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FLOOD FREQUENCY CHARACTERISTICS OF SOME ARIZONA WATERSHEDS[1]

W. C. Boughton and K. G. Renard[2]

ABSTRACT: The flood frequency characteristics of 18 watersheds in southeastern Arizona were studied using the log-Boughton and the log-Pearson Type 3 distribution. From the flood frequency study, a generalized envelope for Q_{100} for watersheds 0.01 to 4000 mi^2 in area has been produced for southeastern Arizona. The generalized envelope allows comparisons to be made among the relative flood characteristics of the watersheds used in the study and provides a conservative estimate of Q_{100} for ungaged watersheds in the region.
(KEY TERMS: floods; frequency; probability; watersheds.)

INTRODUCTION

In order to estimate floods of specific recurrence interval from the annual floods taken from a streamflow record, it is usual to either fit a mathematical frequency distribution to the data, or to plot the data on a probability paper and fit a smooth line through the data by eye. Both procedures use an *a priori* decision of the type of distribution that is suitable to the data. There are probability papers available for several different frequency distributions, and the choice of probability paper can influence the estimate of flood frequency in the same way as the choice of a mathematically-fitted distribution.

An alternative to the *a priori* selection of frequency distribution was used by Boughton (1975) in a study of annual floods in Queensland, Australia. The base 10 logarithms of annual floods from 57 watersheds, ranging in size from 10 to 50,000 mi^2, were normalized by subtracting the mean and dividing by the standard deviation in each data set. This produced a set of frequency factors for each data set, each factor associated with a recurrence interval determined by the plotting position formula that was used. The frequency factors from this study were grouped into intervals of 0.01 probability of exceedance, averaged within each interval, and then smoothed into a relationship of frequency factor with recurrence interval. It is possible to produce a probability paper from this relationship, which is based on available data, without the need for any prior assumption about the form of the frequency distribution.

The same approach has been used in the present study using data from 18 watersheds in southeastern Arizona. The form of frequency distribution described by Boughton (1980) is used to obtain estimates of Q_{100} for these 18 watersheds. A generalized envelope of these estimates is used to make comparisons among the relative flood characteristics of the watersheds and to provide a conservative estimate of Q_{100} for ungaged watersheds in the region.

DATA

The annual floods in this study were from watersheds ranging in size from 0.0072 mi^2 (4.6 acres) to 4010 mi^2, a spread of nearly six orders of magnitude. Watersheds of larger size in this region were excluded mainly because reservoirs regulate streamflow which in turn affect the magnitude of annual floods.

The 18 watersheds considered in the study (Table 1) are shown in Figure 1. The watersheds are located primarily in the Southeastern Arizona Basin and Range land resource area, but also drain from the Southern Desertic Basins, Plains, and Mountains land resource area (Figure 2), and the Arizona and New Mexico Mountains land resource area (Soil Conservation Service, 1981).

Soils in the study region are derived from a wide variety of parent materials and are generally young, coarse-textured, shallow soils developed, usually, on rolling topography. The soils are neutral to moderately alkaline in pH and generally very low in organic matter content. The soils are used mostly for rangeland forage production due to low precipitation, poor fertility and a high erosion potential.

Vegetation, like soils, are highly variable in the area, with mixtures of grass to grass/brush, to forests, at some of the highest elevations. Generally, the vegetation is sparse with basal areas of 5-10 percent being common in the more arid areas. Some variation in vegetation density also results with aspect where north facing slopes may have more dense cover.

Five of the smaller watersheds (less than 6 mi^2 in area) are in the Walnut Gulch Experimental Watershed complex gaged by the Agricultural Research Service of the USDA using pre-calibrated runoff-measuring devices. Data from the inactive (discontinued) Safford watersheds were obtained by the same

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[2] Respectively, Reader, School of Australian Environmental Studies, Griffith University, Brisbane 4111, Australia; and Research Hydraulic Engineer, USDA, Agricultural Research Service, Southwest Rangeland Watershed Research Center, 2000 East Allen Road, Tucson, Arizona 85719.

TABLE 1. Watersheds Used in the Study.

Figure Identification	Watershed Location	Watershed Identification	Watershed Size (mi^2)	Period of Record
1	Walnut Gulch	63.112	0.0072	1962-79
2	Walnut Gulch	63.104	0.0175	1963-79
3	Safford	WS 1	0.811	1939-68
4	Safford	WS 5	1.13	1939-67
5	Cemetery Wash	Tucson	1.3	1966-78
6	Walnut Gulch	63.011	3.18	1963-80
7	Walnut Gulch	63.003	3.47	1958-80
8	Rodeo Wash	Tucson	5.92	1970-79
9	Walnut Gulch	63.008	5.98	1963-80
10	Sabino Creek	Tucson	35.5	1933-79
11	Tanque Verde Creek	Tucson	43	1960-79
12	Willow Creek	Point of Pines	102	1945-67
13	Eagle Creek	Double Circle	377	1944-67
14	Eagle Creek	Above Pumping Plant	613	1944-75
15	San Carlos River	Peridot	1027	1930-75
16	Santa Cruz River	Tucson	2220	1915-79
17	Gila River	Virden	3203	1927-75
18	Gila River	Clifton	4010	1911-17 1928-75

agency. Cemetery Wash and Rodeo Wash, urban watersheds draining parts of the city of Tucson, are gaged by the U.S. Geological Survey, as are the other watersheds using conventional current meter stations. Sabino Creek and Tanque Verde Creek drain from steep watersheds in the Santa Catalina and Rincon Mountains near the northeastern suburbs of Tucson. The Santa Cruz River has its headwaters in Mexico and flows north, passing through the western side of Tucson before flowing northwesterly towards the Gila River below Phoenix. All of the other watersheds drain from the mountains and plateaus of southeast Arizona and southwest New Mexico, and are tributaries or headwaters of the Gila River above Coolidge Dam (San Carlos Reservoir).

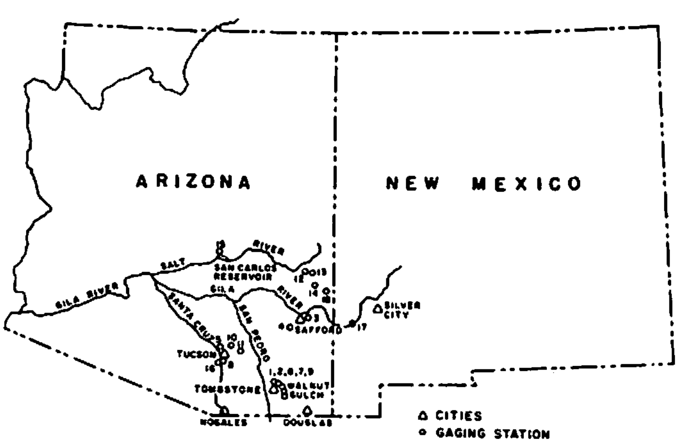


Figure 1. Location of Watersheds (numbers identify watersheds in Table 1).

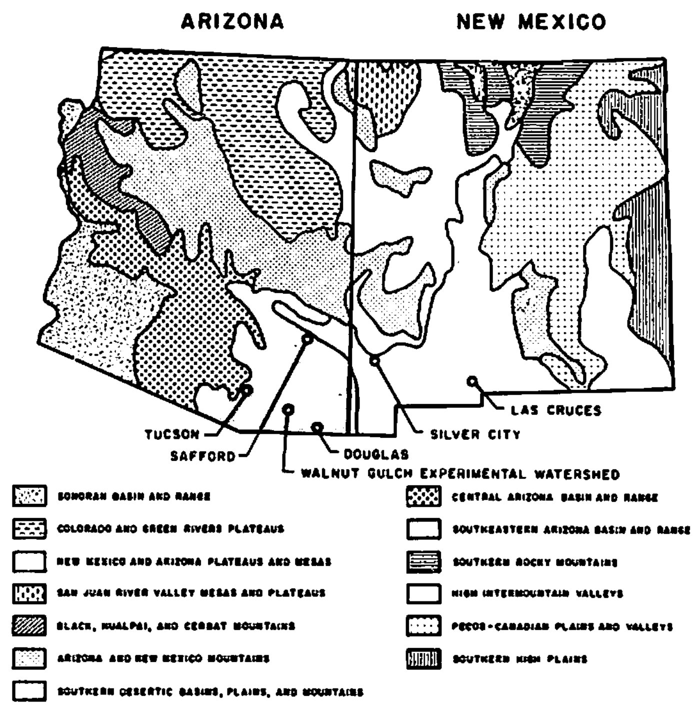


Figure 2. Land Resource Areas in Arizona and New Mexico.

Precipitation, and the resulting runoff, is orographically influenced. The high mountain areas of the larger watersheds are often snow-covered in the winter, with the smaller watersheds generally contained in the intermountain valleys where limited air-mass thunderstorms dominate the annual precipitation total (e.g., the Walnut Gulch watersheds receive about 2/3 of their 14-inch annual rainfall during the June-October period from limited areal extent, high-intensity thunderstorms, Renard and Brakensick, 1976). Thus, the runoff generally results from summer thunderstorms on the smaller watersheds, whereas the larger watersheds often have a mixed population of snowmelt, rain on snow, and thunderstorms.

METHOD

The primary transformation of the data was to take the base 10 logarithm of each annual flood. All analyses reported here use the logarithms of the annual floods.

For each watershed, the logarithms were normalized by subtracting the mean and dividing by the standard deviation. This gave a set of frequency factors for each watershed.

$$K_i = \frac{X_i - \bar{X}}{S} \quad (i = 1 \text{ to } N) \tag{1}$$

where:

X_i = base 10 logarithm of annual flood,

$\bar{X}$ = mean of the logarithms,

S = standard deviation of the logarithms,

K_i = frequency factor, and

N = number of data values.

Each frequency factor is associated with a recurrence interval, T, determined by the plotting position formula. The Cunnane (1978) formula was used throughout this study; this formula is:

$$P = \frac{m - 0.4}{N + 0.2} \tag{2}$$

and

$$T = \frac{1}{P} \tag{3}$$

where:

P = probability of exceedence ($0 < P < 1.0$),

T = average recurrence interval, years, and

m = rank number of flood (1 for the largest flood on record).

The frequency factors from the 18 watersheds listed in Table 1 were tabulated into 1 percent class intervals of exceedence probability (0.005 – 0.015; 0.015 – 0.025; etc.) and averaged within each interval. This gave a set of average frequency factors for exceedence probabilities of 0.01, 0.02 . . . 0.99.

The results are shown in Figure 3, where average frequency factor K is plotted against the lnln(T/(T – 1)) function of recurrence interval. This form of presentation is used to give a comparison with the Gumbel distribution, which is based on a linear relationship between K and lnln(T/(T – 1)), and with the log-Boughton distribution, which uses a curvilinear relationship between these variables.

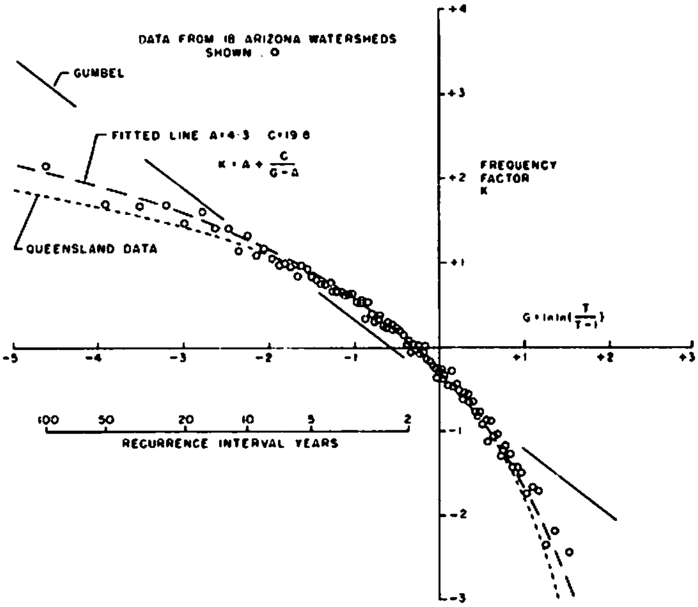


Figure 3. Relationship Between Frequency Factor K and lnln(T/(T−1)) Function of Recurrence Interval for 18 Watersheds in Southeastern Arizona.

The K:lnln(T/(T−1)) relationship obtained from the Arizona watersheds is very similar to the relationship found on Queensland catchments by Boughton (1975, 1980). This suggested a fitting of the log-Boughton distribution to the data values in order to obtain a smoothed relationship. The fitted distribution is shown in Figure 3, which is obtained by parameter values of A = 4.3 and C = 19.8 in the following equation:

$$K = A + C/\left[\ln\ln(T/(T-1)) - A\right] = A + \frac{C}{G - A} \tag{4}$$

where:

$$G = \ln\ln[T/(T-1)].$$

By comparison, the average Queensland results were best fitted using A = 3.21 and C = 11.0 in the same equation. The similarity between the relationships of Arizona and Queensland data is more noteworthy than the difference.

PROBABILITY PAPER

The relationship between frequency factor and the function of recurrence interval shown in Figure 3 is singular and so can be used to draw a probability paper. A computer program was written for the computing facilities at the Southwest Rangeland

Watershed Research Center, which includes a graphics terminal and hardcopy attachment, to automatically draw the probability paper and to plot each data set.

Figure 4 shows the probability paper drawn from the average relationship in Figure 3, with three of the data sets plotted on the paper. The plotted data show the annual floods from the Santa Cruz (2220 mi^2), Sabino Creek (35.5 mi^2), and Safford WS1 (0.81 mi^2) watersheds. These watersheds cover a wide range in area and illustrate that the proability paper is useful as a general paper for Arizona streams; however, the computer program mentioned above can fit the log-Boughton distribution to individual data sets and will automatically scale the probability paper to linearize the fitted distribution, if required.

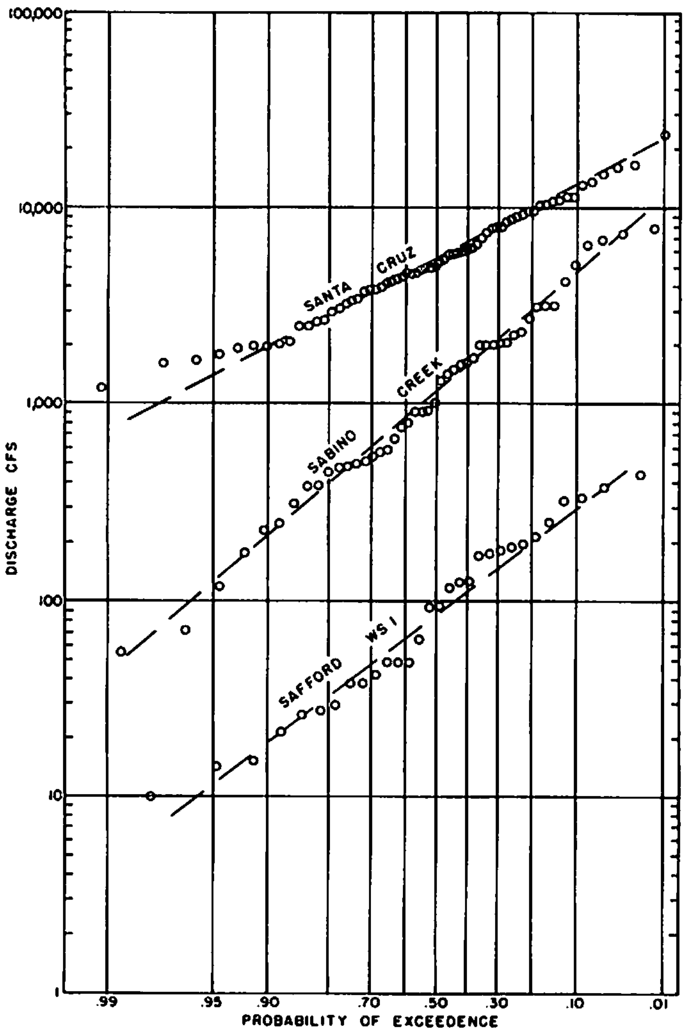


Figure 4. Probability Paper Drawn from the Fitted Line of Figure 3 (A = 4.3; C = 19.8).

VARIATION IN SKEWNESS

The log-Boughton distribution is based upon a curvilinear relationship between frequency factor K and the lnln(T/(T−1)) function of recurrence interval T. For brevity, let $G = \ln\ln(T/(T-1))$.

Figure 5a illustrates the form of relationship given by KG = constant. By shifting the axis by an amount A, as shown in Figure 5b, we obtain the relationship (K−A) (G−A) = constant. By rearranging, the frequency factor is given by the equation

$$K = A + \frac{C}{G-A} \qquad (5)$$

where

A = coordinate shift, and

C = constant.

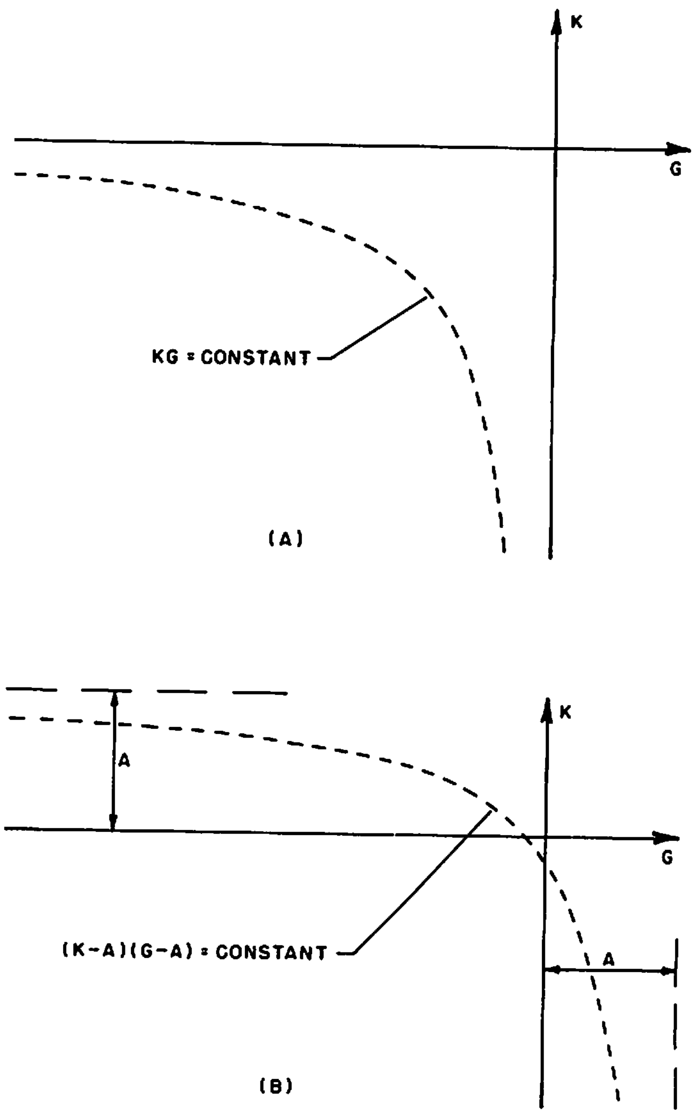


Figure 5. Basis of the Relationship Used in the Log-Boughton Distribution.

It was shown earlier in the paper that the average of the Arizona data are fitted by values A = 4.3 and C = 19.8; these values were used to prepare the probability paper shown in Figure 4. The value of C is obtained from the value of A (see Boughton and Shirley, 1983; Boughton, 1980; and Equation (7)).

A change in the value of A is equivalent to a change in the skewness of the distribution – a lower value of A corresponds to a more negative skew coefficient, and a higher value of A corresponds to a more positive skew coefficient.

The skew coefficient can be substantially affected by one or more very low flood values. Figure 6, taken from Boughton and Shirley (1983), shows this effect using data from 24 years of record on the 57 mi^2 Flume 1 watershed at Walnut Gulch. Annual floods of only 0.6 cfs in 1979 and 54 cfs in 1960 have a substantial effect on the fitting of the log-Pearson type 3 distribution. These very low flood values give a large negative skew to the data set (–2.84), resulting in a poor fit of the LP3 distribution to the larger flood values.

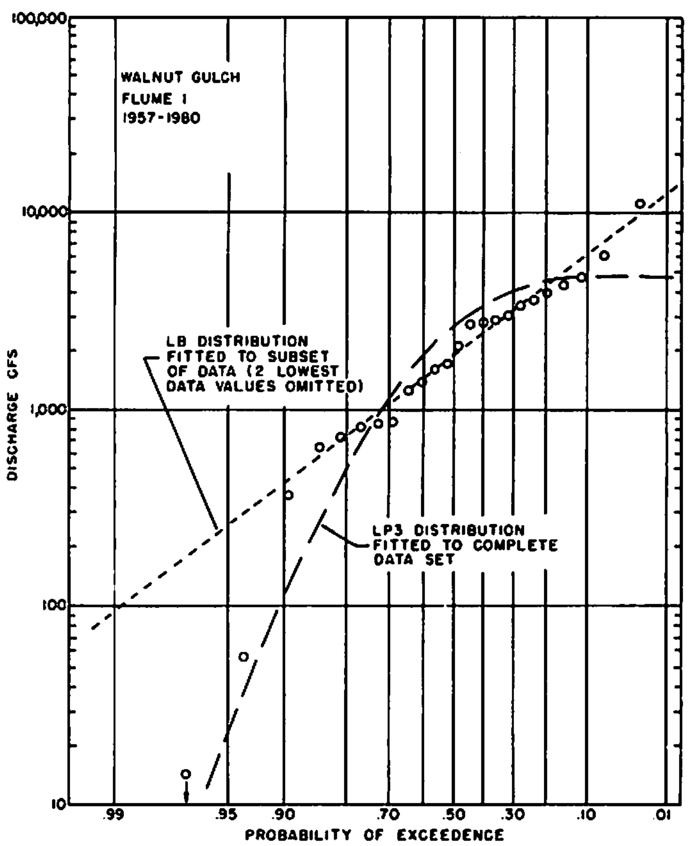


Figure 6. Comparison of Distributions – LP3 Fitted to Complete Data Set and LB Fitted to Subset of Data (lowest two values omitted).

The procedures described by Boughton and Shirley (1983) allow for fitting the distribution to a subset of data, ignoring the very low values. Figure 6 shows the fit of the log-Boughton distribution when the lowest two flood values were omitted from the fitting procedure. When the higher end of the distribution is of most importance, as in flood frequency analysis, this procedure gives a more practical fit to the data (see visual inspection in Figure 6). It should be noted that the very low flood values distort the log-Boughton distribution in a manner similar to the LP3 distribution when all data values are included. The advantage of the fitting procedure developed by Boughton and Shirley (1983) is that very low values can be omitted from the fitting while maintaining the correct plotting positions of the other data. There is no procedure available for doing this with the LP3 distribution.

Using the procedure for fitting to subsets of data, the log-Boughton distribution was fitted to each data set, and values of the coordinate shift A were determined for each watershed. The skew coefficients for the log-Pearson type 3 distribution were determined using the complete data set for each watershed. The values of A are shown plotted against watershed area (log-log scales) in Figure 7a. There is a trend of increasing value of A with increasing size of watershed area. By contrast, there is a wide scatter of points in Figure 7b, where skew coefficient is plotted against watershed area. Although there is a trend toward increasing skew coefficient with increasing area, the relationship is less clear than the relationship between the coordinate shift A and watershed area.

A linear regression of coordinate shift A on watershed area, based on the logarithms of both variables, is shown on Figure 7a. The equation for this regression converts to:

$$A = 3.27\, D_a^{0.0693} \qquad (6)$$

where:

A = coordinate shift and

D_a = watershed area in mi^2.

A relationship between the constant C and coordinate shift A was given by Boughton (1980) as follows:

$$C = 1.009\, A^{2.04} \qquad (7)$$

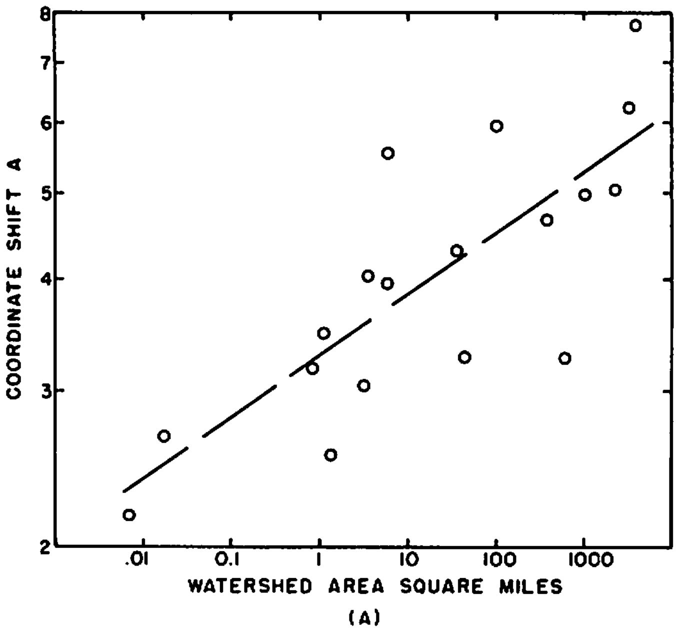
Combining Equations (6) and (7) gives:

$$C = 11.313\, D_a^{0.1414} \qquad (8)$$

Equations (6) and (8) were used to estimate 1 in 100 years flood magnitudes for each of the watersheds. These estimates are compared with LP3 estimates and the highest floods in each data set in the following section.

ESTIMATES OF Q_{100}

Where a long record of streamflow is available for flood frequency analysis, and assuming that there are no outliers that are significantly distant from the main body of data, then several distributions will give similar estimates of the 1 in 100 years flood (Q_{100}) when fitted to the data set. For example, the Santa Cruz River at Tucson (2220 mi^2– has 65 years of available record, and there are no apparent outliers (Figure 4). The log-Boughton and log-Pearson type 3 distributions were fitted in turn to the Santa Cruz data sets and then used to estimate flood magnitudes of 2, 10, and 100 year recurrence intervals. The results are shown in Table 2.



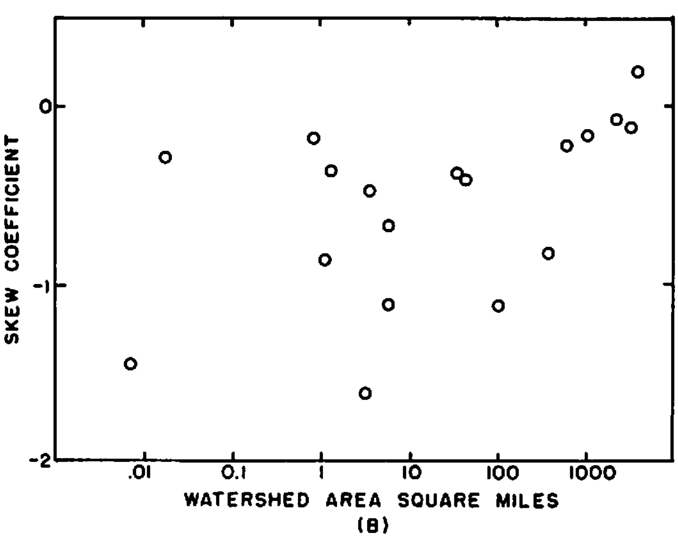


Figure 7. Variations in Coordinate Shift A and Skew Coefficient with Watershed Area.

The highest flood in the 65 years of record is 23700 cfs (in 1978), and a recurrence interval of 109 years is attributed to this Rank 1 flood by the Cunnane plotting position formula. Although the true value of Q_{100} for this watershed is unknown, there is consistency among the estimates in Table 2 and the highest recorded flood.

TABLE 2. Santa Cruz River (comparison of LB and LP3 estimates of floods, units-cfs).

Distribution	Recurrence Interval		
	2 Years	10 Years	100 Years
Log-Boughton	5450	12000	20200
Log-Pearson Type 3	5280	12200	23500

This consistency is not common, as shown in Table 3 where estimates of Q_{100} by the log-Boughton distribution (using Equations (6) and (8)) and by the log-Pearson type 3 distribution, are compared with the highest recorded flood magnitude in each data set. For the nine smallest watersheds, the log-Pearson Type 3 estimates of Q_{100} were made using the mean, standard deviation, and coefficient of skewness of the base 10 logarithms with frequency factors interpolated from the tabulated values given by the Water Resources Council (1976). For the nine largest watersheds, the estimates of Q_{100} were taken from the published values of the U.S. Geological Survey (Anderson and White, 1979).

Columns (1), (2), and (3) of Table 3 show significant differences between the LP3, LB, and Q_{100} ENV estimates of Q_{100}, and some instances where the maximum recorded flood in records of about 25 years in length (Column 4) exceeds both estimates of Q_{100}. For example, watersheds 63.011 and 63.008 in the Walnut Gulch experimental area have records only 16 years in length, and in both instances, the maximum recorded flood exceeds the estimates of Q_{100}. In the case of watershed 63.011, the maximum recorded flood is 77 percent higher than the estimate of Q_{100} by the log-Pearson Type 3 distribution.

The true value of Q_{100} cannot be determined with any certainty, and there is value in comparing the estimate of Q_{100} on one watershed with estimates from other watersheds in the same region. Such comparisons are useful as regional flood frequency studies for estimating Q_{100} on ungaged watersheds. Figure 8 shows the log-Boughton estimates of Q_{100} from Table 3, plotted as open circles, compared with three previous studies of regional flood frequencies in southern Arizona.

Osborn and Laursen (1973) combined some earlier results from Grove (1962) and Lewis (1963) with a detailed analysis of flood frequencies on two watersheds at Walnut Gulch to study how flood magnitude increased with watershed area and recurrence interval in southeastern Arizona. These results have been redrawn to produce the line marked by their names on Figure 8.

Roeske (1978), of the U.S. Geological Survey, prepared a method for estimating regional flood frequencies in six flood frequency regions of Arizona. Roeske's region No. 5 covers

TABLE 3. Estimates of Q_{100} Compared with Largest Recorded Flood in Each Data Set.

	(1)	(2)	(3)	(4)	(5)
	Estimates of Q_{100}			Largest Flood in Record	
Watershed	by LP3 (cfs)	by LB (cfs)	Q_{100} ENV by Equation (13) (cfs)	(cfs)	Estimated T* (yrs)
1. WG 63.112	21	24	25	16	30
2. WG 63.104	80	56	63	45	29
3. Safford WS1	814	592	1880	437	50
4. Safford WS5	763	877	2400	675	48
5. Cemetery Wash	920	800	2660	600	22
6. WG 63.011	2480	3900	4910	4388	30
7. WG 63.003	2460	2100	5200	1376	38
8. Rodeo Wash	1370	1170	7270	898	17
9. WG 63.008	3140	3910	7320	4061	30
10. Sabino Creek	9560	11200	19300	7730	77
11. Tanque Verde	6080	7000	21200	4100	32
12. Willow Creek	6250	4370	30900	3710	38
13. Eagle-D Circle	24800	19200	49500	13600	40
14. Eagle-Above PP	30100	39800	57100	21000	53
15. San Carlos	53000	58300	65300	40600	77
15. Santa Cruz	23500	20200	77100	23700	109
17. Gila – Virden	26900	29400	82200	41700	83
18. Gila – Clifton	30600	26400	85300	33000	91

*Return period estimates from Cunnane plotting position formula.

NOTE: LP3 = log Pearson Type 3 distribution; LB = log-Boughton distribution.

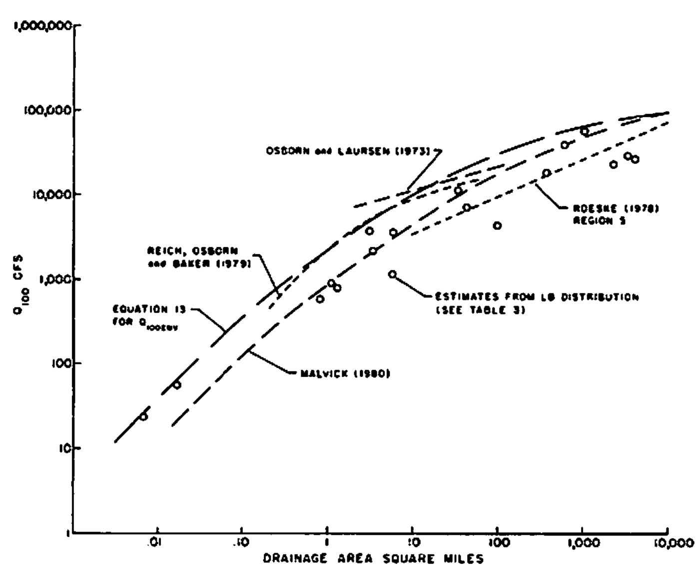


Figure 8. Regional Flood Frequency Relationships for Q_{100} in Southeastern Arizona.

southeastern Arizona and encompasses most of the watersheds used in this study. Roeske's equation for Q_{100} in region No. 5 ($Q_{100} = 1230\ M^{0.447}$) is drawn on Figure 8 and is marked by his name. In general, this equation is significantly lower than many of the estimated Q_{100} data points plotted on the figure.

Reich, Osborn, and Baker (1979) made an independent evaluation of Roeske's estimates for Q_{100} for watershed areas in the range from 1 to 60 mi^2 in region No. 5 using data from two small groups of experimental watersheds. The study suggested that Roeske's equation could underestimate Q_{100} to a significant extent. These authors produced the following relationship between Q_{100} and watershed area based on a detailed study of flood data from 10 watersheds in the Walnut Gulch experimental area:

$$Q_{100} = 2360\, D_a^{(0.688 - 0.128 \log D_a)} \tag{9}$$

This relationship is plotted on Figure 8 and is marked as Reich, Osborn, and Baker (1979).

Malvick (1980) analyzed 3604 station years of data from 151 gaged sites throughout Arizona to produce a set of regional flood frequency curves for a range of watershed size from 0.01 to 100000 mi^2. Malvick's equation for Q_{100} is:

$$Q_{100} = 826\, D_a^{(0.789 - 0.067 \log D_a)} \tag{10}$$

Malvick's equation for Q_{100} is lower than the results of Osborn and Laursen (1973) and of Reich, *et al.* (1979), and is lower than some of the estimates of Q_{100} from this study; however, the shape of the curve plotted from Malvick's equation is close to an envelope over the estimates of Q_{100} plotted as data points in Figure 8. By shifting Malvick's curve sideways from right to left about one-half of a log-cycle, an envelope curve is produced which encompasses much of the earlier results in the following ways:

(1) it matches very closely the envelope curve of Reich, *et al.* (1979) for Q_{100};

(2) it matches closely with the earlier result of Osborn and Laursen (1973) for Q_{100};

(3) it follows the overall pattern of Malvick's results; and

(4) it provides an envelope curve for the estimates of Q_{100} produced in this study.

Malvick's equation is of the form:

$$\log Q_{100} = \log C_1 + C_2 \log D_a + C_3 \log^2 D_a \tag{11}$$

or

$$Q_{100} = C_1 D_a^{(C_2 + C_3 \log D_a)} \tag{12}$$

The constants are determined by choosing three points to lie on the envelope, e.g.:

D_a (mi^2)	$Q_{100\,ENV}$ (cfs)
0.01	35
1	2200
1000	65000

From these values, the constants are evaluated to give the following relationship:

$$Q_{100\,ENV} = 2200\, D_a^{(0.736 - 0.082 \log D_a)} \tag{13}$$

This equation is shown plotted on Figure 8, and the estimated $Q_{100\,ENV}$ for watershed areas corresponding to each of the watersheds used in the study are tabulated in Column (3) of Table 3.

DISCUSSION

The envelope curve defined by Equation (13) gives a maximum estimate of Q_{100} for a given size of watershed and, by definition, most of the estimates of Q_{100} determined by analysis of recorded data will be lower. In addition, Equation (13) takes account only of drainage area and makes no allowance for differences in flood-producing precipitation in different areas or differences in storage effects between watersheds of the same size, or for differences in land use which can affect flood magnitude.

However, the envelope curve summarizes a great deal of data and results of analysis from many watersheds in southeastern Arizona, and is valuable as a guide for making a conservative estimate of Q_{100} on ungaged watersheds in this region.

The results also indicate some of the relative flood characteristics of the watersheds used in the study. Rodeo Wash, an urbanized watershed in the City of Tucson, is almost the same size as rural watershed No. 63.008 at Walnut Gulch (5.92 mi^2 vs. 5.98 mi^2). However, the estimates of Q_{100} on the rural watershed, using the LP3 and LB distributions (see Table 3), are almost three times the estimates of Q_{100} on the urban watershed. This is contrary to the expectation that urban land use will result in higher flood magnitudes than rural land use where watersheds of the same size in the same region are compared. Some of the difference is undoubtedly associated with topographic differences (the Walnut Gulch watershed has steeper slopes) and the annual precipitation is slightly more (14 inch versus 11 inch) for the Walnut Gulch watershed. However, if this anomaly results from shortness of the streamflow records, i.e., sampling variation, then it gives extra importance to generalized results using a relationship such as that in Equation (13).

Another watershed where comment is warranted is the Santa Cruz. Table 2 shows uncommonly good agreement among the LP3 and LB estimates of Q_{100} and the maximum recorded flood of 23700 cfs. However, these values are only about one-third of the estimated $Q_{100\,ENV}$ of 77000 cfs from Equation (13) for a watershed of this size (2220 mi^2). After this paper was prepared and submitted for publication, a flood of 52000 cfs occurred in the Santa Cruz at Tucson (on October 2, 1983).

Table 4 summarizes the ratios of Q_{100} estimated from frequency analysis of recorded floods to $Q_{100\,ENV}$ estimated from Equation (13) for the 18 watersheds used in the study. The ratios range from 0.96 for watershed 63.112 at Walnut Gulch to 0.14 for Willow Creek. If the variations in relative flood characteristics are due mainly to sampling variability in short records, then Equation (13) is of more value than actual records in estimating Q_{100} for practical design purposes. Alternatively, if the variations in relative flood characteristics are due to differences in climate and topography, then the results in Table 4 will be of value in identifying the important factors. At present, there is no way of clarifying the source of the variation.

SUMMARY

A study of flood frequency data from 18 gaged watersheds, 0.01 to 4000 mi^2 in area in southeastern Arizona, showed an average relationship between frequency factor and the $\ln\ln(T/(T-1))$ function of recurrence interval, which closely resembles the relationship for Australian data on which the log-Boughton distribution was originally based. Recently developed fitting techniques allow this distribution to overcome some peculiar fittings produced by one or more very low flood values, and it is then shown that there is a systematic increase in the shape parameter (i.e., the coordinate shift A) with increase in watershed area in the study region.

Using estimates of Q_{100} produced from the above studies and results from earlier regional flood frequency studies, a generalized envelope for Q_{100} for watersheds 0.01 to 4000 mi^2 in area has been produced for southeastern Arizona. The generalized envelope allows comparisons to be made among the relative flood characteristics of the watersheds used in the study and provides a conservative estimate of Q_{100} for ungaged watersheds in the region.

TABLE 4. Relative Flood Characteristics of Watersheds Used in the Study.

Watershed	Ratio $\frac{Q_{100} \text{ from LB}}{Q_{100} \text{ from Eq. 13}}$	Relative Flood Grouping
Walnut Gulch 63.112	0.96	High
San Carlos River	0.89	
Walnut Gulch 63.104	0.89	
Walnut Gulch 63.011	0.79	
Eagle Creek Above PP	0.70	Medium
Sabino Creek	0.58	
Walnut Gulch 63.008	0.53	
Walnut Gulch 63.003	0.40	Low
Eagle Creek – D Circle	0.39	
Safford WS5	0.36	
Gila River – Virden	0.36	
Tanque Verde Creek	0.33	
Gila River – Clifton	0.31	
Safford WS1	0.31	
Santa Cruz River	0.31	
Cemetery Wash	0.30	
Rodeo Wash	0.16	Very Low
Willow Creek	0.14	

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