Computation of a Weighted Frequency Curve for the Congaree River at Columbia, South Carolina

The U.S. Geological Survey (USGS) evaluated the FEMA document "Flood Frequency Analysis for the Congaree River at Columbia, South Carolina" dated July 21, 2000. In their review comments dated July 30, 2000, the USGS stated "Therefore, it may be appropriate to weight the more defensible approach and less complete data of Method 2 and the more questionable and more comprehensive data of Method 3B. Methods 2 and 3B are defined as follows:

Method 2 – The flood frequency curve is estimated by using MOVE.2 (Hirsch, 1982) to estimate regulated peak flows for 1926-29, observed regulated peak flows for 1930-98 and station skew is used as the final skew.

Method 3B – The flood frequency curve is estimated by using MOVE.2 (Hirsch, 1982) to estimate regulated peak flows for 1926-29, peak flows from 1892 to 1925 are converted to regulated flows using Equation 4 in the FEMA document, the 1908 flood is considered the highest since 1852 (historical adjustment) and station skew is used as the final skew.

The approach was to develop a combined frequency curve by weighting the flood discharges of Methods 2 and 3B inversely proportional to their variances. This approach is consistent with Equation 8-1 of Appendix 8 of Bulletin 17B, *Guidelines For Determining Flood Flow Frequency* (Interagency Advisory Committee on Water Data, 1982). The flood discharges for various percent chance exceedances for Methods 2 and 3B are given in the following table. The Bulletin 17B frequency analyses for Methods 2 and 3B are given in Appendices 1 and 2, respectively.

Table 1. Summary of flood discharges for Methods 2 and 3B and the weighted flood discharges.

Percent chance exceedance	Method 2 (cfs)	Method 2 Variance (log units^2)	Method 3B (cfs)	Method 3B Variance (log units^2)	Weighted frequency curve (cfs)
50	70,060	0.000771	72,960	0.000560	71,700
20	109,100	0.001103	116,900	0.000835	114,000
10	140,700	0.001781	152,600	0.001316	148,000
4	187,900	0.003550	206,000	0.002551	198,000
2	228,800	0.005673	252,200	0.004017	242,000
1	274,900	0.008550	304,400	0.005988	292,000
0.5	327,200	0.012236	363,400	0.008500	349,000
0.2	406,900	0.018433	453,400	0.012695	434,000

The variances in Table 1 were estimated using procedures in Kite (1988). The equation for the variance of a flood discharge for a given percent chance exceedance has the following form

$$\text{Var}(p) = [\text{Var} / N] / R_p^2 \qquad (1)$$

where

Var (p) is the variance in log units squared of the flood discharge with p-percent chance of exceedance in any given year,

Var is the variance of the annual peak flows in log units squared [0.046829 log units^2 $(0.2164)^2$ for Method 2 and 0.053870 log units^2 $(0.2321)^2$ for Method 3B; see Appendices 1 and 2],

N is the length of record or sample size in years, and

R_p^2 is a Pearson Type III frequency factor for a given skew coefficient [0.417 for Method 2 and 0.390 for Method 3B; see Appendices 1 and 2] and p-percent chance flood.

The frequency curve for Method 2 was based on 73 years of record (1926-98) so N in Equation 1 was 73. The frequency curve for Method 3B was based on 107 years of record (1892 to 1998) with the 1908 flood considered the highest since 1852 (highest in 146 years). Even though a historical adjustment was applied to the 1908 flood, 107 years was used for N in computing the variance in Equation 1. In reality, the equivalent years of record is somewhere between 107 and 146 years.

The weighted flood discharges in Table 1 were computed from the following equation also given in Appendix 8 of Bulletin 17B.

$$Q_w = [Q_{m2} * \text{Var}_{m3B} + Q_{m3B} * \text{Var}_{m2}] / \text{Var}_{m2} + \text{Var}_{m3B} \qquad (2)$$

where

Q_w is the weighted flood discharge in cubic feet per second (cfs),

Q_{m2} is the flood discharge from Method 2 in cfs,

Q_{m3B} is the flood discharge from Method 3B in cfs.

Var_{m2} is the variance of Method 2 in log units^2,

Var_{m3B} is the variance of Method 3B in log unit^2.

Equation 2 was applied for each p-percent chance flood in Table 1. A weighted frequency curve was also obtained by converting the flood discharges for Methods 2 and 3B to log units before

weighting them according to Equation 2. The same weighted frequency curve was obtained when flood discharges were rounded to three significant figures. The weighting in log units is actually more logical since the flood discharges and variances are computed in log units. However, since the same frequency curve resulted, Equation 2 is shown in cfs units.

The weighted frequency curve from Table 1 is given in Figure 1.

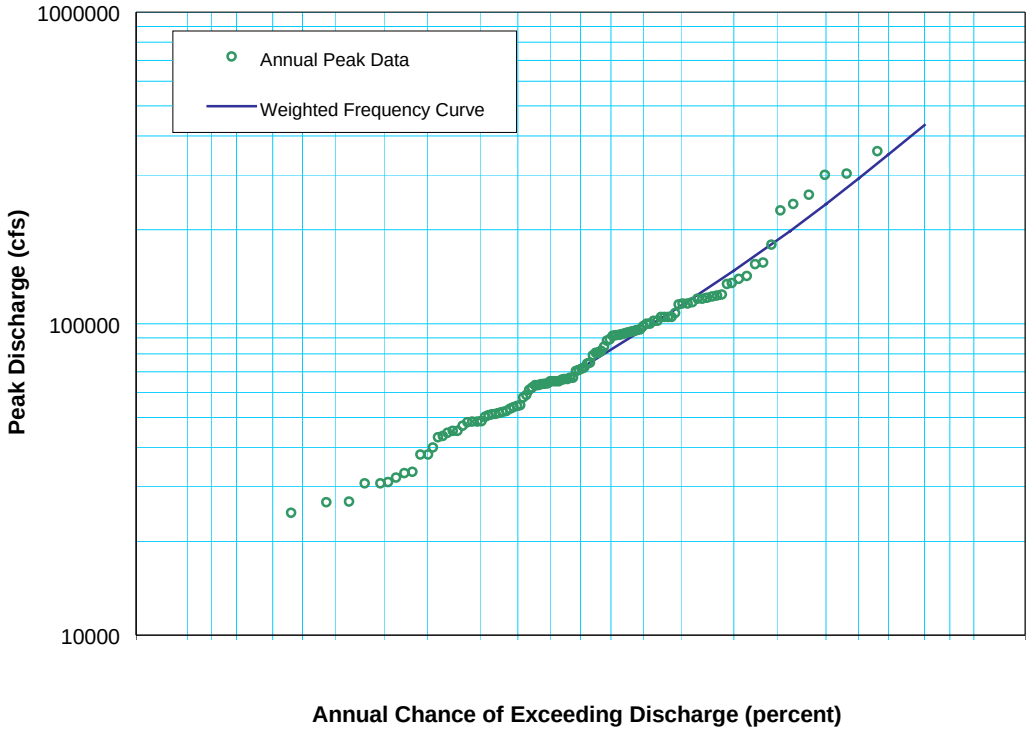

Figure 1. Weighted frequency curve by weighting flood discharges from Methods 2 and 3B.

The weighted frequency curve shown in Figure 1 is plotted with the 107 years of data from 1892 to 1998 using the Weibull plotting position. The weighted frequency curve is consistent with these plotting positions. The 1-percent chance flood discharge for the weighted frequency curve in Figure 1 and in Table 1 is 292,000 cfs. The standard error of this discharge was not estimated because we do not know the equivalent years of record of the weighted flood frequency curve. However, it is likely that the standard error of the weighted 1-percent chance discharge is in the range 18-22 percent, the standard errors for Methods 3B and 2, respectively.

References

Hirsch, R. M., 1982, *A Comparison of Four Streamflow Record Extension Techniques*: Water Resources Research, Vol. 18, No. 4, pages 1081-1088.

Interagency Advisory Committee on Water Data, 1982, *Guidelines for Determining Flood Flow Frequency*: Bulletin 17B of the Hydrology Subcommittee, Office of Water Data Coordination, U.S. Geological Survey, Reston, Virginia, 183 p.

Kite, G. W., 1988, *Frequency and Risk Analyses*: Water Resources Publications, Littleton, Colorado, 257 p.

Appendix 1. – Flood frequency analysis for the period 1926 to 1998 with peak flows for 1926 to 1929 estimated by MOVE.2 (Method 2).

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                        U. S. GEOLOGICAL SURVEY
                     ANNUAL PEAK FLOW FREQUENCY ANALYSIS
                     Following Bulletin 17-B Guidelines
                               Program peakfq
                          (Version 2.4, Apr, 1998)

      Station - 02169500                    CONGAREE RIVER AT COLUMBIA, SC
                             1900 MAY 24 15:20:59


                          I N P U T   D A T A   S U M M A R Y

                    Number of peaks in record           =       73
                    Peaks not used in analysis          =        0
                    Systematic peaks in analysis        =       73
                    Historic peaks in analysis          =        0
                    Years of historic record            =        0
                    Generalized skew                    =   -0.100
                    Standard error of generalized skew  =    0.550
                    Skew option                         = STATION SKEW
                    Gage base discharge                 =      0.0
                    User supplied high outlier threshold =   --
                    User supplied low outlier criterion  =   --
                    Plotting position parameter         =     0.00


  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.    310316.3
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.          17101.3
   *WCF151I-WRC WEIGHTED SKEW REPLACED BY USER OPTION.     0.328     0.471
-1


      Station - 02169500                    CONGAREE RIVER AT COLUMBIA, SC
                             1900 MAY 24 15:20:59


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                          FLOOD BASE                    LOGARITHMIC
                    ----------------------  --------------------------------
                                EXCEEDANCE                 STANDARD
                     DISCHARGE PROBABILITY     MEAN      DEVIATION     SKEW
                    ------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     4.8624      0.2164      0.471
 BULL.17B ESTIMATE       0.0     1.0000     4.8624      0.2164      0.471
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ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	'EXPECTED SYSTEMATIC RECORD	PROBABILITY' ESTIMATE	84-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	25130.0	25130.0	24470.0	22440.0	27740.0
0.9900	27200.0	27200.0	26600.0	24430.0	29880.0
0.9500	34480.0	34480.0	34060.0	31500.0	37360.0
0.9000	39650.0	39650.0	39330.0	36550.0	42650.0
0.8000	47550.0	47550.0	47340.0	44280.0	50750.0
0.5000	70060.0	70060.0	70060.0	66080.0	74250.0
0.2000	109100.0	109100.0	109800.0	102300.0	117000.0
0.1000	140700.0	140700.0	142600.0	130500.0	153200.0
0.0400	187900.0	187900.0	192600.0	171500.0	208700.0
0.0200	228800.0	228800.0	237100.0	206200.0	257900.0
0.0100	274900.0	274900.0	288700.0	244800.0	314500.0
0.0050	327200.0	327200.0	348800.0	287900.0	379600.0
0.0020	406900.0	406900.0	443800.0	352700.0	480700.0

Station - 02169500 CONGAREE RIVER AT COLUMBIA, SC
1900 MAY 24 15:20:59

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1926	45200.0		1963	91800.0	K
1927	30700.0		1964	142000.0	K
1928	300000.0		1965	120000.0	K
1929	157000.0		1966	80600.0	K
1930	303000.0		1967	97900.0	K
1931	26800.0	K	1968	61200.0	K
1932	71600.0	K	1969	94200.0	K
1933	115000.0	K	1970	45200.0	K
1934	33400.0	K	1971	79100.0	K
1935	92300.0	K	1972	63900.0	K
1936	231000.0	K	1973	99800.0	K
1937	70900.0	K	1974	51600.0	K
1938	57900.0	K	1975	122000.0	K
1939	66400.0	K	1976	48400.0	K
1940	121000.0	K	1977	155000.0	K
1941	52000.0	K	1978	81700.0	K
1942	52400.0	K	1979	94500.0	K
1943	63400.0	K	1980	93100.0	K
1944	105000.0	K	1981	51300.0	K
1945	102000.0	K	1982	84200.0	K
1946	62200.0	K	1983	66000.0	K

1947	63400.0	K	1984	70300.0	K
1948	54400.0	K	1985	54700.0	K
1949	116000.0	K	1986	58900.0	K
1950	50200.0	K	1987	123000.0	K
1951	32000.0	K	1988	24700.0	K
1952	91400.0	K	1989	48400.0	K
1953	43500.0	K	1990	93700.0	K
1954	65200.0	K	1991	135000.0	K
1955	47000.0	K	1992	51200.0	K
1956	43100.0	K	1993	65200.0	K
1957	31000.0	K	1994	72300.0	K
1958	64000.0	K	1995	116000.0	K
1959	53900.0	K	1996	74900.0	K
1960	65200.0	K	1997	50800.0	K
1961	74400.0	K	1998	95200.0	K
1962	65200.0	K			

Explanation of peak discharge qualification codes

PEAKFQ CODE	WATSTORE CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

Station - 02169500 CONGAREE RIVER AT COLUMBIA, SC
1900 MAY 24 15:20:59

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1930	303000.0	0.0135	0.0135
1928	300000.0	0.0270	0.0270
1936	231000.0	0.0405	0.0405
1929	157000.0	0.0541	0.0541
1977	155000.0	0.0676	0.0676
1964	142000.0	0.0811	0.0811
1991	135000.0	0.0946	0.0946
1987	123000.0	0.1081	0.1081
1975	122000.0	0.1216	0.1216
1940	121000.0	0.1351	0.1351
1965	120000.0	0.1486	0.1486
1949	116000.0	0.1622	0.1622
1995	116000.0	0.1757	0.1757
1933	115000.0	0.1892	0.1892

1944	105000.0	0.2027	0.2027
1945	102000.0	0.2162	0.2162
1973	99800.0	0.2297	0.2297
1967	97900.0	0.2432	0.2432
1998	95200.0	0.2568	0.2568
1979	94500.0	0.2703	0.2703
1969	94200.0	0.2838	0.2838
1990	93700.0	0.2973	0.2973
1980	93100.0	0.3108	0.3108
1935	92300.0	0.3243	0.3243
1963	91800.0	0.3378	0.3378
1952	91400.0	0.3514	0.3514
1982	84200.0	0.3649	0.3649
1978	81700.0	0.3784	0.3784
1966	80600.0	0.3919	0.3919
1971	79100.0	0.4054	0.4054
1996	74900.0	0.4189	0.4189
1961	74400.0	0.4324	0.4324
1994	72300.0	0.4459	0.4459
1932	71600.0	0.4595	0.4595
1937	70900.0	0.4730	0.4730
1984	70300.0	0.4865	0.4865
1939	66400.0	0.5000	0.5000
1983	66000.0	0.5135	0.5135
1954	65200.0	0.5270	0.5270
1960	65200.0	0.5405	0.5405
1962	65200.0	0.5541	0.5541
1993	65200.0	0.5676	0.5676
1958	64000.0	0.5811	0.5811
1972	63900.0	0.5946	0.5946
1943	63400.0	0.6081	0.6081
1947	63400.0	0.6216	0.6216
1946	62200.0	0.6351	0.6351
1968	61200.0	0.6486	0.6486
1986	58900.0	0.6622	0.6622
1938	57900.0	0.6757	0.6757
1985	54700.0	0.6892	0.6892
1948	54400.0	0.7027	0.7027
1959	53900.0	0.7162	0.7162
1942	52400.0	0.7297	0.7297
1941	52000.0	0.7432	0.7432
1974	51600.0	0.7568	0.7568
1981	51300.0	0.7703	0.7703
1992	51200.0	0.7838	0.7838
1997	50800.0	0.7973	0.7973
1950	50200.0	0.8108	0.8108
1976	48400.0	0.8243	0.8243
1989	48400.0	0.8378	0.8378
1955	47000.0	0.8514	0.8514
1926	45200.0	0.8649	0.8649
1970	45200.0	0.8784	0.8784
1953	43500.0	0.8919	0.8919
1956	43100.0	0.9054	0.9054
1934	33400.0	0.9189	0.9189

1951	32000.0	0.9324	0.9324
1957	31000.0	0.9459	0.9459
1927	30700.0	0.9595	0.9595
1931	26800.0	0.9730	0.9730
1988	24700.0	0.9865	0.9865

Appendix 2. Flood frequency analysis for the period 1892 to 1998 with peak flows prior to 1930 estimated by MOVE.2 (Method 3B).

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                        U. S. GEOLOGICAL SURVEY
                    ANNUAL PEAK FLOW FREQUENCY ANALYSIS
                    Following Bulletin 17-B Guidelines
                              Program peakfq
                         (Version 2.4, Apr, 1998)
      Station - 02169500                    CONGAREE RIVER AT COLUMBIA, SC
                          1900 JUL 19 10:49:56

                    I N P U T   D A T A   S U M M A R Y

                Number of peaks in record            =      108
                Peaks not used in analysis           =        1
                Systematic peaks in analysis         =      107
                Historic peaks in analysis           =        0
                Years of historic record             =      146
                Generalized skew                     =   -0.100
                Standard error of generalized skew   =    0.550
                Skew option                          = STATION SKEW
                Gage base discharge                  =      0.0
                User supplied high outlier threshold =   350000.0
                User supplied low outlier criterion  =   --
                Plotting position parameter          =     0.00

  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =  107
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
   *WCF161I-USER HIGH OUTLIER CRITERION REPLACES WRC.   350000.0   391284.4
    WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE.  1  0   349999.8
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.          14094.1
   *WCF151I-WRC WEIGHTED SKEW REPLACED BY USER OPTION.     0.317     0.390
-1
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2


      Station - 02169500                    CONGAREE RIVER AT COLUMBIA, SC
                          1900 JUL 19 10:49:56

           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                    LOGARITHMIC
                  ----------------------  --------------------------------
                              EXCEEDANCE                 STANDARD
                   DISCHARGE PROBABILITY     MEAN      DEVIATION     SKEW
                  ------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     4.8798      0.2346      0.419
 BULL.17B ESTIMATE       0.0     1.0000     4.8781      0.2321      0.390
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ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	'EXPECTED SYSTEMATIC RECORD	PROBABILITY' ESTIMATE	84-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	23180.0	23320.0	22690.0	20950.0	25380.0
0.9900	25440.0	25540.0	24990.0	23110.0	27710.0
0.9500	33400.0	33410.0	33090.0	30840.0	35910.0
0.9000	39090.0	39060.0	38850.0	36390.0	41730.0
0.8000	47830.0	47770.0	47680.0	44940.0	50700.0
0.5000	72960.0	73030.0	72960.0	69280.0	76810.0
0.2000	116900.0	117800.0	117400.0	110400.0	124300.0
0.1000	152600.0	154500.0	154000.0	142700.0	164300.0
0.0400	206000.0	210000.0	209600.0	189900.0	225500.0
0.0200	252200.0	258500.0	258600.0	230100.0	279600.0
0.0100	304400.0	313600.0	314900.0	274900.0	341600.0
0.0050	363400.0	376400.0	379800.0	324900.0	412600.0
0.0020	453400.0	472800.0	481000.0	400100.0	522400.0

Station - 02169500 CONGAREE RIVER AT COLUMBIA, SC

1900 JUL 19 10:49:56

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1852	-8888.0		1945	102000.0	K
1892	139000.0		1946	62200.0	K
1893	95700.0		1947	63400.0	K
1894	40000.0		1948	54400.0	K
1895	89000.0		1949	116000.0	K
1896	67000.0		1950	50200.0	K
1897	100000.0		1951	32000.0	K
1898	30700.0		1952	91400.0	K
1899	102000.0		1953	43500.0	K
1900	105000.0		1954	65200.0	K
1901	117000.0		1955	47000.0	K
1902	105000.0		1956	43100.0	K
1903	179000.0		1957	31000.0	K
1904	38000.0		1958	64000.0	K
1905	48600.0		1959	53900.0	K
1906	88100.0		1960	65200.0	K
1907	26700.0		1961	74400.0	K
1908	357000.0		1962	65200.0	K
1909	105000.0		1963	91800.0	K
1910	44600.0		1964	142000.0	K
1911	33100.0		1965	120000.0	K
1912	242000.0		1966	80600.0	K
1913	120000.0		1967	97900.0	K
1914	48200.0		1968	61200.0	K

1915	64200.0		1969	94200.0	K
1916	259000.0		1970	45200.0	K
1917	67000.0		1971	79100.0	K
1918	38000.0		1972	63900.0	K
1919	91900.0		1973	99800.0	K
1920	80600.0		1974	51600.0	K
1921	134000.0		1975	122000.0	K
1922	108000.0		1976	48400.0	K
1923	66300.0		1977	155000.0	K
1924	53300.0		1978	81700.0	K
1925	124000.0		1979	94500.0	K
1926	45200.0		1980	93100.0	K
1927	30700.0		1981	51300.0	K
1928	300000.0		1982	84200.0	K
1929	157000.0		1983	66000.0	K
1930	303000.0		1984	70300.0	K
1931	26800.0	K	1985	54700.0	K
1932	71600.0	K	1986	58900.0	K
1933	115000.0	K	1987	123000.0	K
1934	33400.0	K	1988	24700.0	K
1935	92300.0	K	1989	48400.0	K
1936	231000.0	K	1990	93700.0	K
1937	70900.0	K	1991	135000.0	K
1938	57900.0	K	1992	51200.0	K
1939	66400.0	K	1993	65200.0	K
1940	121000.0	K	1994	72300.0	K
1941	52000.0	K	1995	116000.0	K
1942	52400.0	K	1996	74900.0	K
1943	63400.0	K	1997	50800.0	K
1944	105000.0	K	1998	95200.0	K

Explanation of peak discharge qualification codes

PEAKFQ CODE	WATSTORE CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

Station - 02169500 CONGAREE RIVER AT COLUMBIA, SC
1900 JUL 19 10:49:56

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1908	357000.0	0.0093	0.0068
1930	303000.0	0.0185	0.0149
1928	300000.0	0.0278	0.0242
1916	259000.0	0.0370	0.0335

1912	242000.0	0.0463	0.0428
1936	231000.0	0.0556	0.0521
1903	179000.0	0.0648	0.0614
1929	157000.0	0.0741	0.0707
1977	155000.0	0.0833	0.0800
1964	142000.0	0.0926	0.0893
1892	139000.0	0.1019	0.0986
1991	135000.0	0.1111	0.1079
1921	134000.0	0.1204	0.1172
1925	124000.0	0.1296	0.1265
1987	123000.0	0.1389	0.1358
1975	122000.0	0.1481	0.1451
1940	121000.0	0.1574	0.1544
1913	120000.0	0.1667	0.1637
1965	120000.0	0.1759	0.1731
1901	117000.0	0.1852	0.1824
1949	116000.0	0.1944	0.1917
1995	116000.0	0.2037	0.2010
1933	115000.0	0.2130	0.2103
1922	108000.0	0.2222	0.2196
1900	105000.0	0.2315	0.2289
1902	105000.0	0.2407	0.2382
1909	105000.0	0.2500	0.2475
1944	105000.0	0.2593	0.2568
1899	102000.0	0.2685	0.2661
1945	102000.0	0.2778	0.2754
1897	100000.0	0.2870	0.2847
1973	99800.0	0.2963	0.2940
1967	97900.0	0.3056	0.3033
1893	95700.0	0.3148	0.3126
1998	95200.0	0.3241	0.3219
1979	94500.0	0.3333	0.3312
1969	94200.0	0.3426	0.3406
1990	93700.0	0.3519	0.3499
1980	93100.0	0.3611	0.3592
1935	92300.0	0.3704	0.3685
1919	91900.0	0.3796	0.3778
1963	91800.0	0.3889	0.3871
1952	91400.0	0.3981	0.3964
1895	89000.0	0.4074	0.4057
1906	88100.0	0.4167	0.4150
1982	84200.0	0.4259	0.4243
1978	81700.0	0.4352	0.4336
1920	80600.0	0.4444	0.4429
1966	80600.0	0.4537	0.4522
1971	79100.0	0.4630	0.4615
1996	74900.0	0.4722	0.4708
1961	74400.0	0.4815	0.4801
1994	72300.0	0.4907	0.4894
1932	71600.0	0.5000	0.4987
1937	70900.0	0.5093	0.5081
1984	70300.0	0.5185	0.5174
1896	67000.0	0.5278	0.5267
1917	67000.0	0.5370	0.5360
1939	66400.0	0.5463	0.5453

1923	66300.0	0.5556	0.5546
1983	66000.0	0.5648	0.5639
1954	65200.0	0.5741	0.5732
1960	65200.0	0.5833	0.5825
1962	65200.0	0.5926	0.5918
1993	65200.0	0.6019	0.6011
1915	64200.0	0.6111	0.6104
1958	64000.0	0.6204	0.6197
1972	63900.0	0.6296	0.6290
1943	63400.0	0.6389	0.6383
1947	63400.0	0.6481	0.6476
1946	62200.0	0.6574	0.6569
1968	61200.0	0.6667	0.6662
1986	58900.0	0.6759	0.6756
1938	57900.0	0.6852	0.6849
1985	54700.0	0.6944	0.6942
1948	54400.0	0.7037	0.7035
1959	53900.0	0.7130	0.7128
1924	53300.0	0.7222	0.7221
1942	52400.0	0.7315	0.7314
1941	52000.0	0.7407	0.7407
1974	51600.0	0.7500	0.7500
1981	51300.0	0.7593	0.7593
1992	51200.0	0.7685	0.7686
1997	50800.0	0.7778	0.7779
1950	50200.0	0.7870	0.7872
1905	48600.0	0.7963	0.7965
1976	48400.0	0.8056	0.8058
1989	48400.0	0.8148	0.8151
1914	48200.0	0.8241	0.8244
1955	47000.0	0.8333	0.8338
1926	45200.0	0.8426	0.8431
1970	45200.0	0.8519	0.8524
1910	44600.0	0.8611	0.8617
1953	43500.0	0.8704	0.8710
1956	43100.0	0.8796	0.8803
1894	40000.0	0.8889	0.8896
1904	38000.0	0.8981	0.8989
1918	38000.0	0.9074	0.9082
1934	33400.0	0.9167	0.9175
1911	33100.0	0.9259	0.9268
1951	32000.0	0.9352	0.9361
1957	31000.0	0.9444	0.9454
1898	30700.0	0.9537	0.9547
1927	30700.0	0.9630	0.9640
1931	26800.0	0.9722	0.9733
1907	26700.0	0.9815	0.9826
1988	24700.0	0.9907	0.9919
1852	-8888.0	--	--