APPENDIX A

DEVELOPMENT OF THE HYDROLOGIC METHODOLOGY

INTRODUCTION

In order to conduct the master drainage study for Fort Bend County, a methodology has been established for computing flows and water levels for all drainage analyses to be performed. It was initially determined that the established methodology should satisfy the following objectives:

(1) Be technically sound;
(2) Be easy to apply;
(3) Be capable of showing the effects of development on the flow regime of a watershed; and
(4) Be a useful tool for evaluating drainage regulation strategies for the County.

After reviewing a number of methodologies that had been utilized in Fort Bend County, it was concluded that use of a computer model employing the unit hydrograph theory would be the best approach for providing the necessary capabilities; and, therefore, this was adopted as the basic hydrologic methodology for the subsequent drainage studies.

Harris County had recently adopted its hydrologic methodology that was accepted by the Federal Emergency Management Agency (FEMA) and was used to revise the Flood Insurance Study that had been conducted for that county. This methodology has also been used to evaluate and design drainage improvements throughout Harris County. This method involved the use of a computer model (HEC-HMS) that includes the unit hydrograph approach (using Clark's unitgraph coefficients). As a result, we reviewed Harris County's methodology with the intent of adopting their approach with some changes, such as simplifying the procedure and making it more suitable for the type of watersheds typical of Fort Bend County. The following is a detailed explanation of the derivation of the hydrologic methodology developed and used for the Fort Bend County Master Drainage Study.

DERIVATION OF METHODOLOGY

The general hydrologic method adopted for conducting storm water computations in Fort Bend County is very similar to that used in Harris County. It includes use of the Clark unit hydrograph approach and a rainfall-loss exponential function contained in the HEC-HMS computer program that accounts for variation of loss with intensity of basin-average rainfall as well as with increasing ground wetness during the storm.

For unit hydrograph computations, a standard time-area function contained in HEC-HMS is used, along with Clark's unitgraph parameters TC (time of concentration) and R (Storage coefficient).

For the exponential loss rate function contained in HEC-HMS, the loss parameters used are initial coefficient (STRKR in HEC-1), coefficient ratio (RTIOL in HEC-1) and exponent (ERAIN in HEC-1) in the equations:

$$L = K \times P^{ERAIN} \qquad \text{(Eq. 1)}$$

and

$$K = (\text{initial coefficient or STRKR}) / (\text{coefficient ratio or RTIOL})^{(0.1 \times CUML)} \qquad \text{(Eq. 20)}$$

where: L = loss rate in inches per hour

K = loss rate coefficient

P = rainfall intensity in inches per hour

ERAIN = exponent between 0.0 (constant loss) and 1.0 (loss proportional to rainfall)

Initial coefficient or STRKR = loss coefficient at start of storm

coefficient ratio or RTIOL = loss recession coefficient

CUML = accumulated loss since start of storm in inches

These unit hydrograph (TC and R) and loss (initial coefficient or STRKR, coefficient ration or RTIOL and exponent or ERAIN) parameters, required as input into the HEC-HMS program, have been derived from observed flood data and, insofar as is feasible, related to various basin characteristics (such as length, slope, percent development) so that information can be generated on the rainfall-runoff relationship for a given watershed where no runoff data are available. Derivation of these parameters is based on optimization studies using primarily rainfall and runoff data for those gages in the Houston metropolitan area (the best source of data for watersheds located close to Fort Bend County) considered most representative of streams in Fort Bend County.

BASIC DATA

Rainfall and runoff data for large storms published in open file reports of the U.S. Geological Survey were used for derivation of Unit hydrograph and loss parameters. Table 1 lists the stations and storms used.

Basin characteristics for the watershed area above these stations were obtained in part from previous reports and in part from topographic maps and aerial photographs. A summary of the pertinent basin characteristics is contained in Table 2.

The lst 12 stations listed in Tables 1 and 2 are supplementary stations selected from earlier studies made by the U.S. Army Corps of Engineers and turner, Collie and Braden, Inc. in order to provide data on TC and R for areas with steep slopes and other ranges of basin characteristics.

HYDROGRAPH ANALYSIS

The unit-hydrograph and loss-rate optimization routine in HEC-1 was used to derive values of the 2 unit-hydrograph and 3 loss-rate parameters for each of the 33 storms analyzed. HEC-HMS is the developed version of HEC-1, therefore the parametric values (such as loss parameters) of HEC-1 can be used for HEC-HMS. This manual has been revised with recommendation to replace HEC-1 by HEC-HMS for future use. Since TC and R have similar impacts on a unit hydrograph, the HEC-1 program uses transformed parameters of TC+R and R/(TC+R) for optimization computations.

The results of the reconstitution of these storm hydrographs were considered to be generally of high quality. Average error of the first run showed computed peak versus observed peak flow to be 6 percent, with about half of the computed peaks higher and half lower than observed peaks. Results of the first run are given in Table 3.

Parameter values of the loss function have no individual meaning. In order to compare values of initial coefficient (STRKR-the primary loss parameter) it is necessary to use the same values of exponent (ERAIN) and the same values of coefficient ratio (RTIOL) for every storm. A second computer run was made using a constant exponent (ERAIN - 0.6) and constant coefficient ratio (RTIOL - 3.0) approximately equal to the average values obtained in the first run. (Substantial rounding of these averages was permitted, since their standard error is large). This increased the average error to 7 percent, which is very minor compared to the substantial simplifications of the model thus obtained. Results of this second run are also given in Table 3.

A third run was then made using the relationship of TC/(TC+R) shown in Figure 1 (obtained from the second run results) as well as constant values of exponent (ERAIN -0.6) and coefficient ratio (RTIOL - 3.0). Thus, only the 2 parameters, TC+R and initial coefficient or STRKR, were derived in this third run. Errors in peak flows increased to 10 percent on the average, but the reconstitutions still are generally very good and unbiased. Results of this run are given in the last 2 columns of Table 3.

CORRELATION WITH BASIN CHARACTERISTICS

Since variables exponent or ERAIN and coefficient ratio or RTIOL in equations 1 and 2 are assigned values about equal to the averages obtained in the unit hydrograph derivations of the first 16 stations of Table 1 (areas hydrologically similar to those in Fort Bend County), the only variables remaining to be related to basin characteristics are initial coefficient or STRKR, TC+R and R/(TC+R).

The loss index initial coefficient (STRKR), does not correlate significantly with soil characteristics within Harris County where the loss data were derived. Table 4 shows an analysis of variance, which indicates that the variance of initial coefficient (STRKR) between storms at the same station is even greater than between station averages. This simply means that the data are inadequate to distinguish loss indexes at different locations. It is also considered that losses in this region are similar to those in Fort Bend County. Consequently an average coefficient of 0.5 for initial coefficient (STRKR) is adopted for Fort Bend County areas.

Values of TC/(TC+R) or R/(TC+R) do not correlate appreciably with any basin characteristics within the Harris County area represented by the first 17 stations of Table 2. However, when data for other stations (18 thru 29 of Table 3A) are considered, there is a good correlation with basin slope, as shown in Figure 1. The relationship shown was adopted for Fort Bend County and is considered to reflect adequately the logical relationship between basin slope and basin storage. Upper and lower limits on the ratio were set arbitrarily to prevent unreasonably small values of TC or R in future applications.

The log of the variable TC+R (from Table 3 and 3A) was correlated with several variables in an attempt to find the best correlation with certain basin characteristics with results as follows:

Variables	Correlation Coefficient
log L	.840
log $L/\sqrt{S}$ .821	
log $L/\sqrt{S}$, log N	.913
log $L/\sqrt{S}$, log N, D	.931
log $L/\sqrt{S}$, log N, D, log S_0	9.31

On the basis of these results and the fact that including the last variable, S_0, provides a logical addition to the resulting relationship, the following regression equation was adopted:

$$TC+R = 128 \frac{(L\sqrt{S})^{.57} \quad N^{.8}}{S_0^{.11} \times 10^{I}} \qquad \text{(Eq. 3)}$$

Where: TC = Clark's time of concentration

R = Clark's storage coefficient

L = length of the longest watercourse within a subarea (in miles)

S = average slope of the longest watercourse in its middle 75 percent (in feet/mile)

N = Manning's roughness coefficient for the longest watercourse weighted in proportion to distance from upstream end

S_0 = average basin slope of land draining into the longest watercourse (in feet/mile)

I = effective imperviousness ratio (.0035D for the regression analysis)

D = percent urban development

This function is plotted on Figure 2 along with the basic data used.

PONDING

Certain subareas, for which a flood hydrograph is to be computed, have ponding areas that will have an effect on the runoff being generated from the subarea. As the flood hydrograph passes through these ponding areas, the peak flow is reduced, and the time at which that peak flow occurs is delayed. An appropriate means to account for this effect in computing the flood hydrograph for such a subarea, using the hydrology methodology previously discussed, is to adjust upward the Clark's R coefficient, since this coefficient represents the storage-routing characteristics of the subareas.

The Soil Conservation Service, in their Technical Report No. 55, presents three tables of adjustment factors to the peak discharges of various frequency flood events in relation to the percent ponding in the subarea. The difference among the three tables is in the amount of the subarea's runoff that is affected by the ponding area (i.e. whether it is located either in the upper middle or lower portion of the subarea). Figure 3 provides a set of equations and curves that relate the percent of ponding (i.e. the percent ratio of the pond's surface area to the total drainage area of the subarea) to an adjustment factor for Clark's R coefficient. These equations correspond to the SCS table that presumes virtually all of the runoff from the drainage area passes through the ponding areas. Therefore, once the appropriate adjustment factor, RM, is derived from these equations, this factor needs to be prorated downward as the percent of the drainage are that is affected by the ponding area(s) goes from 100% down towards 0%. For example, if a subarea of 5 square miles has two lakes with a total combined surface area of ½ square mile, the percent ponding would be 10 and the RM factor for a 100-year event would be 164%. This would be the adjustment factor to be applied to the R coefficient previously computed from TC+R only if 100% of the subarea drains into or through these two lakes. If only 50% of the subarea drains into these two lakes, then the RM factor of 164% would be reduced to 132% as the appropriate adjustment factor to be applied to the R coefficient. If R had previously been determined to be 19.7, the new R that reflects the effect of ponding would be 19.7 x 1.32 = 26.0.

If a ponding area does not allow runoff to pass through it (e.g. a gravel pit), then that portion of the area that drains into the pond, plus the pond surface area itself, should be eliminated from the drainage area of the subarea as being non-contributing area.

COMPARISON OF METHODOLOGIES

A comparison was made between the newly developed hydrology methodology and other previously used methodologies for information purposes. Table 5 shows a comparison of 100-yer computed discharge values for a number of the watersheds used in developing the new methodology. The variability in the results is inherent in the use of different methodologies and may also reflect differences in drainage area size and percent imperviousness. Table 6 shows a comparison of 100-year computed discharge values for some of the watersheds studied in Fort Bend County during the Master Drainage Study. Here, the variability in the values as shown in the table is directly related to the differences in the methodologies used.

CONCLUSION

The hydrologic methodology developed for use in the Fort Bend County watershed studies is very similar to that used in Harris County, and will produce similar results. It is designed to be easier, more direct and more definitive in application. The ponding adjustment procedure is also very similar to that used in the Harris County methodology; however, the differences in the two procedures are a result of the different approaches taken in development of the hydrologic methodologies and the way that ponding is defined and accounted for in computing the unit graph parameters.

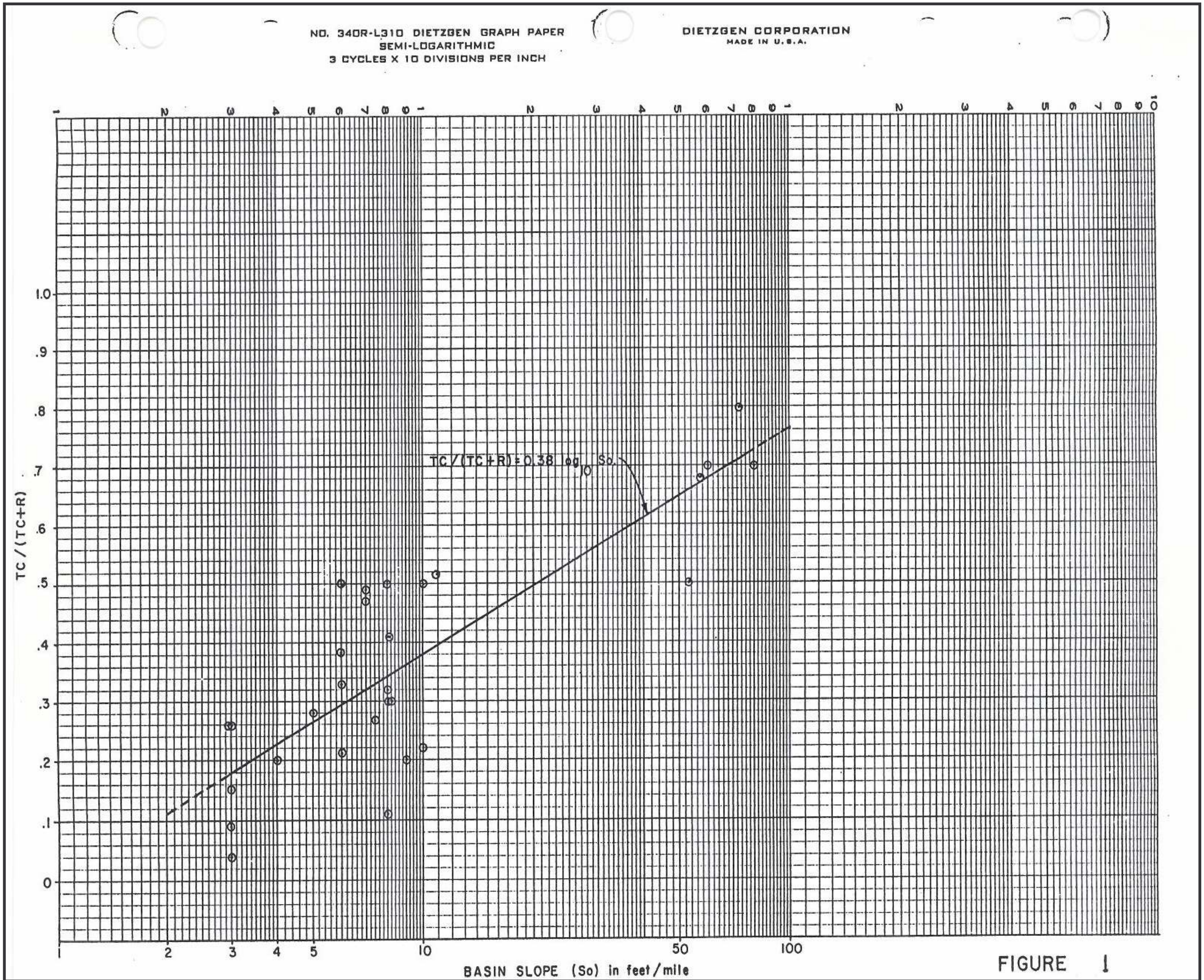

NO. 340R-L310 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
3 CYCLES X 10 DIVISIONS PER INCH
DIETZGEN CORPORATION
MADE IN U.S.A.
TC / (TC+R)
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
TC/(TC+R) = 0.38 log10 So
1
2
3
4
5
10
50
100
BASIN SLOPE (So) in feet/mile

FIGURE 1

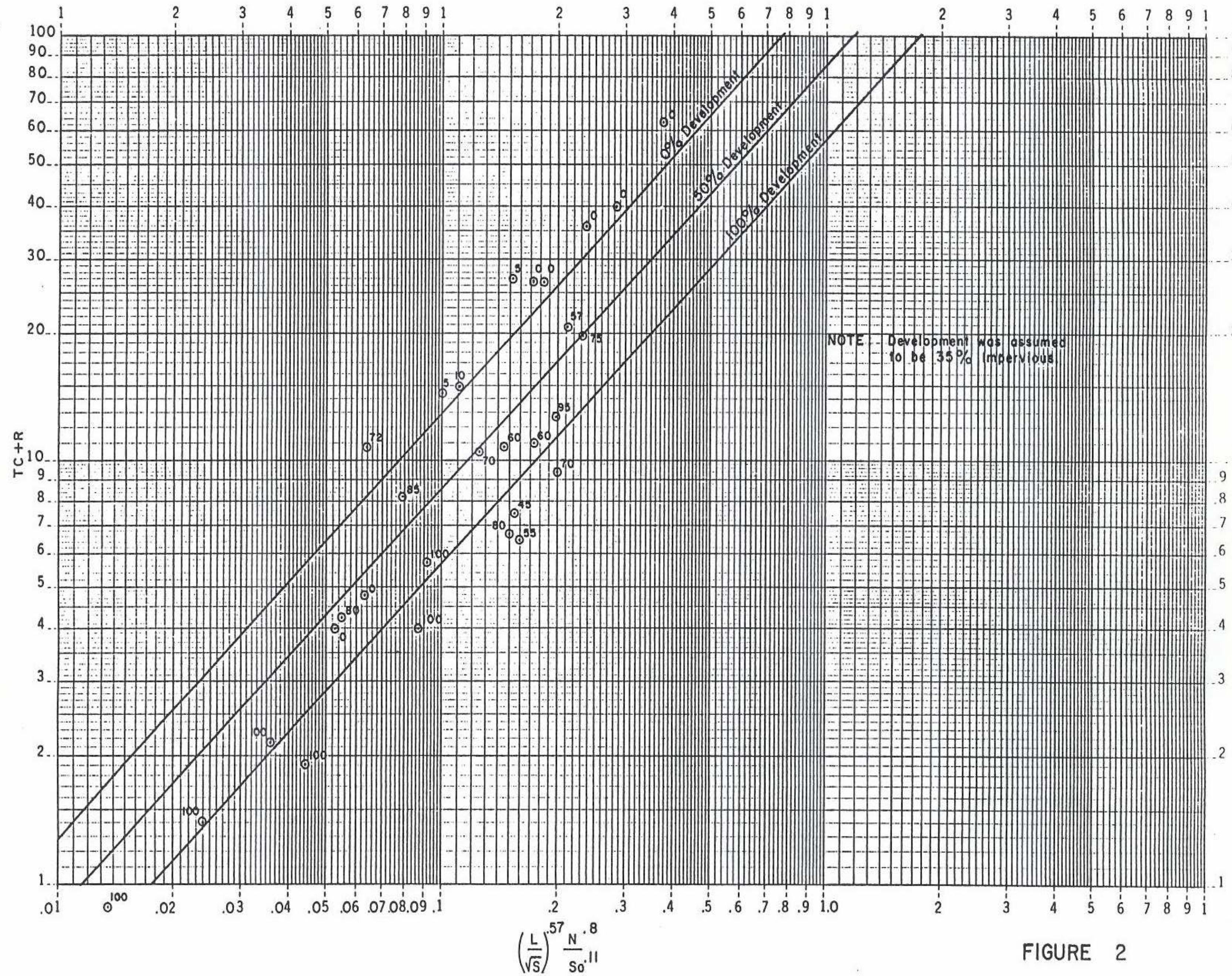
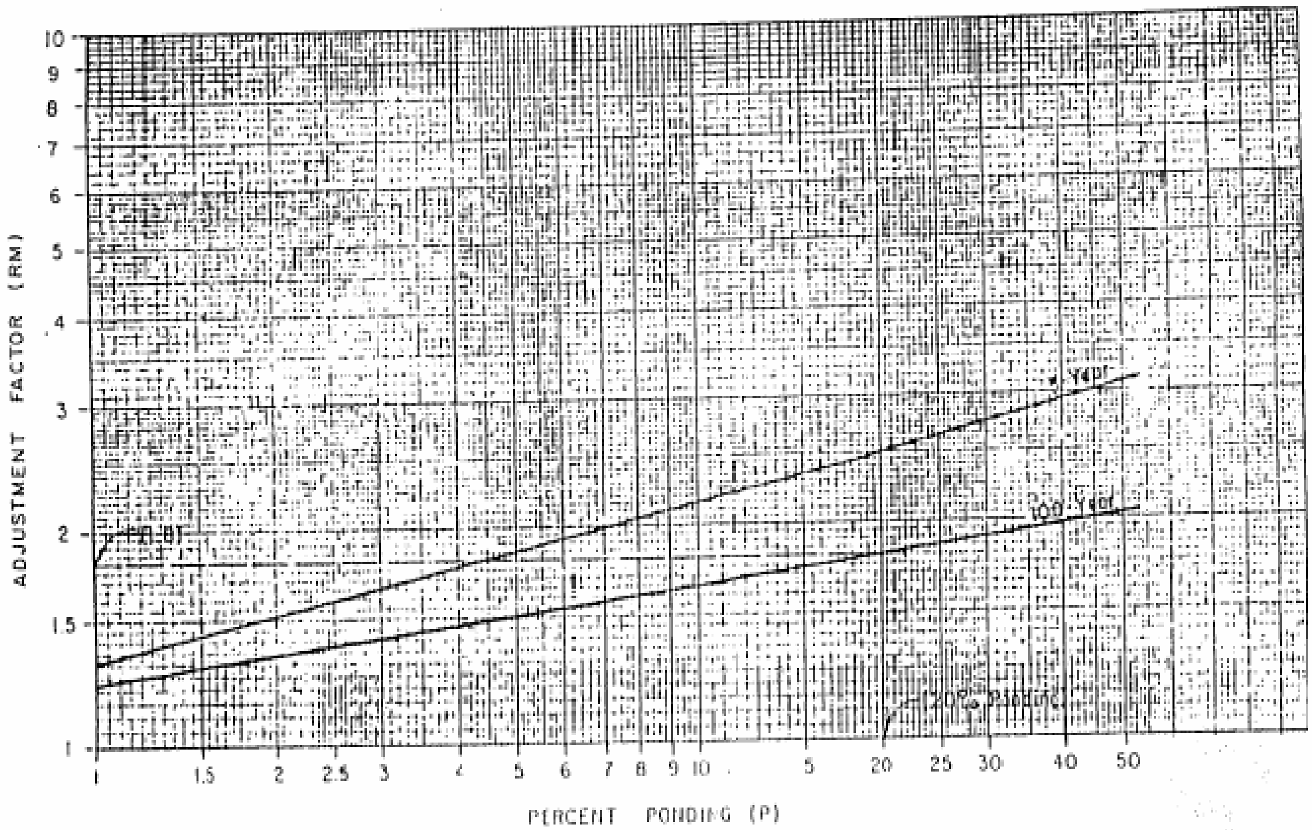

0% Development
50% Development
100% Development
NOTE – Development was assumed to be 35% impervious
TC+R
$\left(\frac{L}{\sqrt{S}}\right)^{.57} \frac{N^{.8}}{So^{.11}}$

FIGURE 2



PONDING ADJUSTMENT FACTOR FOR CLARKS STORAGE COEFFICIENT (R) FOR FORT BEND COUNTY, TEXAS

STORM EVENT	ADJUSTMENT FACTOR (RM) EQUATION
5 YEAR	$RM = 1.31\ P^{0.214}$
10 YEAR	$RM = 1.28\ P^{0.199}$
25 YEAR	$RM = 1.25\ P^{0.171}$
50 YEAR	$RM = 1.23\ P^{0.153}$
100 YEAR	$RM = 1.21\ P^{0.132}$
500 YEAR	$RM = 1.17\ P^{0.086}$

Source:
Criteria Manual for Design of Flood Control and Drainage Facilities in Harris County, Texas, February, 1984.

August 1986	FIGURE 3

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8. "HEC-1 Flood Hydrograph Package, Users Manual", U.S. Army Corps of Engineers, Davis, California, September 1981.

9. "Hydrologic Data for Urban Studies in the Houston, Texas Metropolitan Area", U.S. Geological Survey, Open-File Reports, 1964 to 1982.

10. Johnson, S.L. and Sayre, D.M., "Effects of Urbanization on Floods in the Houston, Texas Metropolitan Area", U.S. Geological Survey Water-Resources Investigation 3-73, April 1973.

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12. "Soil Survey for Fort Bend County, Texas", U.S. Department of Agriculture, Soil Conservation Service, February 1960.

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TABLE 1
STORMS ANALYZED IN CORRELATION STUDIES

Station	Storm No.	USGS Sta. I.D. No.	Station Name	Storm Date
1	1a	0807 3630	Bettina St. Ditch at Kimberly St.	7/20/79
	1b	“	“	4/23/81
2	2a	0807 4250	Brickhouse Gully at Costa Rica St.	3/20/72
	2b	“	“	4/19/79
3	3a	0807 4500	Whiteoak Bayou at Heights Blvd.	3/20/72
	3b	“	“	1/6/79
	3b	“	“	5/13/82
4	4a	0807 4540	Little Whiteoak Bayou at Trimble St.	5/3/81
	4b	“	“	8/30/81
	4c	“	“	5/13/82
5	5	0807 4760	Brays Bayou at Alief	5/13/82
6	6	0807-4780	Keegans Bayou at Keegan Road	8/30/81
7	7a	0807-4800	Keegans Bayou at Roark Road	8/30/81
	7b	“	“	5/13/82
8	8a	0870 4810	Brays Bayou at Gessner Dr.	10/31/81
	8b	“	“	5/13/82
9	9a	0807 4910	Hummingbird St. Ditch at Mullins St.	7/1/79
	9b	“	“	5/13/82
10	10a	0807 5000	Brays Bayou at Main St.	4/19/79
	10b	“	“	5/13/82
11	11a	0807 5400	Sims Bayou at Hiram Clarke St.	6/11/73
	11b	“	“	5/13/82
12	12a	0807 5500	Sims Bayou at Highway 35	6/11/73
	12b	“	“	8/30/81
	12c	“	“	10/5/81
13	13a	0807 5550	Berry Bayou at Gilpin St.	5/19/79
	13b	“	“	5/13/82
14	14a	0807 5650	Berry Bayou at Forest Oaks St.	7/25/79
	14b	“	“	5/13/82
15	15a	0807 5730	Vince Bayou at Pasadena	3/19/79
	15b	“	“	7/25/79
	15c	“	“	5/13/82
16	16	0807 5770	Hunting Bayou at IH 610	5/17/82

TABLE 1 (Conclude)
STORMS ANALYZED IN CORRELATION STUDIES

Station	Storm No.	USGS Sta. I.D. No.	Station Name	Storm Date
17	17	0807 5900	Greens Bayou at US 75	9/19/79
18		0806 8450	Panther Br. nr Spring (Montgomery Cty)	CE Data[a]
19		0811 4900	Seabourne Cr. nr Rosenberg (Ft Bend Cty)	CE Data[a]
20		0811 6400	Dry Cr. nr Rosenberg (Ft Bend Cty)	CE Data[a]
21		0811 5500	Fairchild Cr. nr Needville (Ft Bend Cty)	CE Data[a]
22		0811 5000	Big Cr. nr Needville (Ft Bend Cty)	CE Data[a]
23		0806 7550	Welch Cr. (Montgomery Cty)	TC&B Data[b]
24		0806 8300	Mill Cr. Trib. nr Dobbin (Montgomery Cty)	CE Data[a]
25		0807 0500	Caney Cr. nr Splendora (Montgomery Cty)	CE Data[a]
26		0807 1000	Peace Cr. at Splendora (Montgomery Cty)	CE Data[a]
27		0806 8500	Spring Cr. nr Spring (Montgomery Cty)	CE Data[a]
28		0807 4400	Lazybrook	TC&B Data[b]
29		0807 3750	Stoneybrook Street Ditch	TC&B Data[b]

Note: All gages in Harris County unless otherwise noted.
a. Corps of Engineer's data for this station.
b. Turner, Collie & Braden, Inc. data used for this station.

(Ref. for a & b: "Harris County Flood Hazard Study Final Report", dated September 1984, prepared by TC&B and Pate Engineers, Inc.)

TABLE 2
BASIN CHARACTERISTIS FOR GAGES ANALYZED

Station No.	Drainage Area (mi^2)	Basin Length (mi)	Length to Centroid (mi)	Channel Slope (ft/mi)	Watershed Slope (ft/mi)	Weighted Manning's "n" value	Percent Development (@ 1980)
1	1.37	1.00	0.50	2.50	3.0	.025	100
2	11.40	6.35	3.55	7.90	8.0	.02	80
3	86.30	21.30	12.10	5.50	8.0	.025	60
4	18.00	7.89	3.39	14.40	8.0	.04	100
5	14.10	8.76	3.79	2.00	7.0	.04	60
6	7.47	6.50	2.90	2.35	3.0	.04	45
7	11.50	8.70	3.03	2.35	10.0	.04	55
8	53.20	13.80	7.50	3.30	6.0	.04	70
9	0.32	0.80	0.40	3.00	3.0	.04	100
10	94.90	21.60	11.30	3.10	6.0	.02	80
11	202.0	6.06	3.41	2.90	7.40	.04	70
12	63.00	18.20	7.95	3.10	7.20	.04	75
13	2.56	2.00	1.00	4.00	5.0	.4	72
14	10.70	5.00	2.50	10.00	8.0	.04	85
15	7.32	5.25	1.75	4.90	3.0	.03	100
16	15.80	6.55	3.00	2.20	7.0	.06	95
17	36.10	11.70	5.20	4.20	4.0	.05	57
18	34.50	13.10	7.80	6.30	57	.06	0
19	5.70	5.30	2.60	4.42	9.0	.04	5
20	8.60	6.63	3.06	5.08	8.0	.04	10
21	24.90	7.70	3.80	4.10	6.0	.06	0
22	42.80	14.00	7.42	3.20	10.0	.03	5
23	2.35	4.00	2.60	19.5	73	.06	0
24	4.07	3.60	1.70	33.0	53	.06	0
25	105	35.40	13.10	7.90	59	.06	0
26	117	26.80	15.40	7.70	80	.06	0
27	409	52.40	27.00	6.90	50	.06	0
28	0.13	0.66	0.27	5.20	8.0	.015	100
29	0.50	0.76	0.33	2.40	6.0	.020	100

TABLE 3
OPTIMIZATION RESULTS

Storm No.	% Imperv. [1]	First Run					Second Run[2]		Final Study[2,3]		
		TC+R	R/(TC+R)	STRKR	RTIOL	ERAIN	TC+R	R/(TC+R)	TC+R	STRKR	
										Storm	Station
1a	35	1.68	0.78	0.47	1.90	0.62	1.71	.79	1.77	0.50	.55
1b	.35	2.14	.069	.071	1.90	0.62	2.12	.68	2.50	0.60	
2a	21	5.81	0.83	0.20	1.00	0.82	6.14	.86	5.56	0.32	.32
2b	28	2.93	0.54	0.32	1.00	0.82	2.92	.52	2.89	0.32	
3a	9.1	12.01	0.53	0.55	2.71	0.64	12.2	.53	13.7	0.56	
3b	20	8.65	0.70	0.28	2.71	0.64	8.62	.70	8.39	0.33	.37
3c	21	10.55	0.59	0.20	2.71	0.64	10.2	.55	10.5	0.21	
4a	35	6.79	0.76	0.48	3.88	0.51	6.55	.73	6.36	0.53	
4b	35	4.92	0.74	1.57	3.88	0.51	4.89	.75	4.77	1.92	1.02
4c	35	5.96	0.62	0.60	3.88	0.51	5.85	.63	5.84	0.62	
5	21	9.36	0.43	0.47	5.23	0.12	10.0	.53	11.0	0.50	0.50
6	15.8	7.75	0.97	0.81	2.11	1.00	7.57	.96	7.53	0.95	0.95
7a	19.3	8.70	0.97	0.52	1.73	0.87	9.24	.97	7.60	0.63	0.62
7b	19.3	5.54	0.81	0.63	1.73	0.87	6.13	.85	5.42	0.62	
8a	24.5	9.43	0.63	0.97	2.66	0.39	9.72	.65	10.2	0.98	0.73
8b	24.5	7.59	0.58	0.44	2.66	0.39	7.80	.58	8.38	0.48	
9a	35	1.68	0.67	0.92	3.26	0.80	1.8	.81	1.92	0.94	0.84
9b	35	1.84	0.59	0.79	3.26	0.80	1.87	.67	1.93	0.73	
10a	28	7.00	0.70	0.13	1.88	0.65	7.01	.70	6.86	0.12	0.34
10b	28	6.70	0.66	0.51	1.88	0.65	6.68	.64	6.65	0.56	
11a	19.3	12.86	0.84	0.02	3.20	0.42	13.2	.80	11.5	0.04	0.45
11b	24.5	9.08	0.69	0.84	3.20	0.42	8.65	.66	9.21	0.86	
12a	21	20.84	0.72	0.08	2.92	0.50	20.5	.70	20.4	0.08	

TABLE 3
OPTIMIZATION RESULTS

Storm No.	% Imperv. [1]	First Run TC+R	First Run R/(TC+R)	First Run STRKR	First Run RTIOL	First Run ERAIN	Second Run[2] TC+R	Second Run[2] R/(TC+R)	Final Study[2,3] TC+R	Final Study[2,3] STRKR Storm	Final Study[2,3] STRKR Station
12b26.3	19.64	0.42	0.59	2.92	0.50	19.3	.43	21.4	0.59	0.52	
12c	26.3	15.87	0.56	0.89	2.92	0.50	16.0	.59	17.4	0.90	
13a	24.5	13.17	0.97	0.14	1.08	0.89	13.2	.97	14.0	0.16	0.39
13b	24.5	6.33	0.50	0.59	1.08	0.89	6.17	.48	7.74	0.62	
14a	29.8	9.58	0.83	0.02	4.64	0.71	9.61	.82	9.83	0.04	0.41
14b	29.8	6.23	0.60	0.82	4.64	0.71	5.97	.57	6.59	0.78	
15a	35	3.62	0.84	0.31	2.07	0.92	3.85	.87	3.76	0.29	
15b	35	5.68	0.77	0.00	2.07	0.92	5.67	.77	5.57	0.00	0.28
15c	35	2.82	0.91	0.49	2.07	0.92	2.85	.91	2.69	0.55	
16	33.3	12.10	0.54	0.15	2.00	0.48	12.0	.51	12.9	0.13	0.13
17	3.5	-	-	-	-	-	21.2	.80	20.8	0.37	0.37

1 Assumes % Imperv. = 0.35 x % Development for the storm date.
2 Using RTIOL = 3.0 and ERAIN = 0.6 for all storms.
3 Using TC/(TC+R) = 0.38 log S_0 (See Figure 1).

TABLE 3A
FINAL VALUES ADOPTED
FOR OTHER STATIONS

Station No.	TC+R	R/(TC+R)
18	27	.3
19	14.5	.8
20	15.0	.5
21	26.5	.5
22	27.0	.5
23	4.8	.2
24	4.0	.5
25	40	.3
26	36	.3
27	63.8	.2
28	0.90	.9
29	1.40	.8

Reference: "Harris County Flood Hazard Study Final Report", dated September 1984 by TC&B and Pate Engineers, Inc.

TABLE 4
ANALYSIS OF VARIANCE – LOSS COEFFICIENT

Station	Values of X (STRKR) Storm a	Storm b	Σ X	$\sum(X^{2)}$	$\sum X^2 - \frac{(\sum x)^2}{2}$
1	0.50	0.60	1.1000	0.6100	0.00500
2	0.32	0.32	0.6400	0.2048	0.0000
3	0.56	0.33	0.89	0.4225	0.02645
4	0.53	1.92	2.4500	3.9673	0.96605
7	0.63	0.62	1.2500	0.7813	0.00005
8	0.98	0.48	1.4600	1.1908	0.12500
9	0.94	0.73	1.6700	1.4165	0.02205
10	0.12	0.56	0.6800	0.3280	0.09680
11	0.04	0.86	0.9000	0.742	0.33620
12	0.08	0.59	0.6700	0.3545	0.13005
13	0.16	0.62	0.7800	0.4100	0.10580
14	0.04	0.78	0.8200	0.6100	0.27380
15	0.29	0.00	0.2900	0.0841	0.04205
			13.6000	11.1210	2.12930

Total variance = 11.1210 – $(13.60)^2$ .26) = 4.0072

Average variance between storms = 2.1293/13 = 0.1638

Average variance between stations = (4.0072 – 2.1293)/12 = 0.1565

Average value of STRKR = 13.60/26 = 0.52

TABLE 5
COMPARISON OF 100-YEAR DISCHARGE COMPUTATIONS

		METHODOLOGY					
				U.S.G. WRI 80-17			
U.S.G.S. ID No.	D.A (mi)^2	Ft Bend County	Harris County	Frequency Analysis from observed data	Frequency Analysis with simulated data	Regional Equation	USGS WRI 3-73 Frequency Analysis with Simulated Data
0807 4250	11.4	10,100	8,200	8,210	6,500	4,600	7,110
0807 4500	86.3	26,600	33,800	23,600	23,960	27,550	22,600
0807 4780	7.5	2,000	3,300	1,250	870	1,400	600
0807 4800	11.5	3,860	4,780	1,880	1,740	2,190	1,790
0807 5000	94.9	32,300	39,100	40,600	33,700	36,670	20,700
0807 5400	20.2	8,730	7,430	5,680	5,590	6,330	5,750
0807 5500	63.0	15,600	17,410	16,140	15,300	14,400	16,300
0807 5550	2.56	1,900	-	1,000	870	1,000	880
0807 5650	10.7	7,800	6,230	8,280	6,020	6,220	7,570
0807 5730	7.3	4,520	8,400	4,620	5,000	3,850	-
0807 5770	15.8	5,770	4,650	4,900	4,910	5,820	5,930

Note: The drainage area indicated for each location is that as determined for the Fort Bend County analysis and in some instances may differ from previously published data. A slight variation in discharge may occur attributable to the differences in drainage area.

TABLE 6
COMPARISON OF 100-YEAR DISCHARGE (cfs) FOR DIFFERENT METHODOLOGIES

Watershed	Drainage Area (mi^2)	Percent Developed	Methodology: Fort Bend County	Harris County	Cypress Creek	Johnson-Sayre Nomograph
Clear Creek	1.61	10	597	610	501	400
	3.99	7	1662	1282	899	800
	6.71	8	1433	1213	1395	1450
Keegans Bayou	0.43	75	464	334	260	330
	1.16	30	578	273	450	500
	3.41	80	1830	914	1335	2000
	4.93	75	3134	4034	1689	2670
	5.50	70	3598	5034	1782	3000
Long Point Slough	0.44	0	174	183	164	80
	1.49	5	530	740	454	300
	3.72	0	1298	1540	857	500
	10.66	0	2469	2592	1827	1350
Willow Fork	0.43	25	254	192	192	200
	1.25	0	782	682	385	190
	5.01	0	1665	1420	1062	650