INVESTIGATION OF TECHNIQUES TO ESTIMATE RAINFALL-LOSS PARAMETERS FOR ILLINOIS

By Linda S. Weiss and Audrey L. Ishii

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 87-4151

Prepared in cooperation with

ILLINOIS DEPARTMENT OF TRANSPORTATION,

DIVISION OF WATER RESOURCES

Urbana, Illinois

1987

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information,
write to:

District Chief
U.S. Geological Survey
Water Resources Division
102 E. Main Street, 4th Floor
Urbana, IL 61801

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center
Box 25425
Denver, CO 80225

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS

Page

TABLES

TABLES

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI)

For the convenience of readers who may want to use metric (International System) units, the inch-pound values in this report may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.40	millimeter (mm)
	0.02540	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)

INVESTIGATION OF TECHNIQUES TO ESTIMATE RAINFALL-LOSS PARAMETERS FOR ILLINOIS

by Linda S. Weiss and Audrey L. Ishii

ABSTRACT

An investigation of techniques for estimating values of parameters for two rainfall-loss computation methods used in the U.S. Army Corps of Engineers' flood-hydrograph model (HEC-1) was conducted by the U.S. Geological Survey. Estimates of six rainfall-loss parameters were investigated--four for the Exponential Loss-Rate method (the dimensionless-exponent parameter, ERAIN; the rate-of-decrease parameter, RTIOL; the initial-value parameter, STRKR; and the antecent soil-moisture parameter, DLTKR) and two for the Initial and Uniform Loss-Rate method (the initial-value parameter, STRTL, and the constant parameter, CNSTL). Multiple-regression analyses using data from 616 storms at 98 gaged basins were used to attempt to develop parameter-estimation techniques for these six parameters for use at ungaged basins in Illinois.

ERAIN values are estimated using a statewide mean value of 0.50. RTIOL values are estimated from a third-order areal trend surface. STRKR values are estimated by a two-step technique of region and mean values or equations with main channel slope. CNSTL values are estimated from a first-order areal trend surface. DLTKR and STRTL values are median monthly values. Standard errors of estimation for the techniques for ERAIN, RTIOL, STRKR, DLTKR, STRTL, and CNSTL are, respectively, 0.044, 1.10, 0.109 inch per hour, 1.30 inches, 0.757 inch, and 0.03 inch per hour. The techniques explain 30, 42, 18, 21, and 19 percent of the variation in the parameters RTIOL, STRKR, DLTKR, STRTL, and CNSTL, respectively. The technique for estimating ERAIN is a mean value, and thus has no percent variation.

Parameter-estimation techniques were evaluated using 102 storms at 36 uncalibrated gaged basins. Estimated unit-hydrograph and rainfall-loss parameter values for both rainfall-loss functions were input to the model. Three computed discharge hydrograph characteristics (sum of incremental flows, V; peak discharge, Q; and time to peak discharge, T) were compared with characteristics of observed discharge hydrographs. Of the 102 simulations for the Exponential Loss-Rate method, 72 storms (71 percent) produced valid hydrographs (hydrographs that were neither flat nor had errors greater than three standard deviations from the mean hydrograph error). Standard deviations for the 72 hydrographs that were produced for V, Q, and T were 66, 69, and 75 percent, respectively. For the Initial and Uniform Loss-Rate method, 48 storms (47 percent) produced valid hydrographs. Standard deviations for the 48 hydrographs that were produced for V, Q, and T were 54, 57, and 86 percent, respectively.

Sensitivity analyses of the model to one standard error of estimate indicate that DLTKR and STRTL are the most significant parameters in reproducing sum of incremental flows and peak discharge for each loss-rate method. Time of concentration (TC) is the most significant parameter in reproducing time to peak discharge, and storage coefficient (R) is the second most significant parameter in contributing to error in peak discharge.

The small percentage of variation explained by the estimation techniques and the results of the evaluation using the 102 storms indicate that there is a large degree of uncertainty in the hydrographs computed using these techniques.

INTRODUCTION

Water-resources managers commonly need to estimate peak discharge, volume of runoff, and time distribution of runoff from rainfall on ungaged watersheds. Unit-hydrograph methods are frequently used. These methods require estimates of unit-hydrograph and rainfall-loss function parameter values that reflect conditions of the ungaged basins. The U.S. Geological Survey (Survey) has developed a technique for estimating the unit-hydrograph parameters for ungaged basins in Illinois (Graf and others, 1982a). Techniques for estimating, or guidelines for selecting, parameter values of the rainfall-loss functions were not available.

Purpose and Scope

This report describes the results of a study that attempted to develop techniques for estimating parameters of two rainfall-loss computation methods. The techniques were evaluated using data from uncalibrated gaged basins. The report presents a description of the two rainfall-loss computation methods, optimized model parameters calculated for 98 gaged basins in Illinois, statistical methods used to develop techniques for estimating parameters of the two rainfall-loss functions for ungaged basins, and evaluation of the parameter-estimation techniques. The techniques are evaluated by analyzing errors in discharge-hydrograph characteristics when estimated rainfall-loss parameters are used. The report is organized according to the progression that was followed in the study. First, the theoretical basis for the parameters is discussed, then the methods and results of the study are presented, and finally, the meaning of the results are analyzed. Refer to "Glossary of Technical Terms" for definitions of terms used throughout this report. This investigation was conducted in cooperation with the Illinois Department of Transportation, Division of Water Resources.

Previous Work

The U.S. Army Corps of Engineers' Hydrologic Engineering Center flood-hydrograph model (HEC-1) (1981) was used to calculate two unit-hydrograph parameters for 98 gaged drainage basins in Illinois--TC, time of concentration, and R, storage coefficient (Graf and others, 1982b). The drainage basins used by Graf and others are those used in this investigation (fig. 1). Drainage areas ranged from 0.45 to 362 mi^2 (square miles), with a mean of 73.9 mi^2. A total of 621 storms occurring from February through November was used for model calibration. Graf and others (1982a, 1982b) have published unit-hydrograph parameter values and a technique for estimating TC and R for ungaged basins.

As part of their investigation, Graf and others (1982b) calibrated the model for the 98 gaged basins using a four-parameter function to compute rainfall excess. This function--the Exponential Loss-Rate function--relates rainfall loss rate to rainfall intensity and accumulated losses (U.S. Army Corps of Engineers, 1981). The four loss-rate parameters that can be adjusted are ERAIN, RTIOL, STRKR, and DLTKR.

Using a different function to compute rainfall losses, Garklavs and Oberg (1986) calibrated the HEC-1 model for 32 of the original 98 basins. A total of 209 storms was used for model calibration. The Initial and Uniform Loss-Rate method has two adjustable parameters, STRTL and CNSTL. Garklavs and Oberg (1986) found that there is no significant difference in the accuracy of modeled hydrographs computed using either method for estimating rainfall excess.

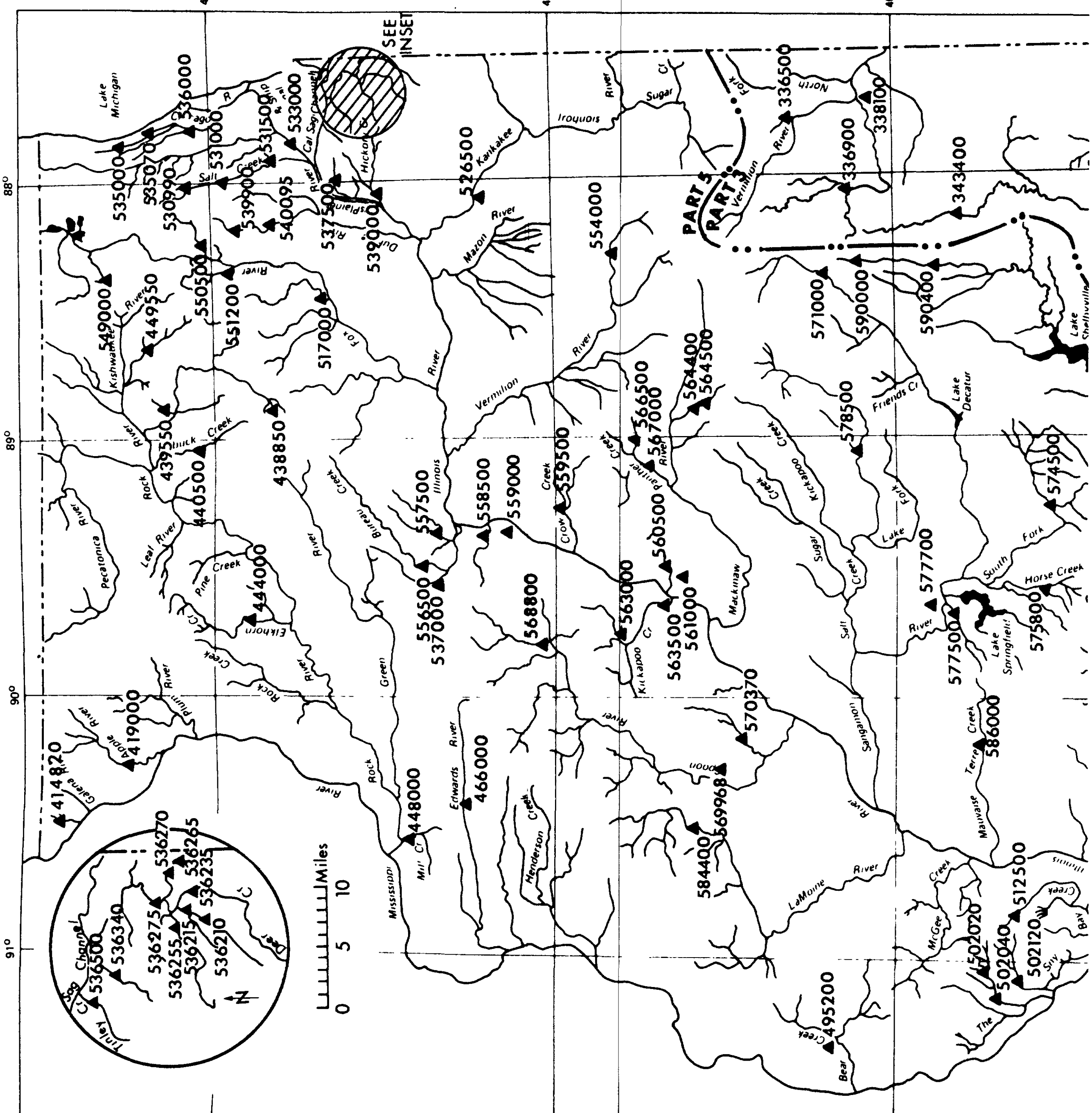
MODEL DESCRIPTION

The HEC-1 flood-hydrograph model (U.S. Army Corps of Engineers, 1981) is a computer program used to model surface runoff. The instantaneous-unit-hydrograph concept and linear-routing scheme (Clark, 1945) are used to route excess rainfall to the basin outlet, producing a runoff hydrograph at the most downstream point in the basin. Rainfall is assumed to be evenly distributed throughout the basin and channel storage is assumed to be linearly related to discharge at the point of basin outflow. The HEC-1 model is applicable only to single-storm analyses, because no provision is made for recovery of soil-moisture capacity and no accounting is made of rainfall losses.

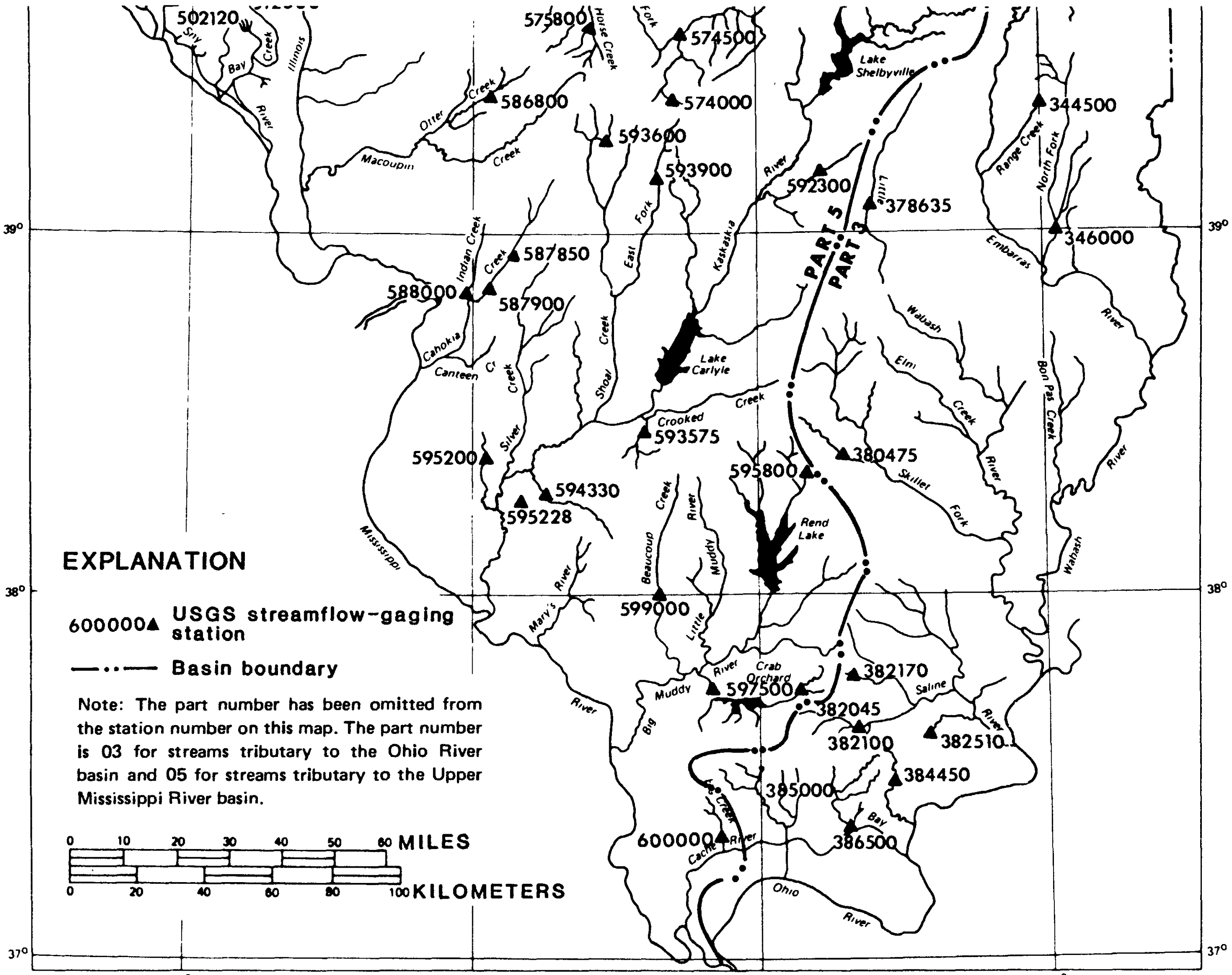
Rainfall-Excess Computation Methods

Rainfall excess is that part of rainfall contributing directly to surface runoff. Rainfall not contributing to runoff is considered lost to the modeled system. Four methods for computing rainfall excess are provided in HEC-1. These methods are the (1) Exponential Loss-Rate, (2) Initial and Uniform Loss-Rate, (3) Soil Conservation Service Curve Number, and (4) Holtan Loss-Rate methods. Parameters for these methods must be input or optimized. Methods 1 and 2 are examined in this report.

The Exponential Loss-Rate method (fig. 2), which relates rainfall-loss rate to rainfall intensity and accumulated losses, is characterized by four adjustable parameters, ERAIN, RTIOL, STRKR, and DLTKR. The rainfall excess hyetograph is computed by subtracting the calculated losses from the observed basin-average rainfall for each computation interval. The equations describing the Exponential Loss-Rate function are as follows:



42°
41°
40°
88°
89°
90°
91°
SEE INSET
PART 5
PART 3
Lake Michigan
Miles
0 5 10
535000
535070
336000
531000
530990
531500
533000
539900
540095
537500
539000
526500
554000
336500
336900
338100
343400
549000
449550
550500
551200
517000
571000
590000
590400
439550
440500
438850
557500
558500
559000
559500
566500
567000
564400
564500
578500
574500
560500
563000
556500
537000
568800
563500
561000
577700
577500
575800
444000
419000
414820
570370
586000
466000
448000
569968
584400
512500
502020
502040
502120
495200
536500
536340
536275
536270
536265
536255
536235
536215
536210
Kankakee
Iroquois
Vermilion
Illinois
Fox
Rock
Pecatonica
Kishwaukee
Mazon
Sangamon
Mackinaw
Kickapoo
LaMoine
Edwards
Henderson
Green
Mississippi
Lake Decatur
Lake Springfield
Lake Shelbyville
Horse Creek
Friends Cr
Sugar Creek
Salt Creek
Crow Creek
Panther Creek
Bureau
Elkhorn
Pine Creek
Leaf River
Apple River
Galena River
Plum River
Bear Creek
McGee Creek
Terre Creek
Mauvaise
Mill Cr
Cal Sag Channel
Hickory Cr
Des Plaines
Du Page
Salt Creek
Tinley Cr
Deer Cr



Base from U.S. Geological Survey
State base map, 1:1,000,000

Figure 1.--Location of U.S. Geological Survey streamflow-gaging stations used in this investigation.

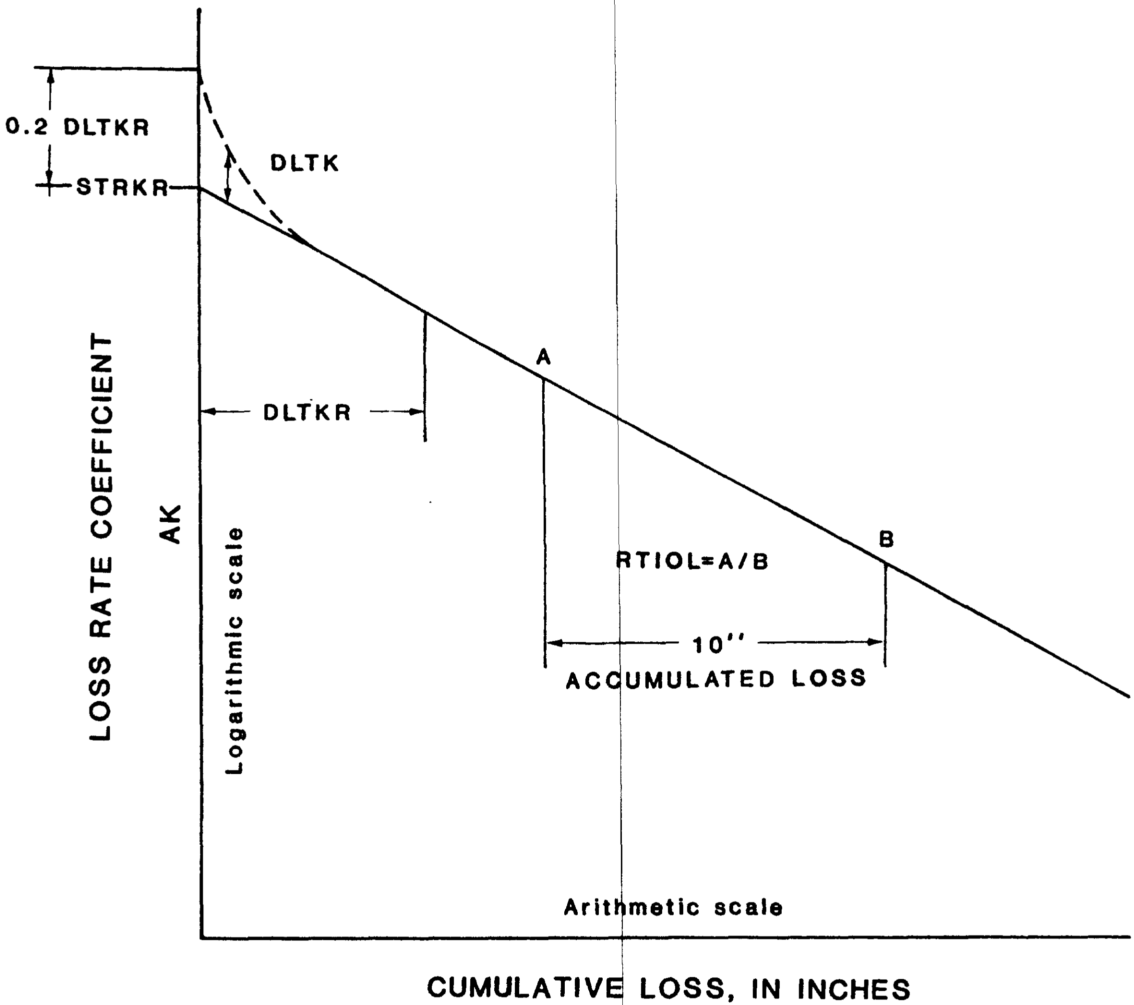


Figure 2.--Exponential Loss-Rate function (from U.S. Army Corps of Engineers, 1981, fig. 1).

$$ALOSS = (AK + DLTK)\ PRCP^{ERAIN} \qquad (1)$$

where $$AK = STRKR/(RTIOL^{0.1\ CUML}), \text{ and} \qquad (2)$$

$$DLTK = 0.2\ DLTKR\ [1 - (CUML/DLTKR)]^2 \text{ for } CUML \leq DLTKR. \qquad (3)$$

ALOSS is the rate of potential rainfall loss and is calculated by multiplying a loss-rate coefficient by an exponential function of precipitation. AK is the loss-rate coefficient at the beginning of each computation interval. DLTK is the incremental increase in rainfall-loss coefficient, AK, during the first DLTKR inches of accumulated loss, CUML. DLTKR, related to antecedent soil-moisture conditions, is the amount of initial accumulated rainfall loss during which the loss-rate coefficient is increased. STRKR is a function of infiltration capacity and is the initial value of the loss-rate coefficient. RTIOL, related to the ability of a basin to absorb rainfall, is the rate of exponential decrease of the loss-rate coefficient with accumulated rainfall loss. PRCP is the amount of basin-average rainfall available during each computation interval. ERAIN is a dimensionless exponent related to storm variability on a regional basis.

The Initial and Uniform Loss-Rate method (fig. 3) is similar to methods using an infiltration index, defined as that rate of rainfall above which the rainfall volume equals the runoff volume (Linsley and others, 1975, p. 273-274). The Initial and Uniform Loss-Rate method has two adjustable parameters, STRTL and CNSTL. All rainfall, up to the depth specified by STRTL, the initial loss, is considered lost to abstractions. This initial loss is the amount of rainfall used to satisfy antecedent soil-moisture deficiency. Thereafter, rainfall-loss rate is constant, equal to CNSTL. Excess rainfall is computed by subtracting calculated losses from the observed basin-average rainfall for each computation interval.

Optimization Technique

Unit-hydrograph (TC, R) and loss-rate parameters (ERAIN, RTIOL, STRKR, and DLTKR for the Exponential Loss-Rate method and STRTL and CNSTL for the Initial and Uniform Loss-Rate method) were calculated using a nonlinear optimization technique in the HEC-1 model. This technique minimizes an objective function, which is the square root of the weighted-squared differences between observed and computed discharges. Input data included drainage area and a time-area curve for each basin, rainfall data, observed discharge hydrographs, and values for baseflow variables for each storm. Output from the model included optimized values of the unit-hydrograph and rainfall-loss parameters and a computed outflow discharge hydrograph for each storm. The parameters ERAIN, RTIOL, STRKR, and CNSTL were optimized to basin-average values, while the parameters DLTKR and STRTL were optimized to individual storm values. This method was used to reflect the theoretical dependence of ERAIN, RTIOL, STRKR, and CNSTL on spatially-varying basin or regional characteristics, and the dependence of DLTKR and STRTL on temporally varying storm or seasonal characteristics. DLTKR and STRTL were the last parameters fixed and, consequently,

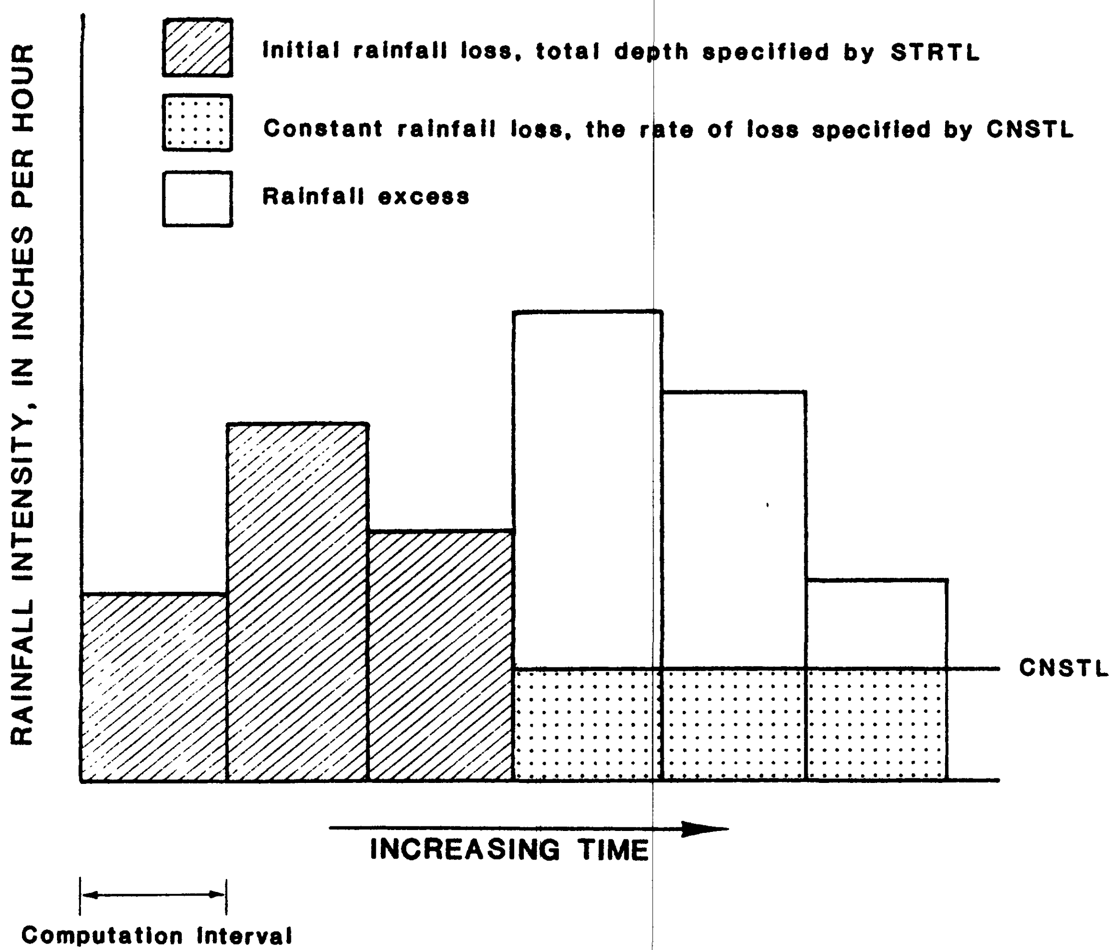


Figure 3.--Application of Initial and Uniform Loss-Rate method (from Garklavs and Oberg, 1986, fig. 2).

included "slack" from the averaging process. The reader is referred to the HEC-1 users' manual for a more detailed explanation of the two rainfall-loss functions and optimization techniques (U.S. Army Corps of Engineers, 1981).

RAINFALL-LOSS PARAMETER-ESTIMATION TECHNIQUES

The following sections of the report describe the development and evaluation of the rainfall-loss parameter-estimation techniques for two rainfall-loss functions. In the first section, the methods used to develop the parameter-estimation techniques are discussed and the techniques are presented for the Exponential Loss-Rate and the Initial and Uniform Loss-Rate methods. In the second section, the techniques are evaluated by error analyses of estimated discharge hydrographs at 36 independent gaging stations and by sensitivity analyses.

Development

The HEC-1 model had been calibrated prior to this study using the Initial and Uniform Loss-Rate method for 32 of the 98 basins originally studied by Graf and others (1982b) (Garklavs and Oberg, 1986). The remaining 66 basins were calibrated to provide a complete set of loss-rate and unit-hydrograph parameters for this study. Values of TC, R, ERAIN, RTIOL, STRKR, and DLTKR computed for the Exponential Loss-Rate method, and TC, R, CNSTL, and STRTL computed for the Initial and Uniform Loss-Rate method for each of the 621 storms at the 98 gaging stations are presented in table 1. Peak discharge and corresponding recurrence interval are also given for each storm. The recurrence intervals were calculated from the Survey gaging-station frequency curves as noted in the headnote to table 1 (Hydrology Subcommittee of Interagency Advisory Committee on Water Data, 1982), except at one station that is footnoted as having been calculated by the technique of Curtis (1977). Storms occurring in February and November were not included in the technique development, due to the small number of storms (five) in these months. A total of 616 storms occurring during March through October were left. Thus, 98 basin-averaged optimized values of ERAIN, RTIOL, STRKR, and CNSTL, and 616 storm-event optimized values of DLTKR and STRTL were available for analysis. Table 2 shows a statistical summary of the computed loss-rate and unit-hydrograph parameter values. The table describes the range and variation of parameter values for Illinois.

Statistical methods were used to develop techniques for estimating values for loss-rate parameters. The distributions of the parameters were tested for normality using tests for skewness and kurtosis. All of the distributions were normal or nearly normal. The range of values for most loss-rate parameters in the HEC-1 model are bounded by numerical limitations (U.S. Army Corps of Engineers, 1981, p. 44, 45). This helps explain why some of the distributions are not exactly normal. The strength of relations between the rainfall-loss parameters and various selected characteristics were determined using correlation analyses. Means testing with t-tests was used to determine possible groupings, and for some parameters, means or medians were selected as the best technique. Regressions were performed and the F-test was used to determine statistical significance. Regression analyses included linear, polynomial, and stepwise or multiple regressions with combined and transformed variables as appropriate. Spatial trends were evaluated using polynomial trend analysis. All relations were tested for significance at the 5-percent level or better. The estimating techniques presented were determined to be the most reasonable, based on results of the statistical analyses, sensitivity, and hydrograph error analyses (refer to "Evaluation" section).

Rainfall-loss parameter values obtained from calibration of the model for the 98 gaged basins (table 1) may be related to basin characteristics that have little or no regional trend (drainage area, channel length, slope) or to those that may have regional trends (topography, rainfall distribution, land use, geology). Values of rainfall-loss parameters that vary from storm to storm may be related to climatological characteristics such as air temperature, evapotranspiration, and antecedent soil moisture.

Regional trends in loss-rate parameters were identified using polynomial trend analysis (O'Leary and others, 1966). Multiple-regression models are formed from polynomials of successively higher degree. This multiple-regression technique uses map coordinates as independent variables, and the parameter for which the regional trend is being investigated as the dependent variable. Each regression model defines a surface, a first-degree model defining a planar surface, a second-degree model defining a parabolic surface, and successively higher-degree models describing surfaces of increasing complexity. First, second, and third-degree models, respectively, are represented by equations of the form

$$z = b_0 + b_1x + b_2y \tag{4}$$

$$z = b_0 + b_1x + b_2y + b_3x^2 + b_4xy + b_5y^2 \tag{5}$$

$$z = b_0 + b_1x + b_2y + b_3x^2 + b_4xy + b_5y^2 + b_6x^3 + b_7x^2y + b_8xy^2 + b_9y^3 \tag{6}$$

where x and y are map coordinates, z is the estimated value of the dependent variable, and b_0 through b_9 are regression coefficients computed by the least squares method. Successively higher degree models are tested for significance at the 5-percent level, and the model that best represents the data selected. As in other regression models, the goal is to identify systematic trends and to separate those trends from random variation (Davis, 1973).

The relation of loss-rate parameters to drainage area, slope, and length was investigated. Other basin characteristics were also considered, including surface storage area, percent forest cover, and latitude and longitude. Storm-dependent loss-rate parameters (DLTKR, STRTL) were also related to mean monthly precipitation, evapotranspiration, and air temperature. Groups were defined using nominal data including hydrologic region (Mitchell, 1954); rural or urban drainage basin (urban is defined as greater than about 7-percent impervious area) (Graf and others, 1982a); the presence of strip-mined land; and month (March through October). These characteristics were selected for their availability to users of the techniques.

Exponential Loss-Rate Method

The standard error of the estimating techniques was determined using the equation

$$\text{standard error of estimate} = \sqrt{\frac{\Sigma\ (Y-\hat{Y})^2}{n-k-1}} \tag{7}$$

where
- Y = computed value of parameter,
- $\hat{Y}$ = estimated value of parameter,
- n = number of observations, and
- k = number of regression coefficients estimated.

The percent of variation explained by the statistical models used in the techniques is a measure of the improvement in the technique obtained by using the independent variable or grouping. It may be calculated by the equation

$$\text{percent variation explained} = \frac{SSY-SSE}{SSY} \times 100 \tag{8}$$

where
- $SSY = (Y-\overline{Y})^2$,
- $SSE = (Y-\hat{Y})^2$,
- Y = computed value of parameter,
- $\overline{Y}$ = mean value of parameter set from model calibration, and
- $\hat{Y}$ = estimated value of parameter.

The percent of variation explained by the model is equivalent to the square of the correlation coefficient.

The best technique for estimating ERAIN was found to be a statewide mean value of 0.50.

The standard error of estimate and the percent of variation explained by the estimating technique (where applicable) for ERAIN and other parameters are given in table 3.

Polynomial trend analysis indicated that RTIOL has a significant third-degree regional trend. The third-degree trend surface was contoured and is presented in figure 4.

Values of STRKR have a significant first-degree regional trend. STRKR is further correlated with drainage area, length, and slope. Illinois was thus divided into regions based on the contoured first-degree areal trend (fig. 5).

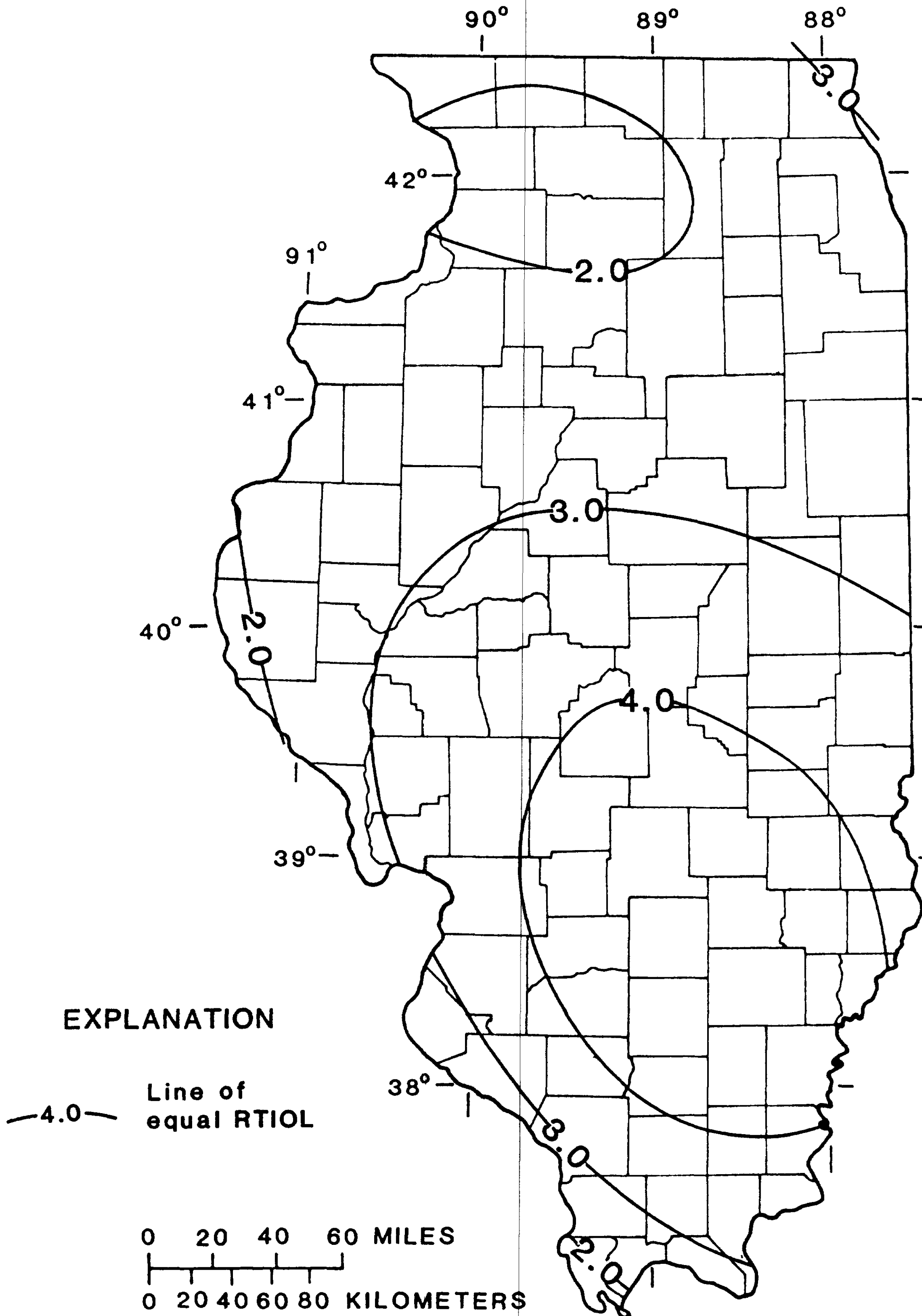


Figure 4.--Regional values of the rate-of-decrease loss-rate parameter used in the Exponential Loss-Rate method.

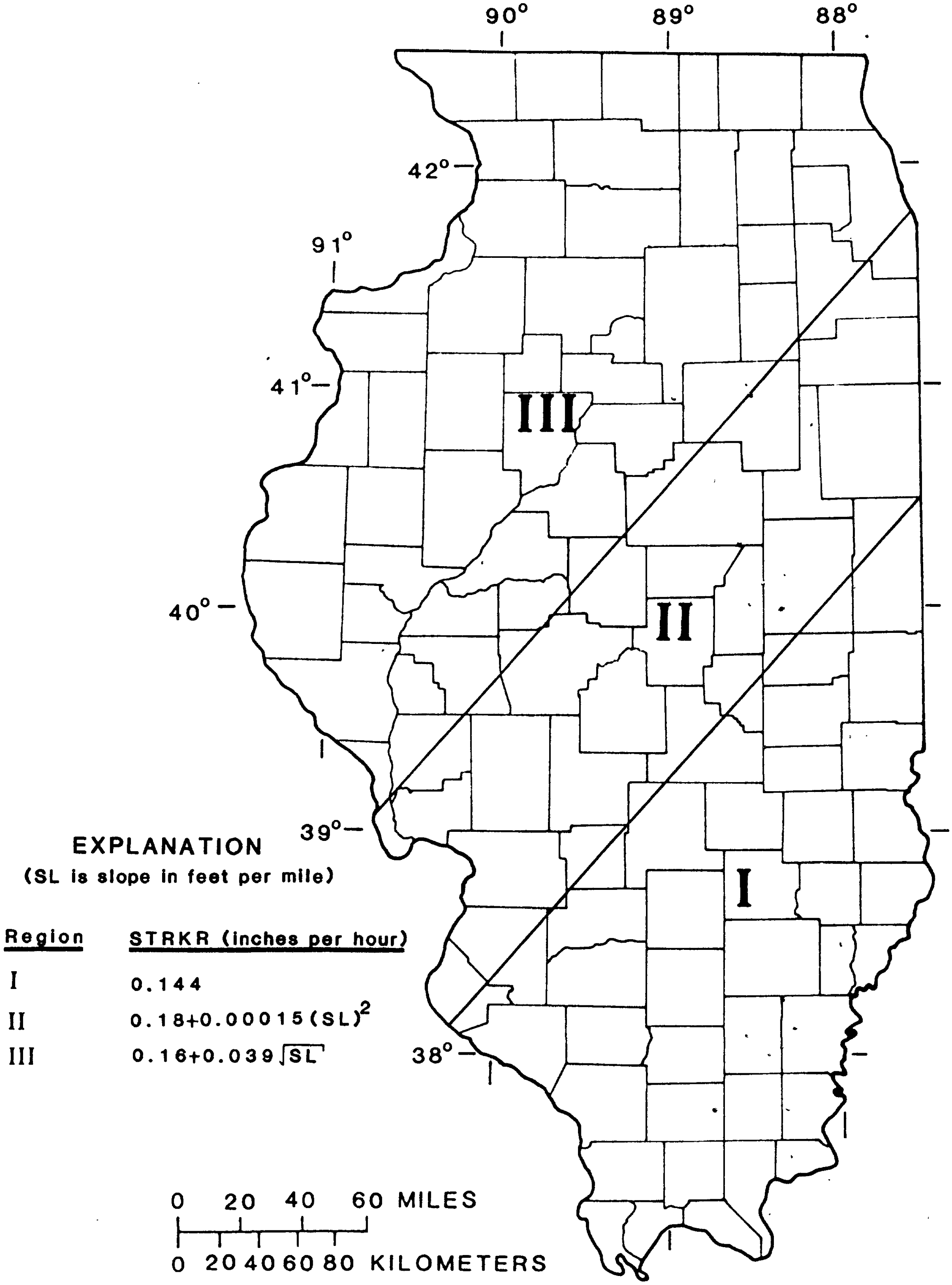


Figure 5.--Regions for the initial-value loss-rate parameter used in the Exponential Loss-Rate method.

A relation between STRKR and basin characteristics was obtained by forward stepwise regression of STRKR on drainage area, length, and slope in each of the regions (fig. 5). Estimating relations for STRKR are given in figure 5. In Region I (fig. 5), STRKR may be estimated by a mean value equal to 0.144 in/h. For Region II, STRKR was regressed with the square of slope to obtain the equation

$$STRKR_e = 0.18 + 0.00016(SL)^2 \qquad (9)$$

where SL is the main channel slope for the basin in feet per mile. Slope was calculated as the average difference in elevation for points located 10 and 85 percent of the length of the main channel from the stream gage. For Region III, STRKR was regressed with the square root of slope to obtain the equation

$$STRKR_e = 0.16 + 0.039 \sqrt{SL}. \qquad (10)$$

DLTKR is correlated with evapotranspiration, temperature, and mean monthly precipitation, and thus may be significantly grouped according to the indicator variable MONTH, because evapotranspiration, temperature, and precipitation are highly intercorrelated, and all may be grouped according to MONTH. MONTH incorporates the seasonal variation of these variables. Hence, DLTKR values were separated into eight monthly data sets. A statistical summary of monthly DLTKR values is shown in table 4. Due to the skewed distributions of monthly DLTKR values, median values were selected for the estimating technique for DLTKR. (Mean monthly DLTKR values tended to overestimate the rainfall loss for most storms.) Monthly values of standard error of estimate for DLTKR are given in table 4.

Initial and Uniform Loss-Rate Method

STRTL is correlated with evapotranspiration, temperature, and mean monthly precipitation, and thus may be significantly grouped according to the indicator variable MONTH, as explained above for DLTKR. Hence, STRTL values were separated into eight monthly data sets. A statistical summary of monthly STRTL values is shown in table 5. Due to the skewed distributions of monthly STRTL values, median values were selected for the estimating technique for STRTL. (Mean monthly STRTL values tended to overestimate the rainfall loss for most storms.) Monthly values of standard error of estimate for STRTL are given in table 5.

Values of CNSTL have a significant first-degree regional trend. The first-degree trend surface was contoured and is presented in figure 6.

Percent of variation and standard error of estimate values for the techniques for estimating the unit-hydrograph parameters TC and R (Graf and others, 1982a) were also calculated and are presented in table 3.

Table 6 shows a statistical summary of all estimated loss-rate and unit-hydrograph parameters. Estimating techniques for the loss-rate parameters are presented in this report, and estimating techniques for the unit-hydrograph

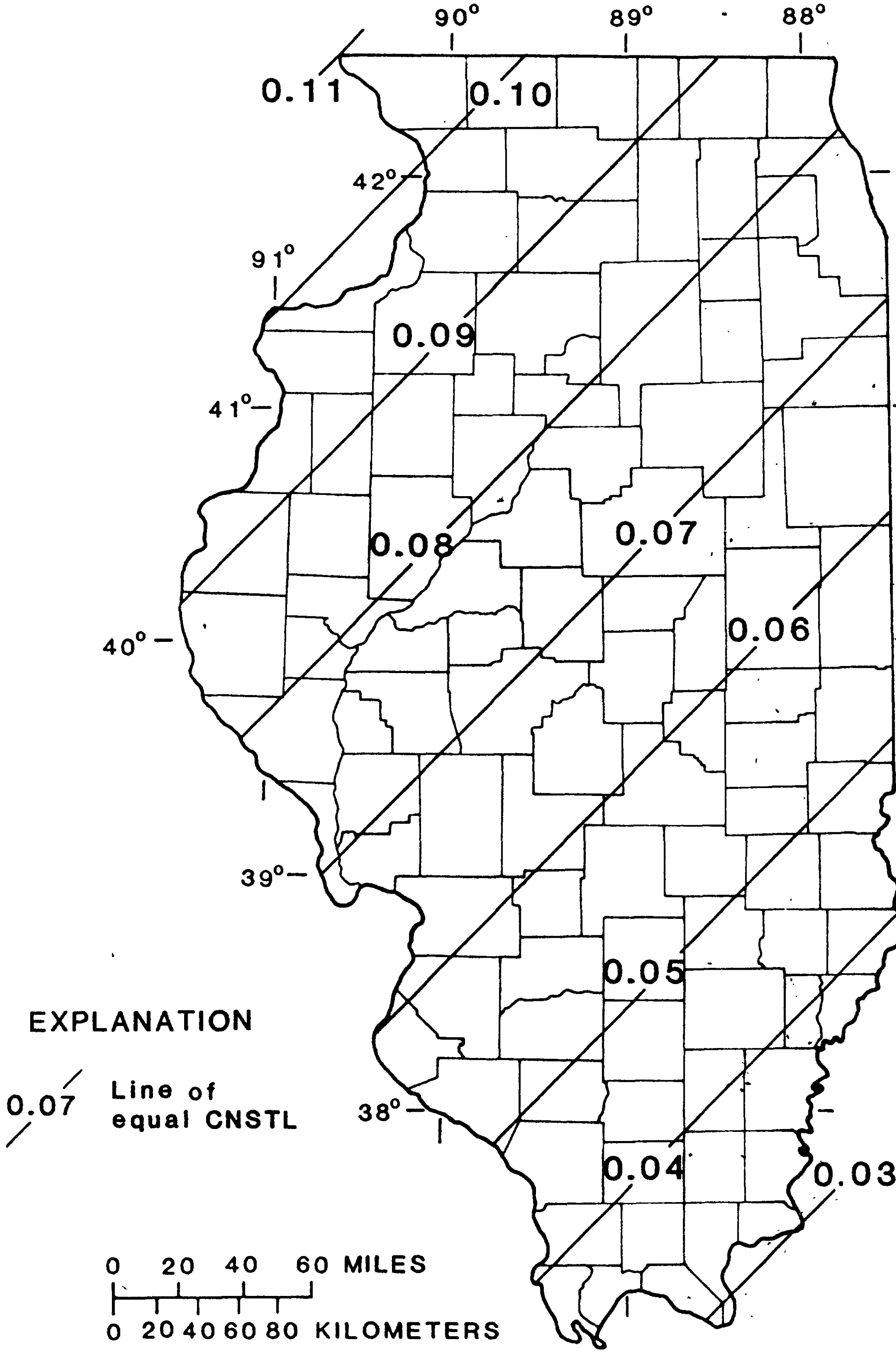


Figure 6.--Regional values of the constant loss-rate parameter used in the Initial and Uniform Loss-Rate method.

parameters were developed by Graf and others (1982a). Comparison of table 6 (estimated parameters) with table 2 (computed parameters) gives an indication of the accuracy with which the estimating techniques preserve the various measures of the original data. In general, the parameter-estimation techniques preserve the means and reduce the variations of the distributions.

Evaluation

Parameter-estimation techniques were evaluated using two methods. First, computed discharge hydrographs were compared with observed discharge hydrographs for an independent set of gaged basins. Second, sensitivity analyses were performed to determine the effects of a variation equal to 25 percent in each individual parameter value and a variation equal to one standard error of estimate in each individual parameter value on computed discharge hydrograph characteristics. These sensitivity analyses were to determine the sensitivity of the model to each parameter and to the maximum expected error for estimated parameter values two-thirds of the time.

Discharge Hydrograph Characteristics for an Independent Set of Gaged Basins

Thirty-six uncalibrated gaged basins with approximately three storms each (102 storms) were used for evaluation of the parameter-estimation techniques (fig. 7). Basin locations were selected to be areally distributed over the State. Drainage areas for the 36 basins range from 0.52 to 473 mi^2 with a mean of 112.4 mi^2. Although the average area is 50 percent larger than that of the original 98 basins, there is no significant difference in hydrograph modeling accuracy for the larger drainage basins.

Computed discharge hydrographs were obtained by modeling the 102 storms using parameters estimated using the parameter-estimation techniques for both loss-rate methods presented in this report, and for the unit-hydrograph parameters presented in Graf and others (1982a). Since all estimated parameters (rainfall-loss and unit-hydrograph) are evaluated simultaneously, errors are compounded.

Parameter-estimation techniques are evaluated using three computed discharge hydrograph characteristics: V, sum of incremental flows (indicative of the total volume of flow), in cubic feet per second; Q, instantaneous peak discharge, in cubic feet per second; and T, time to peak discharge, in hours. Three sets of V, Q, and T were available for comparison: (1) One set for the 102 observed hydrographs; (2) one set for the corresponding computed hydrographs obtained when using techniques for estimating Exponential Loss-Rate method parameters (this report) and unit-hydrograph parameters (Graf and others, 1982a); and (3) one set for the corresponding computed hydrographs obtained when using techniques for estimating Initial and Uniform Loss-Rate method parameters (this report) and unit-hydrograph parameters (Graf and others, 1982a). Percent differences, hereafter referred to as errors, in V, Q, and T, were calculated using the equation

$$PD(Y) = [(Y_o - Y_x) \div Y_o] \times 100 \quad (11)$$

where PD(Y) is the error for the hydrograph characteristic V, Q, or T; Y_o is the value of V, Q, or T for the observed hydrograph; and Y_x is the value of V, Q, or T for the hydrograph computed when unit-hydrograph and rainfall-loss parameters are estimated using either method of calculating rainfall excess.

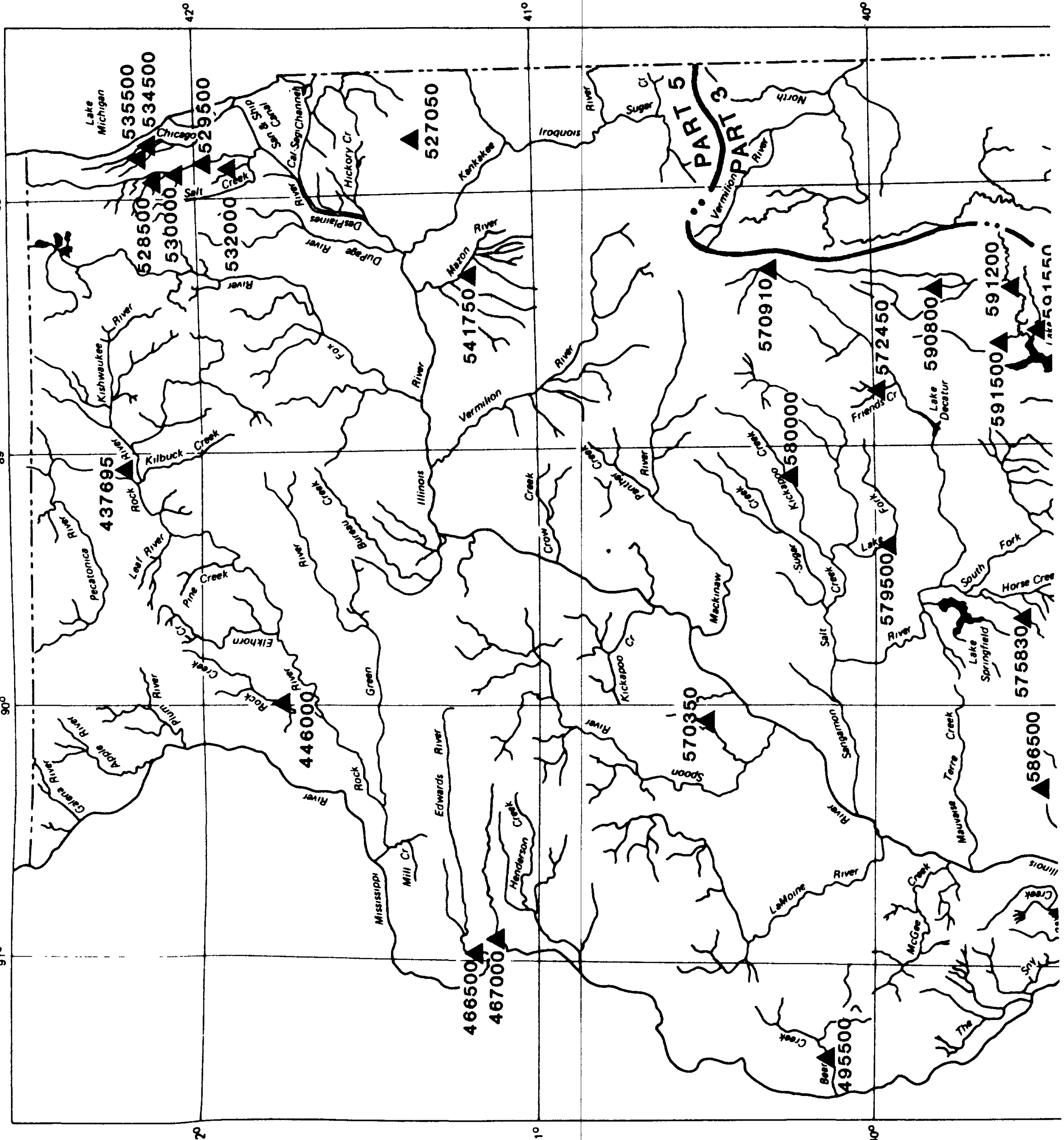
For the set of computed hydrographs obtained using estimated parameters for the Exponential Loss-Rate method, 19 of the 102 simulations (19 percent) produced no hydrograph at all or only the recession limb (rainfall loss exceeds precipitation) of a hydrograph. Of the 83 simulations that produced hydrographs, 11 storms (13 percent) were considered outliers, because these storms had a hydrograph error for V, Q, or T greater than three standard deviations from the mean hydrograph error for that characteristic. Thus, 29 percent of the 102 simulations resulted in invalid hydrographs. Table 7 shows a statistical summary of the errors in computed hydrograph characteristics for the simulations producing hydrographs, with and without outliers. Negative errors indicate that computed values of the hydrograph characteristic are too large; positive errors indicate computed values are too small.

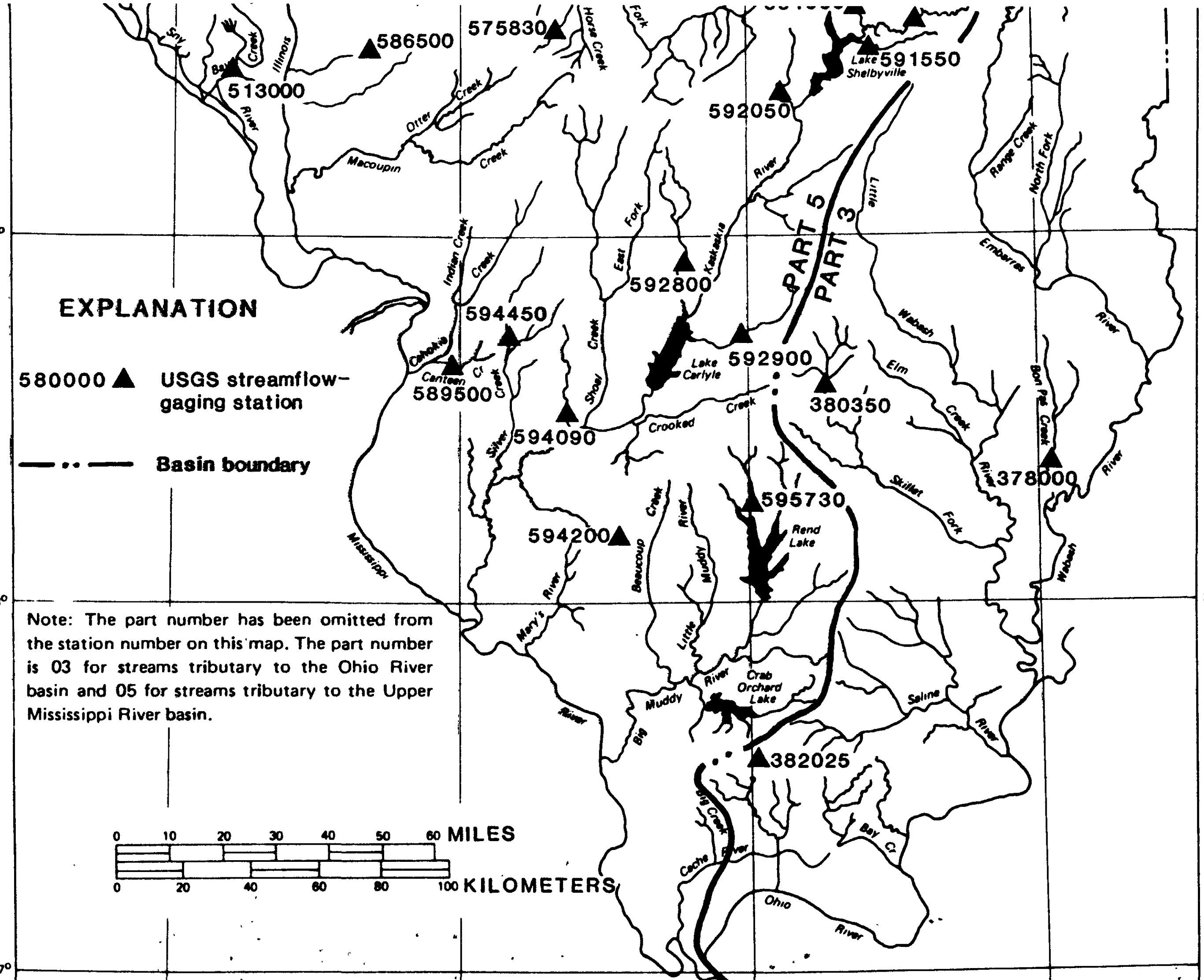
For the set of computed hydrographs obtained using estimated parameters for the Initial and Uniform Loss-Rate method, 49 of the 102 simulations (48 percent) produced no hydrograph at all or only the recession limb of a hydrograph. Of the 53 simulations that produced hydrographs, 5 storms (9 percent) were considered outliers. Thus, 53 percent of the 102 simulations resulted in invalid hydrographs. Table 8 shows a statistical summary of the errors in computed hydrograph characteristics for simulations producing hydrographs, with and without outliers.

If the hydrographs computed using estimated parameters reproduced observed hydrographs accurately, the expected distribution of the values of the mean of errors of V, Q, and T for an infinite number of storms would be normal about zero. Statistics from tables 7 and 8 show that for both loss-rate methods, storm hydrographs (without the outliers) have positive mean errors in V and Q, and negative mean error in T. For both rainfall-loss methods, V is reproduced more accurately than Q. The large negative mean error in T means that the time to peak flow is overestimated. The distributions of all measures of hydrograph error for both methods have slightly negative coefficients of skewness and standard deviations that are large compared to the mean. These results indicate that more hydrograph errors are to the right of the mean hydrograph error and are distributed more uniformly (from the minimum value to the maximum value) than a normal distribution. Some skew is to be expected because errors are bounded on one side by 100 percent and unbounded on the other side.

The outlier errors for both methods average about -250 percent for V and Q. When these large negative errors are included in the set of hydrograph errors, the means are decreased and the skew becomes more negative, yielding a much less normal distribution of errors.

The evaluation of the parameter-estimation techniques using discharge hydrograph characteristics for an independent set of gaged basins resulted in 29 and 53 percent invalid hydrographs for the Exponential Loss-Rate and Initial


42°
41°
40°
88°
89°
90°
91°
PART 5
PART 3
535500
534500
529500
527050
528500
530000
532000
541750
570910
572450
590800
591200
591500
580000
579500
575830
586500
570350
437695
446000
466500
467000
495500
Lake Michigan
Chicago
Kankakee
Iroquois
Vermilion
Illinois
Mississippi
Rock River
Fox River
DuPage River
Des Plaines
Kishwaukee River
Kilbuck Creek
Pecatonica River
Galena River
Apple River
Plum River
Elkhorn
Pine Creek
Leaf River
Green River
Bureau Creek
Edwards River
Henderson Creek
Mill Cr
Mazon River
Crow Creek
Panther Creek
Mackinaw
Kickapoo Cr
Spoon River
LaMoine River
Sangamon River
Salt Creek
Sugar Creek
Lake Decatur
Friends Cr
Lake Springfield
South Fork
Horse Creek
Mauvaise Terre Creek
McGee Creek
Bear Creek
Hickory Cr
Salt Creek



Base from U.S. Geological Survey
State base map, 1:1,000,000

Figure 7.--Location of gaging stations used for evaluation of parameter-estimation techniques.

and Uniform Loss-Rate methods, respectively. Standard deviations of V, Q, and T for those computed were 66, 69, and 75 percent, respectively, for the Exponential Loss-Rate method and 54, 57, and 86 percent, respectively, for the Initial and Uniform Loss-Rate method. The small percent of variation explained by the estimation techniques (table 3), and the results of the evaluation using the 102 storms indicate that there is a large degree of uncertainty in the hydrographs computed using the estimation techniques.

Sensitivity Analysis

Two types of sensitivity analyses were performed. These analyses were to (1) test the effects of a variation of 25 percent in each parameter value individually (a model sensitivity to the parameters), and (2) test the effects of a variation equal to one standard error of estimate in each parameter value individually on computed discharge hydrograph characteristics. Both pieces of information are necessary in determining the relative contributions of each parameter to the hydrograph error. For example, the model is sensitive to ERAIN, but using the technique to estimate ERAIN leads to little error, because ERAIN has a small standard error of estimate.

The first sensitivity analysis presents information to help the user adjust the parameters. In this analysis, optimized rainfall-loss and unit-hydrograph parameters were varied individually by 25 percent to determine the sensitivity of the hydrograph characteristics to each parameter. Data used were for six storms at Cahokia Creek at Edwardsville, Illinois (station 05587900), and for seven storms at South Branch Kishwaukee River tributary near Irene, Illinois (station 05439550). The stations were selected so that the mean values of their parameters were close to the mean values of all station parameters used in the study. The sensitivity of the model was measured by change in the three hydrograph characteristics V, Q, and T. Percentage change in hydrograph characteristics V, Q, and T was calculated using equation 11 with Y_o equal to the value of the hydrograph characteristic obtained with optimized parameters and Y_x equal to the value of the hydrograph characteristic obtained when optimized parameters are increased and decreased by 25 percent. Table 9 shows percentage change averaged over the six storms at Cahokia Creek for the Exponential Loss-Rate method, and table 10 shows similar results for the Initial and Uniform Loss-Rate method. Table 11 shows percentage change averaged over the seven storms at South Branch Kishwaukee River tributary for the Exponential Loss-Rate method, and table 12 shows similar results for the Initial and Uniform Loss-Rate method. The model is most sensitive in the hydrograph characteristics V and Q to changes in DLTKR for the Exponential Loss-Rate method, and to changes in STRTL for the Initial and Uniform Loss-Rate method. For both methods, the model is most sensitive to changes in TC in the hydrograph characteristic T. The model is not sensitive to changes in RTIOL.

In the second sensitivity analysis, optimized rainfall-loss and unit-hydrograph parameters for data for 21 storms at three gaging stations were varied by one standard error of estimate for each parameter individually (monthly values for DLTKR and STRTL). The error in the estimated parameters would be less than or equal to this amount about two-thirds of the time. This analysis was to determine the maximum expected error in hydrograph characteristics for two-thirds of the hydrographs produced by using the estimation techniques. Percentage change in hydrograph characteristics was averaged for the storms at each station.

These average values for each station were then averaged over the three stations. Table 13 shows percentage change averaged over the three stations for the Exponential Loss-Rate method, and table 14 shows similar results for the Initial and Uniform Loss-Rate method. For the Exponential Loss-Rate method, the model is most sensitive in the hydrograph characteristic V to changes in STRKR and DLTKR; in Q to changes in STRKR, DLTKR, TC, and R; and in T to changes in TC. For the Initial and Uniform Loss-Rate method, the model is most sensitive in V to changes in STRTL and CNSTL; in Q to changes in STRTL and R; and in T to changes in TC and STRTL.

Figures 8 and 9 show the effect that positive and negative standard error of estimate for each parameter have on a typical hydrograph. The August 17, 1968, storm at Deer Creek near Chicago Heights, Illinois (station 05536235), was used for the analysis. The hydrograph was selected because its calibrated parameters were close to the mean values of parameters.

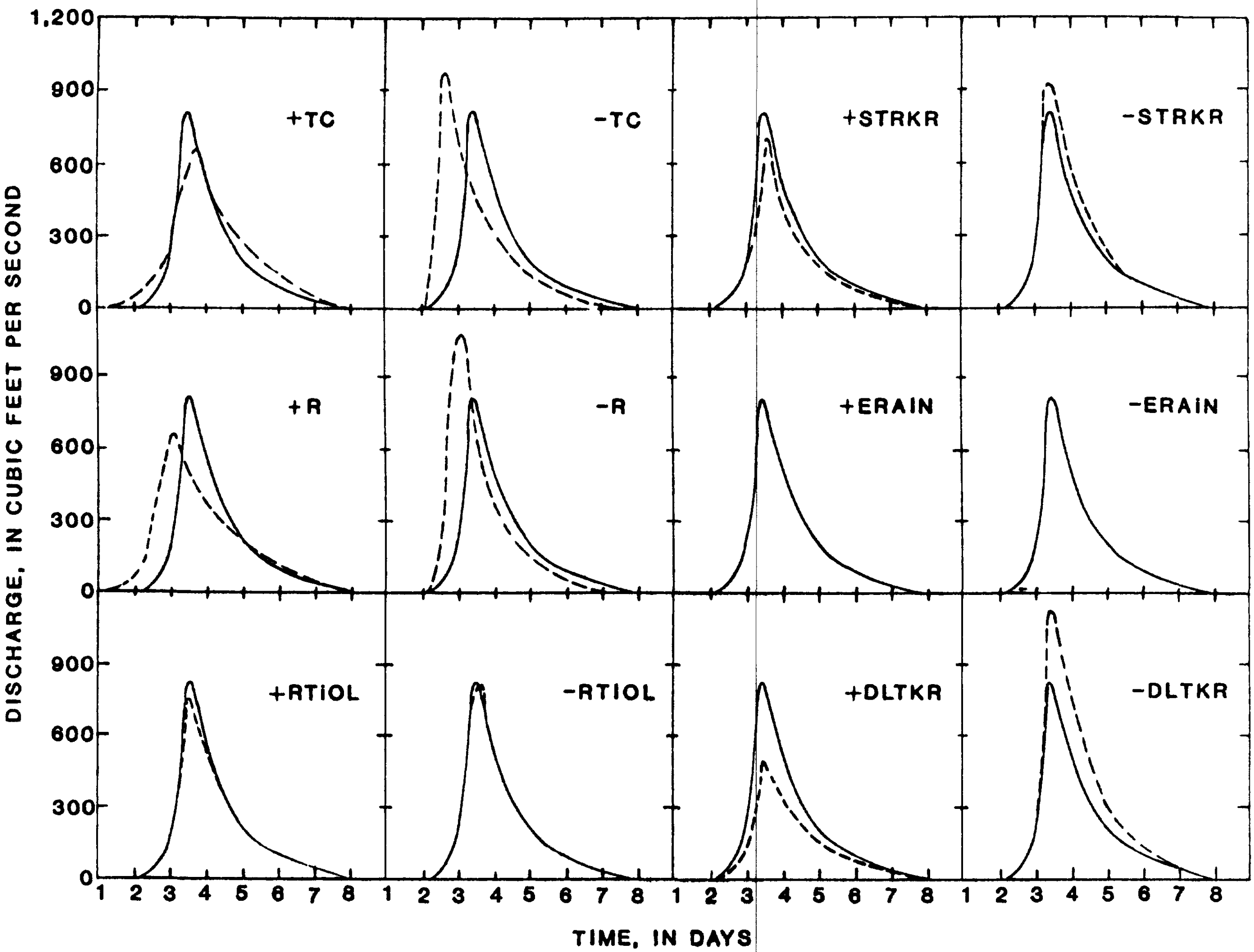
Based on the results of these sensitivity analyses, DLTKR is the most significant parameter in reproducing sum of incremental flows (V) and peak discharge (Q) for the Exponential Loss-Rate method. For the Initial and Uniform Loss-Rate method, STRTL is the most significant parameter in reproducing V and Q. Because the model is the most sensitive to the parameters DLTKR and STRTL and because these parameters vary the most (table 2), DLTKR and STRTL have large relative importance. For both methods, TC is the most significant parameter in reproducing time to peak discharge (T).

Discussion

Three methods have been used in the development of the parameter estimation techniques. They are polynomial trend surfaces, regression equations, and median monthly values. The physical significance of each of the estimation techniques in relation to the individual parameter is discussed in this section.

ERAIN is the exponent of precipitation in the Exponential Loss-Rate function and reflects the influence of precipitation rate on the basin-average loss characteristics. It reflects the manner in which storms occur within an area and may be considered a characteristic of a particular area. The estimation technique for ERAIN is a statewide mean value of 0.50.

Regionally varying basin characteristics are indirectly considered in the estimation techniques presented for RTIOL, STRKR, and CNSTL through the use of polynomial trend analyses. RTIOL is the ratio of the rainfall-loss coefficient on the Exponential Loss-Rate curve to that corresponding to 10 inches more of accumulated loss. This parameter is related to the ability of the surface to absorb precipitation. It is the slope of the infiltration curve; hence, higher slope indicates greater decreases in loss rate as time progresses. Larger values of RTIOL indicate little capacity for infiltration.



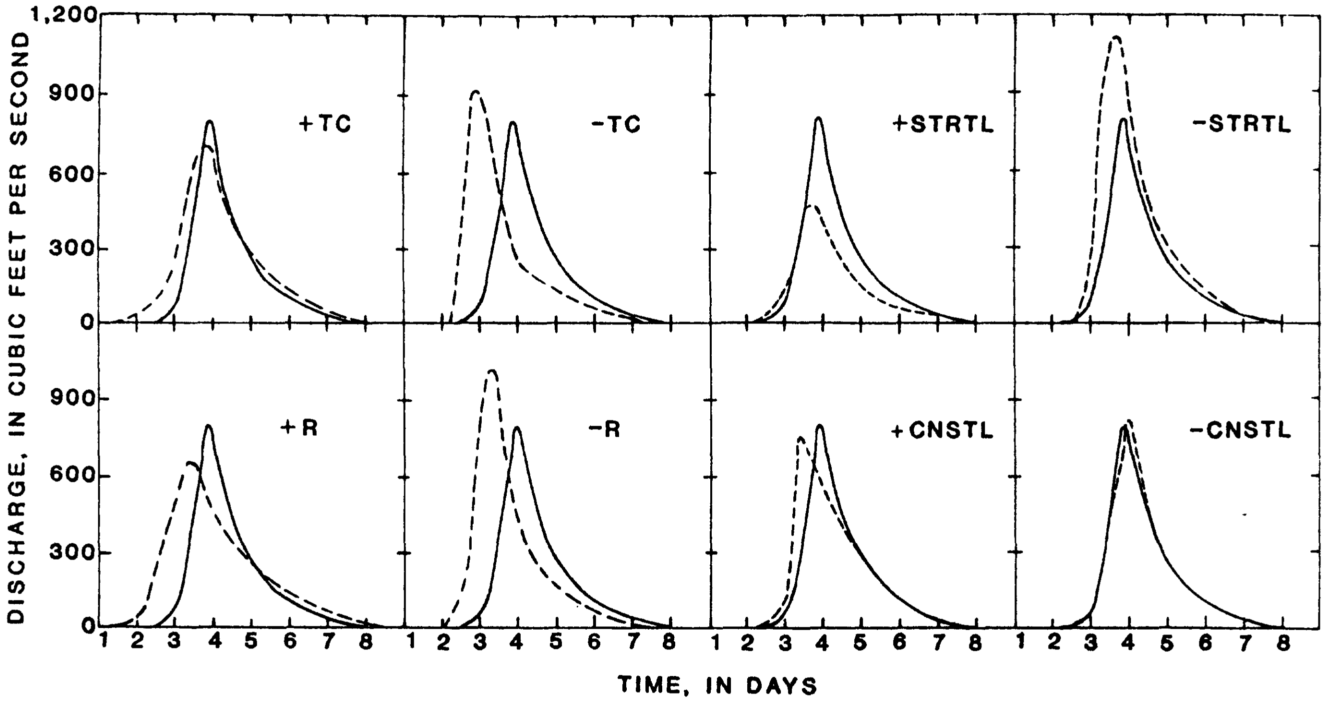
Deer Creek near Chicago Heights, Ill.
August 17, 1968 (Station 05536235)

[Peak discharge equals 874 cubic feet per second; recurrence interval equals 15 years]

Parameter	Optimized parameter value	Standard error of estimate
TC (h)	15.5	10.56
R (h)	25.8	8.62
ERAIN	.55	.0442
RTIOL	3.21	1.10
STRKR (in/h)	.21	.109
DLTKR (in.)	2.64	1.32

Note: Solid lines are optimized hydrographs; dashed lines are hydrographs resulting from a positive or negative change of one standard error of estimate in parameter value, indicated on each graph.

Figure 8.--Effect of one standard error of estimate change in parameter value for a typical hydrograph using the Exponential Loss-Rate method.



Deer Creek near Chicago Heights, Ill.
August 17, 1968 (Station 05536235)

[Peak discharge equals 874 cubic feet per second; recurrence interval equals 15 years]

Parameter	Optimized parameter value	Standard error of estimate
TC (h)	21.7	10.56
R (h)	25.0	8.62
STRTL (in.)	1.69	.871
CNSTL (in.)	.11	.03

Note: Solid lines are optimized hydrographs; dashed lines are hydrographs resulting from a positive or negative change of one standard error of estimate in parameter value, indicated on each graph.

Figure 9.--Effect of one standard error of estimate change in parameter value for a typical hydrograph using the Initial and Uniform Loss-Rate method.

Mitchell (1954) defined 15 hydrologic regions for Illinois based on physiographic divisions of the State (Leighton and others, 1948). Characteristics of the hydrologic regions that may affect infiltration and runoff include land slopes, depth and permeability of the soils, distribution and intensity of precipitation and associated temperatures, stream patterns, and storage capacities. According to Mitchell (1954), the Rock River Hill Region has deep and very permeable soils. These and other physiographic characteristics may be reflected in the low RTIOL values in the northwestern part of the State. RTIOL values increase to the southeast with largest values in the Mt. Vernon Hill Region. The Mt. Vernon Hill Region is characterized by a primarily bedrock surface that may contribute to large runoff. Smaller values of RTIOL along the western and southwestern edge of the State may be attributable to more permeable alluvial deposits.

STRKR is the starting value of the loss coefficient on the exponential recession curve for rainfall losses. The starting value is a function of infiltration capacity and so depends on basin characteristics such as soil type, land use, and vegetal cover and on the moisture conditions at the start of the storm. STRKR has a significant first-order areal trend, decreasing in value from northwest to southeast. High values of STRKR indicate high loss to infiltration and less runoff. The gradual decrease may be a reflection of climatological factors (see CNSTL explanation below), and resembles contours of average annual runoff for Illinois, 1951-80 (Garrelts, 1986, p. 14). STRKR is also correlated with channel slope (for the stations used in the analysis). Based on the first-order trend contours, STRKR was divided into three general regions (fig. 5) incorporating topographical variations. Drainage basins used in Region I in southern Illinois have channel slopes ranging from 2.6 to 41.8 ft/mi (feet per mile), with a mean of 12.1 ft/mi, a standard deviation of 9.6 ft/mi, and coefficient of variation of 79.8 percent. The variation in slope is smaller than for Regions II and III, which may explain why slope was not included in an equation for Region I. Region I includes all Ohio River drainage and upland drainage to the Kaskaskia River (fig. 1).

Region III in northern Illinois has channel slopes ranging from 2.9 to 78.7 ft/mi, with a mean of 14.3 ft/mi, a standard deviation of 15.3 ft/mi, and coefficient of variation of 107 percent for the stations used. These slopes cover a wide range, from higher slopes in the northwest to low slopes towards the center of the State. Region III is characterized by areas widely varying in relief and includes basins draining to the Illinois River and basins to the northwest.

Region II in the center of the State is flatter than Region III and, for the stations used, has channel slopes ranging from 2.0 to 42.5 ft/mi, with a mean of 10.3 ft/mi, a standard deviation of 9.57 ft/mi, and coefficient of variation of 92.8 percent. The corridor defined by Region II follows the divide separating Illinois River drainage and Kaskaskia River and Wabash River drainage.

The parameter CNSTL is the constant rate of rainfall loss in the Initial and Uniform Loss-Rate method. It is similar to the parameter STRKR in the Exponential Loss-Rate method. CNSTL values (fig. 6) are greatest in the northwest and smallest in the southeast. Large values indicate more rainfall is lost to infiltration, and so less goes to runoff. The gradual decrease from large values in the north to small values in the south may be a reflection of the effect of temperature and precipitation (factors that affect antecedent soil-moisture) on the ability of the soil to accept water. Climatological factors, including temperature and amount, intensity, and distribution of precipitation tend to produce larger mean annual floods in southern than northern Illinois (Mitchell, 1954, p. 335).

DLTKR is the amount of initial accumulated rainfall loss during which the loss-rate coefficient is increased. It is a function primarily of antecedent soil-moisture and is storm dependent. STRTL, the total depth of the initial rainfall loss in the Initial and Uniform Loss-Rate method, is analogous to DLTKR. Both parameters exhibit seasonal trends and reflect moisture conditions that are a function of climatological factors, soil type, surficial geology, vegetative cover, or land use. High values of DLTKR or STRTL indicate greater infiltration due to low antecedent soil moisture. DLTKR and STRTL values (tables 4 and 5) are lowest in the spring when the soil is saturated, hence, more runoff. Values are higher in August through October, when soil is dry and evapotranspiration is higher.

For the Exponential Loss-Rate method, the model is more sensitive in the hydrograph characteristics V and Q to changes in the parameters STRKR and DLTKR (tables 9, 11, and 13) than to changes in ERAIN, RTIOL, TC, and R. For the Initial and Uniform Loss-Rate method, the model is more sensitive in V and Q to changes in CNSTL and STRTL (tables 10, 12, and 14) than to changes in TC and R. The model is also very sensitive in Q to the unit-hydrograph parameter R. The two parameters STRKR and DLTKR are analogous to the two parameters CNSTL and STRTL. If both parameters STRKR and DLTKR or CNSTL and STRTL are overestimated (or underestimated), simulations may produce hydrographs so small (or large) as to produce no hydrograph at all or only the recession limb, or outliers.

From the results of the sensitivity analyses, it can be seen that variations in DLTKR (tables 9, 11, and 13) for the Exponential Loss-Rate method and STRTL (tables 10, 12, and 14) for the Initial and Uniform Loss-Rate method produce the largest changes in the hydrograph characteristics V and Q. The coefficients of variation (table 2) for DLTKR and STRTL are the largest of the loss-rate parameters. These two parameters are dependent on antecedent soil moisture, and so are different for each storm at each basin. They are the last variables to be fixed in model calibration and so are "slack variables," accounting for conceptual, analytical, and numerical approximations, data error, user judgment, and other inaccuracies inherent in the model. The standard error of estimates for monthly values of DLTKR (table 4) and STRTL (table 5) are an indication of expected error. Variations in these parameters yield large changes in V and Q, and modifications to DLTKR and STRTL alone may be sufficient to increase or decrease V and Q, when these hydrograph characteristics exceed reasonable bounds.

For both methods, time of concentration (TC) is the most significant parameter in reproducing time to peak discharge, and storage coefficient (R) is the second largest contributor to error in peak discharge.

SUMMARY

An attempt was made to develop estimation techniques for selection of values of parameters for two rainfall-loss functions used in the HEC-1 flood-hydrograph model. The Exponential Loss-Rate method has four rainfall-loss parameters (ERAIN, RTIOL, STRKR, and DLTKR), and the Initial and Uniform Loss-Rate method has two rainfall-loss parameters (STRTL and CNSTL).

Calibrated rainfall-loss function parameters from 616 storms at 98 gaged basins in Illinois were related to basin and climatological characteristics using multiple-regression analyses. Parameter-estimation techniques include areal trend surfaces, mean values for regions, regression equations, and median monthly values. Standard errors of estimation for the techniques for ERAIN, RTIOL, STRKR, DLTKR, STRTL, and CNSTL are, respectively, 0.044, 1.10, 0.109 in/h, 1.30 in., 0.757 in., and 0.03 in/h. The techniques explain 30, 42, 18, 21, and 19 percent of the variation in the parameters RTIOL, STRKR, DLTKR, STRTL, and CNSTL, respectively. The technique for estimating ERAIN is a mean value, and thus has no percent variation.

Data from 102 storms at 36 uncalibrated gaged basins were used to evaluate the parameter-estimation techniques. Three computed discharge hydrograph characteristics (sum of incremental flows, V; peak discharge, Q; and time to peak discharge, T) were compared with observed hydrograph characteristics. Of the 102 simulations for the Exponential Loss-Rate method, 72 storms (71 percent) produced valid hydrographs. Standard deviations for the 72 hydrographs that were produced for V, Q, and T were 66, 69, and 75 percent, respectively. For the Initial and Uniform Loss-Rate method, 48 storms (47 percent) produced valid hydrographs. Standard deviations for the 48 hydrographs that were produced for V, Q, and T were 54, 57, and 86 percent, respectively.

Sensitivity analyses on rainfall-loss parameters and unit-hydrograph parameters (TC and R) indicated that DLTKR (for the Exponential Loss-Rate method) and STRTL (for the Initial and Uniform Loss-Rate method) are the most significant parameters in reproducing V and Q. For both methods, TC is the most significant parameter in reproducing T, and storage coefficient (R) is the second most significant parameter in contributing to error in Q.

The small percentage of variation explained by the estimation techniques and the results of the evaluation using the 102 storms indicate that there is a large degree of uncertainty in the hydrographs computed using these techniques.

REFERENCES CITED

Clark, C. O., 1945, Storage and the unit hydrograph: American Society of Civil Engineers Transactions, v. 110, p. 1419-1488.

Curtis, G. W., 1977, Technique for estimating magnitude and frequency of floods in Illinois: U.S. Geological Survey Water-Resources Investigations 77-117, 70 p.

Davis, J. C., 1973, Statistics and data analysis in geology: Lawrence, Kansas, John Wiley and Sons, Incorporated, 550 p.

Garklavs, George, and Oberg, K. A., 1986, Effect of rainfall excess calculations on modeled hydrograph accuracy and unit-hydrograph parameters: Water Resources Bulletin Paper No. 85063, v. 22, no. 4, p. 565-572.

Garrelts, M. L., 1986, Water resources activities in Illinois, 1985: U.S. Geological Survey Open-File Report 86-130, 99 p.

Graf, J. B., Garklavs, George, and Oberg, K. A., 1982a, A technique for estimating time of concentration and storage coefficient values for Illinois streams: U.S. Geological Survey Water-Resources Investigations 82-22. 16 p.

-----1982b, Time of concentration and storage coefficient values for Illinois streams: U.S. Geological Survey Water-Resources Investigations 82-13, 35 p.

Hydrology Subcommittee of Interagency Advisory Committee on Water Data, 1982, Bulletin 17B, Guidelines for determining flood flow frequency: U.S. Geological Survey, Office of Water Data Coordination, Reston, Va., 28 p.

Leighton, M. M., Ekblaw, G. E., and Horberg, Leland, 1948, Physiographic divisions of Illinois: Illinois State Geological Report of Investigations 129, 33 p.

Linsley, R. K., Jr., Kohler, M. A., and Paulhus, J. L. H., 1975, Hydrology for Engineers: New York, McGraw-Hill, 482 p.

Mitchell, W. D., 1954, Floods in Illinois: magnitude and frequency: Illinois Department of Public Works and Buildings, Division of Waterways, 386 p.

O'Leary, Mont, Lippert, R. H., and Spitz, O. T., 1966, Fortran IV and map program for computation and plotting of trend surfaces for degrees 1 through 6: Kansas Geological Survey Computer Contribution, v. 3, 48 p.

U.S. Army Corps of Engineers, 1981, HEC-1 flood hydrograph package users manual: Davis, Calif., Hydrologic Engineering Center, 25 p.

GLOSSARY OF TECHNICAL TERMS

CNSTL is an Initial and Uniform Loss-Rate function parameter used in the HEC-1 model that is a constant rate of rainfall loss after the initial volume of rainfall loss is satisfied, in inches per hour.

COEFFICIENT OF VARIATION is a measure of the amount of variation in the sample. It is equal to the standard deviation of the dependent variable divided by the mean of the dependent variable times 100. Coefficient of variation is dimensionless.

DIRECT RUNOFF is the runoff entering stream channels promptly after rainfall.

DISCHARGE is the volume of water that passes a given point within a given period of time, in cubic feet per second.

DLTKR is an Exponential Loss-Rate function parameter used in the HEC-1 model that is the amount of initial accumulated rainfall loss, in inches, during which the decrease in loss-rate coefficient is parabolic.

DRAINAGE AREA (DA) is the area, measured in a horizontal plane, that is enclosed by a drainage divide, in square miles.

ERAIN is a parameter that is the exponent of precipitation in the Exponential Loss-Rate function, dimensionless.

GAGING STATION is a particular site on a stream where systematic observations of gage height or discharge are obtained.

HEC-1 is the U.S. Army Corps of Engineers Hydrologic Engineering Center flood-hydrograph model used to model direct runoff.

HYDROGRAPH is a graph showing stage, discharge, velocity, or any other property of water with respect to time. In this study, it refers to a graph of discharge as a function of time.

HYETOGRAPH is a graph showing precipitation with respect to time.

INSTANTANEOUS UNIT HYDROGRAPH is a hydrograph of direct runoff resulting from one inch of uniformly-distributed rainfall excess occurring instantaneously over the entire drainage area.

LENGTH (L) is the distance measured along the main channel from the gage to the basin divide, in miles.

LOSS-RATE PARAMETERS are variables that account for the difference between observed rainfall and direct runoff from a basin.

RAINFALL EXCESS is the volume of rainfall available for direct runoff.

RECURRENCE INTERVAL is the average interval of time within which a given flood will be exceeded once. Also called return period.

REGRESSION EQUATION is a mathematical relationship between a dependent variable and one or more independent variables.

RTIOL is an Exponential Loss-Rate function parameter used in the HEC-1 model that is the rate of exponential decrease of the loss-rate coefficient with accumulated rain fall loss, dimensionless.

SKEW COEFFICIENT is a measure of the symmetry of a distribution. A positive skew coefficient indicates that the probability histogram has a longer tail to the right than to the left; a negative skew coefficient indicates that the probability histogram has a longer tail to the left than to the right. A normal distribution has a coefficient of skewness of zero.

SLOPE (SL) is the main-channel slope determined from elevations at points 10 and 85 percent of the total distance along the channel from the gaging station to the drainage basin divide, in feet per mile.

STANDARD ERROR OF ESTIMATE is a measure of the reliability of an estimating technique. It is defined as the standard deviation of the distribution of residuals about the estimating technique.

STORAGE is the volume of water detained in a drainage basin.

STORAGE COEFFICIENT (R) is a proportionality constant between storage and discharge at the outflow point of a basin, a time characteristic of a basin indicative of channel storage capacity.

STRKR is an Exponential Loss-Rate function parameter used in the HEC-1 model that is the initial value of the loss-rate coefficient at the start of rainfall for DLTKR equal to zero, in inches per hour.

STRTL is an Initial and Uniform Loss-Rate function parameter used in the HEC-1 model that is the initial volume of rainfall used to satisfy antecedent soil-moisture deficiency, in inches.

SURFACE RUNOFF is that part of runoff that travels over the soil surface to the nearest stream channel.

TIME OF CONCENTRATION (TC) is the time required for runoff from the remotest point of a drainage area to reach the outlet or point of discharge on the stream.

UNIT HYDROGRAPH is a hydrograph of direct runoff resulting from one inch of uniformly-distributed rainfall excess occurring in unit time.

page 31 follows

TABLES 1-14

Table 1.--Peak discharges and computed values of loss-rate and unit-hydrograph parameters

[Values in this table are listed in order of U.S. Geological Survey gaging station number. The parameter values for the Exponential Loss-Rate method are from Graf and others (1982b) for TC and R, and from unpublished work of the same investigators for ERAIN, RTIOL, STRKR, DLTKR, and peak discharge. The Initial and Uniform Loss-Rate method parameters are from Weiss and others (this report) except where noted. The recurrence intervals are calculated from U.S. Geological Survey gaging-station frequency curves except where noted. ft^3/s, cubic feet per second; h, hours; in/h, inches per hour; in., inches; <, less than; >greater than]

					Exponential Loss-Rate method						Initial and Uniform Loss-Rate method			
Station No.	Station name	Storm date	Peak discharge (ft^3/s)	Recurrence interval (years)	TC (h)	R (h)	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)
03336500	Bluegrass Creek at Potomac, Ill.	03-21-62	1,680	<2	12.0	5.5	0.40	4.04	0.14	0.14	10.5	5.8	0	0.05
		04-04-68	1,390	<2	12.0	5.5	.40	4.04	.14	2.00	10.5	5.8	1.28	.05
		04-20-64	4,500	25	12.0	5.5	.40	4.04	.14	.10	10.5	5.8	1.92	.05
		05-07-67	1,140	<2	12.0	5.5	.40	4.04	.14	.10	10.5	5.8	.06	.05
		07-14-62	2,040	2	12.0	5.5	.40	4.04	.14	3.00	10.5	5.8	2.80	.05
		08-04-68	1,820	2	12.0	5.5	.40	4.04	.14	2.50	10.5	5.8	1.35	.05
03336900	Salt Fork near St. Joseph, Ill.	04-04-68	1,580	<2	15.4	22.0	.50	2.90	.27	.56	9.5	29.1	.34	.04
		06-05-73	1,500	<2	15.4	22.0	.50	2.90	.27	.10	9.5	29.1	.12	.04
		06-21-64	1,860	<2	15.4	22.0	.50	2.90	.27	2.45	9.5	29.1	1.60	.04
		07-13-78	1,300	<2	15.4	22.0	.50	2.90	.27	1.75	9.5	29.1	.95	.04
		08-04-68	1,550	<2	15.4	22.0	.50	2.90	.27	3.68	9.5	29.1	2.50	.04
		08-14-75	1,660	<2	15.4	22.0	.50	2.90	.27	2.06	9.5	29.1	1.19	.04
03338100	Salt Fork tributary near Catlin, Ill.	04-19-70	215	2	2.1	2.1	.58	1.12	.18	2.80	1.9	2.5	.79	.08
		04-19-70	141	<2	2.1	2.1	.58	1.12	.18	3.30	1.9	2.5	1.08	.08
		04-22-73	146	<2	2.1	2.1	.58	1.12	.18	.90	1.9	2.5	0	.08
		06-22-74	275	3	2.1	2.1	.58	1.12	.18	.40	1.9	2.5	.31	.08
		07-09-71	87	<2	2.1	2.1	.58	1.12	.18	3.20	1.9	2.5	.81	.08
		08-04-68	432	7	2.1	2.1	.58	1.12	.18	2.90	1.9	2.5	1.65	.08
03343400	Embarras River near Camargo, Ill.	04-05-65	2,180	<2	54.0	25.0	.50	2.90	.20	1.93	43.0	53.0	.87	.04
		04-21-64	3,080	<2	54.0	25.0	.50	2.90	.20	5.30	43.0	53.0	3.27	.04
		05-06-77	2,160	<2	54.0	25.0	.50	2.90	.20	2.43	43.0	53.0	1.30	.04
		06-17-68	1,040	<2	54.0	25.0	.50	2.90	.20	2.95	43.0	53.0	2.10	.04
		06-23-74	6,230	15	54.0	25.0	.50	2.90	.20	0	43.0	53.0	.10	.04
		06-27-75	1,280	<2	54.0	25.0	.50	2.90	.20	2.07	43.0	53.0	1.40	.04
03344500	Range Creek near Casey, Ill.	03-12-75	538	<2	7.4	1.2	.51	7.45	.03	.08	5.9	1.5	.21	0
		03-14-73	610	<2	7.4	1.2	.51	7.45	.03	.00	5.9	1.5	0	0
		04-24-70	976	<2	7.4	1.2	.51	7.45	.03	.00	5.9	1.5	.20	0
		05-07-66	414	<2	7.4	1.2	.51	7.45	.03	.08	5.9	1.5	.20	0
		05-07-67	530	<2	7.4	1.2	.51	7.45	.03	.45	5.9	1.5	.78	0
		09-12-74	1,130	<2	7.4	1.2	.51	7.45	.03	.00	5.9	1.5	.16	0

03346000	North Fork Embarras River near Oblong, Ill.[1]	03-13-75	3,900	<2	60.0	19.1	.51	4.50	.13	.55	55.8	18.8	.20	.05
		03-28-73	3,570	<2	60.0	19.1	.51	4.50	.13	0	55.8	18.8	.05	.05
		03-29-77	4,400	<2	60.0	19.1	.51	4.50	.13	2.07	55.8	18.8	.97	.05
		04-04-68	3,490	<2	60.0	19.1	.51	4.50	.13	1.23	55.8	18.8	.75	.05
		04-22-74	2,560	<2	60.0	19.1	.51	4.50	.13	0	55.8	18.8	.02	.05
		06-19-73	3,580	<2	60.0	19.1	.51	4.50	.13	1.33	55.8	18.8	.64	.05
		06-22-74	3,480	<2	60.0	19.1	.51	4.50	.13	.98	55.8	18.8	.01	.05
03378635	Little Wabash River near Effingham, Ill.[1]	03-26-73	3,580	<2	27.9	12.0	.49	3.00	.16	.03	27.0	13.0	.21	.07
		04-23-73	4,710	<2	27.9	12.0	.49	3.00	.16	.03	27.0	13.0	0	.07
		06-15-70	5,400	2	27.9	12.0	.49	3.00	.16	4.10	27.0	13.0	2.20	.07
		06-19-73	4,200	<2	27.9	12.0	.49	3.00	.16	2.00	27.0	13.0	.95	.07
		06-23-74	4,050	<2	27.9	12.0	.49	3.00	.16	2.45	27.0	13.0	1.12	.07
		10-13-69	2,320	<2	27.9	12.0	.49	3.00	.16	4.36	27.0	13.0	2.32	.07
03380475	Horse Creek near Keenes, Ill.[1]	03-28-77	5,890	4	31.5	12.6	.43	6.90	.02	.68	31.0	13.8	.47	.01
		03-29-75	2,660	<2	31.5	12.6	.43	6.90	.02	.52	31.0	13.8	.19	.01
		04-08-74	2,720	<2	31.5	12.6	.43	6.90	.02	.54	31.0	13.8	.18	.01
		04-20-70	2,410	<2	31.5	12.6	.43	6.90	.02	.82	31.0	13.8	.51	.01
		04-28-70	1,810	<2	31.5	12.6	.43	6.90	.02	.06	31.0	13.8	.02	.01
		06-05-70	3,800	<2	31.5	12.6	.43	6.90	.02	.42	31.0	13.8	.14	.01
		07-11-67	3,850	<2	31.5	12.6	.43	6.90	.02	.53	31.0	13.8	.29	.01
03382045	Little Cana Creek near Creal Springs, Ill.[2]	03-16-80	264	<2	1.1	.60	.53	6.10	.08	0	1.0	.7	.55	.05
		03-23-79	279	<2	1.1	.60	.53	6.10	.08	0	1.0	.7	.26	.05
		03-23-79	104	<2	1.1	.60	.53	6.10	.08	0	1.0	.7	.03	.05
		04-11-79	518	6	1.1	.60	.53	6.10	.08	0	1.0	.7	.08	.05
		05-03-79	55	<2	1.1	.60	.53	6.10	.08	1.80	1.0	.7	.49	.05
		08-11-79	244	<2	1.1	.60	.53	6.10	.08	4.20	1.0	.7	1.90	.05
		11-08-79	31	<2	1.1	.60	.53	6.10	.08	4.20	1.0	.7	1.64	.05
03382100	South Fork Saline River near Carrier Mills, Ill.	03-03-77	1,440	<2	19.9	20.0	.52	3.82	.20	.60	18.7	23.8	.42	.04
		03-16-72	900	<2	19.9	20.0	.52	3.82	.20	.20	18.7	23.8	.14	.04
		04-11-78	842	<2	19.9	20.0	.52	3.82	.20	1.30	18.7	23.8	.80	.04
		05-23-74	1,410	<2	19.9	20.0	.52	3.82	.20	.35	18.7	23.8	.36	.04
		05-25-71	1,140	<2	19.9	20.0	.52	3.82	.20	1.20	18.7	23.8	.70	.04
		06-02-71	928	<2	19.9	20.0	.52	3.82	.20	1.50	18.7	23.8	.82	.04
		08-01-68	720	<2	19.9	20.0	.52	3.82	.20	2.00	18.7	23.8	1.20	.04
03382170	Brushy Creek near Harco, Ill.	04-19-70	879	<2	5.4	4.8	.64	4.17	.22	1.46	6.2	3.9	1.02	.07
		04-19-73	867	<2	5.4	4.8	.64	4.17	.22	1.43	6.2	3.9	.89	.07
		05-08-73	772	<2	5.4	4.8	.64	4.17	.22	0	6.2	3.9	0	.07
		05-10-70	776	<2	5.4	4.8	.64	4.17	.22	2.73	6.2	3.9	1.65	.07
		05-18-69	1,110	<2	5.4	4.8	.64	4.17	.22	0	6.2	3.9	.05	.07
		09-19-77	1,250	<2	5.4	4.8	.64	4.17	.22	1.99	6.2	3.9	1.39	.07

[1] Initial and Uniform Loss-Rate method unit-hydrograph parameters TC and R are from Garklavs and Oberg (1986); loss-rate parameters STRTL and CNSTL are from unpublished work by same investigators.

[2] Recurrence intervals calculated by technique of Curtis (1977).

Table 1.--Peak discharges and computed values of loss-rate and unit-hydrograph parameters--Continued

Station No.	Station name	Storm date	Peak discharge (ft^3/s)	Recurrence interval (years)	Exponential Loss-Rate method: TC (h)	R (h)	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	Initial and Uniform Loss-Rate method: TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)
03382510	Eagle Creek near Equality, Ill.[1]	03-11-73	468	<2	7.4	5.8	0.36	2.20	0.06	0.60	7.5	5.8	0.21	0.02
		03-12-75	469	<2	7.4	5.8	.36	2.20	.06	.10	7.5	5.8	.02	.02
		03-14-78	553	<2	7.4	5.8	.36	2.20	.06	.10	7.5	5.8	.02	.02
		03-24-69	269	<2	7.4	5.8	.36	2.20	.06	.60	7.5	5.8	.22	.02
		05-11-68	359	<2	7.4	5.8	.36	2.20	.06	1.90	7.5	5.8	1.47	.02
		05-27-73	654	<2	7.4	5.8	.36	2.20	.06	3.80	7.5	5.8	2.00	.02
		07-03-76	457	<2	7.4	5.8	.36	2.20	.06	1.90	7.5	5.8	1.35	.02
03384450	Lusk Creek near Eddyville, Ill.	04-09-69	1,840	<2	3.8	3.2	.51	1.21	.19	.10	4.0	5.0	0	.07
		05-10-70	6,510	3	3.8	3.2	.51	1.21	.19	1.07	4.0	5.0	.69	.07
		06-13-73	1,380	<2	3.8	3.2	.51	1.21	.19	0	4.0	5.0	.02	.07
		06-23-69	6,120	3	3.8	3.2	.51	1.21	.19	.59	4.0	5.0	.89	.07
		07-03-76	4,530	<2	3.8	3.2	.51	1.21	.19	1.26	4.0	5.0	.80	.07
		08-09-74	2,100	<2	3.8	3.2	.51	1.21	.19	2.51	4.0	5.0	1.47	.07
03385000	Hayes Creek at Glendale, Ill.	03-11-73	1,240	<2	10.0	7.0	.45	5.74	.13	0	10.3	5.6	.40	.04
		04-15-72	3,530	5	10.0	7.0	.45	5.74	.13	3.16	10.3	5.6	2.66	.04
		05-10-70	3,530	5	10.0	7.0	.45	5.74	.13	.12	10.3	5.6	.59	.04
		05-18-66	780	<2	10.0	7.0	.45	5.74	.13	.37	10.3	5.6	.39	.04
		05-24-66	920	<2	10.0	7.0	.45	5.74	.13	1.46	10.3	5.6	.99	.04
		08-29-74	887	<2	10.0	7.0	.45	5.74	.13	2.59	10.3	5.6	1.78	.04
03386500	Sugar Creek near Dixon Springs, Ill.	03-18-52	453	<2	1.2	1.9	.52	1.40	.23	1.00	1.0	2.4	.60	.08
		03-25-63	720	<2	1.2	1.9	.52	1.40	.23	2.55	1.0	2.4	.82	.08
		04-03-56	1,080	<2	1.2	1.9	.52	1.40	.23	1.55	1.0	2.4	.78	.08
		04-06-54	975	<2	1.2	1.9	.52	1.40	.23	.80	1.0	2.4	.44	.08
		04-12-61	641	<2	1.2	1.9	.52	1.40	.23	.05	1.0	2.4	.28	.08
		04-21-55	518	<2	1.2	1.9	.52	1.40	.23	1.00	1.0	2.4	.40	.08
		07-22-58	1,830	<2	1.2	1.9	.52	1.40	.23	.05	1.0	2.4	.37	.08
05414820	Sinsinawa River near Menominee, Ill.[1]	07-08-68	545	<2	4.5	2.0	.54	2.0	.37	1.74	4.6	1.9	1.13	.15
		07-09-72	671	<2	4.5	2.0	.54	2.0	.37	2.08	4.6	1.9	1.32	.15
		07-18-77	7,360	<2	4.5	2.0	.54	2.0	.37	2.75	4.6	1.9	2.49	.15
		07-20-78	1,090	<2	4.5	2.0	.54	2.0	.37	1.94	4.6	1.9	1.24	.15
		07-23-68	810	<2	4.5	2.0	.54	2.0	.37	2.25	4.6	1.9	1.45	.15
		09-13-72	7,530	<2	4.5	2.0	.54	2.0	.37	0	4.6	1.9	.58	.15
		09-23-68	780	<2	4.5	2.0	.54	2.0	.37	2.08	4.6	1.9	1.36	.15
05419000	Apple River near Hanover, Ill.[1]	03-07-73	6,830	4	14.0	10.8	.50	2.0	.15	.14	13.5	10.5	.02	.09
		04-14-74	2,290	<2	14.0	10.8	.50	2.0	.15	1.65	13.5	10.5	.50	.09
		04-29-74	2,070	<2	14.0	10.8	.50	2.0	.15	2.20	13.5	10.5	.90	.09
		06-09-74	2,930	<2	14.0	10.8	.50	2.0	.15	2.10	13.5	10.5	.79	.09

		07-17-77	2,440	<2	14.0	10.8	.50	2.0	.15	5.70	13.5	10.5	2.92	.09
		09-02-72	3,070	<2	14.0	10.8	.50	2.0	.15	4.25	13.5	10.5	2.41	.09
		10-23-72	3,090	<2	14.0	10.8	.50	2.0	.15	1.00	13.5	10.5	.15	.09
05438250	Coon Creek at Riley, Ill.	04-22-73	3,000	8	17.0	28.0	.44	2.36	.10	0	18.0	30.4	0	.06
		05-12-66	530	<2	17.0	28.0	.44	2.36	.10	2.70	18.0	30.4	1.20	.06
		06-02-70	1,920	4	17.0	28.0	.44	2.36	.10	2.30	18.0	30.4	1.32	.06
		06-08-69	1,060	<2	17.0	28.0	.44	2.36	.10	2.45	18.0	30.4	.36	.06
		06-10-74	495	<2	17.0	28.0	.44	2.36	.10	4.30	18.0	30.4	1.60	.06
		06-20-72	1,760	3	17.0	28.0	.44	2.36	.10	0	18.0	30.4	0	.06
		08-26-72	1,010	<2	17.0	28.0	.44	2.36	.10	5.00	18.0	30.4	2.70	.06
05438850	Middle Branch of South Branch Kishwaukee River near Malta, Ill.	03-14-71	59	<2	1.0	.8	.54	2.66	.55	.30	.3	1.5	.27	.13
		04-04-69	100	<2	1.0	.8	.54	2.66	.55	5.00	.3	1.5	1.15	.13
		05-17-74	160	2	1.0	.8	.54	2.66	.55	2.50	.3	1.5	1.02	.13
		06-02-70	143	2	1.0	.8	.54	2.66	.55	3.55	.3	1.5	1.66	.13
		06-08-69	109	<2	1.0	.8	.54	2.66	.55	4.00	.3	1.5	1.14	.13
		08-25-72	216	4	1.0	.8	.54	2.66	.55	4.50	.3	1.5	2.25	.13
05439550	South Branch Kishwaukee River tributary near Irene, Ill.	03-15-71	376	20	1.3	.7	.56	1.80	.55	.03	.8	1.0	.45	.08
		04-21-73	248	6	1.3	.7	.56	1.80	.55	3.10	.8	1.0	1.43	.08
		05-03-73	173	4	1.3	.7	.56	1.80	.55	1.40	.8	1.0	.67	.08
		05-16-74	293	10	1.3	.7	.56	1.80	.55	1.30	.8	1.0	1.20	.08
		05-27-73	248	6	1.3	.7	.56	1.80	.55	1.90	.8	1.0	.71	.08
		08-24-72	164	4	1.3	.7	.56	1.80	.55	1.85	.8	1.0	.79	.08
		09-13-72	207	5	1.3	.7	.56	1.80	.55	4.40	.8	1.0	2.35	.08
05440500	Killbuck Creek near Monroe Center, Ill.[1]	04-28-59	932	<2	12.0	9.2	.50	2.54	.34	1.41	11.6	9.6	1.28	.10
		05-05-56	910	<2	12.0	9.2	.50	2.54	.34	.01	11.6	9.6	.55	.10
		06-09-58	829	<2	12.0	9.2	.50	2.54	.34	1.28	11.6	9.6	.86	.10
		07-13-56	3,120	3	12.0	9.2	.50	2.54	.34	.17	11.6	9.6	.54	.10
		08-02-66	511	<2	12.0	9.2	.50	2.54	.34	2.15	11.6	9.6	1.39	.10
		08-03-57	812	<2	12.0	9.2	.50	2.54	.34	1.30	11.6	9.6	.82	.10
		08-17-68	1,640	<2	12.0	9.2	.50	2.54	.34	3.32	11.6	9.6	2.20	.10
05444000	Elkhorn Creek near Penrose, Ill.[1]	03-05-76	4,270	4	8.2	17.4	.52	1.90	.26	1.75	8.4	14.7	.94	.11
		03-07-73	2,080	<2	8.2	17.4	.52	1.90	.26	1.08	8.4	14.7	.56	.11
		05-08-73	1,090	<2	8.2	17.4	.52	1.90	.26	.59	8.4	14.7	.79	.11
		05-17-74	6,560	25	8.2	17.4	.52	1.90	.26	1.39	8.4	14.7	1.29	.11
		06-08-69	1,520	<2	8.2	17.4	.52	1.90	.26	2.99	8.4	14.7	1.97	.11
		06-17-73	4,470	4	8.2	17.4	.52	1.90	.26	4.33	8.4	14.7	2.73	.11
05448000	Mill Creek at Milan, Ill.[1]	05-18-74	3,430	3	7.2	3.0	.52	1.65	.30	1.40	6.6	3.9	.91	.13
		06-22-74	3,850	3	7.2	3.0	.52	1.65	.30	2.90	6.6	3.9	1.80	.13
		07-08-56	3,840	4	7.2	3.0	.52	1.65	.30	1.30	6.6	3.9	.82	.13
		07-30-59	3,480	3	7.2	3.0	.52	1.65	.30	.01	6.6	3.9	.20	.13
		09-13-61	3,740	3	7.2	3.0	.52	1.65	.30	5.05	6.6	3.9	3.90	.13

[1] Initial and Uniform Loss-Rate method unit-hydrograph parameters TC and R are from Garklavs and Oberg (1986); loss-rate parameters STRTL and CNSTL are from unpublished work by same investigators.

Table 1.--Peak discharges and computed values of loss-rate and unit-hydrograph parameters--Continued

Station No.	Station name	Storm date	Peak dis-charge (ft^3/s)	Recur-rence interval (years)	Exponential Loss-Rate method TC (h)	R (h)	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	Initial and Uniform Loss-Rate method TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)
05466000	Edwards River near Orion, Ill.	05-08-73	3,330	2	13.0	15.0	0.47	2.93	0.09	0.25	12.8	18.0	0	0.04
		05-12-66	2,500	<2	13.0	15.0	.47	2.93	.09	2.75	12.8	18.0	1.30	.04
		05-13-78	2,800	<2	13.0	15.0	.47	2.93	.09	1.50	12.8	18.0	.43	.04
		05-18-74	3,630	3	13.0	15.0	.47	2.93	.09	1.25	12.8	18.0	.70	.04
		06-02-70	2,770	<2	13.0	15.0	.47	2.93	.09	1.75	12.8	18.0	.46	.04
		06-23-74	5,740	8	13.0	15.0	.47	2.93	.09	2.25	12.8	18.0	1.50	.04
05495200	Little Creek near Breckenridge, Ill.[1]	04-19-64	302	<2	.3	.9	.49	2.13	.42	1.80	.4	.7	1.08	.06
		05-19-74	790	6	.3	.9	.49	2.13	.42	.05	.4	.7	.63	.06
		05-30-74	247	<2	.3	.9	.49	2.13	.42	1.80	.4	.7	.82	.06
		06-18-73	486	2	.3	.9	.49	2.13	.42	2.60	.4	.7	1.46	.06
		07-14-65	498	2	.3	.9	.49	2.13	.42	4.40	.4	.7	1.31	.06
		07-29-73	422	2	.3	.9	.49	2.13	.42	1.00	.4	.7	.82	.06
05502020	Hadley Creek near Barry, Ill.[1]	03-20-62	3,380	<2	4.1	1.9	.50	1.90	.20	.10	3.6	2.2	.10	.10
		04-22-57	3,080	<2	4.1	1.9	.50	1.90	.20	.10	3.6	2.2	.01	.10
		04-29-56	8,000	10	4.1	1.9	.50	1.90	.20	3.00	3.6	2.2	1.80	.10
		06-03-62	5,490	3	4.1	1.9	.50	1.90	.20	.40	3.6	2.2	.47	.10
		07-03-62	2,150	<2	4.1	1.9	.50	1.90	.20	4.25	3.6	2.2	1.95	.10
		08-01-58	2,280	<2	4.1	1.9	.50	1.90	.20	2.80	3.6	2.2	.80	.10
		09-13-61	4,080	<2	4.1	1.9	.50	1.90	.20	4.75	3.6	2.2	2.70	.10
05502040	Hadley Creek at Kinderhook, Ill.	03-20-62	7,520	3	6.8	2.1	.50	1.90	.08	.10	6.7	2.6	0	.04
		04-22-57	6,680	2	6.8	2.1	.50	1.90	.08	.10	6.7	2.6	0	.04
		04-29-56	12,150	8	6.8	2.1	.50	1.90	.08	3.40	6.7	2.6	1.70	.04
		06-03-62	12,250	10	6.8	2.1	.50	1.90	.08	.25	6.7	2.6	0	.04
		07-03-62	3,490	<2	6.8	2.1	.50	1.90	.08	4.75	6.7	2.6	1.95	.04
		08-01-58	5,010	<2	6.8	2.1	.50	1.90	.08	1.60	6.7	2.6	.50	.04
		09-13-61	7,230	2	6.8	2.1	.50	1.90	.08	4.80	6.7	2.6	2.51	.04
05502120	Kiser Creek tributary near Barry, Ill.	05-10-62	338	<2	.6	.6	.45	2.05	.47	1.50	.3	.6	.90	.05
		05-30-74	252	<2	.6	.6	.45	2.05	.47	2.35	.3	.6	.66	.05
		05-31-74	400	2	.6	.6	.45	2.05	.47	1.90	.3	.6	.73	.05
		06-07-74	238	<2	.6	.6	.45	2.05	.47	.35	.3	.6	.50	.05
		06-09-62	372	2	.6	.6	.45	2.05	.47	.13	.3	.6	.50	.05
		07-28-73	176	<2	.6	.6	.45	2.05	.47	2.75	.3	.6	.57	.05
		08-09-61	532	4	.6	.6	.45	2.05	.47	1.30	.3	.6	1.10	.05
05512500	Bay Creek at Pittsfield, Ill.[1]	04-05-65	1,420	<2	3.2	1.7	.50	2.08	.35	.01	2.0	2.3	.26	.18
		04-05-64	1,320	<2	3.2	1.7	.50	2.20	.35	.01	2.0	2.3	.33	.18
		07-28-63	1,780	<2	3.2	1.7	.50	2.20	.35	3.00	2.0	2.3	1.36	.18
		08-01-61	1,540	<2	3.2	1.7	.50	2.20	.35	3.50	2.0	2.3	1.71	.18

		08-05-62	912	<2	3.2	1.7	.50	2.20	.35	1.15	2.0	2.3	.47	.18
		08-12-63	1,290	<2	3.2	1.7	.50	2.20	.35	2.20	2.0	2.3	.90	.18
		09-03-61	1,380	<2	3.2	1.7	.50	2.20	.35	1.90	2.0	2.3	.75	.18
05526500	Terry Creek near Custer Park, Ill.[1]	06-06-74	436	10	6.2	10.0	.50	3.43	.27	1.35	5.8	13.0	.88	.04
		06-14-67	137	<2	6.2	10.0	.50	3.43	.27	.60	5.8	13.0	.40	.04
		06-16-60	119	<2	6.2	10.0	.50	3.43	.27	.40	5.8	13.0	.25	.04
		06-25-68	230	3	6.2	10.0	.50	3.43	.27	2.80	5.8	13.0	1.84	.04
		07-14-58	225	3	6.2	10.0	.50	3.43	.27	.01	5.8	13.0	.43	.04
		08-03-57	108	<2	6.2	10.0	.50	3.43	.27	2.10	5.8	13.0	.70	.04
05530990	Salt Creek at Rolling Meadows, Ill.	06-23-76	197	<2	1.2	6.4	.51	1.75	.35	.55	1.0	8.5	.47	.09
		07-20-78	549	<2	1.2	6.4	.51	1.75	.35	.60	1.0	8.5	.63	.09
		07-21-76	393	<2	1.2	6.4	.51	1.75	.35	2.50	1.0	8.5	1.39	.09
		08-06-76	125	<2	1.2	6.4	.51	1.75	.35	1.49	1.0	8.5	.67	.09
		10-01-77	169	<2	1.2	6.4	.51	1.75	.35	1.05	1.0	8.5	.84	.09
		10-14-74	230	<2	1.2	6.4	.51	1.75	.35	1.25	1.0	8.5	1.04	.09
05531000	Salt Creek near Arlington Heights, Ill.	07-08-71	132	<2	2.6	15.0	.52	2.11	.47	1.30	.1	19.0	1.15	.11
		07-19-70	174	<2	2.6	15.0	.52	2.11	.47	.60	.1	19.0	.95	.11
		07-27-66	290	<2	2.6	15.0	.52	2.11	.47	.10	.1	19.0	1.29	.11
		09-06-70	312	<2	2.6	15.0	.52	2.11	.47	.10	.1	19.0	.83	.11
		09-14-61	402	<2	2.6	15.0	.52	2.11	.47	2.30	.1	19.0	1.82	.11
		09-22-64	208	<2	2.6	15.0	.52	2.11	.47	1.55	.1	19.0	1.06	.11
05531500	Salt Creek at Western Springs, Ill.	04-28-59	604	<2	5.7	8.6	.50	2.08	.39	3.75	3.8	15.4	2.32	.08
		05-17-63	253	<2	5.7	8.6	.50	2.08	.39	.49	3.8	15.4	.57	.08
		05-23-59	426	<2	5.7	8.6	.50	2.08	.39	.70	3.8	15.4	.91	.08
		05-24-55	311	<2	5.7	8.6	.50	2.08	.39	2.27	3.8	15.4	1.67	.08
		07-01-59	307	<2	5.7	8.6	.50	2.08	.39	1.42	3.8	15.4	1.12	.08
		80-10-61	368	<2	5.7	8.6	.50	2.08	.39	1.03	3.8	15.4	.97	.08
		09-27-64	229	<2	5.7	8.6	.50	2.08	.39	.12	3.8	15.4	.89	.08
05533000	Flag Creek near Willow Springs, Ill.	04-28-59	1,420	7	2.4	7.0	.52	3.00	.27	.05	2.1	7.9	.34	.08
		05-12-66	912	2	2.4	7.0	.52	3.00	.27	.05	2.1	7.9	.25	.08
		06-30-77	419	<2	2.4	7.0	.52	3.00	.27	2.65	2.1	7.9	1.73	.08
		07-13-57	1,300	5	2.4	7.0	.52	3.00	.27	5.00	2.1	7.9	3.89	.08
		07-18-64	351	<2	2.4	7.0	.52	3.00	.27	1.75	2.1	7.9	.96	.08
		08-26-72	740	2	2.4	7.0	.52	3.00	.27	2.65	2.1	7.9	1.55	.08
		09-25-73	408	<2	2.4	7.0	.52	3.00	.27	2.00	2.1	7.9	1.26	.08
05535000	Skokie River at Lake Forest, Ill.[1]	03-25-54	197	<2	3.4	14.5	.47	2.21	.29	4.33	2.9	17.6	2.96	.09
		03-26-59	135	<2	3.4	14.5	.47	2.21	.29	.30	2.9	17.6	.23	.09
		04-25-54	259	3	3.4	14.5	.47	2.21	.29	.75	2.9	17.6	1.20	.09
		05-19-57	198	<2	3.4	14.5	.47	2.21	.29	.30	2.9	17.6	.02	.09
		07-29-54	110	<2	3.4	14.5	.47	2.21	.29	2.05	2.9	17.6	1.16	.09
		07-07-54	238	3	3.4	14.5	.47	2.21	.29	1.20	2.9	17.6	1.23	.09

[1] Initial and Uniform Loss-Rate method unit-hydrograph parameters TC and R are from Garklavs and Oberg (1986); loss-rate parameters STRTL and CNSTL are from unpublished work by same investigators.

Table 1.--Peak discharges and computed values of loss-rate and unit-hydrograph parameters--Continued

Station No.	Station name	Storm date	Peak discharge (ft^3/s)	Recurrence interval (years)	Exponential Loss-Rate method TC (h)	R (h)	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	Initial and Uniform Loss-Rate method TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)
05535070	Skokie River near Highland Park, Ill.	06-13-70	216	<2	5.6	9.9	0.51	2.41	0.40	1.53	4.1	10.8	1.40	0.08
		06-15-72	497	4	5.6	9.9	.51	2.41	.40	.16	4.1	10.8	1.10	.08
		06-19-71	183	<2	5.6	9.9	.51	2.41	.40	.55	4.1	10.8	.37	.08
		07-05-71	155	<2	5.6	9.9	.51	2.41	.40	.50	4.1	10.8	.83	.08
		07-08-71	216	<2	5.6	9.9	.51	2.41	.40	2.11	4.1	10.8	.88	.08
		08-17-68	360	<2	5.6	9.9	.51	2.41	.40	1.80	4.1	10.8	1.80	.08
		09-06-70	260	<2	5.6	9.9	.51	2.41	.40	1.40	4.1	10.8	1.04	.08
05536000	North Branch Chicago River at Niles, Ill.[1]	03-27-59	445	<2	13.3	25.3	.53	2.66	.35	.20	12.8	22.0	.15	.13
		04-26-54	1,490	7	13.3	25.3	.53	2.66	.35	.20	12.8	22.0	.14	.13
		06-11-67	2,200	80	13.3	25.3	.53	2.66	.35	.80	12.8	22.0	1.45	.13
		06-15-72	1,440	6	13.3	25.3	.53	2.66	.35	.30	12.8	22.0	.30	.13
		07-27-66	584	<2	13.3	25.3	.53	2.66	.35	1.70	12.8	22.0	1.27	.13
		10-17-68	896	<2	13.3	25.3	.53	2.66	.35	3.55	12.8	22.0	2.40	.13
05536210	Thorn Creek near Chicago Heights, Ill.	04-01-67	635	<2	4.1	10.1	.45	2.70	.16	.06	4.3	8.4	.40	.06
		05-06-76	936	<2	4.1	10.1	.45	2.70	.16	.06	4.3	8.4	.03	.06
		05-14-70	856	<2	4.1	10.1	.45	2.70	.16	.41	4.3	8.4	.57	.06
		06-07-74	2,200	30	4.1	10.1	.45	2.70	.16	1.15	4.3	8.4	1.70	.06
		06-25-68	1,200	20	4.1	10.1	.45	2.70	.16	2.95	4.3	8.4	2.33	.06
		08-17-68	3,200	>100	4.1	10.1	.45	2.70	.16	1.12	4.3	8.4	1.20	.06
05536215	Thorn Creek at Glenwood, Ill.	04-01-67	915	<2	7.3	12.6	.45	3.20	.18	.03	7.2	16.1	.22	.06
		05-06-76	1,200	2	7.3	12.6	.45	3.20	.18	.03	7.2	16.1	.02	.06
		05-10-51	821	<2	7.3	12.6	.45	3.20	.18	.03	7.2	16.1	.35	.06
		05-14-70	1,080	<2	7.3	12.6	.45	3.20	.18	.15	7.2	16.1	.28	.06
		07-13-57	2,360	15	7.3	12.6	.45	3.20	.18	3.72	7.2	16.1	2.43	.06
		10-10-54	916	<2	7.3	12.6	.45	3.20	.18	6.78	7.2	16.1	4.50	.06
05536235	Deer Creek near Chicago Heights, Ill.	05-06-76	547	2	15.5	25.8	.55	3.21	.21	1.19	21.7	25.0	.32	.11
		05-11-51	473	<2	15.5	25.8	.55	3.21	.21	2.26	21.7	25.0	.34	.11
		05-15-70	445	<2	15.5	25.8	.55	3.21	.21	2.09	21.7	25.0	.02	.11
		06-06-74	518	2	15.5	25.8	.55	3.21	.21	1.60	21.7	25.0	.49	.11
		06-26-68	361	<2	15.5	25.8	.55	3.21	.21	4.11	21.7	25.0	2.48	.11
		08-17-68	874	15	15.5	25.8	.55	3.21	.21	2.64	21.7	25.0	1.69	.11
		10-11-54	634	3	15.5	25.8	.55	3.21	.21	7.00	21.7	25.0	4.07	.11
05536255	Butterfield Creek at Flossmoor, Ill.	05-06-76	581	<2	5.8	14.9	.45	3.00	.25	.21	5.9	17.0	.15	.09
		05-14-70	666	2	5.8	14.9	.45	3.00	.25	.21	5.9	17.0	.16	.09
		06-07-74	1,590	10	5.8	14.9	.45	3.00	.25	1.60	5.9	17.0	1.40	.09
		06-25-68	852	3	5.8	14.9	.45	3.00	.25	3.26	5.9	17.0	2.54	.09

		07-13-57	2,420	45	5.8	14.9	.45	3.00	.25	0	5.9	17.0	.81	.09
		08-17-68	1,900	20	5.8	14.9	.45	3.00	.25	3.51	5.9	17.0	2.77	.09
		10-10-54	1,490	10	5.8	14.9	.45	3.00	.25	5.60	5.9	17.0	3.82	.09
05536265	Lansing Ditch near Lansing, Ill.	05-11-51	427	20	12.3	26.0	.45	1.90	.17	0	8.2	31.7	1.60	.09
		05-14-70	347	8	12.3	26.0	.45	1.90	.17	2.82	8.2	31.7	1.18	.09
		05-14-76	135	<2	12.3	26.0	.45	1.90	.17	.16	8.2	31.7	.20	.09
		06-09-74	208	2	12.3	26.0	.45	1.90	.17	2.92	8.2	31.7	1.61	.09
		06-25-68	152	<2	12.3	26.0	.45	1.90	.17	3.83	8.2	31.7	2.49	.09
		10-10-54	302	6	12.3	26.0	.45	1.90	.17	2.64	8.2	31.7	1.60	.09
05536270	North Creek near Lansing, Ill.	05-06-76	380	2	9.6	28.2	.34	2.07	.18	.10	8.5	39.0	.15	.06
		05-11-51	649	10	9.6	28.2	.34	2.07	.18	.10	8.5	39.0	0	.06
		06-09-74	244	<2	9.6	28.2	.34	2.07	.18	4.15	8.5	39.0	.88	.06
		06-25-68	371	<2	9.6	28.2	.34	2.07	.18	2.12	8.5	39.0	2.40	.06
		07-13-57	515	5	9.6	28.2	.34	2.07	.18	2.69	8.5	39.0	1.76	.06
		08-17-68	353	2	9.6	28.2	.34	2.07	.18	4.61	8.5	39.0	2.38	.06
		10-10-54	692	15	9.6	28.2	.34	2.07	.18	.86	8.5	39.0	.47	.06
05536275	Thorn Creek at Thornton, Ill.	05-06-76	1,890	<2	24.3	25.8	.45	1.60	.21	.05	17.0	28.2	0	.13
		05-15-70	1,820	<2	24.3	25.8	.45	1.60	.21	.05	17.0	28.2	0	.13
		06-07-74	2,960	5	24.3	25.8	.45	1.60	.21	3.18	17.0	28.2	2.55	.13
		06-25-68	1,820	<2	24.3	25.8	.45	1.60	.21	2.08	17.0	28.2	.97	.13
		07-13-57	4,700	45	24.3	25.8	.45	1.60	.21	2.84	17.0	28.2	1.15	.13
		08-17-68	3,420	8	24.3	25.8	.45	1.60	.21	2.99	17.0	28.2	1.30	.13
		10-11-54	5,000	50	24.3	25.8	.45	1.60	.21	2.77	17.0	28.2	1.50	.13
05536340	Midlothian Creek at Oak Forest, Ill.	04-22-73	613	70	15.0	23.2	.38	2.19	.16	.07	12.0	30.7	0	.06
		05-06-76	152	<2	15.0	23.2	.38	2.19	.16	.01	12.0	30.7	0	.06
		06-10-53	386	6	15.0	23.2	.38	2.19	.16	3.15	12.0	30.7	1.46	.06
		06-25-68	283	2	15.0	23.2	.38	2.19	.16	4.50	12.0	30.7	2.53	.06
		07-13-57	550	30	15.0	23.2	.38	2.19	.16	3.46	12.0	30.7	1.60	.06
		10-11-54	570	40	15.0	23.2	.38	2.19	.16	.77	12.0	30.7	1.86	.06
05536500	Tinley Creek near Palos Park, Ill.	04-22-73	750	3	10.0	11.0	.45	1.70	.17	0	9.0	12.5	.06	.05
		05-06-76	399	<2	10.0	11.0	.45	1.70	.17	.02	9.0	12.5	0	.05
		05-10-53	532	<2	10.0	11.0	.45	1.70	.17	1.47	9.0	12.5	1.07	.05
		06-25-68	297	<2	10.0	11.0	.45	1.70	.17	4.51	9.0	12.5	2.91	.05
		07-13-57	667	3	10.0	11.0	.45	1.70	.17	5.25	9.0	12.5	3.72	.05
		10-11-54	1,120	8	10.0	11.0	.45	1.70	.17	0	9.0	12.5	.82	.05
05537500	Long Run near Lemont, Ill.[1]	04-28-59	401	<2	4.1	8.3	.53	3.32	.36	2.84	3.7	12.6	1.91	.12
		05-17-74	960	4	4.1	8.3	.53	3.32	.36	.26	3.7	12.6	.19	.12
		06-10-53	501	<2	4.1	8.3	.53	3.32	.36	.46	3.7	12.6	.43	.12
		07-03-58	191	<2	4.1	8.3	.53	3.32	.36	2.15	3.7	12.6	1.35	.12
		07-07-54	259	<2	4.1	8.3	.53	3.32	.36	2.45	3.7	12.6	1.67	.12
		07-12-57	2,330	30	4.1	8.3	.53	3.32	.36	3.33	3.7	12.6	1.77	.12
		08-26-72	796	3	4.1	8.3	.53	3.32	.36	1.77	3.7	12.6	1.36	.12

[1]Initial and Uniform Loss-Rate method unit-hydrograph parameters TC and R are from Garklavs and Oberg (1986); loss-rate parameters STRTL and CNSTL are from unpublished work by same investigators.

Table 1.--Peak discharges and computed values of loss-rate and unit-hydrograph parameters--Continued

Station No.	Station name	Storm date	Peak dis-charge (ft³/s)	Recur-rence interval (years)	Exponential Loss-Rate method TC (h)	R (h)	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	Initial and Uniform Loss-Rate method TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)
05539000	Hickory Creek at Joliet, Ill.	03-25-54	3,160	2	12.5	14.0	0.54	3.50	0.07	1.50	11.5	18.0	0.52	0.03
		04-29-56	1,810	<2	12.5	14.0	.54	3.50	.07	2.00	11.5	18.0	.92	.03
		05-06-76	2,340	<2	12.5	14.0	.54	3.50	.07	1.50	11.5	18.0	.33	.03
		05-17-74	5,020	5	12.5	14.0	.54	3.50	.07	.10	11.5	18.0	0	.03
		06-10-53	2,340	<2	12.5	14.0	.54	3.50	.07	1.50	11.5	18.0	.55	.03
		06-25-68	2,430	<2	12.5	14.0	.54	3.50	.07	2.00	11.5	18.0	.98	.03
		06-28-57	3,490	2	12.5	14.0	.54	3.50	.07	2.00	11.5	18.0	0	.03
05539900	West Branch Du Page River near West Chicago, Ill.	04-22-73	383	<2	18.8	25.0	.41	1.75	.17	1.80	18.0	21.5	1.47	.06
		05-01-70	225	<2	18.8	25.0	.41	1.75	.17	.46	18.0	21.5	.61	.06
		05-12-66	651	5	18.8	25.0	.41	1.75	.17	.60	18.0	21.5	1.45	.06
		06-09-69	329	<2	18.8	25.0	.41	1.75	.17	1.93	18.0	21.5	1.55	.06
		06-10-67	1,510	>100	18.8	25.0	.41	1.75	.17	.30	18.0	21.5	.90	.06
		06-10-74	243	<2	18.8	25.0	.41	1.75	.17	2.28	18.0	21.5	2.00	.06
		08-26-72	715	7	18.8	25.0	.41	1.75	.17	3.23	18.0	21.5	2.60	.06
05540095	West Branch Du Page River near Warrenville, Ill.	04-19-75	1,080	<2	37.3	18.0	.50	2.63	.26	2.19	27.6	41.4	1.65	.04
		04-28-75	903	<2	37.3	18.0	.50	2.63	.26	.95	27.6	41.4	.76	.04
		05-07-76	1,090	<2	37.3	18.0	.50	2.63	.26	.10	27.6	41.4	.02	.04
		06-03-70	998	<2	37.3	18.0	.50	2.63	.26	.63	27.6	41.4	.62	.04
		06-21-72	675	<2	37.3	18.0	.50	2.63	.26	.10	27.6	41.4	.23	.04
		09-12-78	918	<2	37.3	18.0	.50	2.63	.26	3.33	27.6	41.4	2.08	.04
05549000	Boone Creek near McHenry, Ill.[1]	04-22-73	161	3	8.3	10.0	.54	2.36	.38	2.41	6.8	12.7	1.30	.14
		05-02-73	129	2	8.3	10.0	.54	2.36	.38	.04	6.8	12.7	.40	.14
		05-12-66	78	<2	8.3	10.0	.54	2.36	.38	.10	6.8	12.7	.38	.14
		06-02-70	264	6	8.3	10.0	.54	2.36	.38	4.20	6.8	12.7	2.65	.14
		06-09-74	80	<2	8.3	10.0	.54	2.36	.38	3.95	6.8	12.7	2.42	.14
		06-11-67	110	<2	8.3	10.0	.54	2.36	.38	3.22	6.8	12.7	2.19	.14
		09-13-72	223	4	8.3	10.0	.54	2.36	.38	2.40	6.8	12.7	1.30	.14
05550500	Poplar Creek at Elgin, Ill.	05-01-70	149	<2	11.6	40.0	.48	2.00	.19	1.28	11.6	50.1	1.16	.05
		05-12-66	406	3	11.6	40.0	.48	2.00	.19	1.63	11.6	50.1	1.16	.05
		06-02-70	560	5	11.6	40.0	.48	2.00	.19	1.10	11.6	50.1	.30	.05
		06-09-69	245	<2	11.6	40.0	.48	2.00	.19	2.11	11.6	50.1	1.25	.05
		06-10-67	793	30	11.6	40.0	.48	2.00	.19	2.09	11.6	50.1	1.12	.05
		06-10-74	388	2	11.6	40.0	.48	2.00	.19	2.30	11.6	50.1	.83	.05
05551200	Ferson Creek near St. Charles, Ill.	05-10-70	306	<2	16.8	27.0	.53	3.46	.23	1.63	14.8	25.0	1.19	.07
		05-12-66	996	2	16.8	27.0	.53	3.46	.23	.21	14.8	25.0	.44	.07
		06-02-70	1,460	4	16.8	27.0	.53	3.46	.23	.02	14.8	25.0	.36	.07
		06-08-69	656	<2	16.8	27.0	.53	3.46	.23	2.28	14.8	25.0	1.35	.07

		06-10-67	482	<2	16.8	27.0	.53	3.46	.23	3.59	14.8	25.0	2.14	.07
		06-10-74	792	<2	16.8	27.0	.53	3.46	.23	1.70	14.8	25.0	.65	.07
		08-26-72	408	<2	16.8	27.0	.53	3.46	.23	4.07	14.8	25.0	2.40	.07
05551700	Blackberry Creek	04-23-73	612	2	60.3	30.0	.43	2.10	.20	.02	52.6	52.0	.86	.05
	near Yorkville,	05-02-70	537	<2	60.3	30.0	.43	2.10	.20	.02	52.6	52.0	.26	.05
	Ill.[1]	05-13-66	906	3	60.3	30.0	.43	2.10	.20	.02	52.6	52.0	.15	.05
		06-03-70	1,300	8	60.3	30.0	.43	2.10	.20	.02	52.6	52.0	.13	.05
		06-09-69	302	<2	60.3	30.0	.43	2.10	.20	2.00	52.6	52.0	1.17	.05
		06-12-67	578	<2	60.3	30.0	.43	2.10	.20	2.88	52.6	52.0	1.79	.05
		08-27-72	334	<2	60.3	30.0	.43	2.10	.20	7.30	52.6	52.0	4.68	.05
05554000	North Fork	03-06-59	1,140	<2	13.2	22.0	.51	3.44	.26	.70	13.0	23.4	.49	.07
	Vermilion River	03-21-62	2,730	3	13.2	22.0	.51	3.44	.26	.05	13.0	23.4	0	.07
	near Charlotte,	04-22-61	958	<2	13.2	22.0	.51	3.44	.26	1.42	13.0	23.4	.93	.07
	Ill.[1]	05-11-62	2,770	3	13.2	22.0	.51	3.44	.26	1.60	13.0	23.4	.99	.07
		06-23-60	755	<2	13.2	22.0	.51	3.44	.26	1.45	13.0	23.4	.90	.07
		07-13-57	1,890	<2	13.2	22.0	.51	3.44	.26	2.65	13.0	23.4	1.55	.07
		07-14-58	3,720	7	13.2	22.0	.51	3.44	.26	1.70	13.0	23.4	1.65	.07
05556500	Big Bureau Creek	05-12-66	8,070	10	7.4	18.4	.52	2.17	.20	.02	7.2	14.8	.62	.07
	at Princeton,	06-08-52	1,180	<2	7.4	18.4	.52	2.17	.20	2.35	7.2	14.8	.95	.07
	Ill.[1]	06-09-72	2,900	<2	7.4	18.4	.52	2.17	.20	1.00	7.2	14.8	.71	.07
		06-11-55	2,180	<2	7.4	18.4	.52	2.17	.20	1.10	7.2	14.8	.73	.07
		06-13-58	8,160	<2	7.4	18.4	.52	2.17	.20	.75	7.2	14.8	.71	.07
		08-26-54	1,650	<2	7.4	18.4	.52	2.17	.20	2.43	7.2	14.8	1.50	.07
05557000	West Bureau Creek	06-01-54	1,650	<2	3.7	4.9	.51	1.56	.34	2.00	2.7	6.3	1.41	.08
	at Wyanet, Ill.	06-11-55	1,900	<2	3.7	4.9	.51	1.56	.34	.05	2.7	6.3	.71	.08
		06-12-52	2,970	2	3.7	4.9	.51	1.56	.34	3.00	2.7	6.3	1.50	.08
		06-13-58	1,640	<2	3.7	4.9	.51	1.56	.34	.80	2.7	6.3	.46	.08
		06-21-51	2,760	<2	3.7	4.9	.51	1.56	.34	.04	2.7	6.3	.74	.08
05557500	East Bureau Creek	06-13-52	3,000	3	1.9	5.1	.50	1.74	.62	.33	1.0	5.3	.96	.18
	near Bureau, Ill.	07-05-53	3,370	4	1.9	5.1	.50	1.74	.62	.70	1.0	5.3	1.88	.18
		07-14-63	504	<2	1.9	5.1	.50	1.74	.62	2.34	1.0	5.3	1.86	.18
		09-13-61	412	<2	1.9	5.1	.50	1.74	.62	2.90	1.0	5.3	2.68	.18
05558500	Crow Creek (West)	03-17-65	1,450	<2	9.6	5.6	.52	2.56	.24	.05	8.2	7.8	0	.06
	near Henry, Ill.	04-01-67	895	<2	9.6	5.6	.52	2.56	.24	3.00	8.2	7.8	2.00	.06
		04-29-67	1,690	2	9.6	5.6	.52	2.56	.24	.65	8.2	7.8	.65	.06
		05-26-60	2,660	4	9.6	5.6	.52	2.56	.24	.45	8.2	7.8	.32	.06
		07-06-53	1,420	<2	9.6	5.6	.52	2.56	.24	3.80	8.2	7.8	2.59	.06
		08-21-52	1,130	<2	9.6	5.6	.52	2.56	.24	2.65	8.2	7.8	1.40	.06
		08-31-65	1,010	<2	9.6	5.6	.52	2.56	.24	2.40	8.2	7.8	1.63	.06

[1]Initial and Uniform Loss-Rate method unit-hydrograph parameters TC and R are from Garklavs and Oberg (1986); loss-rate parameters STRTL amd CNSTL are from unpublished work by same investigators.

Table 1.--Peak discharges and computed values of loss-rate and unit-hydrograph parameters--Continued

Station No.	Station name	Storm date	Peak discharge (ft^3/s)	Recurrence interval (years)	Exponential Loss-Rate method TC (h)	R (h)	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	Initial and Uniform Loss-Rate method TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)
05559000	Gimlet Creek at Sparland, Ill.	04-01-67	406	<2	1.6	1.1	0.44	2.00	0.30	1.85	1.0	1.5	1.40	0.08
		04-05-65	558	<2	1.6	1.1	.44	2.00	.30	0	1.0	1.5	.30	.08
		05-25-60	354	<2	1.6	1.1	.44	2.00	.30	1.10	1.0	1.5	.53	.08
		07-02-58	1,860	15	1.6	1.1	.44	2.00	.30	1.25	1.0	1.5	.97	.08
		08-18-60	249	<2	1.6	1.1	.44	2.00	.30	1.65	1.0	1.5	.68	.08
		09-17-65	895	2	1.6	1.1	.44	2.00	.30	.85	1.0	1.5	.70	.08
05559500	Crow Creek near Washburn, Ill.	04-13-52	1,920	<2	5.0	9.0	.51	1.62	.23	.85	6.0	12.5	0	.09
		06-03-54	2,640	3	5.0	9.0	.51	1.62	.23	.60	6.0	12.5	0	.09
		06-13-53	1,450	<2	5.0	9.0	.51	1.62	.23	1.10	6.0	12.5	.69	.09
		06-13-58	2,350	2	5.0	9.0	.51	1.62	.23	1.50	6.0	12.5	.56	.09
		06-28-57	2,180	<2	5.0	9.0	.51	1.62	.23	1.95	6.0	12.5	.89	.09
		07-11-62	1,360	<2	5.0	9.0	.51	1.62	.23	2.40	6.0	12.5	1.56	.09
05560500	Farm Creek at Farmdale, Ill.	03-25-54	488	<2	5.5	5.0	.50	2.41	.29	5.10	3.6	8.5	1.33	.06
		04-28-66	532	<2	5.5	5.0	.50	2.41	.29	.35	3.6	8.5	.50	.06
		05-08-65	474	<2	5.5	5.0	.50	2.41	.29	.60	3.6	8.5	.53	.06
		05-30-76	645	4	5.5	5.0	.50	2.41	.29	.20	3.6	8.5	.78	.06
		07-09-78	665	4	5.5	5.0	.50	2.41	.29	2.50	3.6	8.5	1.56	.06
		07-18-68	446	<2	5.5	5.0	.50	2.41	.29	1.40	3.6	8.5	.90	.06
05561000	Ackerman Creek at Farmdale, Ill.	04-28-66	177	<2	2.0	2.1	.50	2.00	.42	1.00	1.7	2.2	.68	.09
		06-05-75	631	<2	2.0	2.1	.50	2.00	.42	.03	1.7	2.2	.29	.09
		06-19-73	623	<2	2.0	2.1	.50	2.00	.42	.15	1.7	2.2	.71	.09
		06-28-76	697	2	2.0	2.1	.50	2.00	.42	1.10	1.7	2.2	1.01	.09
		07-09-78	1,250	4	2.0	2.1	.50	2.00	.42	1.60	1.7	2.2	1.15	.09
		08-07-77	817	3	2.0	2.1	.50	2.00	.42	3.10	1.7	2.2	1.69	.09
		09-05-75	408	<2	2.0	2.1	.50	2.00	.42	2.85	1.7	2.2	1.26	.09
05563000	Kickapoo Creek near Kickapoo, Ill.[1]	06-11-55	3,120	<2	5.0	3.0	.50	1.40	.45	.05	3.6	4.1	1.04	.14
		06-14-57	7,370	3	5.0	3.0	.50	1.40	.45	.05	3.6	4.1	.40	.14
		07-09-51	8,330	<2	5.0	3.0	.50	1.40	.45	4.25	3.6	4.1	2.57	.14
		07-22-51	18,400	10	5.0	3.0	.50	1.40	.45	1.45	3.6	4.1	1.70	.14
		07-23-55	1,820	<2	5.0	3.0	.50	1.40	.45	1.50	3.6	4.1	1.20	.14
		08-04-61	1,050	<2	5.0	3.0	.50	1.40	.45	3.00	3.6	4.1	1.70	.14
		10-10-54	1,770	<2	5.0	3.0	.50	1.40	.45	1.50	3.6	4.1	1.05	.14
05563500	Kickapoo Creek at Peoria, Ill.[1]	04-17-60	2,610	<2	20.5	9.5	.50	2.10	.49	.15	18.2	13.3	.60	.10
		04-20-55	3,630	<2	20.5	9.5	.50	2.10	.49	.10	18.2	13.3	1.04	.10
		04-27-59	4,470	<2	20.5	9.5	.50	2.10	.49	2.30	18.2	13.3	1.57	.10
		05-26-60	8,430	2	20.5	9.5	.50	2.10	.49	.10	18.2	13.3	.62	.10
		06-15-57	2,620	<2	20.5	9.5	.50	2.10	.49	1.75	18.2	13.3	.99	.10
		07-01-59	1,940	<2	20.5	9.5	.50	2.10	.49	2.60	18.2	13.3	1.57	.10

05564400	Money Creek near Towanda, Ill.[1]	03-21-62	954	2	26.2	5.6	.48	3.32	.21	.05	24.6	6.0	.01	.08
		04-23-61	371	<2	26.2	5.6	.48	3.32	.21	2.80	24.6	6.0	1.60	.08
		05-16-68	876	2	26.2	5.6	.48	3.32	.21	4.75	24.6	6.0	2.78	.08
		05-27-59	217	<2	26.2	5.6	.48	3.32	.21	1.85	24.6	6.0	.95	.08
		06-24-60	920	2	26.2	5.6	.48	3.32	.21	1.85	24.6	6.0	1.05	.08
		07-13-71	681	<2	26.2	5.6	.48	3.32	.21	2.80	24.6	6.0	1.47	.08
		08-07-77	820	<2	26.2	5.6	.48	3.32	.21	5.30	24.6	6.0	3.90	.08
05564500	Money Creek above Lake Bloomington, Ill.	04-11-54	720	<2	16.9	11.8	.50	3.58	.29	.18	16.1	13.5	.28	.09
		04-23-52	770	<2	16.9	11.8	.50	3.58	.29	.31	16.1	13.5	.51	.09
		06-03-52	308	<2	16.9	11.8	.50	3.58	.29	1.13	16.1	13.5	.91	.09
		06-15-49	362	<2	16.9	11.8	.50	3.58	.29	2.65	16.1	13.5	1.60	.09
		07-09-51	1,090	2	16.9	11.8	.50	3.58	.29	6.35	16.1	13.5	5.23	.09
		08-16-52	372	<2	16.9	11.8	.50	3.58	.29	2.02	16.1	13.5	1.10	.09
05566500	East Branch Panther Creek at El Paso, Ill.	03-05-76	636	2	5.8	15.0	.50	2.60	.13	1.85	5.8	18.0	.86	.06
		03-21-62	439	<2	5.8	15.0	.50	2.60	.13	1.00	5.8	18.0	.09	.06
		05-01-70	587	2	5.8	15.0	.50	2.60	.13	1.25	5.8	18.0	.10	.06
		05-10-62	481	<2	5.8	15.0	.50	2.60	.13	.55	5.8	18.0	.09	.06
		05-13-57	372	<2	5.8	15.0	.50	2.60	.13	1.20	5.8	18.0	.17	.06
		05-15-68	484	<2	5.8	15.0	.50	2.60	.13	2.45	5.8	18.0	1.05	.06
		06-13-60	677	2	5.8	15.0	.50	2.60	.13	1.25	5.8	18.0	.63	.06
05567000	Panther Creek near El Paso, Ill.	04-04-50	999	<2	9.8	13.5	.52	3.50	.09	2.00	9.0	16.8	.76	.04
		04-12-52	2,350	2	9.8	13.5	.52	3.50	.09	.05	9.0	16.8	0	.04
		04-25-50	2,690	4	9.8	13.5	.52	3.50	.09	1.10	9.0	16.8	0	.04
		06-01-58	617	<2	9.8	13.5	.52	3.50	.09	4.30	9.0	16.8	1.63	.04
		06-13-53	780	<2	9.8	13.5	.52	3.50	.09	2.90	9.0	16.8	1.00	.04
		07-06-53	780	<2	9.8	13.5	.52	3.50	.09	4.10	9.0	16.8	1.60	.04
05568800	Indian Creek near Wyoming, Ill.[1]	04-21-73	1,570	2	18.6	11.0	.50	2.28	.25	.18	13.8	10.3	1.15	.04
		05-08-73	923	<2	18.6	11.0	.50	2.28	.25	.18	13.8	10.3	.69	.04
		06-20-64	1,270	<2	18.6	11.0	.50	2.28	.25	3.50	13.8	10.3	2.93	.04
		06-21-70	1,130	<2	18.6	11.0	.50	2.28	.25	1.80	13.8	10.3	1.22	.04
		09-24-77	775	<2	18.6	11.0	.50	2.28	.25	.18	13.8	10.3	.50	.04
05569968	Turkey Creek near Fiatt, Ill.[1]	03-19-79	258	<2	4.8	2.5	.53	5.30	.19	.85	3.6	2.9	.45	.06
		03-29-79	353	<2	4.8	2.5	.53	5.30	.19	.85	3.6	2.9	.60	.06
		04-11-79	957	<2	4.8	2.5	.53	5.30	.19	.15	3.6	2.9	1.06	.06
		07-25-79	317	<2	4.8	2.5	.53	5.30	.19	5.40	3.6	2.9	2.58	.06
05570370	Big Creek near Bryant, Ill.	04-21-73	735	<2	17.2	12.0	.52	2.67	.36	.40	14.2	16.0	.63	.12
		05-06-77	464	<2	17.2	12.0	.52	2.67	.36	.80	14.2	16.0	1.42	.12
		07-24-75	592	<2	17.2	12.0	.52	2.67	.36	1.90	14.2	16.0	1.68	.12
		07-27-76	488	<2	17.2	12.0	.52	2.67	.36	2.80	14.2	16.0	1.90	.12
		09-14-72	385	<2	17.2	12.0	.52	2.67	.36	2.90	14.2	16.0	1.92	.12
		10-13-73	636	<2	17.2	12.0	.52	2.67	.36	1.35	14.2	16.0	.98	.12

[1]Initial and Uniform Loss-Rate method unit-hydrograph parameters TC and R are from Garklavs and Oberg (1986); loss-rate parameters STRTL and CNSTL are from unpublished work by same investigators.

Table 1.--Peak discharges and computed values of loss-rate and unit-hydrograph parameters--Continued

Station No.	Station name	Storm date	Peak discharge (ft^3/s)	Recurrence interval (years)	Exponential Loss-Rate method TC (h)	R (h)	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	Initial and Uniform Loss-Rate method TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)
05571000	Sangamon River near Mahomet, Ill.	04-02-63	1,030	<2	47.5	37.0	0.35	3.25	0.13	1.10	45.5	42.5	0.60	0.04
		04-21-73	9,020	10	47.5	37.0	.35	3.25	.13	1.80	45.5	42.5	1.50	.04
		04-23-73	6,760	4	47.5	37.0	.35	3.25	.13	.50	45.5	42.5	.74	.04
		05-10-72	3,110	<2	47.5	37.0	.35	3.25	.13	2.61	45.5	42.5	.15	.04
		05-16-68	11,120	20	47.5	37.0	.35	3.25	.13	2.66	45.5	42.5	1.80	.04
		06-06-73	6,840	5	47.5	37.0	.35	3.25	.13	.01	45.5	42.5	0	.04
		06-22-64	1,390	<2	47.5	37.0	.35	3.25	.13	2.94	45.5	42.5	2.45	.04
05574000	South Fork Sangamon River near Nokomis, Ill.[1]	04-29-56	393	<2	2.5	2.5	.52	2.40	.24	1.60	1.7	2.5	.79	.08
		05-25-60	530	<2	2.5	2.5	.52	2.40	.24	2.50	1.7	2.5	1.34	.08
		06-10-58	592	<2	2.5	2.5	.52	2.40	.24	1.35	1.7	2.5	.66	.08
		06-23-60	805	<2	2.5	2.5	.52	2.40	.24	.60	1.7	2.5	.43	.08
		07-27-58	792	<2	2.5	2.5	.52	2.40	.24	2.30	1.7	2.5	1.14	.08
		08-03-57	1,580	3	2.5	2.5	.52	2.40	.24	.05	1.7	2.5	.14	.08
		08-06-59	1,380	3	2.5	2.5	.52	2.40	.24	2.10	1.7	2.5	1.11	.08
05574500	Flat Branch near Taylorville, Ill.	03-22-67	1,600	<2	41.6	51.3	.48	3.12	.15	.73	41.0	54.0	.30	.05
		04-24-66	2,170	<2	41.6	51.3	.48	3.12	.15	.99	41.0	54.0	.56	.05
		04-25-75	1,800	<2	41.6	51.3	.48	3.12	.15	2.03	41.0	54.0	1.00	.05
		06-01-74	4,740	3	41.6	51.3	.48	3.12	.15	.37	41.0	54.0	.41	.05
		06-16-70	8,610	15	41.6	51.3	.48	3.12	.15	.30	41.0	54.0	.98	.05
		06-23-74	7,540	8	41.6	51.3	.48	3.12	.15	.04	41.0	54.0	.17	.05
05575800	Horse Creek at Pawnee, Ill.	04-21-73	4,800	30	17.7	8.5	.51	6.65	.10	.10	18.5	5.0	.77	.02
		05-01-71	3,580	10	17.7	8.5	.51	6.65	.10	1.00	18.5	5.0	.79	.02
		05-06-77	3,260	5	17.7	8.5	.51	6.65	.10	3.38	18.5	5.0	2.45	.02
		06-15-74	846	<2	17.7	8.5	.51	6.65	.10	1.56	18.5	5.0	.76	.02
		06-16-70	2,370	3	17.7	8.5	.51	6.65	.10	3.10	18.5	5.0	1.83	.02
		07-10-71	3,120	5	17.7	8.5	.51	6.65	.10	.50	18.5	5.0	.71	.02
		10-13-69	2,840	4	17.7	8.5	.51	6.65	.10	.60	18.5	5.0	.49	.02
05577500	Spring Creek at Springfield, Ill.	04-22-73	2,870	3	17.3	16.0	.55	4.62	.23	1.21	16.7	17.8	.92	.06
		05-01-70	4,740	7	17.3	16.0	.55	4.62	.23	1.10	16.7	17.8	1.21	.06
		05-06-77	5,780	10	17.3	16.0	.55	4.62	.23	2.50	16.7	17.8	1.83	.06
		06-15-68	755	<2	17.3	16.0	.55	4.62	.23	1.66	16.7	17.8	1.04	.06
		06-22-74	1,760	<2	17.3	16.0	.55	4.62	.23	.83	16.7	17.8	.54	.06
		08-11-74	744	<2	17.3	16.0	.55	4.62	.23	3.44	16.7	17.8	2.30	.06
05577700	Sangamon River tributary at Andrew, Ill.[1]	04-19-64	452	7	1.2	.8	.50	2.04	.43	1.35	.9	.7	.89	.10
		04-20-64	483	8	1.2	.8	.50	2.04	.43	.25	.9	.7	.46	.10
		05-08-61	403	5	1.2	.8	.50	2.04	.43	.66	.9	.7	.87	.10
		05-21-74	206	<2	1.2	.8	.50	2.04	.43	.86	.9	.7	.59	.10
		06-01-65	441	6	1.2	.8	.50	2.04	.43	2.75	.9	.7	1.54	.10
		08-30-65	229	2	1.2	.8	.50	2.04	.43	1.75	.9	.7	.95	.10

05578500	Salt Creek near Rowell, Ill.	03-12-74	1,960	<2	66.0	70.0	.41	3.30	.05	.09	59.0	67.5	0	.02
		04-05-68	2,320	<2	66.0	70.0	.41	3.30	.05	1.65	59.0	67.5	.89	.02
		04-23-72	1,370	<2	66.0	70.0	.41	3.30	.05	.82	59.0	67.5	.39	.02
		05-02-70	2,180	<2	66.0	70.0	.41	3.30	.05	.19	59.0	67.5	0	.02
		06-21-73	2,100	<2	66.0	70.0	.41	3.30	.05	0	59.0	67.5	0	.02
		06-28-75	3,960	2	66.0	70.0	.41	3.30	.05	.90	59.0	67.5	.25	.02
05584400	Drowning Fork near Bushnell, Ill.	04-16-72	231	<2	17.3	16.5	.50	3.25	.15	.78	14.5	14.6	.47	.06
		05-08-73	256	<2	17.3	16.5	.50	3.25	.15	1.73	14.5	14.6	1.02	.06
		06-02-70	645	2	17.3	16.5	.50	3.25	.15	1.75	14.5	14.6	1.00	.06
		06-25-68	244	<2	17.3	16.5	.50	3.25	.15	5.00	14.5	14.6	2.88	.06
		06-26-73	638	2	17.3	16.5	.50	3.25	.15	1.29	14.5	14.6	.72	.06
		08-31-65	235	<2	17.3	16.5	.50	3.25	.15	3.87	14.5	14.6	2.25	.06
05586000	North Fork Mauvaise Terre Creek near Jacksonville, Ill.[1]	03-21-62	612	<2	12.1	6.6	.55	3.51	.14	2.25	10.8	10.6	1.18	.03
		06-02-65	1,230	2	12.1	6.6	.55	3.51	.14	3.50	10.8	10.6	1.97	.03
		06-14-57	1,460	3	12.1	6.6	.55	3.51	.14	.05	10.8	10.6	.01	.03
		06-19-73	1,700	7	12.1	6.6	.55	3.51	.14	.80	10.8	10.6	.40	.03
		06-22-74	1,190	2	12.1	6.6	.55	3.51	.14	.10	10.8	10.6	.12	.03
		06-23-60	1,470	3	12.1	6.6	.55	3.51	.14	1.20	10.8	10.6	.61	.03
		09-14-61	520	<2	12.1	6.6	.55	3.51	.14	4.70	10.8	10.6	2.24	.03
05586800	Otter Creek near Palmyra, Ill.	04-21-73	6,400	6	20.6	11.0	.50	6.08	.07	0	22.6	6.0	.20	.02
		04-24-75	1,090	<2	20.6	11.0	.50	6.08	.07	1.60	22.6	6.0	1.09	.02
		05-01-70	5,600	4	20.6	11.0	.50	6.08	.07	.22	22.6	6.0	.80	.02
		05-06-77	4,300	4	20.6	11.0	.50	6.08	.07	.47	22.6	6.0	1.04	.02
		05-18-66	1,490	<2	20.6	11.0	.50	6.08	.07	.98	22.6	6.0	.89	.02
		06-15-74	1,200	<2	20.6	11.0	.50	6.08	.07	1.83	22.6	6.0	1.03	.02
		10-13-69	3,340	3	20.6	11.0	.50	6.08	.07	3.12	22.6	6.0	2.35	.02
05587850	Cahokia Creek tributary No. 2 near Carpenter, Ill.	05-01-62	36	<2	.6	.8	.58	3.73	.85	1.60	.3	.9	.95	.15
		05-08-61	92	<2	.6	.8	.58	3.73	.85	3.55	.3	.9	1.76	.15
		07-06-62	23	<2	.6	.8	.58	3.73	.85	.01	.3	.9	.74	.15
		08-10-61	112	<2	.6	.8	.58	3.73	.85	2.90	.3	.9	2.36	.15
05587900	Cahokia Creek at Edwardsville, Ill.	05-13-70	1,890	<2	7.2	8.6	.50	2.01	.20	.53	6.0	8.9	.22	.07
		06-17-75	2,030	<2	7.2	8.6	.50	2.01	.20	1.90	6.0	8.9	.87	.07
		07-20-69	2,260	<2	7.2	8.6	.50	2.01	.20	.40	6.0	8.9	.12	.07
		08-15-76	1,600	<2	7.2	8.6	.50	2.01	.20	2.45	6.0	8.9	1.10	.07
		08-23-77	2,370	<2	7.2	8.6	.50	2.01	.20	2.94	6.0	8.9	1.50	.07
		09-12-77	1,720	<2	7.2	8.6	.50	2.01	.20	1.90	6.0	8.9	.76	.07
05588000	Indian Creek at Wanda, Ill.	03-24-69	630	<2	18.0	3.5	.53	5.10	.22	.92	16.0	4.0	.07	.09
		03-28-77	2,600	3	18.0	3.5	.53	5.10	.22	2.00	16.0	4.0	1.37	.09
		04-19-70	1,340	<2	18.0	3.5	.53	5.10	.22	1.80	16.0	4.0	.62	.09
		06-01-68	905	<2	18.0	3.5	.53	5.10	.22	.60	16.0	4.0	.32	.09
		06-22-69	809	<2	18.0	3.5	.53	5.10	.22	2.40	16.0	4.0	1.36	.09
		08-15-76	767	<2	18.0	3.5	.53	5.10	.22	2.25	16.0	4.0	.98	.09
		08-23-77	1,360	<2	18.0	3.5	.53	5.10	.22	3.80	16.0	4.0	2.06	.09

[1] Initial and Uniform Loss-Rate method unit-hydrograph parameters TC and R are from Garklavs and Oberg (1986); loss-rate parameters STRTL and CNSTL are from unpublished work by same investigators.

Table 1.--Peak discharges and computed values of loss-rate and unit-hydrograph parameters--Continued

Station No.	Station name	Storm date	Peak discharge (ft^3/s)	Recurrence interval (years)	Exponential Loss-Rate method TC (h)	R (h)	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	Initial and Uniform Loss-Rate method TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)
05590000	Kaskaskia Ditch at Bondville, Ill.	03-14-53	228	<2	2.5	11.0	0.50	1.86	0.40	2.25	1.8	4.6	0.91	0.11
		04-11-54	201	<2	2.5	11.0	.50	1.86	.40	.05	1.8	4.6	.56	.11
		07-09-51	305	<2	2.5	11.0	.50	1.86	.40	3.40	1.8	4.6	1.85	.11
		07-13-62	302	<2	2.5	11.0	.50	1.86	.40	.41	1.8	4.6	.50	.11
05590400	Kaskaskia River near Pesotum, Ill.[1]	04-13-74	1,210	<2	13.6	11.5	.50	2.70	.35	.40	12.7	9.8	.59	.08
		05-16-68	1,400	<2	13.6	11.5	.50	2.70	.35	2.30	12.7	9.8	1.80	.08
		06-16-70	1,120	<2	13.6	11.5	.50	2.70	.35	1.40	12.7	9.8	1.13	.08
		06-19-73	1,610	<2	13.6	11.5	.50	2.70	.35	.05	12.7	9.8	.88	.08
		06-26-75	1,240	<2	13.6	11.5	.50	2.70	.35	1.90	12.7	9.8	1.41	.08
		07-26-73	1,300	<2	13.6	11.5	.50	2.70	.35	.40	12.7	9.8	1.05	.08
		08-02-78	1,320	<2	13.6	11.5	.50	2.70	.35	1.40	12.7	9.8	1.34	.08
05592300	Wolf Creek near Beecher City, Ill.	02-22-74	1,920	<2	25.5	3.5	.49	3.00	.02	.72	22.0	1.3	.52	.02
		03-12-75	1,480	<2	25.5	3.5	.49	3.00	.02	.42	22.0	1.3	.09	.02
		03-21-67	2,990	<2	25.5	3.5	.49	3.00	.02	0	22.0	1.3	0	.02
		03-25-73	1,530	<2	25.5	3.5	.49	3.00	.02	.90	22.0	1.3	.41	.02
		04-22-74	2,080	<2	25.5	3.5	.49	3.00	.02	.34	22.0	1.3	.21	.02
		06-19-73	1,730	<2	25.5	3.5	.49	3.00	.02	2.48	22.0	1.3	1.30	.02
		11-27-66	2,800	<2	25.5	3.5	.49	3.00	.02	.42	22.0	1.3	0	.02
05593575	Little Crooked Creek near New Minden, Ill.	03-12-75	2,880	<2	21.0	11.9	.50	2.39	.07	.02	20.4	14.0	.01	.02
		03-29-75	1,770	<2	21.0	11.9	.50	2.39	.07	1.05	20.4	14.0	.40	.02
		04-17-74	1,050	<2	21.0	11.9	.50	2.39	.07	.50	20.4	14.0	.09	.02
		04-24-75	2,580	<2	21.0	11.9	.50	2.39	.07	.85	20.4	14.0	.37	.02
		06-15-74	1,240	<2	21.0	11.9	.50	2.39	.07	1.60	20.4	14.0	.66	.02
		09-01-74	521	<2	21.0	11.9	.50	2.39	.07	3.34	20.4	14.0	1.19	.02
05593600	Blue Grass Creek near Raymond, Ill.	04-19-70	915	<2	7.5	6.7	.54	4.50	.15	1.45	7.4	8.5	.10	.09
		05-06-77	942	<2	7.5	6.7	.54	4.50	.15	2.20	7.4	8.5	2.14	.09
		06-18-73	800	<2	7.5	6.7	.54	4.50	.15	1.80	7.4	8.5	.41	.09
		06-27-73	1,250	3	7.5	6.7	.54	4.50	.15	1.00	7.4	8.5	0	.09
		08-13-73	1,260	3	7.5	6.7	.54	4.50	.15	1.00	7.4	8.5	.18	.09
		09-17-69	563	<2	7.5	6.7	.54	4.50	.15	6.00	7.4	8.5	3.77	.09
05593900	East Fork Shoal Creek near Coffeen, Ill.	04-22-73	2,090	<2	11.3	13.0	.50	6.49	.05	1.68	11.0	13.5	.66	.04
		05-31-74	2,860	3	11.3	13.0	.50	6.49	.05	.96	11.0	13.5	0	.04
		06-27-73	3,020	3	11.3	13.0	.50	6.49	.05	.05	11.0	13.5	0	.04
		09-12-74	1,600	<2	11.3	13.0	.50	6.49	.05	2.37	11.0	13.5	1.75	.04
		09-18-69	1,610	<2	11.3	13.0	.50	6.49	.05	6.46	11.0	13.5	3.76	.04
		10-12-69	4,570	10	11.3	13.0	.50	6.49	.05	1.44	11.0	13.5	.39	.04

05594330	Mud Creek near	04-25-75	2,550	3	24.3	10.0	.50	4.50	.14	0	21.5	17.5	0	.04
	Marissa, Ill.	05-08-73	1,160	<2	24.3	10.0	.50	4.50	.14	1.05	21.5	17.5	.59	.04
		05-31-74	698	<2	24.3	10.0	.50	4.50	.14	.75	21.5	17.5	.40	.04
		06-15-74	1,380	<2	24.3	10.0	.50	4.50	.14	1.47	21.5	17.5	.76	.04
		06-19-73	1,000	<2	24.3	10.0	.50	4.50	.14	.66	21.5	17.5	.30	.04
		09-01-74	1,620	<2	24.3	10.0	.50	4.50	.14	.55	21.5	17.5	.29	.04
		11-02-72	1,730	<2	24.3	10.0	.50	4.50	.14	3.42	21.5	17.5	2.29	.04
05595200	Richland Creek	04-09-73	1,840	<2	11.0	9.5	.50	1.97	.16	.09	10.9	9.5	.02	.06
	near Hecker,	05-01-70	2,030	<2	11.0	9.5	.50	1.97	.16	.80	10.9	9.5	.36	.06
	Ill.[1]	05-31-74	2,580	<2	11.0	9.5	.50	1.97	.16	1.40	10.9	9.5	.74	.06
		06-15-74	1,960	<2	11.0	9.5	.50	1.97	.16	1.90	10.9	9.5	1.07	.06
		06-19-73	2,500	<2	11.0	9.5	.50	1.97	.16	1.35	10.9	9.5	.59	.06
		06-25-70	1,510	<2	11.0	9.5	.50	1.97	.16	1.30	10.9	9.5	.56	.06
		09-09-73	3,040	<2	11.0	9.5	.50	1.97	.16	1.55	10.9	9.5	.82	.06
05595228	South Branch	03-20-79	235	<2	6.7	5.3	.50	2.40	.32	1.50	2.8	7.5	1.15	.08
	Doza Creek near	03-30-80	185	<2	6.7	5.3	.50	2.40	.32	0	2.8	7.5	.41	.08
	Lenzburg, Ill.	07-26-78	21	<2	6.7	5.3	.50	2.40	.32	2.70	2.8	7.5	1.08	.08
		07-28-79	419	<2	6.7	5.3	.50	2.40	.32	5.30	2.8	7.5	3.13	.08
		11-25-78	39	<2	6.7	5.3	.50	2.40	.32	1.45	2.8	7.5	1.01	.08
05595800	Sevenmile Creek	03-20-62	730	<2	8.8	3.7	.54	3.60	.23	.10	7.2	4.5	.32	.04
	near Mt. Vernon,	03-20-64	256	<2	8.8	3.7	.54	3.60	.23	.10	7.2	4.5	.36	.04
	Ill.[1]	04-04-68	827	<2	8.8	3.7	.54	3.60	.23	1.00	7.2	4.5	.64	.04
		06-18-64	736	<2	8.8	3.7	.54	3.60	.23	1.55	7.2	4.5	1.11	.04
		07-13-63	150	<2	8.8	3.7	.54	3.60	.23	1.75	7.2	4.5	1.63	.04
		07-29-63	362	<2	8.8	3.7	.54	3.60	.23	1.95	7.2	4.5	1.14	.04
		08-10-61	263	<2	8.8	3.7	.54	3.60	.23	5.20	7.2	4.5	3.01	.04
05597500	Crab Orchard	04-04-68	1,360	<2	15.7	11.8	.48	4.23	.18	.06	14.0	11.6	.20	.05
	Creek near	04-11-78	424	<2	15.7	11.8	.48	4.23	.18	.40	14.0	11.6	.39	.05
	Marion, Ill.[1]	05-01-70	458	<2	15.7	11.8	.48	4.23	.18	.50	14.0	11.6	.42	.05
		05-10-70	692	<2	15.7	11.8	.48	4.23	.18	1.92	14.0	11.6	1.29	.05
		05-27-73	1,260	<2	15.7	11.8	.48	4.23	.18	2.30	14.0	11.6	1.55	.05
		06-22-67	454	<2	15.7	11.8	.48	4.23	.18	2.03	14.0	11.6	1.21	.05
		06-23-69	544	<2	15.7	11.8	.48	4.23	.18	2.55	14.0	11.6	1.45	.05
05599000	Beaucoup Creek	03-22-68	3,060	<2	77.5	30.0	.41	3.05	.06	.05	77.1	34.5	0	.02
	near Matthews,	04-07-52	2,730	<2	77.5	30.0	.41	3.05	.06	.30	77.1	34.5	.17	.02
	Ill.	04-22-70	3,010	<2	77.5	30.0	.41	3.05	.06	.45	77.1	34.5	.20	.02
		05-17-67	1,820	<2	77.5	30.0	.41	3.05	.06	1.85	77.1	34.5	1.20	.02
		06-27-55	1,460	<2	77.5	30.0	.41	3.05	.06	1.45	77.1	34.5	.82	.02
		08-12-61	4,280	<2	77.5	30.0	.41	3.05	.06	1.60	77.1	34.5	1.15	.02
05600000	Big Creek near	03-22-52	2,260	<2	7.2	4.3	.55	1.79	.16	.05	6.2	5.5	.02	.04
	Wetaug, Ill.[1]	04-06-64	1,400	<2	7.2	4.3	.55	1.79	.16	1.00	6.2	5.5	.67	.04
		04-12-61	1,190	<2	7.2	4.3	.55	1.79	.16	.30	6.2	5.5	.26	.04
		04-18-53	1,230	<2	7.2	4.3	.55	1.79	.16	1.05	6.2	5.5	.55	.04
		05-15-61	1,290	<2	7.2	4.3	.55	1.79	.16	.60	6.2	5.5	.25	.04
		06-03-54	2,010	<2	7.2	4.3	.55	1.79	.16	1.90	6.2	5.5	.78	.04
		06-11-58	1,220	<2	7.2	4.3	.55	1.79	.16	1.90	6.2	5.5	1.05	.04

[1]Initial and Uniform Loss-Rate method unit-hydrograph parameters TC and R are from Garklavs and Oberg (1986); loss-rate parameters STRTL and CNSTL are from unpublished work by same investigators.

Table 2.--Statistical summary of computed loss-rate and unit-hydrograph parameter values

[h, hours; in/h; inches per hour; in., inches; ERAIN and RTIOL are dimensionless]

	Exponential Loss-Rate method						Initial and Uniform Loss-Rate method			
	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	TC (h)	R (h)	STRTL (in.)	CNSTL (in/h)	TC (h)	R (h)
Number of observations	98	98	98	616	98	98	616	98	98	98
Mean	.50	2.94	.24	1.61	13.7	12.2	1.01	.07	12.4	14.3
Standard deviation	.05	1.32	.14	1.41	14.8	11.4	.83	.04	13.7	13.6
Minimum	.32	1.12	.02	0	.3	.6	0	0	.1	.6
Maximum	.64	7.45	.85	7.30	77.5	70.0	5.23	.18	77.1	67.5
Coefficient of variation (percent)	9.6	45.1	59.4	87.6	108.1	93.4	82.2	51.2	110.6	95.0

Table 3.--Variation explained and standard error of estimate for loss-rate and unit-hydrograph parameter-estimation techniques

[in/h, inches per hour; in., inches; h, hours]

Parameter	Estimating technique	Variation explained (in percent)	Standard error of estimating technique
	Exponential Loss Rate		
ERAIN	0.50	--	0.044
RTIOL	map, fig. 4	30	1.10
STRKR	map, fig. 5	42	.109 in/h
	Region I	--	.079 in/h
	Region II	27	.107 in/h
	Region III	15	.126 in/h
DLTKR	median monthly values, table 4	18	1.30 in.
	Initial and Uniform Loss Rate		
STRTL	median monthly values, table 5	21	.757 in.
CNSTL	map, fig. 6	19	.03 in/h
	Hydrograph Parameters		
TC	Graf and others (1982a)	38	10.5 h
R	Graf and others (1982a)	31	8.62 h

Table 4.--Statistical summary for the antecedent soil-moisture loss-rate parameter used in the Exponential Loss-Rate method

[in., inches]

Month	Number of observations	Mean monthly DLTKR (in.)	Standard deviation (in.)	Median monthly DLTKR (in.)	Minimum (in.)	Maximum (in.)	Coefficient of variation (percent)	Coefficient of skewness (dimensionless)	Standard error of estimate (in.)
March	56	0.75	1.04	0.30	0	5.10	140.0	2.19	1.15
April	106	1.09	1.12	.85	0	5.30	102.8	1.30	1.15
May	117	1.09	1.01	.93	0	4.75	91.8	.91	1.03
June	156	1.70	1.24	1.60	0	5.00	72.9	.50	1.25
July	76	2.23	1.52	2.10	0	6.35	68.2	.60	1.53
August	56	2.69	1.29	2.50	.05	7.30	48.0	.96	1.32
September	31	2.55	1.81	2.30	0	6.46	71.0	.37	1.86
October	18	2.53	2.14	1.47	0	7.00	84.6	.87	2.48

Table 5.--Statistical summary for the initial-value loss-rate parameter used in the Initial and Uniform Loss-Rate method

[in., inches]

Month	Number of observa-tions	Mean monthly DLTKR (in.)	Standard deviation (in.)	Median monthly DLTKR (in.)	Minimum (in.)	Maximum (in.)	Coefficient of variation (percent)	Coefficient of skewness (dimensionless)	Standard error of estimate (in.)
March	56	0.40	0.51	0.28	0	2.96	127.5	2.61	0.526
April	106	.72	.62	.63	0	3.27	86.1	1.29	.629
May	117	.72	.59	.63	0	2.78	81.9	.90	.596
June	156	1.03	.73	.91	0	2.93	70.9	.72	.741
July	76	1.46	.87	1.30	.12	5.23	59.6	1.64	.887
August	56	1.59	.85	1.45	.14	4.68	53.5	1.12	.871
September	31	1.61	1.02	1.33	.16	3.90	63.4	.75	1.08
October	18	1.70	1.31	1.01	.15	4.50	77.1	.82	1.54

Table 6.--Statistical summary of estimated loss-rate and unit-hydrograph parameter values

[h, hours; in/h, inches per hour; in., inches; ERAIN and RTIOL are dimensionless]

	ERAIN	RTIOL	STRKR (in/h)	DLTKR (in.)	STRTL (in.)	CNSTL (in/h)	TC (h)	R (h)
Number of observations	98	98	98	616	616	98	98	98
Mean	0.50	2.93	0.24	1.40	0.87	0.07	12.0	11.4
Standard deviation	.02	.72	.08	.65	.34	.02	9.76	8.47
Minimum	.45	1.90	.14	.30	.28	.04	.76	.50
Maximum	.52	4.60	.51	2.50	1.45	.11	49.1	41.4
Coefficient of variation (percent)	3.9	24.6	35.0	46.6	39.6	22.6	81.4	74.2

Table 7.--Statistical summary of errors in computed hydrograph characteristics using the Exponential Loss-Rate method

[Hydrograph error, in percent, is defined as $((Y_o - Y_x) \div Y_o) \times 100$ where Y_o is the value of the observed hydrograph characteristics and Y_x is the value of the computed hydrograph characteristic when estimated parameter values are used. Outliers are storms having a value of hydrograph error greater than three standard deviations from the mean hydrograph error.]

	Sum of incremental flows, V		Peak discharge, Q		Time to peak discharge, T	
	All simulations producing hydrographs[1]	Simulations producing hydrographs minus outliers	All simulations producing hydrographs	Simulations producing hydrographs minus outliers	All simulations producing hydrographs	Simulations producing hydrographs minus outliers
Number of observations	83	72	83	72	83	72
Mean, in percent	-26	3	-20	10	-66	-51
Standard deviation, in percent	114	66	121	69	100	75
Minimum, in percent	-416	-149	-466	-157	-533	-214
Maximum, in percent	94	94	92	92	100	100
Coefficient of skewness (dimensionless)	-2	-1	-2	-1	-2	0

[1]Number of simulations producing no hydrograph or only the recession limb of a hydrograph equals 19. Statistics for these storms have not been included.

Table 8.--Statistical summary of errors in computed hydrograph characteristics using the Initial and Uniform Loss-Rate method

[Hydrograph error, in percent, is defined as $((Y_o - Y_x) \div Y_o) \times 100$ where Y_o is the value of the observed hydrograph characteristics and Y_x is the value of the computed hydrograph characteristic when estimated parameter values are used. Outliers are storms having a value of hydrograph error greater than three standard deviations from the mean hydrograph error.]

	Sum of incremental flows, V		Peak discharge, Q		Time to peak discharge, T	
	All simulations producing hydrographs[1]	Simulations producing hydrographs minus outliers	All simulations producing hydrographs	Simulations producing hydrographs minus outliers	All simulations producing hydrographs	Simulations producing hydrographs minus outliers
Number of observations	53	48	53	48	53	48
Mean, in percent	-12	6	-13	7	-46	-39
Standard deviation, in percent	86	54	98	57	90	86
Minimum, in percent	-321	-152	-370	-100	-295	-220
Maximum, in percent	88	88	92	92	178	178
Coefficient of skewness (dimensionless)	-2	-1	-2	0	0	0

[1]Number of simulations producing no hydrograph or only the recession limb of a hydrograph equals 49. Statistics for these storms have not been included.

Table 9.--Sensitivity of computed hydrograph characteristics to a 25-percent change in rainfall-loss and unit-hydrograph parameters for Cahokia Creek at Edwardsville, Illinois (station 05587900), using the Exponential Loss-Rate method

[Percentage change is defined as $((Y_o - Y_x) \div Y_o) \times 100$ averaged over six storms where Y_o is the value of the hydrograph characteristic obtained with optimized parameters and Y_x is the value of the hydrograph characteristic obtained when optimized parameters are increased and decreased by 25 percent. ERAIN and RTIOL are dimensionless; in/h, inches per hour; in., inches; h, hours]

Parameter		Change in hydrograph characteristic, in percent		
Name	Change in value	Sum of incremental flows, V	Peak discharge, Q	Time of discharge, T
ERAIN	+0.12	-40	-41	1
	-.12	35	39	0
RTIOL	+.50	-1	-1	0
	-.50	2	2	0
STRKR (in/h)	+.05	30	32	0
	-.05	-37	-34	0
DLTKR[1] (in.)	+.42	51	54	0
	-.42	-60	-60	1
TC (h)	+1.50	0	7	-11
	-1.50	0	-6	11
R (h)	+2.15	2	14	0
	-2.15	-2	-18	1

[1]Change in parameter value is average of changes in parameter values for six storms.

Table 10.--Sensitivity of computed hydrograph characteristics to a 25-percent change in rainfall-loss and unit-hydrograph parameters for Cahokia Creek at Edwardsville, Illinois (station 05587900), using the Initial and Uniform Loss-Rate method

[Percentage change is defined as $((Y_o - Y_x) \div Y_o) \times 100$ averaged over six storms where Y_o is the value of the hydrograph characteristic obtained with optimized parameters and Y_x is the value of the hydrograph characteristic obtained when optimized parameters are increased and decreased by 25 percent. in/h, inches per hour; in., inches; h, hours]

Parameter		Change in hydrograph characteristic, in percent		
Name	Change in value	Sum of incremental flows, V	Peak discharge, Q	Time of discharge, T
STRTL[1] (in.)	+0.19	60	62	48
	-.19	-82	-87	0
CNSTL (in/h)	+.02	16	18	0
	-.02	-15	-17	0
TC (h)	+1.50	0	6	-7
	-1.50	0	-5	9
R (h)	+2.23	2	14	-1
	-2.23	-2	-20	4

[1]Change in parameter value is average of changes in parameter values for six storms.

Table 11.--Sensitivity of computed hydrograph characteristics to a 25-percent change in rainfall-loss and unit-hydrograph parameters for South Branch Kishwaukee River tributary near Irene, Illinois (station 05439550), using the Exponential Loss-Rate method

[Percentage change is defined as $((Y_o-Y_x) \div Y_o) \times 100$ averaged over seven storms where Y_o is the value of the hydrograph characteristic obtained with optimized parameters and Y_x is the value of the hydrograph characteristic obtained when optimized parameters are increased and decreased by 25 percent. ERAIN and RTIOL are dimensionless; in/h, inches per hour; in., inches; h, hours]

Parameter		Change in hydrograph characteristic, in percent		
Name	Change in value	Sum of incremental flows, V	Peak discharge, Q	Time of discharge, T
ERAIN	+0.14	1	5	-1
	-.14	-4	-6	-1
RTIOL	+.45	-2	-2	-1
	-.45	2	2	1
STRKR (in/h)	+.14	31	32	0
	-.14	-34	-38	0
DLTKR[1] (in.)	+.50	21	24	-2
	-.50	-23	-23	0
TC (h)	+.33	22	44	-3
	-.33	20	23	12
R (h)	+.18	21	44	-8
	-.18	6	36	11

[1]Change in parameter value is average of changes in parameter values for seven storms.

Table 12.--Sensitivity of computed hydrograph characteristics to a 25-percent change in rainfall-loss and unit-hydrograph parameters for South Branch Kishwaukee River tributary near Irene, Illinois (station 05439550), using the Initial and Uniform Loss-Rate method

[Percentage change is defined as $((Y_o - Y_x) \div Y_o) \times 100$ averaged over seven storms where Y_o is the value of the hydrograph characteristic obtained with optimized parameters and Y_x is the value of the hydrograph characteristic obtained when optimized parameters are increased and decreased by 25 percent. in/h, inches per hour; in., inches; h, hours]

Parameter		Change in hydrograph characteristic, in percent		
Name	Change in value	Sum of incremental flows, V	Peak discharge, Q	Time of discharge, T
STRTL[1] (in.)	+0.27	55	55	7
	-.27	-58	-57	6
CNSTL (in/h)	+.02	3	3	0
	-.02	-3	-3	0
TC (h)	+.20	0	4	-5
	-.20	0	-4	7
R (h)	+.25	3	13	-1
	-.25	-3	-17	2

[1]Change in parameter value is average of changes in parameter values for seven storms.

Table 13.--Sensitivity of computed hydrograph characteristics to a standard error of estimate change in rainfall-loss and unit-hydrograph parameters using the Exponential Loss-Rate method

[Percentage change is defined as $((Y_o-Y_x) \div Y_o) \times 100$ averaged over 21 storms at three stations (seven storms at Sugar Creek near Dixon Springs, Ill. (station 03386500); seven storms at Deer Creek near Chicago Heights, Ill. (station 05536235); seven storms at South Fork Saline River near Carrier Mills, Ill. (station 03382100)). Y_o is the value of the hydrograph characteristic obtained with optimized parameters and Y_x is the value of the hydrograph characteristic obtained when optimized parameters are increased and decreased by one standard error of estimate. ERAIN and RTIOL are dimensionless; in/h, inches per hour; in., inches; h, hours]

Parameter		Change in hydrograph characteristic, in percent		
Name	Change in value	Sum of incremental flows, V	Peak discharge, Q	Time of discharge, T
ERAIN	+0.0442	-6	-7	0
	-.0442	6	6	0
RTIOL	+1.10	-2	-2	0
	-1.10	3	4	0
STRKR (in/h)	+.109	36	36	-1
	-.109	-37	-40	0
DLTKR[1] (in.)	+mse[2]	47	54	3
	-mse[2]	-44	-46	1
TC (h)	+10.56	2	20	-36
	-10.56	-1	-11	14
R (h)	+8.62	9	35	-8
	-8.62	-4	-39	4

[1]Some negative changes are restricted by minimum allowable parameter values.

[2]mse refers to monthly standard error (table 4).

Table 14.--Sensitivity of computed hydrograph characteristics to a standard error of estimate change in rainfall-loss and unit-hydrograph parameters using the Initial and Uniform Loss-Rate method

[Percentage change is defined as $((Y_o-Y_x) \div Y_o) \times 100$ averaged over 21 storms at three stations (seven storms at Sugar Creek near Dixon Springs, Ill. (station 03386500); seven storms at Deer Creek near Chicago Heights, Ill. (station 05536235); seven storms at South Fork Saline River near Carrier Mills, Ill. (station 03382100)). Y_o is the value of the hydrograph characteristic obtained with optimized parameters and Y_x is the value of the hydrograph characteristic obtained when optimized parameters are increased and decreased by one standard error of estimate. in/h, inches per hour; in., inches; h, hours]

Parameter		Change in hydrograph characteristic, in percent		
Name	Change in value	Sum of incremental flows, V	Peak discharge, Q	Time of discharge, T
	1.11	111	111	11
STRTL (in.)	+mse[2]	60	65	31
	-mse[2]	-57	-61	4
CNSTL (in/h)	+0.03	15	17	1
	-.03	-21	-22	0
TC[1] (h)	+10.56	2	23	-29
	-10.56	-1	-11	13
R[1] (h)	+8.62	9	34	-3
	-8.62	-4	-50	7

[1]Some negative changes are restricted by minimum allowable parameter values.

[2]mse refers to monthly standard error (table 5).

☆U.S. GOVERNMENT PRINTING OFFICE: 1987-745-014