ABSTRACT

Title of Document: A NEW APPROCH TO EVALUATING THE EFFECT OF WATERSHED STORAGE ON FLOOD SKEW

Daniel Habete, Masters of Science, 2010

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Estimates of flood skew are inaccurate and the inaccuracy influences flood discharge estimates using the log Pearson Type III distribution. The skew map is commonly used despite the fact that it's inaccurate, lacks a conceptual basis, and does not reflect watershed processes. Attempts at regionalizing station skew using regression analysis have only provided marginal improvements in accuracy, possibly because the predictor variables are not good indicators of the physical characteristics that influence the variation in skewness. Therefore, a new approach is needed to improve skew estimates. This research explored the potential of using a distributed model that includes predictor variables that better represent watershed storage. The results showed that watershed storage is the main factor that affects flood skew, and that increases in watershed storage causes flood skews to be algebraically more negative.

A NEW APPROCH TO EVALUATING THE EFFECT OF WATERSHED STORAGE ON FLOOD SKEW

By

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CHAPTER 1: INTRODUCTION

1.1. PROBLEM STATEMENT

Designing hydrologic structures such as detention basins, levees, dams, storm water management basins, and small water supply reservoirs requires accurate estimates of the magnitude and frequency of the peak flood for a given return period. This is necessary for the structures to perform their intended purpose efficiently. To identify the relationship between magnitude and frequency of floods for rural and unregulated streams the Interagency Advisory Committee on Water Data (IACWD) (1982), known as Bulletin 17B, recommended fitting the logarithms of an annual peak discharge record using the log Pearson Type III distribution. In order to use the log Pearson Type-III distribution, the sample mean, standard deviation, and skew of the annual peak discharge record must be computed using logarithms. The coefficient of skewness is a very sensitive statistic. Errors in estimation can result in either overestimates or underestimates of design peak discharge rates. Inaccuracies of peak discharge estimates can lead to either under sizing, which causes more drainage problems, or over sizing, which unnecessarily increases project costs.

Bulletin 17B (IACWD 1982) includes a nationwide map with contours that represent generalized estimates of the coefficient of skew. The skew map was developed as a part of the report, and the map has been used to estimate the skew coefficient for more than two decades. The skew map provides an estimate of generalized skew for all locations in the United States. It was developed for unregulated watersheds drainage areas less than

3,000 square miles. The map skew value cannot be used if flows are significantly regulated.

Mapping skew suggests that skew only varies with latitude and longitude, but geographic location cannot cause skew; therefore, a more rational assessment of the causes of skew is needed. The cause(s) of variation in skew has been hypothesized but not verified. Because accurate estimates of the skew coefficient are difficult to obtain for stations with short records of peak discharge, Bulletin 17B (IACWD 1982) recommended weighting the data-derived station skew coefficient values with the generalized skew values from the map.

Skew values can be mapped for uniform regions, i.e., regions with similar rainfall and watershed characteristics (Tasker and Stedinger 1986), but mapping may be incorrect where rainfall or watershed characteristics vary. Variation in watershed characteristics, such as mixed land use/storage areas, will likely result in different values of skew even within a small geographic area. Two adjacent watersheds, one forested and the other urbanized, should not be expected to have the same skew coefficient even though they are subject to the same rainfall. As a watershed undergoes land use change, it is widely recognized that the magnitudes of floods will change with time, so changes in the skew should be expected.

It is also important to note that the standard error of the skew map is 0.55, which is just slightly less than the standard error of the mean of the data used to develop the map (McCuen and Smith 2008). This indicates that mapping skew does not lead to significant improvements in estimates of skew, most likely because latitude and longitude do not reflect the primary causes of variation in skew.

When estimating generalized skew coefficients for annual peak discharges for sites within a specific region, Bulletin 17B (IACWD 1982) suggests either to create a skew map or to develop a prediction equation that relates skew coefficients to predictor variables for the region of interest. Predictors that are often used in skew coefficient analyses include topographic and climatic variables such as drainage area, mean annual precipitation, and basin storage. Unfortunately, attempts to develop regression equations have largely been unsuccessful as indicated by the goodness-of-fit statistics. Reasons for the poor correlations include: (1) the predictor variables are not capable of reflecting the full effect of watershed storage; (2) the variables do not vary sufficiently over the region of study; and (3) watershed mean values such as channel slope or roughness do not reflect the effect of the watershed processes.

Other studies (McCuen and Hromadka 1988, McCuen 2001) have shown that the current skew map used to estimate coefficient of skewness is inaccurate. Although watershed storage is a major factor that can affect the skew value, at present neither an accurate empirical formula nor a theoretical relation that can relate watershed storage to flood skew is available. Landwehr et al. (1978) suggested that the concept of watershed skew, which means skew that reflects the watershed processes, as a measure of generalized skew needs to be considered. This is because watershed skew has an underlying rational physical basis that the Bulletin 17B map lacks. Also watershed skew should reflect the skew of rainfall at specific location as well as the effect of watershed process on the runoff. The amount of watershed storage is a function of soil type, land cover, depression storage, and the location of the water table. In urbanized basins, flood skews may show little differences from rainfall skew, but for rural watersheds, flood skew will vary considerably from the rainfall skew. This is due to the fact that rural areas have more watershed storage than urbanized areas. Bulletin 17B suggested that the future work should be toward development of the concept of watershed skew to get national skew map. This is not likely possible. This would be problematic because skew cannot be mapped.

Previous studies have shown that, if design accuracy needs to be improved, our understanding of uncertain variables such as the skew needs to be advanced. In addition, the physical processes that actually affect sample skew coefficients need to be known.

The skew coefficient of a peak discharge record is very sensitive to extreme values; therefore, accurate values are difficult to obtain for stations with short annual maximum discharge records. Before a new map or method for estimating skew can be developed, it is important to identify and understand the factors that can affect a sample skew. The skewness is a function of watershed processes not just climatic variation. Conceptually, runoff is caused by rainfall, and watershed characteristics transform rainfall to runoff. Therefore, the physical processes of a watershed need to be incorporated into skew estimates. At this time, our understanding of skew needs to be advanced and a different approach to computing regional skew should be developed to obtain more accurate values for local flood frequency analyses. Accurate predictions of skew are important because peak discharges estimates are very sensitive to skew, and accurate estimates of skew are needed to provide accurate peak discharge rates.

Flood skew is a central element of making estimates of T-year floods using annual maximum flood records. Station skew is sometimes adjusted using map skew with the thought that the adjusted skew is more accurate than the station skew. However, the map skew is of concern for several reasons. First, the Bulletin 17B map is not accurate, as its mean square error is not much better than the standard error of the station skews used in developing the map. Second, many maps could have been developed from the same data that could have been equally accurate. Third, the use of a map implies that skew is location dependent, rather than being dependent on the watershed processes that influence the magnitudes of floods. A skew value taken from a map implies that skew depends only on latitude and longitude, which would imply that the map skew for a flood series of a highly urban watershed would be essentially the same as the skew for a nearby forested watershed.

As an alternative to map skew, the regional influence on the skew could be assessed using a regression analysis of regional station skews on watershed characteristics; however, the specific characteristics to use are not known. More importantly, the predictor variables ultimately used in the regression equation should help to physically understand the hydrologic processes that are important in transforming rainfall into runoff and the statistical distribution of precipitation into the statistical distribution of runoff. While past attempts at regionalizing station skews using regression analysis have provided an improved level of accuracy relative to the map, they have not been assessed to identify the physical characteristics that influence the variation in flood exceedance probabilities, i.e., the skewness.

1.2. RESEARCH GOAL AND OBJECTIVES

The hypothesis about which this research centered is that watershed and channel storages along with rainfall are the physical processes that influence the skew of an annual maximum flood series. The distribution of rainfall at any one location has a skew coefficient that is a reflection of the intensity-duration-frequency characteristics of the location. Watershed processes modify the rainfall distribution, with the change in timing, peak magnitudes, and volumes the obvious characteristics modified. The inability of regression analysis to provide highly accurate estimates of runoff skew likely results from the inability of currently computed, single-valued storage related predictor variables to reflect the time and spatial variation of storage. Variables such as the percentage of forest cover or the average watershed curve number appear not to be good predictors because of their inability to fully reflect the effect of storage on annual maximum flood peaks.

The goal of this research was to develop a better understanding of the skew coefficient of annual maximum discharges and the factors that influence its variation. To meet this goal the following objectives were studied:

1. To analyze the inaccuracy of estimating skew coefficients using regression equations. To meet this objective the following tasks were studied:
    - Analyze the statistical significance of correlations between station skew coefficients and storage related watershed characteristics;
    - Assess the sensitivity of station skew coefficient to outliers;
    - Perform a regression analyses using skew computed from program PeakFQ; and

- Evaluate the effect of watershed storage in the transformation of rainfall skew to runoff skew.

2. Complete an exploratory study to analyze the effect of watershed storage on runoff skew. To meet this objective the following tasks were undertaken:

    - Study the effect of rainfall skew on flood skew;
    - Develop a watershed model that allow for spatial variation of watershed processes; and
    - Examine the effect of watershed storage on flood skew.

CHAPTER 2: LITRATURE REVIEW

2.1. OVERVIEW OF BULLETIN 17B GUIDELINES

Hydrologic analyses are used to determine the instantaneous flood discharge-frequency relations for a given watershed; Bulletin 17B (IACWD, 1982) is the most widely used procedure for the analysis of flood magnitudes at gauged locations. The guidance recommends the use of the log-Pearson type III distribution to predict a peak discharge for any return period. Predicted peak discharge rates using the recommended method are significantly affected by the skew coefficient. Currently, the skew map is the central tool used to predict a skew coefficient despite the fact that the skew map is known to be inaccurate. Central problems are that the causes of flood skew are not fully understood, and the sample skew coefficient is very sensitive to outliers. The following sections discuss the procedures used to fit flood data to the log-Pearson type III distribution and to assess the effect of outliers.

2.1.1. Fitting log-Pearson III distribution

The estimation of peak discharge rates using a log-Pearson III type distribution requires sample estimates of the first, second, and third moments of the peak discharge record. The procedures suggested by Bulletin 17B use a record of flood magnitude (X) of sample size N. Then the logarithm of each of the X values is computed and denoted as Y. The following equations are used to compute the three log statistics:

$$Y = \log X \qquad (2-1)$$

$$Y^* = \sum_{i=1}^{n} \frac{Y_i}{N} \qquad (2-2)$$

$$SD = \sqrt{\frac{\sum(Y - Y^*)^2}{N-1}} \qquad (2-3)$$

$$G = \frac{N\sum(Y - Y^*)^3}{(N-1)(N-2)SD^3} \qquad (2-4)$$

where Y = logarithm of annual peak flow, N = sample size, Y^* = mean of the logarithms (has same unite as Y), SD = standard deviation of the logarithms (has the same unit as Y), and G= skew coefficient of the logarithms (dimensionless).

2.1.2 Outlier analysis

When estimating peak discharge rates, individual flood events can significantly influence the three moments. The mean, standard deviation, and especially the skew coefficient are very sensitive to extreme events. The focus of this section is on the analysis of the effect of outliers on the coefficient of skew. The outliers can be high or low, and for each outlier two different procedures are presented in Bulletin 17B. Low outliers are low peak discharge rates that are proven to significantly differ from the remaining peak discharges. High outliers are high peak discharge rates in which the values are significantly larger than the other events. Outliers can significantly affect a sample skew coefficient; therefore, a careful analysis is required to identify the outliers.

Bulletin 17B suggests the first step is to calculate the station skew based on the annual flood record using Equation 2-4. If the calculated station skew is greater than +0.4, then the high outlier test should be applied first. If the station skew is less than -0.4, then a low outlier test should be applied first. Finally, if the station skew is between -0.4 and +0.4, then tests should be made for both low and high outliers. The following equations are recommended by Bulletin 17B for high and low outliers calculations:

$$\mathrm{Y_H} = \mathrm{Y^*} + \mathrm{K_N SD} \qquad (2-5)$$

$$\mathrm{Y_L} = \mathrm{Y^*} - \mathrm{K_N SD} \qquad (2-6)$$

where $\mathrm{Y_H}$ = high outliers threshold in logarthmic unit, $\mathrm{Y_L}$=low outlier threshold in logarithmic units, $\mathrm{Y^*}$ = mean logarthmic peak, SD = standard deviation , and $\mathrm{K_N}$ = LP3 deviate (see Appendix C).

2.2. MEAN SQUARE ERROR (MSEs)

Bulletin 17B provides an equation to compute the mean square error for the station skew value. The MSE is a measure of the error variation in sample skews. The MSE is a measure of accuracy and can serve as a measure of the effect of outliers. For example, assume a set of annual maximum peak discharge rate is used to calculate the station skew using Eq. 2-4. Then outliers can be identified using the methods described in section 2.1.2. Then the outliers are removed and the station skew is recomputed using the Eq. 2-4. After calculating the station skew with and without outliers, the next step is to calculate the mean square error for both skews.

$$MSE = 10^{\left[A-B\left[Log\left(\frac{N}{10}\right)\right]\right]} \qquad (2-7)$$

where A = -0.33 + 0.08|G| if |G| ≤ 0.90

= -0.52 + 0.30|G| if |G| > 0.90

B = 0.94 – 0.26 |G| if |G| ≤ 1.50

= 0.55 if |G| > 1.50

where $|G|$ is the absolute value of the station skew calculated using Eq. 2-4, and N is the record length.

2.3. SKEW MAP, RAINFALL SKEW, AND FLOOD SKEW

Watershed change can affect the magnitude of the annual peak discharges. These changes could be due to urbanization, which decreases watershed storage, or afforestation, which increases watershed storage. Any change in the watershed that affects the watershed storage could potentially affect the accuracy of a flood-frequency analysis. The coefficient of skew is the most sensitive parameter used in a flood-frequency analysis. Its value is usually obtained from the Bulletin 17B skew map. McCuen and Smith (2008) showed that the skew map is inaccurate because the map value only varies with latitude and longitude and does not take into account the physical processes of the watershed. For small, uniform watersheds skew map showed some success, but the map cannot be accurate, if used for larger regions where watershed characteristics vary. McCuen and Smith (2008) concluded that skew map reflect the statistics of precipitation, not runoff. In order to improve the accuracy of estimates of peak discharges using the log Pearson type III distribution, runoff skew should be a function of both watershed characteristics and rainfall skew. This is because flood skew could show the effect of watershed processes, especially watershed storage.

The hydrologic processes that take place within the watershed can be thought as a model. Any model should have at least three components, namely an input, a system, and an output. In hydrologic process, watershed can act as a system, rainfall can be an input to the system, and the runoff can be output of the system. The system, which is the watershed characteristics, can greatly influence the characteristics of the output, i.e., the runoff. The major processes in the watershed that could alter the runoff skew from that of the rainfall skew are watershed and channel storage. Therefore, if a regression equation is developed to estimate skew, factors that reflect watershed storage have to be important predictor variables. If the distribution of precipitation is known, this makes estimation of flood skew a derived distribution problem.

McCuen and Smith (2008) also showed that the factors that could affect the accuracy of estimates of skew coefficients from the annual maximum flood series. These factors were the distributions of rainfall, watershed processes, the presence of extreme events, the nonstationarity of watershed processes, and time sampling variations. Therefore, analyses of these factors before developing a skew equation could make a model better and more conceptually sound. The presence of extreme events could distort the sample watershed skew and produce a runoff skew with value larger than the rainfall skew. McCuen and Smith (2008) suggested the effect of outliers needs to be investigated before using the annual peak discharges as a criterion variable in regression analyses.

The 2-yr, 10-yr, and 100-yr rainfall depths can be used to compute rainfall skew. The rainfall depths for any station can be found from NOAA atlas website (NOAA, 2010). Eq. 2-8 was obtained from Bulletin 17B and can be used to estimate rainfall skew:

$$\text{Rainfall skew} = -2.5 + 3.12\left[\frac{\log\left(\frac{P_{100}}{P_{10}}\right)}{\log\left(\frac{P_{10}}{P_2}\right)}\right] \tag{2-8}$$

where P_2 = 2-yr rainfall depth (in.), P_{10} = 10-yr rainfall depth (in.), and P_{100} = 100-yr rainfall depth (in.).

2.4. FLOOD SKEW AND UNGAGED WATERSHED

Currently, estimates of skew are obtained for ungaged watersheds from the Bulletin 17B skew map (IACWD, 1982). This approach can lead to a inaccurate estimate of peak discharges. The standard error of the Bulletin 17B skew map is greater than 0.5 (McCuen and Hromadka 1988). This is very large error that could significantly affect the estimate of skew coefficients, and then peak discharges. Consider two adjacent watershed (with less storage) and watershed (with high storage) if the skew map used to estimate the value of skew coefficients, then the two watersheds would have similar values, because the mapped values only vary with latitude and longitude, they does not reflect the physical process that take place in the watershed. Obviously this approach is wrong, because the two watersheds had difference in watershed storage capacity; therefore, a different value of skew was expected. A watershed with high storage is expected to have a smaller skew value than a watershed with less watershed storage. McCuen and Hromadka (1988) showed that runoff skew obtained from the Rational Method and skew obtained from the map had different values for the same areas. Using the rational method for ungaged watersheds located in Baltimore, Maryland, a runoff skew was computed and found to be 0.3. This was based on varying the intensity obtained from IDF curve. On the other hand, using the Bulletin 17B skew map the skew was 0.7. The same result was obtained for an ungaged watershed located at Tucson, Arizona. Using rational method skew was found to be 0.2, but based on the Bulletin 17B skew map skew value was found to be -0.2. In both cases the differences between skew obtained from the map and from rational methods analyses was 0.4. This is very high and could have a significant change in estimates of peak discharges.

McCuen and Hromadka (1988) showed that it is possible to develop a skew map, but this could be inaccurate because skew are not only a function of latitude and longitude, it significantly affected by watershed processes. For small watersheds, watershed storage can be a dominant variable that controls the volume of the runoff. In order to get accurate estimates of skew, predictor variables that accurately represent the watershed storage have to be incorporated into the model.

CHAPTER 3: INACCURACY OF REGRESSION IN DETERMINING SKEW

Regression analysis is one of the most commonly used statistical tools used to investigate the relationship between dependent (Criterion) and independent (predictor) variables. In this section, correlation and regression analyses are used to show the difficulties in getting accurate estimates of station skew. The first step in the regression analysis was to compute a criterion variable, i.e., skew. Skew was computed from annual peak discharge of 22 stations. The stations are located on the Eastern Coastal Plain of Maryland. The annual peak discharges can be accessed on the USGS stream gage web site. Each of the 22 annual peak discharge records had 10 or more years of record. The characteristics of individual annual peak discharges are not the same for all stations. Some of the gage records had low or/and high outliers, some of them had historic peaks, some of them had peak discharges less than the indicated value which is minimum recordable discharge at the site or greater than the indicated value which is above the recordable discharge for the site, and some of them are affected by regulation or failure of dam. To compute the station skews the following methods were made: (1) Skew calculated using Eq. 2-4, using all the annual peak discharges of each of the 22 stations with no adjustments; (2) skews were computed using the USGS program PeakFQ, which gives two kinds of skew estimates (as explained in section 3.3). The three watershed characteristics (drainage area, percentage of storage, and percentage of forest cover) for the 22 gaging stations were obtained from Dillow (1996). Storage is defined (Dillow, 1996) as the part of a drainage basin that exists as a lake, pond, or swamp; forest is defined as that part of a drainage basin where the land is covered with trees. The watershed characteristics are listed in Table 3-1.

Regression and correlation analyses were performed using an excel 2007 program (Data>>Data analysis >> regression/correlation). The purpose of the analyses was to estimate the regression line of Eq. 3-1:

$$skew = C + b_1x_1 + b_2x_2 + b_3x_3 \qquad (3\text{-}1)$$

where C = constant, x_1= drainage area (sq. mi.), x_2 = storage (%), x_3 = forest cover (%), and the b_j values are regression coefficients.

The ratio of the standard error of estimate and the standard deviation of the 22 skew values (Se/Sy) can be used to assess the accuracy of the regression equations. The standard deviation of the observed skew can be computed using Eq. 2-3. The standard error of estimate can be computed using the following equation:

$$S_e = \sqrt{\frac{\sum e^2}{(n-p-1)}} \qquad (3-2)$$

where e = residual, which is the difference between estimated value and predicted value, n = number of observations, and p = number of predictor variables.

3.1. CORRELATION AND REGRESSION ANALYSES USING ALL RECORDED STATION DATA.

Statistical analyses were performed to identify the significance of correlation between the sample skew and the three watershed characteristics. After assembling the watershed characteristics for the 22 stations, the following steps were performed to analyze the correlation between skew and watershed characteristics:

1. For each of the 22 stations, the skew was computed using Eq. 2-4. (see Table 3-1)
2. The three watershed characteristics for the 22 gages station were collected from the USGS report (Dillow 1996).
3. Correlation analyses were performed on the computed skew and the three watershed characteristics using the excel 2007 program.
4. The correlations between the percentage of forest cover, the percentage of storage, the drainage area, and skew were analyzed.

The results of the correlation analyses are summarized in Table 3-2. The values show that forest had the strongest correlation with skew and the sign is negative. The statistical significance of the correlation coefficients of skew was tested with a one-tailed-test. The one-tailed test is used because either a negative or a positive, but not both, correlation is expected. For n=22, the degrees of freedom is 20; therefore, the critical values for the Pearson correlation coefficient were 0.2841, 0.3599, and 0.5368 for 10%, 5% , and 1%, respectively (Ayyub and McCuen 2003).

TABLE 3-1. Basin characteristics for the selected drainage basins in the Eastern Coastal Plain of Maryland and the computed skews.

Station number	Years of record	Drainage area (sq. mi.)	Storage (%)	Forest cover (%)	Systematic skew	Bulletin 17B skew	skew with outliers	skew without outliers
1485000	58	60.50	15.80	30	0.44	0.94	0.44	0.82
1485500	60	44.90	6.20	85	0.34	0.34	0.22	-0.13
1486000	56	4.80	0.00	57	-0.61	0.09	-0.61	-0.10
1486100	10	4.10	2.90	77	-0.31	0.32	-0.31	-0.31
1489000	42	7.10	0.47	33	-0.19	0.09	-0.22	-0.22
1490000	39	15.00	0.10	50	0.46	0.55	0.49	-0.01
1490800	10	3.90	0.71	29	0.28	0.54	0.28	0.28
1491000	62	113.00	1.91	35	-0.71	-0.04	-0.71	-0.28
1491050	10	3.80	0.07	25	1.91	0.96	1.98	0.18
1492000	32	5.85	0.00	26	0.71	0.71	0.71	0.42
1492050	11	8.40	0.00	23	1.29	0.88	1.28	-0.05
1492500	39	8.09	0.00	32	0.16	0.33	0.16	0.16
1492550	11	4.60	0.34	14	2.25	0.98	2.25	-0.40
1493000	61	22.30	1.54	43	0.01	0.17	-0.01	-0.01
1493500	58	12.70	0.20	8	0.98	0.83	0.90	-0.15
1494000	13	12.50	0.01	24	0.62	0.66	0.62	0.62
1495000	78	52.60	0.05	14	-0.28	0.25	-0.05	0.32
1495500	12	26.80	0.07	23	1.97	0.94	1.61	1.73
1496000	37	24.30	0.09	22	0.38	0.49	0.81	0.38
1496080	10	1.70	0.03	96	-0.45	0.23	-0.01	-0.01
1496200	27	9.03	0.02	17	0.26	0.43	0.18	0.18
1578500	44	193.00	0.00	32	0.68	0.67	0.32	0.32

TABLE 3-2. Correlation matrix of the three watershed characteristics and skew with outliers.

	DA (sq. mi.)	Storage (%)	Forest (%)	Skew
DA	1			
Storage	0.19	1		
Forest	-0.06	0.18	1	
Skew	-0.23	-0.12	-0.47	1

3.1.1. Correlation between forest and skew

As indicated by the negative correlation coefficient, Fig. 3-1 shows that there was a negative relationship between skew and the percentage of forest cover. As the forest cover increases the flood skew would become algebraically more negative.

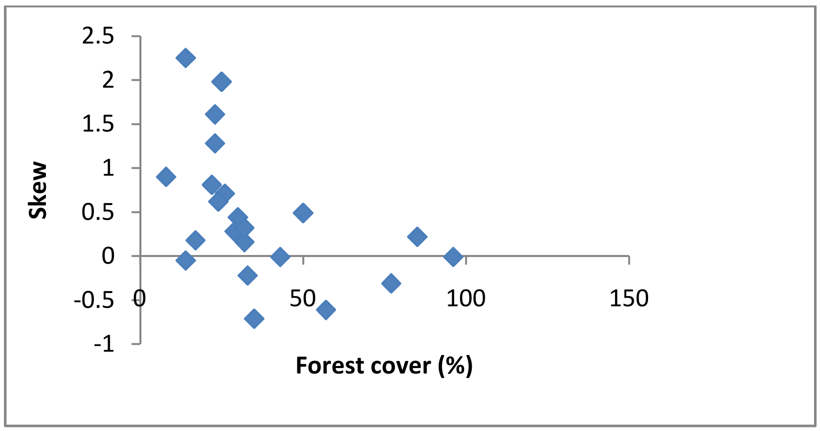


FIGURE 3-1. Plot of station skew with outliers vs. forest cover.

The correlation coefficient for the skew and percentage of forest cover was -0.47. This is statistically significant at the 5% level of significance but not the 1%. The sign of the correlation was negative which is physically rational because the skew was expected to decrease as percentage of forest cover increased. High forest covers represent more storage and the negative correlation coefficient was expected.

3.1.2. Correlation between storage and skew

An inverse relationship between skew and storage is shown in Fig. 3-2. The sign of the correlation coefficient R between skew and percent of storage was negative (R=-0.12). The sign was rational because as the storage increased, the skew would be expected to decrease. Even though the sign was rational, the magnitude of correlation is not statistically significant. The lack of significance likely results from the small range of storage values. Most of storage values are less than 0.5%, which makes it difficult to show the true effect of storage.

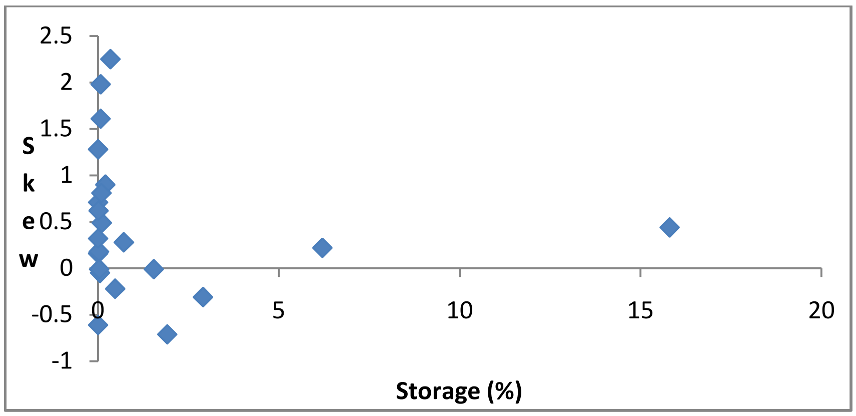


FIGURE 3-2. Plot of station skew with outliers vs. storage.

Given a volume of storage, when a small storm occurs, the storage will control much of the flow. However, for large storms, the storage has little effect. Thus, small amounts of storage dominate the low peaks but not the high peaks, which cause the skew to be algebraically more negative. Therefore, the negative R of -0.124 was expected.

3.1.3. Correlation between drainage area and skew

The drainage areas varied from 1.7 square miles to 193 square miles. These represent a large variation in the drainage areas. Fig. 3-3 shows an inverse relationship between skew and drainage area. In addition, the correlation analysis showed a negative relation between skew and drainage area. Large drainage areas have a more dominant channel system, which potentially may suggest considerable channel storage. More channel storage, especially with a more pronounced and vegetated floodplain, would cause a more negative skew. As such, the computed correlation is rational in sign, but not statistically significant in magnitude. Unlike the percentage of storage, the range of drainage areas is large. In this case, the lack of a significant correlation may indicate that channel storage is not a dominant factor in the controlling the skew of flood series.

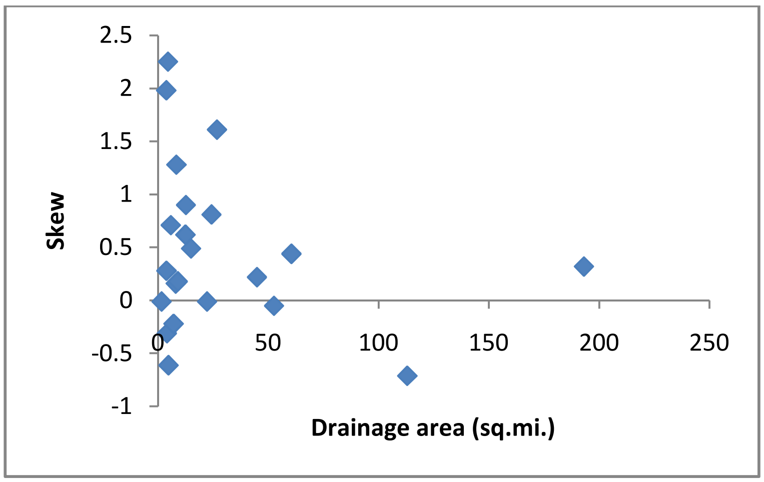


FIGURE 3-3. Plot of station skew with outliers vs. drainage area.

3.2. SENSITVITY OF STATION SKEW TO OUTLIERS

3.2.1. Identifying and analyzing outliers

In order to analyze and identify the sensitivity of a station skew to the presence of extreme events, annual peak discharges of the 22 stations were used. The outlier test was performed on each of the 22 flood records. Individual peak discharges with the following characteristics were not subject to the outlier test: (1) A discharge affected by dam failure, non-recurrent flow anomaly, (2) a discharge greater than the recordable value for the site, (3) a discharge less than the recordable value for the site, (4) peak discharges affected by known effect of regulation or urbanization, and (5) historic peaks. For the identification of outliers the following steps were made:

1. The annual peak discharge record for each station was collected (see appendix A).
2. The skew of each record was calculated using Eq. 2-4.
3. Low and high outliers were identified using Eqs. 2-5 and 2-6.
4. Identified outliers were censored, and the skew of the remaining record was recomputed using Eq. 2-4.
5. The skew of the annual peak discharge record with and without outliers were assessed to show the effect of extreme events.

The sensitivity of a station skew to the characteristics of the data sample, especially the presence of extreme events, was analyzed. Twelve of the 22 stations had either high or/and low outliers that could affect the statistical distributions. The results of the sensitivity analyses are summarized in Table 3-3.

TABLE 3-3. Summary of outlier analyses and change in skews for the 12 stations that had at least one outliers.

Station number	Record length	Skew with outliers	Skew without outliers	Change in skew (with outliers out – with outliers)	Type of outlier	Number of outliers	Years of occurrence
1486000	56	-0.61	-0.10	0.51	Low	1	1981
1490000	39	-0.01	0.49	0.50	High	1	2006
1491000	62	-0.71	-0.28	0.43	Low	1	1966
1495000	78	-0.05	0.32	0.37	Low	1	2002
1495500	12	1.61	1.73	0.12	High	1	1999
1492000	32	0.71	0.42	-0.29	High	1	1960
1485500	60	0.22	-0.13	-0.35	High	1	1989
1485000	58	0.44	0.38	-0.06	Both	2	19,811,989
1493500	58	0.90	-0.15	-1.05	High	2	1972, 1999
1492050	11	1.28	-0.05	-1.33	High	1	1975
1491050	10	1.98	0.18	-1.80	High	1	1967
1492550	11	2.25	-0.40	-2.65	High	1	1967

The changes in skew ranged from -0.51 to 2.65 as shown in Table 3-3. This indicates that a station skew is very sensitive to extreme events. For example, station number 1492550 included one outlier among 11 years of record data. When the outlier was censored, the skew changed from 2.25 to -0.40. This change would have a large effect on a frequency curve and on estimates of peak discharge rates. Station number 1491050 produced a similar result; one outlier was identified in the 10 years of record. The skew value for this station changed from 1.98 to 0.18. Again, the change in skew would greatly influence the shape of the flood frequency curve.

3.2.2. Effect of outliers on regression

To analyze the effect of outliers on a regression for predicting skew, the skew values were regressed on the three watershed characteristics. Separate analyses were made for the skews based on the flood records with and without outliers. The watershed characteristics and the skew values with and without outliers are shown in Table 3-1. For these analyses the numbers of observations were 22, with the same three predictor variables. Skew with and without outliers regressed on the three watershed characteristics with the following results:

$$skew = -0.0044DA + 0.0035ST - 0.0160FT + 1.1711 \tag{3-3}$$

$$skew^{*} = 0.0004DA + 0.0271ST - 0.0072FT + 0.4004 \tag{3-4}$$

where $skew$ =skew with outliers, $skew^{*}$=skew without outliers.

TABLE 3-4. The result of regression statistics analyses using the three watershed characteristics as predictor variable and the skew with and without outliers as a criterion variable.

Regression Statistics	with outliers	without outliers
Multiple R	0.53	0.38
R squared	0.28	0.14
Standard error (Se)	0.70	0.48
Standard deviation (Sy)	0.77	0.48
Se/Sy	0.91	1.00
$\sum e^2$	8.92	4.21
Predictor variables	3	3
Observations	22	22

The goodness-of-fit statistics of the regression analyses with and without outliers are given in Table 3-4. The results of the regression analysis without outliers resulted in poorer accuracy compared to the results of the analysis with outliers. Removing the outliers caused the R squared to decrease by 0.14 (50% reduction). The lower R results from the removal of outliers that reduced the variation in the skew value. Removing outliers decreases the accuracy of the predicting equation as evident from the increase in Se/Sy. Removing the outliers changed the Se/Sy from 0.91 to 1.00. The Se/Sy of 0.91 indicates there was no relation between sample skew and the watershed characteristics. Removing the outliers made predictions even less accurate.

3.2.3. Effect of outliers on mean square error of the station skew

The accuracy of a station skew can be assessed using the mean square error. A small change of skew can significantly affect the mean square error (MSE) of station skew. In the previous section, outliers were identified in 12 of the 22 stations. For the 22 stations the MSEs were computed using Eq. 2-7. The results of the analyses are summarized in Table 3-5. For a station that had no outliers identified, MSEs would not change. The results of the analyses show that the low and the high extreme events significantly affected the mean square error of the station skews. Table 3-5 shows that extreme events significantly affected the MSEs. For example, for station number 1492550, the removal of the outliers decreased the MSE by 0.852. This indicates outliers have to be identified and proper treatment has to be taken.

TABLE 3-5. Results of the mean square error analysis for the twenty two stations.

Station number	Years of record with outlier	Years of record without outlier	Skew with outliers	Skew with outliers	MSE with outliers	MSE without outliers	change in MSE (with - without outliers)
1485000	58	57	0.44	0.05	0.1188	0.1555	-0.037
1485500	60	59	0.22	-0.13	0.1001	0.0959	0.004
1486000	56	55	-0.61	-0.10	0.1362	0.1003	0.036
1486100	10	10	-0.31	-0.31	0.4952	0.4952	0.000
1489000	42	42	-0.22	-0.22	0.1372	0.1372	0.000
1490000	39	38	0.49	-0.01	0.1694	0.1341	0.035
1490800	10	10	0.28	0.28	0.4925	0.4925	0.000
1491000	62	61	-0.71	-0.28	0.1343	0.1027	0.032
1491050	10	9	1.98	0.18	1.1858	0.5312	0.655
1492000	32	31	0.71	0.42	0.2214	0.1974	0.024
1492050	11	10	1.28	-0.05	0.6900	0.4721	0.218
1492500	39	39	0.16	0.16	0.1418	0.1418	0.000
1492550	11	10	2.25	-0.40	1.3559	0.5035	0.852
1493000	61	61	-0.01	-0.01	0.0860	0.0860	0.000
1493500	58	56	0.90	-0.15	0.1596	0.1018	0.058
1494000	13	13	0.62	0.62	0.4275	0.4274	0.000
1495000	78	76	-0.05	0.32	0.0703	0.0873	-0.017
1495500	12	11	1.61	1.73	0.8307	0.9467	-0.116
1496000	37	37	0.81	0.38	0.2091	0.2091	0.000
1496080	10	10	-0.01	-0.01	0.4686	0.4686	0.000
1496200	27	27	0.18	0.18	0.1991	0.1991	0.000
1578500	44	44	0.32	0.32	0.1394	0.1394	0.000

3.3. REGRESSION ANALYSES USING SKEW FROM PROGRAM PEAKFQ

Program PeakFQ was used to perform statistical flood-frequency analyses of the annual peak discharges. The program was developed based on the procedures recommended in

Bulletin 17B and is distributed by USGS. Two values of skew are computed using this program. The first one is computed from systematic record (explained below), referred to hereafter as systematic skew, and the second skew is computed from the systematic record with adjustments of low, high, historic peaks, and generalized skew based on Bulletin 17B procedures, referred to hereafter as Bulletin 17B skew.

3.3.1. Regression analyses of the systematic records

Systematic records are records of annual peak discharges obtained from a continues trace of river stage or from periodic observations (IACWD, 1982). A systematic-record analysis is the first step in estimating the statistical parameters that are used in fitting a frequency curve. Annual peak discharges that are identified as outliers are included in the systematic analysis. Annual peak discharges with the following characteristics are not included in the systematic analysis: (1) Peak discharges affected by dam failure, non-recurrent flow anomaly, (2) discharges greater than the maximum recordable value at the site, (3) discharges less than the minimum recordable value at the site, (4) peak discharges affected by regulation or urbanization, and (5) historic peaks.

The systematic skew (criterion variable) was regressed on the three watershed characters parameters (predictor variables) with the following result:

$$skew = -0.0029DA + \ 0.0051ST - 0.0176FT + \ 1.18 \tag{3-5}$$

where skew = skew computed from systematic data, DA= drainage area (sq. mi.), ST = storage (%), and FT = forest cover (%).

Eq. 3-5 suggests that the rate of change of skew with drainage area DA is -0.0029, with the percentage of storage ST is 0.0051, and with percentage of forest cover FT is -0.0176. The standard error for Eq. 3-5 is 0.76 (see Table 3-6). The R squared value of 0.26 was small, but it is statistically significant at the rejection probability of 1%.

Se/Sy is a good indicator for the accuracy of regression equation. Generally speaking, a value of Se/Sy less than 0.3 is very good, values between 0.3 and 0.5 are good, values between 0.5 and 0.7 are fair but if the value greater than 0.7 it is not very good , which means there is no relation between criterion and predictor variables. As shown in Table 3-6 the Se/Sy was found to be 0.93. Based on the criteria described above, Eq. 3-5 was not accurate to use it in predicting skew for this region.

TABLE 3-6. Summary outputs of regression analysis using the three watershed characteristics as predictor variables and the systematic skew as criterion variable.

Regression Statistics	
Multiple R	0.51
R squared	0.26
Se	0.76
Sy	0.82
Se/Sy	0.93
Σe^2	10.41
predictor variables	3
Observations	22

3.3.2. Regression analysis using Bulletin 17B skews as criterion variables.

The Bulletin 17B skew estimate is the same as the systematic skew analysis but with the adjustments of low outliers, high outliers, historic peaks, and generalized skew based on the Bulletin 17B procedures. The computed Bulletin 17B skews are listed in Table 3-1. Using Bulletin 17B skew as the criterion variable and the three watershed characteristics (Table 3-1) as predictor variables, regression analyses was performed and the following equation was developed:

$$skew = -0.0011\,DA + 0.0249\,ST - 0.0074\,FT + 0.7787 \tag{3-6}$$

Eq. 3-6 suggests that the rate of change of skew with drainage area DA is -0.0011, with the percentage of storage ST is 0.0249, and with the percentage of forest cover FT is -0.0074. The Se/Sy is 0.9. This indicated that Eq. 3-6 is not sufficiently accurate to use in predicting skew. The R squared value of 0.31 was not good but it is statistically significant. The results of the regression analyzes are summarized in Table 3-7.

The correlation matrix (see Table 3-2) showed that percentage of storage had a negative correlation coefficient. However, all the regression equations had a positive coefficient for storage, but a negative value would be expected. This discrepancy could be due to the inter correlation effect

TABLE 3-7. Summary of regression analysis using the three watershed characteristics as a predictor variables and the Bulletin 17B skew as a criterion variable.

Regression Statistics	
Multiple R	0.56
R squared	0.31
Se	0.29
Sy	0.32
Se/Sy	0.90
Σe^2	1.48
Predictor variables	3
Observations	22

3.4. EFFECT OF WATERSHED STORAGE IN THE TRANSFORMATION OF RUNOFF SKEW TO RAINFALL SKEW

Runoff is the result of rainfall and the hydrologic processes within a watershed. For a steep, impervious surface, the time distribution of runoff should have characteristics similar to those of the rainfall. Specifically, similar variations in magnitude. Additionally, the time difference between the rainfall and runoff peaks should be short. Therefore, the skew of the distribution of peak discharge should be similar to the skew of the peak rainfall distribution. For low sloped, pervious surfaces, the physical processes significantly change the magnitude and timing of the runoff such that statistical characteristics of the runoff differ from those of the rainfall. Thus, a change in skew is not unexpected. Sampling variation is another significant factor that governs values of sample skew.

3.4.1. Hypothetical data analyses and discussion of results

Two hypothetical data sets were created and analyzed, one with negative rainfall skew and the second one with positive rainfall skew. These were performed to see how a homogeneous watershed would react if only the storage variable varied. The curve numbers (CN) were used to represent the watershed storages with storage decreasing as CN increased. The curve numbers used for the analyses were 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, and 98. The following procedure was used for the analyses:

1. Generate two sets of rainfall depths such that the logarithms of set #1 has a negative skew (-0.49) and the logarithms of set #2 has a positive skew (0.22). The skews were computed with Eq. 2-8.
2. Using 1 of 11 CNs, the NRCS rainfall-runoff equation was used with each of the 27 rainfalls to compute a runoff depth. The logarithms of the 27 runoff depths were computed and the skew of the logarithms was then computed for that CN. For example, when the CN of 50 is used, the runoff skew is -1.12 for rainfall set #1 (see Table 3-9) and -0.60 for rainfall set #2 (see Table 3-10).
3. Step 2 is repeated for each of the other 10 CNs, with the resulting runoff skews shown in Tables 3-9 and 3-10.

TABLE 3-8. Twenty-seven rainfalls that produce negative skew (set #1) and 27 rainfalls that produce positive skew (set #2).

Set #1 Rainfall (in.)		Set # 2 Rainfall (in.)	
2.50	6.75	2.50	6.75
5.50	4.00	5.50	4.00
8.50	7.00	13.00	7.00
2.75	4.25	2.75	4.25
5.75	7.25	5.75	8.00
8.75	4.50	14.00	4.50
3.00	7.50	3.00	9.00
6.00	4.75	6.00	4.75
9.00	7.75	15.00	10.00
3.25	5.00	3.25	5.00
6.25	8.00	6.25	11.00
3.50	5.25	3.50	5.25
6.50	8.25	6.50	12.00
3.75		3.75	

For the first set of the hypothetical rainfall depths with negative skew (see Table 3-8), the logarithmic mean, standard deviation, and skew were calculated and found to be 0.73, 0.16, and -0.49, respectively. As expected, the runoff skew of -0.51 for curve number of 98 is almost identical to the rainfall skew of -0.49, as there was little storage, i.e., high curve number. As the curve number decreased, the storage increased, and the runoff skew became algebraically more negative. So, it is important to note that the runoff skew was always algebraically more negative than rainfall skew. This result may not happen with actual data, but only because sampling variation can distort sample statistics, especially with small samples.

TABLE 3-9. Runoff characteristics based on analyses using negative rainfall skew.

Curve number	log mean	log sd	log skew
50	-0.15	0.56	-1.12
55	0.02	0.45	-0.92
60	0.15	0.39	-0.82
65	0.25	0.34	-0.76
70	0.34	0.31	-0.72
75	0.42	0.28	-0.68
80	0.5	0.25	-0.65
85	0.56	0.23	-0.62
90	0.62	0.21	-0.59
95	0.68	0.19	-0.54
98	0.71	0.17	-0.51

For the second set of rainfall depths (see Table 3-8), the rainfall skew was positive. The rainfall depths ranged from 2.5 inches to 15 inches. The logarithmic mean, standard deviation, and rainfall skew were computed as 0 .77, 0.22, and 0.22, respectively. The runoff depths were computed using the NRCS rainfall-runoff relationship. The runoff skews were computed using Eq. 2-4. The results of the analyses are summarized in Table 3-10.

TABLE 3-10. Runoff characteristics based on analyses using positive rainfall skew.

Curve number	log mean	Log sd	log skew
50	-0.07	0.65	-0.60
55	0.09	0.54	-0.38
60	0.22	0.47	-0.26
65	0.32	0.42	-0.18
70	0.41	0.38	-0.12
75	0.48	0.35	-0.07
80	0.55	0.32	-0.02
85	0.61	0.29	0.02
90	0.67	0.27	0.08
95	0.72	0.25	0.14
98	0.75	0.23	0.18

The runoff skew value became closer and closer to the rainfall skew as the curve number increased. For curve number 98 the runoff skew was 0.18 which was just slightly less than the rainfall skew of 0.22. From the analyses it was understood that watershed storage could be the primary physical process that controls the skewness of the runoff.

3.4.2. Effects of variations within peak discharges on station skew

3.4.2.1. Correlation analyses

The correlation and regression analyses of the measured data from the Eastern Coastal Plain of Maryland did not result in firm conclusions, as sampling variation distorts small sample. As discussed in the previous sections, the correlation coefficients between station skew and the three watershed characteristics were low. The results of the regression analyses showed that the R squared values are very small and the standard errors and Se/Sy values were high. The results suggest that acceptable accuracy was not achieved using regression analysis. One reason for the inaccurate skews could be the fact that annual peak discharge data are quite varied. Twelve of the 22 stations had outliers. Therefore, to examine the effect of variation within individual annual peak discharge records on station skew, the following steps were performed:

1. For each of the 22 stations, the annual peak discharges were sorted from the smallest (X_1) to the largest (X_n) values.
2. Two indices (high and low indices) were computed using Eqs. 3-7 and 3-8; the results are shown in Table 3-11 (see appendix 1 for the annual peak discharge records used for these analyses):

$$\mathrm{R_L} = \frac{\mathrm{X_1} - \mathrm{X_2}}{\mathrm{X_1} - \mathrm{X_n}} \qquad (3-7)$$

$$R_S = \frac{X_{n-1} - X_n}{X_1 - X_n} \qquad (3-8)$$

in which $\mathrm{R_L}$ = low event index, $\mathrm{R_S}$ = high event index, $\mathrm{X_1}$ = largest flood of record, $\mathrm{X_2}$ = second largest flood of record, $\mathrm{X_{n-1}}$ = next to smallest flood of record, and $\mathrm{X_n}$ = smallest flood of record. These indices are created to assess the importance of the extreme events in a flood series.

3. For each station compute the skew using Eq. 2-4.

4. To assess the effect of extreme events, both high and low values, the two indices were created and included as predictor variables with the three watershed characteristics (DA, ST, and FT) and regression analyses were made.

TABLE 3-11. Watershed characteristics including the high and low event indices and flood skew with outliers.

Station Number	Year of Record	R_L	R_S	Drainage Area (sq. mi.)	Storage (%)	Forest cover (%)	Skew with outlier
1485000	58	0.32	0.08	60.50	15.80	30	0.44
1485500	60	0.43	0.01	44.90	6.20	85	0.22
1486000	56	0.35	0.05	4.80	0.00	57	-0.61
1486100	10	0.24	0.11	4.10	2.90	77	-0.31
1489000	42	0.24	0.01	7.10	0.47	33	-0.22
1490000	39	0.44	0.00	15.00	0.10	50	0.49
1490800	10	0.55	0.05	3.90	0.71	29	0.28
1491000	62	0.08	0.03	113.00	1.91	35	-0.71
1491050	10	0.87	0.01	3.80	0.07	25	1.98
1492000	32	0.54	0.02	5.85	0.00	26	0.71
1492050	11	0.72	0.03	8.40	0.00	23	1.28
1492500	39	0.21	0.01	8.09	0.00	32	0.16
1492550	11	0.91	0.01	4.60	0.34	14	2.25
1493000	61	0.57	0.01	22.30	1.54	43	-0.01
1493500	58	0.33	0.00	12.70	0.20	8	0.90
1494000	13	0.18	0.02	12.50	0.01	24	0.62
1495000	78	0.42	0.03	52.60	0.05	14	-0.05
1495500	12	0.44	0.02	26.80	0.07	23	1.61
1496000	37	0.51	0.02	24.30	0.09	22	0.81
1496080	10	0.15	0.04	1.70	0.03	96	-0.01
1496200	27	0.41	0.02	9.03	0.02	17	0.18
1578500	44	0.42	0.01	193.00	0.00	32	0.32

The two indices were computed and included with the other three variables in regression analyses to predict skew. The results of a correlation analysis are shown in Table 3-12. The results showed that R_L was the dominant variable with a correlation coefficient of 0.76. The sample skew was highly correlated with R_L more than any of the watershed characteristics. Most importantly, these analyses indicated that the individual peak discharges within a sample are very influential, possible even more than the watershed characteristics. Therefore, good correlation between station skew and watershed characteristics may be difficult to achieve with measured flood series, especially small samples.

TABLE 3-12. Correlation matrix using the skew with outlier as criterion variable and the three watershed characteristics including the two event indices as predictor variables.

	RL	Rs	Drainage area (sq.mi.)	Storage (%)	Forest cover (%)	skew
RL	1					
RS	-0.27	1				
Drainage area	-0.20	-0.07	1			
Storage	-0.15	0.49	0.19	1		
Forest cover	-0.36	0.36	-0.06	0.18	1	
Skew	0.76	-0.35	-0.23	-0.12	-0.47	1

3.4.2.2 Regression analysis

The R squared value and Se/Sy are good indicators of the goodness-of-fit of a regression analysis. From the regression analyses performed in section 3.2.2 for data with outliers, the computed R squared value was 0.28 and Se/Sy was 0.91. Removing the outliers decreased the R squared to 0.14 and increased the Se/Sy to 1.00 (see Table 3-4). In these cases, the R squared was small and the Se/Sy was large; therefore, it was concluded that regression analyses may not be accurate when estimating station skews.

In this section, a regression analysis was performed using skews based on the flood series that included outliers as the criterion variable, three watershed characteristics, and the two indices: R_L and R_S. The addition of R_L and R_S as a predictor variables increased the R squared value from 0.28 to 0.65. The results of the regression analyses are summarized in Table 3-13. The R value increased from 0.53 to 0.81. This increase could be influenced by the fact that R_L, R_S, and station skews were calculated from the same set of data. In addition, the presence of R_L and R_S decreased the Se/Sy value from 0.91 to 0.67. The two new predictor variables, i.e., R_L, and R_S, appeared to be important predictors. This partially explains why it was difficult to get an accurate regression equation that can be used to predict skew using watershed characteristics.

TABLE 3-13. Summary of goodness-of-fit statistical parameters resulted from skew with outliers regressed on the three watershed characteristics including the two event indices.

Regression Statistics	
Multiple R	0.81
R squared	0.65
Standard Error (Se)	0.52
Standard deviation (Sy)	0.77
Se/Sy	0.67
$\sum e^2$	4.32
predictor variables	5
Observations	22

3.5. SUMMARY

The results of the correlation and regression analyses showed that it was difficult to get accurate sample estimates of flood skew using the annual maximum flood series because of sampling variation and presence of extreme events. There were high variations within the predictor variables. The mean and standard deviation of percentage of storage were 1.39 and 3.53, respectively. Almost all of the storage values are less than 0.5% with the highest value of 15.8%. This variation made it impossible to show the effects of storage on skew.

CHAPTER 4: NEW APPROACH TO ANALYZE THE EFFECT OF WATERSHED STORAGE ON COEFFICIENT OF SKEW

Watersheds are always in a constant state of change either due to manmade modifications or natural causes. For a given watershed, storage could change year to year due to urbanization. Urban development could increase the percentage of imperviousness, which would affect the skew of a flood series. The percentage of storage used in the analyses in Chapter 3 is not used in this chapter to represent storage. Instead, watershed roughness, watershed slope and ultimate infiltration rate (f_{cu}) were used to represent a watershed storage. One or two extreme events in a flood series can distort the sample skew. Even small inaccuracies in a computed skew could cause inaccurate estimates of peak discharge rates. Therefore, knowledge of physical factors that influence skew is needed.

4.1 EFFECT OF WATERSHED STORAGE ON SKEW COEFFICIENT

The basic hypothesis here is that storage is the main watershed characteristic that can cause variation in a sample coefficient of skew. The physical processes of a watershed influence the skew of the annual maximum series. All physical processes, both watershed surface and channel, create storage. Wedge and prism storage are related to channel flow. Infiltration rates and soil types reflect groundwater storage. Floodplain roughness reflects surface storage. All of these factors influence the individual discharges of an annual maximum flood series. Since the antecedent moisture storage differs from storm to storm, the varying amounts of available storage introduce considerable apparent random variation into the individual discharges and thus the sample skew.

Given estimates of the 2-yr, 10-yr, and 100-yr discharges for a log-Pearson III distribution, an estimate of skew can be computed using:

$$G_s = -2.5 + 3.12 * \frac{\log\left(\frac{Q_{0.01}}{Q_{0.10}}\right)}{\log\left(\frac{Q_{0.10}}{Q_{0.50}}\right)} \qquad (4-1)$$

If the second term is less than 2.5, then the skew will be negative. Therefore, negative skew results from causes where the ratio of logarithms is less than 0.8:

$$\frac{\log\left(\frac{Q_{0.01}}{Q_{0.10}}\right)}{\log\left(\frac{Q_{0.10}}{Q_{0.50}}\right)} < \frac{2.5}{3.12} = 0.8013 \qquad (4-2)$$

Equation 4-2 is useful for understanding the effects of storage on flood skew.

If storage has the effect of reducing the 100-yr event more than the 2-yr and 10-yr events, then the logarithm ratio will be less than 0.8, which produces a negative skew. As the storage for the conditions of the 100-year event increases, the ratio will continue to decrease and the skew will become algebraically more negative. Qualitatively, if $\log\left(\frac{Q_{0.01}}{Q_{0.10}}\right) > \log\left(\frac{Q_{0.10}}{Q_{0.50}}\right)$, then storage has less of an effect for the larger events than the smaller events, and skew will likely be positive. As the rain becomes heavier toward the 10-yr rainfall, the ground becomes more saturated and storage is less available, which makes for higher flow velocities and volumes. But then a different type of storage must be available to cause the 100-yr discharge to be not much greater than the 10-yr discharge. This could possibly be due to variation in watershed and channel storage characteristics with the magnitude of a storm. Channel storage can be influenced by the degree of sinuosity that is reflected by the amount of meandering or roughness. For events larger than bankfull flow, which may be about the 2-yr event, then floodplain storage may be a factor. Floodplains with high roughness reflect high storage. Watershed storage is influenced by roughness; the degree of hilliness, which influences the depression storage; and the availability of ground water storage. The extent to which these sources of storage influence the flood magnitudes will greatly influence the station skew obtained from a flood record. For a flood series to have a positive skew, the relative storage would have to continually decrease with increasing storm magnitude. Thus, floods would continually increase proportionally as rainfall increased. If, for example, channel storage even on the floodplain was minimal for all flood magnitudes, then as watershed storage was filled, the floods would increase proportionally.

The issue here is that skew is greatly influenced by the variation of storage over the range of rainfall magnitudes. Most predictor variables used in regression analyses are related to land cover (e.g., forest cover or curve number) or surface characteristics (e.g., watershed slope). It is rare that channel characteristics or soil characteristics are used as variables to predict skew. Measures of channel or floodplain storage (e.g., roughness) or infiltration parameters might make better predictors. A spatio-temporal model was developed to test this hypothesis.

4.2 A SPATIO-TEMPORAL MODEL OF A WATERSHED

In order to understand the effect of watershed storage on flood skew, a simple model was developed. In order to write a program that helps to analyze the watershed processes, answers to several questions were needed: (1) How can channel storage be measured?

(2) What physical characteristics of a channel influence storage? (3) What are the dominant characteristics that reflect watershed storage? Answers to these questions made it possible to create a simple model, spatially and temporally distributed, to show the effect of watershed and channel storage and the effects on runoff, specifically the coefficient of the skew.

4.2.1 Layout of the model

For modeling purposes 32 cells each with an area of 1 square mile was assumed. All subareas have overland flow with the direction of flow from the subbasins shown in Fig. 4-1. Some subareas flow directly into a channel section, while others contribute surface flow into a down-gradient subarea. There are nine channel sections, which are labeled as CR in the Fig. 4-1. Flow velocities are estimated using Manning's equations, both for overland flow and channel flow. The depth of the flow of the watershed surface at any time is used as the hydraulic radius. For channel flow, the hydraulic radius is computed from the bottom width and flow depth in the channel. For the floodplain, the hydraulic radius is computed from the cross-sectional area and wetted perimeter.

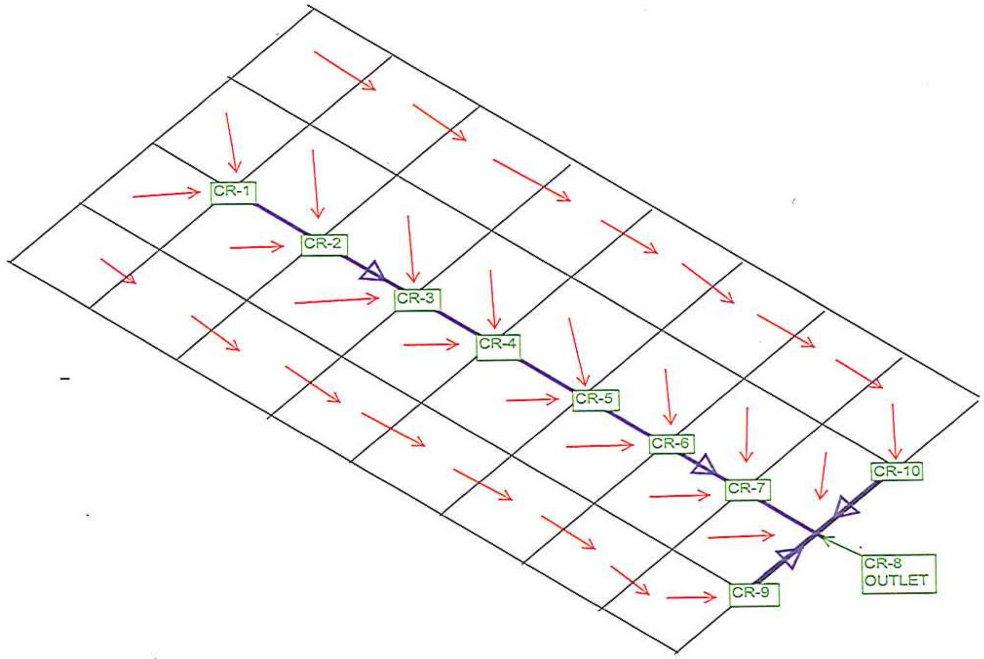


FIGURE 4-1. Layout of the watershed model.

4.2.2 Rainfall distribution

The temporal distribution of rainfall is triangular over a period of 24 hours and uniform in space. Calculations are extended for an addition 24 hours to allow more of the water to drain from the system. The input is the rainfall depth for a 24-hour event for a specified return period. The rainfall values used in the analyses are 3.03 in., 5.05 in., and 7.61 in. for 2-yr, 10-yr and 100-yr events, respectively. These values yield a skew of 0.0 for the event rainfall. Other rainfall depths were used to generate rainfall skews of -1 and +1.

4.2.3. Channel characteristics

A rectangular channel was assumed with a depth equal to 1/20 of the bottom width. The channel may or may not have full flow. In order to set the bottom widths of each channel section, the 2-year, 24- hour rainfall depth was used. The main channel was assumed to flow full for the 2-year event, with no flow on the floodplain. The widths were adjusted until full channel flow was achieved. The same fitted channel widths were used for the 10-yr and 100-yr events, which produced flow on the floodplain.

4.2.4. Infiltration

Infiltration coefficients and Manning's n were used to reflect watershed storage. The watershed storage can be modeled to reflect increased and decreased storage as storm magnitude varies. As the rainfall intensity increases, the infiltration rate increases to reflect greater pressure head. Infiltration was made to vary with time. Generally, as time advanced, then infiltration decreased because less void space was available to hold water. The Hortorian infiltration equation as commonly used was assumed as the base model, which is independent of rainfall intensity. To incorporate intensity into the model, Horton's parameter f_o was made a function of intensity or the depth of water stored on the watershed. The Horton coefficient f_o was assumed to be approximately equal to $4f_c$ and that f_o increases with rainfall intensity. Thus, the infiltration rate is:

$$f = \left(f_{cu} + \Delta f_c e^{-Li}\right)[1.0 + (f_o - f_c)e^{-kt}] \tag{4-3}$$

where f =infiltration rate (in./hr), t =time (hr), i =rainfall intensity (in./hr), f_{cu}= ultimate infiltration rate (in./hr), f_c =f_{cu}, $f_o = 4f_c$, Δf_c= change in f_c due to rainfall intensity, L= intensity decay coefficient (per in./hr), and K= time decay coefficient(1/hr).

4.2.5 Inputs of the model

For each run 13 inputs are required. A separate text file needs to be prepared for each watershed. The model can be used for one analysis at a time. The inputs are:

1. Fcu (in./hr) for infiltration: is the ultimate infiltration
2. Delta f_c (in./hr) for infiltration, the dependence of ultimate infiltration on intensity
3. Intensity coefficient L (per in./hr) for infiltration
4. Storm time coefficient K (per hr) for infiltration
5. Rainfall depth (inch)
6. Baseflow(ft^3/s)
7. Channel width (ft)
8. Channel slope(ft/ft)
9. Watershed slope(ft/ft)
10. Watershed roughness
11. Floodplain roughness
12. Channel roughness
13. Floodplain cross section slope Z

4.3. MODEL ANALYSES

Using the developed model it was possible to investigate the effects of both rainfall skew and watershed storage on runoff skew.

4.3.1. Effect of rainfall skew on flood skew

To control rainfall skew, which is a partial determinant of runoff skew, the values of rainfall depths for 2-yr, 10-yr, and 100-yr return periods and 24-hour storms were determined from the IDF curve to produce rainfall skews of -1, 0, and +1. The rainfall skews were calculated using Eq. 2-8. The rainfall depths and the computed rainfall skews are given in Table 4-1.

TABLE 4-1. Summary of rainfall depth (in.) for -1, 0, and 1 skews.

Rainfall skew	2-year	10-year	100-year
-1	2.25	5.05	7.45
0	3.03	5.05	7.61
1	3.03	5.05	9.03

The watershed parameters selected to perform the analysis are shown in Table 4-2. The values were selected just to show the effect of variation of rainfall skew on the runoff skew. The manning 'n' values and watershed slope were assumed to have similar values as the watershed characteristics of the eastern shore of Maryland. The channel widths (ft) fitted for this step and held fixed for the rest of analyses in this chapter are 22, 35, 44, 49, 55, 60, 61, 65, 40, and 40. The channel widths were selected by performing several trials using the 2-year rainfall depth from the 0 skew distrbution until no runoff occurred on the floodplain, i.e., all flow was contained within the channel. Then to see the effect of zero rainfall skew on runoff skew, rainfall depths 3.03 in. (24-hr, 2-year), 5.05 in. (24 –hr, 10-year), and 7.61 in. (24-hr, 100-year) were used. To see the effect of negative rainfall skew on runoff skew, 2.25 in. (24-hr, 2-year), 5.05 in. (24-hr,10-year), and 7.45 in. (24-hour,100-year) were used. Finally, rainfall depth of 3.03 in. (24-hr, 2-year), 5.05 in. (24-hr, 10-year) and 9.03 in. (24-hr, 100-year) were used to analyze the effect of a positive rainfall skew on runoff skew.

TABLE 4-2. Summary of input values to analyze the effect of rainfall skew on runoff skew.

Parameters	values
Fcu (in./hr) infiltration	0.02
deltaFc (in./hr) for infiltration	0.03
intensity coeff L (per in./hr)	2
storm time coeff K (per hr)	0.8
rainfall depth (in.)	varies
Baseflow (ft^3/s)	0
channel slope (ft/ft)	0.2
watershed slope (ft/ft)	0.03
watershed roughness	0.15
floodplain roughness	0.06
channel roughness	0.04
floodplain cross slope z	50

The 2-yr, 10-yr, and 100-yr peak discharges were obtained from the analyses of data shown in Table 4-2 and rainfall skews of -1, 0, and 1. Then using Eq. 4-1 runoff skews were computed from the results (see Table 4-3). As expected, each runoff skew was always more algebraically negative than the corresponding rainfall skew. The rainfall skew of 0 resulted in a runoff skew of -0.46. This result is rational because for a given rainfall part of the rainfall is intercepted due to infiltration and groundwater storage, which causes smaller peak discharges than would be expected at the outlet. Therefore, a negative flood skew is expected from a 0 rainfall skew. For a rainfall skew of -1, the runoff skew was -1.24. This result is also rational. The analysis using a rainfall skew of +1 resulted a runoff skew of 0.65. Again, an algebraic reduction in the skew resulted.

TABLE 4-3. Summary of 2-yr, 10-yr, and 100-yr peak discharges and the computed runoff skews using the rainfall skews of -1, 0, 1.

Rainfall skew	2-year	10-year	100-year	Runoff skew
-1	139	504	848	-1.24
0	234	514	860	-0.46
1	234	500	1076	0.65

4.3.2. Effect of watershed storage on flood skew

Watershed storage can be represented by watershed roughness, watershed slope, and infiltration characteristics. Therefore, in order to analyze the effect of watershed storage on flood skew, the above mentioned parameters were adjusted. By varying these parameters, the change of the watershed storage on flood skew was analyzed.

4.3.2.1 Watershed roughness and flood skew

Watershed roughness reflects the resistance of the surface covers to the flow of runoff. As watershed roughness increases, the velocity of the water decreases, which means that more water can be held on the watershed. The concept used here is that watershed storage is directly proportional to the watershed roughness. The model watershed roughness was varied and the effect of watershed storage on flood skew was analyzed. To analyze the effect of watershed storage on runoff skew the watershed parameters shown in Table 4-4 and rainfalls with a skew of 0 were used. Three different analyses were made, each with similar watershed characteristics, except different watershed roughness.

TABLE 4-4. Input parameters used to show the effect of watershed roughness on flood skew.

Watershed parameters	Analysis 1	Analysis 2	Analysis 3
Fcu(in./hr) for infiltration	0.02	0.02	0.02
deltaFc (in./hr) for infiltration	0.03	0.03	0.03
intensity coeff L (per in./hr)	2	2	2
storm time coeff K (per hr)	0.8	0.8	0.8
Baseflow (ft^3/s)	0	0	0
channel slope (ft/ft)	0.02	0.02	0.02
watershed slope (ft/ft)	0.03	0.03	0.03
watershed roughness	**0.06**	**0.10**	**0.15**
floodplain roughness	0.06	0.06	0.06
channel roughness	0.04	0.04	0.04
floodplain cross slope z	50	50	50

The watershed roughness values increased from 0.06 in the first analysis to 0.15 in the third analysis (see Table 4-5). Increasing the watershed roughness means increasing watershed storage. The peak discharges for 2-yr, 10-yr, and 100-yr event were generated with the model and using Eq. 4-1 flood skews were computed; the results are presented in Table 4-5. As the watershed storage decreased, the peak discharges increased, and the flood skew become algebraically less negative. For example, when watershed roughness increased from 0.06 to 0.15, then the flood skew changed from -0.05 to -0.46. The important observation from the results of these analyses is that the flood skew increased in magnitude as the roughness increased when the rainfalls had a skew of 0. For a relatively smooth watershed (n=0.06) the skew changed only from a rainfall skew of 0 to a runoff skew of -0.05. For the rougher watershed (n=0.15) the change in skew was much greater, i.e., 0.0 to -0.46.

TABLE 4-5. Effect on flood skew of watershed roughness on the 2-yr, 10-yr, and 100-yr (cfs) for rainfall skew of 0.0.

Analyses	watershed roughness (n)	2-yr	10-yr	100-yr	Flood skew
1	0.06	336.3	601.5	971.9	-0.05
2	0.10	276.2	577.4	929.5	-0.23
3	0.15	234.4	514.2	861.3	-0.46

4.3.2.2 Watershed slope and flood skew

Watershed slope reflects the momentum of the runoff. Vegetation will offer less resistance to runoff when the slope is steep, as vegetation cannot retard the high runoff rates. The experiment here is to represent three different types of watershed storage by varying watershed slope. A steeper watershed has less watershed storage. In order to analyze the effect of watershed storage on runoff skew, rainfalls with zero skew and the watershed characteristics shown in Table 4-6 were used. The analyses were performed by only varying watershed slope.

TABLE 4-6. Input parameters used to show the effect of watershed slope on flood skew.

Inputs	Analysis 1	Analysis 2	Analysis 3
Fcu(in./hr) for infiltration	0.02	0.02	0.02
deltaFc (in./hr) for infiltration	0.03	0.03	0.03
intensity coeff L (per in./hr)	2	2	2
storm time coeff K (per hr)	0.8	0.8	0.8
Baseflow (ft^3/s)	0	0	0
channel slope (ft/ft)	0.02	0.02	0.02
watershed slope (ft/ft)	**0.040**	**0.035**	**0.030**
watershed roughness	0.15	0.15	0.15
floodplain roughness	0.06	0.06	0.06
channel roughness	0.04	0.04	0.04
floodplain cross slope z	50	50	50

The 2-yr, 10-yr, and 100-yr peak discharges were obtained from the model and runoff skews were computed using Equation 4-1. The results of the runoff skews are shown in Table 4-7. The analyses of the data showed that for steeper watershed slopes, i.e., decreased watershed storage, the flood skew increased and became algebraically less negative. For example, when the channel slope was reduced from 0.04 to 0.03, the flood skew changed from -0.26 to -0.46. The results show that as the slope decreased and the storage increases, and the skew becomes more negative. In all cases, the runoff skew is algebraically less than the rainfall skew of 0.

TABLE 4-7. Summary of relationship between runoff skew and watershed slope.

Analysis	watershed Slope (ft/ft)	2-yr	10-yr	100-yr	Flood skew
1	0.040	248.9	522.3	889.7	-0.26
2	0.035	242.1	520.7	877.2	-0.38
3	0.030	234.4	514.2	860.3	-0.46

4.3.2.3 Groundwater storage and flood skew

Infiltration is the process of the water penetrating the soil surface and into the pore space of the soil structures. The rate of infiltration depends on the initial water content of the soil, the level of ground water table, and the soil porosity. Infiltration will continue as long as space in the pores of the soil is available. As the infiltration capacity decreases with time, then less runoff will be intercepted before it gets in to the outlet of the watershed. The experiment here was to represent the groundwater storage by varying the infiltration parameter f_{cu}. Ground soil water storage is directly proportional to f_{cu}; therefore, as Fcu increases, the water storage also increases.

TABLE 4-8. Input parameters used to show the effect of ultimate infiltration constant on flood skew.

Inputs	Analysis 1	Analysis 2	Analysis 3
Fcu(in./hr) for infiltration	**0.02**	**0.03**	**0.05**
deltaFc (in./hr) for infiltration	0.03	0.03	0.03
intensity coeff L (per in./hr)	2	2	2
storm time coeff K (per hr)	0.8	0.8	0.8
Baseflow (ft^3/s)	0	0	0
channel slope (ft/ft)	0.02	0.02	0.02
watershed slope (ft/ft)	0.03	0.03	0.03
watershed roughness	0.15	0.15	0.15
floodplain roughness	0.06	0.06	0.06
channel roughness	0.04	0.04	0.04
floodplain cross slope z	50	50	50

In order to analyze the effect of subsurface water storage on flood skew, a rainfall skew of 0 and the watershed parameters shown in Table 4-8 were used. Three separate analyses were performed by varying only f_{cu}. The 2-yr, 10-yr, and 100-yr peak discharges were obtained from the model analyses, and then using Eq. 4-1 the flood skews were computed, with the results summarized in Table 4-9. Fcu was varied from 0.02 to 0.05, in the third analysis which caused the flood skew to change from -0.46 to -0.53. Increasing f_{cu} represents increasing groundwater storage and the peak discharges decreased with the flood skew algebraically became more negative.

TABLE 4-9. Summary of change in flood skew due to change in ultimate infiltration rate (f_{cu}).

Analysis	f_{cu} (in./hr)	2-yr	10-yr	100-yr	Flood Skew
1	0.02	234.4	514.2	860.3	-0.457
2	0.03	212.5	490.8	834.5	-0.522
3	0.05	171.3	436.5	786.5	-0.530

The percentage of total infiltration depth, total runoff, and water remaining in storage were part of the output of the model analyses. The results shown in Table 4-10 were found from the analyses using watershed data shown in Table 4-8 and rainfall skew of 0. The total infiltration decreased as the rainfall intensity increased, because for the 2-year rainfall intensity the soil would absorb the majority of the rainfall. As the rainfall intensity increased, the soil became more and more saturated and the storage capacity of the soil pores decreased. Eventually, the watershed acted like an impervious surface. After the soil was saturated, the infiltration rate decreased but the runoff volume increased as the rainfall intensity increased.

TABLE 4-10. Summary of percentage of total infiltration, total runoff, and water remaining in storage for the selected return periods.

Analysis	parameters	2-year	10-year	100-year
	Total infiltration (%)	37.62	22.04	14.34
1	Total runoff (%)	58.03	72.53	79.77
	Water remaining in storage (%)	4.35	5.43	5.90
	Total infiltration (%)	46.19	27.91	18.50
2	Total runoff (%)	50.17	67.34	76.16
	Water remaining in storage (%)	3.64	4.75	5.34
	Total infiltration (%)	60.71	38.04	25.77
3	Total runoff (%)	36.49	57.85	69.42
	Water remaining in storage (%)	2.81	4.11	4.81

Percentage of water remaining in the storage is the water that remains in the watershed storage that would eventually drain out of the watershed over time. The change in of infiltration volumes with change in the infiltration rate f_{cu} can be shown graphically. The lines shown in Fig. 4-2 have a positive slope. This indicates a positive relationship between the percentage of total infiltration and f_{cu}. For the 2-year rainfall depth, the increase of f_{cu} from 0.02 to 0.05 caused the fraction of infiltration to increase from 37.62% to 60.71%. For the10-year rainfall depth, the same change in f_{cu} results in the fraction of infiltration increasing from 22.04% to 38.04%. For 100-year rainfall depth, the fraction of infiltration increased from 14.34% to 25.77%. Even though, all of the results follow the same trend, i.e., as f_{cu} increased, the infiltration rate increased for the 2-yr, 10-yr, and 100-yr events, it was observed that the amount of the change decreased as the as the rainfall depth increased. This is rational because for 2-year rainfall intensity, the soil pore space would be sufficient to store much of the water regardless of the ultimate infiltration capacity. As the rainfall intensity increased, then the soil became more and more saturated which means that space for groundwater storage is not available. Thus, the percentage of runoff would increase because the watershed storage decreased.

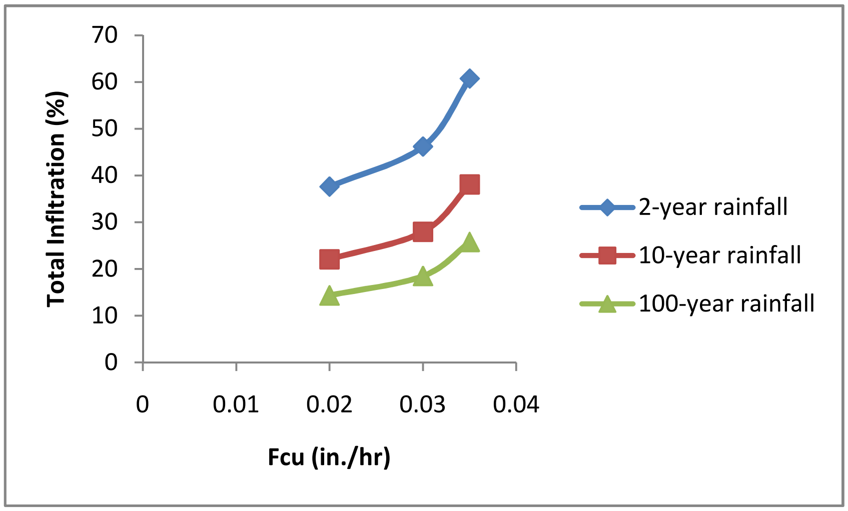


FIGURE 4-2. Graph of total infiltration vs. Fcu for 2-year, 10-year, and 100-year rainfall depths.

During rainfall, the infiltration rate decreased until the soil is saturated. Once the soil structure is filled with water, then the excess water appears as surface runoff. The graphs shown in Fig. 4-3 have negative slopes because of the inverse relationship between total runoff and f_{cu}. As f_{cu} was increased, the runoff decreased, but the percentage change depended on the rainfall intensity. When f_{cu} was increased from 0.02 to 0.05, then the total runoff decreased from 58.03% to 36.49% for the 2-year rainfall depth, from 72.53% to 57.85% for the 10-year rainfall depth, and from 79.77% to 69.42% for the 100-year rainfall depth. In addition, Fig. 4-3 shows that the rainfall depth is directly proportional to the percentage of runoff. For example, for f_{cu} equal to 0.02, as the rainfall was increased from 3.03 in. to 7.61 in., then the percentage of runoff increased from 58.03% to 79.77%.

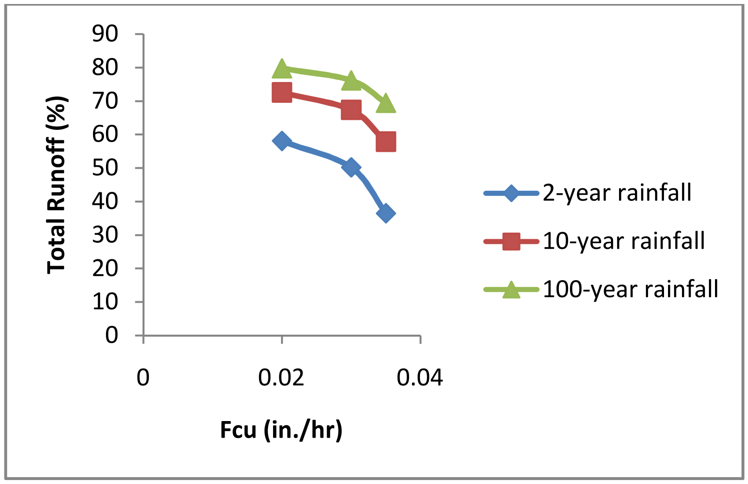


FIGURE 4-3. Graph of total runoff vs. Fcu for 2-year, 10-year, and 100-year rainfall depths.

4.4. SUMMARY

The developed watershed model was able to show the effect of watershed storage on flood skew. From the analyses of the model it was clear that watershed storage is the main factor that affects the variation of flood skew. Flood skew is inversely proportional to watershed storage and always algebraically more negative than rainfall skew.

CHAPTER 5: CONCLUSIONS

The skew coefficient is an important and sensitive parameter in determining flood discharge rates using the log Pearson Type III distribution. If the accuracy of predicted discharge rates is to be improved, knowledge of skew needs to be improved. The accuracy of a skew map is limited because it wrongly assumes that skew only varies with location. A map of skew, if done properly, can only reflect the skew of the rainfall unless it is for a regionally small homogenous area. However, a national map cannot reflect variation in watershed characteristics.

The population flood skew depends on two factors: the distribution of the rainfall and the effect of watershed characteristics on individual rainfall-runoff events. A third factor is important in any individual sample flood skew, namely sampling variation and the presence of extreme events. The current approach to estimate flood skew at a site is to compute a weighted average between the sample estimate and a generalized value obtained from the Bulletin 17B skew map. The map itself is known to be inaccurate, with a standard error that is not much different from the standard deviation of the gage estimates. Since the flood records used to develop the map included both the effects of rainfall skew and the watershed characteristics for the gaged sites, mapping skew does not seem to be effective way of regionalizing skew.

Several statistical analyses were performed in Chapter 3 to show the inaccuracy of regression analyses in predicting skew. The regional analysis of the correlation between station skew with outlier and the three watershed characteristics showed that good correlation was not achieved. However, forest was the dominant predictor variable with a correlation coefficient of -0.47. The sign was rational and the magnitude was statistically significant at 5 % level of significance; however, the resulting regression equation still did not provide good prediction.

The sensitivity analysis of the annual maximum peak discharges showed that 12 of the 22 stations had at least one outlier. The presence of the outliers significantly affected the skew (see Table 3-3). The presence of one outlier at gage number 1492550 changed the skew from 2.25 to -0.40. This is a significant change and could affect the estimate of peak discharge.

Regression analyses using skew with and without outliers indicated that the removal of the outliers decreased the accuracy of the predicting equation as evident from the increases in Se/Sy from 0.91 to 1.00. The R squared decreased from 0.28 to 0.14 (see Table 3-4). This apparent reduction in accuracy is likely the result of significant reduction of the total variation of the criterion variable when the outlier is removed. It does not imply that outliers should not be censored. The presence of outliers significantly affected the MSEs. As summarized in Table 3-5 removing outliers significantly changed the values of MSE. For example, for station 1492550, when the outlier removed the MSEs changed from 1.3559 to 0.5035.

The correlation and regression analyses of the watershed data and sample flood skew did not provide reliable results. One reason was the effect of variation within the annual maximum peak discharges was significant. Indices were computed and added as predictor variables, in addition to the drainage area, the percentage of storage, and the percentage of forest cover. R_L represents the difference between the largest and the second largest flood records divided by the difference of the largest and the smallest flood records (see Eq. 3-7). The result of the correlation analyses indicated that skew depended on RL more than any of the watershed characteristics. The correlation coefficient for RL was 0.76 which was much higher than the forest cover (R= -0.47). Moreover, the inclusion of RL as a predictor improved the Se/Sy and sum of squares of error significantly. The regression analyses with the two indices resulted in a Se/Sy of 0.67. This value is much lower than the value obtained without indices. This analysis implied that the computed station skews were too sensitive to individual peak discharge rates.

The regression analyses for predicting flood skew demonstrate the difficulty in developing models to predict skew at ungaged sites. This observation results, in part, from the inability of traditional watershed characteristics to reflect the level of storage in a watershed. This creates the need for a better way to obtain more accurate estimated of flood skew as well as the development of watershed indices that better reflect the integration of storage throughout the watershed.

A model was developed to show the effects of watershed storage and rainfall skew on flood skew. As shown in Chapter 4, a small change in watershed storage could result a significant change in skew. This would have an impact on estimates of flood discharges. One of the problems that make it unlikely to obtain accurate estimated skew using a regression equation is because the predictor variables used in the equations do not actually represent the factors that actually affect the skew, i.e., watershed storage. In the model analyses, specific parameters were selected to represent storage. These variables are not typically used in regression analyses and the skew map does not reflect these quantities. Watershed storage was represented by watershed roughness and watershed slope. Groundwater storage was represented by an infiltration parameter.

The analyses of the effect of rainfall skew on runoff skew showed that flood skews were algebraically more negative than the rainfall skews. For a rainfall skew of 0, the runoff skew was -0.46. For rainfall skew of -1, the runoff skew was -1.24, and for a rainfall skew of +1, the runoff skew was 0.65. Therefore, the runoff skew was always algebraically more negative than the rainfall skew.

In order to show the effect of watershed storage on flood skew, watershed roughness and watershed slope were used to represent the watershed storage. In addition f_{cu} was used to represent groundwater storage. Watershed roughness and f_{cu} were directly proportional to watershed storage. Watershed slope was inversely proportional to watershed storage. When watershed roughness increased from 0.06 to 0.15, i.e., increased watershed storage, the flood skew became more negative, i.e., from -0.15 to -0.46. When watershed slope changed from 0.03 to 0.04, i.e., increased watershed storage, the flood skew changed from -0.26 to -0.46. Finally, the effect of ground water storage on flood skew was shown by increasing f_{cu} from 0.02 to 0.05. The flood skew became more negative from -0.46 to -0.53. All of the results showed that, as watershed storage increases, the flood skew becomes more and more algebraically negative.

The results of the analyses clearly showed that channel storage and rainfall distribution affect the flood skew. Using rainfall with an array of skews and the developed model it was able to show that, as storage increases, the flood skew becomes more algebraically negative, which supports the hypothesis of this research.

Appendix

Appendix A: Outputs of the USGS program PeakFQ analyses

```
                                    1485000.PRT
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2               Annual peak flow frequency analysis      Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines       08/06/2010 09:59

                            --- PROCESSING OPTIONS ---

                         Plot option         = Graphics device
                         Basin char output   = None
                         Print option        = Yes
                         Debug print         = No
                         Input peaks listing = Long
                         Input peaks format  = WATSTORE peak file

                         Input files used:
                            peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1485000.TXT
                            specifications - PKFQWPSF.TMP

                         Output file(s):
                            main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1485000.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2               Annual peak flow frequency analysis      Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines       08/06/2010 09:59

              Station - 01485000  POCOMOKE RIVER NEAR WILLARDS, MD


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

                   Number of peaks in record           =       58
                   Peaks not used in analysis          =        0
                   Systematic peaks in analysis        =       58
                   Historic peaks in analysis          =        0
                   Years of historic record            =        0
                   Generalized skew                    =    0.700
                        Standard error                 =    0.550
                        Mean Square error              =    0.303
                   Skew option                         =   WEIGHTED
                   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
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1     2500.8
    WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.       1        215.5
1

  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2               Annual peak flow frequency analysis      Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines       08/06/2010 09:59

              Station - 01485000  POCOMOKE RIVER NEAR WILLARDS, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                         FLOOD BASE                  LOGARITHMIC
                    ----------------------  ------------------------------
                               EXCEEDANCE                STANDARD
                     DISCHARGE PROBABILITY      MEAN     DEVIATION      SKEW
                    ------------------------------------------------------
 SYSTEMATIC RECORD         0.0     1.0000     2.8658      0.1885       0.441
 BULL.17B ESTIMATE       215.5     0.9828     2.8723      0.1742       0.940
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	--	287.1	--	--	--
0.9900	--	308.3	--	--	--
0.9500	435.5	381.1	431.9	380.5	485.6
0.9000	471.7	431.3	468.8	416.4	522.6
0.8000	529.1	506.3	527.1	473.4	581.7
0.6667	600.5	594.4	599.4	543.7	656.3
0.5000	700.4	711.1	700.4	640.3	763.9
0.4292	751.5	768.6	752.2	688.6	820.6
0.2000	1013.0	1045.0	1019.0	923.0	1128.0
0.1000	1276.0	1302.0	1294.0	1144.0	1460.0
0.0400	1681.0	1669.0	1732.0	1468.0	2004.0
0.0200	2045.0	1976.0	2138.0	1747.0	2513.0
0.0100	2467.0	2313.0	2627.0	2062.0	3128.0
0.0050	2958.0	2684.0	3220.0	2419.0	3867.0
0.0020	3734.0	3233.0	4206.0	2967.0	5081.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 09:59

Station - 01485000 POCOMOKE RIVER NEAR WILLARDS, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1950	502.0		1979	1870.0	
1951	391.0		1980	1190.0	
1952	830.0		1981	190.0	
1953	816.0		1982	553.0	
1954	679.0		1983	1050.0	
1955	645.0		1984	1070.0	
1956	670.0		1985	722.0	
1957	559.0		1986	754.0	
1958	882.0		1987	662.0	
1959	562.0		1988	534.0	
1960	565.0		1989	2820.0	
1961	709.0		1990	609.0	
1962	884.0		1991	767.0	
1963	690.0		1992	672.0	
1964	796.0		1993	1300.0	
1965	503.0		1994	1470.0	
1966	445.0		1995	431.0	
1967	586.0		1996	928.0	
1968	560.0		1997	1050.0	
1969	541.0		1998	1970.0	
1970	492.0		1999	589.0	
1971	452.0		2000	1480.0	
1972	924.0		2001	659.0	
1973	710.0		2002	707.0	
1974	522.0		2003	905.0	
1975	1000.0		2004	803.0	
1976	567.0		2007	702.0	
1977	640.0		2008	526.0	
1978	1230.0		2009	747.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 09:59

Station - 01485000 POCOMOKE RIVER NEAR WILLARDS, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1989	2820.0	0.0169	0.0169
1998	1970.0	0.0339	0.0339
1979	1870.0	0.0508	0.0508
2000	1480.0	0.0678	0.0678
1994	1470.0	0.0847	0.0847
1993	1300.0	0.1017	0.1017
1978	1230.0	0.1186	0.1186
1980	1190.0	0.1356	0.1356
1984	1070.0	0.1525	0.1525
1983	1050.0	0.1695	0.1695
1997	1050.0	0.1864	0.1864
1975	1000.0	0.2034	0.2034
1996	928.0	0.2203	0.2203
1972	924.0	0.2373	0.2373
2003	905.0	0.2542	0.2542
1962	884.0	0.2712	0.2712
1958	882.0	0.2881	0.2881
1952	830.0	0.3051	0.3051
1953	816.0	0.3220	0.3220
2004	803.0	0.3390	0.3390
1964	796.0	0.3559	0.3559
1991	767.0	0.3729	0.3729
1986	754.0	0.3898	0.3898
2009	747.0	0.4068	0.4068
1985	722.0	0.4237	0.4237
1973	710.0	0.4407	0.4407
1961	709.0	0.4576	0.4576
2002	707.0	0.4746	0.4746
2007	702.0	0.4915	0.4915
1963	690.0	0.5085	0.5085
1954	679.0	0.5254	0.5254
1992	672.0	0.5424	0.5424
1956	670.0	0.5593	0.5593
1987	662.0	0.5763	0.5763
2001	659.0	0.5932	0.5932
1955	645.0	0.6102	0.6102
1977	640.0	0.6271	0.6271
1990	609.0	0.6441	0.6441
1999	589.0	0.6610	0.6610
1967	586.0	0.6780	0.6780
1976	567.0	0.6949	0.6949
1960	565.0	0.7119	0.7119
1959	562.0	0.7288	0.7288
1968	560.0	0.7458	0.7458
1957	559.0	0.7627	0.7627
1982	553.0	0.7797	0.7797
1969	541.0	0.7966	0.7966
1988	534.0	0.8136	0.8136
2008	526.0	0.8305	0.8305
1974	522.0	0.8475	0.8475
1965	503.0	0.8644	0.8644
1950	502.0	0.8814	0.8814
1970	492.0	0.8983	0.8983
1971	452.0	0.9153	0.9153
1966	445.0	0.9322	0.9322
1995	431.0	0.9492	0.9492
1951	391.0	0.9661	0.9661
1981	190.0	0.9831	0.9831

```
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      58


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01485000       USGS POCOMOKE RIVER NEAR WILLARDS,


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2          Annual peak flow frequency analysis      Run Date / Time
  11/01/2007        following Bulletin 17-B Guidelines       08/06/2010 09:59

                       --- PROCESSING OPTIONS ---

                    Plot option          = Graphics device
                    Basin char output    = None
                    Print option         = Yes
                    Debug print          = No
                    Input peaks listing  = Long
                    Input peaks format   = WATSTORE peak file

                    Input files used:
                       peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1485500.TXT
                       specifications - PKFQWPSF.TMP

                    Output file(s):
                       main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1485500.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2          Annual peak flow frequency analysis      Run Date / Time
  11/01/2007        following Bulletin 17-B Guidelines       08/06/2010 09:59

            Station - 01485500  NASSAWANGO CREEK NEAR SNOW HILL, MD


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

                Number of peaks in record           =       60
                Peaks not used in analysis          =        0
                Systematic peaks in analysis        =       60
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.700
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                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
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.              98.1
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1    3635.2
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2          Annual peak flow frequency analysis      Run Date / Time
  11/01/2007        following Bulletin 17-B Guidelines       08/06/2010 09:59

            Station - 01485500  NASSAWANGO CREEK NEAR SNOW HILL, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                       FLOOD BASE                 LOGARITHMIC
                  ----------------------  ------------------------------
                            EXCEEDANCE                STANDARD
                   DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                  ------------------------------------------------------
 SYSTEMATIC RECORD       0.0      1.0000    2.7761      0.2765     0.216
 BULL.17B ESTIMATE       0.0      1.0000    2.7761      0.2765     0.336
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	141.6	131.8	134.8	105.4	177.9
0.9900	159.2	150.4	152.9	120.6	197.4
0.9500	223.5	218.2	218.8	178.0	268.0
0.9000	271.2	268.4	267.4	221.5	319.8
0.8000	346.8	347.5	344.2	291.6	402.1
0.6667	441.6	445.8	440.2	379.5	506.7
0.5000	576.3	583.7	576.3	502.1	660.3
0.4292	646.0	654.2	646.8	564.1	742.4
0.2000	1007.0	1013.0	1017.0	869.9	1196.0
0.1000	1377.0	1369.0	1403.0	1163.0	1695.0
0.0400	1953.0	1906.0	2022.0	1597.0	2524.0
0.0200	2469.0	2374.0	2597.0	1970.0	3307.0
0.0100	3067.0	2903.0	3286.0	2389.0	4252.0
0.0050	3760.0	3502.0	4114.0	2861.0	5387.0
0.0020	4844.0	4413.0	5473.0	3578.0	7236.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 09:59

Station - 01485500 NASSAWANGO CREEK NEAR SNOW HILL, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1950	215.0		1980	1210.0	
1951	258.0		1981	181.0	
1952	486.0		1982	386.0	
1953	988.0		1983	806.0	
1954	430.0		1984	864.0	
1955	920.0		1985	635.0	
1956	348.0		1986	434.0	
1957	542.0		1987	445.0	
1958	761.0		1988	400.0	
1959	597.0		1989	3930.0	
1960	361.0		1990	636.0	
1961	653.0		1991	546.0	
1962	669.0		1992	695.0	
1963	615.0		1993	1210.0	
1964	597.0		1994	1760.0	
1965	121.0		1995	171.0	
1966	200.0		1996	739.0	
1967	452.0		1997	660.0	
1968	434.0		1998	2300.0	
1969	480.0		1999	598.0	
1970	437.0		2000	1320.0	
1971	347.0		2001	781.0	
1972	1320.0		2002	1100.0	
1973	760.0		2003	564.0	
1974	365.0		2004	787.0	
1975	615.0		2005	1170.0	
1976	416.0		2006	437.0	
1977	463.0		2007	699.0	
1978	1270.0		2008	338.0	
1979	1940.0		2009	470.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

```
-  Minus-flagged discharge -- Not used in computation
      -8888.0 -- No discharge value given
-  Minus-flagged water year -- Historic peak used in computation
```

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.004
Ver. 5.2           Annual peak flow frequency analysis       Run Date / Time
11/01/2007         following Bulletin 17-B Guidelines        08/06/2010 09:59

         Station - 01485500  NASSAWANGO CREEK NEAR SNOW HILL, MD
```

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1989	3930.0	0.0164	0.0164
1998	2300.0	0.0328	0.0328
1979	1940.0	0.0492	0.0492
1994	1760.0	0.0656	0.0656
1972	1320.0	0.0820	0.0820
2000	1320.0	0.0984	0.0984
1978	1270.0	0.1148	0.1148
1980	1210.0	0.1311	0.1311
1993	1210.0	0.1475	0.1475
2005	1170.0	0.1639	0.1639
2002	1100.0	0.1803	0.1803
1953	988.0	0.1967	0.1967
1955	920.0	0.2131	0.2131
1984	864.0	0.2295	0.2295
1983	806.0	0.2459	0.2459
2004	787.0	0.2623	0.2623
2001	781.0	0.2787	0.2787
1958	761.0	0.2951	0.2951
1973	760.0	0.3115	0.3115
1996	739.0	0.3279	0.3279
2007	699.0	0.3443	0.3443
1992	695.0	0.3607	0.3607
1962	669.0	0.3770	0.3770
1997	660.0	0.3934	0.3934
1961	653.0	0.4098	0.4098
1990	636.0	0.4262	0.4262
1985	635.0	0.4426	0.4426
1963	615.0	0.4590	0.4590
1975	615.0	0.4754	0.4754
1999	598.0	0.4918	0.4918
1959	597.0	0.5082	0.5082
1964	597.0	0.5246	0.5246
2003	564.0	0.5410	0.5410
1991	546.0	0.5574	0.5574
1957	542.0	0.5738	0.5738
1952	486.0	0.5902	0.5902
1969	480.0	0.6066	0.6066
2009	470.0	0.6230	0.6230
1977	463.0	0.6393	0.6393
1967	452.0	0.6557	0.6557
1987	445.0	0.6721	0.6721
1970	437.0	0.6885	0.6885
2006	437.0	0.7049	0.7049
1968	434.0	0.7213	0.7213
1986	434.0	0.7377	0.7377
1954	430.0	0.7541	0.7541
1976	416.0	0.7705	0.7705
1988	400.0	0.7869	0.7869
1982	386.0	0.8033	0.8033
1974	365.0	0.8197	0.8197
1960	361.0	0.8361	0.8361
1956	348.0	0.8525	0.8525
1971	347.0	0.8689	0.8689
2008	338.0	0.8852	0.8852
1951	258.0	0.9016	0.9016
1950	215.0	0.9180	0.9180
1966	200.0	0.9344	0.9344

```
       1981          181.0          0.9508          0.9508
       1995          171.0          0.9672          0.9672
       1965          121.0          0.9836          0.9836
1


 End PeakFQ analysis.
   Stations processed :        1
   Number of errors   :        0
   Stations skipped   :        0
   Station years      :       60


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01485500       USGS NASSAWANGO CREEK NEAR SNOW HI


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.000.000
  Ver. 5.2           Annual peak flow frequency analysis     Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines      08/06/2010 10:00

                        --- PROCESSING OPTIONS ---

                     Plot option          = Graphics device
                     Basin char output    = None
                     Print option         = Yes
                     Debug print          = No
                     Input peaks listing  = Long
                     Input peaks format   = WATSTORE peak file

                     Input files used:
                        peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1486000.TXT
                        specifications - PKFQWPSF.TMP

                     Output file(s):
                        main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1486000.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.001
  Ver. 5.2           Annual peak flow frequency analysis     Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines      08/06/2010 10:00

          Station - 01486000  MANOKIN BRANCH NEAR PRINCESS ANNE, MD


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

                Number of peaks in record            =       56
                Peaks not used in analysis           =        0
                Systematic peaks in analysis         =       56
                Historic peaks in analysis           =        0
                Years of historic record             =        0
                Generalized skew                     =    0.700
                     Standard error                  =    0.550
                     Mean Square error               =    0.303
                Skew option                          =   WEIGHTED
                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
    WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.       1         18.7
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.        859.5
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.002
  Ver. 5.2           Annual peak flow frequency analysis     Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines      08/06/2010 10:00

          Station - 01486000  MANOKIN BRANCH NEAR PRINCESS ANNE, MD


          ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                 LOGARITHMIC
                  ----------------------  -------------------------------
                             EXCEEDANCE              STANDARD
                   DISCHARGE PROBABILITY     MEAN    DEVIATION     SKEW
                  ---------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     2.1376     0.3082    -0.611
 BULL.17B ESTIMATE      18.7     0.9821     2.1494     0.2803     0.091
```

1486000.PRT

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	--	14.8	--	--	--
0.9900	--	19.3	--	--	--
0.9500	49.6	38.3	48.3	38.8	60.3
0.9000	62.1	53.5	61.1	50.0	73.9
0.8000	81.7	77.9	81.0	68.1	95.4
0.6667	106.0	107.8	105.6	90.5	122.4
0.5000	139.7	147.5	139.7	121.0	161.2
0.4292	156.8	166.7	157.0	136.0	181.7
0.2000	242.1	252.3	244.3	207.5	290.3
0.1000	324.5	321.4	330.5	272.3	403.4
0.0400	445.5	404.8	460.6	362.8	579.6
0.0200	547.9	463.3	574.5	436.6	736.3
0.0100	661.1	518.3	704.3	515.9	915.8
0.0050	786.0	570.1	852.6	601.2	1121.0
0.0020	971.2	634.0	1082.0	724.3	1435.0

1

Program PeakFq	U. S. GEOLOGICAL SURVEY	Seq.001.003
Ver. 5.2	Annual peak flow frequency analysis	Run Date / Time
11/01/2007	following Bulletin 17-B Guidelines	08/06/2010 10:00

Station - 01486000 MANOKIN BRANCH NEAR PRINCESS ANNE, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1951	97.0		1982	58.0	
1952	84.0		1983	127.0	
1953	210.0		1984	126.0	
1954	41.0		1985	347.0	
1955	237.0		1986	80.0	
1956	54.0		1987	90.0	
1957	154.0		1988	84.0	
1958	174.0		1989	179.0	
1959	111.0		1990	145.0	
1960	184.0		1991	129.0	
1961	152.0		1992	105.0	
1962	218.0		1993	204.0	
1963	224.0		1994	303.0	
1964	140.0		1995	60.0	
1965	38.0		1996	137.0	
1966	46.0		1997	122.0	
1967	72.0		1998	332.0	
1968	126.0		1999	257.0	
1969	547.0		2000	316.0	
1970	311.0		2001	314.0	
1971	194.0		2002	70.0	
1975	265.0		2003	72.0	
1976	97.0		2004	305.0	
1977	79.0		2005	349.0	
1978	355.0		2006	97.0	
1979	361.0		2007	176.0	
1980	201.0		2008	117.0	
1981	13.0		2009	73.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation

1486000.PRT

-8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:00

Station - 01486000 MANOKIN BRANCH NEAR PRINCESS ANNE, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1969	547.0	0.0175	0.0175
1979	361.0	0.0351	0.0351
1978	355.0	0.0526	0.0526
2005	349.0	0.0702	0.0702
1985	347.0	0.0877	0.0877
1998	332.0	0.1053	0.1053
2000	316.0	0.1228	0.1228
2001	314.0	0.1404	0.1404
1970	311.0	0.1579	0.1579
2004	305.0	0.1754	0.1754
1994	303.0	0.1930	0.1930
1975	265.0	0.2105	0.2105
1999	257.0	0.2281	0.2281
1955	237.0	0.2456	0.2456
1963	224.0	0.2632	0.2632
1962	218.0	0.2807	0.2807
1953	210.0	0.2982	0.2982
1993	204.0	0.3158	0.3158
1980	201.0	0.3333	0.3333
1971	194.0	0.3509	0.3509
1960	184.0	0.3684	0.3684
1989	179.0	0.3860	0.3860
2007	176.0	0.4035	0.4035
1958	174.0	0.4211	0.4211
1957	154.0	0.4386	0.4386
1961	152.0	0.4561	0.4561
1990	145.0	0.4737	0.4737
1964	140.0	0.4912	0.4912
1996	137.0	0.5088	0.5088
1991	129.0	0.5263	0.5263
1983	127.0	0.5439	0.5439
1968	126.0	0.5614	0.5614
1984	126.0	0.5789	0.5789
1997	122.0	0.5965	0.5965
2008	117.0	0.6140	0.6140
1959	111.0	0.6316	0.6316
1992	105.0	0.6491	0.6491
1951	97.0	0.6667	0.6667
1976	97.0	0.6842	0.6842
2006	97.0	0.7018	0.7018
1987	90.0	0.7193	0.7193
1952	84.0	0.7368	0.7368
1988	84.0	0.7544	0.7544
1986	80.0	0.7719	0.7719
1977	79.0	0.7895	0.7895
2009	73.0	0.8070	0.8070
1967	72.0	0.8246	0.8246
2003	72.0	0.8421	0.8421
2002	70.0	0.8596	0.8596
1995	60.0	0.8772	0.8772
1982	58.0	0.8947	0.8947
1956	54.0	0.9123	0.9123
1966	46.0	0.9298	0.9298
1954	41.0	0.9474	0.9474
1965	38.0	0.9649	0.9649
1981	13.0	0.9825	0.9825

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      56

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01486000       USGS MANOKIN BRANCH NEAR PRINCESS


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:00

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1486100.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1486100.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:00

               Station - 01486100  ANDREWS BRANCH NEAR DELMAR, MD


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

                Number of peaks in record            =       10
                Peaks not used in analysis           =        0
                Systematic peaks in analysis         =       10
                Historic peaks in analysis           =        0
                Years of historic record             =        0
                Generalized skew                     =    0.700
                     Standard error                  =    0.550
                     Mean Square error               =    0.303
                Skew option                          =   WEIGHTED
                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
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.             36.6
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       254.3
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:00

               Station - 01486100  ANDREWS BRANCH NEAR DELMAR, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                          FLOOD BASE                LOGARITHMIC
                     ----------------------  -------------------------------
                               EXCEEDANCE                STANDARD
                      DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                     -------------------------------------------------------
 SYSTEMATIC RECORD        0.0      1.0000     1.9847      0.2066     -0.314
 BULL.17B ESTIMATE        0.0      1.0000     1.9847      0.2066      0.316
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	32.6	24.6	24.7	15.3	47.3
0.9900	35.7	28.6	28.6	17.6	50.7
0.9500	46.2	42.4	41.4	26.3	62.3
0.9000	53.4	51.7	49.9	32.9	70.4
0.8000	64.3	65.3	62.0	43.2	83.0
0.6667	77.1	80.3	75.9	55.6	98.8
0.5000	94.1	99.0	94.1	71.6	122.6
0.4292	102.5	107.6	103.2	79.1	135.7
0.2000	142.8	144.9	149.2	110.8	211.2
0.1000	180.1	174.4	197.4	136.0	297.4
0.0400	233.2	210.4	279.9	168.0	442.4
0.0200	277.4	236.3	364.9	192.6	580.5
0.0100	325.6	261.3	479.8	218.0	747.9
0.0050	378.3	285.8	640.2	244.4	949.7
0.0020	455.8	317.2	966.7	281.2	1280.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:00

Station - 01486100 ANDREWS BRANCH NEAR DELMAR, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1967	155.0		1972	112.0	
1968	77.0		1973	191.0	
1969	147.0		1974	58.0	
1970	70.0		1975	118.0	
1971	93.0		1976	42.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:00

Station - 01486100 ANDREWS BRANCH NEAR DELMAR, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1973	191.0	0.0909	0.0909
1967	155.0	0.1818	0.1818
1969	147.0	0.2727	0.2727

```
      1975          118.0         0.3636         0.3636
      1972          112.0         0.4545         0.4545
      1971           93.0         0.5455         0.5455
      1968           77.0         0.6364         0.6364
      1970           70.0         0.7273         0.7273
      1974           58.0         0.8182         0.8182
      1976           42.0         0.9091         0.9091
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      10


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01486100       USGS ANDREWS BRANCH NEAR DELMAR, M


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
                                      1489000.PRT
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2               Annual peak flow frequency analysis      Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines       08/06/2010 10:00

                            --- PROCESSING OPTIONS ---

                         Plot option         = Graphics device
                         Basin char output   = None
                         Print option        = Yes
                         Debug print         = No
                         Input peaks listing = Long
                         Input peaks format  = WATSTORE peak file

                         Input files used:
                            peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1489000.TXT
                            specifications - PKFQWPSF.TMP

                         Output file(s):
                            main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1489000.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2               Annual peak flow frequency analysis      Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines       08/06/2010 10:00

            Station - 01489000  FAULKNER BRANCH AT FEDERALSBURG, MD


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

                Number of peaks in record           =       42
                Peaks not used in analysis          =        0
                Systematic peaks in analysis        =       42
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.700
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                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
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            17.1
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     3493.9
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2               Annual peak flow frequency analysis      Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines       08/06/2010 10:00

            Station - 01489000  FAULKNER BRANCH AT FEDERALSBURG, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                  LOGARITHMIC
                  ----------------------  -------------------------------
                             EXCEEDANCE                 STANDARD
                   DISCHARGE PROBABILITY     MEAN      DEVIATION     SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD      0.0      1.0000     2.3887      0.4277     -0.188
 BULL.17B ESTIMATE      0.0      1.0000     2.3887      0.4277      0.086
```

1489000.PRT

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	21.0	16.3	18.2	11.4	32.7
0.9900	26.4	21.6	23.5	15.0	39.9
0.9500	49.6	46.0	47.0	31.7	69.6
0.9000	69.9	68.0	67.5	47.4	94.7
0.8000	106.4	107.9	104.5	76.8	139.4
0.6667	158.3	164.3	157.1	119.4	203.7
0.5000	241.3	252.4	241.3	187.0	311.0
0.4292	287.7	300.4	288.6	224.0	373.7
0.2000	558.0	564.8	568.7	426.2	773.0
0.1000	872.0	846.1	905.2	642.5	1291.0
0.0400	1412.0	1285.0	1512.0	988.9	2272.0
0.0200	1934.0	1673.0	2132.0	1305.0	3302.0
0.0100	2573.0	2110.0	2931.0	1675.0	4643.0
0.0050	3348.0	2599.0	3957.0	2105.0	6365.0
0.0020	4616.0	3332.0	5768.0	2779.0	9368.0

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.003
Ver. 5.2 — Annual peak flow frequency analysis — Run Date / Time
11/01/2007 — following Bulletin 17-B Guidelines — 08/06/2010 10:00

Station - 01489000 FAULKNER BRANCH AT FEDERALSBURG, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1950	38.0		1971	156.0	
1951	39.0		1972	283.0	
1952	175.0		1973	211.0	
1953	58.0		1974	130.0	
1954	45.0		1975	1680.0	
1955	433.0		1976	189.0	
1956	94.0		1977	76.0	
1957	198.0		1978	319.0	
1958	440.0		1979	1070.0	
1959	250.0		1980	129.0	
1960	728.0		1981	95.0	
1961	298.0		1982	738.0	
1962	203.0		1983	657.0	
1963	283.0		1984	1290.0	
1964	138.0		1985	735.0	
1965	492.0		1986	185.0	
1966	33.0		1987	900.0	
1967	911.0		1988	550.0	
1968	205.0		1989	341.0	
1969	192.0		1990	383.0	
1970	199.0		1991	262.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- \- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- \- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.004
Ver. 5.2 — Annual peak flow frequency analysis — Run Date / Time
11/01/2007 — following Bulletin 17-B Guidelines — 08/06/2010 10:00

Station - 01489000 FAULKNER BRANCH AT FEDERALSBURG, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1975	1680.0	0.0233	0.0233
1984	1290.0	0.0465	0.0465
1979	1070.0	0.0698	0.0698
1967	911.0	0.0930	0.0930
1987	900.0	0.1163	0.1163
1982	738.0	0.1395	0.1395
1985	735.0	0.1628	0.1628
1960	728.0	0.1860	0.1860
1983	657.0	0.2093	0.2093
1988	550.0	0.2326	0.2326
1965	492.0	0.2558	0.2558
1958	440.0	0.2791	0.2791
1955	433.0	0.3023	0.3023
1990	383.0	0.3256	0.3256
1989	341.0	0.3488	0.3488
1978	319.0	0.3721	0.3721
1961	298.0	0.3953	0.3953
1963	283.0	0.4186	0.4186
1972	283.0	0.4419	0.4419
1991	262.0	0.4651	0.4651
1959	250.0	0.4884	0.4884
1973	211.0	0.5116	0.5116
1968	205.0	0.5349	0.5349
1962	203.0	0.5581	0.5581
1970	199.0	0.5814	0.5814
1957	198.0	0.6047	0.6047
1969	192.0	0.6279	0.6279
1976	189.0	0.6512	0.6512
1986	185.0	0.6744	0.6744
1952	175.0	0.6977	0.6977
1971	156.0	0.7209	0.7209
1964	138.0	0.7442	0.7442
1974	130.0	0.7674	0.7674
1980	129.0	0.7907	0.7907
1981	95.0	0.8140	0.8140
1956	94.0	0.8372	0.8372
1977	76.0	0.8605	0.8605
1953	58.0	0.8837	0.8837
1954	45.0	0.9070	0.9070
1951	39.0	0.9302	0.9302
1950	38.0	0.9535	0.9535
1966	33.0	0.9767	0.9767

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 42

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01489000 USGS FAULKNER BRANCH AT FEDERALSBU

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

[redacted]

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:00

                           --- PROCESSING OPTIONS ---

                        Plot option          = Graphics device
                        Basin char output    = None
                        Print option         = Yes
                        Debug print          = No
                        Input peaks listing = Long
                        Input peaks format   = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1490000.TXT
                           specifications - PKFQWPSF.TMP

                        Output file(s):
                           main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1490000.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:00

           Station - 01490000  CHICAMACOMICO RIVER NEAR SALEM, MD


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

                  Number of peaks in record          =       39
                  Peaks not used in analysis         =        1
                  Systematic peaks in analysis       =       38
                  Historic peaks in analysis         =        0
                  Years of historic record           =        0
                  Generalized skew                   =    0.700
                       Standard error                =    0.550
                       Mean Square error             =    0.303
                  Skew option                        =   WEIGHTED
                  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.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   38
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                    0.0
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1    1366.8
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.              39.3
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:00

           Station - 01490000  CHICAMACOMICO RIVER NEAR SALEM, MD

         ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                         FLOOD BASE                LOGARITHMIC
                   ---------------------- -------------------------------
                              EXCEEDANCE              STANDARD
                    DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                   -------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     2.3648      0.2897      0.464
 BULL.17B ESTIMATE       0.0     1.0000     2.3648      0.2897      0.549
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	58.5	55.5	54.9	40.0	77.1
0.9900	64.4	61.8	61.1	44.9	83.9
0.9500	86.6	85.0	84.1	63.9	108.9
0.9000	103.5	102.5	101.4	78.8	127.8
0.8000	130.8	130.9	129.3	103.3	158.5
0.6667	166.1	167.1	165.2	135.2	198.9
0.5000	218.0	220.0	218.0	181.3	260.8
0.4292	245.6	247.9	246.1	205.2	295.2
0.2000	396.1	398.0	402.4	327.5	498.8
0.1000	561.0	559.1	580.0	450.7	746.7
0.0400	836.3	822.5	892.6	642.2	1201.0
0.0200	1100.0	1070.0	1211.0	815.1	1670.0
0.0100	1422.0	1367.0	1625.0	1018.0	2280.0
0.0050	1815.0	1723.0	2166.0	1255.0	3069.0
0.0020	2469.0	2304.0	3154.0	1632.0	4468.0

1

Program PeakFq	U. S. GEOLOGICAL SURVEY	Seq.001.003
Ver. 5.2	Annual peak flow frequency analysis	Run Date / Time
11/01/2007	following Bulletin 17-B Guidelines	08/06/2010 10:00

Station - 01490000 CHICAMACOMICO RIVER NEAR SALEM, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1951	85.0		1971	210.0	
1952	326.0		1972	300.0	
1953	152.0		1973	542.0	
1954	106.0		1974	168.0	
1955	314.0		1975	478.0	
1956	78.0		1976	166.0	
1957	260.0		1977	163.0	
1958	285.0		1978	326.0	
1959	202.0		1979	-1030.0	D
1960	419.0		1980	233.0	
1961	470.0		2001	403.0	
1962	157.0		2002	67.0	
1963	230.0		2003	436.0	
1964	176.0		2004	241.0	
1965	182.0		2005	309.0	
1966	128.0		2006	1840.0	
1967	518.0		2007	507.0	
1968	226.0		2008	104.0	
1969	169.0		2009	74.0	
1970	218.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.004
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:00

Station - 01490000 CHICAMACOMICO RIVER NEAR SALEM, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
2006	1840.0	0.0256	0.0256
1973	542.0	0.0513	0.0513
1967	518.0	0.0769	0.0769
2007	507.0	0.1026	0.1026
1975	478.0	0.1282	0.1282
1961	470.0	0.1538	0.1538
2003	436.0	0.1795	0.1795
1960	419.0	0.2051	0.2051
2001	403.0	0.2308	0.2308
1952	326.0	0.2564	0.2564
1978	326.0	0.2821	0.2821
1955	314.0	0.3077	0.3077
2005	309.0	0.3333	0.3333
1972	300.0	0.3590	0.3590
1958	285.0	0.3846	0.3846
1957	260.0	0.4103	0.4103
2004	241.0	0.4359	0.4359
1980	233.0	0.4615	0.4615
1963	230.0	0.4872	0.4872
1968	226.0	0.5128	0.5128
1970	218.0	0.5385	0.5385
1971	210.0	0.5641	0.5641
1959	202.0	0.5897	0.5897
1965	182.0	0.6154	0.6154
1964	176.0	0.6410	0.6410
1969	169.0	0.6667	0.6667
1974	168.0	0.6923	0.6923
1976	166.0	0.7179	0.7179
1977	163.0	0.7436	0.7436
1962	157.0	0.7692	0.7692
1953	152.0	0.7949	0.7949
1966	128.0	0.8205	0.8205
1954	106.0	0.8462	0.8462
2008	104.0	0.8718	0.8718
1951	85.0	0.8974	0.8974
1956	78.0	0.9231	0.9231
2009	74.0	0.9487	0.9487
2002	67.0	0.9744	0.9744
1979	-1030.0	--	--

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 39

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01490000 USGS CHICAMACOMICO RIVER NEAR SALE

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
                                      1490800.PRT
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2              Annual peak flow frequency analysis     Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:00

                           --- PROCESSING OPTIONS ---

                        Plot option         = Graphics device
                        Basin char output   = None
                        Print option        = Yes
                        Debug print         = No
                        Input peaks listing = Long
                        Input peaks format  = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1490800.TXT
                           specifications - PKFQWPSF.TMP

                        Output file(s):
                           main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1490800.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2              Annual peak flow frequency analysis     Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:00

              Station - 01490800  OLDTOWN BRANCH AT GOLDSBORO, MD


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

                Number of peaks in record           =       10
                Peaks not used in analysis          =        0
                Systematic peaks in analysis        =       10
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.699
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                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
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.             50.5
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       780.6
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis     Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:00

              Station - 01490800  OLDTOWN BRANCH AT GOLDSBORO, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                  LOGARITHMIC
                    ----------------------  -------------------------------
                              EXCEEDANCE                STANDARD
                     DISCHARGE PROBABILITY      MEAN     DEVIATION      SKEW
                    -------------------------------------------------------
 SYSTEMATIC RECORD        0.0     1.0000     2.2977      0.2921      0.284
 BULL.17B ESTIMATE        0.0     1.0000     2.2977      0.2921      0.541
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	49.3	42.0	37.0	18.4	80.8
0.9900	54.4	47.8	42.9	21.4	87.3
0.9500	73.5	69.5	64.6	34.1	111.3
0.9000	88.0	85.8	80.7	44.8	129.5
0.8000	111.5	111.9	106.4	63.5	159.8
0.6667	142.0	144.9	138.9	88.9	201.5
0.5000	186.8	192.3	186.8	126.3	270.5
0.4292	210.7	216.9	212.7	145.5	311.6
0.2000	341.0	345.7	364.1	238.6	590.3
0.1000	484.0	478.4	557.5	324.9	988.7
0.0400	723.0	686.2	965.8	450.6	1833.0
0.0200	951.8	873.0	1483.0	558.8	2824.0
0.0100	1232.0	1090.0	2334.0	681.1	4252.0
0.0050	1574.0	1342.0	3800.0	820.0	6287.0
0.0020	2143.0	1735.0	7747.0	1033.0	10310.0

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.003
Ver. 5.2              Annual peak flow frequency analysis     Run Date / Time
11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:00
```

Station - 01490800 OLDTOWN BRANCH AT GOLDSBORO, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1967	690.0		1972	340.0	
1968	125.0		1973	350.0	
1969	100.0		1974	68.0	
1970	170.0		1975	200.0	
1971	235.0		1976	170.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.004
Ver. 5.2              Annual peak flow frequency analysis     Run Date / Time
11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:00
```

Station - 01490800 OLDTOWN BRANCH AT GOLDSBORO, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1967	690.0	0.0909	0.0909
1973	350.0	0.1818	0.1818
1972	340.0	0.2727	0.2727

[redacted]

1971	235.0	0.3636	0.3636
1975	200.0	0.4545	0.4545
1970	170.0	0.5455	0.5455
1976	170.0	0.6364	0.6364
1968	125.0	0.7273	0.7273
1969	100.0	0.8182	0.8182
1974	68.0	0.9091	0.9091

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 10

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01490800 USGS OLDTOWN BRANCH AT GOLDSBORO,

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.000.000
  Ver. 5.2           Annual peak flow frequency analysis     Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines      08/06/2010 10:01

                        --- PROCESSING OPTIONS ---

                     Plot option         = Graphics device
                     Basin char output   = None
                     Print option        = Yes
                     Debug print         = No
                     Input peaks listing = Long
                     Input peaks format  = WATSTORE peak file

                     Input files used:
                        peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1491000.TXT
                        specifications - PKFQWPSF.TMP

                     Output file(s):
                        main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1491000.PRT

1

  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.001
  Ver. 5.2           Annual peak flow frequency analysis     Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines      08/06/2010 10:01

             Station - 01491000  CHOPTANK RIVER NEAR GREENSBORO, MD

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

                Number of peaks in record           =       62
                Peaks not used in analysis          =        0
                Systematic peaks in analysis        =       62
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.700
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                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
    WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.       1          220.2
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.      13510.5
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.002
  Ver. 5.2           Annual peak flow frequency analysis     Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines      08/06/2010 10:01

             Station - 01491000  CHOPTANK RIVER NEAR GREENSBORO, MD

           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                 LOGARITHMIC
                  ----------------------  -------------------------------
                             EXCEEDANCE                 STANDARD
                   DISCHARGE PROBABILITY     MEAN       DEVIATION     SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     3.2713       0.3259     -0.713
 BULL.17B ESTIMATE     220.2     0.9839     3.2826       0.2989     -0.041
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	--	164.9	--	--	--
0.9900	--	222.9	--	--	--
0.9500	613.2	476.1	596.5	476.4	749.4
0.9000	791.3	686.6	777.8	636.1	945.6
0.8000	1076.0	1033.0	1066.0	895.8	1259.0
0.6667	1431.0	1464.0	1426.0	1221.0	1655.0
0.5000	1926.0	2040.0	1926.0	1666.0	2228.0
0.4292	2177.0	2318.0	2180.0	1886.0	2529.0
0.2000	3426.0	3553.0	3455.0	2928.0	4115.0
0.1000	4616.0	4531.0	4694.0	3865.0	5738.0
0.0400	6333.0	5684.0	6524.0	5154.0	8213.0
0.0200	7759.0	6470.0	8088.0	6188.0	10360.0
0.0100	9307.0	7191.0	9831.0	7282.0	12780.0
0.0050	10990.0	7854.0	11780.0	8442.0	15480.0
0.0020	13420.0	8649.0	14700.0	10080.0	19520.0

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.003
Ver. 5.2 — Annual peak flow frequency analysis — Run Date / Time
11/01/2007 — following Bulletin 17-B Guidelines — 08/06/2010 10:01

Station - 01491000 CHOPTANK RIVER NEAR GREENSBORO, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1948	1600.0		1979	6110.0	
1949	1700.0		1980	904.0	
1950	1050.0		1981	638.0	
1951	840.0		1982	877.0	
1952	3640.0		1983	3260.0	
1953	1330.0		1984	2600.0	
1954	1180.0		1985	1410.0	
1955	1140.0		1986	1090.0	
1956	989.0		1987	2060.0	
1957	4140.0		1988	1090.0	
1958	4380.0		1989	2510.0	
1959	758.0		1990	1960.0	
1960	5040.0		1991	1260.0	
1961	2400.0		1992	744.0	
1962	1580.0		1993	2260.0	
1963	1890.0		1994	4800.0	
1964	1890.0		1995	1490.0	
1965	525.0		1996	2810.0	
1966	150.0		1997	5120.0	
1967	6970.0		1998	3120.0	
1968	1620.0		1999	6420.0	
1969	1620.0		2000	3130.0	
1970	1650.0		2001	5240.0	
1971	1570.0		2002	406.0	
1972	2760.0		2003	3090.0	
1973	2660.0		2004	2470.0	
1974	944.0		2005	2610.0	
1975	2860.0		2006	2860.0	
1976	2080.0		2007	4720.0	
1977	386.0		2008	2390.0	
1978	3180.0		2009	2890.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

-  Minus-flagged discharge -- Not used in computation
      -8888.0 -- No discharge value given
-  Minus-flagged water year -- Historic peak used in computation
```

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.004
Ver. 5.2           Annual peak flow frequency analysis      Run Date / Time
11/01/2007          following Bulletin 17-B Guidelines      08/06/2010 10:01

           Station - 01491000  CHOPTANK RIVER NEAR GREENSBORO, MD
```

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1967	6970.0	0.0159	0.0159
1999	6420.0	0.0317	0.0317
1979	6110.0	0.0476	0.0476
2001	5240.0	0.0635	0.0635
1997	5120.0	0.0794	0.0794
1960	5040.0	0.0952	0.0952
1994	4800.0	0.1111	0.1111
2007	4720.0	0.1270	0.1270
1958	4380.0	0.1429	0.1429
1957	4140.0	0.1587	0.1587
1952	3640.0	0.1746	0.1746
1983	3260.0	0.1905	0.1905
1978	3180.0	0.2063	0.2063
2000	3130.0	0.2222	0.2222
1998	3120.0	0.2381	0.2381
2003	3090.0	0.2540	0.2540
2009	2890.0	0.2698	0.2698
1975	2860.0	0.2857	0.2857
2006	2860.0	0.3016	0.3016
1996	2810.0	0.3175	0.3175
1972	2760.0	0.3333	0.3333
1973	2660.0	0.3492	0.3492
2005	2610.0	0.3651	0.3651
1984	2600.0	0.3810	0.3810
1989	2510.0	0.3968	0.3968
2004	2470.0	0.4127	0.4127
1961	2400.0	0.4286	0.4286
2008	2390.0	0.4444	0.4444
1993	2260.0	0.4603	0.4603
1976	2080.0	0.4762	0.4762
1987	2060.0	0.4921	0.4921
1990	1960.0	0.5079	0.5079
1963	1890.0	0.5238	0.5238
1964	1890.0	0.5397	0.5397
1949	1700.0	0.5556	0.5556
1970	1650.0	0.5714	0.5714
1968	1620.0	0.5873	0.5873
1969	1620.0	0.6032	0.6032
1948	1600.0	0.6190	0.6190
1962	1580.0	0.6349	0.6349
1971	1570.0	0.6508	0.6508
1995	1490.0	0.6667	0.6667
1985	1410.0	0.6825	0.6825
1953	1330.0	0.6984	0.6984
1991	1260.0	0.7143	0.7143
1954	1180.0	0.7302	0.7302
1955	1140.0	0.7460	0.7460
1986	1090.0	0.7619	0.7619
1988	1090.0	0.7778	0.7778
1950	1050.0	0.7937	0.7937
1956	989.0	0.8095	0.8095
1974	944.0	0.8254	0.8254
1980	904.0	0.8413	0.8413
1982	877.0	0.8571	0.8571
1951	840.0	0.8730	0.8730
1959	758.0	0.8889	0.8889

```
       1992          744.0          0.9048          0.9048
       1981          638.0          0.9206          0.9206
       1965          525.0          0.9365          0.9365
       2002          406.0          0.9524          0.9524
       1977          386.0          0.9683          0.9683
       1966          150.0          0.9841          0.9841
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      62


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01491000       USGS CHOPTANK RIVER NEAR GREENSBOR


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis     Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines      08/06/2010 10:01

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1491050.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1491050.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis     Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines      08/06/2010 10:01

             Station - 01491050  SPRING BRANCH NEAR GREENSBORO, MD


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

                 Number of peaks in record           =       10
                 Peaks not used in analysis          =        0
                 Systematic peaks in analysis        =       10
                 Historic peaks in analysis          =        0
                 Years of historic record            =        0
                 Generalized skew                    =    0.700
                      Standard error                 =    0.550
                      Mean Square error              =    0.303
                 Skew option                         =   WEIGHTED
                 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
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1    607.7
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            12.1
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis     Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines      08/06/2010 10:01

             Station - 01491050  SPRING BRANCH NEAR GREENSBORO, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                       FLOOD BASE                  LOGARITHMIC
                  ----------------------  -------------------------------
                            EXCEEDANCE                 STANDARD
                   DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD        0.0     1.0000     1.9333      0.4177      1.978
 BULL.17B ESTIMATE        0.0     1.0000     1.9333      0.4177      0.960
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	16.8	32.6	13.9	5.0	31.6
0.9900	18.1	32.8	15.2	5.6	33.6
0.9500	23.8	34.2	21.1	8.6	42.2
0.9000	28.8	36.1	26.3	11.4	49.6
0.8000	37.8	40.5	35.7	16.9	63.2
0.6667	51.0	48.4	49.6	25.7	84.2
0.5000	73.7	64.0	73.7	41.5	124.0
0.4292	87.2	74.2	88.4	50.8	150.6
0.2000	178.5	154.7	197.6	107.4	384.5
0.1000	311.1	300.7	392.2	175.6	870.1
0.0400	606.0	722.7	997.3	301.4	2435.0
0.0200	972.2	1402.0	2135.0	435.0	5132.0
0.0100	1531.0	2718.0	4896.0	614.4	10580.0
0.0050	2376.0	5268.0	12260.0	854.8	21410.0
0.0020	4178.0	12630.0	48770.0	1301.0	53120.0

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.003
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:01

Station - 01491050 SPRING BRANCH NEAR GREENSBORO, MD

I N P U T　D A T A　L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1967	965.0		1972	70.0	
1968	42.0		1973	80.0	
1969	33.0		1974	41.0	
1970	95.0		1975	150.0	
1971	82.0		1976	60.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.004
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:01

Station - 01491050 SPRING BRANCH NEAR GREENSBORO, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1967	965.0	0.0909	0.0909
1975	150.0	0.1818	0.1818
1970	95.0	0.2727	0.2727

1971	82.0	0.3636	0.3636
1973	80.0	0.4545	0.4545
1972	70.0	0.5455	0.5455
1976	60.0	0.6364	0.6364
1968	42.0	0.7273	0.7273
1974	41.0	0.8182	0.8182
1969	33.0	0.9091	0.9091

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      10
```

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01491050 USGS SPRING BRANCH NEAR GREENSBORO

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:01

                           --- PROCESSING OPTIONS ---

                        Plot option         = Graphics device
                        Basin char output   = None
                        Print option        = Yes
                        Debug print         = No
                        Input peaks listing = Long
                        Input peaks format  = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1492000.TXT
                           specifications - PKFQWPSF.TMP

                        Output file(s):
                           main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1492000.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:01

              Station - 01492000  BEAVERDAM BRANCH AT MATTHEWS, MD


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

                Number of peaks in record          =       32
                Peaks not used in analysis         =        0
                Systematic peaks in analysis       =       32
                Historic peaks in analysis         =        0
                Years of historic record           =        0
                Generalized skew                   =    0.700
                     Standard error                =    0.550
                     Mean Square error             =    0.303
                Skew option                        =   WEIGHTED
                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
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1    2109.8
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.             40.1
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:01

              Station - 01492000  BEAVERDAM BRANCH AT MATTHEWS, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                       FLOOD BASE                 LOGARITHMIC
                  ----------------------  -------------------------------
                              EXCEEDANCE                STANDARD
                   DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD       0.0      1.0000    2.4640      0.3320     0.711
 BULL.17B ESTIMATE       0.0      1.0000    2.4640      0.3320     0.707
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	67.1	67.3	62.5	42.3	92.9
0.9900	73.4	73.6	69.1	47.3	100.5
0.9500	98.2	98.3	94.7	67.3	129.8
0.9000	117.9	117.9	114.9	83.7	152.8
0.8000	151.2	151.2	148.9	112.1	191.9
0.6667	196.2	196.1	194.9	151.1	245.8
0.5000	266.2	266.0	266.2	211.0	333.0
0.4292	304.9	304.7	305.9	243.4	383.7
0.2000	532.2	532.0	544.3	420.6	711.5
0.1000	806.5	806.6	846.2	614.6	1162.0
0.0400	1311.0	1312.0	1443.0	941.3	2094.0
0.0200	1837.0	1840.0	2120.0	1258.0	3172.0
0.0100	2529.0	2535.0	3093.0	1653.0	4715.0
0.0050	3436.0	3447.0	4499.0	2142.0	6904.0
0.0020	5069.0	5092.0	7394.0	2972.0	11220.0

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.003
Ver. 5.2              Annual peak flow frequency analysis    Run Date / Time
11/01/2007            following Bulletin 17-B Guidelines     08/06/2010 10:01
```

Station - 01492000 BEAVERDAM BRANCH AT MATTHEWS, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1950	181.0		1966	181.0	
1951	148.0		1967	693.0	
1952	276.0		1968	269.0	
1953	222.0		1969	180.0	
1954	133.0		1970	238.0	
1955	476.0		1971	562.0	
1956	109.0		1972	357.0	
1957	1020.0		1973	441.0	
1958	1050.0		1974	150.0	
1959	231.0		1975	301.0	
1960	2200.0		1976	201.0	
1961	251.0		1977	76.0	
1962	162.0		1978	804.0	
1963	307.0		1979	674.0	
1964	116.0		1980	159.0	
1965	545.0		1981	190.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.004
Ver. 5.2              Annual peak flow frequency analysis    Run Date / Time
11/01/2007            following Bulletin 17-B Guidelines     08/06/2010 10:01
```

Station - 01492000 BEAVERDAM BRANCH AT MATTHEWS, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1960	2200.0	0.0303	0.0303
1958	1050.0	0.0606	0.0606
1957	1020.0	0.0909	0.0909
1978	804.0	0.1212	0.1212
1967	693.0	0.1515	0.1515
1979	674.0	0.1818	0.1818
1971	562.0	0.2121	0.2121
1965	545.0	0.2424	0.2424
1955	476.0	0.2727	0.2727
1973	441.0	0.3030	0.3030
1972	357.0	0.3333	0.3333
1963	307.0	0.3636	0.3636
1975	301.0	0.3939	0.3939
1952	276.0	0.4242	0.4242
1968	269.0	0.4545	0.4545
1961	251.0	0.4848	0.4848
1970	238.0	0.5152	0.5152
1959	231.0	0.5455	0.5455
1953	222.0	0.5758	0.5758
1976	201.0	0.6061	0.6061
1981	190.0	0.6364	0.6364
1950	181.0	0.6667	0.6667
1966	181.0	0.6970	0.6970
1969	180.0	0.7273	0.7273
1962	162.0	0.7576	0.7576
1980	159.0	0.7879	0.7879
1974	150.0	0.8182	0.8182
1951	148.0	0.8485	0.8485
1954	133.0	0.8788	0.8788
1964	116.0	0.9091	0.9091
1956	109.0	0.9394	0.9394
1977	76.0	0.9697	0.9697

1

End PeakFQ analysis.
Stations processed :   1
Number of errors   :   0
Stations skipped   :   0
Station years   :   32

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01492000   USGS BEAVERDAM BRANCH AT MATTHEWS,

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
                                       1492050.PRT
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2              Annual peak flow frequency analysis    Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines     08/06/2010 10:01

                           --- PROCESSING OPTIONS ---

                        Plot option         = Graphics device
                        Basin char output   = None
                        Print option        = Yes
                        Debug print         = No
                        Input peaks listing = Long
                        Input peaks format  = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1492050.TXT
                           specifications - PKFQWPSF.TMP

                        Output file(s):
                           main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1492050.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2              Annual peak flow frequency analysis    Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines     08/06/2010 10:01

                    Station - 01492050  GRAVEL RUN AT BEULAH, MD


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

                  Number of peaks in record           =       11
                  Peaks not used in analysis          =        0
                  Systematic peaks in analysis        =       11
                  Historic peaks in analysis          =        0
                  Years of historic record            =        0
                  Generalized skew                    =    0.700
                       Standard error                 =    0.550
                       Mean Square error              =    0.303
                  Skew option                         =   WEIGHTED
                  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
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1     550.4
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.             21.1
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis    Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines     08/06/2010 10:01

                    Station - 01492050  GRAVEL RUN AT BEULAH, MD


             ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                          FLOOD BASE                 LOGARITHMIC
                    ----------------------  -------------------------------
                               EXCEEDANCE                STANDARD
                     DISCHARGE PROBABILITY     MEAN      DEVIATION     SKEW
                    -------------------------------------------------------
 SYSTEMATIC RECORD        0.0      1.0000     2.0324       0.3392      1.285
 BULL.17B ESTIMATE        0.0      1.0000     2.0324       0.3392      0.878
```

[redacted]

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	27.1	35.1	23.0	10.6	44.8
0.9900	29.1	36.3	25.0	11.8	47.5
0.9500	37.2	41.8	33.7	17.0	58.3
0.9000	43.8	46.8	40.8	21.6	67.0
0.8000	55.3	55.9	52.9	30.1	82.4
0.6667	71.1	69.3	69.6	42.4	104.7
0.5000	96.2	91.6	96.2	62.2	143.8
0.4292	110.4	104.6	111.5	73.1	168.2
0.2000	196.8	189.3	211.8	132.6	352.8
0.1000	306.5	306.7	361.2	196.2	664.0
0.0400	519.1	557.8	735.0	301.9	1460.0
0.0200	752.4	860.7	1295.0	404.0	2574.0
0.0100	1073.0	1314.0	2376.0	531.1	4452.0
0.0050	1512.0	1988.0	4591.0	689.4	7577.0
0.0020	2344.0	3404.0	12110.0	959.6	15010.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:01

Station - 01492050 GRAVEL RUN AT BEULAH, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1966	53.0		1972	120.0	
1967	220.0		1973	85.0	
1968	95.0		1974	71.0	
1969	97.0		1975	690.0	
1970	145.0		1976	36.0	
1971	81.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:01

Station - 01492050 GRAVEL RUN AT BEULAH, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1975	690.0	0.0833	0.0833
1967	220.0	0.1667	0.1667

1970	145.0	0.2500	0.2500
1972	120.0	0.3333	0.3333
1969	97.0	0.4167	0.4167
1968	95.0	0.5000	0.5000
1973	85.0	0.5833	0.5833
1971	81.0	0.6667	0.6667
1974	71.0	0.7500	0.7500
1966	53.0	0.8333	0.8333
1976	36.0	0.9167	0.9167

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      11
```

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01492050   USGS GRAVEL RUN AT BEULAH, MD

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.000.000
  Ver. 5.2           Annual peak flow frequency analysis      Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines       08/06/2010 10:01

                        --- PROCESSING OPTIONS ---

                     Plot option         = Graphics device
                     Basin char output   = None
                     Print option        = Yes
                     Debug print         = No
                     Input peaks listing = Long
                     Input peaks format  = WATSTORE peak file

                     Input files used:
                        peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1492500.TXT
                        specifications - PKFQWPSF.TMP

                     Output file(s):
                        main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1492500.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.001
  Ver. 5.2           Annual peak flow frequency analysis      Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines       08/06/2010 10:01

          Station - 01492500  SALLIE HARRIS CREEK NEAR CARMICHAEL, MD


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

               Number of peaks in record           =       39
               Peaks not used in analysis          =        0
               Systematic peaks in analysis        =       39
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =    0.700
                    Standard error                 =    0.550
                    Mean Square error              =    0.303
               Skew option                         =   WEIGHTED
               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
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.             27.2
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.      2082.3
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.002
  Ver. 5.2           Annual peak flow frequency analysis      Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines       08/06/2010 10:01

          Station - 01492500  SALLIE HARRIS CREEK NEAR CARMICHAEL, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                LOGARITHMIC
                  ----------------------  -------------------------------
                             EXCEEDANCE                STANDARD
                   DISCHARGE PROBABILITY     MEAN      DEVIATION      SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     2.3765       0.3527      0.156
 BULL.17B ESTIMATE       0.0     1.0000     2.3765       0.3527      0.329
```

[redacted]

1492500.PRT

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	37.8	33.1	34.2	23.2	53.7
0.9900	43.9	39.5	40.5	27.7	61.2
0.9500	67.8	64.9	65.0	46.6	89.9
0.9000	86.8	85.3	84.5	62.4	112.3
0.8000	119.0	119.5	117.2	89.7	149.9
0.6667	162.0	164.9	161.0	126.9	201.2
0.5000	227.6	233.0	227.6	182.7	282.6
0.4292	263.3	269.5	263.9	212.3	328.9
0.2000	463.8	468.1	472.2	368.7	612.8
0.1000	690.4	682.3	716.1	531.2	970.8
0.0400	1077.0	1029.0	1154.0	788.6	1643.0
0.0200	1450.0	1349.0	1604.0	1023.0	2349.0
0.0100	1911.0	1726.0	2193.0	1300.0	3276.0
0.0050	2475.0	2170.0	2964.0	1624.0	4481.0
0.0020	3413.0	2874.0	4364.0	2140.0	6624.0

1

Program PeakFq	U. S. GEOLOGICAL SURVEY	Seq.001.003
Ver. 5.2	Annual peak flow frequency analysis	Run Date / Time
11/01/2007	following Bulletin 17-B Guidelines	08/06/2010 10:01

Station - 01492500 SALLIE HARRIS CREEK NEAR CARMICHAEL, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1952	327.0		1972	290.0	
1953	214.0		1973	502.0	
1954	116.0		1974	202.0	
1955	1030.0		1975	233.0	
1956	91.0		1976	304.0	
1957	155.0		1977	69.0	
1958	577.0		1978	784.0	
1959	75.0		1979	631.0	
1960	1240.0		1980	282.0	
1961	154.0		1981	161.0	
1962	135.0		2001	313.0	
1963	286.0		2002	86.0	
1964	71.0		2003	273.0	
1965	51.0		2004	352.0	
1966	71.0		2005	352.0	
1967	1180.0		2006	151.0	
1968	304.0		2007	604.0	
1969	136.0		2008	388.0	
1970	219.0		2009	204.0	
1971	220.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:01

Station - 01492500 SALLIE HARRIS CREEK NEAR CARMICHAEL, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1960	1240.0	0.0250	0.0250
1967	1180.0	0.0500	0.0500
1955	1030.0	0.0750	0.0750
1978	784.0	0.1000	0.1000
1979	631.0	0.1250	0.1250
2007	604.0	0.1500	0.1500
1958	577.0	0.1750	0.1750
1973	502.0	0.2000	0.2000
2008	388.0	0.2250	0.2250
2004	352.0	0.2500	0.2500
2005	352.0	0.2750	0.2750
1952	327.0	0.3000	0.3000
2001	313.0	0.3250	0.3250
1968	304.0	0.3500	0.3500
1976	304.0	0.3750	0.3750
1972	290.0	0.4000	0.4000
1963	286.0	0.4250	0.4250
1980	282.0	0.4500	0.4500
2003	273.0	0.4750	0.4750
1975	233.0	0.5000	0.5000
1971	220.0	0.5250	0.5250
1970	219.0	0.5500	0.5500
1953	214.0	0.5750	0.5750
2009	204.0	0.6000	0.6000
1974	202.0	0.6250	0.6250
1981	161.0	0.6500	0.6500
1957	155.0	0.6750	0.6750
1961	154.0	0.7000	0.7000
2006	151.0	0.7250	0.7250
1969	136.0	0.7500	0.7500
1962	135.0	0.7750	0.7750
1954	116.0	0.8000	0.8000
1956	91.0	0.8250	0.8250
2002	86.0	0.8500	0.8500
1959	75.0	0.8750	0.8750
1964	71.0	0.9000	0.9000
1966	71.0	0.9250	0.9250
1977	69.0	0.9500	0.9500
1965	51.0	0.9750	0.9750

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 39

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01492500 USGS SALLIE HARRIS CREEK NEAR CARM

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2           Annual peak flow frequency analysis      Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines       08/06/2010 10:02

                        --- PROCESSING OPTIONS ---

                     Plot option         = Graphics device
                     Basin char output   = None
                     Print option        = Yes
                     Debug print         = No
                     Input peaks listing = Long
                     Input peaks format  = WATSTORE peak file

                     Input files used:
                        peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1492550.TXT
                        specifications - PKFQWPSF.TMP

                     Output file(s):
                        main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1492550.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2           Annual peak flow frequency analysis      Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines       08/06/2010 10:02

               Station - 01492550  MILL CREEK NEAR SKIPTON, MD


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

               Number of peaks in record           =       11
               Peaks not used in analysis          =        0
               Systematic peaks in analysis        =       11
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =    0.700
                    Standard error                 =    0.550
                    Mean Square error              =    0.303
               Skew option                         =   WEIGHTED
               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
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1      874.7
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.              23.9
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2           Annual peak flow frequency analysis      Run Date / Time
  11/01/2007         following Bulletin 17-B Guidelines       08/06/2010 10:02

               Station - 01492550  MILL CREEK NEAR SKIPTON, MD


          ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                  LOGARITHMIC
                 ----------------------  -------------------------------
                             EXCEEDANCE                STANDARD
                  DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                 -------------------------------------------------------
 SYSTEMATIC RECORD       0.0      1.0000     2.1601      0.3744      2.247
 BULL.17B ESTIMATE       0.0      1.0000     2.1601      0.3744      0.983
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	34.0	67.2	29.4	12.6	58.5
0.9900	36.4	67.3	31.7	13.9	61.8
0.9500	46.2	68.5	41.9	19.8	75.4
0.9000	54.5	70.5	50.7	25.2	87.0
0.8000	69.4	76.0	66.3	35.5	107.8
0.6667	90.6	86.6	88.6	51.0	139.0
0.5000	125.8	108.3	125.8	77.4	195.7
0.4292	146.3	122.7	147.9	92.6	232.2
0.2000	278.3	235.4	302.2	180.1	527.9
0.1000	459.1	435.6	553.5	280.6	1078.0
0.0400	838.2	1001.0	1251.0	458.8	2655.0
0.0200	1285.0	1892.0	2413.0	641.4	5105.0
0.0100	1939.0	3597.0	4897.0	879.9	9630.0
0.0050	2888.0	6860.0	10610.0	1191.0	17880.0
0.0020	4819.0	16180.0	33320.0	1751.0	39750.0

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.003
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:02

Station - 01492550　MILL CREEK NEAR SKIPTON, MD

I N P U T　D A T A　L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1966	99.0		1972	105.0	
1967	1520.0		1973	135.0	
1968	190.0		1974	59.0	
1969	88.0		1975	165.0	
1970	165.0		1976	72.0	
1971	140.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.004
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:02

Station - 01492550　MILL CREEK NEAR SKIPTON, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1967	1520.0	0.0833	0.0833
1968	190.0	0.1667	0.1667

```
      1970          165.0          0.2500          0.2500
      1975          165.0          0.3333          0.3333
      1971          140.0          0.4167          0.4167
      1973          135.0          0.5000          0.5000
      1972          105.0          0.5833          0.5833
      1966           99.0          0.6667          0.6667
      1969           88.0          0.7500          0.7500
      1976           72.0          0.8333          0.8333
      1974           59.0          0.9167          0.9167
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      11

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01492550       USGS MILL CREEK NEAR SKIPTON, MD


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2             Annual peak flow frequency analysis      Run Date / Time
  11/01/2007           following Bulletin 17-B Guidelines       08/06/2010 10:02

                          --- PROCESSING OPTIONS ---

                       Plot option         = Graphics device
                       Basin char output   = None
                       Print option        = Yes
                       Debug print         = No
                       Input peaks listing = Long
                       Input peaks format  = WATSTORE peak file

                       Input files used:
                          peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1493000.TXT
                          specifications - PKFQWPSF.TMP

                       Output file(s):
                          main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1493000.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2             Annual peak flow frequency analysis      Run Date / Time
  11/01/2007           following Bulletin 17-B Guidelines       08/06/2010 10:02

            Station - 01493000  UNICORN BRANCH NEAR MILLINGTON, MD


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

                 Number of peaks in record           =       61
                 Peaks not used in analysis          =        2
                 Systematic peaks in analysis        =       59
                 Historic peaks in analysis          =        0
                 Years of historic record            =        0
                 Generalized skew                    =    0.689
                      Standard error                 =    0.550
                      Mean Square error              =    0.303
                 Skew option                         =   WEIGHTED
                 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.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.        2
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   59
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                     0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.               43.5
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       2730.5
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1

  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2             Annual peak flow frequency analysis      Run Date / Time
  11/01/2007           following Bulletin 17-B Guidelines       08/06/2010 10:02

            Station - 01493000  UNICORN BRANCH NEAR MILLINGTON, MD

          ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                             FLOOD BASE                LOGARITHMIC
                      ----------------------  ------------------------------
                                EXCEEDANCE              STANDARD
                       DISCHARGE PROBABILITY     MEAN    DEVIATION     SKEW
                      ------------------------------------------------------
 SYSTEMATIC RECORD         0.0      1.0000     2.5373     0.3175      0.014
 BULL.17B ESTIMATE         0.0      1.0000     2.5373     0.3175      0.167
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	58.8	52.9	54.9	41.0	77.5
0.9900	68.8	63.4	65.2	49.2	89.2
0.9500	107.3	103.8	104.4	81.9	132.9
0.9000	136.9	135.1	134.5	108.1	166.0
0.8000	185.3	186.1	183.6	151.6	219.8
0.6667	247.4	251.1	246.5	207.8	290.0
0.5000	337.6	344.0	337.6	288.0	395.4
0.4292	384.9	391.9	385.4	329.0	452.6
0.2000	633.3	637.2	639.8	534.2	773.1
0.1000	890.2	880.4	908.5	732.9	1132.0
0.0400	1291.0	1244.0	1341.0	1027.0	1729.0
0.0200	1650.0	1555.0	1741.0	1280.0	2294.0
0.0100	2065.0	1902.0	2218.0	1562.0	2973.0
0.0050	2541.0	2287.0	2788.0	1878.0	3784.0
0.0020	3280.0	2861.0	3713.0	2352.0	5094.0

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.003
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:02

Station - 01493000 UNICORN BRANCH NEAR MILLINGTON, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1948	-310.0	G	1979	697.0	
1949	277.0		1980	366.0	
1950	222.0		1981	61.0	
1951	282.0		1982	178.0	
1952	383.0		1983	825.0	
1953	253.0		1984	382.0	
1954	157.0		1985	351.0	
1955	359.0		1986	193.0	
1956	167.0		1987	220.0	
1957	630.0		1988	182.0	
1958	370.0		1989	397.0	
1959	116.0		1990	403.0	
1960	1060.0		1991	224.0	
1961	429.0		1992	175.0	
1962	246.0		1993	434.0	
1963	-840.0	D	1994	649.0	
1964	226.0		1995	204.0	
1965	106.0		1996	1090.0	
1966	85.0		1997	1160.0	
1967	582.0		1998	510.0	
1968	266.0		1999	2600.0	
1969	430.0		2000	498.0	
1970	296.0		2001	649.0	
1971	524.0		2002	94.0	
1972	1020.0		2003	775.0	
1973	467.0		2004	731.0	
1974	168.0		2005	495.0	
1975	365.0		2007	736.0	
1976	332.0		2008	641.0	
1977	108.0		2009	172.0	
1978	482.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:02

Station - 01493000 UNICORN BRANCH NEAR MILLINGTON, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1999	2600.0	0.0167	0.0167
1997	1160.0	0.0333	0.0333
1996	1090.0	0.0500	0.0500
1960	1060.0	0.0667	0.0667
1972	1020.0	0.0833	0.0833
1983	825.0	0.1000	0.1000
2003	775.0	0.1167	0.1167
2007	736.0	0.1333	0.1333
2004	731.0	0.1500	0.1500
1979	697.0	0.1667	0.1667
1994	649.0	0.1833	0.1833
2001	649.0	0.2000	0.2000
2008	641.0	0.2167	0.2167
1957	630.0	0.2333	0.2333
1967	582.0	0.2500	0.2500
1971	524.0	0.2667	0.2667
1998	510.0	0.2833	0.2833
2000	498.0	0.3000	0.3000
2005	495.0	0.3167	0.3167
1978	482.0	0.3333	0.3333
1973	467.0	0.3500	0.3500
1993	434.0	0.3667	0.3667
1969	430.0	0.3833	0.3833
1961	429.0	0.4000	0.4000
1990	403.0	0.4167	0.4167
1989	397.0	0.4333	0.4333
1952	383.0	0.4500	0.4500
1984	382.0	0.4667	0.4667
1958	370.0	0.4833	0.4833
1980	366.0	0.5000	0.5000
1975	365.0	0.5167	0.5167
1955	359.0	0.5333	0.5333
1985	351.0	0.5500	0.5500
1976	332.0	0.5667	0.5667
1970	296.0	0.5833	0.5833
1951	282.0	0.6000	0.6000
1949	277.0	0.6167	0.6167
1968	266.0	0.6333	0.6333
1953	253.0	0.6500	0.6500
1962	246.0	0.6667	0.6667
1964	226.0	0.6833	0.6833
1991	224.0	0.7000	0.7000
1950	222.0	0.7167	0.7167
1987	220.0	0.7333	0.7333
1995	204.0	0.7500	0.7500
1986	193.0	0.7667	0.7667
1988	182.0	0.7833	0.7833
1982	178.0	0.8000	0.8000
1992	175.0	0.8167	0.8167
2009	172.0	0.8333	0.8333
1974	168.0	0.8500	0.8500
1956	167.0	0.8667	0.8667
1954	157.0	0.8833	0.8833

```
       1959           116.0          0.9000         0.9000
       1977           108.0          0.9167         0.9167
       1965           106.0          0.9333         0.9333
       2002            94.0          0.9500         0.9500
       1966            85.0          0.9667         0.9667
       1981            61.0          0.9833         0.9833
       1948          -310.0            --             --
       1963          -840.0            --             --
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      61


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01493000       USGS UNICORN BRANCH NEAR MILLINGTO


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:02

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1493500.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1493500.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:02

            Station - 01493500  MORGAN CREEK NEAR KENNEDYVILLE, MD


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

                Number of peaks in record           =       58
                Peaks not used in analysis          =        0
                Systematic peaks in analysis        =       58
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.685
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                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
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   2    6374.4
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.               26.6
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:02

            Station - 01493500  MORGAN CREEK NEAR KENNEDYVILLE, MD


          ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                LOGARITHMIC
                  ----------------------  ------------------------------
                             EXCEEDANCE                STANDARD
                   DISCHARGE PROBABILITY     MEAN      DEVIATION     SKEW
                  ------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     2.6144      0.4214      0.904
 BULL.17B ESTIMATE       0.0     1.0000     2.6144      0.4214      0.828
```

[redacted]

1493500.PRT

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	70.9	75.7	68.1	47.9	96.4
0.9900	78.1	82.5	75.4	53.6	105.1
0.9500	108.0	110.9	105.6	77.5	141.0
0.9000	133.5	135.3	131.3	98.5	171.3
0.8000	179.4	179.7	177.7	137.0	225.6
0.6667	246.6	244.9	245.5	194.1	305.7
0.5000	360.5	356.2	360.5	290.4	444.8
0.4292	428.0	422.6	428.9	346.5	529.7
0.2000	874.7	867.5	888.6	698.5	1136.0
0.1000	1506.0	1509.0	1559.0	1158.0	2088.0
0.0400	2866.0	2921.0	3071.0	2070.0	4362.0
0.0200	4502.0	4655.0	4991.0	3094.0	7358.0
0.0100	6926.0	7276.0	8002.0	4529.0	12150.0
0.0050	10490.0	11200.0	12720.0	6524.0	19730.0
0.0020	17810.0	19470.0	23330.0	10380.0	36700.0

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.003
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:02

Station - 01493500 MORGAN CREEK NEAR KENNEDYVILLE, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1951	208.0		1980	162.0	
1952	622.0		1981	440.0	
1953	428.0		1982	127.0	
1954	269.0		1983	672.0	
1955	630.0		1984	430.0	
1956	291.0		1985	736.0	
1957	293.0		1986	103.0	
1958	834.0		1987	297.0	
1959	446.0		1988	194.0	
1960	1530.0		1989	588.0	
1961	477.0		1990	359.0	
1962	198.0		1991	571.0	
1963	301.0		1992	174.0	
1964	160.0		1993	303.0	
1965	86.0		1994	743.0	
1966	129.0		1995	277.0	
1967	823.0		1996	936.0	
1968	397.0		1997	825.0	
1969	426.0		1998	356.0	
1970	340.0		1999	11200.0	
1971	760.0		2000	493.0	
1972	7500.0		2001	210.0	
1973	912.0		2002	54.0	
1974	466.0		2003	308.0	
1975	376.0		2004	2560.0	
1976	525.0		2005	280.0	
1977	86.0		2007	755.0	
1978	1430.0		2008	111.0	
1979	876.0		2009	163.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

```
-  Minus-flagged discharge -- Not used in computation
      -8888.0 -- No discharge value given
-  Minus-flagged water year -- Historic peak used in computation
```

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.004
Ver. 5.2              Annual peak flow frequency analysis     Run Date / Time
11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:02
```

Station - 01493500 MORGAN CREEK NEAR KENNEDYVILLE, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1999	11200.0	0.0169	0.0169
1972	7500.0	0.0339	0.0339
2004	2560.0	0.0508	0.0508
1960	1530.0	0.0678	0.0678
1978	1430.0	0.0847	0.0847
1996	936.0	0.1017	0.1017
1973	912.0	0.1186	0.1186
1979	876.0	0.1356	0.1356
1958	834.0	0.1525	0.1525
1997	825.0	0.1695	0.1695
1967	823.0	0.1864	0.1864
1971	760.0	0.2034	0.2034
2007	755.0	0.2203	0.2203
1994	743.0	0.2373	0.2373
1985	736.0	0.2542	0.2542
1983	672.0	0.2712	0.2712
1955	630.0	0.2881	0.2881
1952	622.0	0.3051	0.3051
1989	588.0	0.3220	0.3220
1991	571.0	0.3390	0.3390
1976	525.0	0.3559	0.3559
2000	493.0	0.3729	0.3729
1961	477.0	0.3898	0.3898
1974	466.0	0.4068	0.4068
1959	446.0	0.4237	0.4237
1981	440.0	0.4407	0.4407
1984	430.0	0.4576	0.4576
1953	428.0	0.4746	0.4746
1969	426.0	0.4915	0.4915
1968	397.0	0.5085	0.5085
1975	376.0	0.5254	0.5254
1990	359.0	0.5424	0.5424
1998	356.0	0.5593	0.5593
1970	340.0	0.5763	0.5763
2003	308.0	0.5932	0.5932
1993	303.0	0.6102	0.6102
1963	301.0	0.6271	0.6271
1987	297.0	0.6441	0.6441
1957	293.0	0.6610	0.6610
1956	291.0	0.6780	0.6780
2005	280.0	0.6949	0.6949
1995	277.0	0.7119	0.7119
1954	269.0	0.7288	0.7288
2001	210.0	0.7458	0.7458
1951	208.0	0.7627	0.7627
1962	198.0	0.7797	0.7797
1988	194.0	0.7966	0.7966
1992	174.0	0.8136	0.8136
2009	163.0	0.8305	0.8305
1980	162.0	0.8475	0.8475
1964	160.0	0.8644	0.8644
1966	129.0	0.8814	0.8814
1982	127.0	0.8983	0.8983
2008	111.0	0.9153	0.9153
1986	103.0	0.9322	0.9322
1965	86.0	0.9492	0.9492
1977	86.0	0.9661	0.9661
2002	54.0	0.9831	0.9831

```
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      58


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01493500       USGS MORGAN CREEK NEAR KENNEDYVILL


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

[redacted]

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.000.000
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:02

                           --- PROCESSING OPTIONS ---

                        Plot option         = Graphics device
                        Basin char output   = None
                        Print option        = Yes
                        Debug print         = No
                        Input peaks listing = Long
                        Input peaks format  = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1494000.TXT
                           specifications - PKFQWPSF.TMP

                        Output file(s):
                           main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1494000.PRT

1

  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.001
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:02

            Station - 01494000  SOUTHEAST CREEK AT CHURCH HILL, MD


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

                  Number of peaks in record          =       14
                  Peaks not used in analysis         =        1
                  Systematic peaks in analysis       =       13
                  Historic peaks in analysis         =        0
                  Years of historic record           =        0
                  Generalized skew                   =    0.694
                       Standard error                =    0.550
                       Mean Square error             =    0.303
                  Skew option                        =   WEIGHTED
                  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.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   13
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.      2007.1
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            123.0
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:02

            Station - 01494000  SOUTHEAST CREEK AT CHURCH HILL, MD


          ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE               LOGARITHMIC
                  ----------------------  -------------------------------
                              EXCEEDANCE              STANDARD
                   DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD       0.0      1.0000     2.6962     0.2788      0.623
 BULL.17B ESTIMATE       0.0      1.0000     2.6962     0.2788      0.664
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	141.4	138.0	119.7	68.3	212.7
0.9900	153.2	150.3	132.9	76.7	227.1
0.9500	197.7	195.9	182.1	110.2	280.6
0.9000	231.5	230.5	218.8	137.4	321.2
0.8000	286.6	286.6	277.4	183.8	388.5
0.6667	357.8	358.8	352.4	245.5	479.7
0.5000	463.0	465.0	463.0	335.8	626.9
0.4292	519.0	521.3	522.6	382.3	712.6
0.2000	826.8	828.9	867.7	611.8	1272.0
0.1000	1168.0	1167.0	1297.0	831.2	2039.0
0.0400	1745.0	1732.0	2161.0	1160.0	3613.0
0.0200	2304.0	2276.0	3193.0	1449.0	5411.0
0.0100	2997.0	2943.0	4783.0	1783.0	7955.0
0.0050	3853.0	3762.0	7312.0	2168.0	11520.0
0.0020	5297.0	5131.0	13350.0	2772.0	18470.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:02

Station - 01494000 SOUTHEAST CREEK AT CHURCH HILL, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1952	804.0		1959	328.0	
1953	413.0		1960	-8888.0	
1954	297.0		1961	620.0	
1955	990.0		1962	372.0	
1956	253.0		1963	428.0	
1957	1560.0		1964	313.0	
1958	1320.0		1965	218.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:02

Station - 01494000 SOUTHEAST CREEK AT CHURCH HILL, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER RANKED SYSTEMATIC BULL.17B

YEAR	DISCHARGE	RECORD	ESTIMATE
1957	1560.0	0.0714	0.0714
1958	1320.0	0.1429	0.1429
1955	990.0	0.2143	0.2143
1952	804.0	0.2857	0.2857
1961	620.0	0.3571	0.3571
1963	428.0	0.4286	0.4286
1953	413.0	0.5000	0.5000
1962	372.0	0.5714	0.5714
1959	328.0	0.6429	0.6429
1964	313.0	0.7143	0.7143
1954	297.0	0.7857	0.7857
1956	253.0	0.8571	0.8571
1965	218.0	0.9286	0.9286
1960	-8888.0	--	--

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      14
```

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01494000   USGS SOUTHEAST CREEK AT CHURCH HIL

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:02

                           --- PROCESSING OPTIONS ---

                        Plot option          = Graphics device
                        Basin char output    = None
                        Print option         = Yes
                        Debug print          = No
                        Input peaks listing  = Long
                        Input peaks format   = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1495000.TXT
                           specifications - PKFQWPSF.TMP

                        Output file(s):
                           main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1495000.PRT

1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:02

               Station - 01495000  BIG ELK CREEK AT ELK MILLS, MD

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

                Number of peaks in record           =       78
                Peaks not used in analysis          =        2
                Systematic peaks in analysis        =       76
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.673
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                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.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.        2
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   76
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                     0.0
    WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.        1        467.4
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.      17347.8
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:02

               Station - 01495000  BIG ELK CREEK AT ELK MILLS, MD

           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                          FLOOD BASE              LOGARITHMIC
                   ----------------------  ------------------------------
                               EXCEEDANCE             STANDARD
                    DISCHARGE PROBABILITY     MEAN    DEVIATION     SKEW
                   ------------------------------------------------------
 SYSTEMATIC RECORD        0.0     1.0000     3.4551     0.2688    -0.275
 BULL.17B ESTIMATE      467.4     0.9868     3.4623     0.2522     0.208
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	--	493.8	--	--	--
0.9900	--	597.1	--	--	--
0.9500	1156.0	984.0	1137.0	961.2	1344.0
0.9000	1397.0	1270.0	1382.0	1188.0	1600.0
0.8000	1770.0	1711.0	1760.0	1541.0	1996.0
0.6667	2222.0	2238.0	2217.0	1968.0	2484.0
0.5000	2842.0	2934.0	2842.0	2543.0	3173.0
0.4292	3153.0	3272.0	3156.0	2826.0	3530.0
0.2000	4695.0	4833.0	4725.0	4165.0	5388.0
0.1000	6175.0	6177.0	6254.0	5382.0	7285.0
0.0400	8345.0	7931.0	8544.0	7092.0	10210.0
0.0200	10190.0	9264.0	10530.0	8498.0	12790.0
0.0100	12230.0	10610.0	12790.0	10020.0	15740.0
0.0050	14490.0	11970.0	15370.0	11670.0	19100.0
0.0020	17870.0	13800.0	19330.0	14080.0	24270.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:02

Station - 01495000 BIG ELK CREEK AT ELK MILLS, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1884	-18000.0	H	1970	2640.0	
1932	3020.0		1971	4030.0	
1933	7530.0		1972	8720.0	
1934	2620.0		1973	2010.0	
1935	4720.0		1974	2040.0	
1936	-3250.0	G	1975	4540.0	
1937	10600.0		1976	1530.0	
1938	2310.0		1977	1670.0	
1939	2620.0		1978	5120.0	
1940	2700.0		1979	4250.0	
1941	5680.0		1980	853.0	
1942	3380.0		1981	2030.0	
1943	2860.0		1982	1740.0	
1944	2380.0		1983	1670.0	
1945	6030.0		1984	1480.0	
1946	7080.0		1985	5410.0	
1947	5220.0		1986	880.0	
1948	2120.0		1987	2180.0	
1949	1720.0		1988	4180.0	
1950	3400.0		1989	5030.0	
1951	2620.0		1990	2010.0	
1952	3280.0		1991	1360.0	
1953	2740.0		1992	1350.0	
1954	1340.0		1993	3980.0	
1955	5860.0		1994	5220.0	
1956	1540.0		1995	3090.0	
1957	2880.0		1996	7030.0	
1958	2590.0		1997	5110.0	
1959	3420.0		1998	1380.0	
1960	6180.0		1999	9780.0	
1961	1610.0		2000	4370.0	
1962	2180.0		2002	381.0	
1963	1620.0		2003	3570.0	
1964	3030.0		2004	5270.0	
1965	2020.0		2005	2360.0	
1966	3690.0		2006	2890.0	
1967	6120.0		2007	3220.0	
1968	1570.0		2008	1350.0	
1969	1050.0		2009	2290.0	

[redacted]

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY           Seq.001.004
Ver. 5.2             Annual peak flow frequency analysis   Run Date / Time
11/01/2007           following Bulletin 17-B Guidelines    08/06/2010 10:02

           Station - 01495000  BIG ELK CREEK AT ELK MILLS, MD
```

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1937	10600.0	0.0130	0.0130
1999	9780.0	0.0260	0.0260
1972	8720.0	0.0390	0.0390
1933	7530.0	0.0519	0.0519
1946	7080.0	0.0649	0.0649
1996	7030.0	0.0779	0.0779
1960	6180.0	0.0909	0.0909
1967	6120.0	0.1039	0.1039
1945	6030.0	0.1169	0.1169
1955	5860.0	0.1299	0.1299
1941	5680.0	0.1429	0.1429
1985	5410.0	0.1558	0.1558
2004	5270.0	0.1688	0.1688
1947	5220.0	0.1818	0.1818
1994	5220.0	0.1948	0.1948
1978	5120.0	0.2078	0.2078
1997	5110.0	0.2208	0.2208
1989	5030.0	0.2338	0.2338
1935	4720.0	0.2468	0.2468
1975	4540.0	0.2597	0.2597
2000	4370.0	0.2727	0.2727
1979	4250.0	0.2857	0.2857
1988	4180.0	0.2987	0.2987
1971	4030.0	0.3117	0.3117
1993	3980.0	0.3247	0.3247
1966	3690.0	0.3377	0.3377
2003	3570.0	0.3506	0.3506
1959	3420.0	0.3636	0.3636
1950	3400.0	0.3766	0.3766
1942	3380.0	0.3896	0.3896
1952	3280.0	0.4026	0.4026
2007	3220.0	0.4156	0.4156
1995	3090.0	0.4286	0.4286
1964	3030.0	0.4416	0.4416
1932	3020.0	0.4545	0.4545
2006	2890.0	0.4675	0.4675
1957	2880.0	0.4805	0.4805
1943	2860.0	0.4935	0.4935
1953	2740.0	0.5065	0.5065
1940	2700.0	0.5195	0.5195
1970	2640.0	0.5325	0.5325
1934	2620.0	0.5455	0.5455
1939	2620.0	0.5584	0.5584
1951	2620.0	0.5714	0.5714
1958	2590.0	0.5844	0.5844

1944	2380.0	0.5974	0.5974
2005	2360.0	0.6104	0.6104
1938	2310.0	0.6234	0.6234
2009	2290.0	0.6364	0.6364
1962	2180.0	0.6494	0.6494
1987	2180.0	0.6623	0.6623
1948	2120.0	0.6753	0.6753
1974	2040.0	0.6883	0.6883
1981	2030.0	0.7013	0.7013
1965	2020.0	0.7143	0.7143
1973	2010.0	0.7273	0.7273
1990	2010.0	0.7403	0.7403
1982	1740.0	0.7532	0.7532
1949	1720.0	0.7662	0.7662
1977	1670.0	0.7792	0.7792
1983	1670.0	0.7922	0.7922
1963	1620.0	0.8052	0.8052
1961	1610.0	0.8182	0.8182
1968	1570.0	0.8312	0.8312
1956	1540.0	0.8442	0.8442
1976	1530.0	0.8571	0.8571
1984	1480.0	0.8701	0.8701
1998	1380.0	0.8831	0.8831
1991	1360.0	0.8961	0.8961
1992	1350.0	0.9091	0.9091
2008	1350.0	0.9221	0.9221
1954	1340.0	0.9351	0.9351
1969	1050.0	0.9481	0.9481
1986	880.0	0.9610	0.9610
1980	853.0	0.9740	0.9740
2002	381.0	0.9870	0.9870
1936	-3250.0	--	--
1884	-18000.0	--	--

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 78

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01495000 USGS BIG ELK CREEK AT ELK MILLS, M

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

[redacted]

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2               Annual peak flow frequency analysis     Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines      08/06/2010 10:02

                            --- PROCESSING OPTIONS ---

                         Plot option         = Graphics device
                         Basin char output   = None
                         Print option        = Yes
                         Debug print         = No
                         Input peaks listing = Long
                         Input peaks format  = WATSTORE peak file

                         Input files used:
                            peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1495500.TXT
                            specifications - PKFQWPSF.TMP

                         Output file(s):
                            main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1495500.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2               Annual peak flow frequency analysis     Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines      08/06/2010 10:02

              Station - 01495500  LITTLE ELK CREEK AT CHILDS, MD


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

               Number of peaks in record           =       12
               Peaks not used in analysis          =        2
               Systematic peaks in analysis        =       10
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =    0.672
                    Standard error                 =    0.550
                    Mean Square error              =    0.303
               Skew option                         =   WEIGHTED
               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.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       2
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   10
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                    0.0
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1    4392.7
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           740.9
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2               Annual peak flow frequency analysis     Run Date / Time
  11/01/2007             following Bulletin 17-B Guidelines      08/06/2010 10:02

              Station - 01495500  LITTLE ELK CREEK AT CHILDS, MD

           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                          FLOOD BASE                  LOGARITHMIC
                    ----------------------  ------------------------------
                               EXCEEDANCE              STANDARD
                     DISCHARGE PROBABILITY     MEAN    DEVIATION     SKEW
                    ------------------------------------------------------
 SYSTEMATIC RECORD        0.0     1.0000     3.2563     0.1898      1.967
 BULL.17B ESTIMATE        0.0     1.0000     3.2563     0.1898      0.937
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	851.7	1160.0	778.7	489.0	1138.0
0.9900	883.6	1163.0	812.5	517.5	1172.0
0.9500	1005.0	1186.0	948.2	629.5	1303.0
0.9000	1096.0	1216.0	1051.0	717.5	1404.0
0.8000	1242.0	1283.0	1211.0	861.8	1570.0
0.6667	1426.0	1392.0	1408.0	1045.0	1790.0
0.5000	1687.0	1581.0	1687.0	1300.0	2137.0
0.4292	1821.0	1690.0	1832.0	1425.0	2335.0
0.2000	2520.0	2361.0	2639.0	2001.0	3574.0
0.1000	3240.0	3192.0	3597.0	2498.0	5170.0
0.0400	4377.0	4750.0	5477.0	3188.0	8223.0
0.0200	5415.0	6413.0	7712.0	3761.0	11500.0
0.0100	6641.0	8656.0	11200.0	4393.0	15930.0
0.0050	8092.0	11680.0	16900.0	5096.0	21860.0
0.0020	10430.0	17350.0	31360.0	6153.0	32870.0

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.003
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:02

Station - 01495500 LITTLE ELK CREEK AT CHILDS, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1949	1120.0		1955	5400.0	
1950	1700.0		1956	1520.0	
1951	1540.0		1957	1890.0	
1952	2420.0		1958	1620.0	
1953	1600.0		1989	-2370.0	H
1954	1280.0		1999	-8700.0	H

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.004
Ver. 5.2　　Annual peak flow frequency analysis　　Run Date / Time
11/01/2007　　following Bulletin 17-B Guidelines　　08/06/2010 10:02

Station - 01495500 LITTLE ELK CREEK AT CHILDS, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE

```
       1955        5400.0         0.0909         0.0909
       1952        2420.0         0.1818         0.1818
       1957        1890.0         0.2727         0.2727
       1950        1700.0         0.3636         0.3636
       1958        1620.0         0.4545         0.4545
       1953        1600.0         0.5455         0.5455
       1951        1540.0         0.6364         0.6364
       1956        1520.0         0.7273         0.7273
       1954        1280.0         0.8182         0.8182
       1949        1120.0         0.9091         0.9091
       1989       -2370.0           --             --
       1999       -8700.0           --             --
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      12


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01495500       USGS LITTLE ELK CREEK AT CHILDS, M


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:03

                           --- PROCESSING OPTIONS ---

                        Plot option          = Graphics device
                        Basin char output    = None
                        Print option         = Yes
                        Debug print          = No
                        Input peaks listing  = Long
                        Input peaks format   = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1496000.TXT
                           specifications - PKFQWPSF.TMP

                        Output file(s):
                           main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1496000.PRT

1


  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:03

               Station - 01496000  NORTHEAST CREEK AT LESLIE, MD


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

                Number of peaks in record           =       37
                Peaks not used in analysis          =        1
                Systematic peaks in analysis        =       36
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.670
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                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.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   36
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            412.2
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.      5944.3
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines       08/06/2010 10:03

               Station - 01496000  NORTHEAST CREEK AT LESLIE, MD

           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                  LOGARITHMIC
                  ----------------------  -------------------------------
                              EXCEEDANCE                 STANDARD
                   DISCHARGE PROBABILITY     MEAN     DEVIATION      SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD        0.0     1.0000     3.1946      0.2196      0.382
 BULL.17B ESTIMATE        0.0     1.0000     3.1946      0.2196      0.486
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	535.7	510.1	506.4	395.2	666.0
0.9900	579.6	557.3	553.3	434.8	713.4
0.9500	734.9	722.5	716.5	578.1	879.1
0.9000	845.5	838.9	831.2	682.5	996.8
0.8000	1015.0	1016.0	1006.0	844.4	1179.0
0.6667	1221.0	1228.0	1216.0	1040.0	1405.0
0.5000	1503.0	1516.0	1503.0	1302.0	1729.0
0.4292	1645.0	1660.0	1648.0	1431.0	1899.0
0.2000	2357.0	2367.0	2387.0	2033.0	2824.0
0.1000	3055.0	3044.0	3136.0	2578.0	3820.0
0.0400	4104.0	4039.0	4317.0	3347.0	5437.0
0.0200	5018.0	4889.0	5407.0	3986.0	6938.0
0.0100	6057.0	5836.0	6715.0	4687.0	8727.0
0.0050	7237.0	6895.0	8296.0	5459.0	10850.0
0.0020	9051.0	8489.0	10930.0	6604.0	14280.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:03

Station - 01496000 NORTHEAST CREEK AT LESLIE, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1949	1340.0		1968	912.0	
1950	1640.0		1969	1440.0	
1951	1460.0		1970	1770.0	
1952	2410.0		1971	2040.0	
1953	1870.0		1972	4800.0	
1954	834.0		1973	1560.0	
1955	2590.0		1974	2120.0	
1956	858.0		1975	3410.0	
1957	1850.0		1976	893.0	
1958	3220.0		1977	1120.0	
1959	1210.0		1978	3140.0	
1960	2790.0		1979	2190.0	
1961	1020.0		1980	689.0	
1962	838.0		1981	930.0	
1963	814.0		1982	1120.0	
1964	1020.0		1983	1480.0	
1965	1050.0		1984	1660.0	
1966	2000.0		1999	-9000.0	H
1967	4060.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

```
Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.004
Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:03

             Station - 01496000  NORTHEAST CREEK AT LESLIE, MD
```

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1972	4800.0	0.0270	0.0270
1967	4060.0	0.0541	0.0541
1975	3410.0	0.0811	0.0811
1958	3220.0	0.1081	0.1081
1978	3140.0	0.1351	0.1351
1960	2790.0	0.1622	0.1622
1955	2590.0	0.1892	0.1892
1952	2410.0	0.2162	0.2162
1979	2190.0	0.2432	0.2432
1974	2120.0	0.2703	0.2703
1971	2040.0	0.2973	0.2973
1966	2000.0	0.3243	0.3243
1953	1870.0	0.3514	0.3514
1957	1850.0	0.3784	0.3784
1970	1770.0	0.4054	0.4054
1984	1660.0	0.4324	0.4324
1950	1640.0	0.4595	0.4595
1973	1560.0	0.4865	0.4865
1983	1480.0	0.5135	0.5135
1951	1460.0	0.5405	0.5405
1969	1440.0	0.5676	0.5676
1949	1340.0	0.5946	0.5946
1959	1210.0	0.6216	0.6216
1977	1120.0	0.6486	0.6486
1982	1120.0	0.6757	0.6757
1965	1050.0	0.7027	0.7027
1961	1020.0	0.7297	0.7297
1964	1020.0	0.7568	0.7568
1981	930.0	0.7838	0.7838
1968	912.0	0.8108	0.8108
1976	893.0	0.8378	0.8378
1956	858.0	0.8649	0.8649
1962	838.0	0.8919	0.8919
1954	834.0	0.9189	0.9189
1963	814.0	0.9459	0.9459
1980	689.0	0.9730	0.9730
1999	-9000.0	--	--

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      37

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01496000       USGS NORTHEAST CREEK AT LESLIE, MD


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

[redacted]

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:03

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1496080.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1496080.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:03

       Station - 01496080  NORTHEAST RIVER TRIBUTARY NEAR CHARLESTOWN, MD


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

                Number of peaks in record           =       10
                Peaks not used in analysis          =        0
                Systematic peaks in analysis        =       10
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.671
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                Gage base discharge                 =    125.0
                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.  *********

    WCF133I-SYSTEMATIC PEAKS BELOW GAGE BASE WERE NOTED.         2    125.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            126.9
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       958.8
1

  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       08/06/2010 10:03

       Station - 01496080  NORTHEAST RIVER TRIBUTARY NEAR CHARLESTOWN, MD


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                         FLOOD BASE                  LOGARITHMIC
                  ----------------------  -------------------------------
                             EXCEEDANCE              STANDARD
                   DISCHARGE PROBABILITY     MEAN    DEVIATION     SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD     125.0      0.8000    2.4565      0.2829    -0.448
 BULL.17B ESTIMATE     125.0      0.8000    2.4565      0.2829     0.253
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.8000	--	168.5	--	--	--
0.6667	211.5	225.4	206.8	135.4	296.9
0.5000	278.4	300.3	278.4	191.8	400.2
0.4292	312.8	336.4	315.7	219.6	460.0
0.2000	490.3	499.6	520.2	346.6	839.3
0.1000	669.6	635.0	757.1	456.1	1329.0
0.0400	945.1	804.5	1203.0	604.9	2254.0
0.0200	1189.0	927.9	1704.0	724.8	3228.0
0.0100	1468.0	1048.0	2437.0	853.2	4505.0
0.0050	1787.0	1165.0	3542.0	991.5	6161.0
0.0020	2280.0	1316.0	6020.0	1192.0	9092.0

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.003
Ver. 5.2 — Annual peak flow frequency analysis — Run Date / Time
11/01/2007 — following Bulletin 17-B Guidelines — 08/06/2010 10:03

Station - 01496080 NORTHEAST RIVER TRIBUTARY NEAR CHARLESTOWN, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1967	260.0		1972	615.0	
1968	125.0	L	1973	150.0	
1969	125.0	L	1974	215.0	
1970	480.0		1975	700.0	
1971	395.0		1976	320.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.004
Ver. 5.2 — Annual peak flow frequency analysis — Run Date / Time
11/01/2007 — following Bulletin 17-B Guidelines — 08/06/2010 10:03

Station - 01496080 NORTHEAST RIVER TRIBUTARY NEAR CHARLESTOWN, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1975	700.0	0.0909	0.0909
1972	615.0	0.1818	0.1818
1970	480.0	0.2727	0.2727
1971	395.0	0.3636	0.3636
1976	320.0	0.4545	0.4545
1967	260.0	0.5455	0.5455
1974	215.0	0.6364	0.6364

[redacted]

```
      1973          150.0         0.7273         0.7273
      1968          125.0           --             --
      1969          125.0           --             --
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      10


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01496080       USGS NORTHEAST RIVER TRIBUTARY NEA


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

[redacted]

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis     Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines      08/06/2010 10:03

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1496200.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1496200.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis     Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines      08/06/2010 10:03

         Station - 01496200  PRINCIPIO CREEK NEAR PRINCIPIO FURNACE, MD


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

                Number of peaks in record           =       27
                Peaks not used in analysis          =        1
                Systematic peaks in analysis        =       26
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =    0.665
                     Standard error                 =    0.550
                     Mean Square error              =    0.303
                Skew option                         =   WEIGHTED
                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.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   26
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            150.4
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.      7739.9
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1

  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis     Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines      08/06/2010 10:03

         Station - 01496200  PRINCIPIO CREEK NEAR PRINCIPIO FURNACE, MD

           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                          FLOOD BASE                LOGARITHMIC
                   ----------------------  -------------------------------
                              EXCEEDANCE               STANDARD
                    DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                   -------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     3.0330      0.3420      0.257
 BULL.17B ESTIMATE       0.0     1.0000     3.0330      0.3420      0.426
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	194.3	171.6	170.0	107.2	289.2
0.9900	221.5	200.7	198.6	126.6	323.4
0.9500	327.1	313.7	308.8	206.2	452.6
0.9000	410.4	402.9	394.9	272.7	552.8
0.8000	550.0	551.7	538.5	388.4	721.1
0.6667	736.6	748.5	729.6	546.0	951.3
0.5000	1021.0	1043.0	1021.0	783.1	1321.0
0.4292	1175.0	1201.0	1180.0	908.5	1535.0
0.2000	2049.0	2069.0	2105.0	1567.0	2884.0
0.1000	3047.0	3018.0	3223.0	2244.0	4660.0
0.0400	4773.0	4581.0	5319.0	3315.0	8146.0
0.0200	6468.0	6048.0	7586.0	4294.0	11960.0
0.0100	8584.0	7810.0	10700.0	5449.0	17150.0
0.0050	11210.0	9915.0	15020.0	6812.0	24130.0
0.0020	15660.0	13320.0	23460.0	8991.0	37050.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:03

Station - 01496200 PRINCIPIO CREEK NEAR PRINCIPIO FURNACE, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1967	4260.0		1981	1270.0	
1968	634.0		1982	759.0	
1969	7060.0		1983	1060.0	
1970	896.0		1984	1850.0	
1971	1260.0		1985	1610.0	
1972	3020.0		1986	177.0	
1973	1210.0		1987	1010.0	
1974	934.0		1988	932.0	
1975	3050.0		1989	850.0	
1976	741.0		1990	660.0	
1977	745.0		1991	631.0	
1978	2120.0		1992	386.0	
1979	1150.0		1999	-3430.0	H
1980	345.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 08/06/2010 10:03

Station - 01496200 PRINCIPIO CREEK NEAR PRINCIPIO FURNACE, MD

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1969	7060.0	0.0370	0.0370
1967	4260.0	0.0741	0.0741
1975	3050.0	0.1111	0.1111
1972	3020.0	0.1481	0.1481
1978	2120.0	0.1852	0.1852
1984	1850.0	0.2222	0.2222
1985	1610.0	0.2593	0.2593
1981	1270.0	0.2963	0.2963
1971	1260.0	0.3333	0.3333
1973	1210.0	0.3704	0.3704
1979	1150.0	0.4074	0.4074
1983	1060.0	0.4444	0.4444
1987	1010.0	0.4815	0.4815
1974	934.0	0.5185	0.5185
1988	932.0	0.5556	0.5556
1970	896.0	0.5926	0.5926
1989	850.0	0.6296	0.6296
1982	759.0	0.6667	0.6667
1977	745.0	0.7037	0.7037
1976	741.0	0.7407	0.7407
1990	660.0	0.7778	0.7778
1968	634.0	0.8148	0.8148
1991	631.0	0.8519	0.8519
1992	386.0	0.8889	0.8889
1980	345.0	0.9259	0.9259
1986	177.0	0.9630	0.9630
1999	-3430.0	--	--

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 27

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 01496200 USGS PRINCIPIO CREEK NEAR PRINCIPI

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:03

                           --- PROCESSING OPTIONS ---

                        Plot option         = Graphics device
                        Basin char output   = None
                        Print option        = Yes
                        Debug print         = No
                        Input peaks listing = Long
                        Input peaks format  = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1578500.TXT
                           specifications - PKFQWPSF.TMP

                        Output file(s):
                           main - C:\DOCUMENTS AND SETTINGS\DHABETE\DESKTOP\PEAK
Q\1578500.PRT

1

  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:03

             Station - 01578500  OCTORARO CREEK NEAR RISING SUN, MD


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

               Number of peaks in record           =       44
               Peaks not used in analysis          =       25
               Systematic peaks in analysis        =       19
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =    0.652
                    Standard error                 =    0.550
                    Mean Square error              =    0.303
               Skew option                         =   WEIGHTED
               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.  *********

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.      25
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   19
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     45012.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            656.0
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1

  Program PeakFq          U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis      Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines      08/06/2010 10:03

             Station - 01578500  OCTORARO CREEK NEAR RISING SUN, MD

           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                             FLOOD BASE                LOGARITHMIC
                      ----------------------  ------------------------------
                                 EXCEEDANCE              STANDARD
                       DISCHARGE PROBABILITY     MEAN    DEVIATION     SKEW
                      ------------------------------------------------------
 SYSTEMATIC RECORD        0.0      1.0000      3.7351     0.3889      0.679
 BULL.17B ESTIMATE        0.0      1.0000      3.7351     0.3889      0.665
```

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	941.9	952.6	808.3	436.2	1530.0
0.9900	1054.0	1064.0	924.5	506.0	1680.0
0.9500	1503.0	1509.0	1393.0	806.0	2273.0
0.9000	1873.0	1877.0	1777.0	1071.0	2755.0
0.8000	2522.0	2522.0	2447.0	1559.0	3602.0
0.6667	3438.0	3433.0	3389.0	2272.0	4828.0
0.5000	4924.0	4914.0	4924.0	3433.0	6950.0
0.4292	5775.0	5763.0	5812.0	4082.0	8252.0
0.2000	11060.0	11040.0	11570.0	7777.0	17650.0
0.1000	17900.0	17910.0	19710.0	11980.0	32480.0
0.0400	31350.0	31460.0	38050.0	19310.0	67700.0
0.0200	46210.0	46490.0	61880.0	26620.0	113600.0
0.0100	66690.0	67260.0	100800.0	35930.0	186100.0
0.0050	94690.0	95770.0	165600.0	47730.0	299000.0
0.0020	147700.0	149900.0	325900.0	68250.0	546600.0

1

Program PeakFq	U. S. GEOLOGICAL SURVEY	Seq.001.003
Ver. 5.2	Annual peak flow frequency analysis	Run Date / Time
11/01/2007	following Bulletin 17-B Guidelines	08/06/2010 10:03

Station - 01578500 OCTORARO CREEK NEAR RISING SUN, MD

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1884	-60000.0	H	1952	-9240.0	K
1918	-27700.0	H	1953	-6400.0	K
1932	980.0		1954	-1930.0	K
1933	34500.0		1955	-7960.0	K
1934	2910.0		1956	-2090.0	K
1935	17200.0		1957	-1450.0	K
1936	9340.0		1958	-6870.0	K
1937	2280.0		1963	-7370.0	H
1938	5970.0		1965	-568.0	K
1939	4250.0		1966	-1980.0	K
1940	5080.0		1967	-6870.0	K
1941	3630.0		1968	-2220.0	K
1942	35000.0		1969	-1580.0	K
1943	2780.0		1970	-2830.0	K
1944	8300.0		1971	-11800.0	K
1945	7820.0		1972	-29000.0	K
1946	5900.0		1973	-4880.0	K
1947	3550.0		1974	-5460.0	K
1948	4040.0		1975	-17300.0	K
1949	3550.0		1976	-6250.0	K
1950	2900.0		1977	-2950.0	K
1951	-5600.0	K	1999	-24600.0	H

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS 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

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

```
 Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.001.004
 Ver. 5.2             Annual peak flow frequency analysis      Run Date / Time
 11/01/2007           following Bulletin 17-B Guidelines       08/06/2010 10:03

           Station - 01578500  OCTORARO CREEK NEAR RISING SUN, MD
```

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1942	35000.0	0.0500	0.0500
1933	34500.0	0.1000	0.1000
1935	17200.0	0.1500	0.1500
1936	9340.0	0.2000	0.2000
1944	8300.0	0.2500	0.2500
1945	7820.0	0.3000	0.3000
1938	5970.0	0.3500	0.3500
1946	5900.0	0.4000	0.4000
1940	5080.0	0.4500	0.4500
1939	4250.0	0.5000	0.5000
1948	4040.0	0.5500	0.5500
1941	3630.0	0.6000	0.6000
1947	3550.0	0.6500	0.6500
1949	3550.0	0.7000	0.7000
1934	2910.0	0.7500	0.7500
1950	2900.0	0.8000	0.8000
1943	2780.0	0.8500	0.8500
1937	2280.0	0.9000	0.9000
1932	980.0	0.9500	0.9500
1965	-568.0	--	--
1957	-1450.0	--	--
1969	-1580.0	--	--
1954	-1930.0	--	--
1966	-1980.0	--	--
1956	-2090.0	--	--
1968	-2220.0	--	--
1970	-2830.0	--	--
1977	-2950.0	--	--
1973	-4880.0	--	--
1974	-5460.0	--	--
1951	-5600.0	--	--
1976	-6250.0	--	--
1953	-6400.0	--	--
1958	-6870.0	--	--
1967	-6870.0	--	--
1963	-7370.0	--	--
1955	-7960.0	--	--
1952	-9240.0	--	--
1971	-11800.0	--	--
1975	-17300.0	--	--
1999	-24600.0	--	--
1918	-27700.0	--	--
1972	-29000.0	--	--
1884	-60000.0	--	--

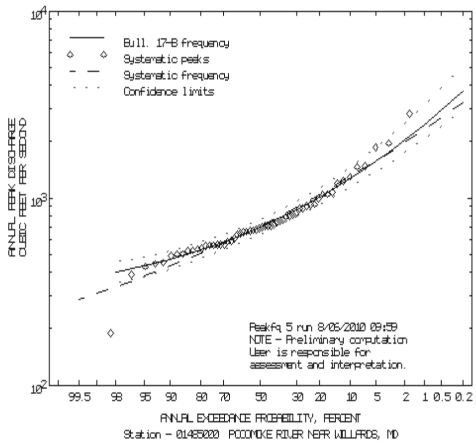
1

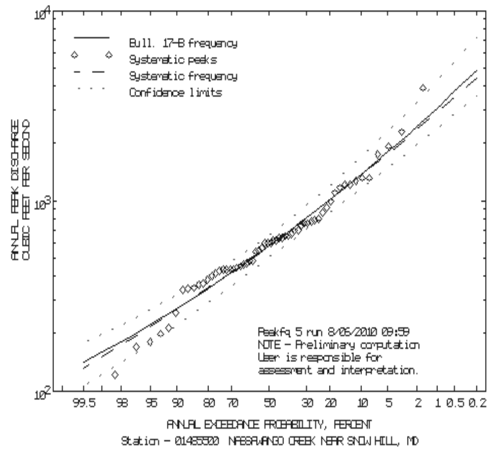
```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      44

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01578500       USGS OCTORARO CREEK NEAR RISING SU
```

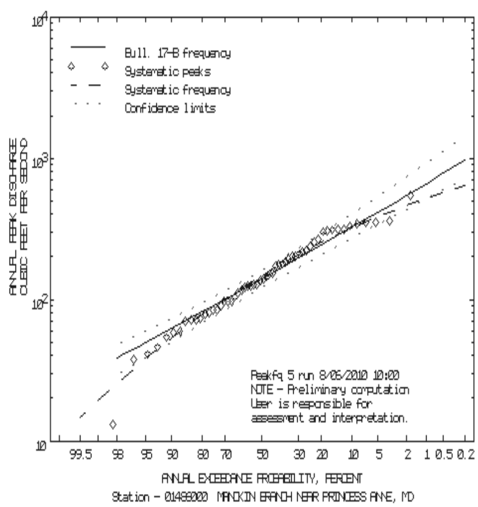
For the station below, the following records were ignored:

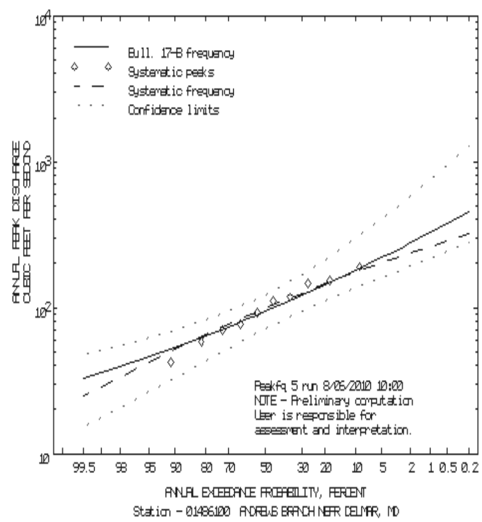
FINISHED PROCESSING STATION:

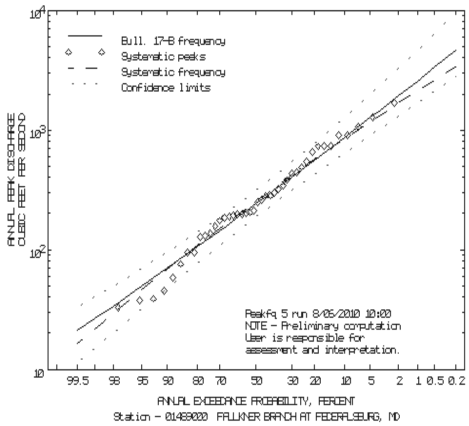
Appendix B: Annual peak flow frequency analyses curve for systematic records and Bulletin 17B estimates (the points can be seen in appendix A outputs).

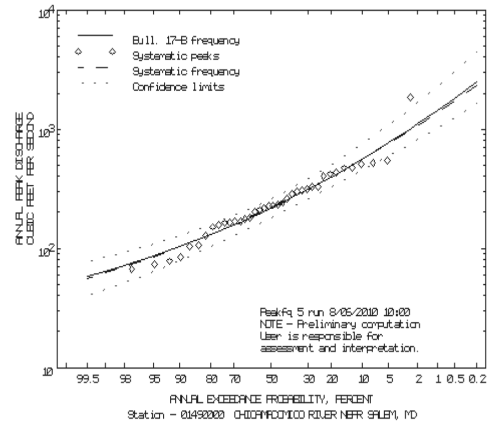


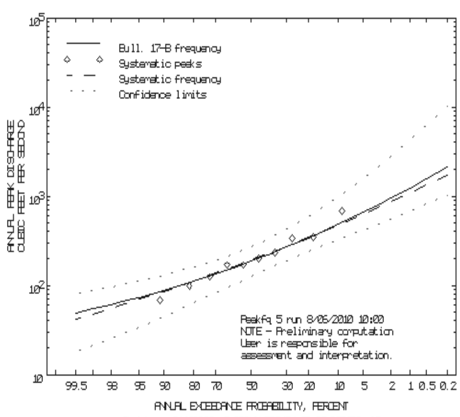


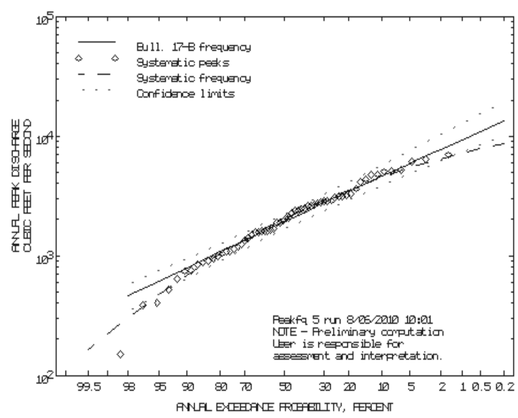




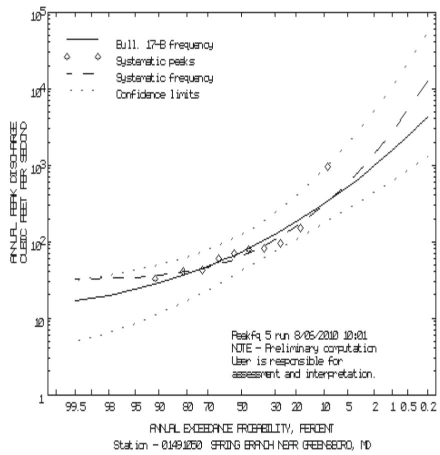

Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE, CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:00
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01489000 FAULKNER BRANCH AT FEDERALSBURG, MD

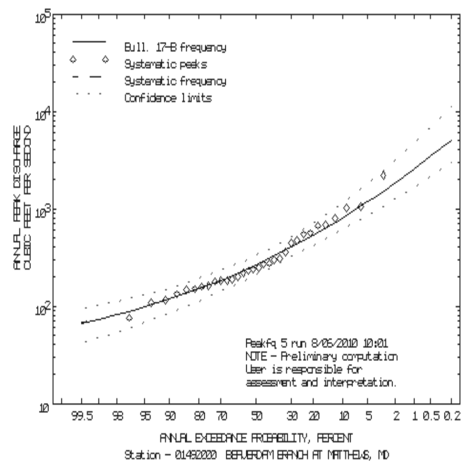

Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE, CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:00
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01490000 CHICAMACOMICO RIVER NEAR SALEM, MD

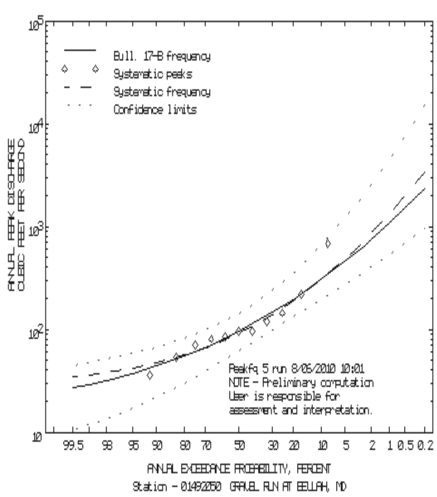

Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE, CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:00
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01490800 OLDTOWN BRANCH AT GOLDSBORO, MD

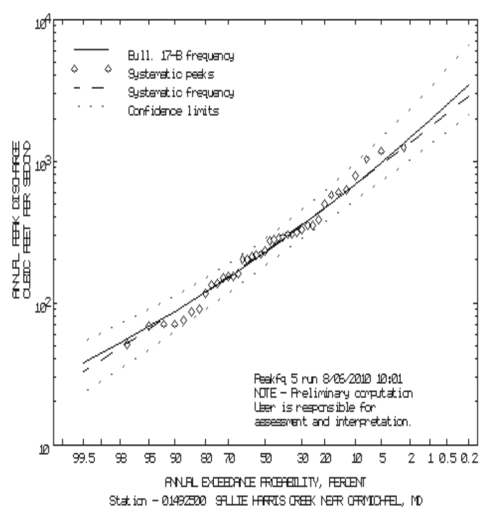

Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE, CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:01
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01491000 CHOPTANK RIVER NEAR GREENSBORO, MD

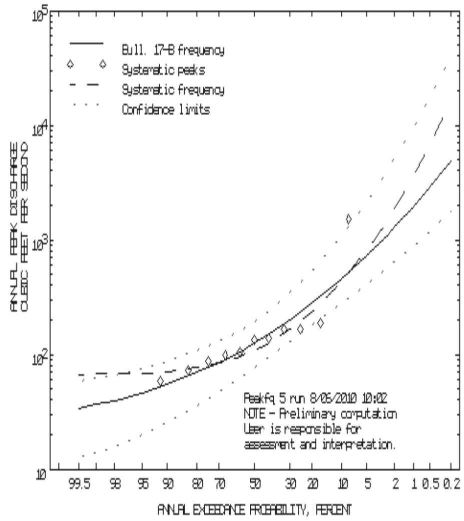
[redacted]


Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:01
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01491050 SPRING BRANCH NEAR GREENSBORO, MD

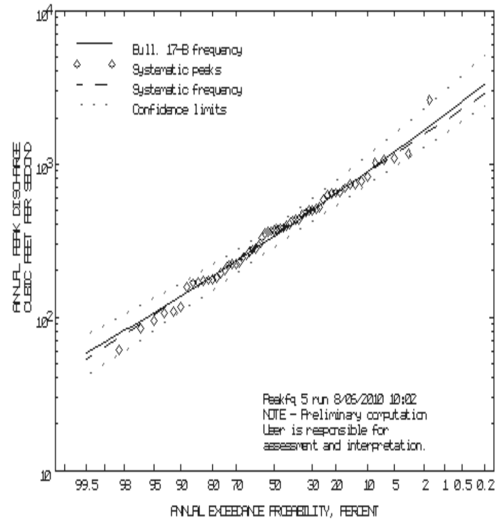

Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:01
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01492000 BEAVERDAM BRANCH AT MATTHEWS, MD


Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:01
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01492050 GRAVEL RUN AT BEULAH, MD

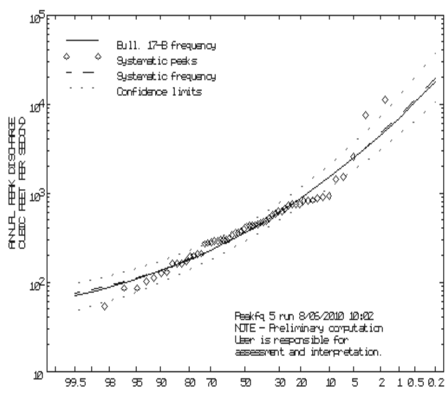

Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:01
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01492500 SALLIE HARRIS CREEK NEAR CARMICHAEL, MD



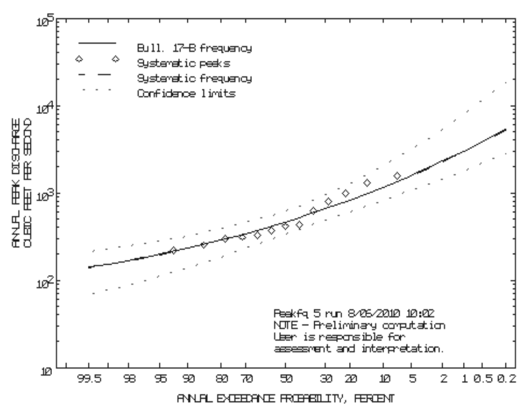
Station - 01492550 MILL CREEK NEAR SKIPTON, MD



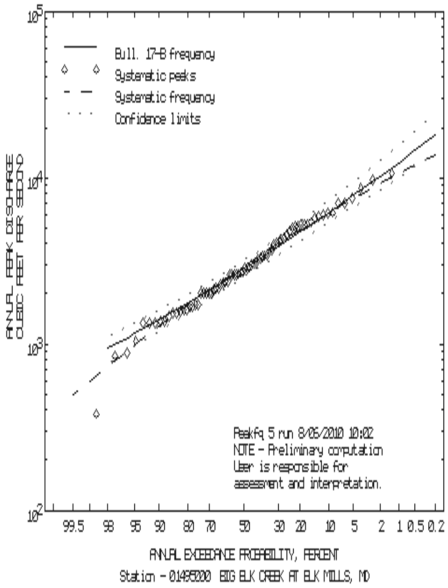
Station - 01493000 UNICORN BRANCH NEAR MILLINGTON, MD

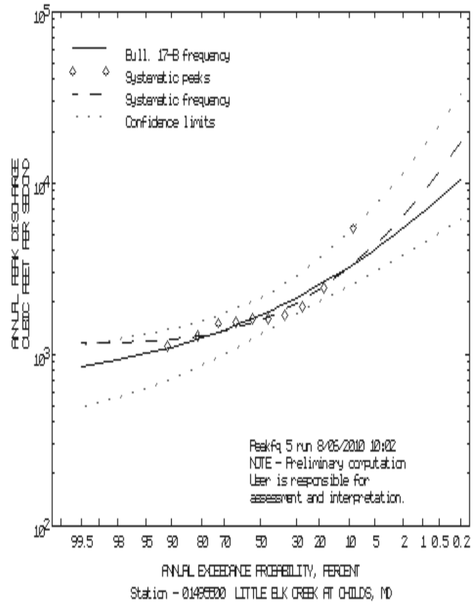


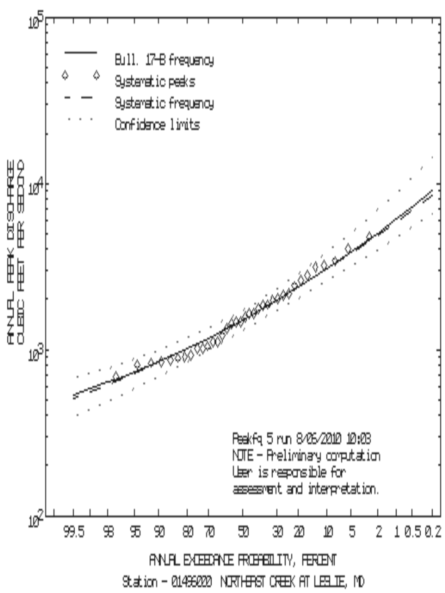
Station - 01493500 MORGAN CREEK NEAR KENNEDYVILLE, MD

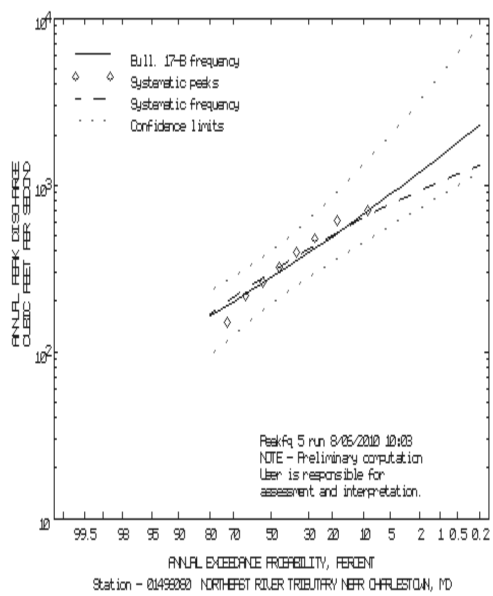


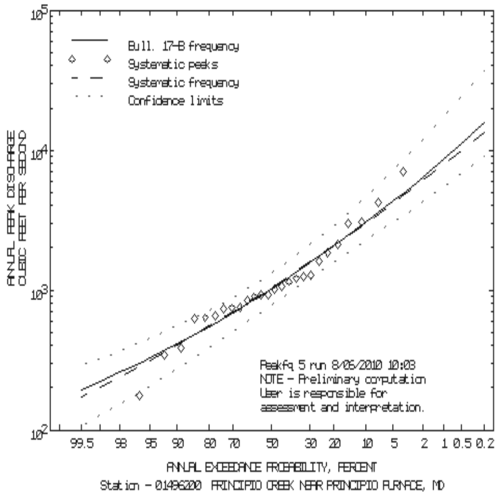
Station - 01494000 SOUTHEAST CREEK AT CHURCH HILL, MD

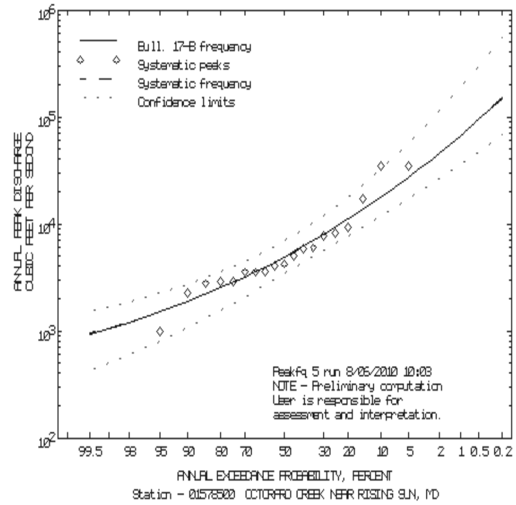

Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE, CUBIC FEET PER SECOND
Peakfq 5 run 8/05/2010 10:02
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01495000 BIG ELK CREEK AT ELK MILLS, MD


Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE, CUBIC FEET PER SECOND
Peakfq 5 run 8/05/2010 10:02
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01495500 LITTLE ELK CREEK AT CHILDS, MD


Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE, CUBIC FEET PER SECOND
Peakfq 5 run 8/05/2010 10:03
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01496000 NORTHEAST CREEK AT LESLIE, MD


Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE, CUBIC FEET PER SECOND
Peakfq 5 run 8/05/2010 10:03
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01496080 NORTHEAST RIVER TRIBUTARY NEAR CHARLESTOWN, MD


Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE
CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:03
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
99.5 98 95 90 80 70 50 30 20 10 5 2 1 0.5 0.2
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01496200 PRINCIPIO CREEK NEAR PRINCIPIO FURNACE, MD


Bull. 17-B frequency
Systematic peaks
Systematic frequency
Confidence limits
ANNUAL PEAK DISCHARGE
CUBIC FEET PER SECOND
Peakfq 5 run 8/06/2010 10:03
NOTE - Preliminary computation
User is responsible for
assessment and interpretation.
99.5 98 95 90 80 70 50 30 20 10 5 2 1 0.5 0.2
ANNUAL EXCEEDANCE PROBABILITY, PERCENT
Station - 01578500 OCTORARO CREEK NEAR RISING SUN, MD

Appendix C: Outlier test K value

The Values on the table below contains 10-percent significant level K values used in the outlier test.

Sample Size	KN Value	Sample Size	KN Value	Sample Size	KN Value	Sample Size	KN Value
10	2.036	45	2.727	80	2.940	115	3.064
11	2.088	46	2.736	81	2.945	116	3.067
12	2.134	47	2.744	82	2.949	117	3.070
13	2.175	48	2.753	83	2.953	118	3.073
14	2.213	49	2.760	84	2.957	119	3.075
15	2.247	50	2.768	85	2.961	120	3.078
16	2.279	51	2.775	86	2.966	121	3.081
17	2.309	52	2.783	87	2.970	122	3.083
18	2.335	53	2.790	88	2.973	123	3.086
19	2.361	54	2.798	89	2.977	124	3.089
20	2.385	55	2.804	90	2.981	125	3.092
21	2.408	56	2.811	91	2.984	126	3.095
22	2.429	57	2.818	92	2.989	127	3.097
23	2.448	58	2.824	93	2.993	128	3.100
24	2.467	59	2.831	94	2.996	129	3.102
25	2.486	60	2.837	95	3.000	130	3.104
26	2.502	61	2.842	96	3.003	131	3.107
27	2.519	62	2.849	97	3.006	132	3.109
28	2.534	63	2.854	98	3.011	133	3.112
29	2.549	64	2.860	99	3.014	134	3.114
30	2.563	65	2.866	100	3.017	135	3.116
31	2.577	66	2.871	101	3.021	136	3.119
32	2.591	67	2.877	102	3.024	137	3.122
33	2.604	68	2.883	103	3.027	138	3.124
34	2.616	69	2.888	104	3.030	139	3.126
35	2.628	70	2.893	105	3.033	140	3.129
36	2.639	71	2.897	106	3.037	141	3.131
37	2.650	72	2.903	107	3.040	142	3.133
38	2.661	73	2.908	108	3.043	143	3.135
39	2.671	74	2.912	109	3.046	144	3.138
40	2.682	75	2.917	110	3.049	145	3.140
41	2.692	76	2.922	111	3.052	146	3.142

42	2.700	77	2.927	112	3.055	147	3.144
43	2.710	78	2.931	113	3.058	148	3.146
44	2.719	79	2.935	114	3.061	149	3.148

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