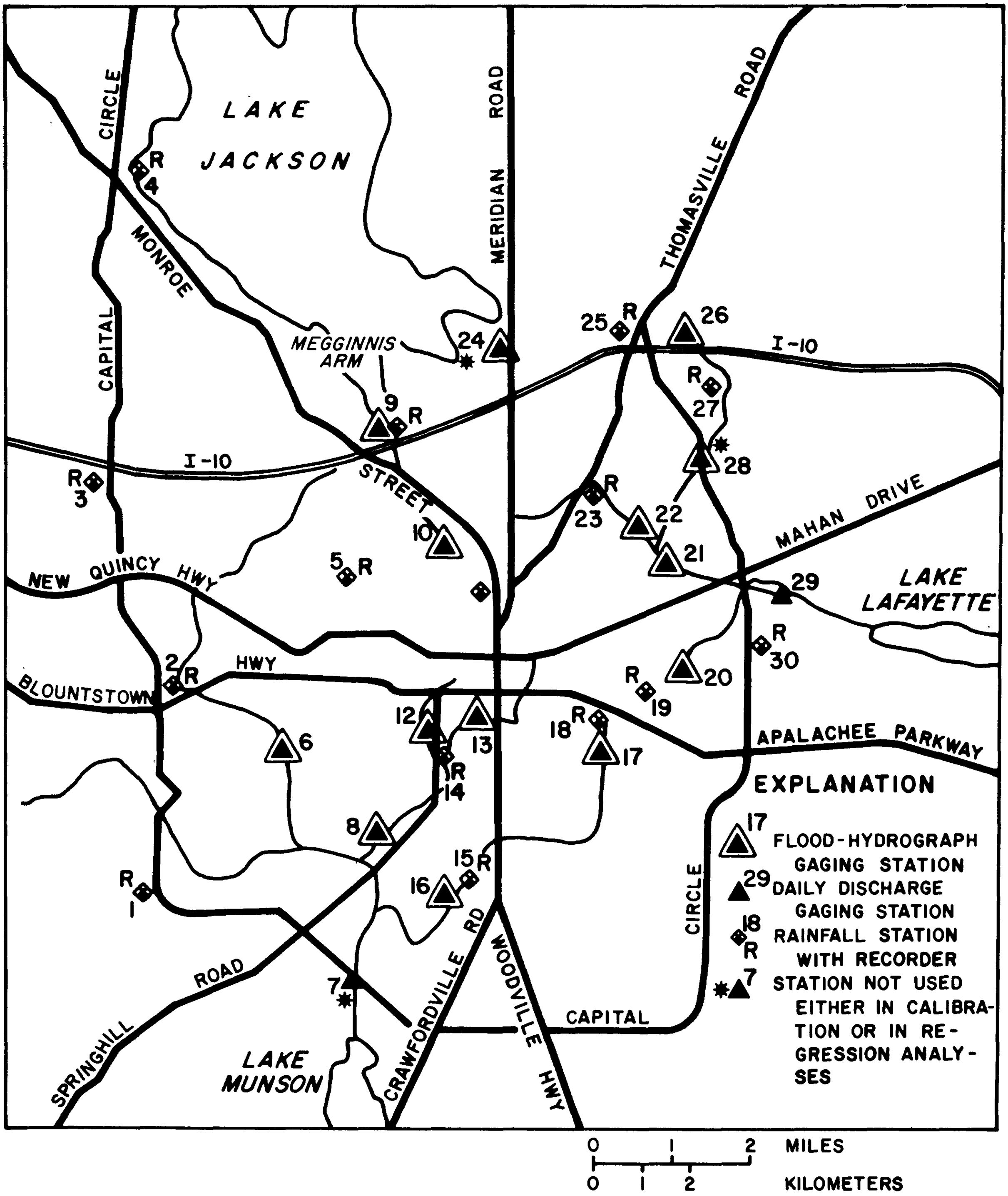

Figure 1.--Location of rainfall- and discharge-collection sites in the Tallahassee area of Leon County, Florida.

Table 1.--Gage identification and location

Map location No.	Station identification No.	Location	Type
1	302347084212300	Tallahassee Municipal Airport near National Weather Service rain gage.	Rainfall
2	302609084211000	Wayne Coloney plant near intersection of Blountstown Highway and Capital Circle.	Rainfall
3	302842084215200	Capital Circle near intersection with Commonwealth Boulevard.	Rainfall
4	303200084212500	Sunset Fish Camp near end of Lake Drive.	Rainfall
5	302731084191600	East end of lake between San Luis Road and Ocala Road.	Rainfall
6	02327012	Left bank upstream from bridge on Roberts Avenue over west side drainage ditch near intersection with Mabry Street.	Discharge
7	02327017	Downstream side of bridge on Capital Circle over Munson Slough.	Discharge
8	02327015	Right upstream end of culvert over central drainage ditch on Orange Avenue near Springhill Road.	Discharge
9	02329186	Right downstream end of culvert over Megginnis Arm Tributary on Meginnis Arm Road near I-10.	Rainfall and discharge
10	02329181	Right bank 20 feet upstream from detention culvert behind Northwood Mall and adjacent to Boone Boulevard.	Discharge
11	302731084165400	North parking lot of the old National Guard Armory between Seventh and Eighth Avenues.	Rainfall

Table 1.--Gage identification and location--Continued

Map location No.	Station identification No.	Location	Type
12	02327013	Left bank downstream of bridge over central drainage ditch on Airport Drive at intersection with Eppes Drive.	Discharge
13	02327014	Left bank upstream of bridge over St. Augustine Branch on Wahnish Way at intersection with Canal Street.	Discharge
14	302536084180500	North wall of sewage disposal plant at intersection of Gamble Street and Lake Bradford Road.	Rainfall
15	302438084172400	Under electrical transmission lines adjacent to Wahnish Way and east drainage ditch on Bragg Drive.	Rainfall
16	02327016	Downstream side of bridge over east drainage ditch on Bragg Drive.	Discharge
17	302549084152900	Left bank upstream of culvert over east drainage ditch on Apakin Nene in Indian Head Acres.	Discharge
18	302601084153600	Near electrical substation between Ostin Nene and Chowkeenin Nene in Indian Head Acres.	Rainfall
19	302622084145800	On dam of Governor's Square detention pond adjacent to Blairstone Road.	Rainfall
20	02326842	Left bank upstream of culvert over Governor's Square drainage ditch on Park Avenue near intersection with Blairstone Road.	Discharge
21	02326838	Right bank upstream of culvert over northeast drainage ditch on Miccosukee Road near intersection with Doomar Drive.	Discharge

Table 1.--Gage identification and location--Continued

Map location No.	Station identification No.	Location	Type
22	02326836	Right bank upstream of culvert over McCord Park Pond drainage ditch on Centerville Road near intersection with Trescott Drive.	Discharge
23	302822094154400	West side of pond in McCord Park between Trescott Drive and Armistead Road.	Rainfall
24	02329161	Left bank of Fords Arm Tributary downstream of Meridian Road near intersection with Lexington Road.	Discharge
25	303010084151200	Inside fence enclosure south side of Timberlane Shops on the Square adjacent to I-10.	Rainfall
26	02326825	Left bank upstream of culvert over northeast drainage ditch on Hadley Road near intersection with Raymond Diehl Road.	Discharge
27	302935084142100	Southeast end of Wembley Way in Eastgate.	Rainfall
28	02326828	Right upstream end of culvert over northeast drainage ditch on Capital Circle at intersection with Centerville Road.	Discharge
29	02326845	Upstream right end of wier across northeast drainage ditch just upstream of Weems Road.	Discharge
30	302707084132400	Inside enclosure of National Guard Armory near Federal Correctional Institute.	Rainfall

Basin Characteristics

The basin characteristics that were determined for testing of significance in the multiple regression are defined below. The observed range in values is given in parentheses. The data for each basin are given in table 2.

Table 2.--Basin characteristics

Map location No.	Drainage area (DA) (mi^2)	Impervious area (IA) (percent)	Main-channel length (L) (miles)	Main-channel slope (SL) (ft/mi)	Storage (ST) (percent)
6	15.9	8.8	6.48	11.9	4.26
8	8.11	27.0	4.69	18.1	1.13
9	3.44	28.3	2.94	32.0	.11
10	.26	43.0	.90	65.6	.00
12	3.29	48.5	2.34	45.3	.35
13	2.06	54.0	2.72	32.2	.05
16	5.40	19.6	4.41	18.6	1.70
17	.21	25.0	.58	128	.00
[a]20	1.04	25.0	1.28	82.0	3.01
[a]21	9.83	23.3	5.26	16.2	2.71
[a]22	2.92	31.2	2.50	32.8	1.88
[a,b]24	1.66	5.8	1.84	46.2	1.08
[a]26	.79	20.3	1.23	54.5	2.54
[a,b]28	3.85	23.0	3.63	26.2	1.19
[a]29	15.7	22	6.50	12.9	2.77

[a]Lake Lafayette basins.
[b]Not used in regression analysis (see text).

Drainage area, (DA), in square miles (0.21 to 15.9): the contributing drainage area planimetered from U.S. Geological Survey 7½-minute topographic maps. Corrections were made for areas that crossed natural divides as a result of storm sewers or streets.

Main-channel length, (L), in miles (0.58 to 6.50): the distance along the main channel between the gage and the basin divide.

Main-channel slope, (SL), in feet per mile (11.9 to 128): the average slope between points 10 percent and 85 percent of the main-channel length measured from the gage to the basin divide. The elevation of the points were taken from the best available topographic map.

Storage, (ST), in percent (0.0 to 4.26): the area of lakes, ponds, and swamps in the contributing drainage area.

Impervious area, (IA), in percent (5.8 to 54): the area of impervious surfaces in the basin. The impervious area for each basin was determined by subdividing the basin into land-use types. The percentage of impervious area for each land-use type was field checked. The area for each type was determined by planimetering. The value was checked by using the grid method.

ANALYTICAL TECHNIQUES

The analysis of runoff data was divided into two phases: Frequency distributions were determined from sythesized records at gaged sites to determine runoff and frequency of flooding; then a multiple-regression analysis was made to extend this information to ungaged sites.

Long periods of gaged records are needed to make reliable estimates of the larger recurrence-interval floods (50- and 100-year). A U.S. Geological Survey rainfall-runoff model was used to extend the data collected during this investigation into a synthesized long-term record. The rainfall-runoff model and the methods used to determine frequency distributions are discussed next.

Model Calibration

The rainfall-runoff model developed by Dawdy and others (1972), with modifications described by Carrigan and others (1977), was used in this investigation. It combines soil-moisture-accounting and rainfall-excess components with the Clark (1945) flood-routing method. This lumped parameter model has three basic components: antecedent moisture, infiltration, and rainfall excess and routing. The Theissen method was used to distribute rainfall over those basins with more than one rain gage. Excess rainfall was routed to the outlet of the basin from 20 time-of-travel bands for which percent impervious area was determined.

The antecedent soil-moisture component assesses the change in soil moisture based on daily rainfall and evaporation. Four parameters were used to simulate continuous antecedent soil moisture. Dawdy and others (1972) described these parameters as follows:

1. EVC, a pan coefficient for converting measured pan evaporation to potential evapotranspiration;

2. RR, the proportion of daily rainfall that infiltrates into the soil;

3. BMSM, a maximum effective amount of base-moisture storage at field capacity, in inches; and

4. DRN, a coefficient controlling the rate of drainage of the infiltrated soil moisture, in inches per day.

The output from this component was the amount of base-moisture and infiltrated-surface-moisture storage.

The infiltration component used the input of storm rainfall and output from the soil-moisture accounting component that indicated soil moisture at the beginning of the storm rainfall. Three parameters were used in the modified Philip (1954) infiltration equation to compute infiltration in the basin.

1. PSP, the suction at the wetted front for soil moisture at field capacity, in inches of pressure;

2. RGF, the ratio of the suction of the wetted front for soil moisture at wilting point to that of field capacity; and

3. KSAT, the effective saturated value of hydraulic conductivity used to determine infiltration rate, in inches per hour.

The rainfall excess computed in the infiltration component was routed to the outlet of the basin. The model used a modification of the Clark flood-routing method as described by Carrigan (1973). Three parameters were used in this step.

1. T_p, time to peak, in minutes;

2. T_c, time base of the translation hydrograph; and

3. KSW, a time characteristic for linear reservoir routing.

Generally, about 40 significant storm events are needed at a rainfall-runoff site to achieve an optimum calibration of the model. However, a successful calibration can be achieved with less. For the period April 1979 to September 1982, a total of 323 events were recorded at the 15 streamflow sites used in model calibration. Many of these events, however, were not used in model calibration. Two reasons for not using flood events were: (1) peak discharge recorded was below a selected base discharge, and (2) recorded rainfall was not representative of the basin rainfall. The streamflow site on Munson Slough at Capital Circle (map number 7) was intended for only a daily discharge site and, therefore, was not used in the calibration of the model.

The model calibration was accomplished in two steps. First, the seven parameters used to compute the volume of runoff were automatically adjusted until the difference between synthesized volumes and the observed volumes of runoff were minimized. The initial values for the seven parameters were determined from soil types, basin characteristics, and climatological factors.

As input to the soil-moisture and inflitration component, calibration of the model required the following: unit and daily rainfall, unit discharge, daily evaporation, and impervious area as a percentage of the total drainage area.

The method of determining optimum parameter values was based on an optimization technique by Rosenbrock (1960). The technique was a trial and error procedure. The model was programmed to change a parameter value and then recompute the objective function based on the new set of values. If an improvement was made, the set was retained; if not, the old set of values was retained. This process was followed for each parameter until improvement stopped. The objective function was computed as the sum of the squared deviations of the logarithms of the difference between the synthesized flood volumes and the observed flood volumes.

In the second step, the volume parameters were held constant and the flow was routed to the outlet of the basin. A line printer plot was generated with the synthesized hydrograph overlaying the observed hydrograph. A visual comparison was made; if there was a significant difference, the parameter input values were checked and revised. The results of the final calibrations are shown in table 3. The allowed range in parameter values is shown in parentheses.

Calibrations for Fords Arm Tributary (map number 24) and northeast drainage ditch at Capital Circle (map number 28) were questionable. Both stations proved to be outliers in the regression analysis for peaks and, therefore, were not used in this analysis.

Flood-Runoff Synthesis

Flood-runoff synthesis is the process whereby flood discharge data are generated from long-term daily rainfall, daily evaporation, and unit rainfall, for the period of record, and from calibrated model parameters for each site. The model generates runoff volume in inches for each event entered for each rainfall-runoff site. Generally, three to five rainfall events are entered into the model for each year of long-term rainfall record. These events are selected to produce the maximum runoff for the year.

The nearest long-term evaporation station is at Milton, Fla. Comparisons of available records indicate that daily evaporation does not vary greatly from Milton to Tallahassee. Also, the model is fairly insensitive to changes in evaporation. The National Weather Service recording rain gage, located initially at Thomasville, Ga., and later moved to Coolidge, Ga., is the nearest long-term station for which unit values are available. Based on information from National Weather Service Technical Report 40 (U.S. Department of Commerce, 1961), it was determined that some correction should be made to account for Tallahassee being nearer the Gulf of Mexico than Thomasville-Coolidge. The nearest long-term rainfall record near the coast is at Pensacola, Fla. It was decided, therefore, to use the Thomasville-Coolidge and Pensacola unit rainfall records to generate two separate 60-year annual runoff series for each gaging station for use in the flood-frequency analysis. A weighted average of the two frequency curves was used as described in the following section.

Table 3.--Calibrated model parameters

Infiltration component

PSP: in inches of pressure, the suction at the wetted front for soil moisture at field capacity (0.5 to 10).

KSAT: in inches per hour, the effective saturated value of hydraulic conductivity (0.01 to 0.5).

RGF: the ratio of the suction at the wetted front for soil moisture at wilting point to that at field capacity (1 to 45).

Antecedent moisture component

BMSM: in inches, the soil moisture storage at field capacity (1 to 12).

EVC: coefficient to convert pan evaporation to potential evapotranspiration (0.65 to 0.75).

RR: the percentage of daily rainfall that infiltrates into the soil (set at 0.85).

DRN: in inches per day, a coefficient controlling the rate of drainage of the infiltrated soil moisture (set at 1.0).

Routing component

KSW: in hours, time characteristic for linear reservoir routing.

TC: in minutes, length of the base of the translation hydrograph.

Number of floods: number of floods used in calibration.

Standard error: standard error of simulated estimate.

Map location No.	Parameters							No. of floods	Standard error
	PSP	KSAT	RGF	BMSM	EVC	KSW	TC		
6	6.43	0.260	33.8	4.61	0.735	15.4	163	15	19.1
8	9.84	.461	44.9	3.92	.704	1.95	31	31	25.5
9	9.80	.440	44.9	3.50	.745	1.30	50	14	20.9
10	9.62	.481	41.6	2.96	.740	.238	52	35	14.9
12	6.60	.120	42.0	8.00	.740	.900	53	39	24.3
13	7.80	.386	30.2	6.76	.743	1.10	26	27	28.4
16	4.08	.163	28.6	4.90	.714	6.00	80	9	22.5
17	4.13	.156	37.3	2.14	.731	.718	19	21	21.1
[a]20	6.00	.270	44.0	7.00	.660	9.60	117	18	26
[a]21	9.00	.418	44.2	8.16	.672	21.6	244	17	25.3
[a]22	9.72	.468	43.2	3.15	.682	8.85	125	13	18.7
[a,b]24	8.41	.156	14.7	5.20	.749	6.65	74	9	24.3
[a]26	7.47	.470	23.8	2.69	.687	3.26	167	9	30.4
[a,b]28	6.44	.365	12.0	2.17	.750	4.88	468	9	50.8
[a]29	5.66	.434	44.6	5.41	.732	12.4	330	15	26.0

[a]Lake Lafayette basins.
[b]Not used in regression analysis (see text).

Runoff-Frequency Analysis

The U.S. Water Resources Council (1981, p. 3) recommends the log-Pearson type III distribution for use as the base method for flood-frequency analysis. In this investigation, a log-Pearson distribution of the maximum annual runoff volume, generated by the model from the long-term record, was made. The log-Pearson type III distribution is defined by three statistical parameters: the mean, the standard deviation, and the skew of the logarithms of the runoff volumes. Station skew was used for all stations because the only available regional skew is based on rural peak flow data, and generally large drainage basins.

Runoff magnitudes for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals were determined for each station for both the Thomasville-Coolidge and Pensacola annual synthetic series. This resulted in two different frequency curves for each station. These frequency curves were then combined into a single frequency curve for each station by computing a weighted average using Technical Report 40 (U.S. Department of Commerce, 1961) as a guide. Flood magnitudes based on the Thomasville-Coolidge rainfall data were multiplied by 0.8, flood magnitudes based on the Pensacola rainfall data were multiplied by 0.2, and the results were summed to obtain the weighted flood magnitudes for each gaging station in Tallahassee. Table 4 gives the weighted synthetic volumes of runoff computed. These were considered the best estimate of runoff frequency for each site and were used in the regression analysis described in the next section of this report.

Table 4.--Runoff, in inches, for various frequency intervals at 13 locations in Leon County, Florida

Map location No.	2-year interval R_2	5-year interval R_5	10-year interval R_{10}	25-year interval R_{25}	50-year interval R_{50}	100-year interval R_{100}	500-year interval R_{500}
6	1.00	1.61	2.08	2.75	3.30	3.89	5.45
8	1.63	2.39	2.93	3.67	4.26	4.88	6.47
9	1.38	2.03	2.51	3.17	3.71	4.28	5.76
10	2.34	3.35	4.06	5.02	5.76	6.54	8.50
12	2.43	3.56	4.36	5.44	6.28	7.15	9.37
13	2.14	3.09	3.77	4.68	5.40	6.15	8.02
16	1.46	2.43	3.19	4.27	5.17	6.13	8.69
[a]17	1.81	2.80	3.52	4.51	5.31	6.16	8.34
[a]20	1.06	1.67	2.16	2.83	3.38	3.95	5.47
[a]21	.57	.95	1.25	1.69	2.06	2.46	3.58
[a]22	.78	1.23	1.58	2.08	2.49	2.95	4.18
[a]26	.58	1.01	1.37	1.90	2.37	2.89	4.35
[a]29	.66	1.12	1.49	2.06	2.56	3.11	4.68

[a]Lake Lafayette basins.

Regression Analysis

Because flood information is collected at only a few of the many sites where flood data are needed, hydrologic information must be extended from the gaged to the ungaged sites by regional analysis. Riggs (1973, p. 2) describes regression analysis as a useful regionalization method. Regression relates a dependent variable such as the runoff volume of a given frequency, to independent variables such as basin characteristics. The regression model has the form:

$$V_T = cA^aB^b \qquad (1)$$

where

V_T is the runoff volume for a T-year recurrence interval;

A and B are basin characteristics; and

a, b, and c are constants for recurrence interval T.

Multiple regression provides a mathematical relation between the dependent variable (runoff frequency) and the independent variables (basin characteristics) as well as a measure of the accuracy of the relation. A measure of the usefulness of each independent variable in the relation is also defined.

Runoff volume is assumed to be linearly related to basin characteristics if logarithmic transformations of each are used. Therefore, all runoff data and basin characteristics were transformed into logarithmic form before the regression was performed.

A data-analysis system called Statistical Analysis System (SAS)[1] was used to perform the multiple regression (Helwig and Council, eds., 1979, p. 392). SAS contains five methods of stepwise regression. The stepwise procedure "maximum R^2 improvement" (MAXR) was selected to determine which of the independent variables would be included in the regression model.

R^2 is the square of the multiple correlation coefficient and measures how much variation in the dependent variable can be accounted for by the model. The MAXR method begins by finding the one-variable model producing the highest R^2 and adds another variable that will produce the largest increase in R^2. Each variable in the two-variable model is compared to each variable not in the model. MAXR determines if removing one variable and replacing it with another would improve R^2. Comparison or replacement of variables continues until the "best" two variable model, three-variable model, and so forth, is developed.

[1]The use of brand-named products in this report is for identification only and does not constitute endorsement by the U.S. Geological Survey.

Magnitude and frequency of flood volumes for the stations previously used in the study by Franklin and Losey (1984) were used in this regression analysis. Of the five basin characteristics used for the stepwise regression, storage was the only basin characteristic significant at the 95 percent confidence level. The resulting equations had a range in R^2 from 0.39 to 0.47 and a range in standard error of regression from ±26 percent for 500-year model to ±41 percent for the 2-year model. However, an evaluation of the results from these models revealed a possible geographical bias similar to that reported by Franklin and Losey (1984).

Wilbert O. Thomas, Jr. (U.S. Geological Survey, Reston, Va., written commun., 1982) suggested using a qualitative variable to account for the possible geographical difference in the characteristic used in the regression. A new "basin characteristic" to indicate the station location was created for these regression analyses. All sites within the Lake Lafayette basin were assigned a location value of ten. All other sites were assigned a value of one. The regression analyses were repeated using the "new" basin characteristics. Impervious area replaced storage as the significant basin characteristic when location was added. Thus, the resulting two-variable models effectively had two regression constants. The regression constant and the station location constant for each model were combined to produce equations with different constants for sites in the Lake Lafayette basin and for all other sites in Leon County. This change produced significant improvement in the regression results. The new equations have a range in R^2 from 0.77 to 0.91 and a range in standard error of the regression from 16 to 18 percent.

The regression models for estimating the magnitude of the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval volume of runoff have the form:

$$R_T = C\ IA^x \qquad (2)$$

or

$$R_T = C_L\ IA^x \qquad (2)$$

where

R_T = the runoff volume for the T-year recurrence interval flood, in inches;

C = the regression constant for all sites outside the Lake Lafayette basin;

C_L = the regression constant for all sites in the Lake Lafayette basin;

IA = the impervious area, in percentage, of the drainage area; and

x = the exponent to which IA is raised.

Table 5 summarizes the constants and coefficients for the regression models for urban Leon County. Impervious area is significant at the 5 percent level for all recurrence intervals except the 500-year which is significant at the 8 percent level. Figure 2 shows a graphical comparison of the computed runoff volume versus the station runoff volume for the 2-year and 100-year recurrence intervals.

Table 5.--Regression model coefficients for urban Leon County

Recurrence interval T, in years	Exceedance probability	Regression constant		Exponent X (IA)	R^2	Standard error of regression, in percent
		C	C_L			
2	0.5	0.33	0.15	0.49	0.91	±18
5	.2	.66	.32	.41	.89	±16
10	.1	.95	.48	.36	.88	±16
25	.04	1.42	.76	.32	.86	±16
50	.02	1.84	1.02	.29	.84	±16
100	.01	2.32	1.32	.26	.82	±16
500	.002	3.72	2.28	.21	.77	±17

The equations presented in this report can be used for the developing areas of Leon County. It is important to note that these equations are based on the range of values for impervious area given in a previous part of this report. Extreme caution should be exercised in using these equations outside of that range. It should also be noted that a runoff volume for a given recurrence interval does not necessarily correspond to the peak discharge for the same recurrence interval computed by equations given in Franklin and Losey (1984).

APPLICATION OF TECHNIQUES

The regression equations presented in this report can be used to compute an estimate of the runoff for any of the developing basins in Leon County. The procedure of weighting station values with regression values (U.S. Water

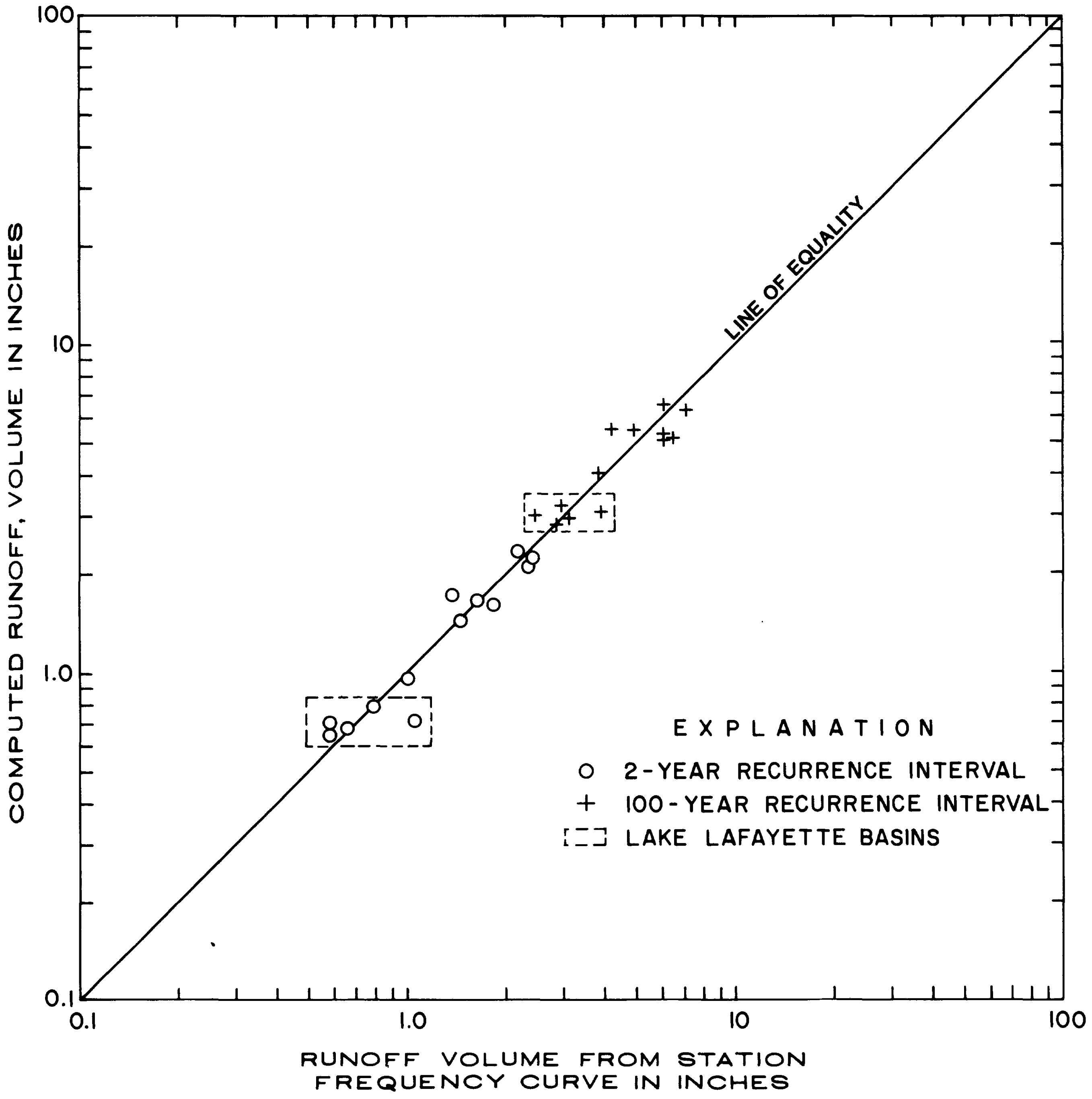

Figure 2.--Comparison of station and regression runoff volume for 2-year and 100-year recurrence interval.

Resources Council, 1981) is not recommended because of the short period of station data available. The regression equation values should be used for all sites of interest.

A step-by-step procedure for determining volume of runoff for the desired recurrence interval is given below:

For example, estimate the runoff for the 25-year and 100-year recurrence intervals for St. Augustine Branch at Wahnish Way (map number 13).

1. Determine the percentage impervious area in the basin (IA = 54 percent).

2. Since the site is not in the Lake Lafayette basin (fig. 1), the appropriate equations are:

25-year runoff volume

$$R_{25} = 1.42\ IA^{0.32}$$

$$R_{25} = 1.42(54)^{0.32}$$

$$R_{25} = 5.09 \text{ inches}$$

100-year runoff volume

$$R_{100} = 2.32\ IA^{0.26}$$

$$R_{100} = 2.32(54)^{0.26}$$

$$R_{100} = 6.54 \text{ inches}$$

SUMMARY

A U.S. Geological Survey urban rainfall-runoff model was calibrated for each of 15 gaging stations in Leon County, Fla. Two of the calibrations were questionable and those stations were not used in the original flood-frequency regional analysis or in this analysis. The calibrated models were used to generate a long-term synthetic runoff-volume record for the remaining 13 stations using the Thomasville-Coolidge, Ga., and Pensacola, Fla., rainfall records.

Volume of runoff-frequency analysis developed from the synthetic runoff record and measured basin characteristics were used in a multiple linear regression analysis to develop the regional runoff-volume-frequency equations. These relations can be used to compute an estimate of the flood-volume magnitude for recurrence intervals from 2 to 500 years. The standard errors of regression range from ±16 percent to ±18 percent, and the standard errors of the rainfall-runoff model ranged from 15 to 26 percent.

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