Illinois Institute of Natural Resources

State Water Survey Division

GROUNDWATER SECTION

SWS Contract Report 246

GROUNDWATER DISCHARGE TO ILLINOIS STREAMS

by

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Prepared for the
Illinois Environmental Protection Agency

under

CONTRACT NO. 1-47-26-84-362

Champaign, Illinois
December 1980

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ABSTRACT

Groundwater contribution to streamflow in the form of base flow was estimated for 78 drainage basins in Illinois using the graphical hydrograph separation technique applied by Walton [1965] in a precursory investigation. Base flow probability distributions were determined for each basin during high streamflows (10% flow-duration), median streamflows (50% flow-duration), and low streamflows (90% flow-duration) based on the analysis of the most recent 10 to 20 years of historical records. The results were presented in the form of $\log_{10}$-probability curves defining the base flow probability distribution for each basin over the range of streamflows from the 10% flow to the 90% flow. The statewide distributions of median base flow values at each of the three flows studied were mapped and regional divisions were drawn. Median base flow per square mile of drainage area generally increases from the southwest to the northeast at all three flow-durations. Highest values were found in the heavily urbanized Chicago metropolitan area and the driftless area in extreme southern Illinois. Lowest values generally coincided with the "claypan" area in the southwest and south-central parts of the state. Numerous factors exert their effects on the regional distribution of base flow including but not limited to land use, point source discharges, surficial soil permeability, basin topography, and climatology.

INTRODUCTION

It is a popular albeit mistaken notion that surface water and groundwater are distinct entities separated by an imaginary barrier at the land-water interface. While it may be convenient to consider water which is visible apart from that which is hidden from sight, the water itself does not recognize this division. Driven by the force of gravity, water continually moves between the land surface and the subsurface environments. Our knowledge of this process is limited by the large number of interdependent factors involved. A better understanding of these factors and their effects is needed if we are to effectively manage our water resources in a comprehensive manner. This study addresses the problem by quantifying the groundwater contribution to streamflow over a large range of discharges for 78 watersheds in Illinois. Quantification is the first step toward understanding the dynamics of this complex phenomenon.

In a precursory investigation, Walton [1965] studied the relationship between annual precipitation and groundwater runoff in Illinois on a statewide basis. The effects of basin characteristics on groundwater discharges were determined for years representing "above average," "near average," and "below average" precipitation. The results of that study were presented in the form of maps indicating the areal distribution of annual groundwater runoff for each climatic condition.

The purpose of this study is to more accurately define the quantity and quality of groundwater runoff, or base flow, for a range of streamflow rates, basin sizes, and regions of the state. It also is intended to provide information needed to advance the decision-making process with respect to the management of both surface water and groundwater supplies in Illinois. The data will be helpful in developing our understanding of the effects of point and non-point discharges on surface water quality by providing reasonable estimates of groundwater discharge that can be applied to mass-balance equations or pollutant dispersion models.

The specific objectives of this project are to:

1) Develop probability curves for total flow and base flow at 78 gaging stations in Illinois having watersheds from 25 to 1000 square miles in area. The study stations were required to have 10 to 20 years of mean daily discharge measurements with the latest record no more than 10 years old.

2) Relate the quantity of base flow to regional hydrologic and geologic properties by grouping them into physiographic or other logical divisions.

3) Select one basin to evaluate the relationship between stream water quality and groundwater quality, especially the effects of direct surface runoff on the quality of the receiving stream.

This report presents the data and summary discussions related to the first two objectives of the project. The third objective is addressed in a companion report entitled "Surface Water - Groundwater Quality Relationships" by Gibb and O'Hearn.

Acknowledgments. The authors are grateful for the cooperation of G. Wayne Curtis, U. S. Geological Survey, Champaign, Illinois, in providing the streamflow data without which this study would not have been possible. The authors also wish to thank Anne Bogner, student Systems Analyst at the Illinois State Water Survey for her invaluable assistance in generating the computer-plotted streamflow hydrographs and performing statistical analysis of base flow data. Joseph Brunty, James Campbell, Jill Davidson, and Mark Koester, students at the University of Illinois, performed most of the base flow separations, data tabulation, and plotting of base flow probability statistics.

The project was conducted under the general supervision of Richard J. Schicht, Assistant Chief, Illinois State Water Survey. The drafting was done by Linda Riggin, William Motherway, and John Brother. Debbie Hayn typed the draft and final manuscripts and Loreena Ivens edited the final manuscript.

DESCRIPTION OF DATA BASE

The U. S. Geological Survey and the State Water Survey, Division of Water Resources, and Division of Highways have had cooperative agreements for the systematic collection of streamflow measurements since 1930. Mean daily streamflow in cubic feet per second is recorded at approximately 200 gaging stations in Illinois. Computer tapes of mean daily flows and flow-duration data were provided by the U. S. Geological Survey, Champaign, Illinois, for the 78 stations selected for study, The selected stations have drainage basins 25 and 1000 square miles in area. They also have a minimum 10 years of mean daily discharge measurements with the most recent data no more than 10 years old.

Table 1 lists the gaging stations used in this study. Figure 1 shows the locations of these stations.

Table 1. Gaging Station Data Used in This Study.

Station number	Station name	Drainage area (sq mi)	Period of record used
419000	Apple River near Hanover	247	1957-76
513000	Bay Creek at Nebo	161	1957-76
512500	Bay Creek at Pittsfield	39.4	1957-76
495500	Bear Creek near Marcelline	349	1957-76
599000	Beaucoup Creek near Matthews	292	1957-76
556500	Big Bureau Creek at Princeton	196	1957-76
600000	Big Creek near Wetaug	32.2	1952-71
596000	Middle Fork Big Muddy River near Benton	502	1951-70
597000	Big Muddy River at Plumfield	794	1957-76
551700	Blackberry Creek near Yorkville	70.2	1961-76
336500	Bluegrass Creek at Potomac	35.0	1952-71
378000	Bonpas Creek at Browns	228	1957-76
612000	Cache River at Forman	244	1957-76
468500	Cedar Creek at Little York	130	1952-71
438250	Coon Creek at Riley	85.1	1962-76
597500	Crab Orchard Creek near Marion	31.7	1957-76
582500	Crane Creek near Easton	26.5	1955-74
558500	Crow Creek (W) near Henry	56.2	1952-71
559500	Crow Creek near Washburn	115	1952-71
529000	Des Plaines River near Des Plaines	360	1957-76
532500	Des Plaines River at Riverside	630	1957-76
584400	Drowning Fork at Bushnell	26.3	1961-76
540500	DuPage River at Shorewood	324	1957-76
566500	East Branch Panther Creek at El Paso	30.5	1957-76
466500	Edwards River near New Boston	445	1957-76
466000	Edwards-River near Orion	155	1957-76
444000	Elkhorn Creek near Penrose	146	1957-76
343400	Embarras River at Camargo	186	1961-76
562000	Farm Creek at East Peoria	61.2	1957-76
560500	Farm Creek at Farmdale	27.4	1957-76
551200	Ferson Creek near St. Charles	51.7	1961-76
574500	Flat Branch near Taylorville	276	1957-76

Table 1. Continued

Station number	Station name	Drainage area (sq mi)	Period of record used
502040	Hadley Creek at Kinderhook	72.7	1954-73
469000	Henderson Creek near Oquawka	432	1957-76
539000	Hickory Creek at Joliet	107	1957-76
380475	Horse Creek near Keenes	97.2	1959-76
588000	Indian Creek at Wanda	36.7	1957-76
568800	Indian Creek near Wyoming	62.7	1960-76
525000	Iroquois River at Iroquois	686	1957-76
580500	Kickapoo Creek near Lincoln	306	1952-71
563500	Kickapoo Creek at Peoria	297	1952-71
580000	Kickapoo Creek at Waynesville	227	1957-76
440500	Killbuck Creek near Monroe Center	117	1952-71
438500	Kishwaukee River at Belvidere	538	1957-76
579500	Lake Fork near Cornland	214	1957-76
584500	La Moine River at Colmar	665	1957-76
536290	Little Calumet River at South Holland	205	1957-76
378900	Little Wabash River at Louisville	745	1966-76
567500	Mackinaw River near Congerville	767	1957-76
587000	Macoupin Creek near Kane	868	1957-76
542000	Mazon River near Coal City	455	1957-76
448000	Mill Creek at Milan	62.4	1957-76
564400	Money Creek near Towanda	49.0	1959-76
536000	North Branch Chicago River at Niles	100	1957-76
586000	N. Fk. Mauvaise Terre Ck. near Jacksonville	29.1	1956-75
346000	North Fork Embarras River near Oblong	319	1957-76
548280	Nippersink Creek near Spring Grove	192	1967-76
586800	Otter Creek near Palmyra	61.1	1960-76
467000	Pope Creek near Keithsburg	183	1967-76
550500	Poplar Creek at Elgin	35.2	1957-76
439500	South Branch Kishwaukee River near Fairdale	387	1957-76
576000	South Fork Sangamon River near Rochester	867	1957-76
382100	South Fork Saline River near Carrier Mills	147	1966-76

Table 1. Concluded

Station number	Station name	Drainage area (sq mi)	Period of record used
469500	South Henderson Creek at Biggsville	82.9	1952-71
57850	Salt Creek near Rowell	335	1957-76
531500	Salt Creek at Western Springs	114	1957-76
336900	Salt Fork near St. Joseph	134	1959-76
571000	Sangamon River at Mahomet	362	1957-76
572000	Sangamon River at Monticello	550	1957-76
594000	Shoal Creek near Breese	735	1957-76
380500	Skillet Fork at Wayne City	464	1957-76
577500	Spring Creek at Springfield	107	1957-76
581500	Sugar Creek near Hartsburg	333	1952-71
525500	Sugar Creek at Milford	446	1957-76
536275	Thorn Creek at Thornton	104	1957-76
554500	Vermilion River at Pontiac	579	1957-76
539900	West Branch DuPage River near West Chicago	28.5	1962-76
592300	Wolf Creek near Beecher City	47.9	1959-76

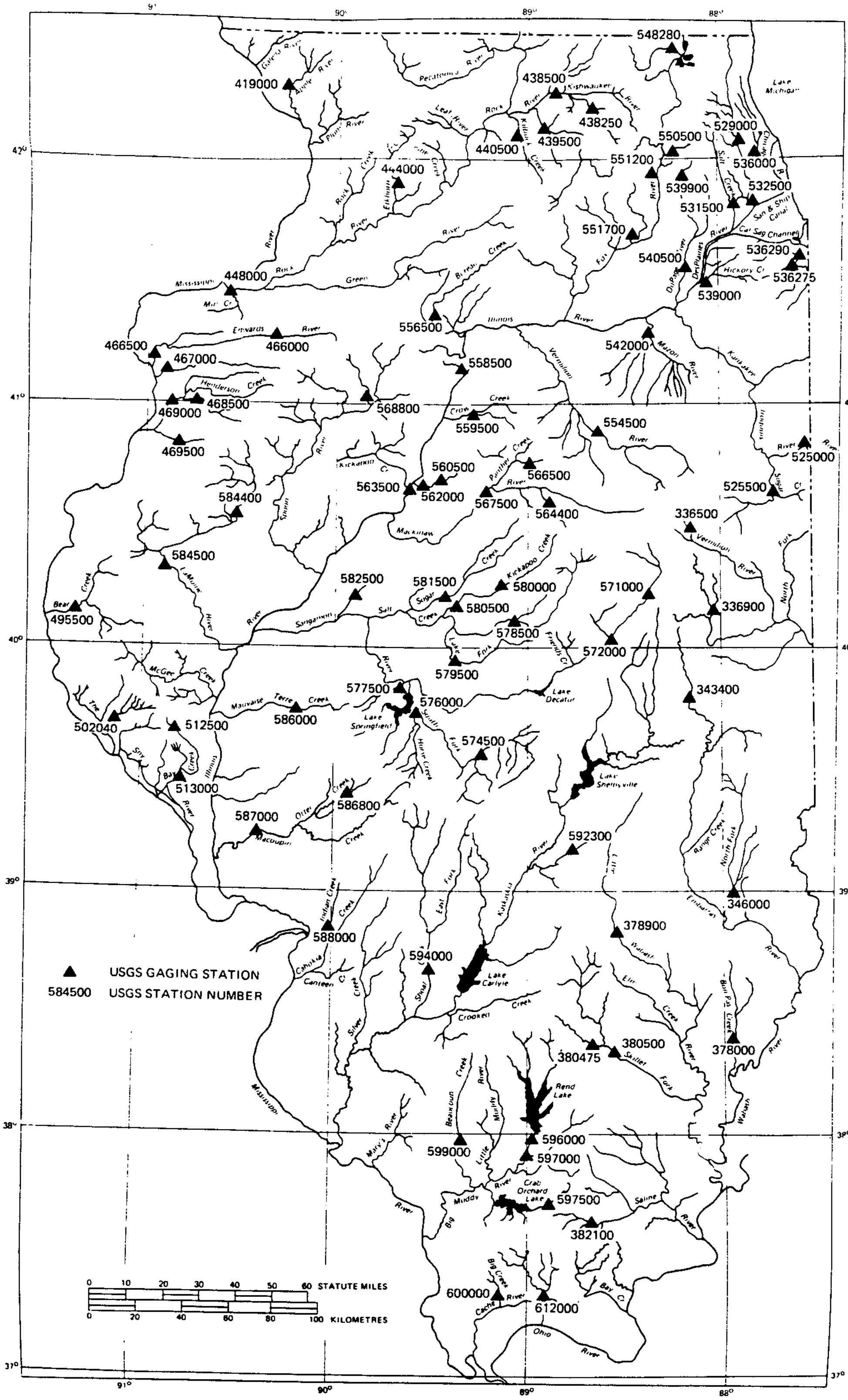

Figure 1. Gaging station location map

METHODOLOGY

Hydrologists have studied base flow recession and hydrograph separation techniques for more than one hundred years. Hall [1968] presented a comprehensive review and historical perspective of previous base flow studies. Historically, approaches to hydrograph analysis have been developed using graphical, empirical, or analytical methods. These methods exhibit varying degrees of sophistication, and the choice of a method is usually dependent upon the amount of data to be analyzed and the degree of accuracy desired. Generally, the more sophisticated the technique employed, the more cumbersome and impractical the method becomes when applied to a large number of long historical streamflow records, as is the case in this investigation. Since base flow during storm events can not be measured directly, it is impossible to determine if the added expense of time and money required by the more sophisticated methods is justified by increased accuracy of the results. For this reason, many hydrologists prefer graphical or empirical techniques for estimating base flow.

The method applied in this study is basically the same as that used by Walton [1965] and first proposed by Linsley and others [1958]. It is a simple graphical technique, yet the authors believe that it gives reasonable estimates of actual base flow values. The statistical base flow parameters derived by this method are representative of the base flow regimes during the periods of record analyzed.

For the purpose of this investigation, streamflow consists of two components: surface runoff, or that amount of precipitation that enters the stream without percolating into the soil, and base flow, or that precipitation which infiltrates into the soil and eventually seeps into the channel. Release of bank storage is included in the base flow component.

For each of the 78 basins studied, a minimum of 10 years and maximum of 20 years of mean daily discharge measurements were plotted on a semi-log scale versus time. Horizontal lines representing the Q_{10}, Q_{50}, and Q_{90} for the basin of interest also were plotted. Q_p is the mean daily streamflow in cubic feet per second that is equaled or exceeded p percent of the time based on the total period of record. At each point where the total stream discharge was equal to one of the three flows of interest, an attempt was made to determine the amount of base flow on that day.

Base flow estimates for storm events were determined by averaging the results of two independent graphical methods. One method, the straight-line method, is entirely objective and probably does not realistically simulate actual base flow conditions during a storm. The second technique, referred to herein as the S-curve method, is highly subjective but is more likely to approximate actual conditions during storm events [Singh, 1968]. The S-curve method indirectly accounts for seasonal differences in streamflow recession rates reported by Farvolden [1971] and others [Singh and Stall, 1971] by extrapolating the observed recession curves. By averaging the results of the two methods, a balance between subjectivity and objectivity is achieved which tends to mitigate the problems associated with both methods when considered separately.

In the straight-line method, a line is drawn from the point of rise of the storm hydrograph to a point on the graph N days after the peak, where N is the time in days after the peak flow at which surface runoff is assumed to cease. The value used for N is calculated for each basin using the formula $N = A^{0.2}$ where A is the area of the drainage basin in square miles. From the point on the hydrograph where the flow is equal to the Q_p of interest, a vertical line is drawn to intersect the straight-line base flow approximation (see Figure 2). The discharge at the point of intersection is recorded.

To determine base flows under storm hydrographs using the S-curve method, the recession curve of the storm being analyzed is projected "by eye" back under the storm from a point N days after the peak to a point directly under the inflection point of the falling limb of the hydrograph. Next, the recession curve from the previous event is continued to a point directly under the peak of the hydrograph. These two theoretical base flow "trend" curves are connected by a straight-line resulting in an S-shaped curve with lower base flows occurring under the rising limb of the hydrograph and higher base flows occurring under the falling Limb. As in the straight-line method, a vertical is drawn from the point on the hydrograph at which Q_p occurs to the S-curve and this value is recorded (see Figure 2).

The base flow estimate for the total flow of interest is equal to the geometric mean of the two base flow values obtained by the two distinct graphical methods. Base flow estimates are differentiated into rising-limb and falling-limb categories. No attempt is made to estimate base flow values for complex storm events. To expedite the analysis of some 1500 basin-years of streamflow data and to develop reproducible results, the following guidelines are followed:

1) If the time between the point of rise of a storm event and the peak of the preceding storm event is less than N days, then both storm hydrographs are considered to be too complex to be analyzed by the methods used in this study.
2) Storm hydrographs which did not exhibit a "typical" falling limb were not considered.
3) Recession curves resulting from long periods of little or no precipitation are assumed to reflect 100% base flow and are tabulated as falling limb base flow values.

Figure 2 is an example of two months of streamflow data for the gaging station on the Mackinaw River near Congerville. Three typical base flow determinations are illustrated. Data tabulated for each point on the hydrograph where the streamflow was equal to Q_{10}, Q_{50}, or Q_{90} include the date of the peak, the streamflow probability (10%, 50%, or 90%), the streamflow at the point of rise (Q_I), the flow at the peak (Q_{Pk}), the flow N days after the peak (Q_N), the base flow under the rising limb using the straight-line method (Q_{RL}), the base flow under the falling limb using the straight-line method (Q_{FL}), and the: base flow under the rising (Q_{RS}) and falling (Q_{FS}) limbs using the S-curve method. The geometric means of the rising-limb base flow estimates (Q_{RA}) and the falling-limb estimates (Q_{FA}) were calculated for each event.

For each basin, the geometric means were grouped into rising- and falling-limb values for each Q_p, and from these data the mean, standard deviation, and cumulative frequency distribution of the base flows were determined. These results are presented alphabetically by basin name in the Appendix in the form of $\log_{10}$-probability curves for all of the basins analyzed in this study.

The use of the base flow probability curves is explained in the following example. Suppose that one wished to estimate the mean daily base flow at the gaging station on the Mackinaw River near Congerville (USGS No. 567500) on a day when the mean daily streamflow was 700 cubic feet per second (the 20% flow-duration). If the stream were rising in response to a precipitation event, then the rising-limb curve (see Appendix) would yield the best estimate. This curve shows that on 50% of all days when the total discharge was 700 cfs and rising, the base flow was likely to equal or exceed 260 cfs or 37% of the total

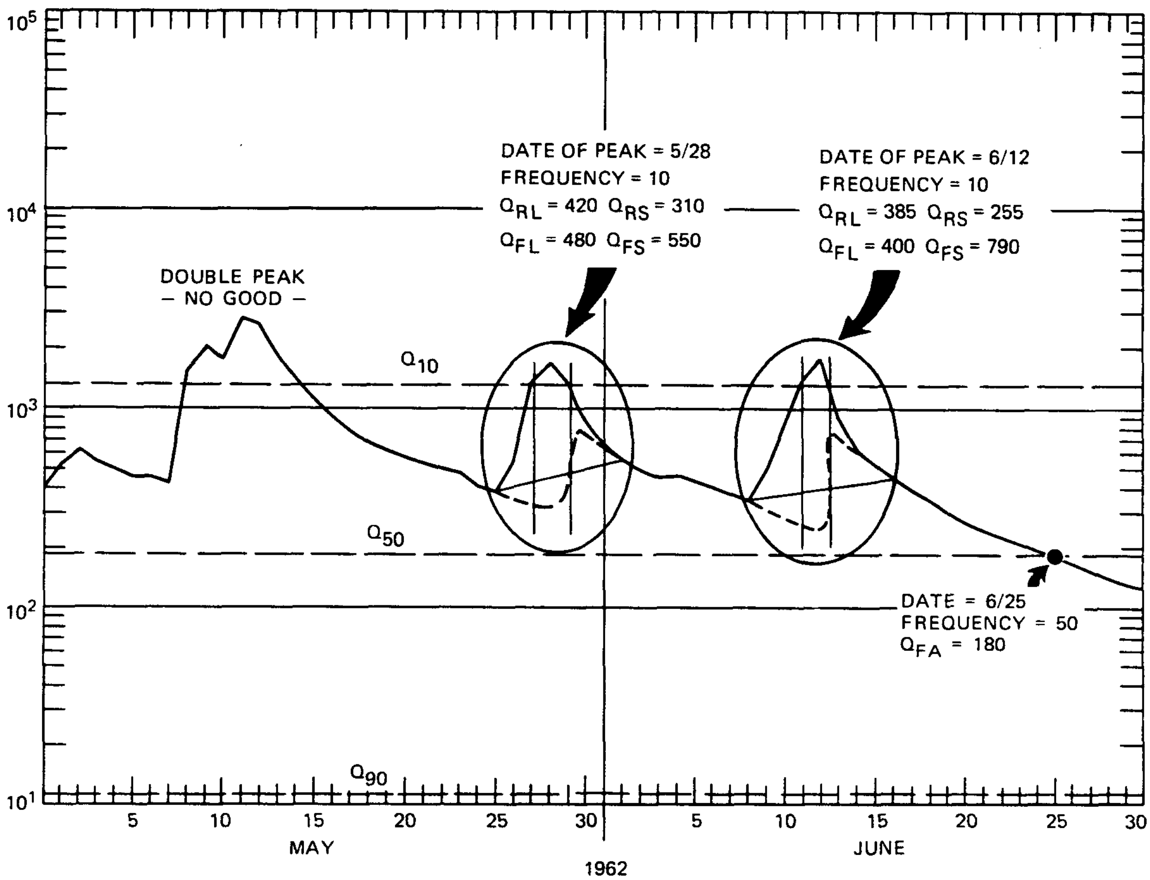

Figure 2. Sample base flow separations

flow. In most cases, this median value would be the desired estimate. However, the curves also show that under the same condition, 9 times out of 10 the base flow would have been at least 47 cfs (7% of the total flow) and at least 580 cfs (93% of the total flow) 1 of every 10 times.

If it were known that the stream was falling after the passing of a flood peak or receding following a protracted period of dry weather, then the falling limb curve (see Appendix) would give the best base flow estimates. At 700 cfs, the falling limb curve shows that the median (i.e., 50% probability of occurrence) base flow is likely to be 690 cfs or 99% of the total flow. In addition, there is a 90% probability that the base flow equaled or exceeded 230 cfs (33% of the total flow) and a 10% chance that the streamflow was entirely base flow.

If it is not known whether the stream was rising or falling, then the base flow can be estimated by averaging the median rising limb and median falling-limb base flow values for the discharge of interest. In the case of our example, this would yield an estimated median base flow of 475 cfs or about 68% of the total flow.

Mean base flow values and standard deviations are also presented on the curves in the Appendix.

The averages of the median rising- and falling-limb base flow estimates for each basin were divided by the drainage area and plotted on state maps to determine the regional distribution of base flow at Q_{10}, Q_{50}, and Q_{90}. Regional divisions were drawn on the maps grouping areas with similar median base flows. Brief descriptions and explanations of the features of each map are presented in the Discussion section. Because of the numerous basin-specific factors which determine base flow magnitudes and because of time limitations in this 7-month study, detailed explanations of the regional distributions of base flow values are outside the scope of this study.

DISCUSSION

Previous studies by Leighton and others [1948] delineated 15 physiographic regions in Illinois primarily based upon geomorphology. Factors such as soil permeability, topography, and geohydrology were taken into account by Singh [1971] in his modifications to the physiographic region boundaries. Singh's work was based on a study of flow-duration characteristics for 120 stream basins in Illinois. The resulting hydrologic divisions are illustrated in Figure 3. Singh showed that the contrast between the hydrologic division characteristics became less marked with lower rates of streamflow. He found that the characteristic curves for each division were barely distinguishable at flows greater than Q_{50}. As a result, he emphasized the low flow characteristics when determining his division boundaries.

Walton [1965] developed three base flow distribution maps for Illinois based on the analysis of streamflow data for 21 basins. He chose only three years of streamflow records for study. One was chosen to represent a year of "above normal" precipitation, one a year of "near normal" precipitation, and one a year of "below normal" precipitation. Hydrograph separations were performed for each basin for the selected year of record using the same basic technique applied in this study. The results were presented in the form of base flow maps for each of the three stated precipitation conditions.

Although Walton used basically the same hydrograph separation technique used in this investigation, the results of the two studies are not directly comparable. Walton considered the entire range of streamflows for a given year when calculating and mapping his base flow statistics. If we assume that the magnitudes of flows for the selected years were normally distributed,

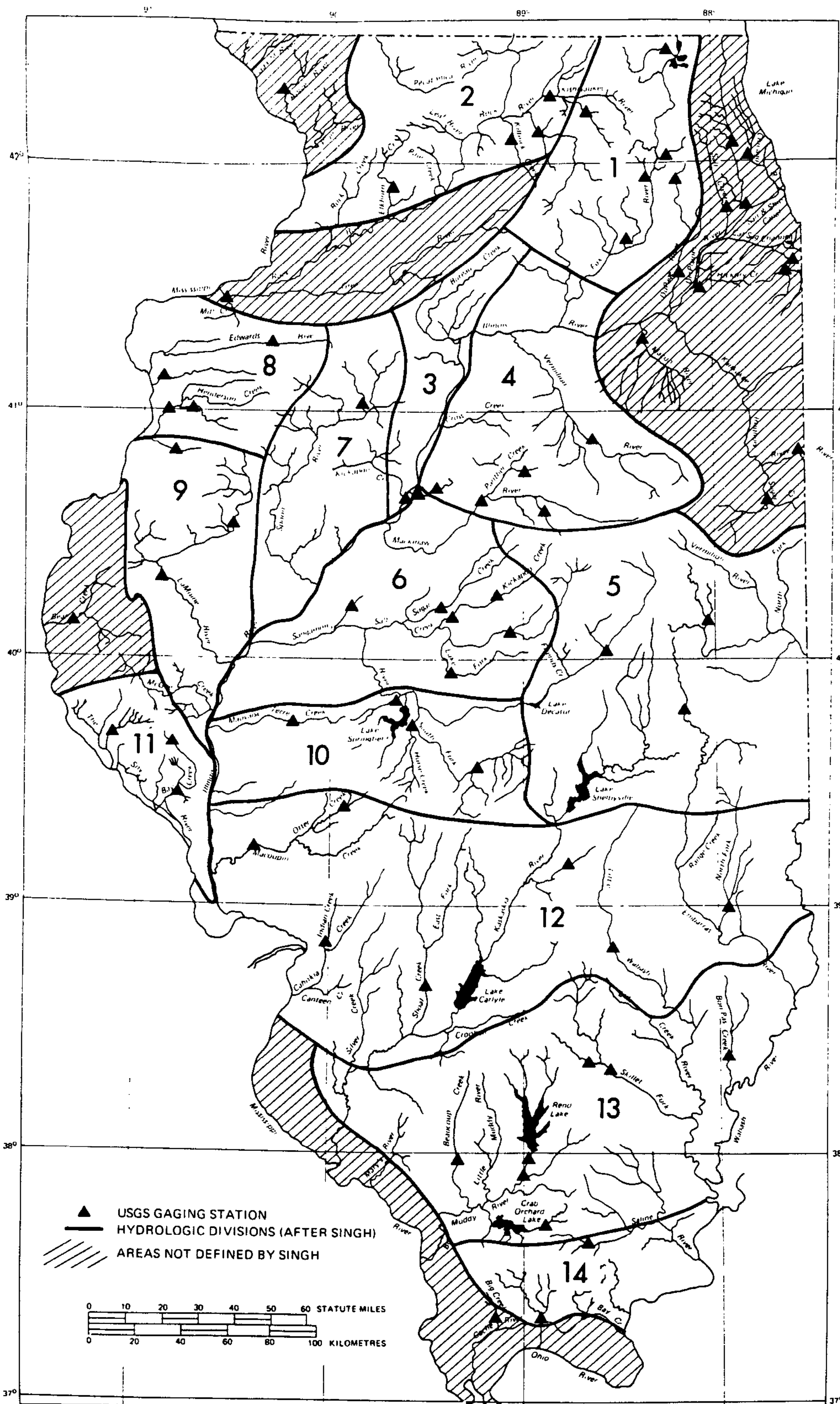

Figure 3. Hydrologic divisions of Illinois (after Singh)

Walton's maps would represent average Q_{50} base flows per unit area for those years. From this reasoning, the most meaningful comparison between Walton's maps and the maps developed in this study would be that for the Q_{50} base flow distribution map and Walton's base flow values for a year of "near normal" precipitation.

The regional distribution of median base flow values during high streamflows (Q_{10}) for the 78 study basins is shown in Figure 4. These values are grouped into seven regions, A through G, based on regional base flow similarities. A summary of the regional base flow values for Q_{10} is presented in Table 2.

The regions with the highest base flow values are A and G in northeastern and southeastern Illinois, respectively. Region A is dominated by permeable surficial glacial deposits which result in less surface runoff, more recharge, and rapid base flow increases following significant rainfall events. Region G is a hilly area of little or no drift, however, permeable alluvial sand and gravel deposits are found in the stream valleys. It is possible that a great deal of the precipitation falling on the upland areas of this region runs off until it reaches the alluvial stream valley deposits where it infiltrates and reaches the stream as base flow. This area also has a higher mean annual precipitation than the rest of the state [U. S. Dept. of Commerce, 1973] which would be conducive to higher streamflows and, therefore, higher base flow magnitudes.

Regions C, D, and E, which constitute most of north-central Illinois, yielded the next highest base flow values at Q_{10}. These regions are characterized by discontinuous surficial sand and gravel deposits associated with glacial drift of Wisconsinan age. Although relatively permeable, their discontinuous and heterogeneous nature reduces the base flow yield from these deposits and lengthens the base flow response time following precipitation events.

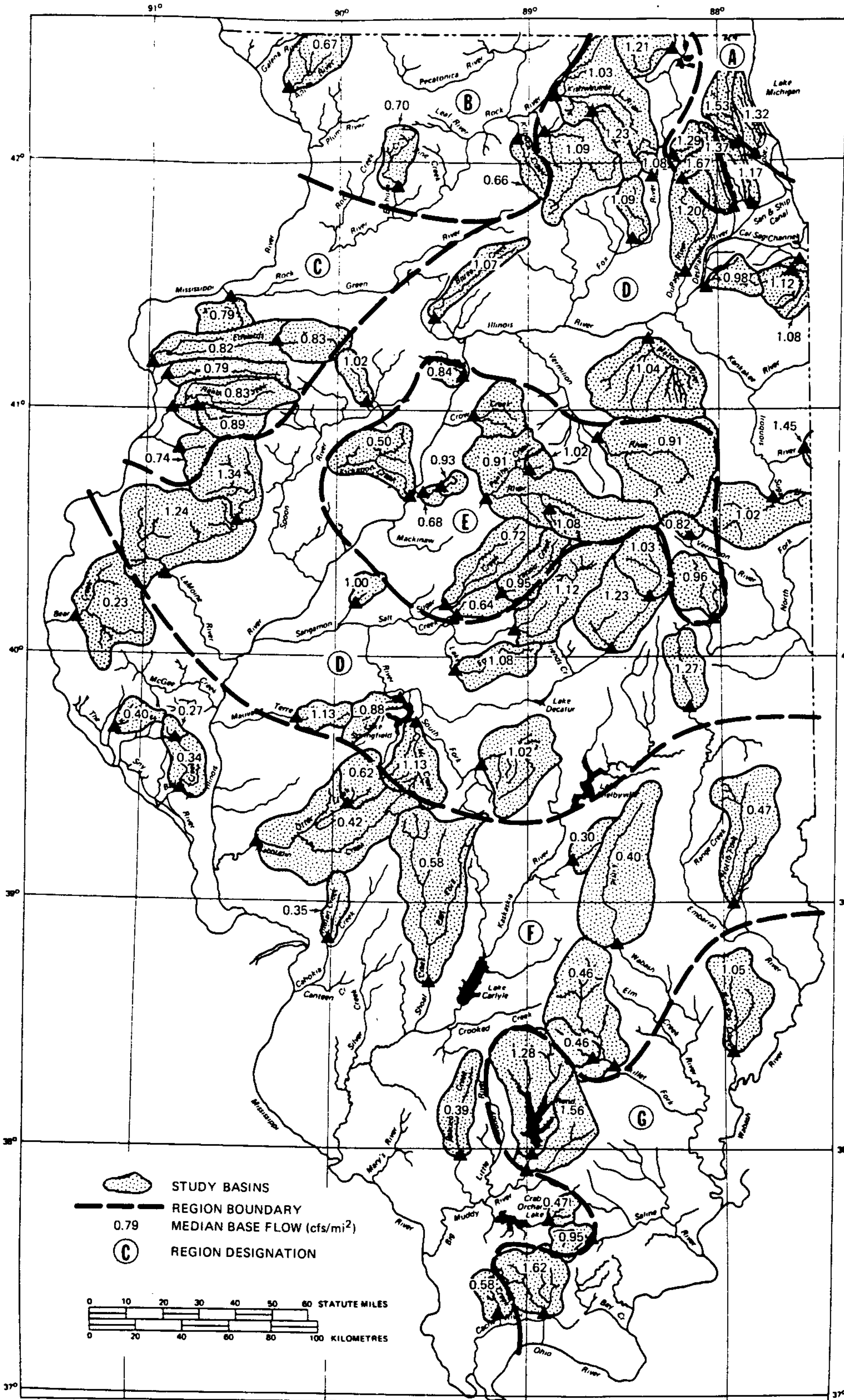

Figure 4. Distribution of median base flows during high (10% frequency) streamflows

Table 2. Summary of Regional Base Flow Parameters for Q_{10}.

Region	Median of median base flows (cfs/mi^2)	Range of median base flows (cfs/mi^2)
A	1.37	1.29-1.67
B	0.67	0.66-0.70
C	0.82	0.74-0.89
D	1.09	0.88-1.45
E	0.91	0.50-1.08
F	0.42	0.23-0.95
G	1.42	1.05-1.62

Regions B and F in extreme northwestern Illinois and southern Illinois, respectively, have the lowest Q_{10} base flow values. Region B has relatively low mean annual precipitation [U. S. Dept. of Commerce, 1973], is topographically well drained, and predominately covered by thin relatively impermeable loess deposits. These conditions tend to reduce the amount of groundwater recharge and, subsequently, the base flow at high flow events (Q_{10}). Region F also is topographically well drained and is predominately covered by clay. The very low permeability of the clay allows little infiltration of rainfall and retards the movement of groundwater to create long base flow response times following precipitation events.

The Q_{10} base flow regions described in this report agree only in a general sense with the hydrologic divisions presented by Singh [1971]. This is to be expected since Singh's divisions emphasized the streamflow characteristics during low flows. The regions also are in general agreement with the data presented by Walton [1965]. The differences are apparently due to the fact that the base flow data in this study are specifically related to streamflow discharge rate whereas Walton's data encompass the entire range of streamflow for a given year.

Table 3. Summary of Regional Base Flow Parameters for Q_{50}.

Region	Median of median base flows (cfs/mi^2)	Range of median base flows (cfs/mi^2)
A[1]	0.34	0.30-0.51
B	0.22	0.17-0.29
C[2]	0.14	0.11-0.19
D	0.21	0.19-0.26
E	0.06	0.03-0.09
F	0.14	0.13-0.14

[1]Except Des Plaines River above Des Plaines (Station No. 529000).

[2]Except Crane Creek above Easton (Station No. 582500).

Figure 5 illustrates the regional distribution of base flow values at median (Q_{50}) streamflows. These data are grouped into six regions, A through F. A summary of data for each region is presented in Table 3.

The distribution of base flow values at median streamflows is generally similar to that for high streamflows. The area of highest base flow values is region A, the heavily urbanized Chicago metropolitan area. The area of lowest base flow values is, again, region E in southern Illinois. The remaining areas, B, C, D, and F, yield relatively moderate base flow values at Q_{50} streamflow events. The base flow yield of basins in extreme northwestern Illinois is relatively greater for Q_{50} events than for Q_{10} events compared with the rest of the state. This probably occurs because the basins in this area have a higher Q_{50} (total flow) relative to the rest of the state. Conversely, the drainage characteristics and surficial permeability of the soils in extreme southern Illinois have moderated the relative base flow values at Q_{50} in this part of the state.

Two basins do not conform to the Q_{50} base flow regions presented in this report. These are Crane Creek above Easton (USGS number 582500) and the Des Plaines River above Des Plaines (USGS number 529000). Crane Creek above

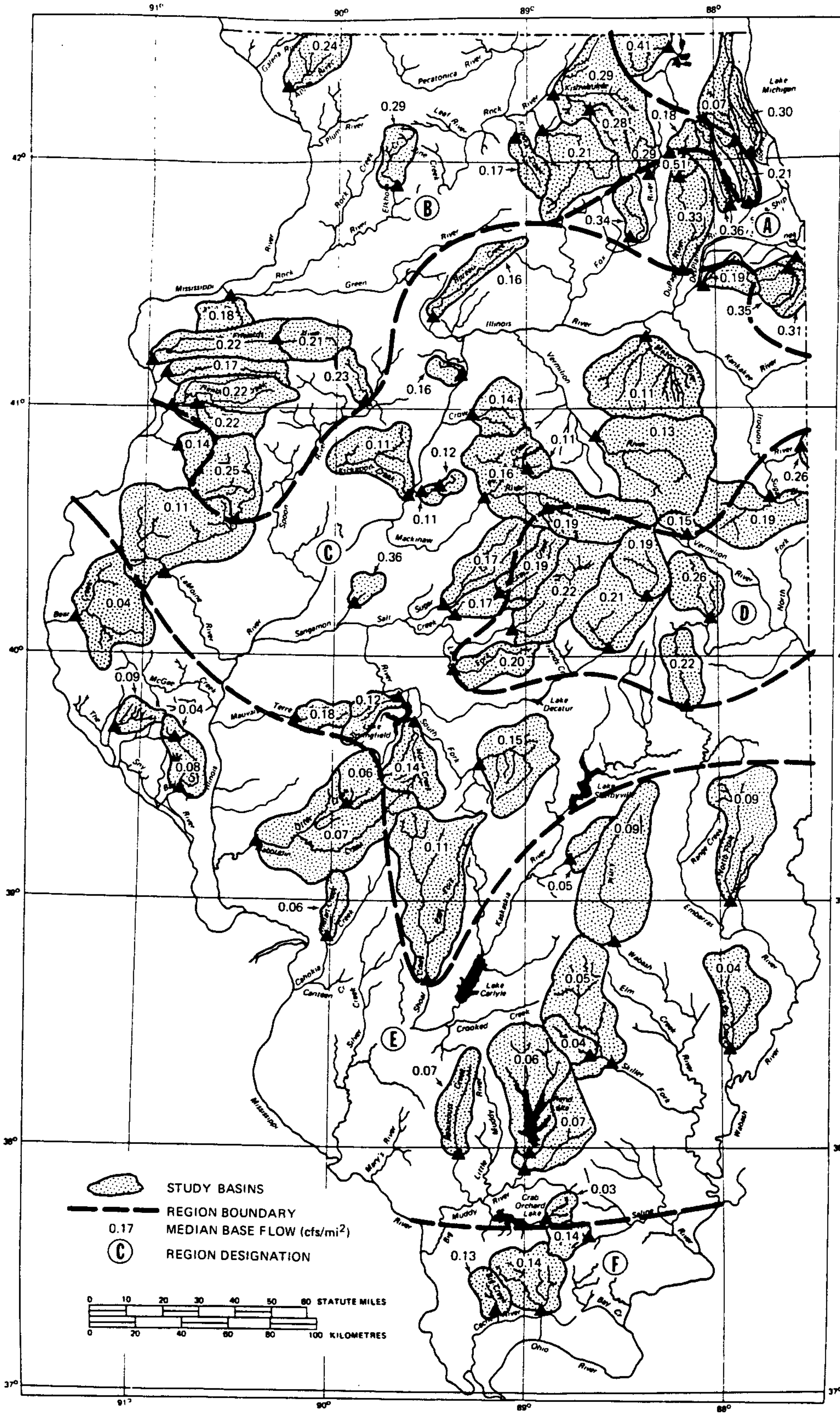

Figure 5. Distribution of median base flows during median (50% frequency) streamflows

Easton drains a portion of the Havanna lowland area in Mason County. This area is known for its extensive sand and gravel deposits and abundant groundwater resources. The presence of these deposits results in unusually high groundwater discharges for this basin. Farvolden [1971] also noted anomalous base flow characteristics for this basin in a study of streamflow recession curve characteristics.

The Des Plaines River above Des. Plaines in region A yielded a Q_{50} base flow value of 0.07 cfs/mi^2 which is much smaller than the base flow values for other basins in this region. Heavy groundwater pumpage from the shallow dolomite aquifers in this basin may have reduced groundwater discharge to the stream by lowering the piezometric surface near the river. Certain segments of the river are influent at times, that is, water is migrating from the river into the glacial materials and underlying dolomite aquifer. This may account for the anomalously low base flow value at Q_{50}.

The Q_{50} regions described in this report are, again, only in general agreement with the hydrologic divisions described by Singh [1971]. Very good agreement is noted between the regional distribution of base flow values at Q_{50} and those presented by Walton [1965] for years of "near normal" precipitation. However, Walton's values are higher suggesting that-the year which he chose to represent "near normal" precipitation exhibited higher streamflows compared to the 20 years of Q_{50} events analyzed for this study.

The areal distribution of mean base flow values during low streamflows (Q_{90}) is shown in Figure 6. These values are grouped into seven regions, A through G. A summary of regional base flow values for Q_{90} is presented in Table 4.

The accuracy of streamflow measurements during low flows can be affected by many factors. Remarks in the USGS Water-Data Reports [1979] frequently allude to poor discharge records during the winter months when low flows often

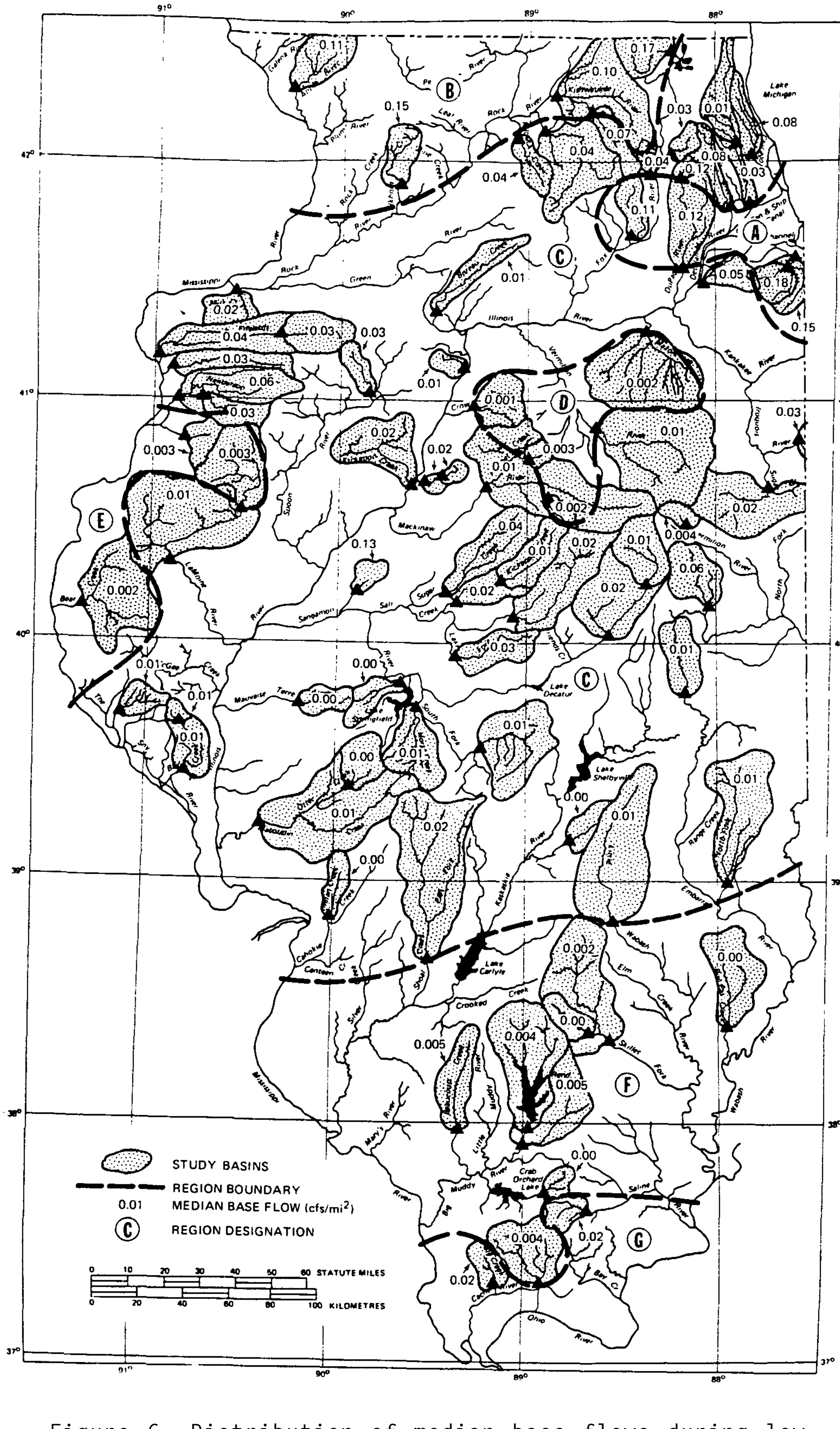

Figure 6. Distribution of median base flows during low (90% frequency) streamflows

occur. Snowmelt and ice complicate low flow measurements during these months. In addition, point-source discharges of sewage effluent and tile drainage exert a greater influence on streamflow data during low flows because they account for a larger proportion of total streamflow. The combined effects of measurement problems, point-source discharges, and streamflow regulation on low flow values suggest that less confidence be placed in base flow estimates obtained at Q_{90} as compared to Q_{50} or Q_{10}.

Base flow values at Q_{90} are high in region A in northeastern Illinois. This part of the state exhibits the highest base flow values over the entire range of streamflows. Conversely, region B exhibits high base flows at Q_{90} and regionally lower values at Q_{50} and Q_{10} base flows. The basins in this region also have higher Q_{50}'s and Q_{90}'s than the rest of the state as shown by "flatter" flow duration curves. Thus, if the percent of total flow composed of base flow remained constant, the base flows of this region would appear to increase relative to the base flow of basins that have steeper flow duration curves. Discharge of groundwater from the creviced limestone and deeper-lying sandstone units intersected by the stream and river valleys of this area may contribute to the apparent reversal in relative base flow values.

Table 4. Summary of Regional Base Flow Parameters for Q_{90}.

Region	Median of median base flows (cfs/mi^2)	Range of median base flows (cfs/mi^2)
A	0.12	0.11-0.18
B	0.13	0.10-0.17
C[1]	0.02	0.00-0.08
D	0.002	0.001-0.003
E	0.003	0.002-0.003
F	0.003	0.000-0.005
G	0.02	0.02-0.02

[1]Except Crane Creek above Easton (Station No. 582500).

The areas with the lowest base flow values at Q_{90} are regions D, E, and F. Regions E and F also exhibit relatively low base flow values at Q_{50} and Q_{10}. No explanation is offered for the low base flow values obtained in region D at Q_{90} streamflows.

Moderate base flow values are noted for regions C and G. These areas are similar to those regions of moderate base flow values at Q_{50} and Q_{10} except that they encompass a larger, area of the state.

A comparison of the Q_{90} base flow regions and the hydrologic divisions of Singh, Figures 6 and 3, respectively, reveals similarities between the two except for the central part of the state. As a whole, region C exhibits relatively consistent Q_{90} base flow values, yet it appears that enough variation was evident in Singh's data for this area to be divided into ten hydrologic divisions. This may be accounted for by the fact that Singh considered both the hydrologic and physiographic properties of each basin in defining the hydrologic division boundaries. In this investigation, regions were delineated solely on the basis of base flow characteristics. Thus, areas with similar hydrologic characteristics but different physiographic traits would be considered one region in this study but several distinct divisions under Singh's criteria.

No meaningful comparison can be made between the Q_{90} base flow distribution and Walton's map of groundwater runoff for a year of "below normal" precipitation because of significant differences in the methods of analysis that were discussed at the beginning of this section.

CONCLUSIONS

1) Base flow probability curves which can be used to estimate base flow for a given streamflow were developed for 78 watersheds in Illinois using historical streamflow records. Each study basin was between 25 and 1000 square miles in drainage area and had a minimum of 10 years and maximum of 20 years of mean daily streamflow measurements. Base flow was determined at high streamflows (Q_{10}), median streamflows (Q_{50}), and low streamflows (Q_{90}) for each basin. Base flow statistics were calculated for rising-limb values, falling-limb values, and combined values. The portion of total streamflow obtained from groundwater base flow increases as the total flow decreases. In 12 basins, the Q_{50} streamflows are all base flow 50 percent of the time for the falling limb. In almost all basins, the Q_{90} streamflows are all base flow 50 percent of the time for the falling limb (see Appendix).

2) The combined median base flow values determined at Q_{10}, Q_{50}, and Q_{90} streamflow events were plotted and regional divisions determined. In general, the median base flow values at the three streamflow frequencies studied were highest in northeastern Illinois and lowest in the claypan regions of southern Illinois. However, because of variations in relative streamflow magnitude, the effects of topography, soil permeability, surficial geology, climatology, and other physical factors, the regional distribution of median base flow is different for each streamflow duration.

3) The regional divisions were compared to each other and to previous work by Singh [1971] and Walton [1965]. The distribution of median base flow values at the Q_{90} streamflows generally agrees with the

hydrologic divisions presented by Singh [1971]. The distribution of values at Q_{50} streamflows generally agrees with that presented by Walton [1965] for a year of "near normal" precipitation.

4) The statistical analysis of base flow data presented in this study is more descriptive and represents a more comprehensive approach than previous work. Use of data presented in this study will result in better informed decisions with respect to management of instream uses and the regulation of point and nonpoint discharges to each basin studied.

5) The graphical base flow separation procedure employed in this study produces reasonable estimates of base flow values for the basins studied. It is more practical than analytical or empirical methods when large numbers of basins and long periods of historical stream-flow records are analyzed.

RECOMMENDATIONS

1) The study of groundwater contribution to streamflow in Illinois should be expanded to include stream basins greater than 1000 square miles in area to better define the areal distribution of base flow on a statewide basis.

2) The effects of urbanization, point-source sewage effluent, tile drain discharges, and meltwater runoff on base flow estimates during periods of low flow need to be studied in greater detail. This additional information is needed if the base flow data presented in this report are to be successfully utilized to accurately determine the effects of non-point sources of pollution on stream water quality.

3) Experience suggests that base flow estimates using graphical methods are highly sensitive to the choice of N, the time lag between the peak of the storm hydrograph and the cessation of surface runoff. The use of an arbitrary value of $N = A^{0.2}$ gives consistent and reasonably accurate results. For the purpose of regional comparison the selection of N is not important: however, other methods for determining this time lag should be investigated. Ideally, these methods should require a minimum of additional information, as opposed to those methods which require historical records of water level fluctuations in nearby wells or electrical conductivity in the stream. Methods not requiring additional information would allow their application to historical streamflow records for basins where such information is not available.

4) Many of the factors which affect base flow in streams can be expected to change with time, especially temporal variation in precipitation and those factors which are directly or indirectly related to human

activities. Therefore, the base flow characteristics of the study basins also are expected to vary with time. Studies have shown that rapid urbanization occurring in some areas of the state is resulting in significant increases in the low flows of certain streams [Singh and Stall, 1974]. In light of this fact, the base flow data compiled in this investigation should periodically be updated, perhaps every five years, so that the base flow statistics are representative of current conditions.

5) The base flow information compiled in this report should be studied in greater detail in order to better define the basin characteristics and mechanisms which control groundwater discharge to Illinois streams.

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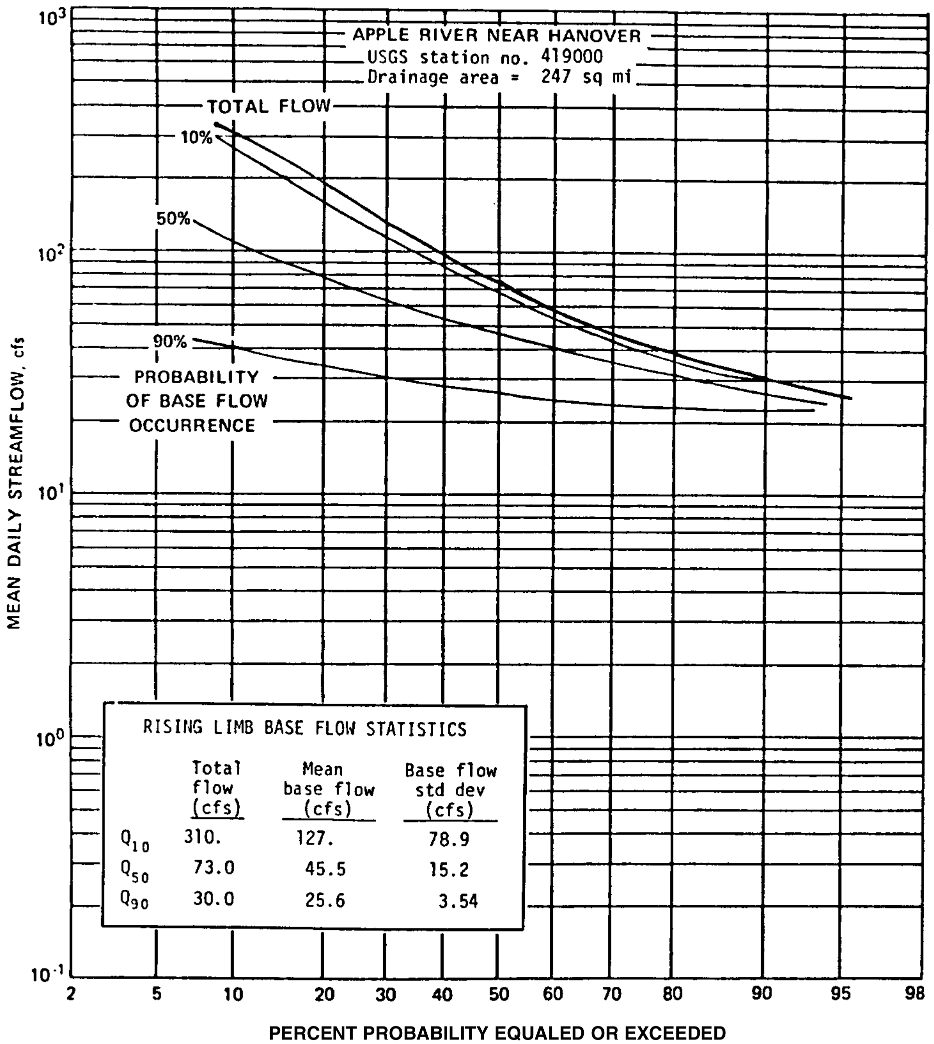
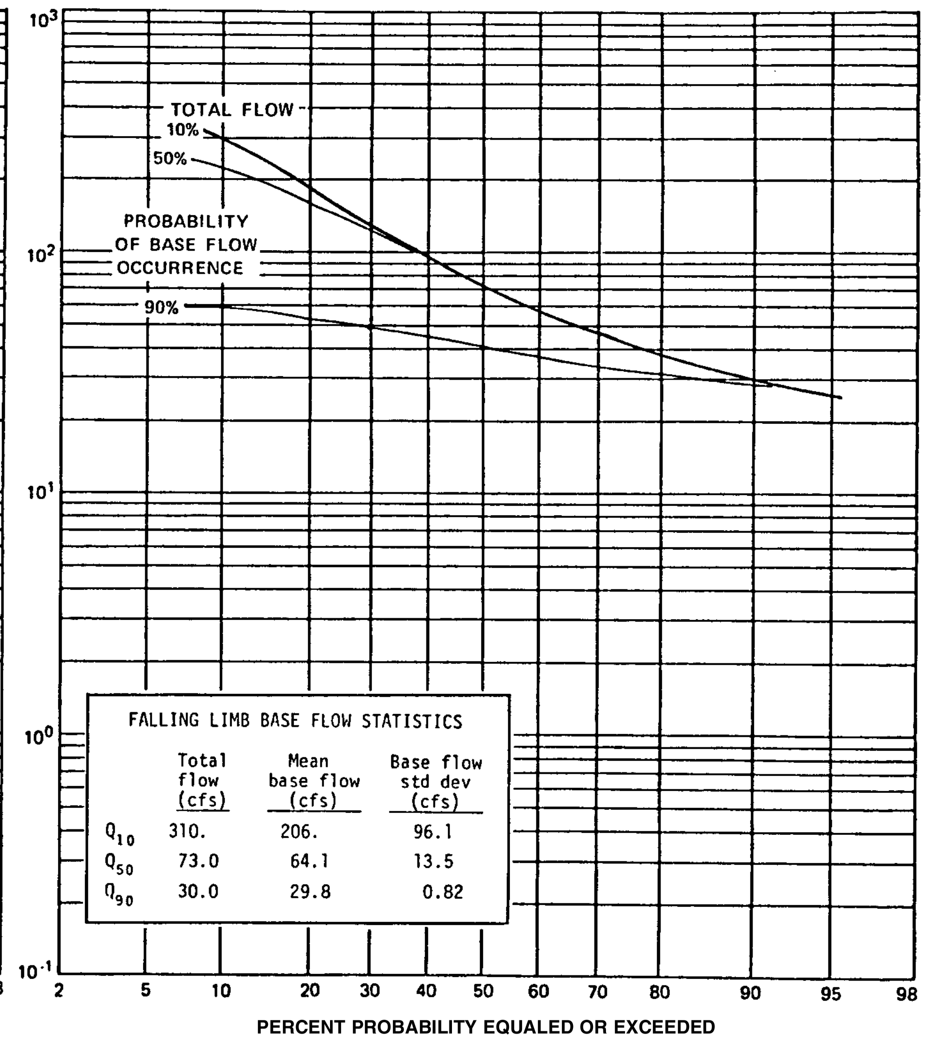
APPENDIX: BASE FLOW PROBABILITY CURVES



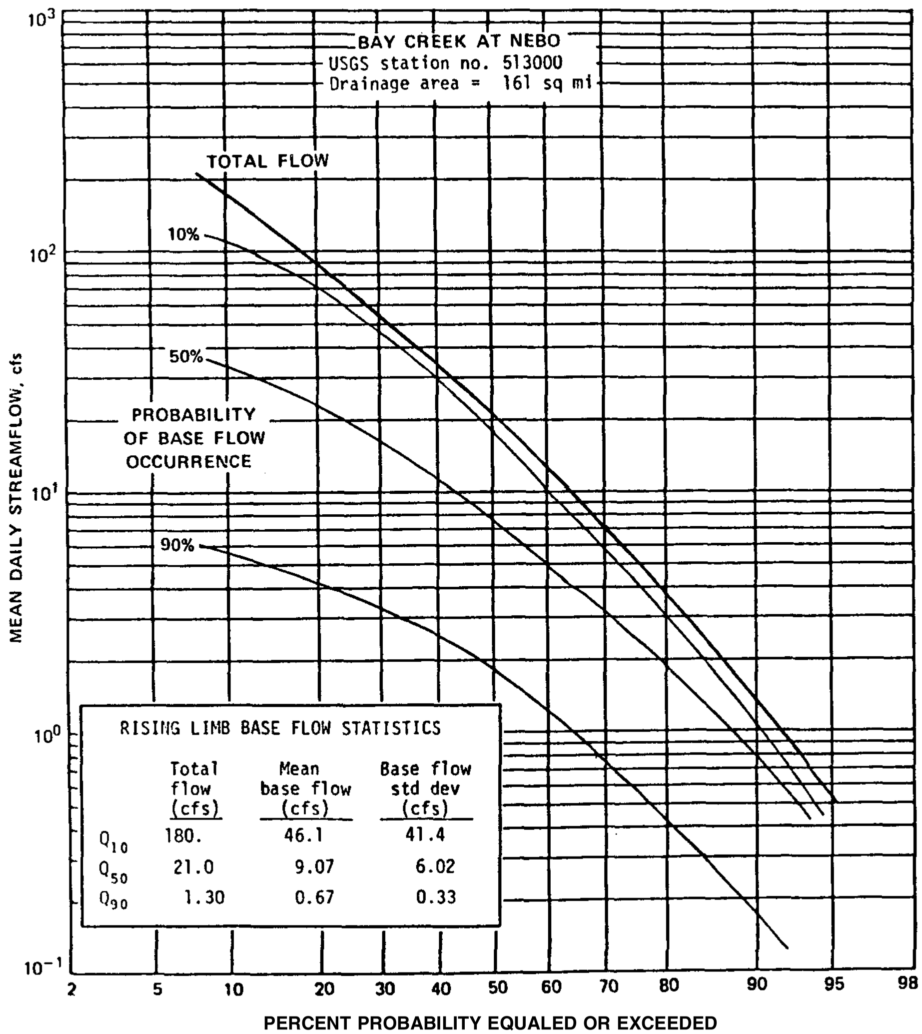
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	310.	127.	78.9
Q_{50}	73.0	45.5	15.2
Q_{90}	30.0	25.6	3.54



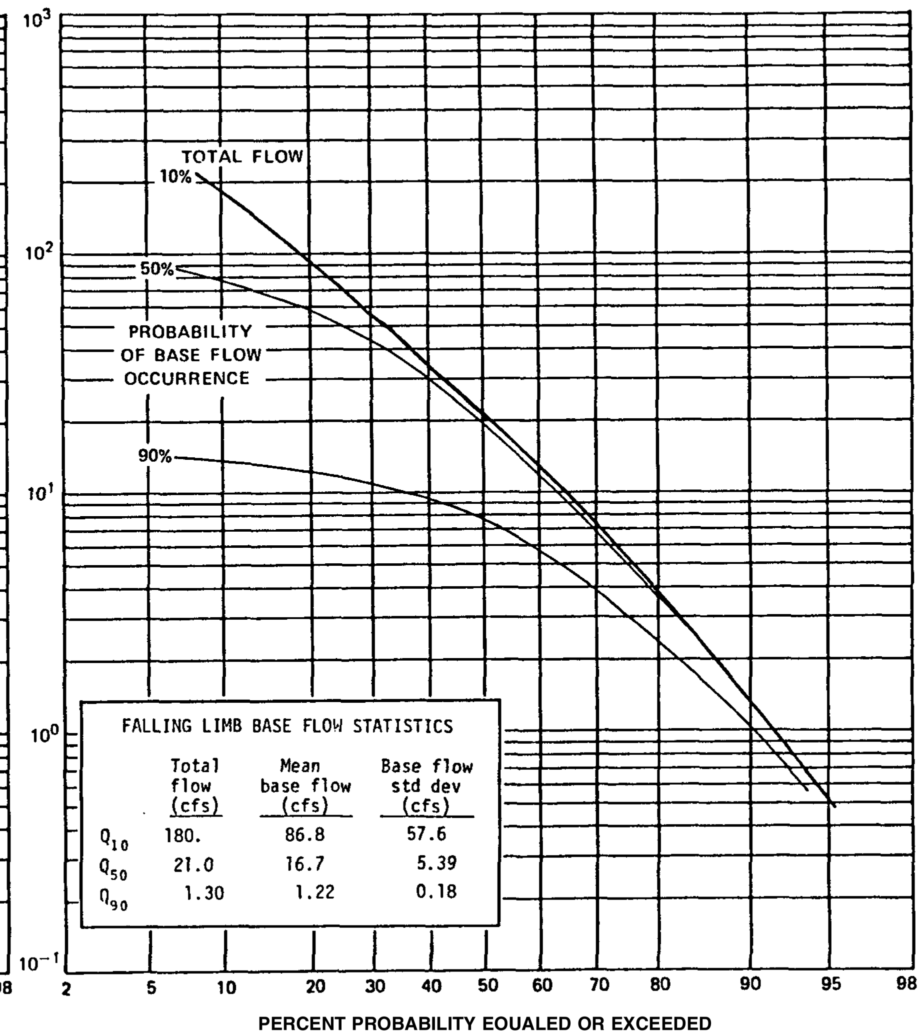
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	310.	206.	96.1
Q_{50}	73.0	64.1	13.5
Q_{90}	30.0	29.8	0.82



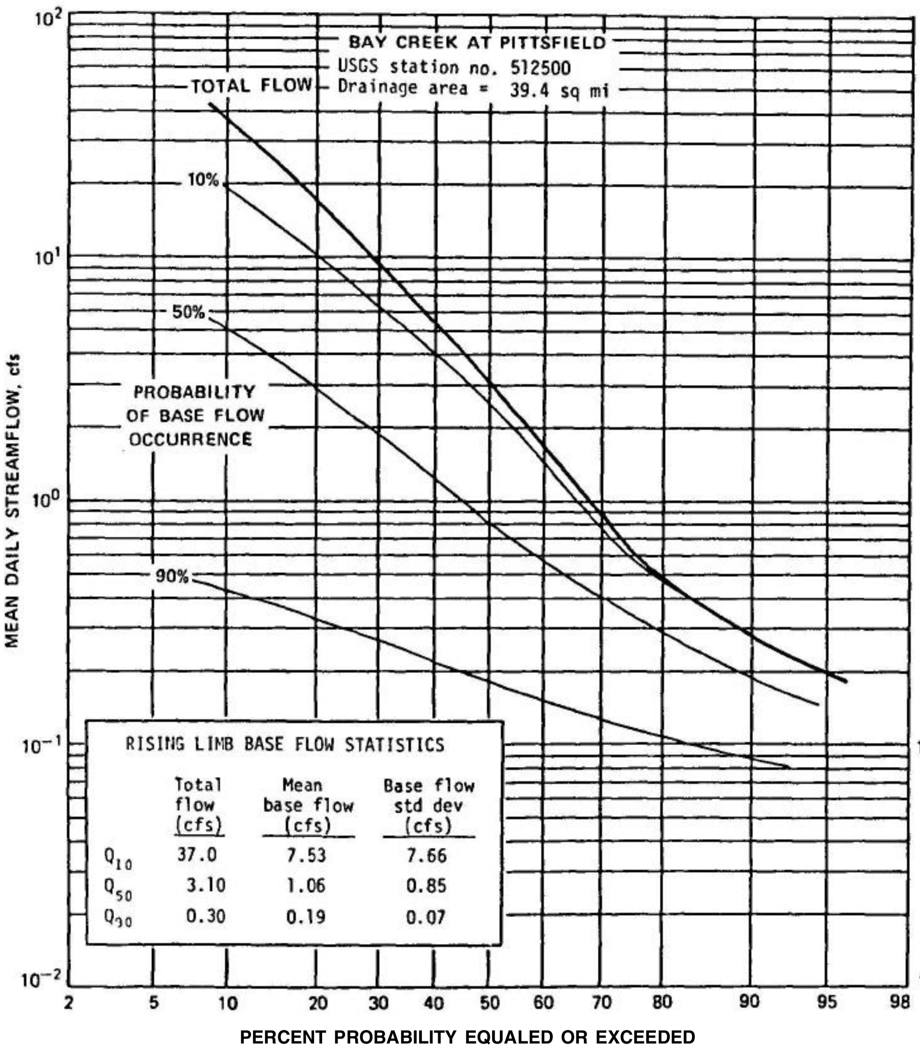
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	180.	46.1	41.4
Q_{50}	21.0	9.07	6.02
Q_{90}	1.30	0.67	0.33



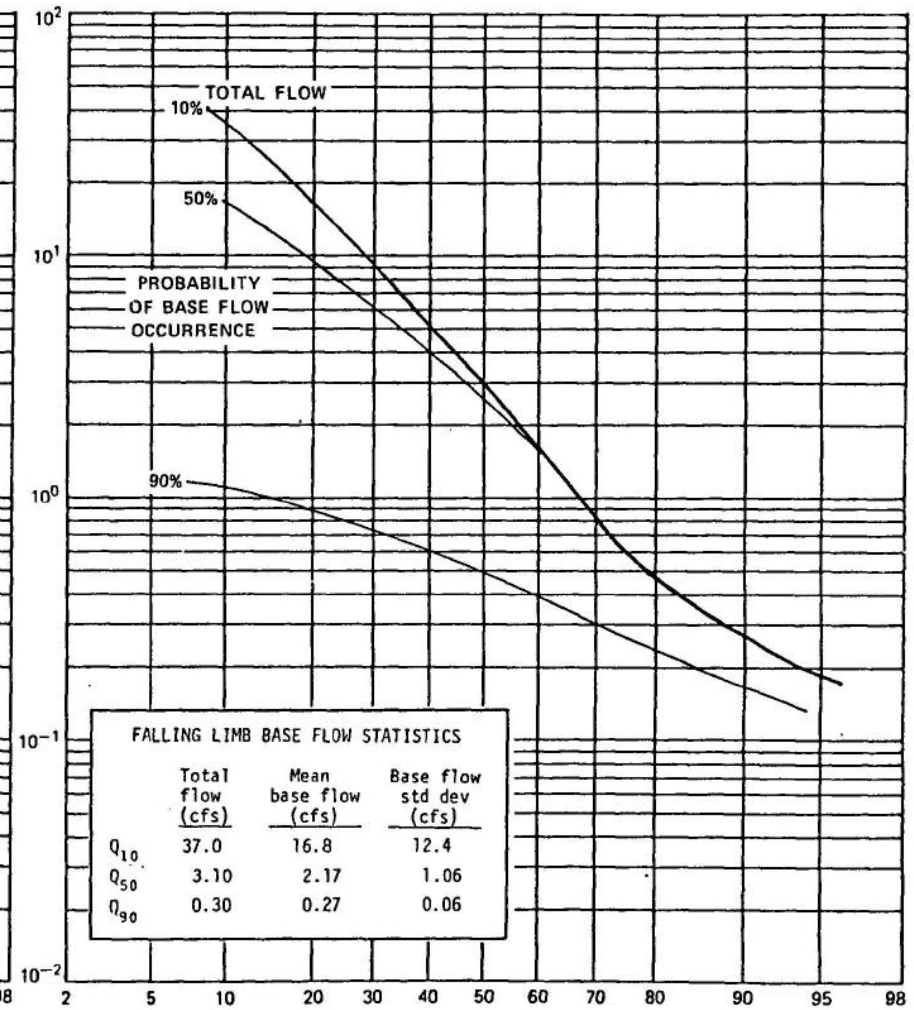
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	180.	86.8	57.6
Q_{50}	21.0	16.7	5.39
Q_{90}	1.30	1.22	0.18



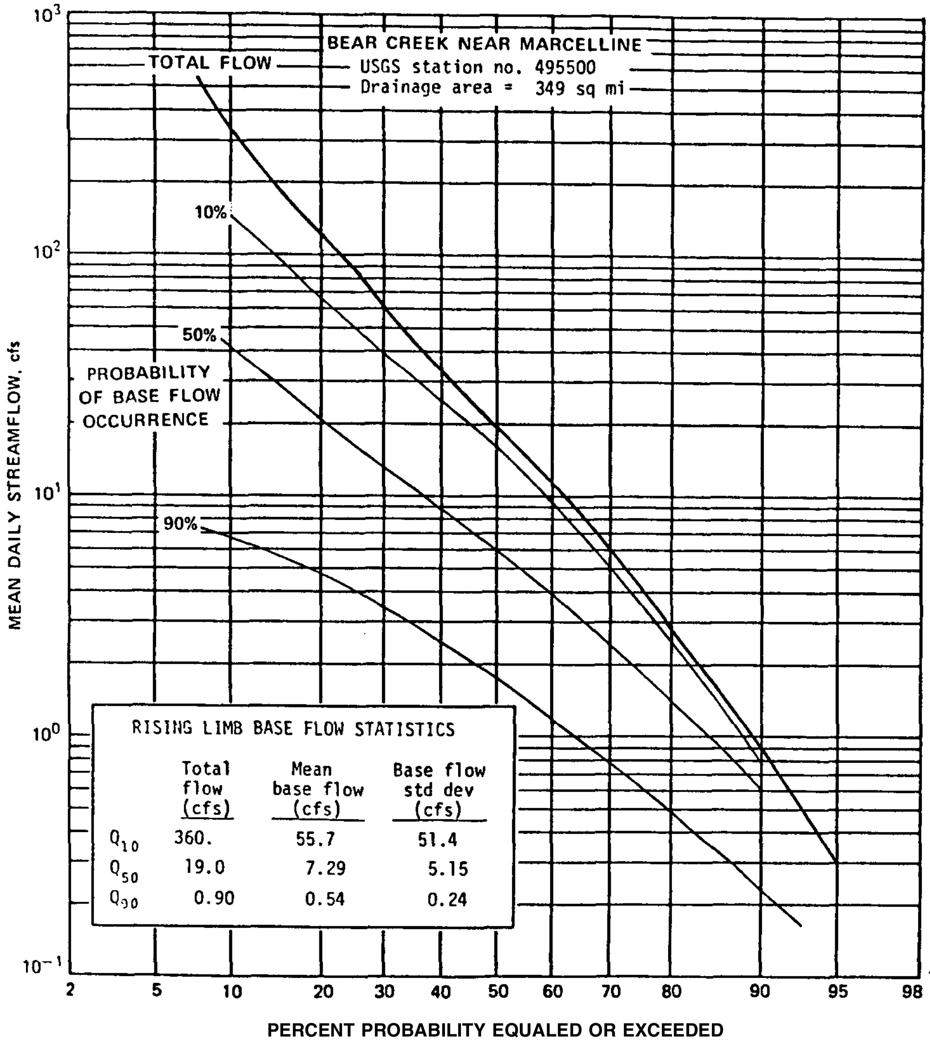
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	37.0	7.53	7.66
Q_{50}	3.10	1.06	0.85
Q_{90}	0.30	0.19	0.07



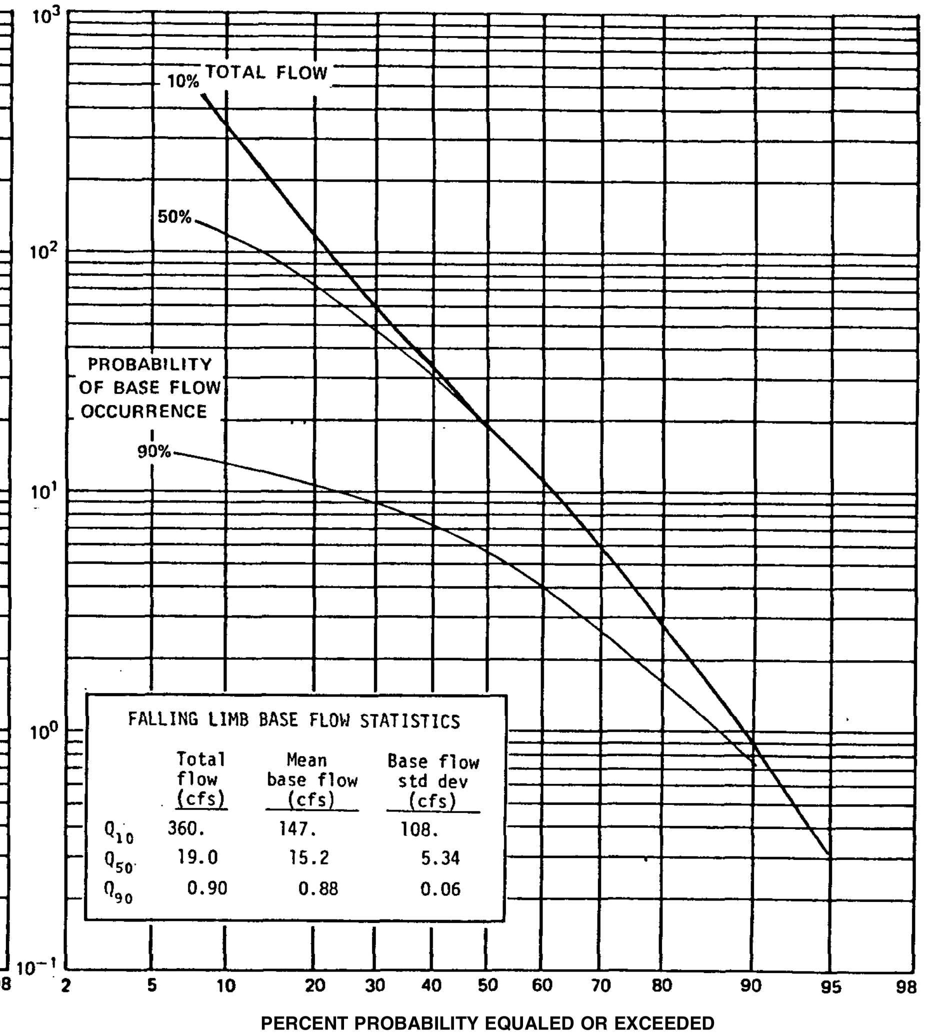
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	37.0	16.8	12.4
Q_{50}	3.10	2.17	1.06
Q_{90}	0.30	0.27	0.06



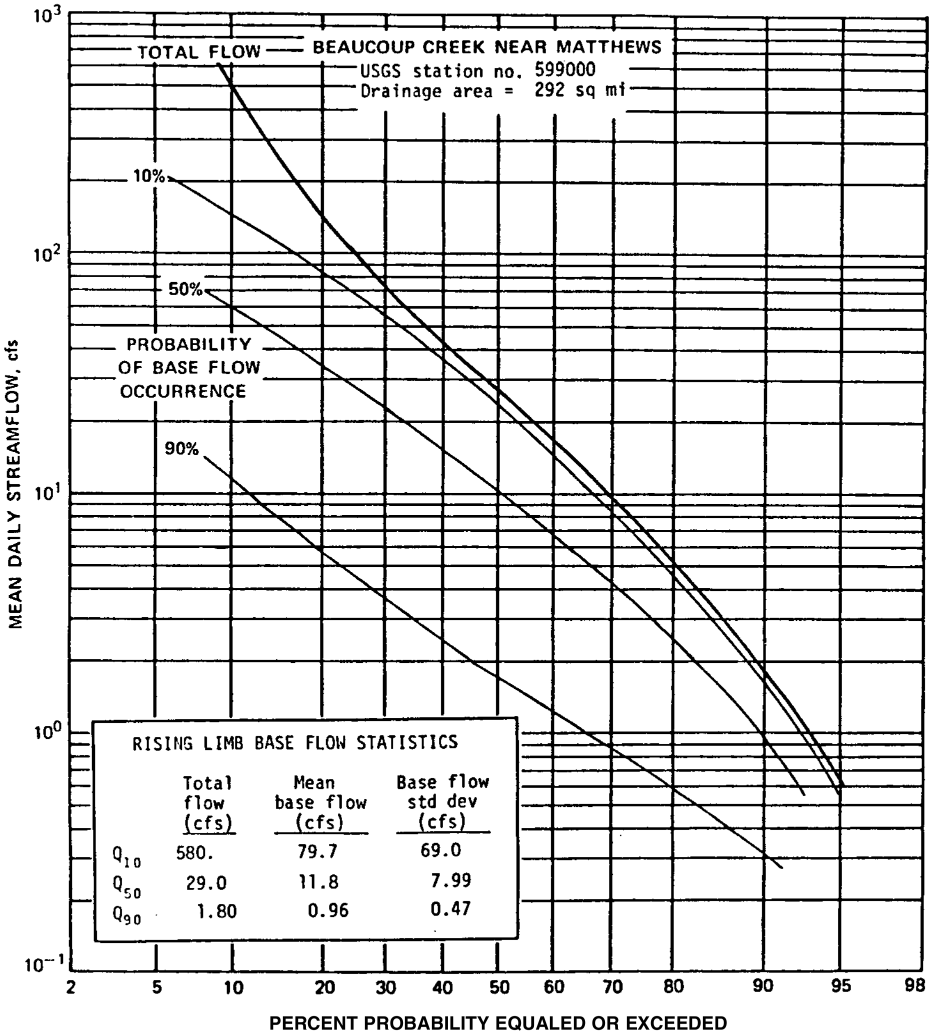
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	360.	55.7	51.4
Q_{50}	19.0	7.29	5.15
Q_{90}	0.90	0.54	0.24



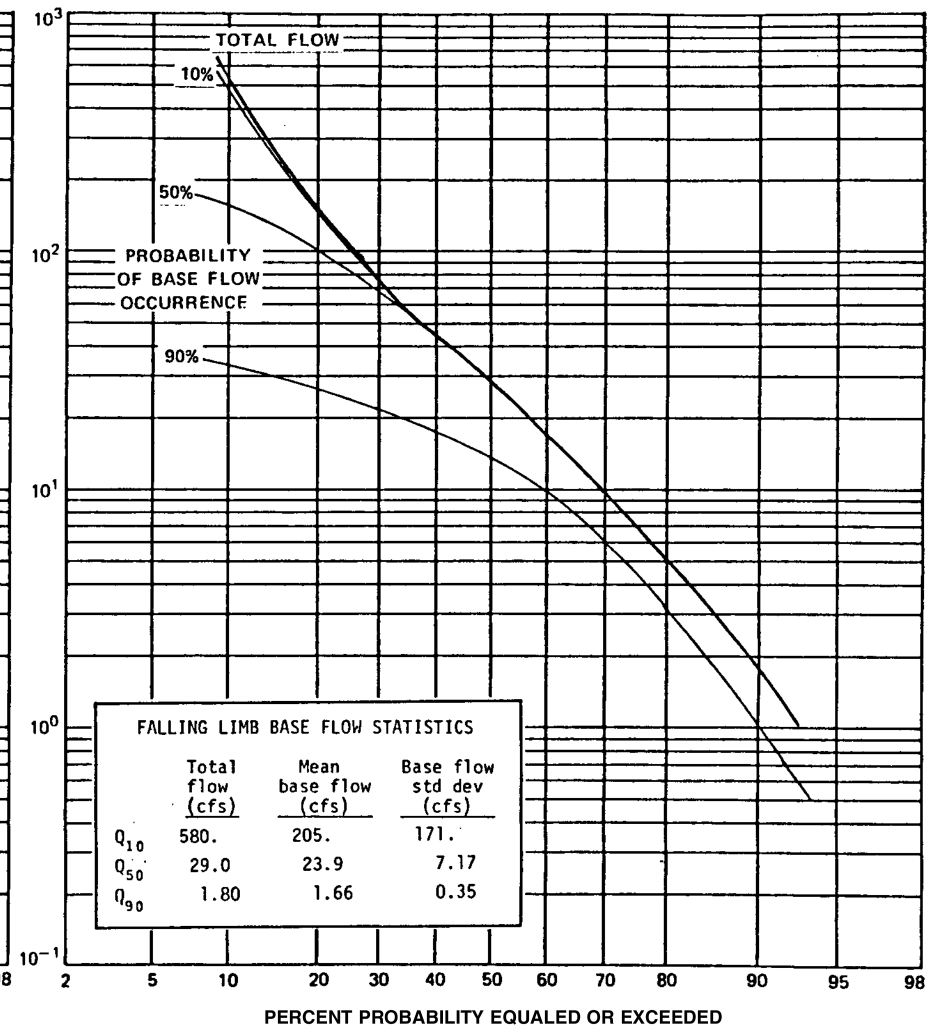
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	360.	147.	108.
Q_{50}	19.0	15.2	5.34
Q_{90}	0.90	0.88	0.06



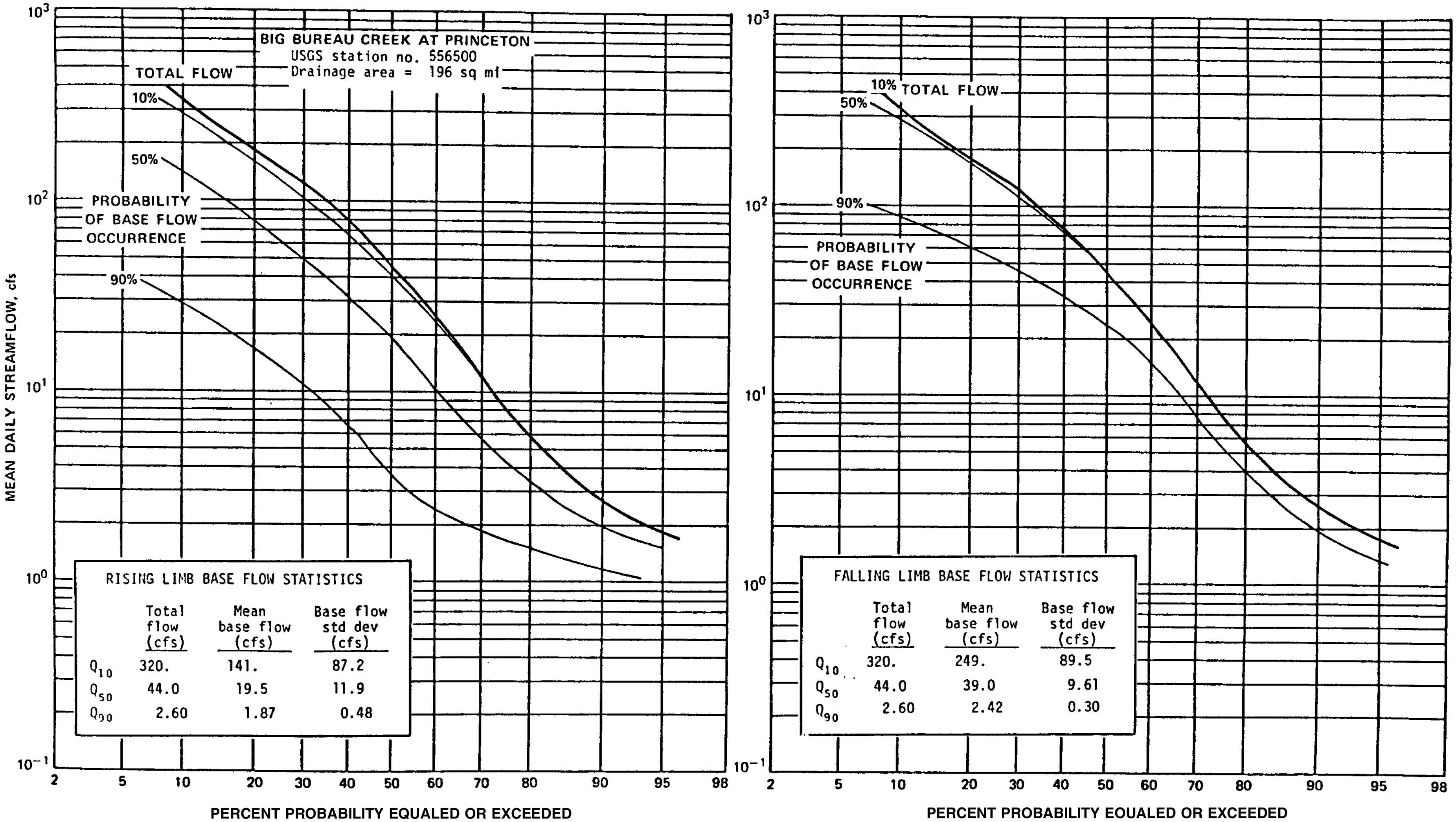
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	580.	79.7	69.0
Q_{50}	29.0	11.8	7.99
Q_{90}	1.80	0.96	0.47



FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	580.	205.	171.
Q_{50}	29.0	23.9	7.17
Q_{90}	1.80	1.66	0.35

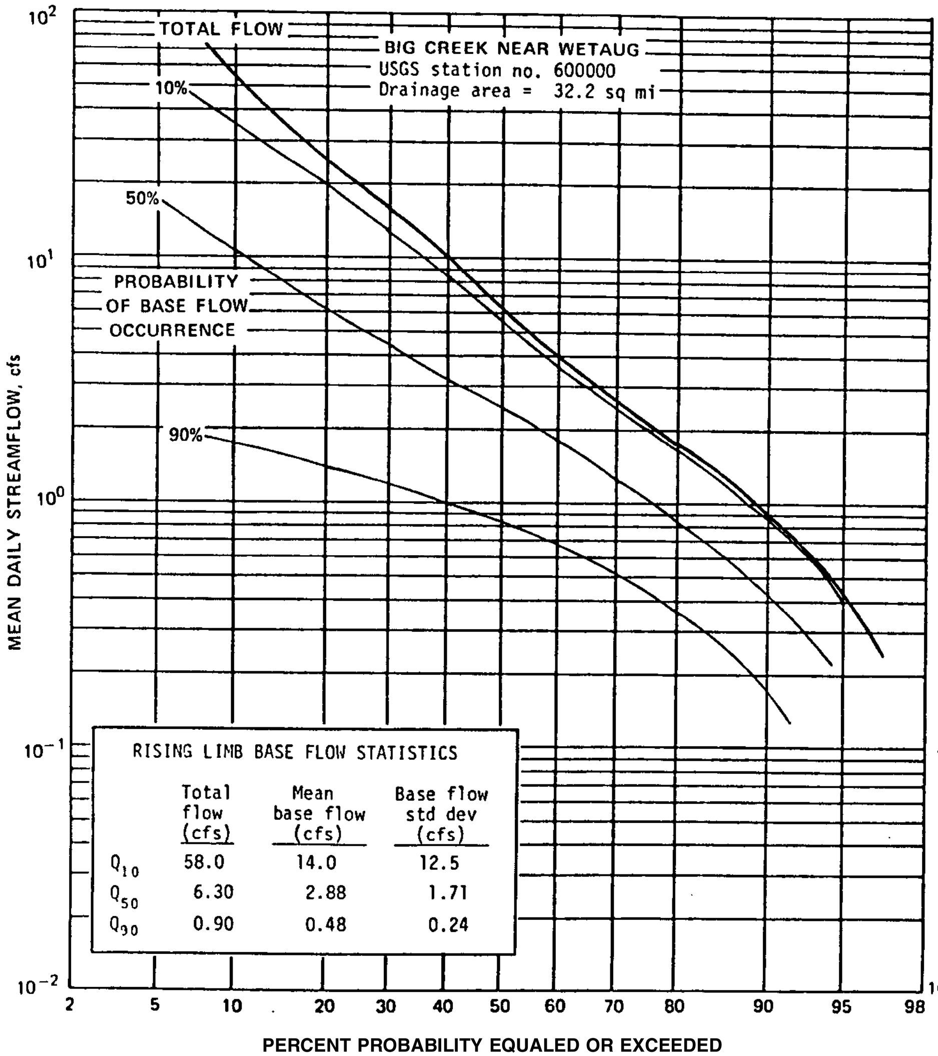


RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	320.	141.	87.2
Q_{50}	44.0	19.5	11.9
Q_{90}	2.60	1.87	0.48

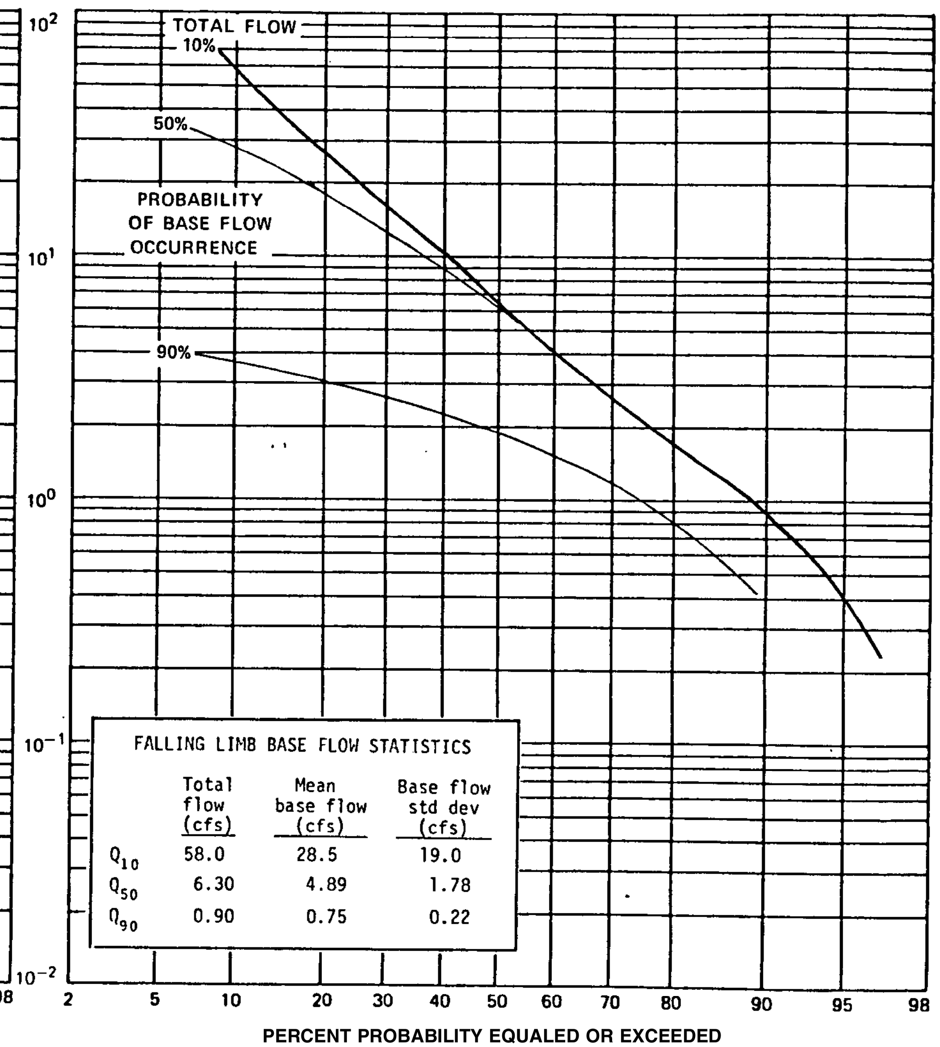
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	320.	249.	89.5
Q_{50}	44.0	39.0	9.61
Q_{90}	2.60	2.42	0.30



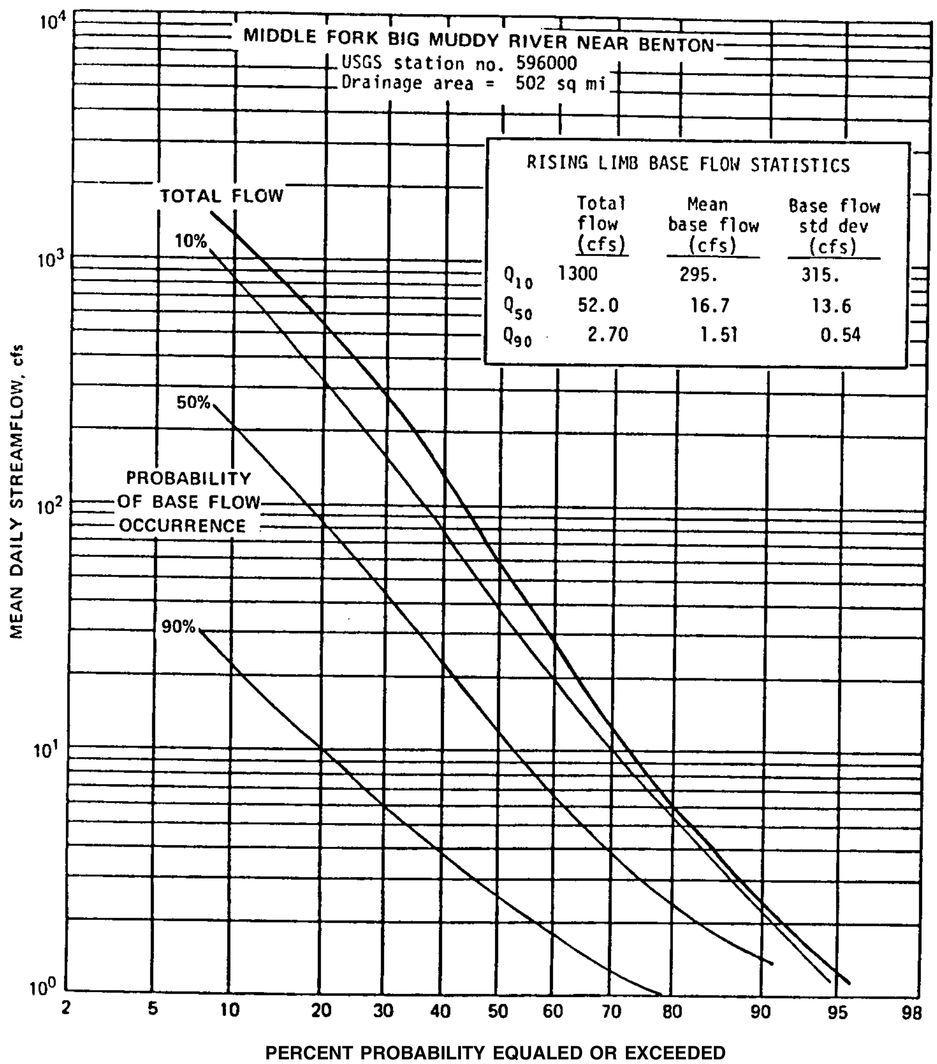
RISING LIMB BASE FLOW STATISTICS

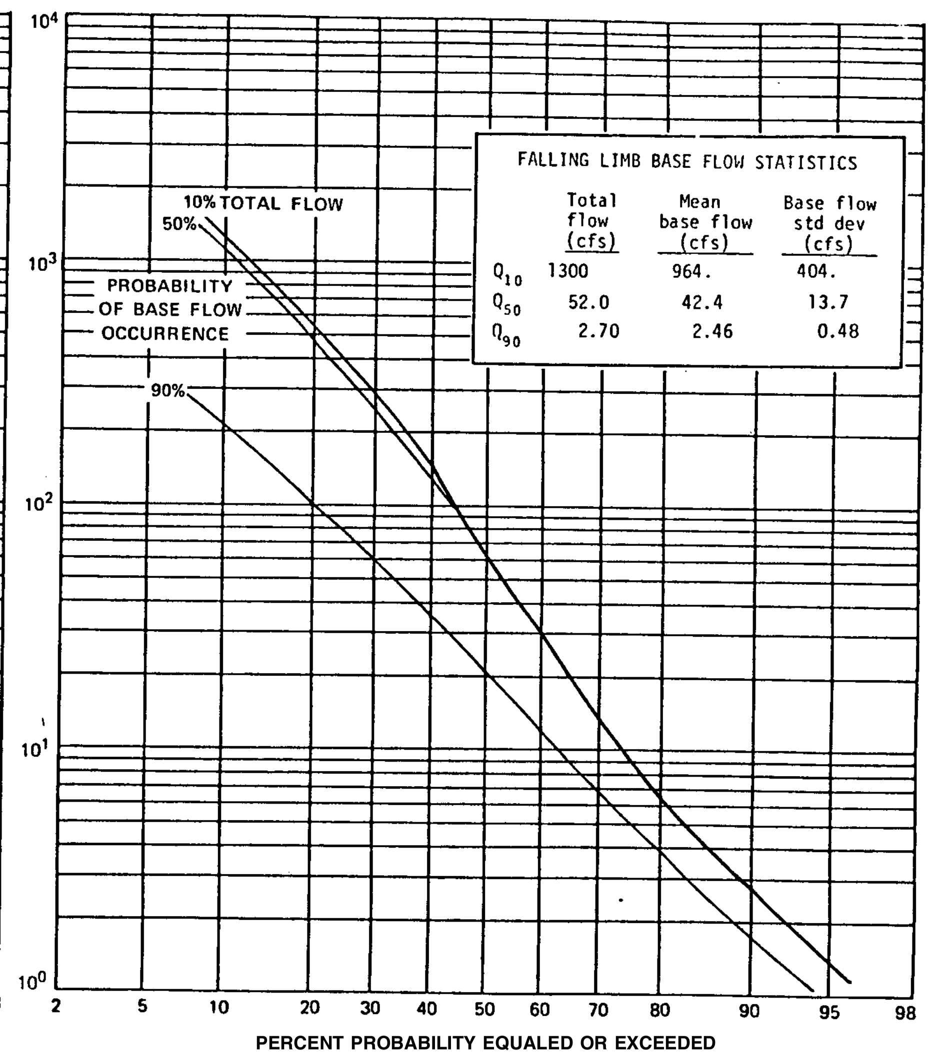
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	58.0	14.0	12.5
Q_{50}	6.30	2.88	1.71
Q_{90}	0.90	0.48	0.24

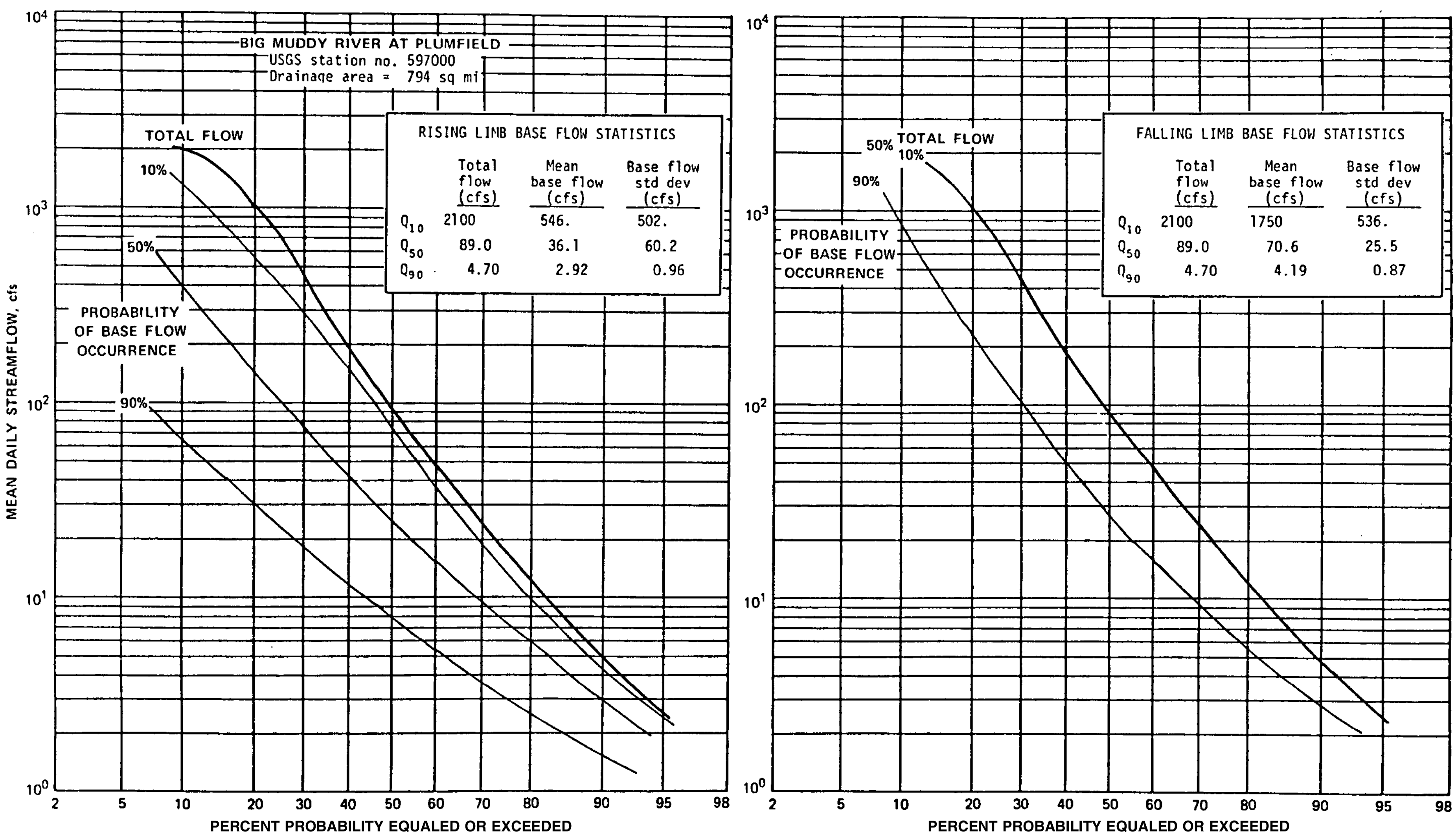


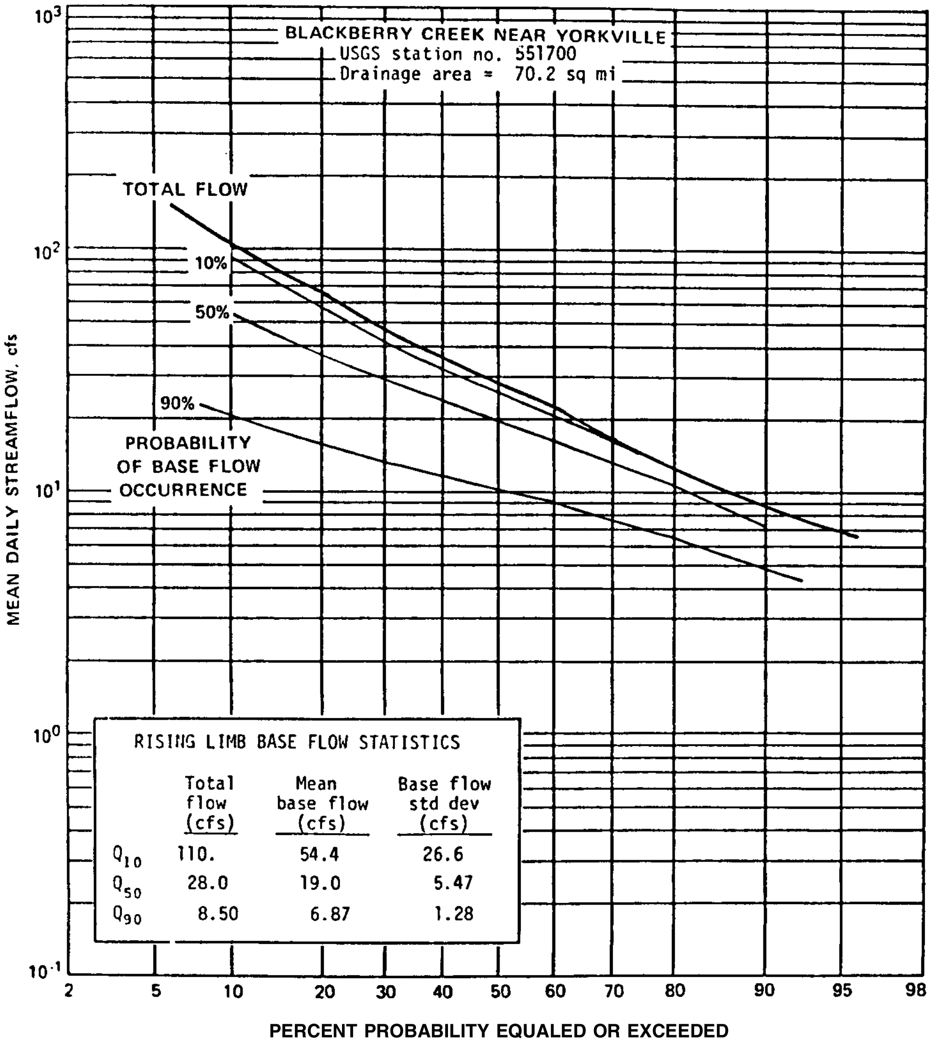
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	58.0	28.5	19.0
Q_{50}	6.30	4.89	1.78
Q_{90}	0.90	0.75	0.22


MIDDLE FORK BIG MUDDY RIVER NEAR BENTON
USGS station no. 596000
Drainage area = 502 sq mi
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q_{10} 1300 295. 315.
Q_{50} 52.0 16.7 13.6
Q_{90} 2.70 1.51 0.54
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
MEAN DAILY STREAMFLOW, cfs
10^4
10^3
10^2
10^1
10^0
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED

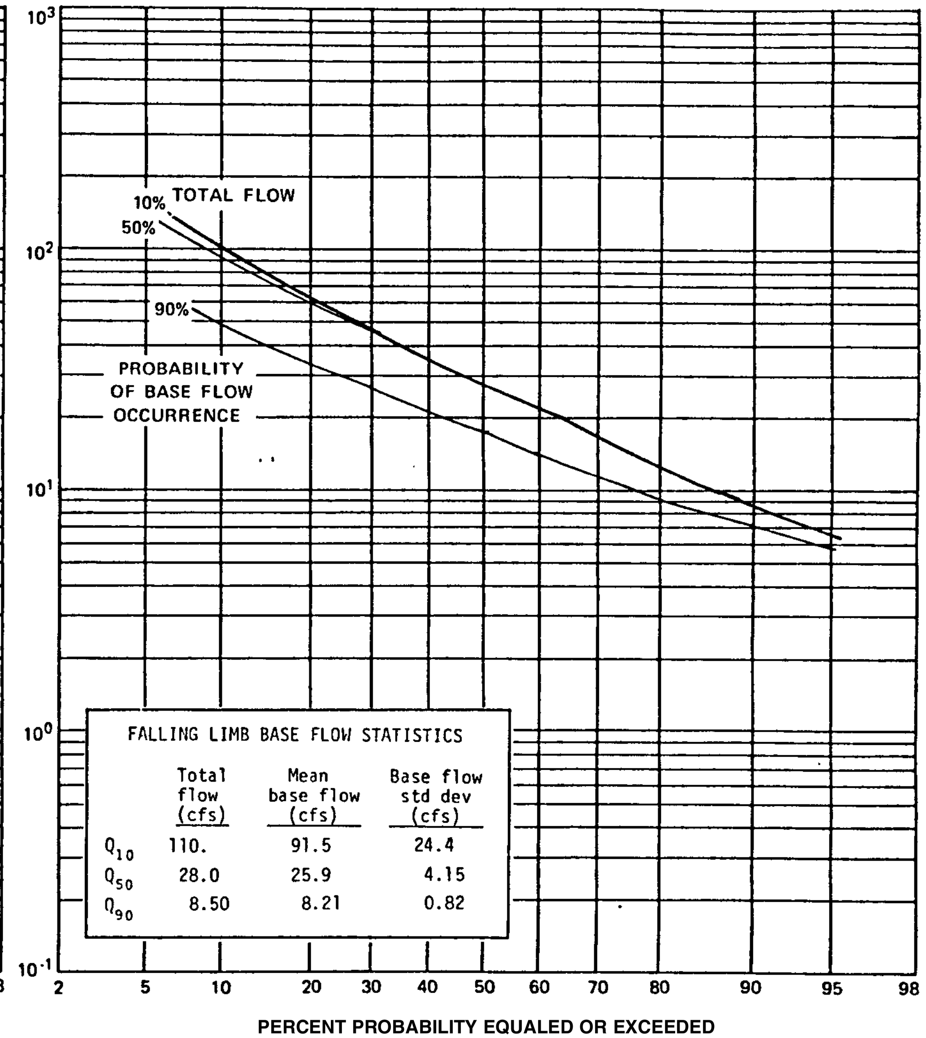

FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q_{10} 1300 964. 404.
Q_{50} 52.0 42.4 13.7
Q_{90} 2.70 2.46 0.48
10% TOTAL FLOW
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
10^4
10^3
10^2
10^1
10^0
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED


BIG MUDDY RIVER AT PLUMFIELD
USGS station no. 597000
Drainage area = 794 sq mi
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q_{10} 2100 546. 502.
Q_{50} 89.0 36.1 60.2
Q_{90} 4.70 2.92 0.96
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
MEAN DAILY STREAMFLOW, cfs
10^0
10^1
10^2
10^3
10^4
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED
FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q_{10} 2100 1750 536.
Q_{50} 89.0 70.6 25.5
Q_{90} 4.70 4.19 0.87
TOTAL FLOW
50%
10%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
10^0
10^1
10^2
10^3
10^4
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED



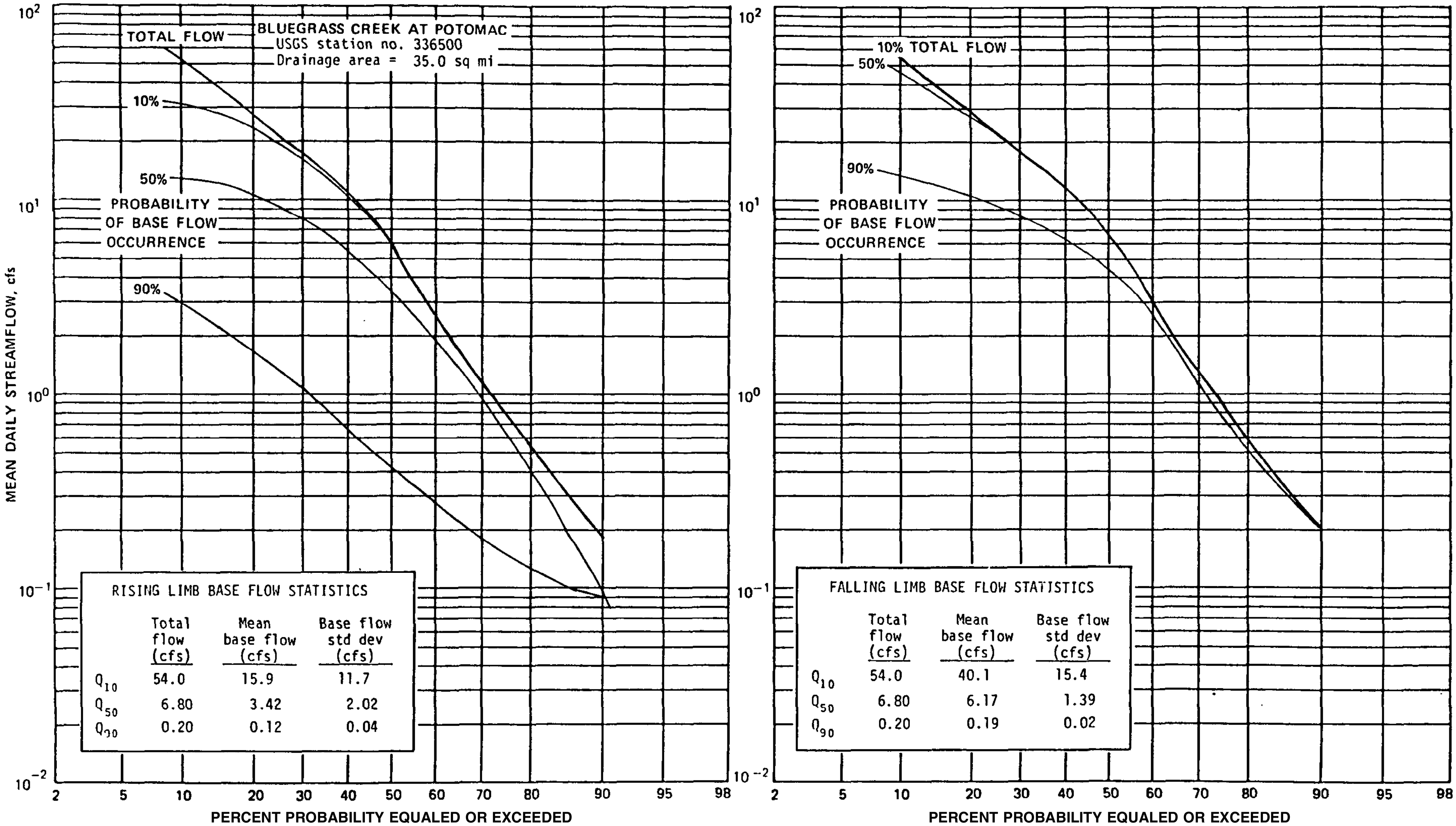
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	110.	54.4	26.6
Q_{50}	28.0	19.0	5.47
Q_{90}	8.50	6.87	1.28



FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	110.	91.5	24.4
Q_{50}	28.0	25.9	4.15
Q_{90}	8.50	8.21	0.82

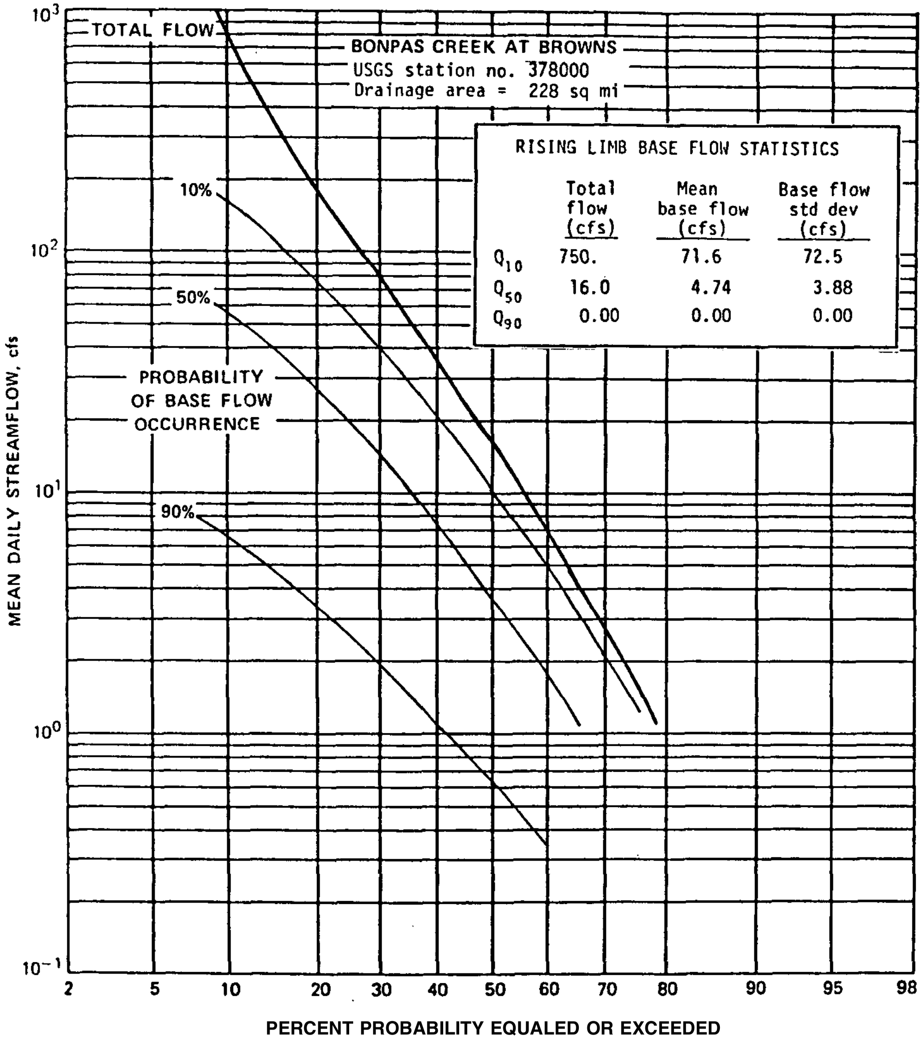


RISING LIMB BASE FLOW STATISTICS

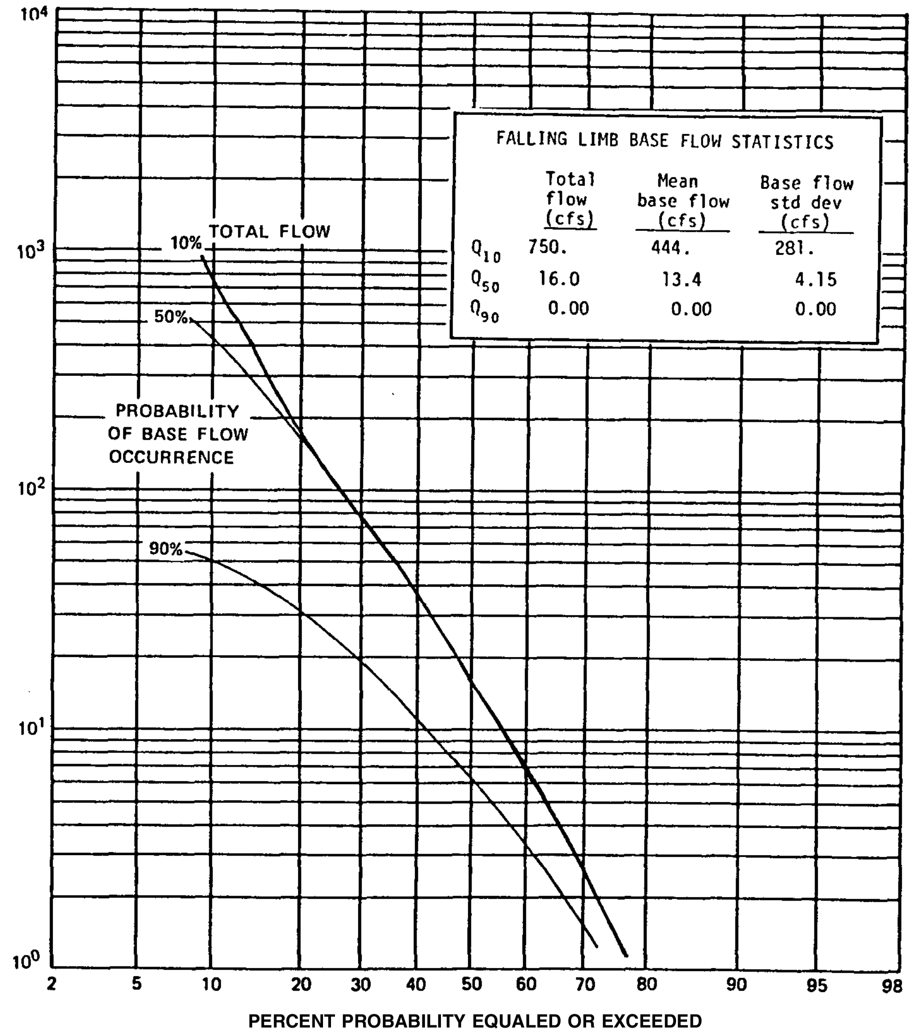
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	54.0	15.9	11.7
Q_{50}	6.80	3.42	2.02
Q_{90}	0.20	0.12	0.04

FALLING LIMB BASE FLOW STATISTICS

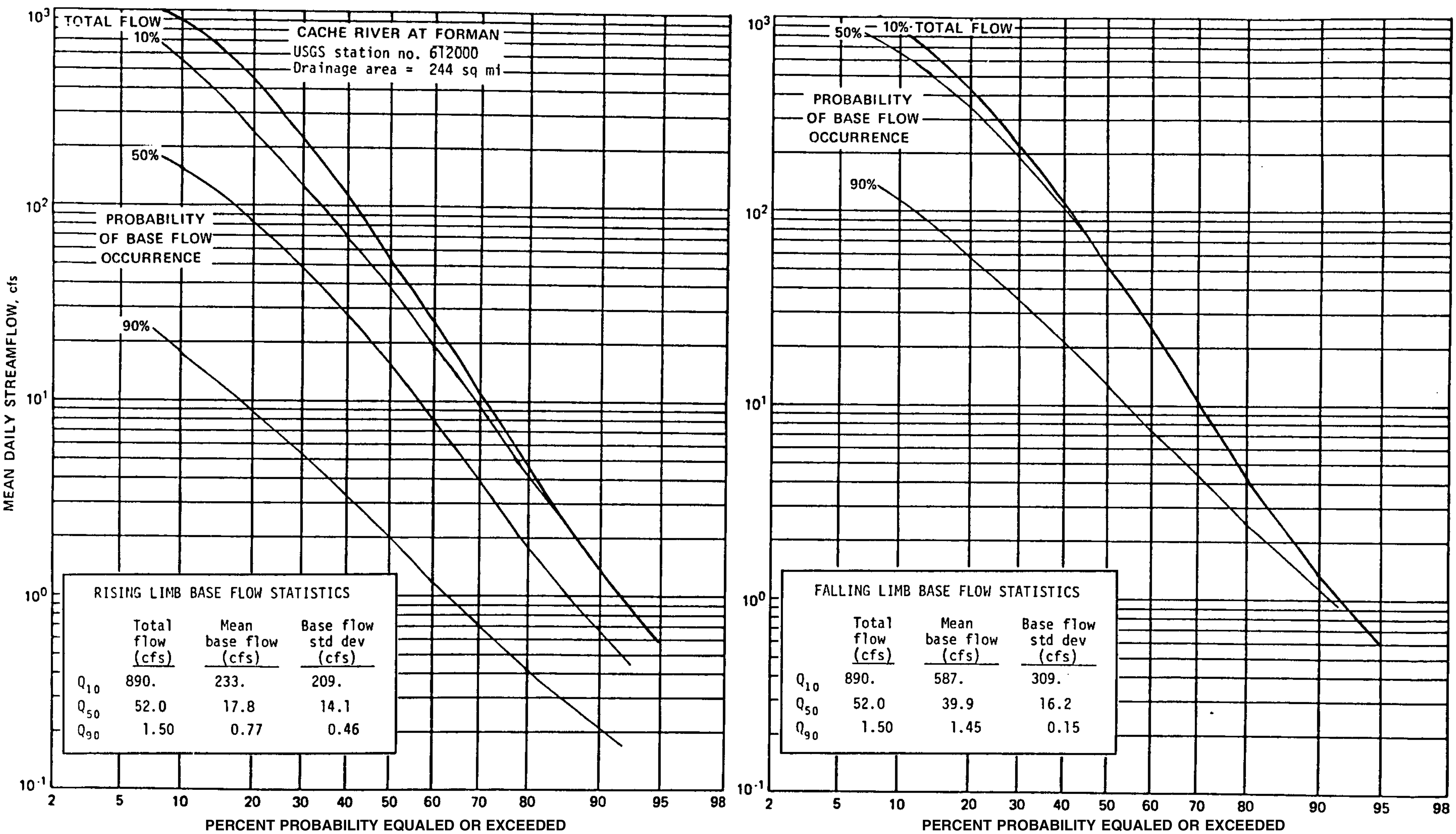
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	54.0	40.1	15.4
Q_{50}	6.80	6.17	1.39
Q_{90}	0.20	0.19	0.02



TOTAL FLOW
BONPAS CREEK AT BROWNS
USGS station no. 378000
Drainage area = 228 sq mi
RISING LIMB BASE FLOW STATISTICS
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	750.	71.6	72.5
Q_{50}	16.0	4.74	3.88
Q_{90}	0.00	0.00	0.00
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
MEAN DAILY STREAMFLOW, cfs
10^3
10^2
10^1
10^0
10^{-1}
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED



FALLING LIMB BASE FLOW STATISTICS
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	750.	444.	281.
Q_{50}	16.0	13.4	4.15
Q_{90}	0.00	0.00	0.00
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
10^4
10^3
10^2
10^1
10^0
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED

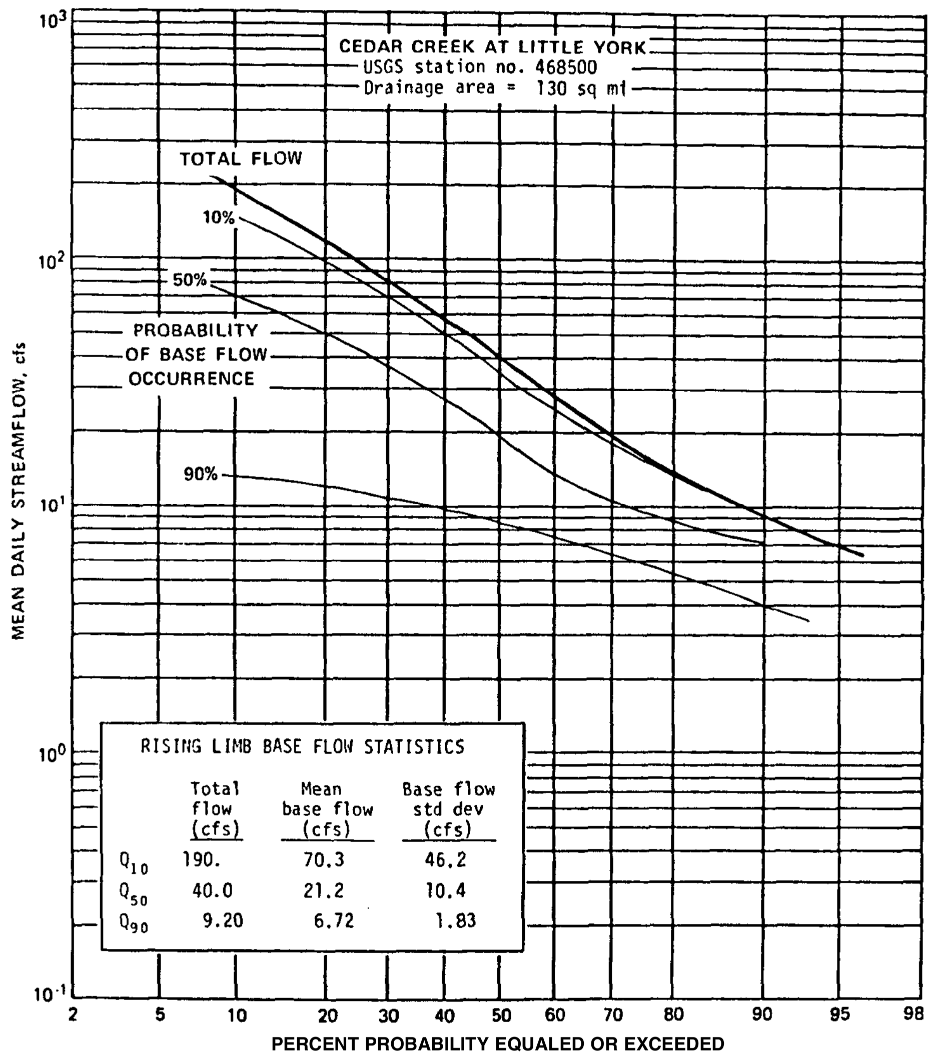


RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	890.	233.	209.
Q_{50}	52.0	17.8	14.1
Q_{90}	1.50	0.77	0.46

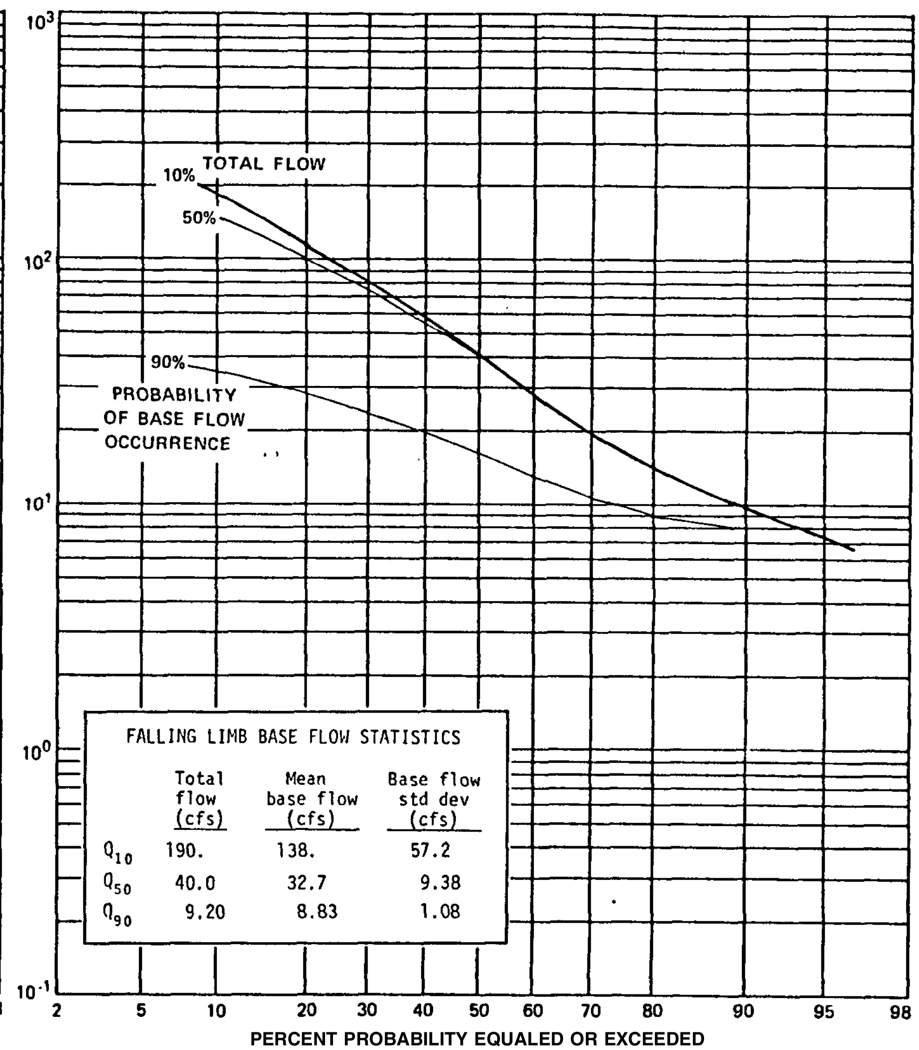
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	890.	587.	309.
Q_{50}	52.0	39.9	16.2
Q_{90}	1.50	1.45	0.15



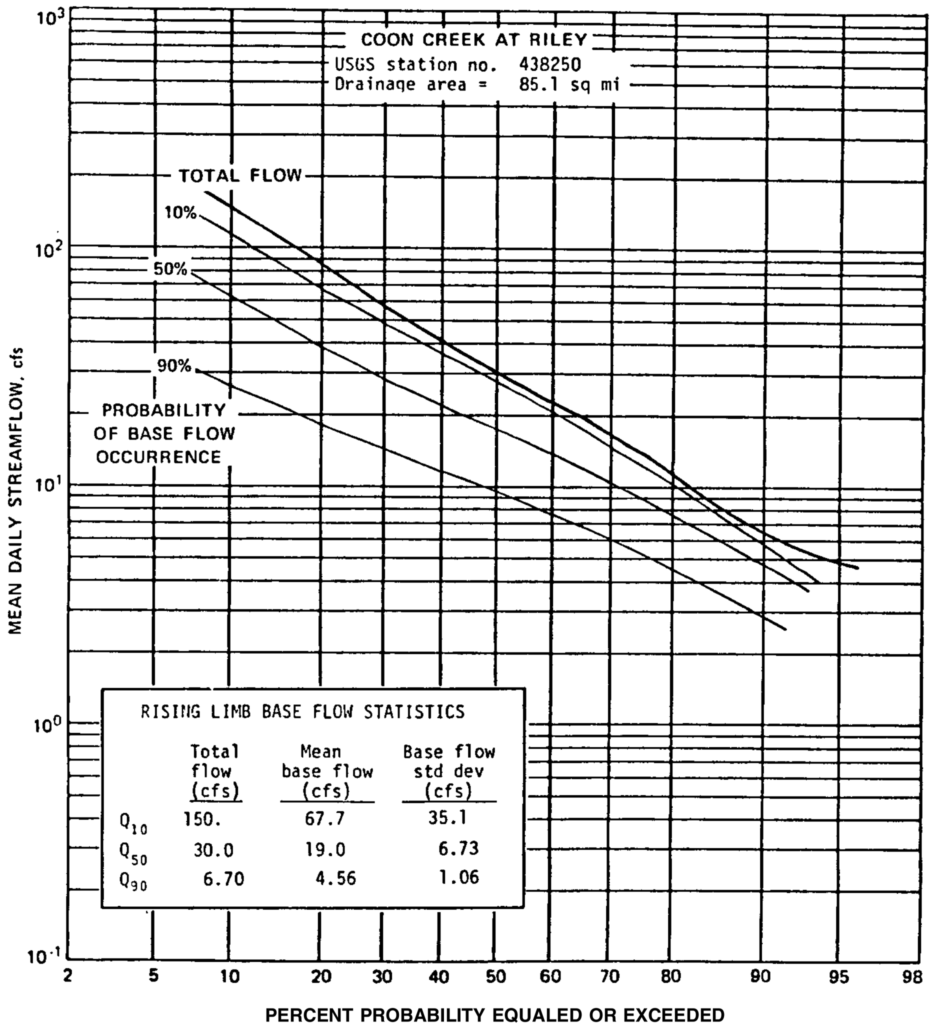
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	190.	70.3	46.2
Q_{50}	40.0	21.2	10.4
Q_{90}	9.20	6.72	1.83



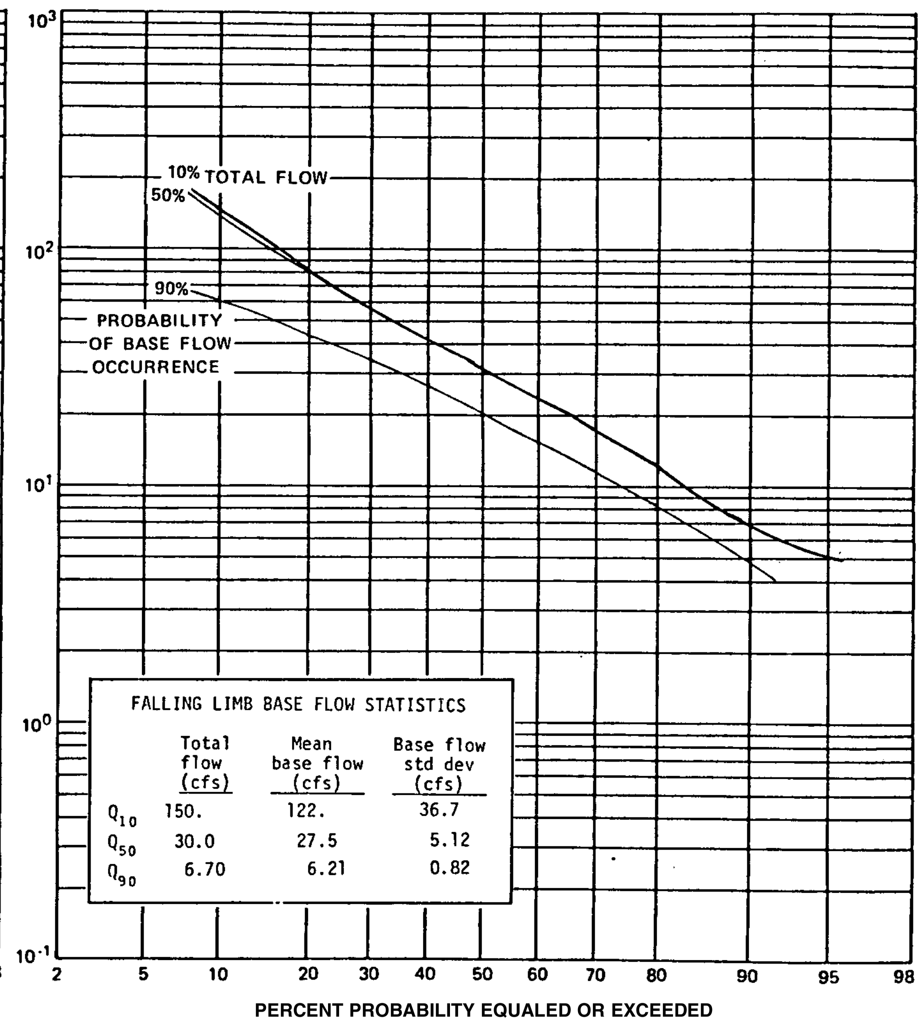
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	190.	138.	57.2
Q_{50}	40.0	32.7	9.38
Q_{90}	9.20	8.83	1.08



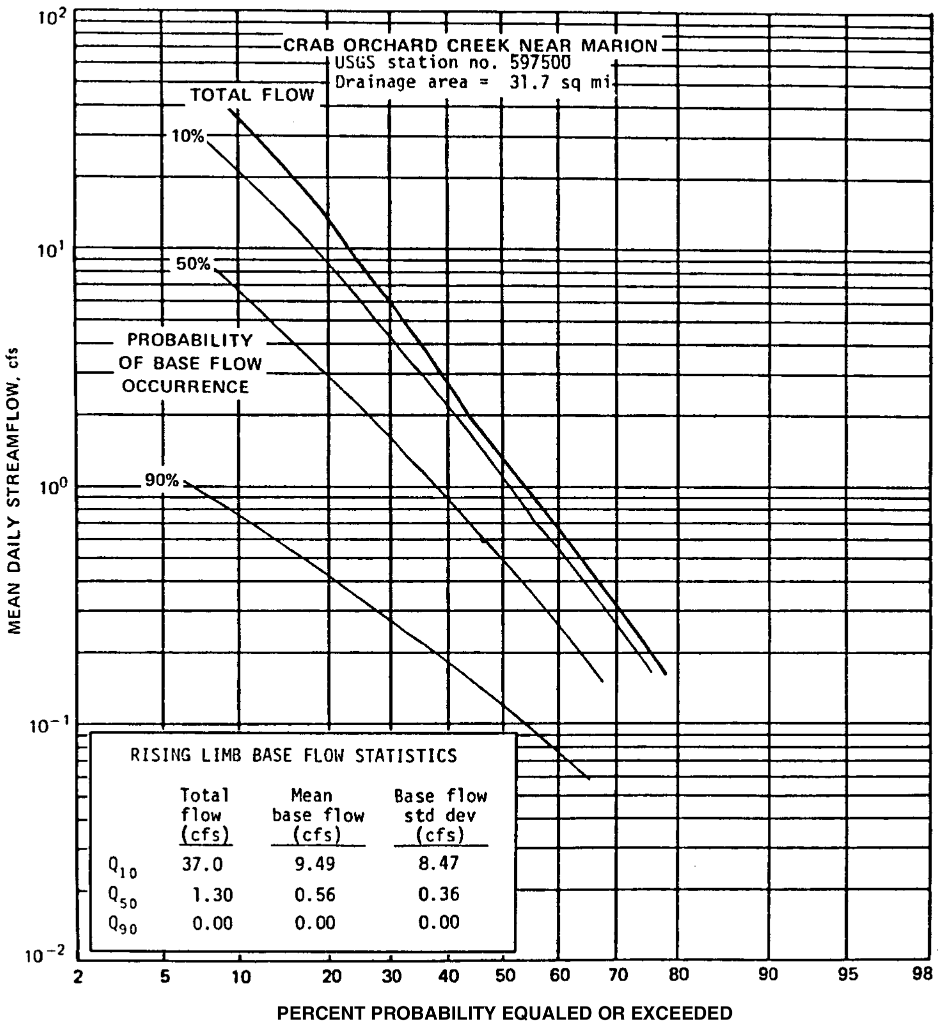
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	150.	67.7	35.1
Q_{50}	30.0	19.0	6.73
Q_{90}	6.70	4.56	1.06



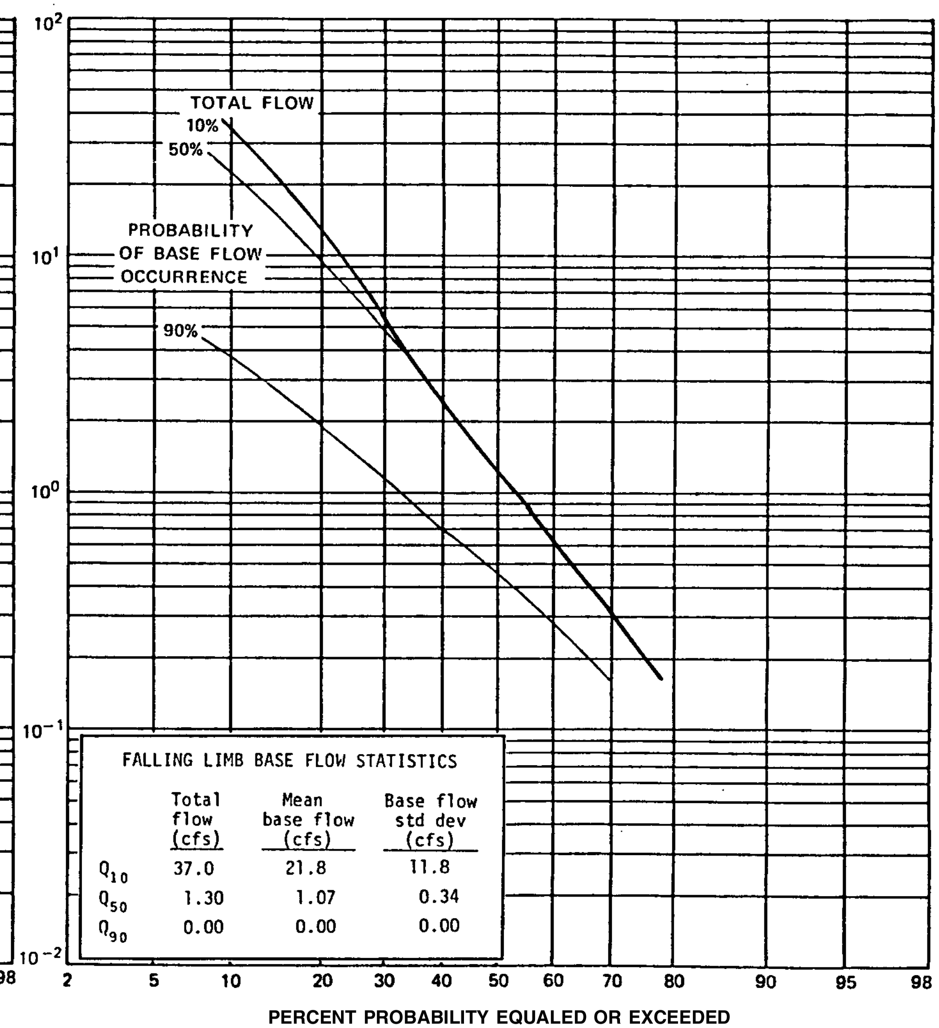
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	150.	122.	36.7
Q_{50}	30.0	27.5	5.12
Q_{90}	6.70	6.21	0.82



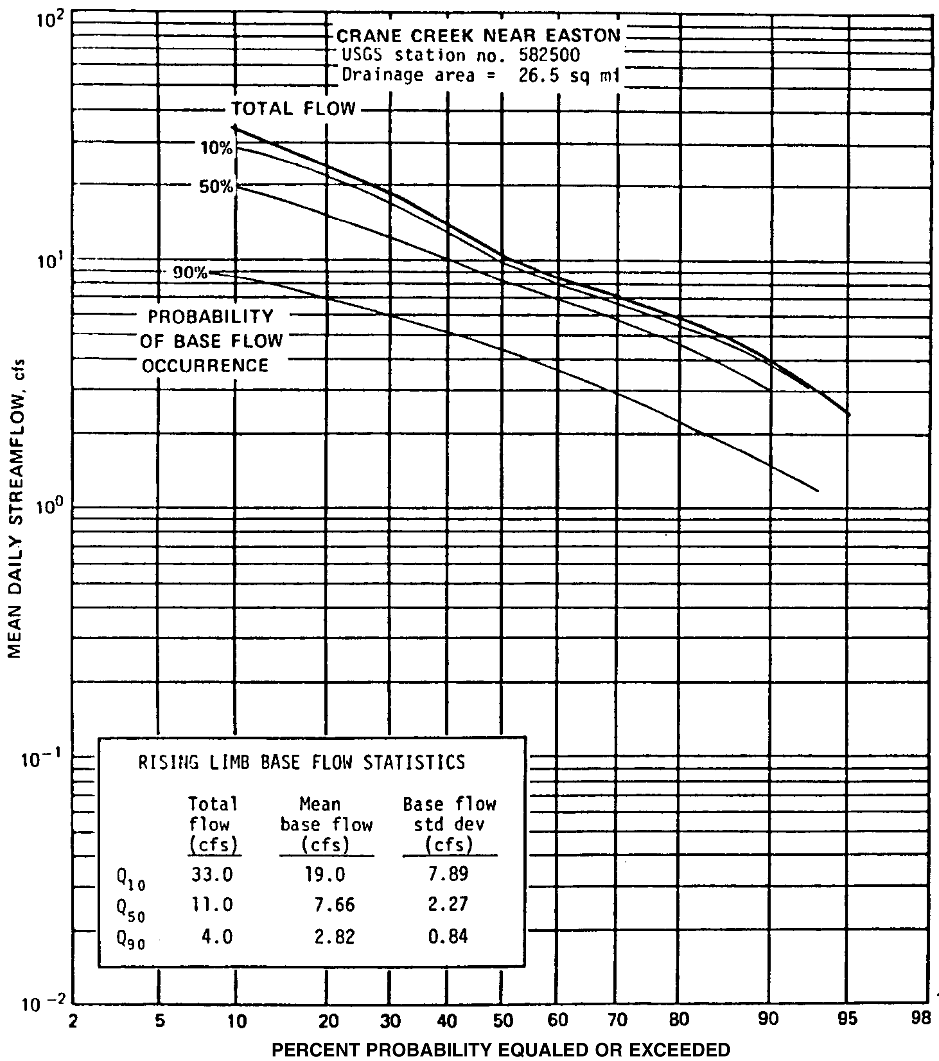
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	37.0	9.49	8.47
Q_{50}	1.30	0.56	0.36
Q_{90}	0.00	0.00	0.00



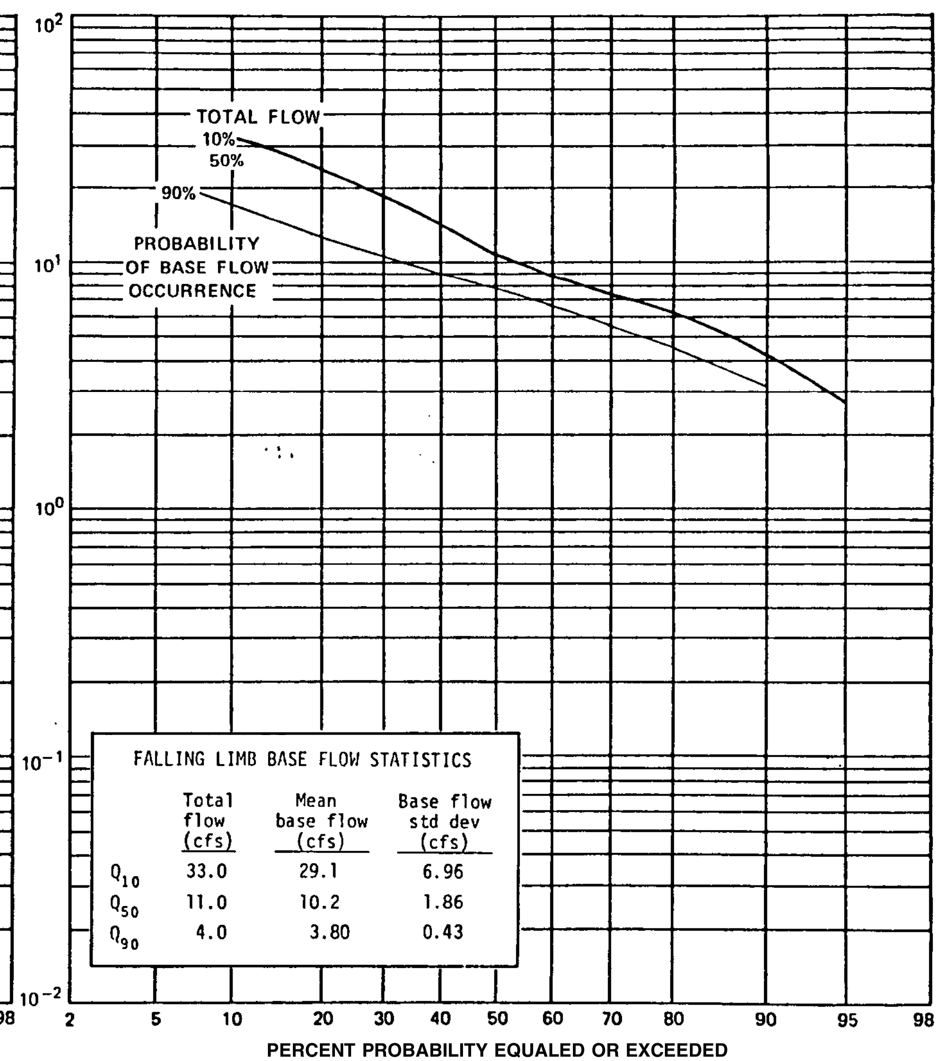
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	37.0	21.8	11.8
Q_{50}	1.30	1.07	0.34
Q_{90}	0.00	0.00	0.00



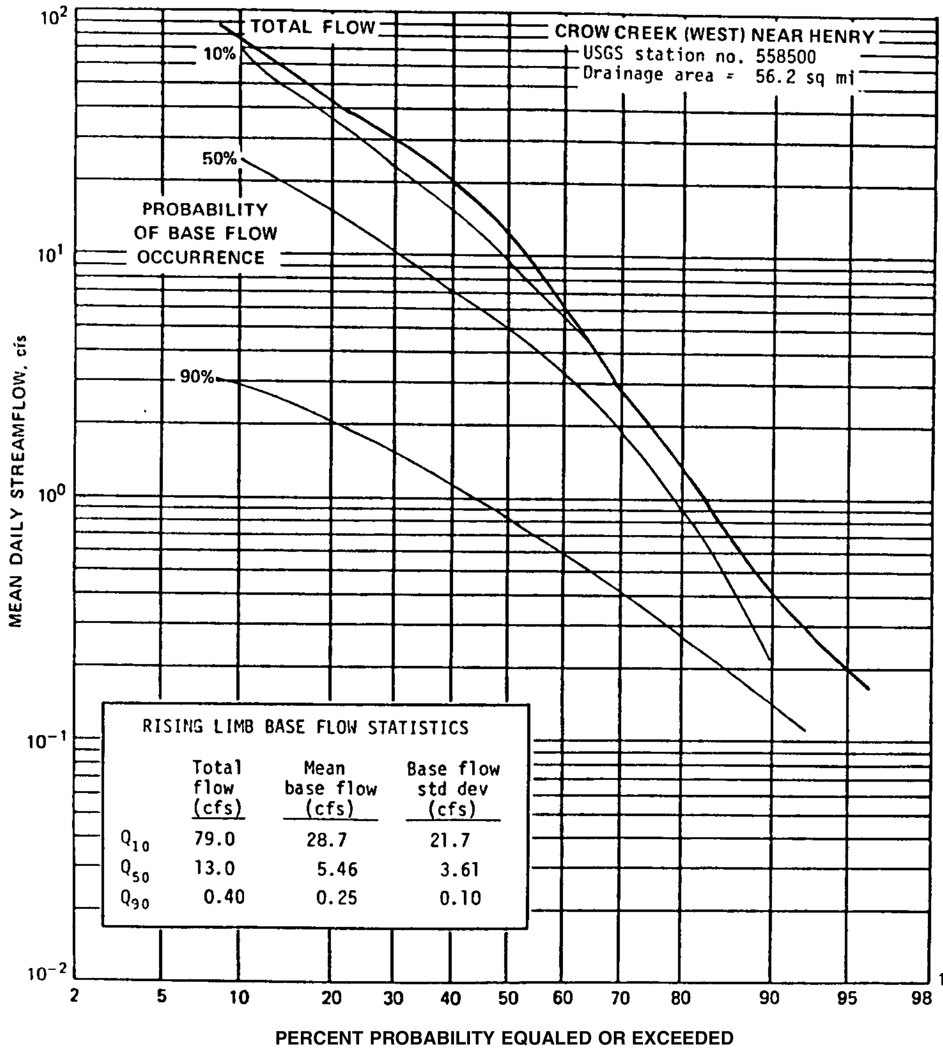
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	33.0	19.0	7.89
Q_{50}	11.0	7.66	2.27
Q_{90}	4.0	2.82	0.84



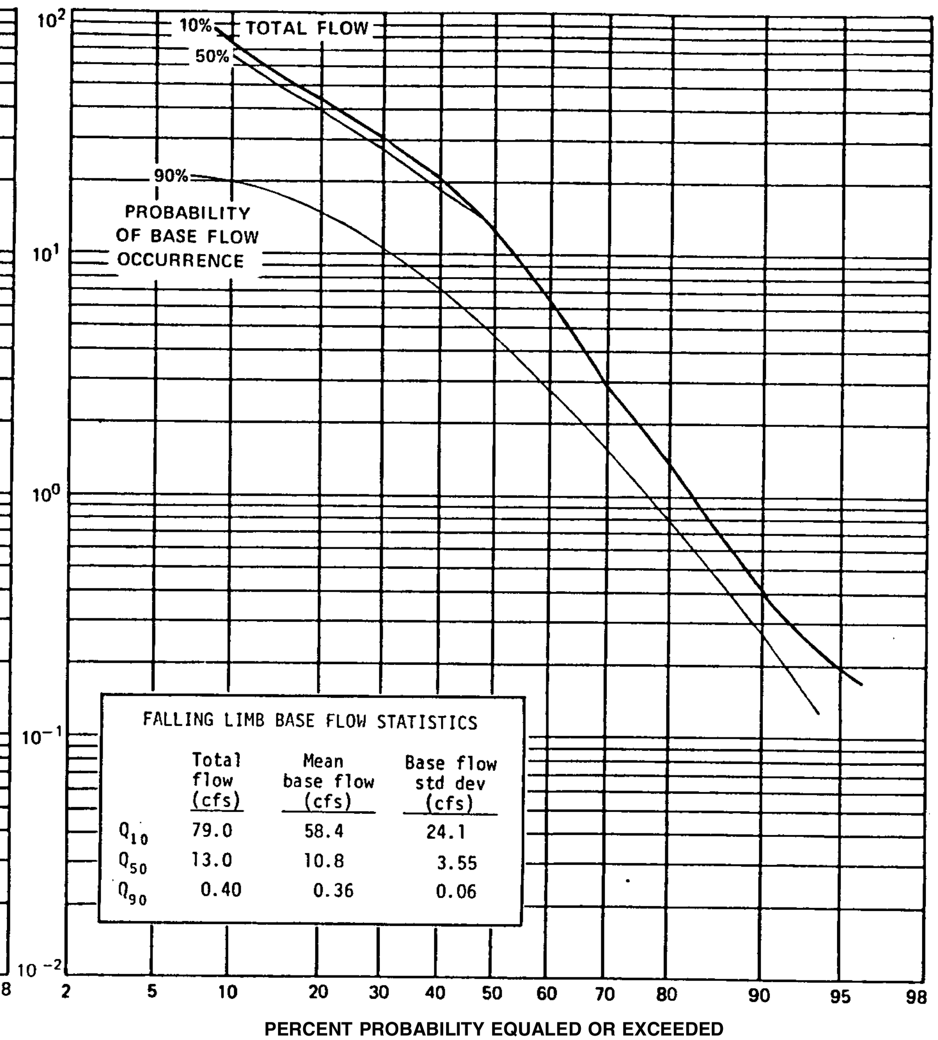
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	33.0	29.1	6.96
Q_{50}	11.0	10.2	1.86
Q_{90}	4.0	3.80	0.43



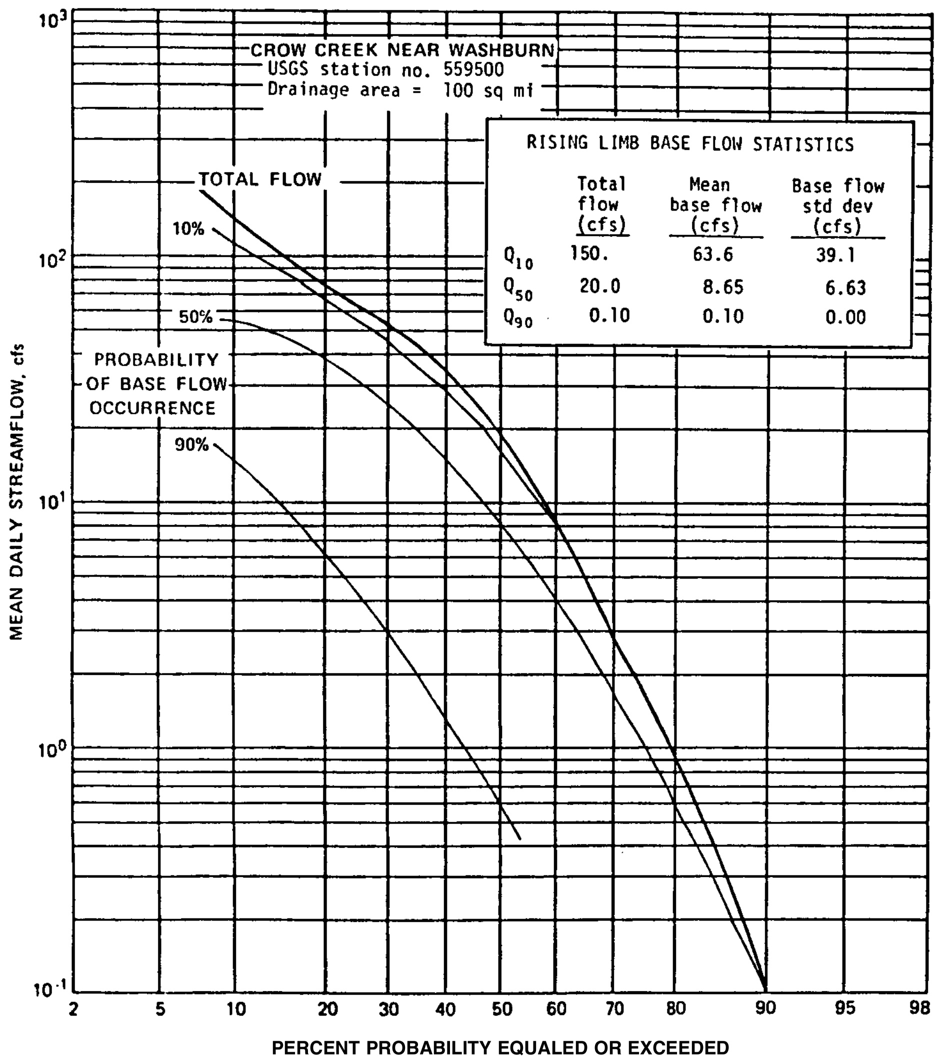
RISING LIMB BASE FLOW STATISTICS

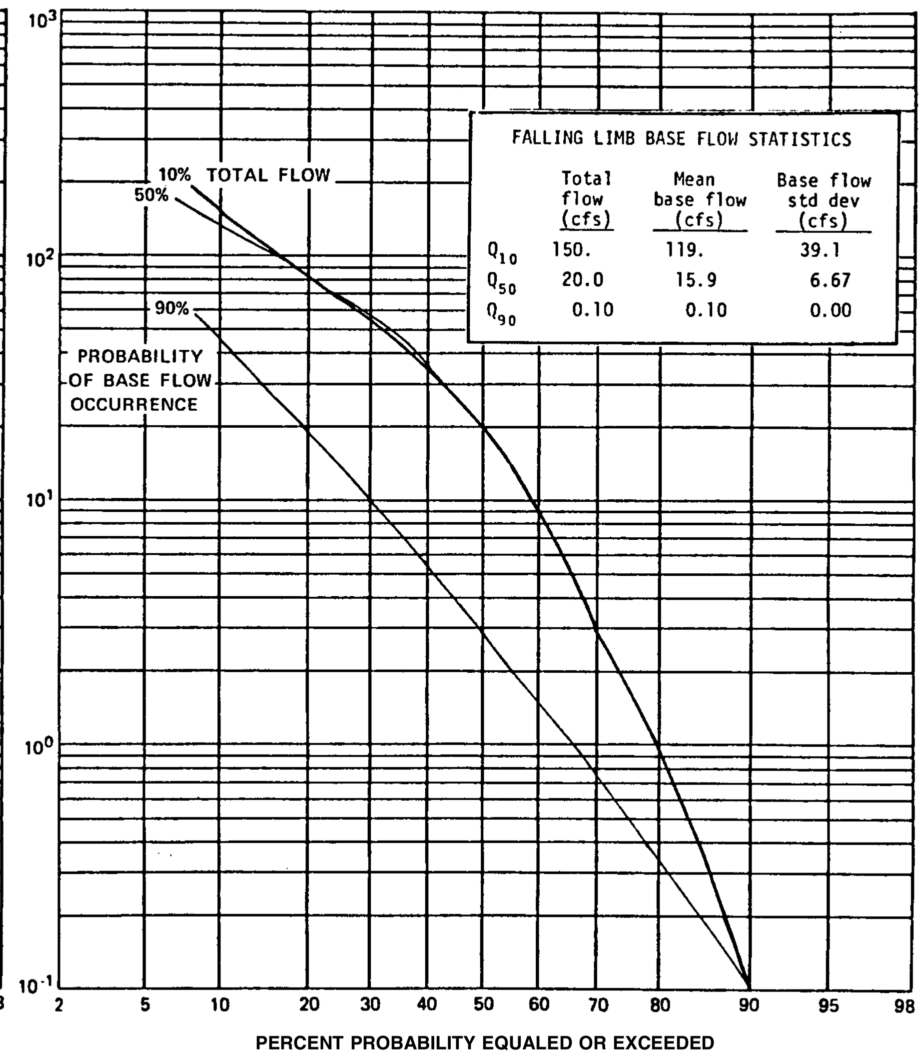
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	79.0	28.7	21.7
Q_{50}	13.0	5.46	3.61
Q_{90}	0.40	0.25	0.10

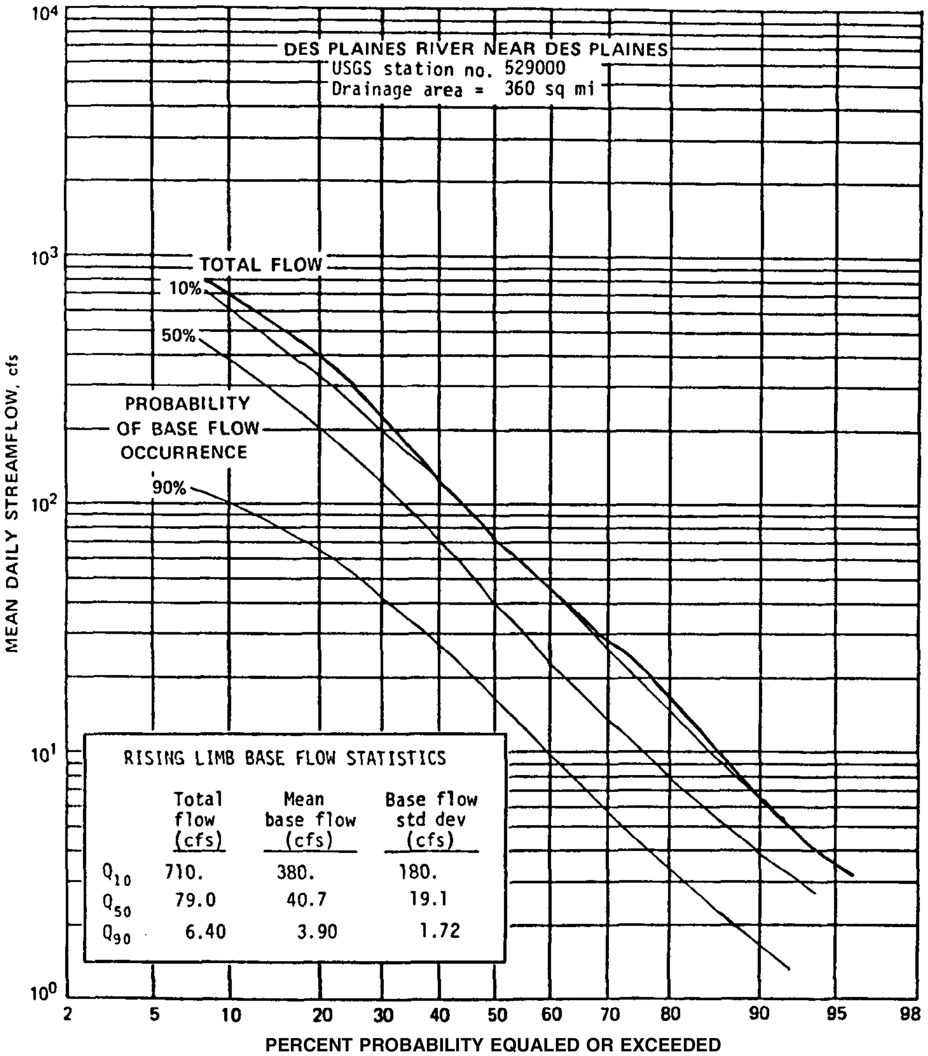


FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	79.0	58.4	24.1
Q_{50}	13.0	10.8	3.55
Q_{90}	0.40	0.36	0.06

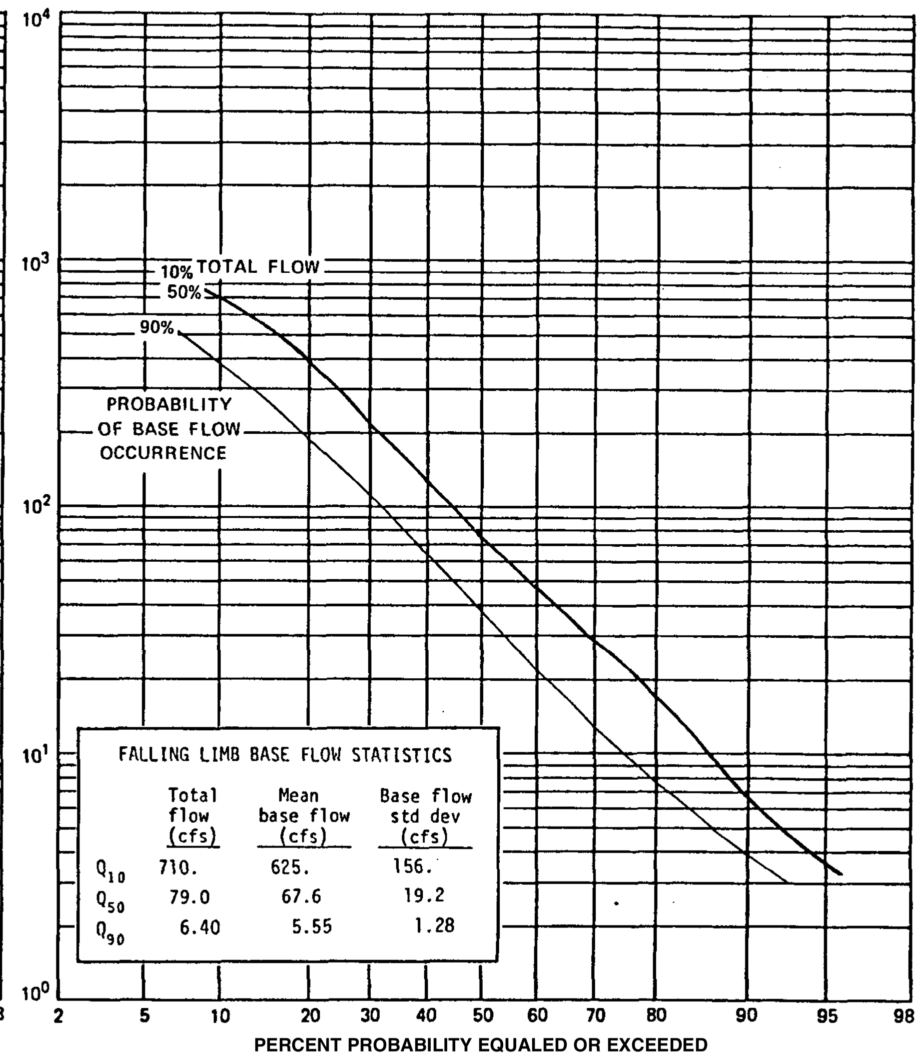

CROW CREEK NEAR WASHBURN
USGS station no. 559500
Drainage area = 100 sq mi
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q_{10} 150. 63.6 39.1
Q_{50} 20.0 8.65 6.63
Q_{90} 0.10 0.10 0.00
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
MEAN DAILY STREAMFLOW, cfs
10^3
10^2
10^1
10^0
10^{-1}
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED


FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q_{10} 150. 119. 39.1
Q_{50} 20.0 15.9 6.67
Q_{90} 0.10 0.10 0.00
10% TOTAL FLOW
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
10^3
10^2
10^1
10^0
10^{-1}
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED



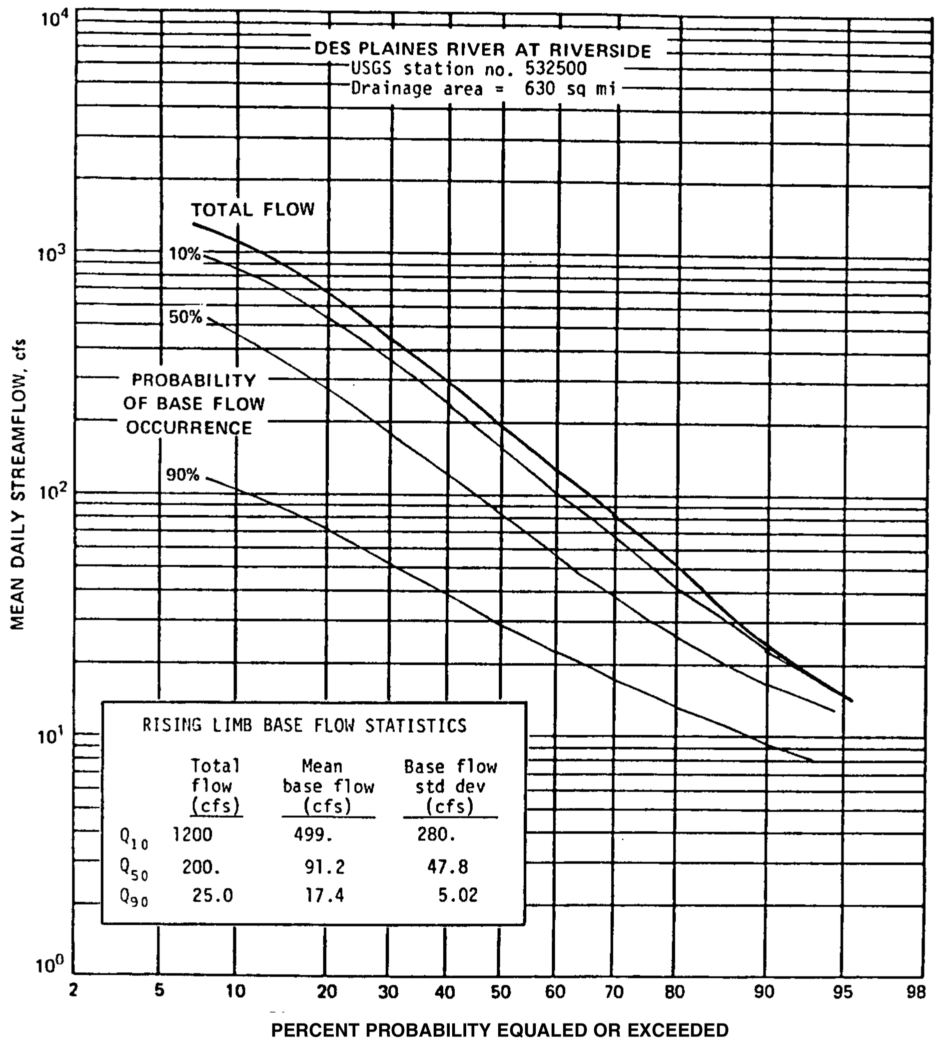
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	710.	380.	180.
Q_{50}	79.0	40.7	19.1
Q_{90}	6.40	3.90	1.72



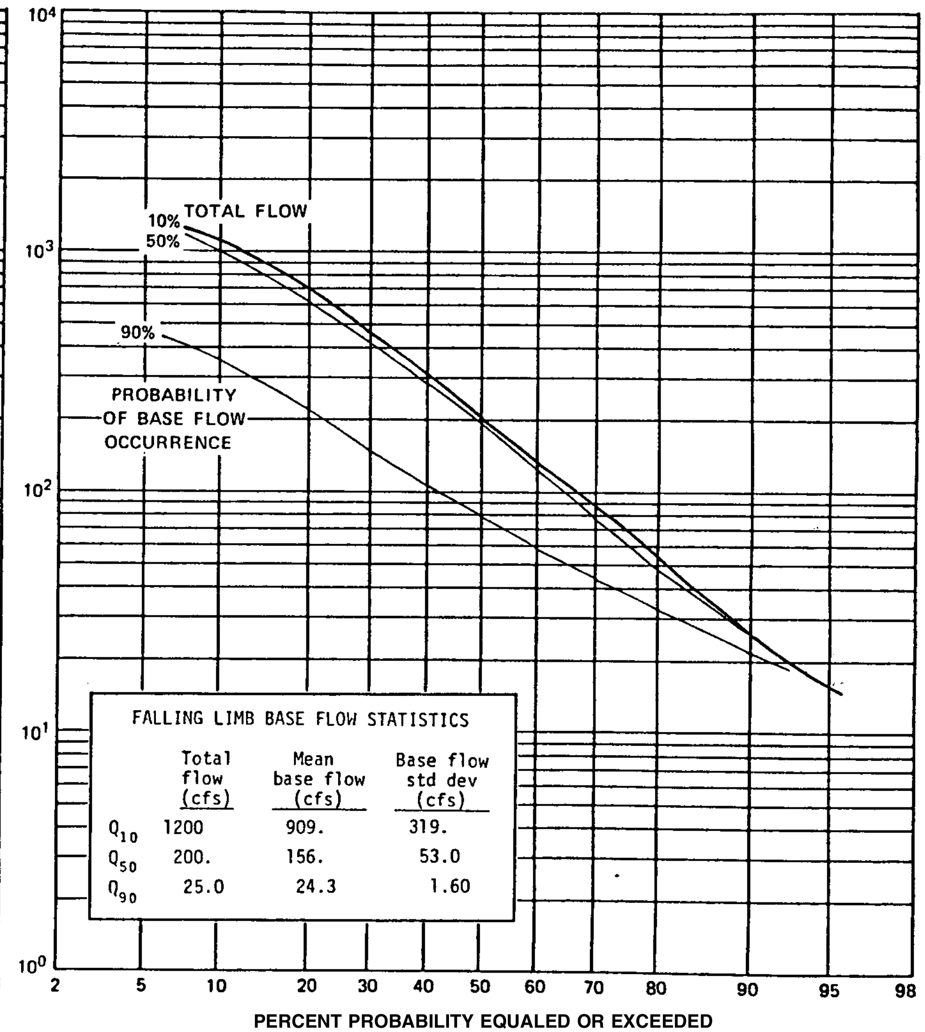
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	710.	625.	156.
Q_{50}	79.0	67.6	19.2
Q_{90}	6.40	5.55	1.28



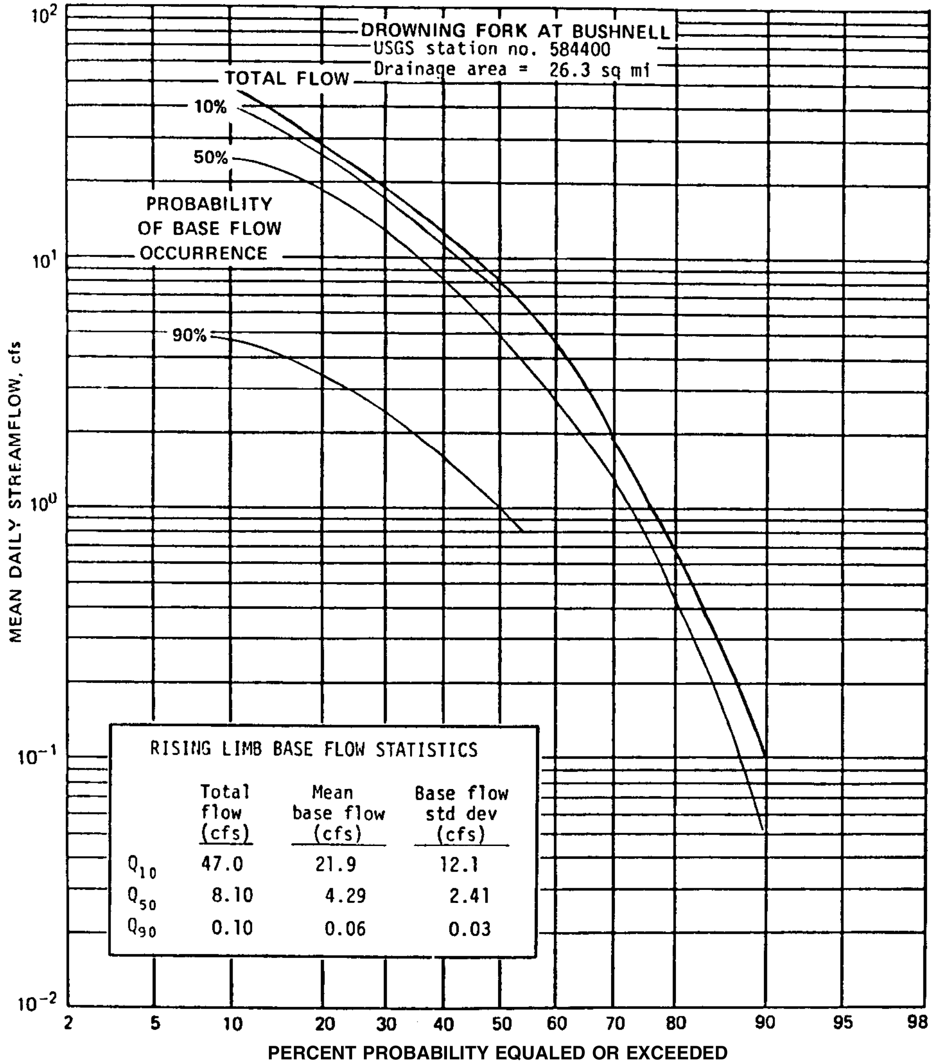
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1200	499.	280.
Q_{50}	200.	91.2	47.8
Q_{90}	25.0	17.4	5.02



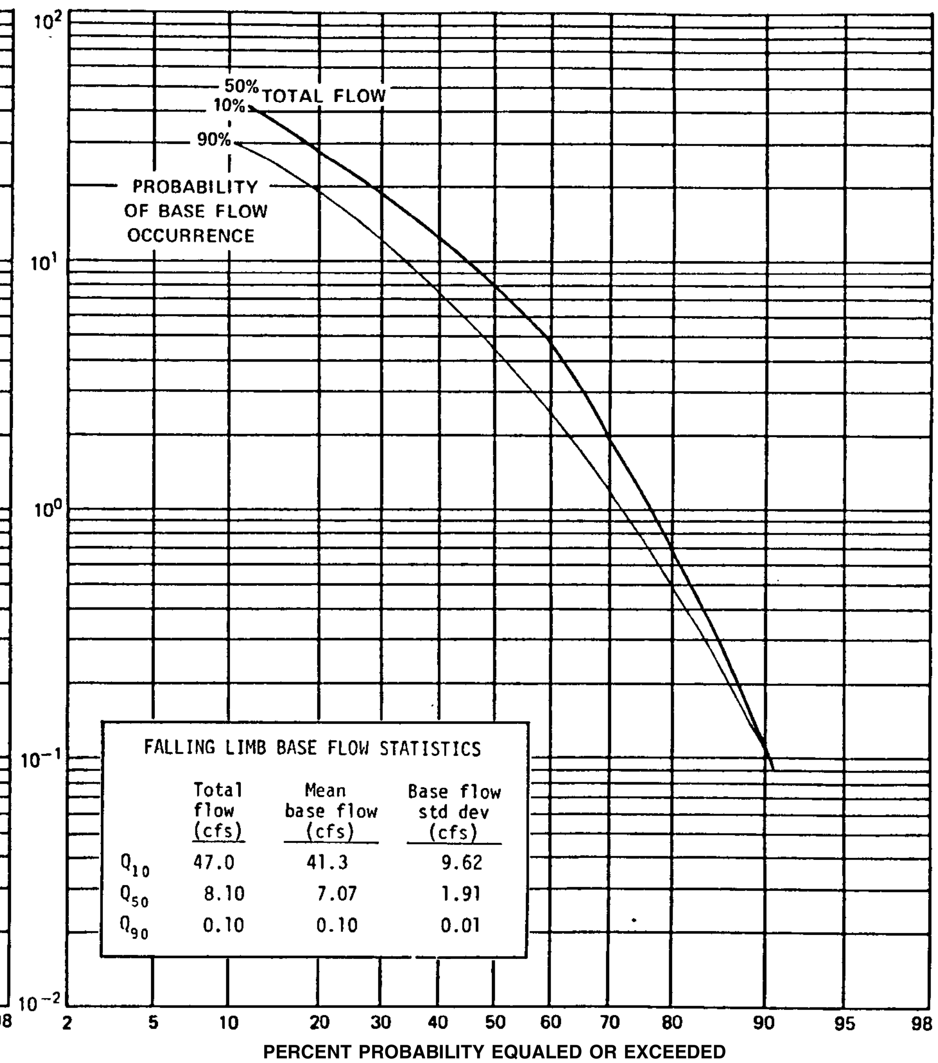
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1200	909.	319.
Q_{50}	200.	156.	53.0
Q_{90}	25.0	24.3	1.60



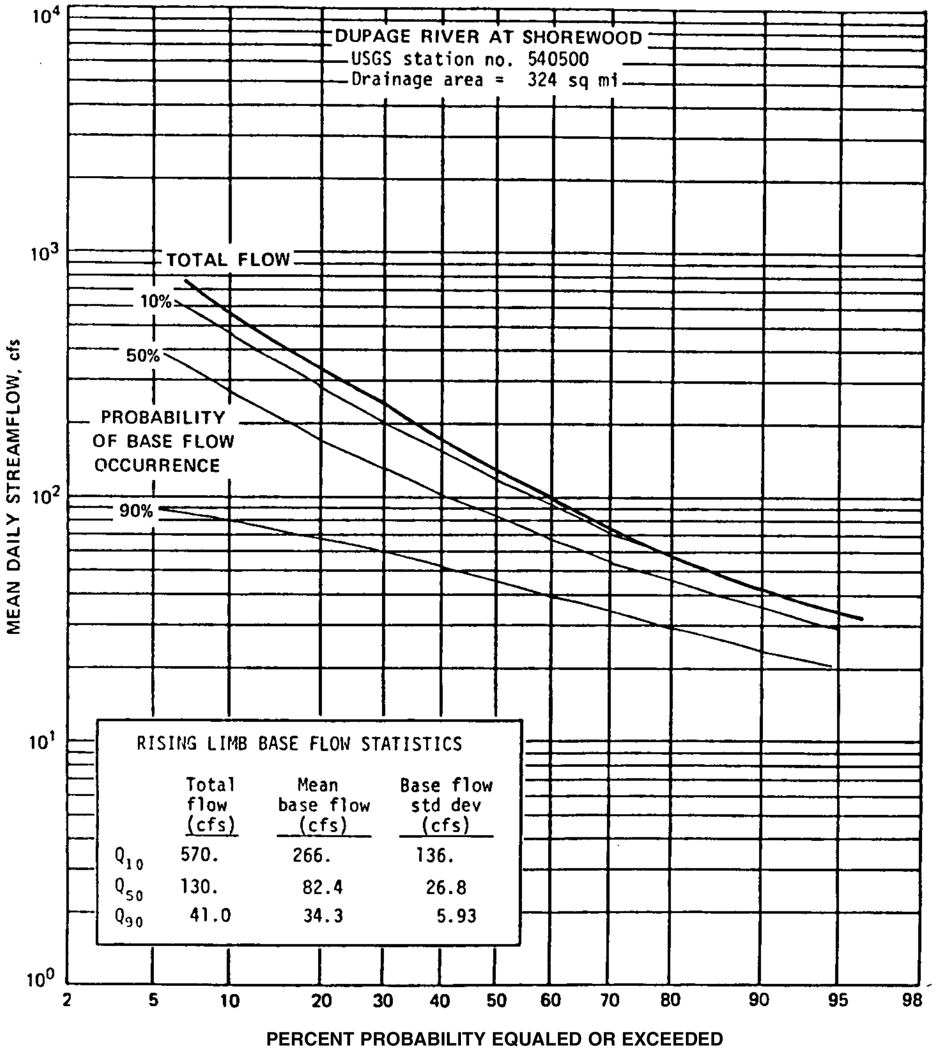
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	47.0	21.9	12.1
Q_{50}	8.10	4.29	2.41
Q_{90}	0.10	0.06	0.03



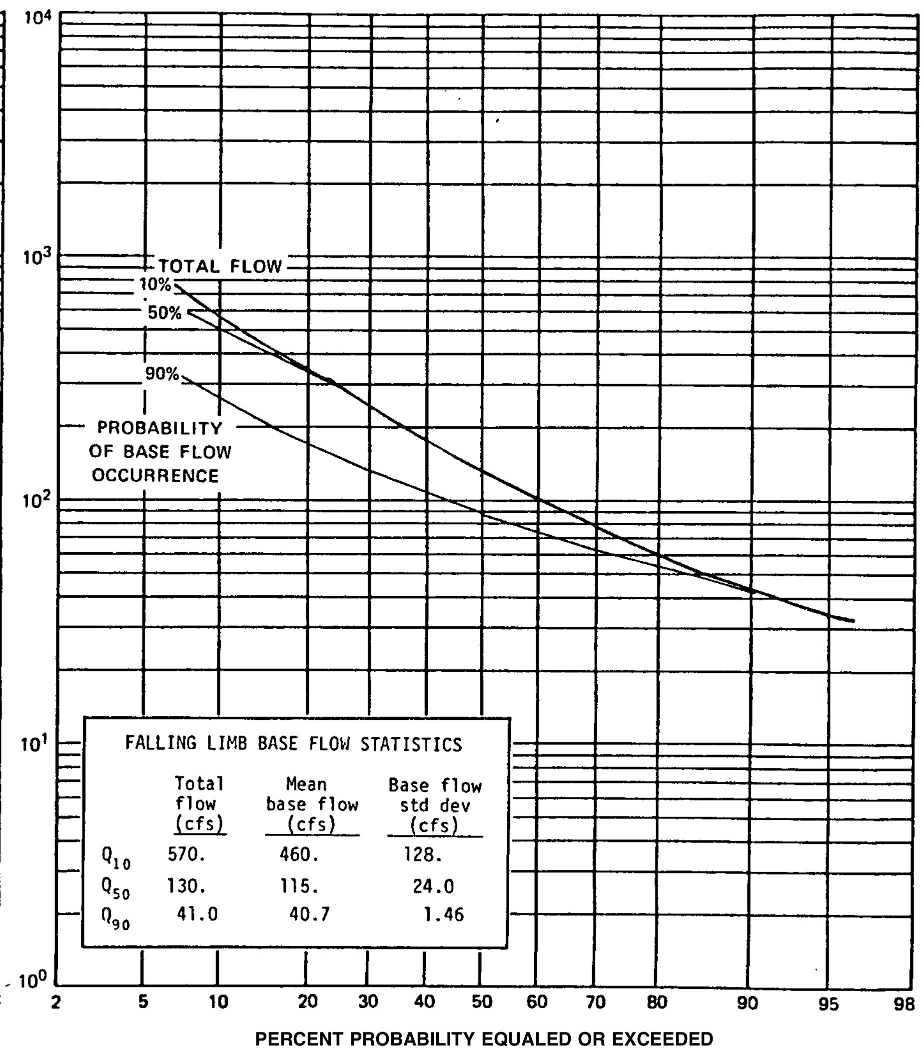
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	47.0	41.3	9.62
Q_{50}	8.10	7.07	1.91
Q_{90}	0.10	0.10	0.01



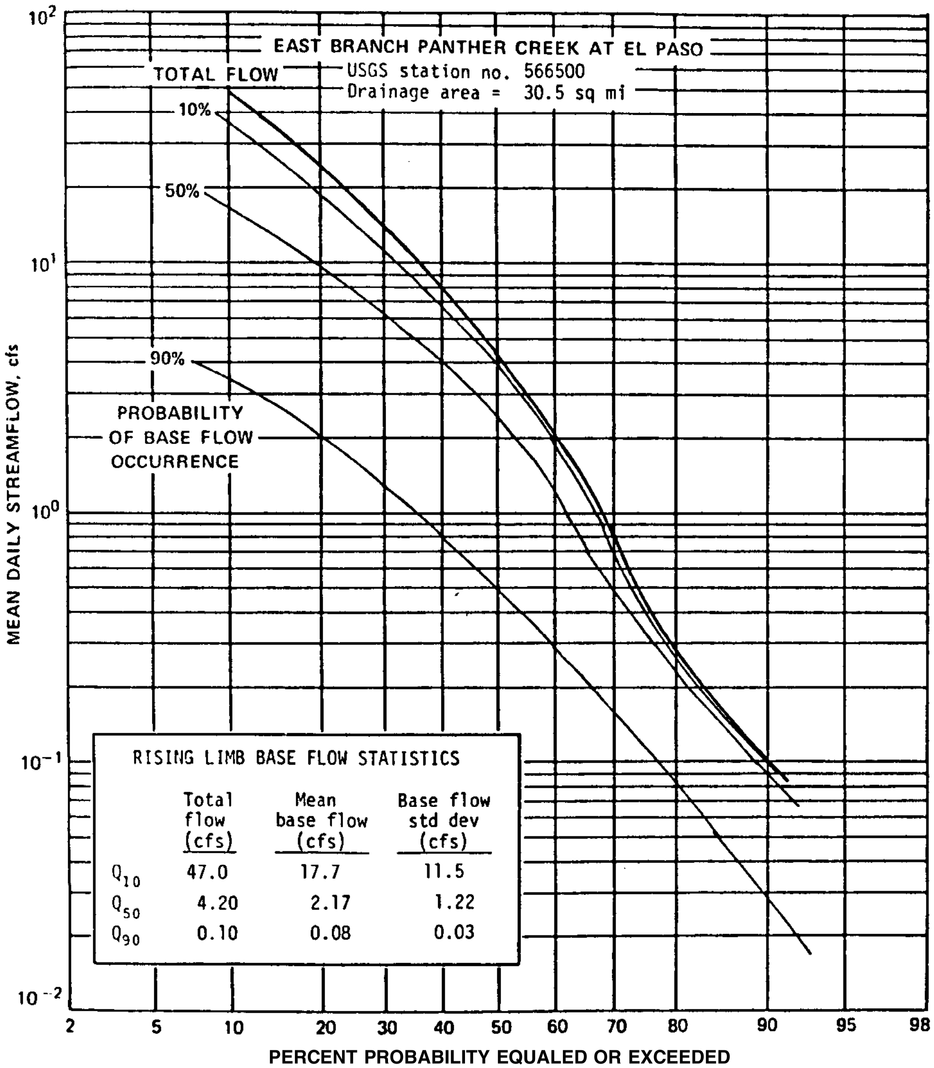
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	570.	266.	136.
Q_{50}	130.	82.4	26.8
Q_{90}	41.0	34.3	5.93



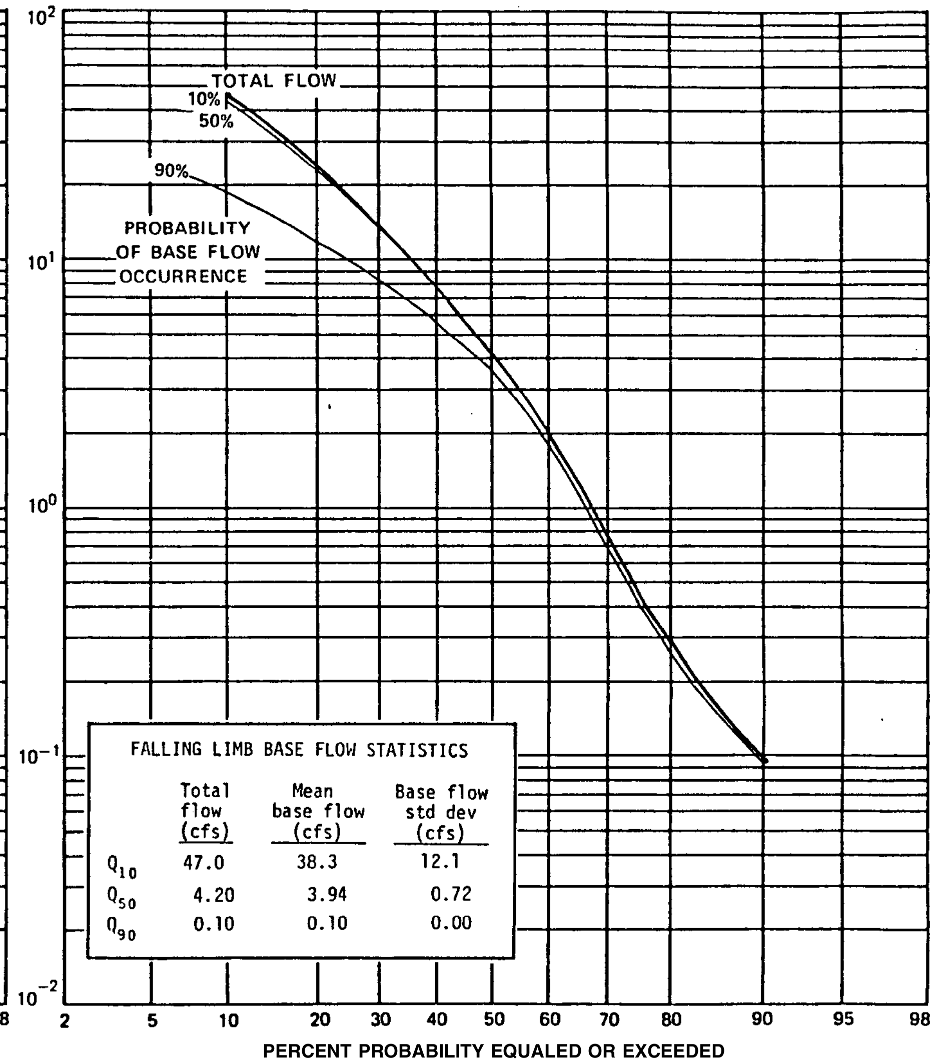
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	570.	460.	128.
Q_{50}	130.	115.	24.0
Q_{90}	41.0	40.7	1.46



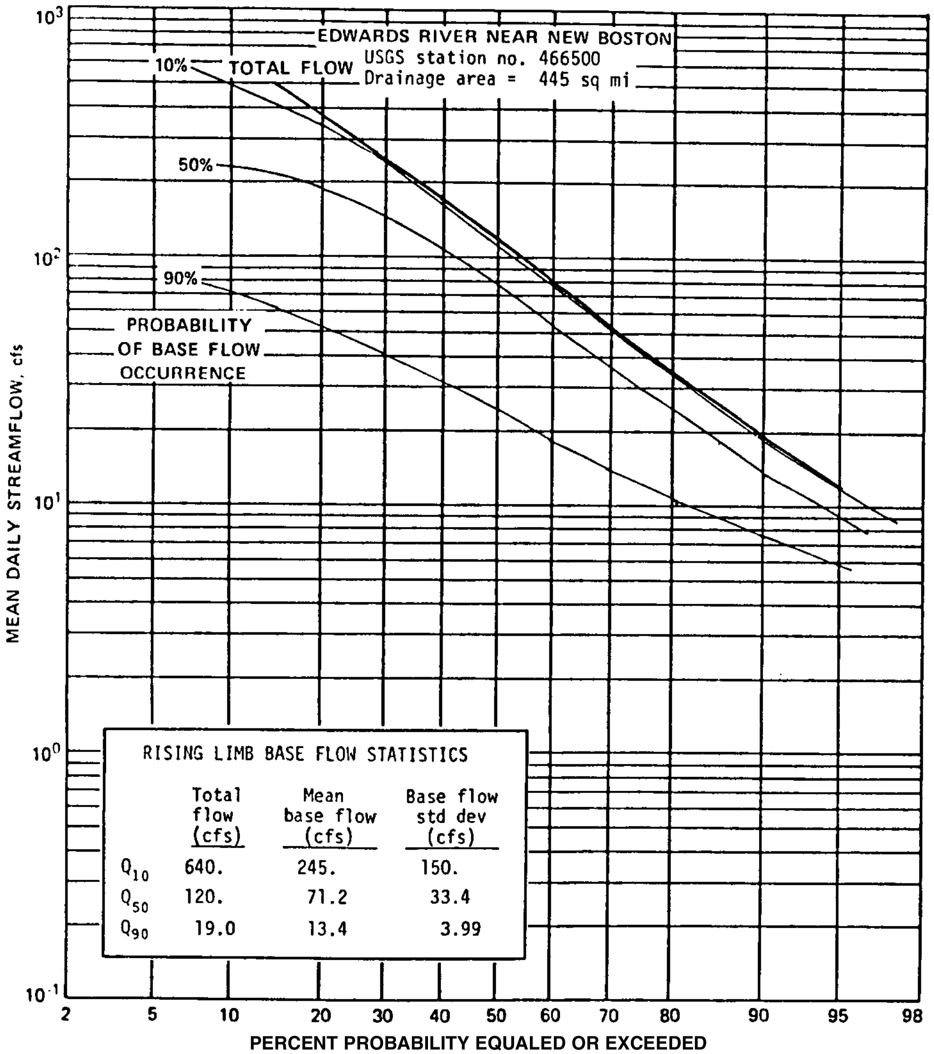
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	47.0	17.7	11.5
Q_{50}	4.20	2.17	1.22
Q_{90}	0.10	0.08	0.03



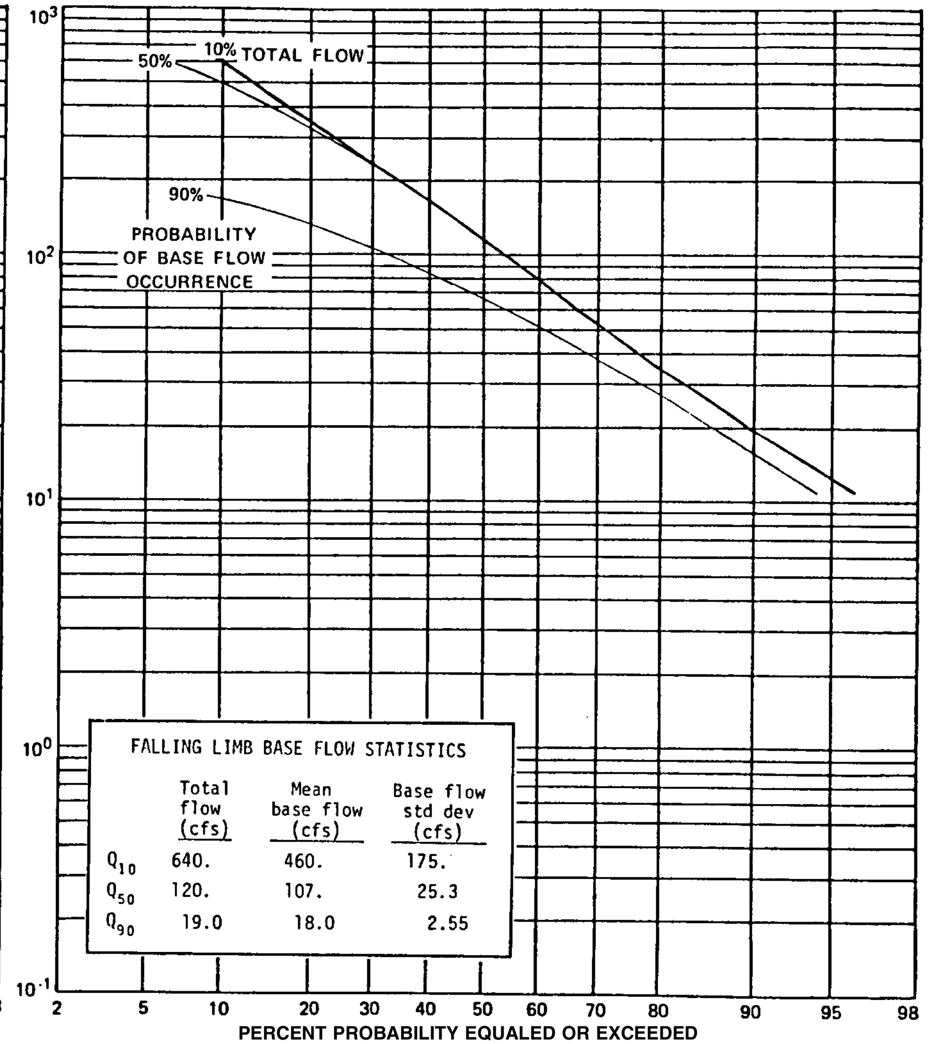
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	47.0	38.3	12.1
Q_{50}	4.20	3.94	0.72
Q_{90}	0.10	0.10	0.00



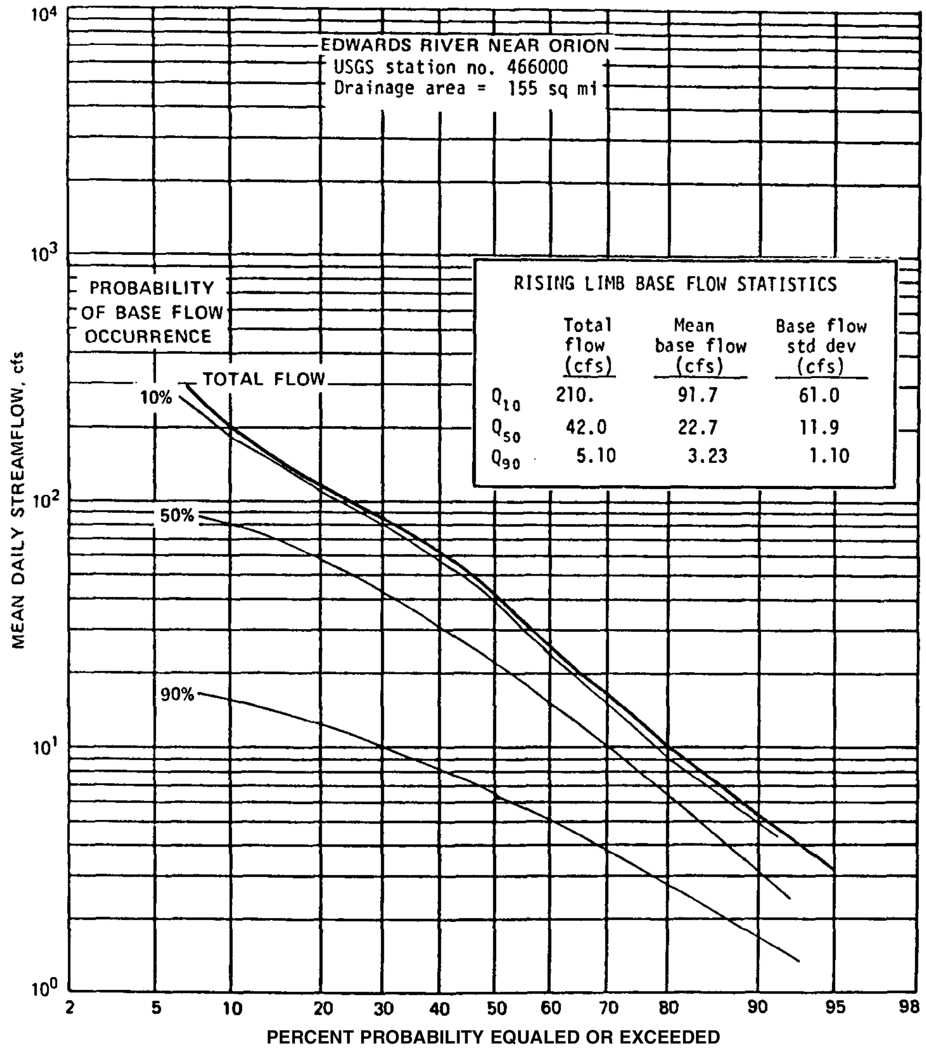
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	640.	245.	150.
Q_{50}	120.	71.2	33.4
Q_{90}	19.0	13.4	3.99



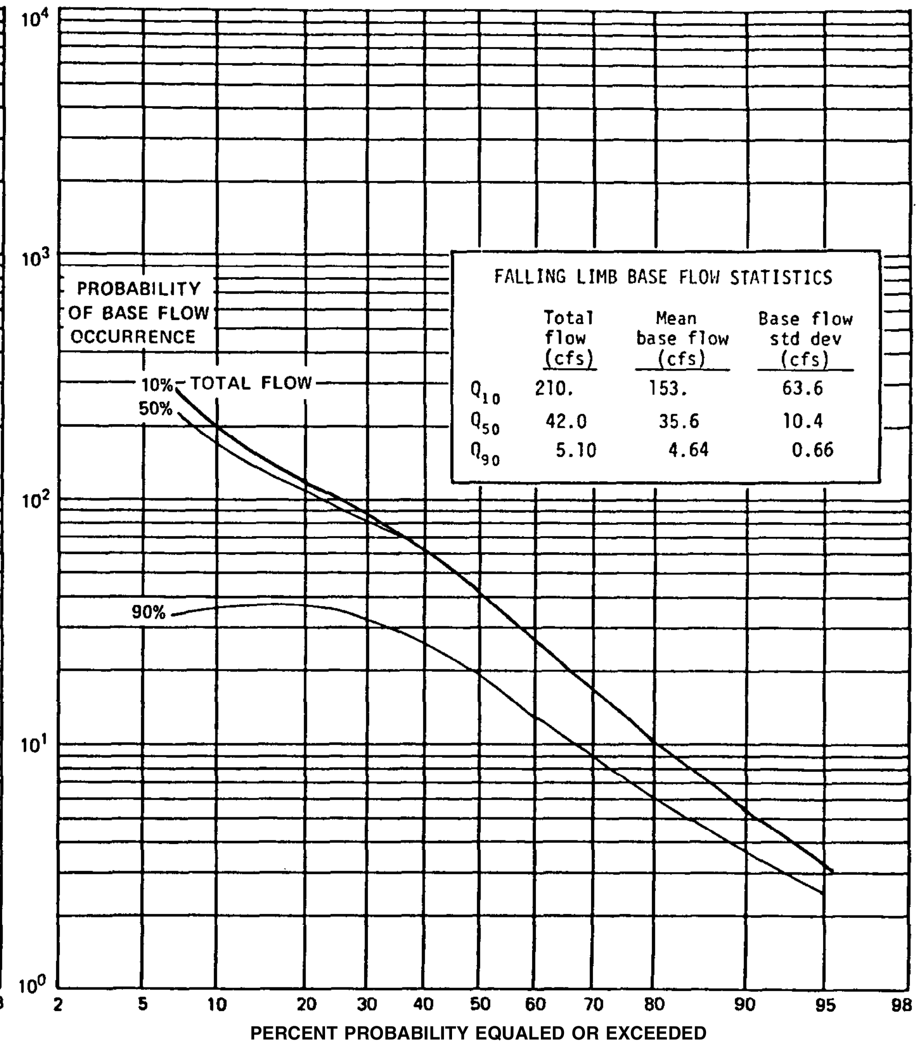
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	640.	460.	175.
Q_{50}	120.	107.	25.3
Q_{90}	19.0	18.0	2.55



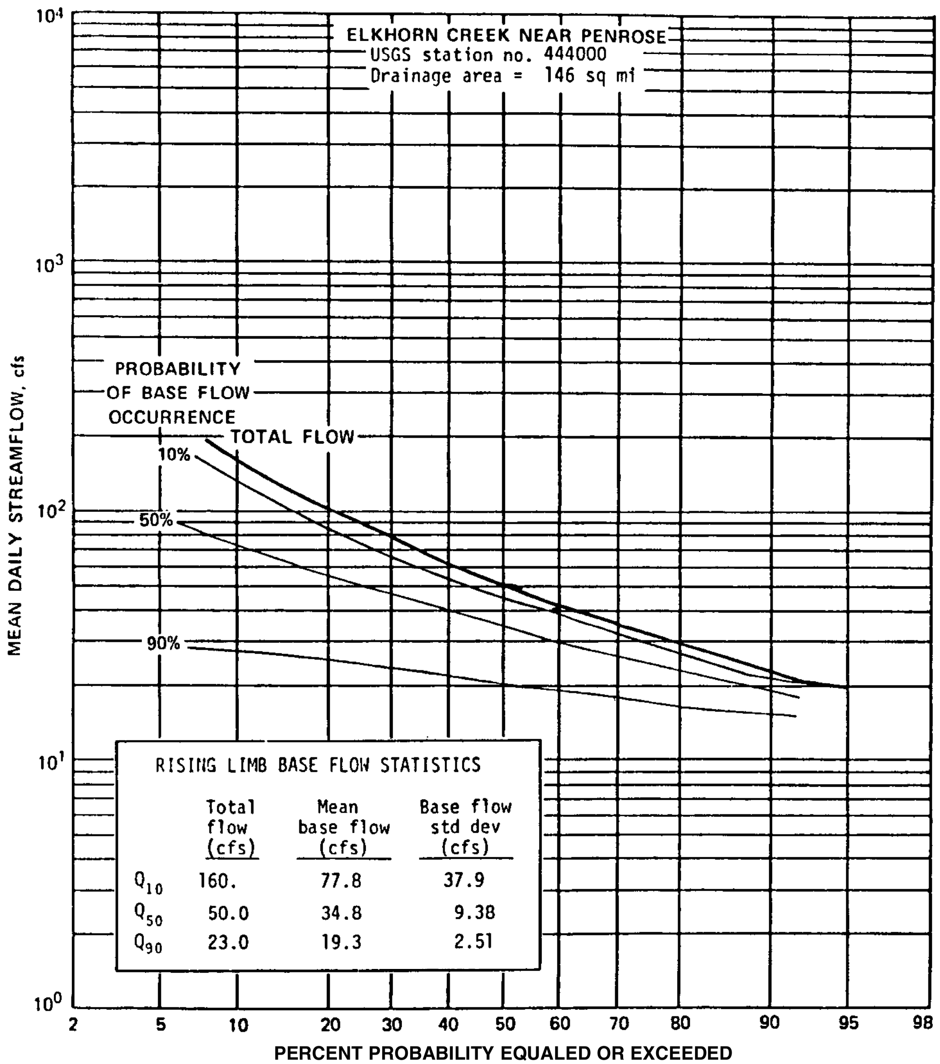
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	210.	91.7	61.0
Q_{50}	42.0	22.7	11.9
Q_{90}	5.10	3.23	1.10



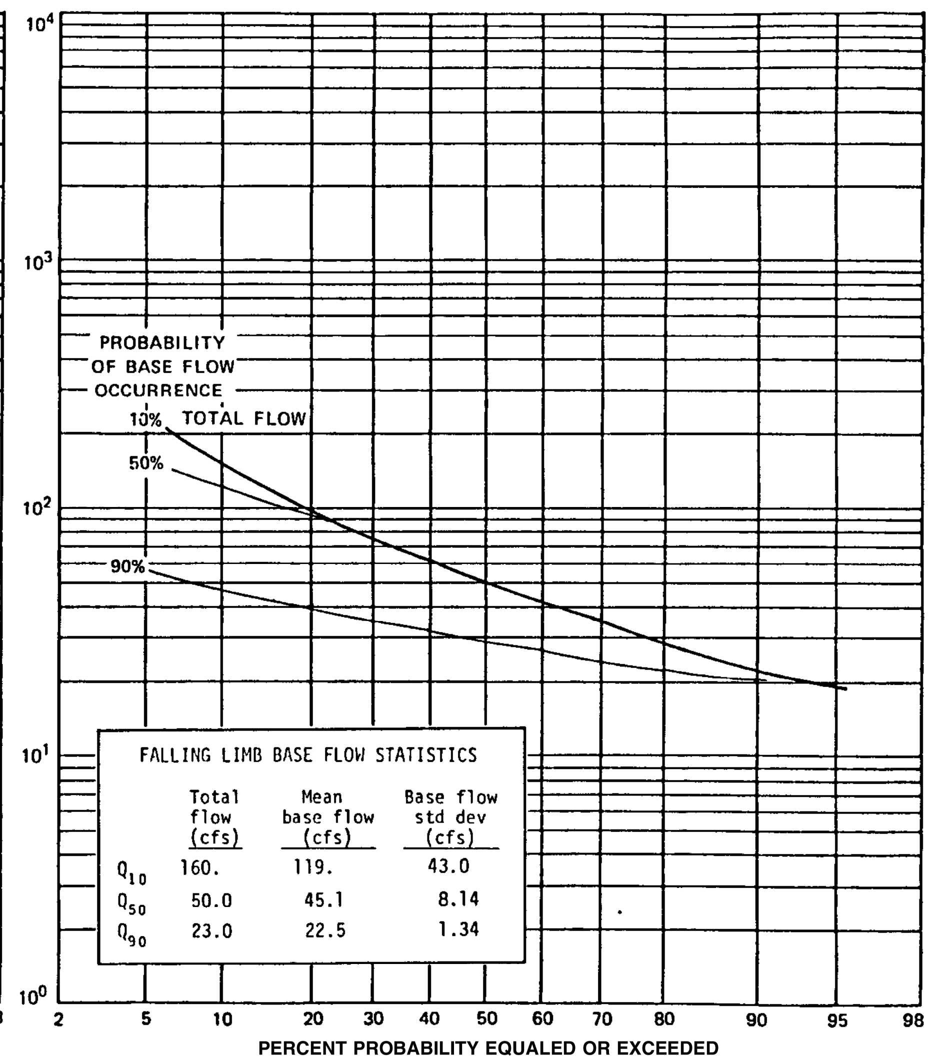
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	210.	153.	63.6
Q_{50}	42.0	35.6	10.4
Q_{90}	5.10	4.64	0.66



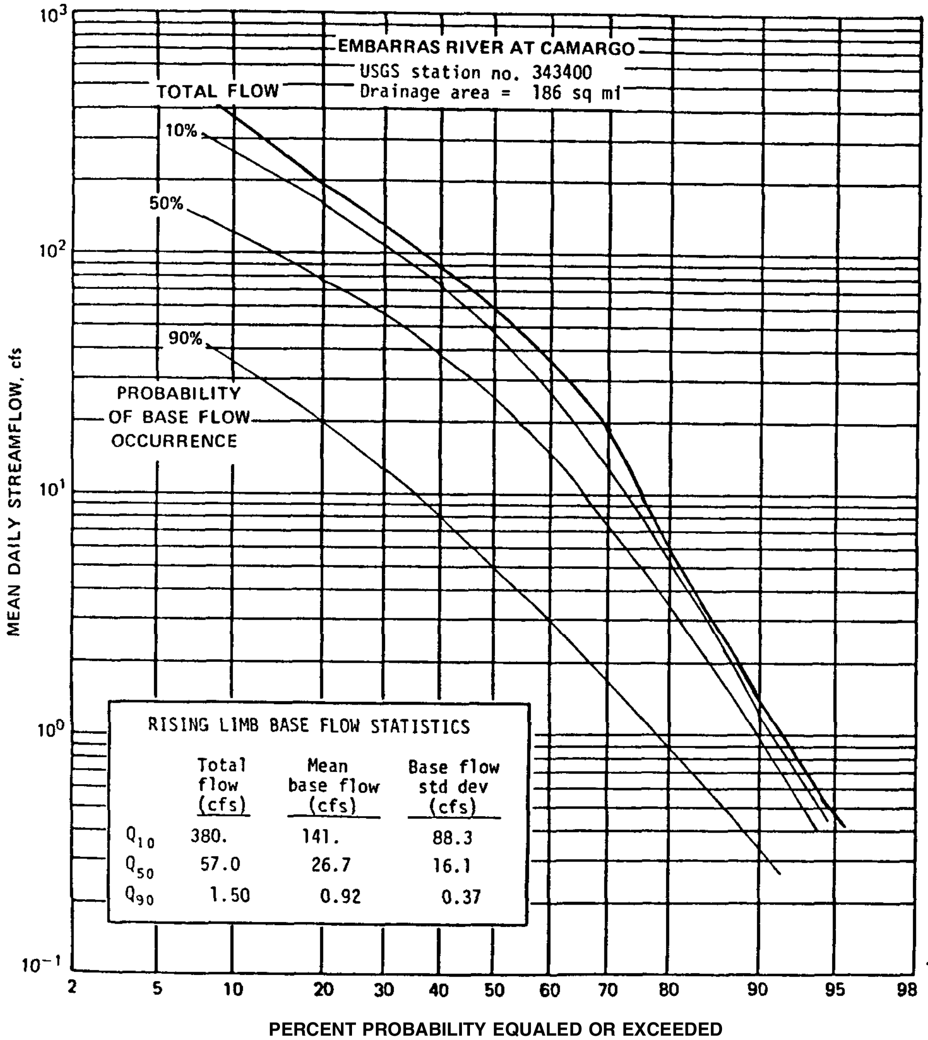
RISING LIMB BASE FLOW STATISTICS

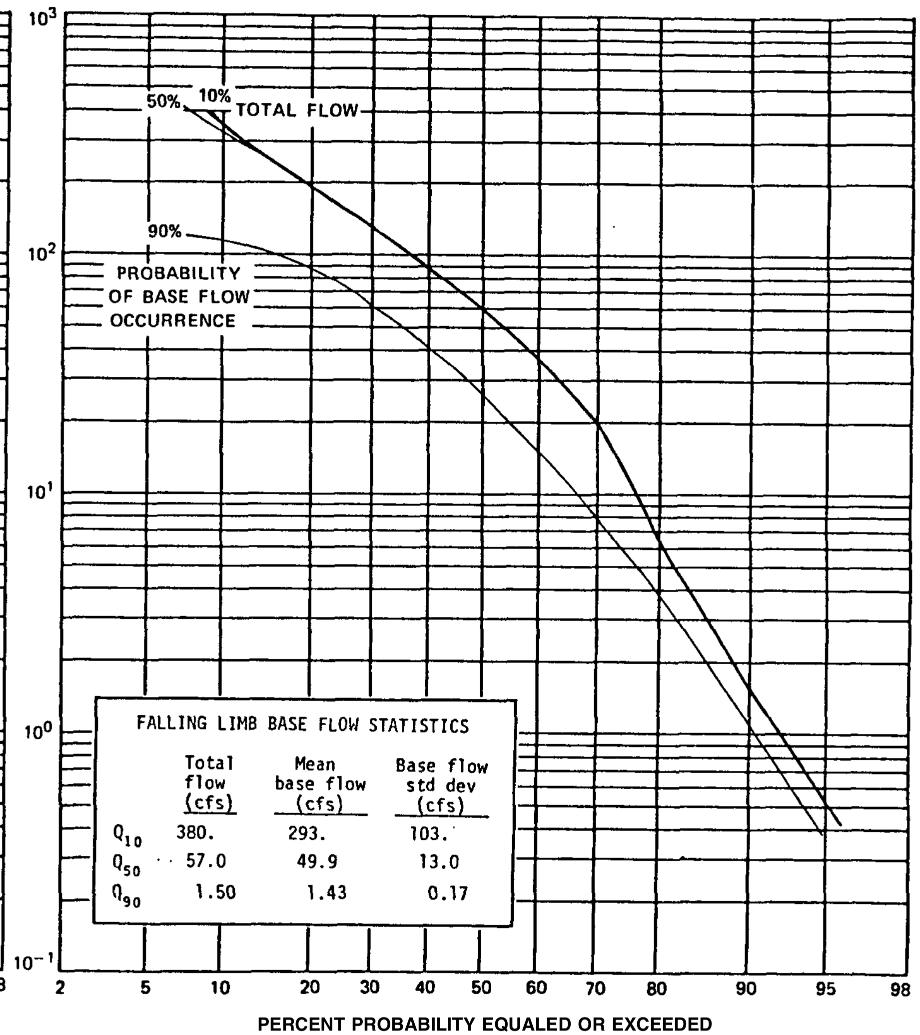
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	160.	77.8	37.9
Q_{50}	50.0	34.8	9.38
Q_{90}	23.0	19.3	2.51

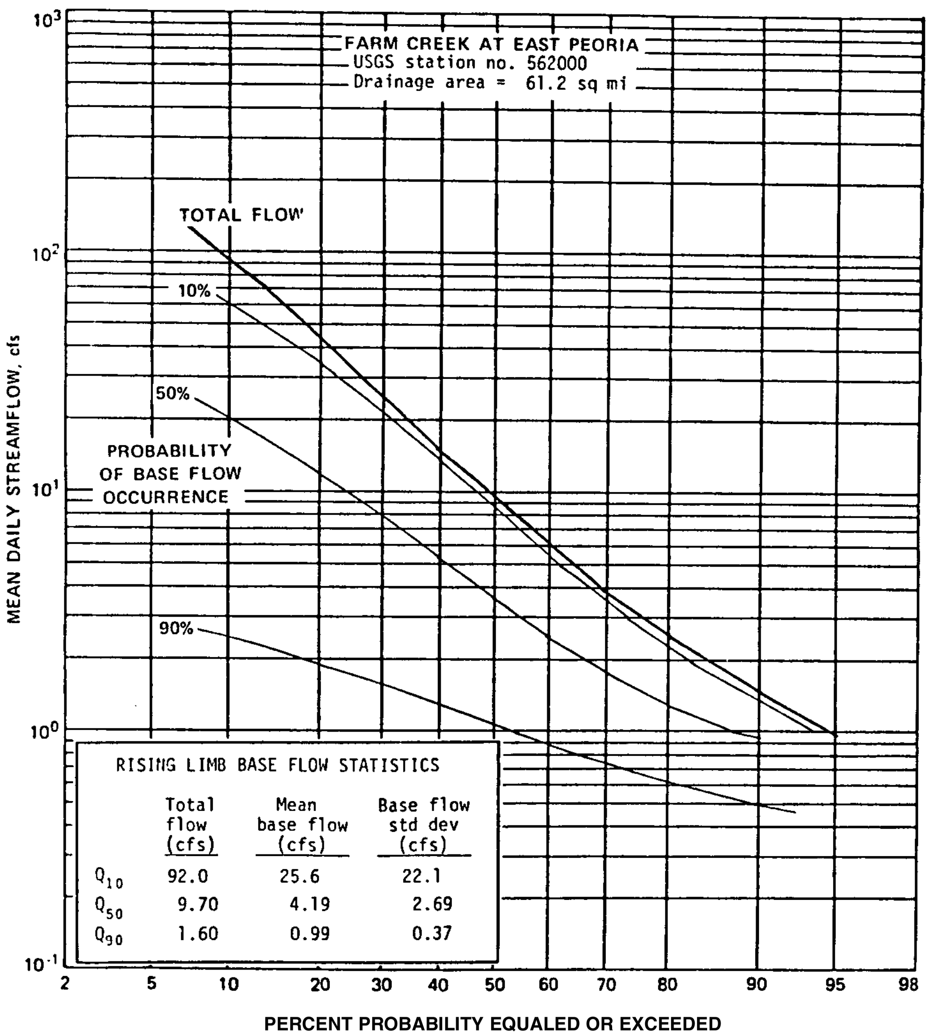


FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	160.	119.	43.0
Q_{50}	50.0	45.1	8.14
Q_{90}	23.0	22.5	1.34

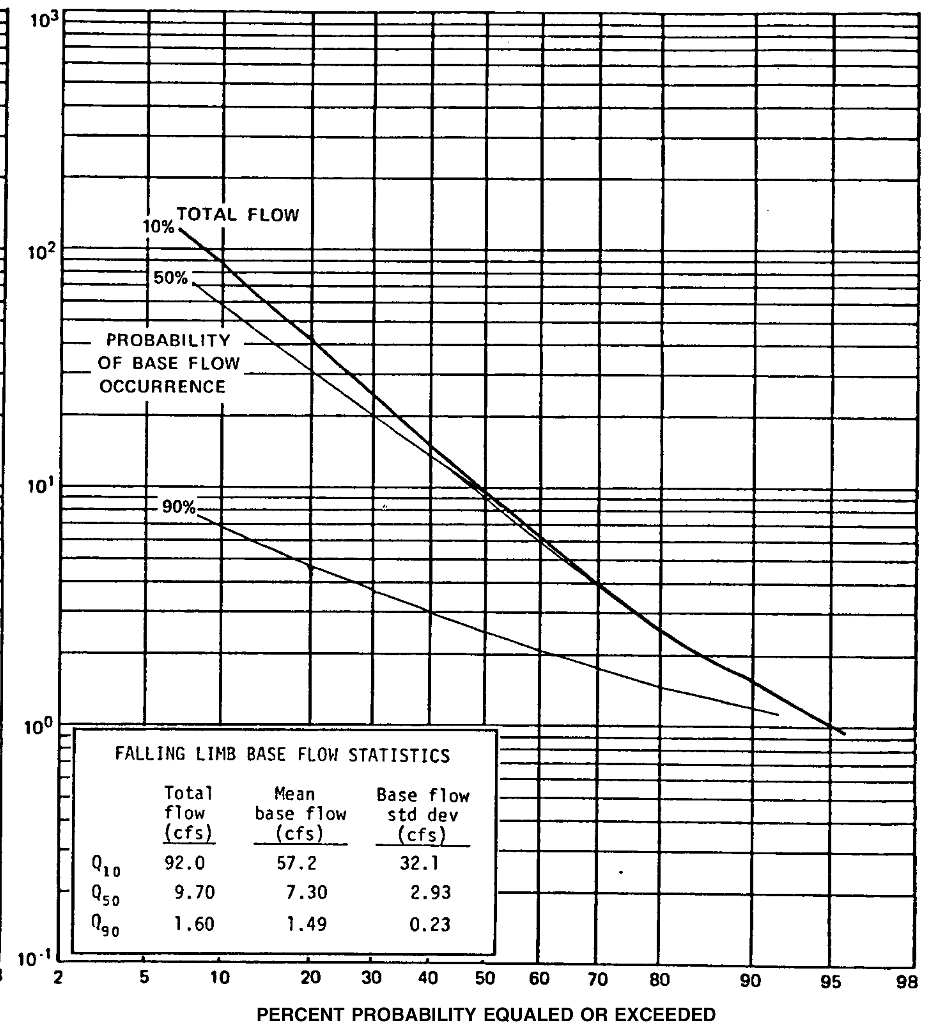

EMBARRAS RIVER AT CAMARGO
USGS station no. 343400
Drainage area = 186 sq mi
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
MEAN DAILY STREAMFLOW, cfs
PERCENT PROBABILITY EQUALED OR EXCEEDED
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 380. 141. 88.3
Q50 57.0 26.7 16.1
Q90 1.50 0.92 0.37


50%
10%
TOTAL FLOW
90%
PROBABILITY OF BASE FLOW OCCURRENCE
PERCENT PROBABILITY EQUALED OR EXCEEDED
FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 380. 293. 103.
Q50 57.0 49.9 13.0
Q90 1.50 1.43 0.17



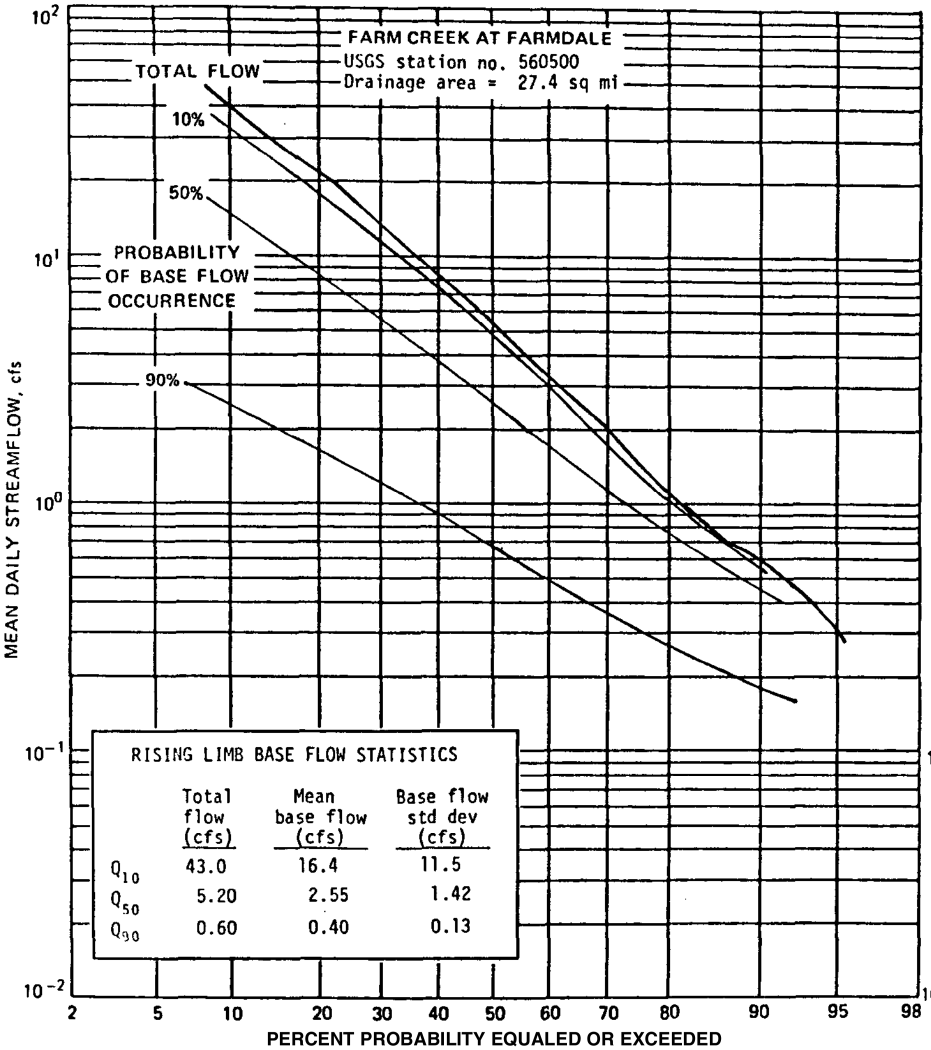
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	92.0	25.6	22.1
Q_{50}	9.70	4.19	2.69
Q_{90}	1.60	0.99	0.37



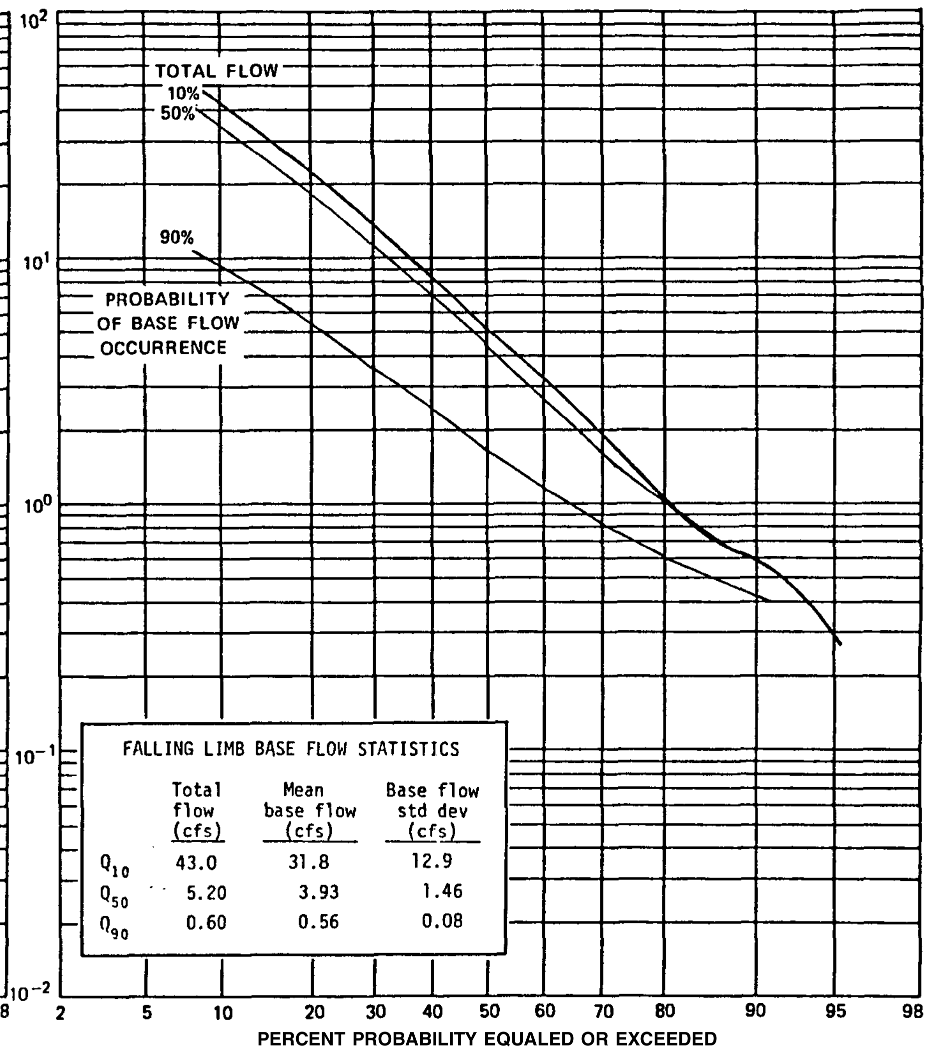
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	92.0	57.2	32.1
Q_{50}	9.70	7.30	2.93
Q_{90}	1.60	1.49	0.23



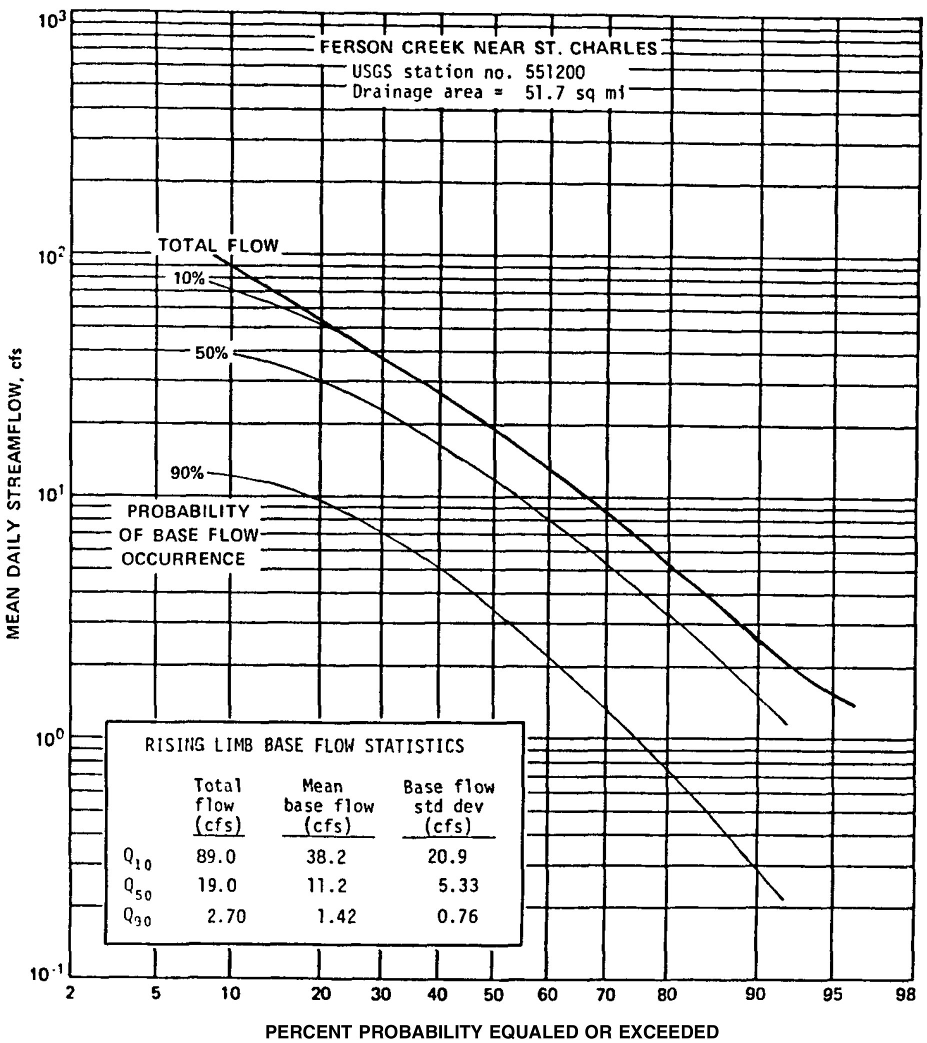
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	43.0	16.4	11.5
Q_{50}	5.20	2.55	1.42
Q_{90}	0.60	0.40	0.13



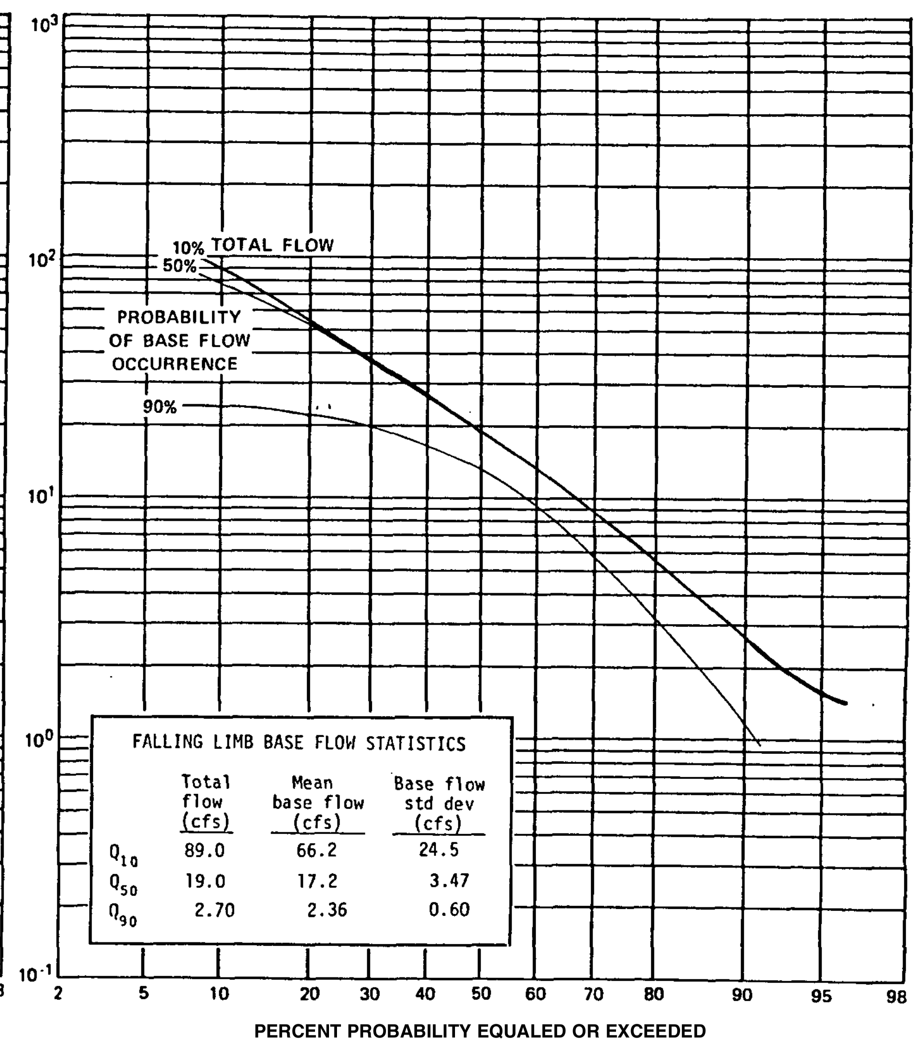
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	43.0	31.8	12.9
Q_{50}	5.20	3.93	1.46
Q_{90}	0.60	0.56	0.08



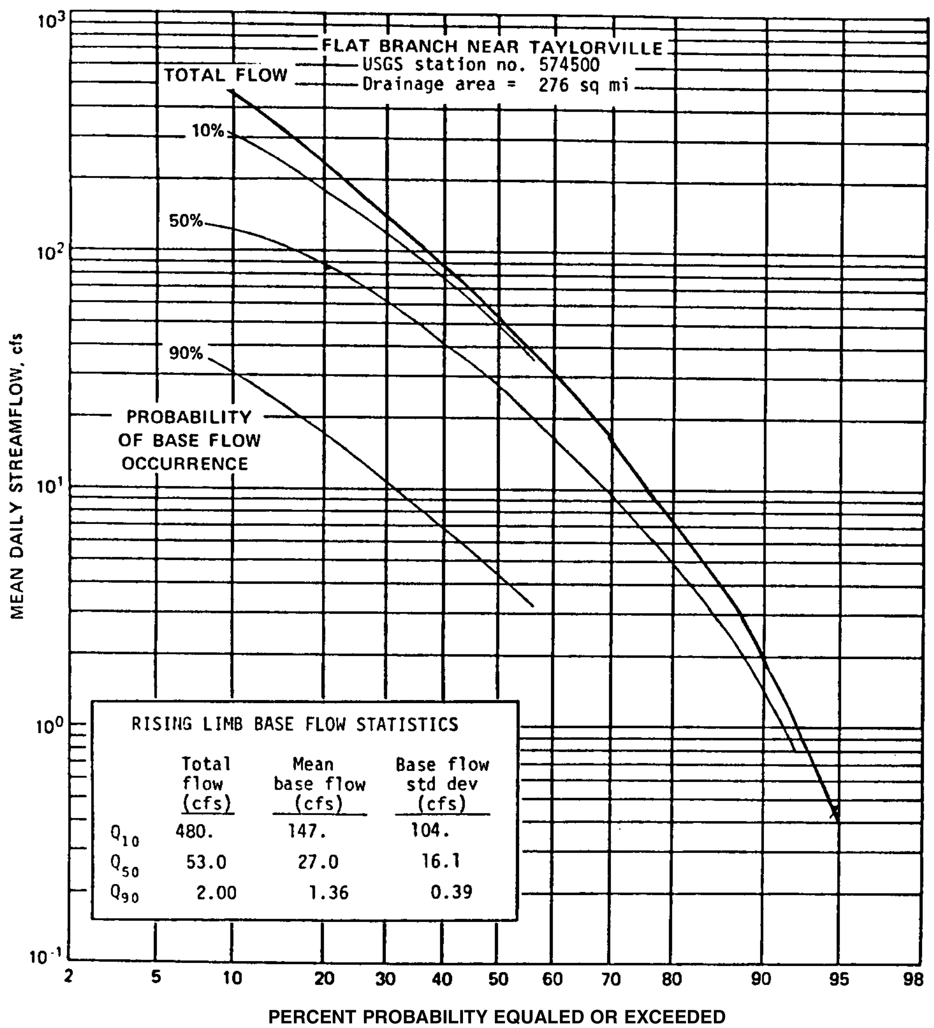
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	89.0	38.2	20.9
Q_{50}	19.0	11.2	5.33
Q_{90}	2.70	1.42	0.76



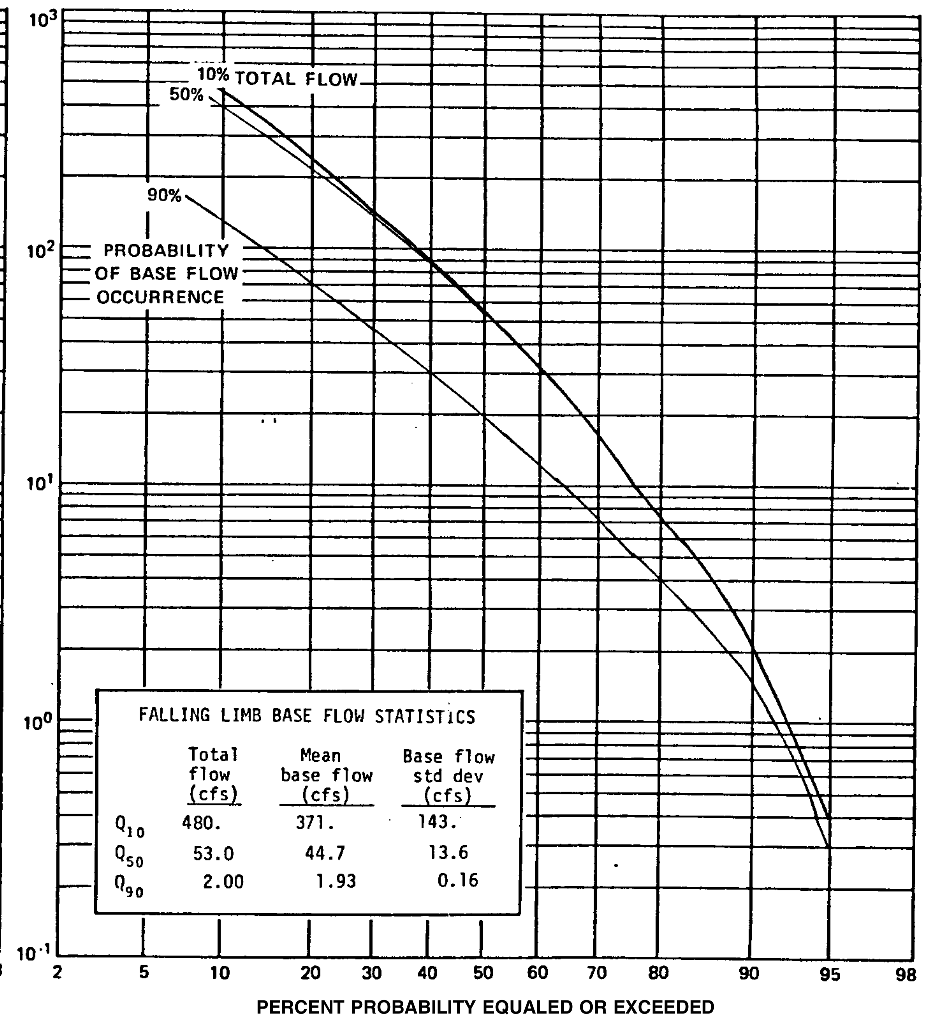
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	89.0	66.2	24.5
Q_{50}	19.0	17.2	3.47
Q_{90}	2.70	2.36	0.60



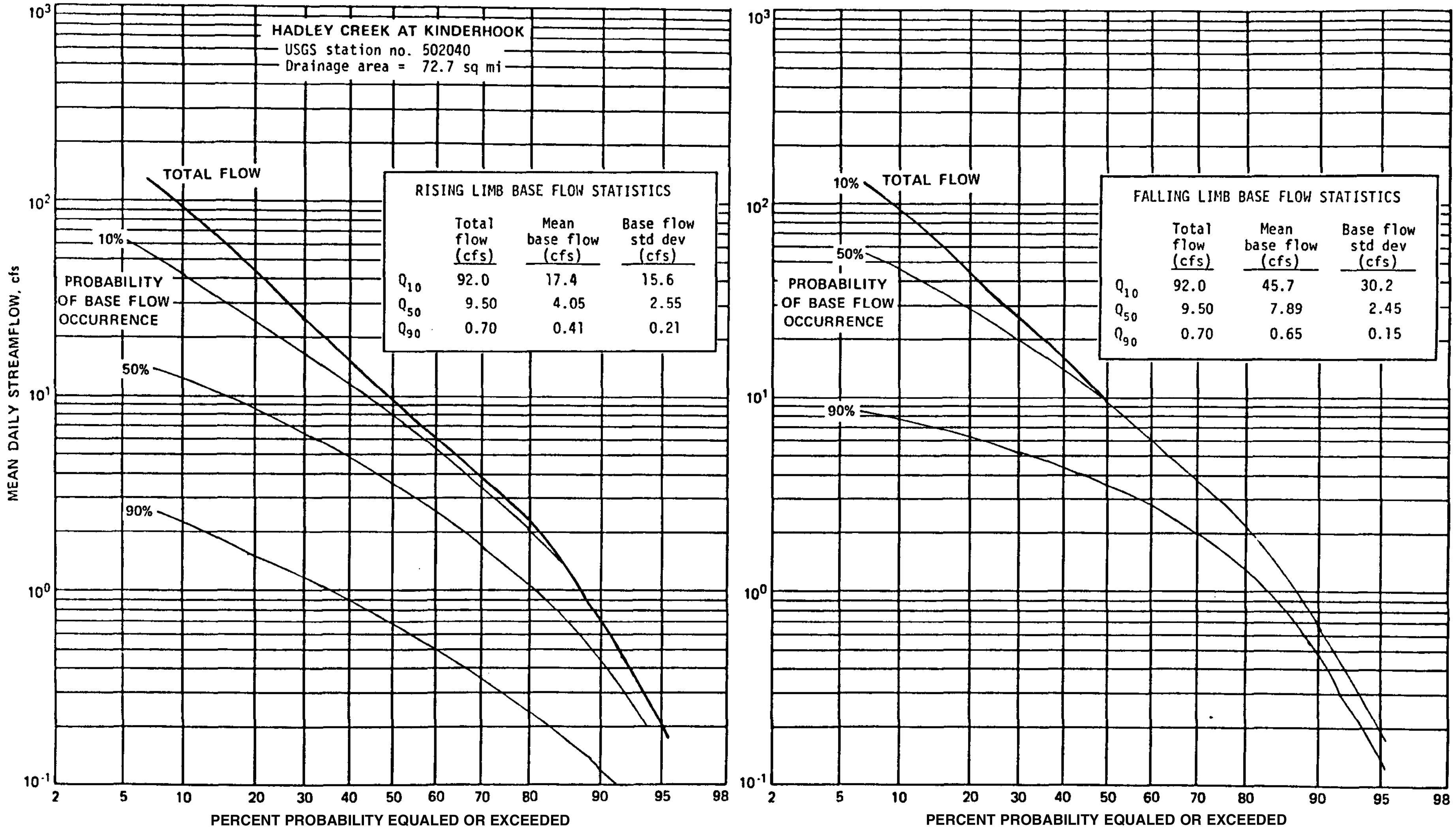
RISING LIMB BASE FLOW STATISTICS

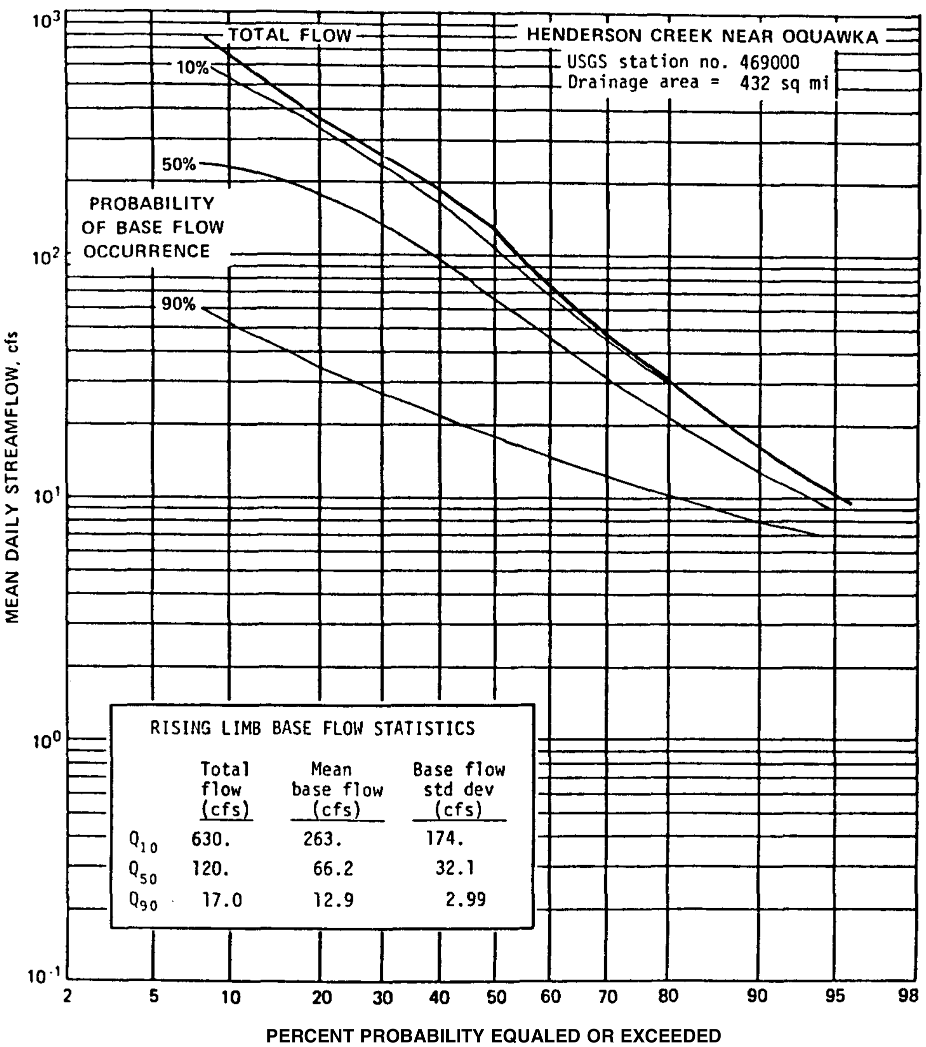
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	480.	147.	104.
Q_{50}	53.0	27.0	16.1
Q_{90}	2.00	1.36	0.39



FALLING LIMB BASE FLOW STATISTICS

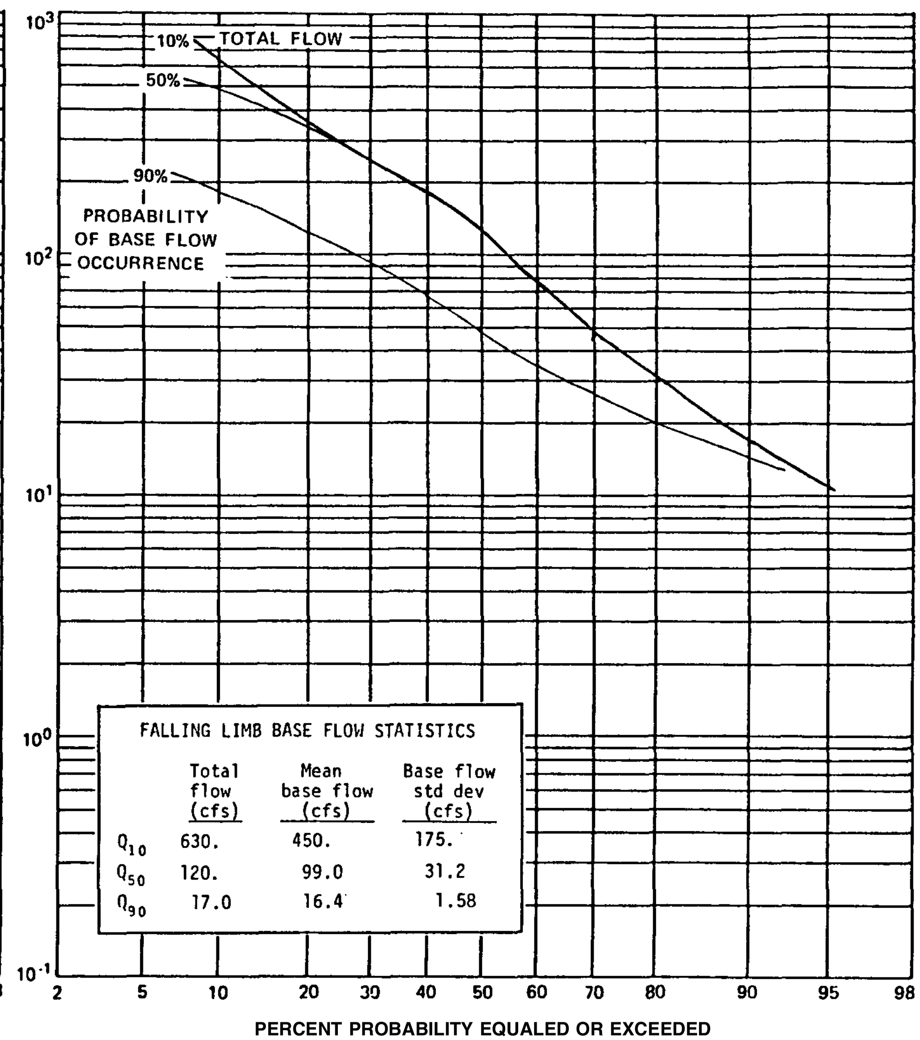
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	480.	371.	143.
Q_{50}	53.0	44.7	13.6
Q_{90}	2.00	1.93	0.16


HADLEY CREEK AT KINDERHOOK
USGS station no. 502040
Drainage area = 72.7 sq mi
TOTAL FLOW
PROBABILITY OF BASE FLOW OCCURRENCE
10%
50%
90%
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q_{10} 92.0 17.4 15.6
Q_{50} 9.50 4.05 2.55
Q_{90} 0.70 0.41 0.21
FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q_{10} 92.0 45.7 30.2
Q_{50} 9.50 7.89 2.45
Q_{90} 0.70 0.65 0.15
MEAN DAILY STREAMFLOW, cfs
10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
2 5 10 20 30 40 50 60 70 80 90 95 98
PERCENT PROBABILITY EQUALED OR EXCEEDED



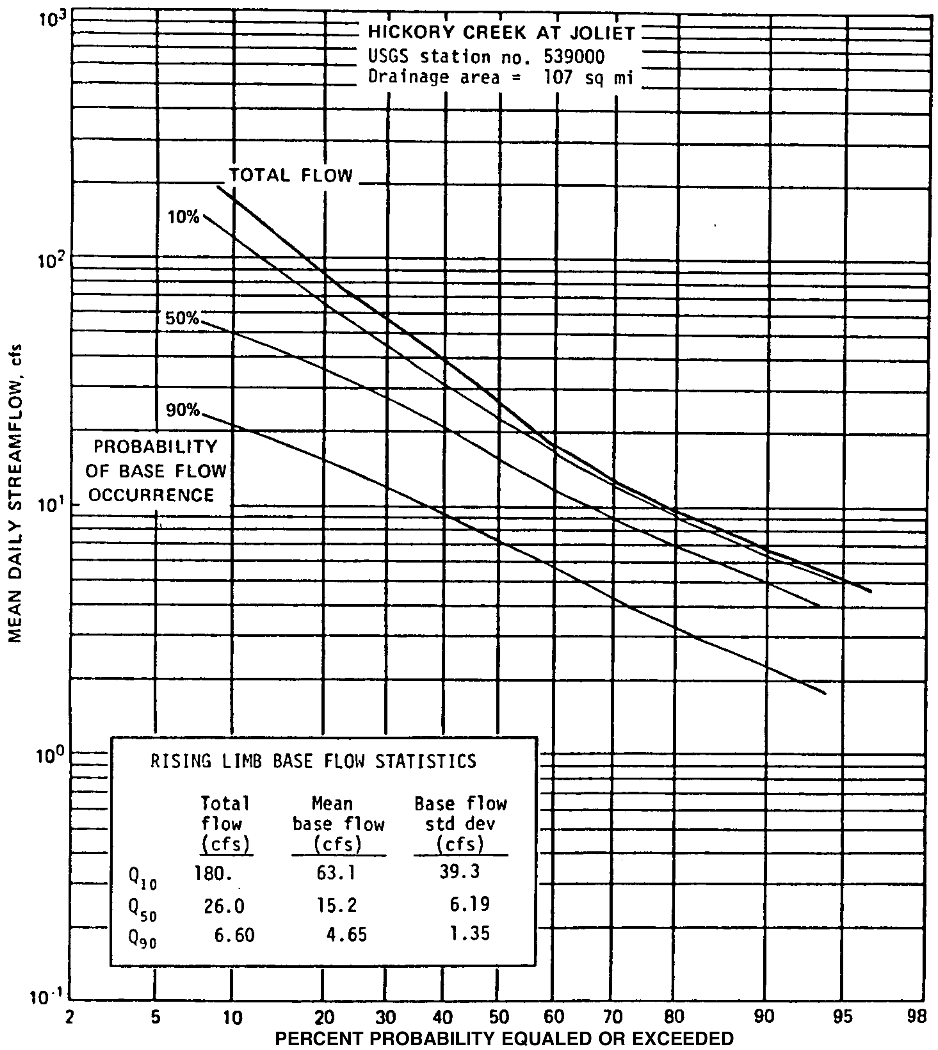
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	630.	263.	174.
Q_{50}	120.	66.2	32.1
Q_{90}	17.0	12.9	2.99



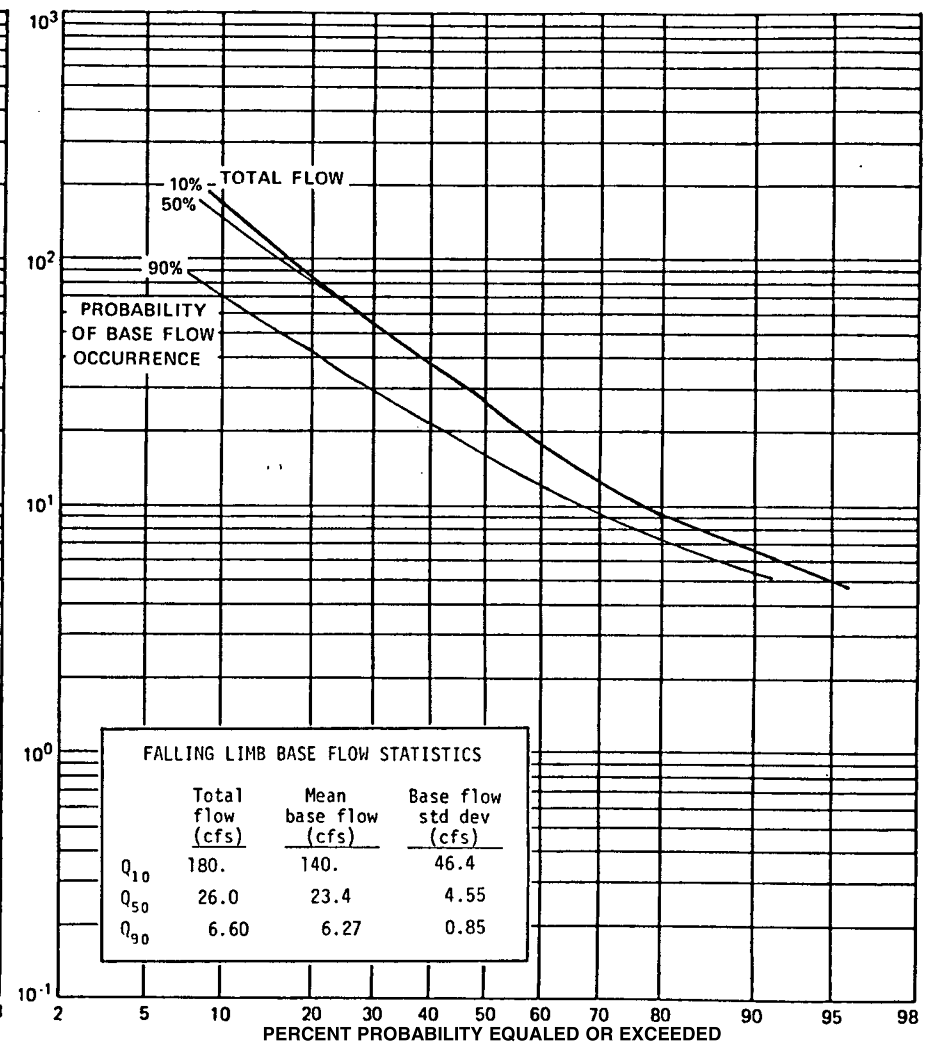
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	630.	450.	175.
Q_{50}	120.	99.0	31.2
Q_{90}	17.0	16.4	1.58



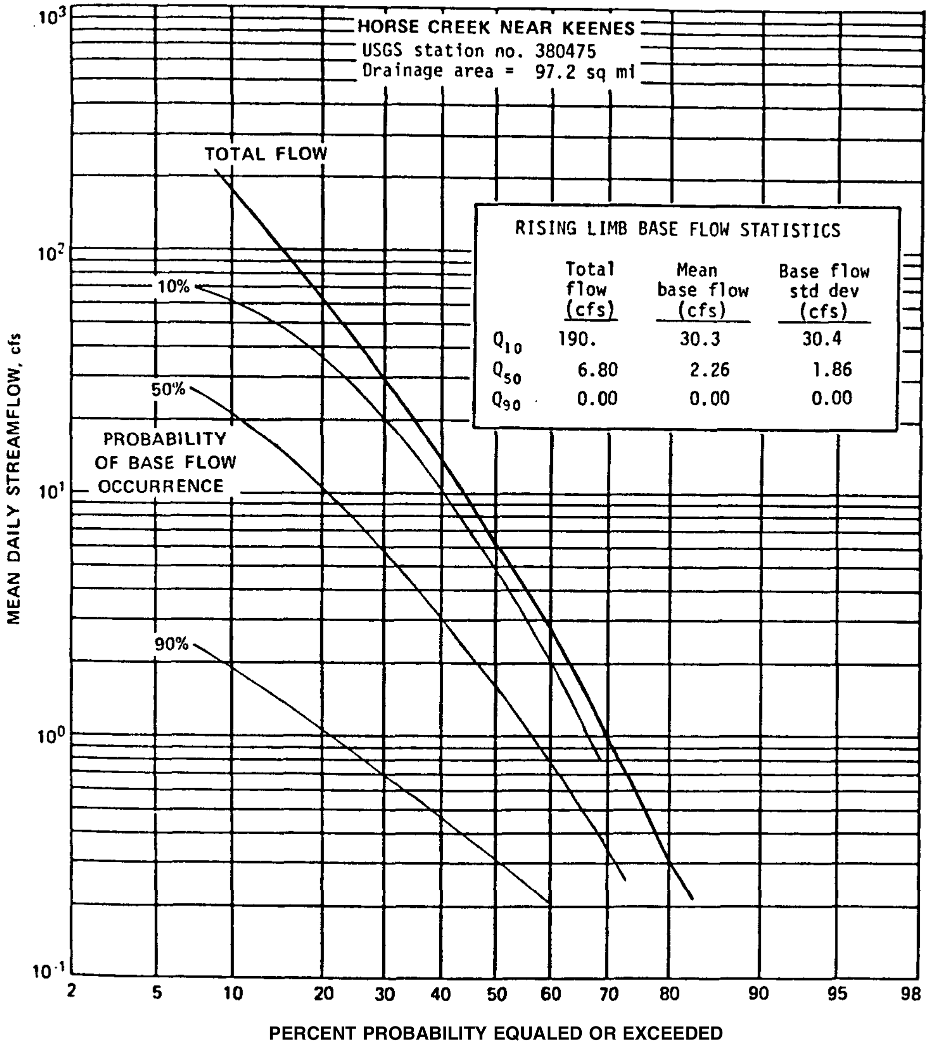
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	180.	63.1	39.3
Q_{50}	26.0	15.2	6.19
Q_{90}	6.60	4.65	1.35



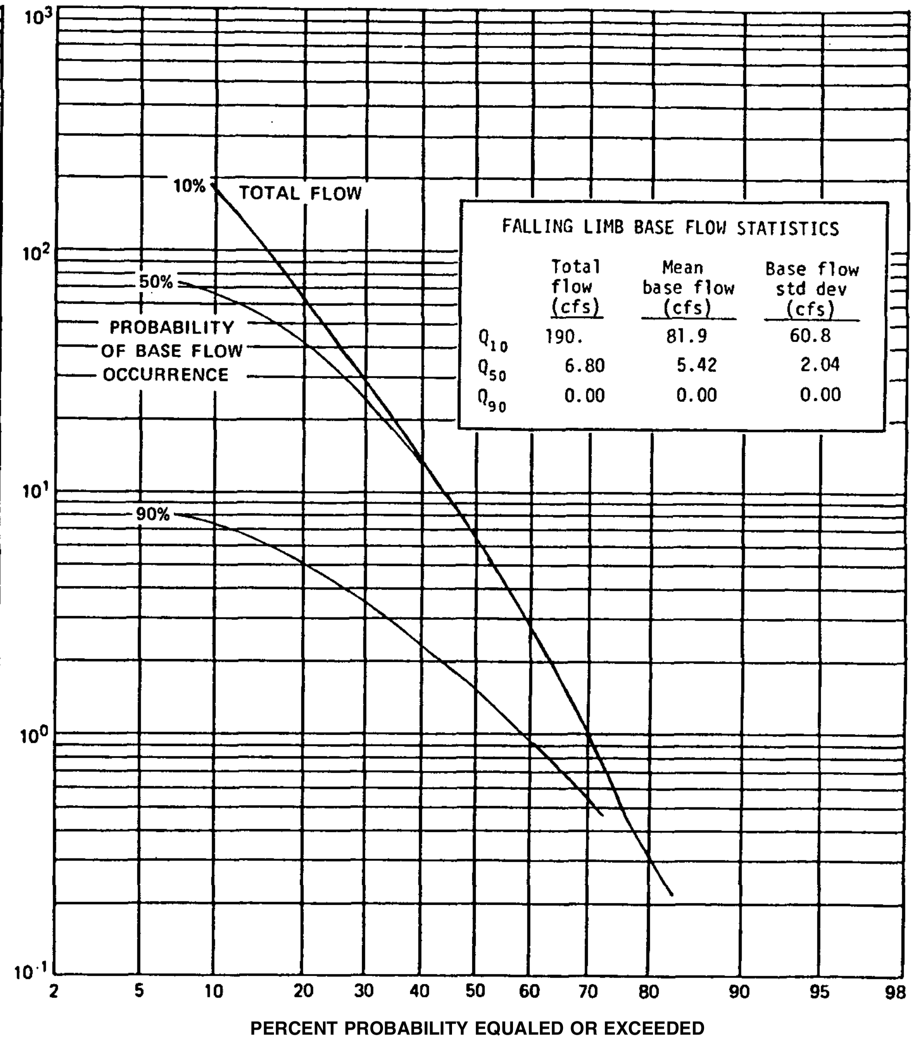
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	180.	140.	46.4
Q_{50}	26.0	23.4	4.55
Q_{90}	6.60	6.27	0.85



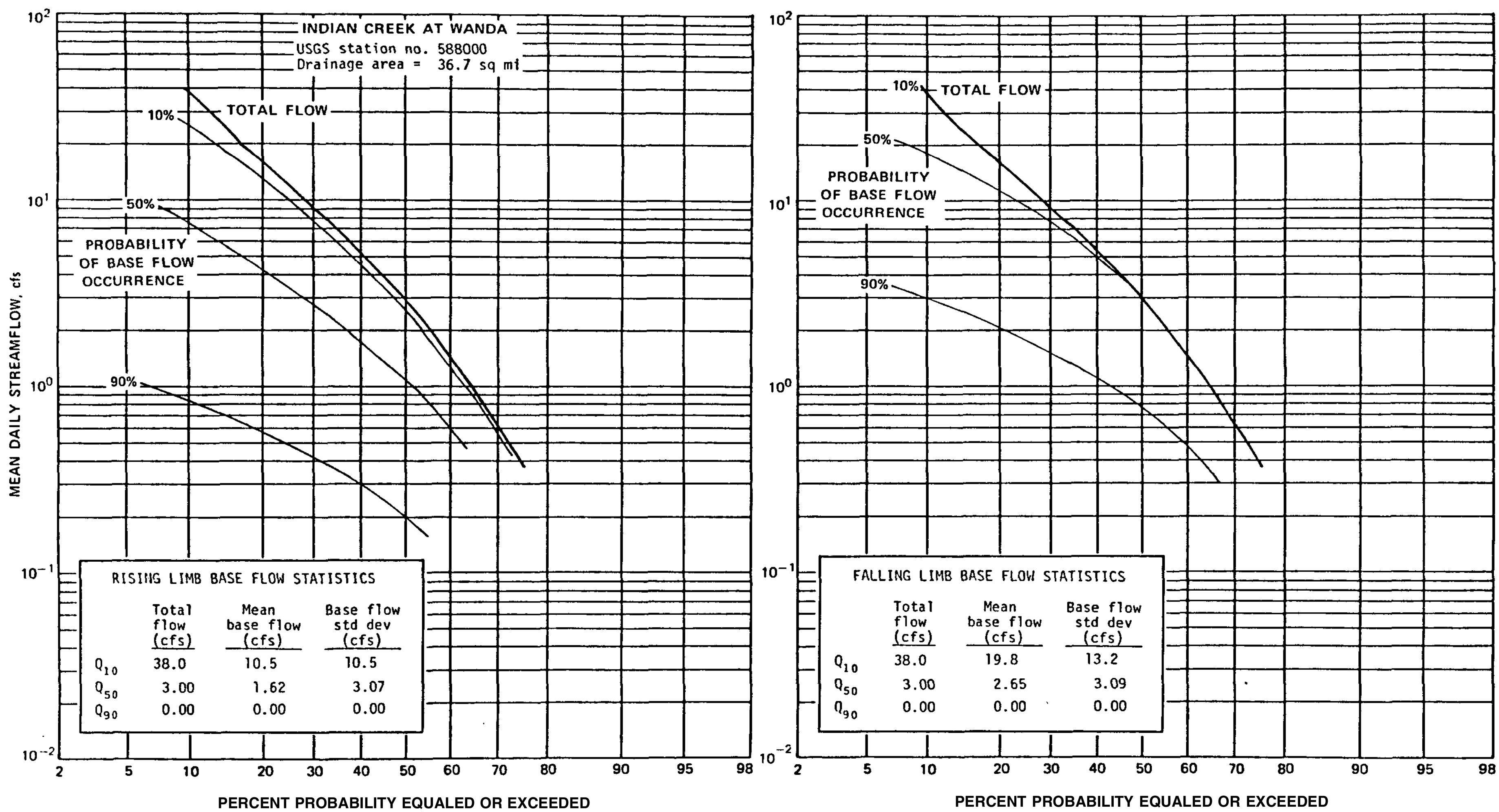
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	190.	30.3	30.4
Q_{50}	6.80	2.26	1.86
Q_{90}	0.00	0.00	0.00



FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	190.	81.9	60.8
Q_{50}	6.80	5.42	2.04
Q_{90}	0.00	0.00	0.00

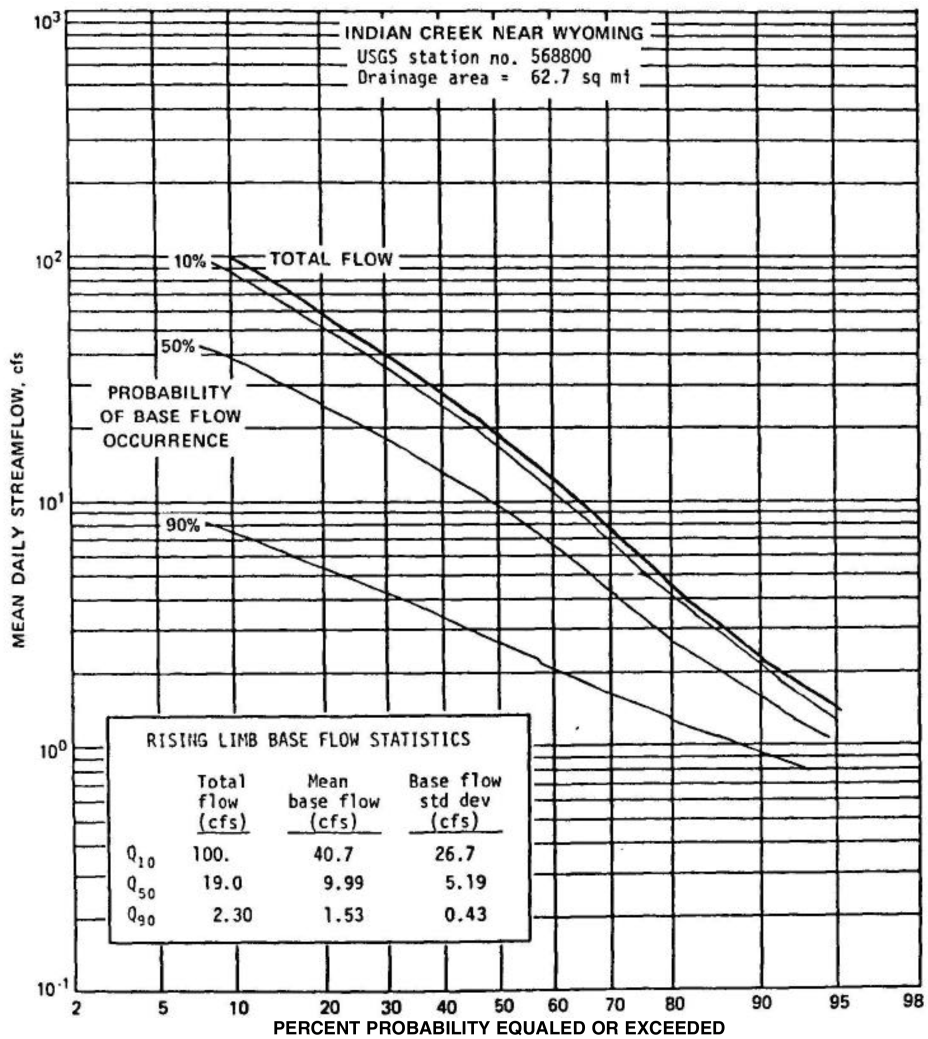


RISING LIMB BASE FLOW STATISTICS

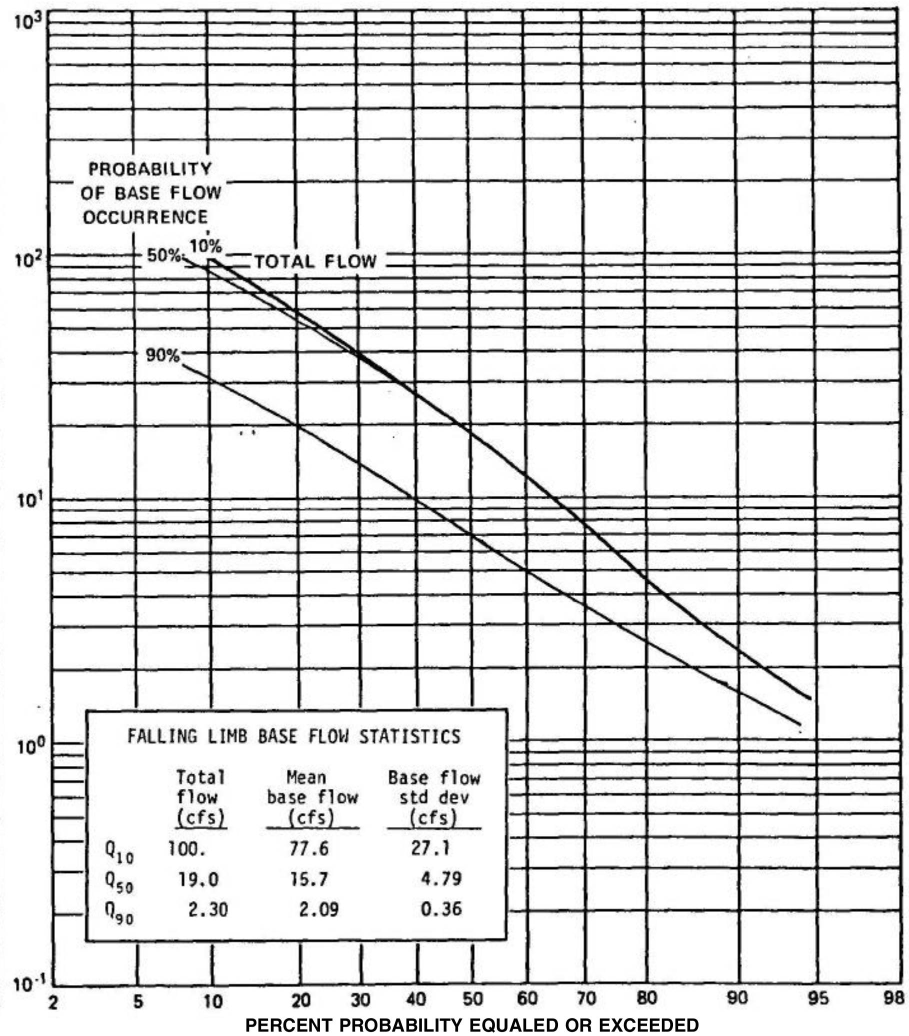
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	38.0	10.5	10.5
Q_{50}	3.00	1.62	3.07
Q_{90}	0.00	0.00	0.00

FALLING LIMB BASE FLOW STATISTICS

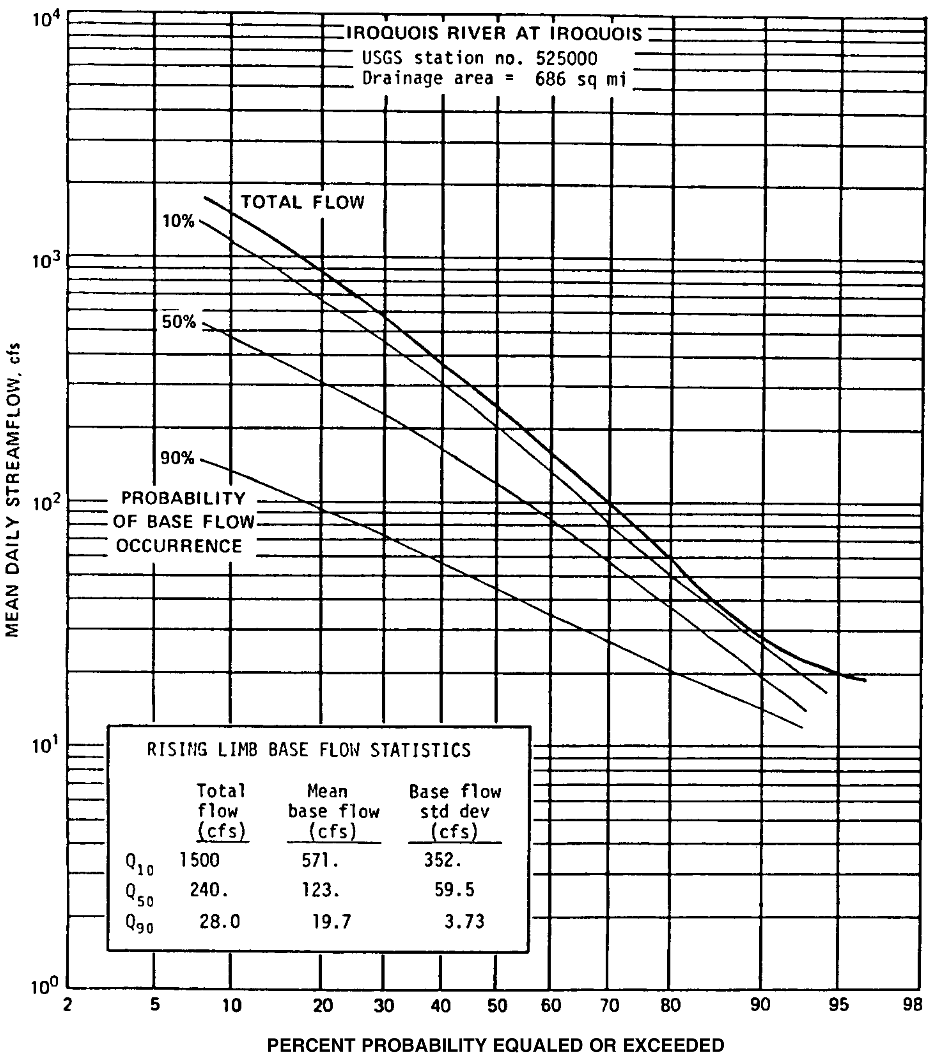
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	38.0	19.8	13.2
Q_{50}	3.00	2.65	3.09
Q_{90}	0.00	0.00	0.00



	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	100.	40.7	26.7
Q_{50}	19.0	9.99	5.19
Q_{90}	2.30	1.53	0.43

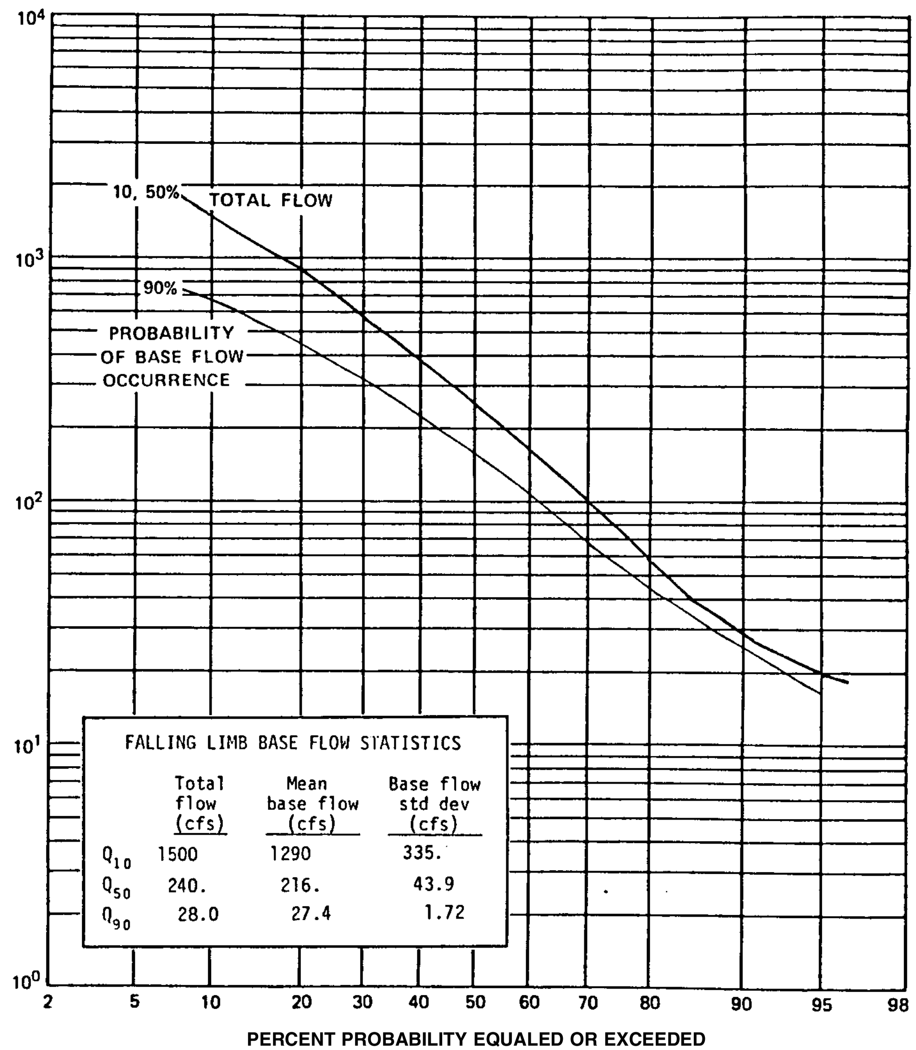


	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	100.	77.6	27.1
Q_{50}	19.0	15.7	4.79
Q_{90}	2.30	2.09	0.36



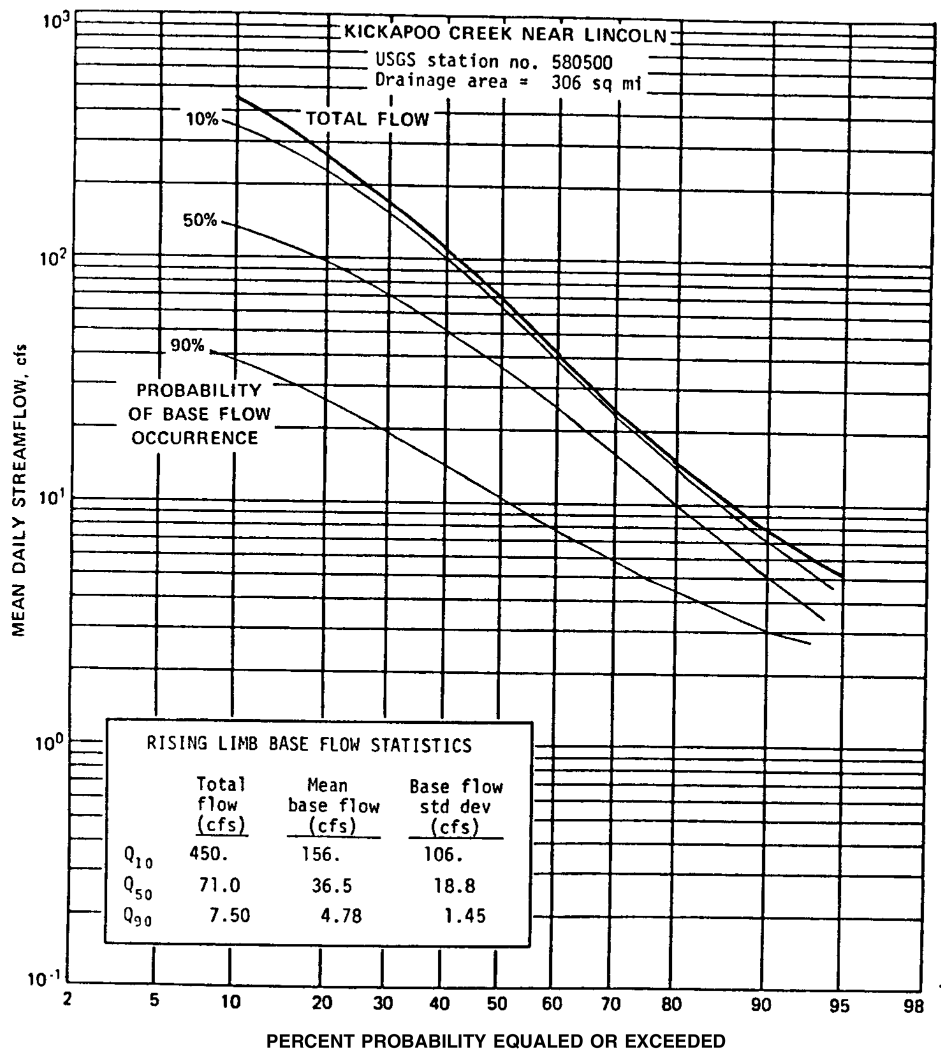
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1500	571.	352.
Q_{50}	240.	123.	59.5
Q_{90}	28.0	19.7	3.73

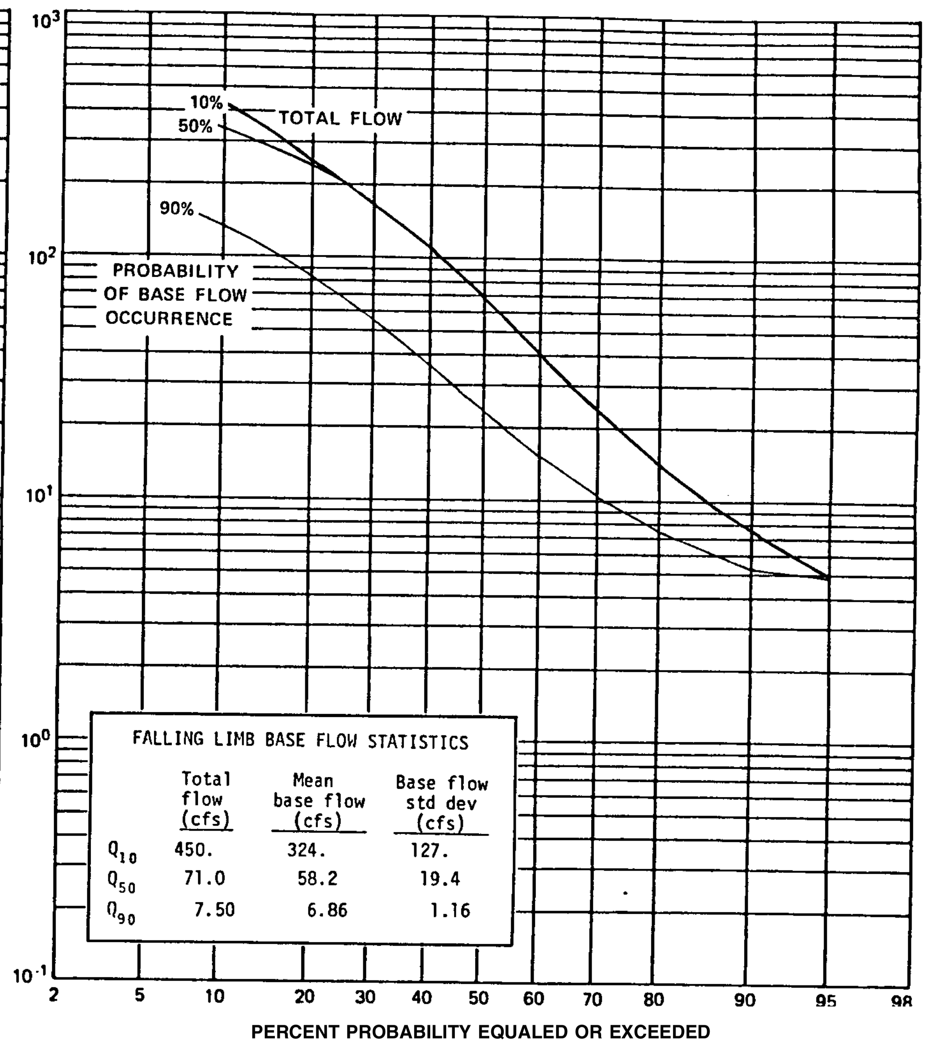


FALLING LIMB BASE FLOW STATISTICS

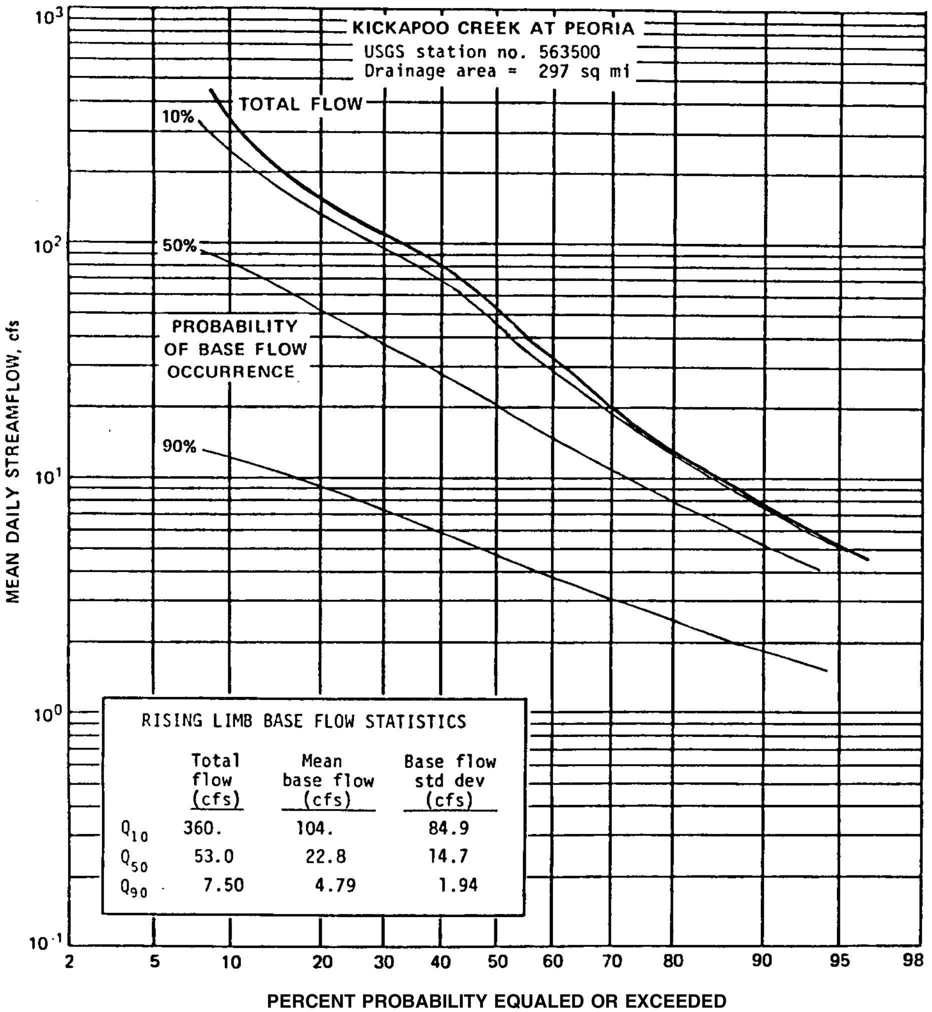
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1500	1290	335.
Q_{50}	240.	216.	43.9
Q_{90}	28.0	27.4	1.72



	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	450.	156.	106.
Q_{50}	71.0	36.5	18.8
Q_{90}	7.50	4.78	1.45

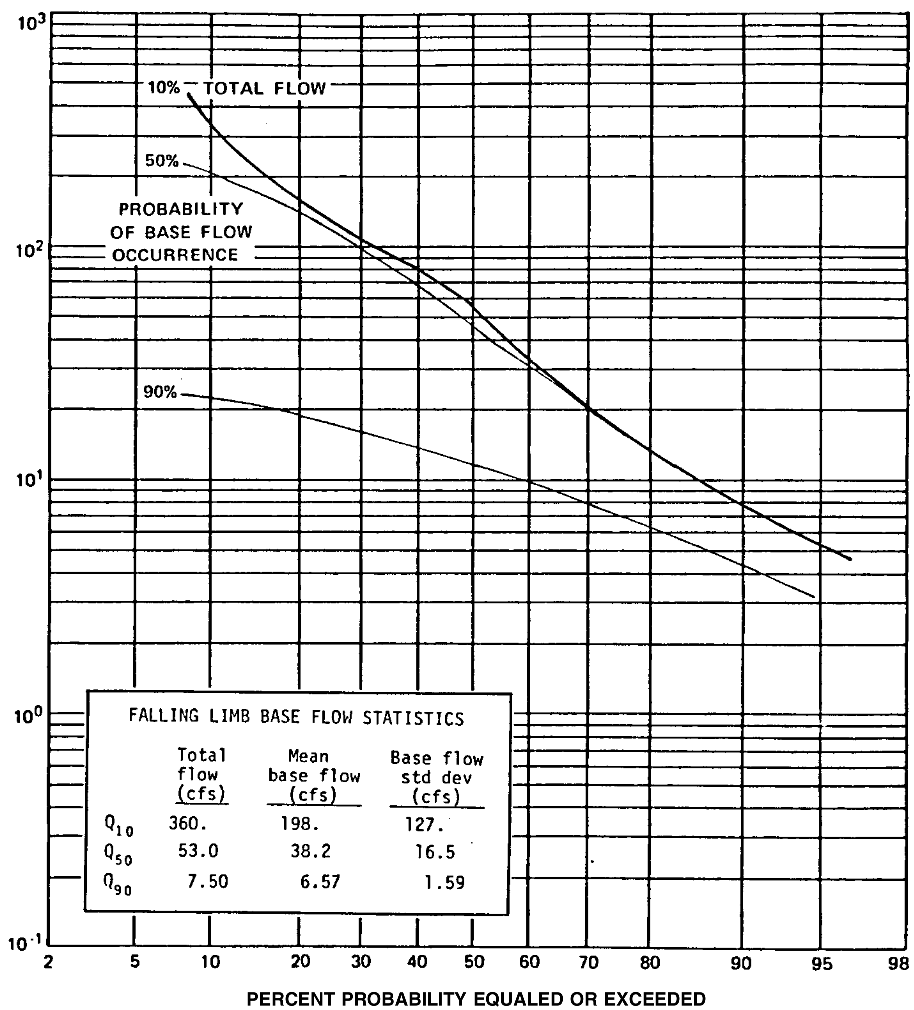


	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	450.	324.	127.
Q_{50}	71.0	58.2	19.4
Q_{90}	7.50	6.86	1.16



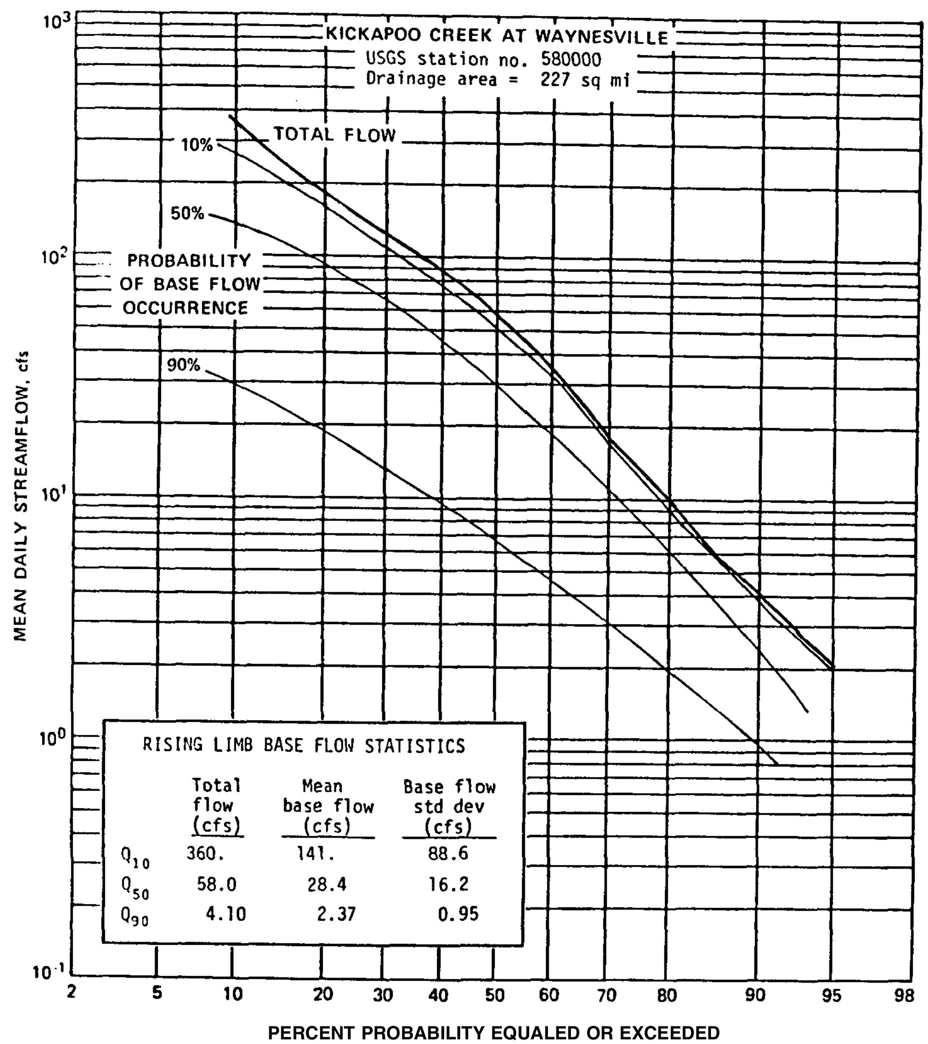
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	360.	104.	84.9
Q_{50}	53.0	22.8	14.7
Q_{90}	7.50	4.79	1.94



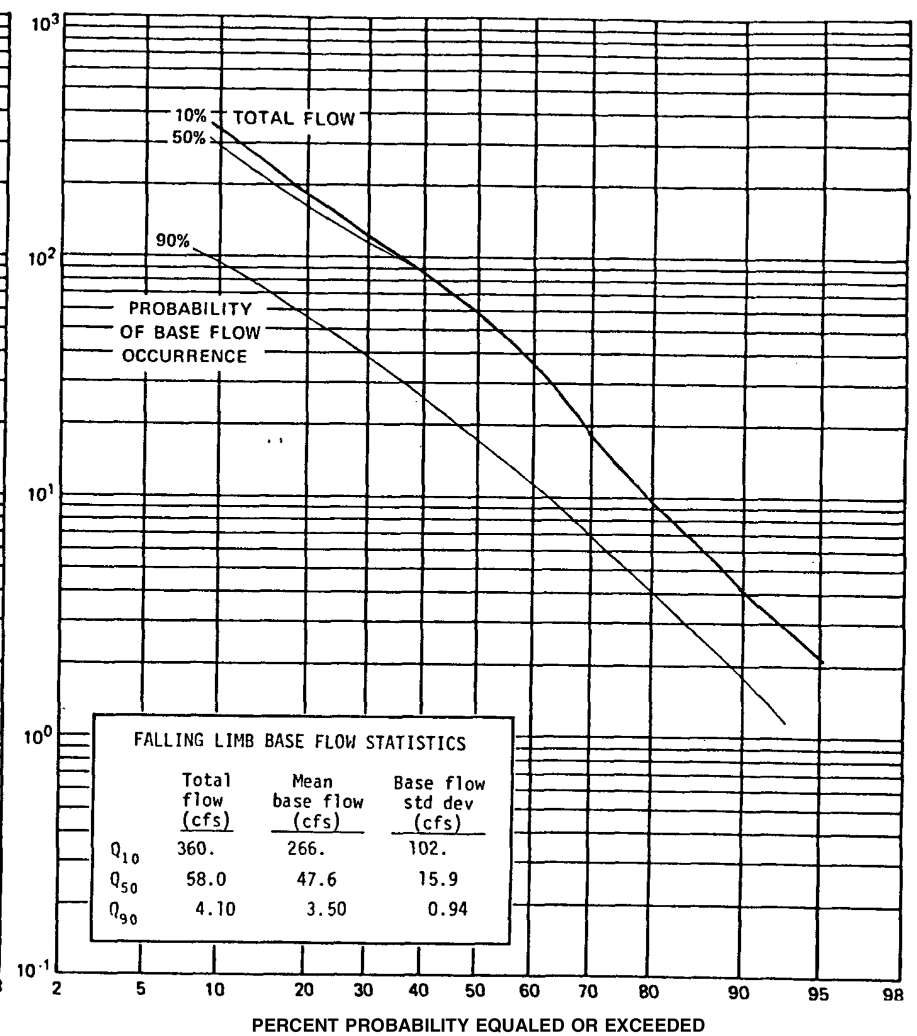
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	360.	198.	127.
Q_{50}	53.0	38.2	16.5
Q_{90}	7.50	6.57	1.59



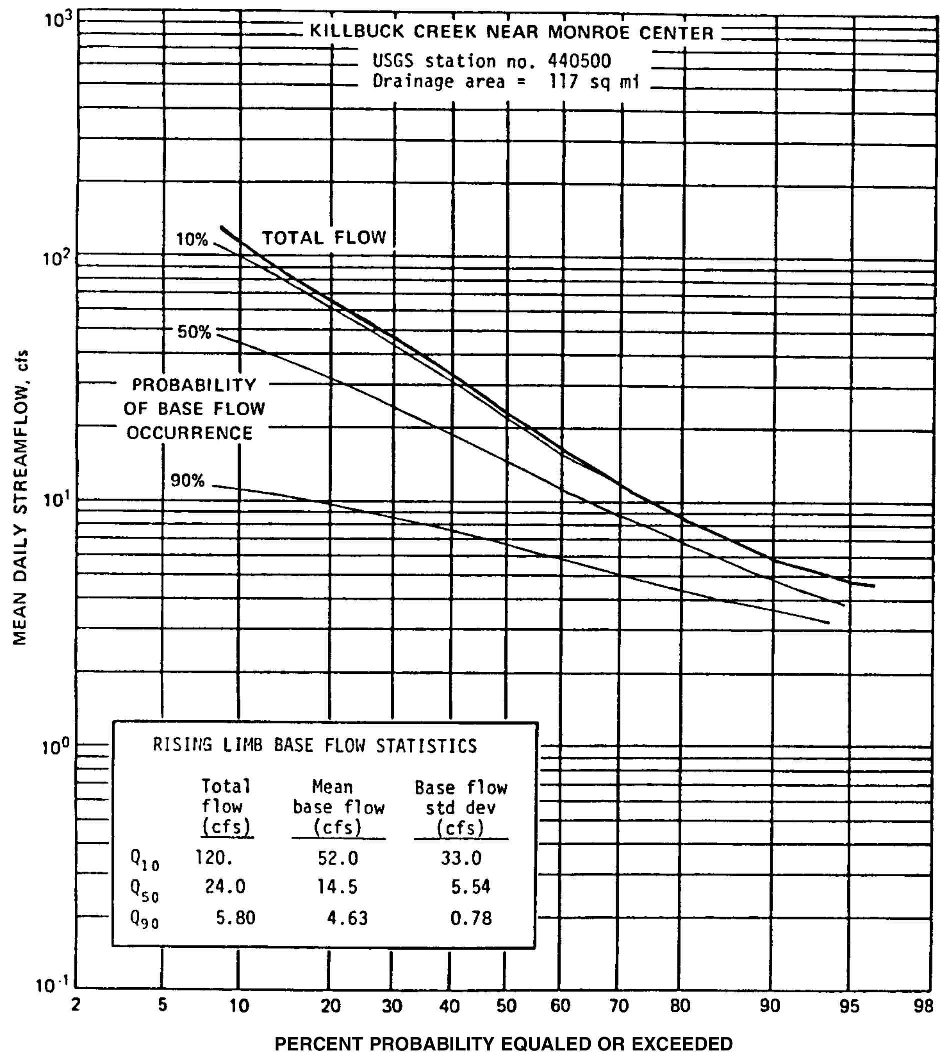
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	360.	141.	88.6
Q_{50}	58.0	28.4	16.2
Q_{90}	4.10	2.37	0.95



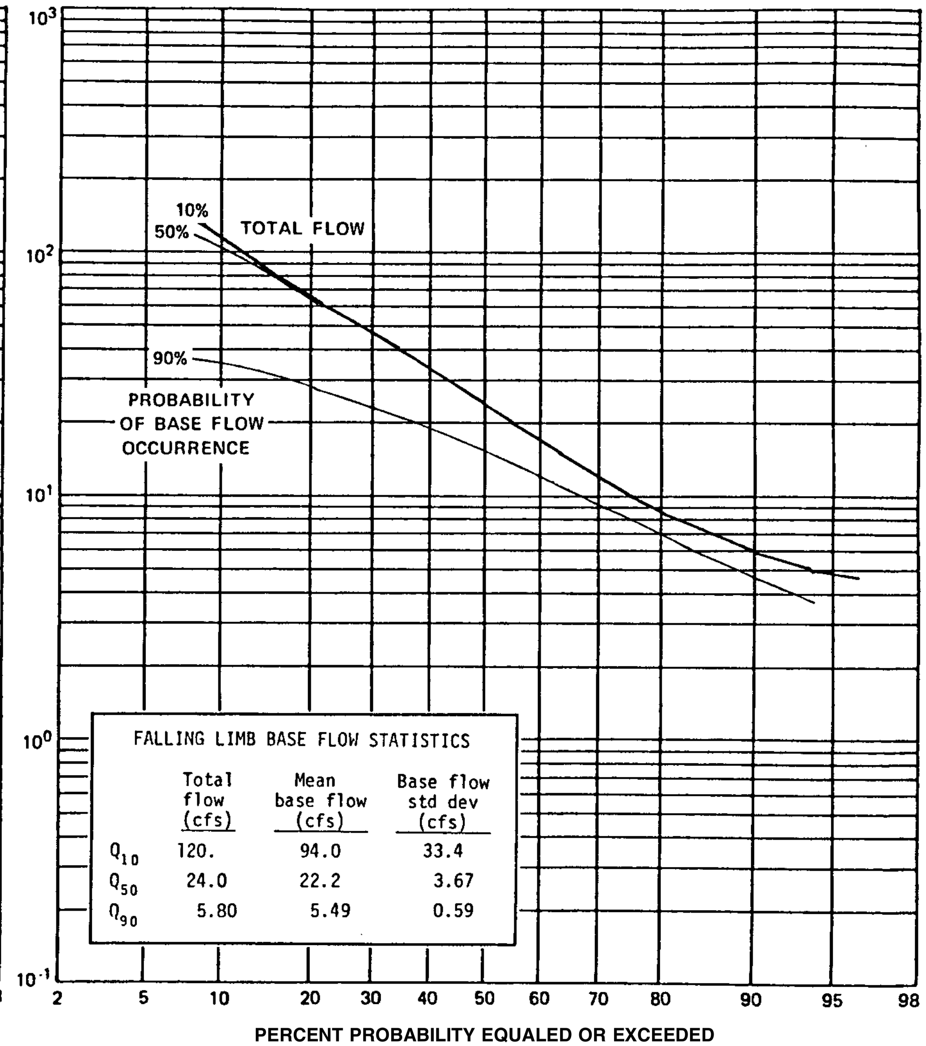
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	360.	266.	102.
Q_{50}	58.0	47.6	15.9
Q_{90}	4.10	3.50	0.94



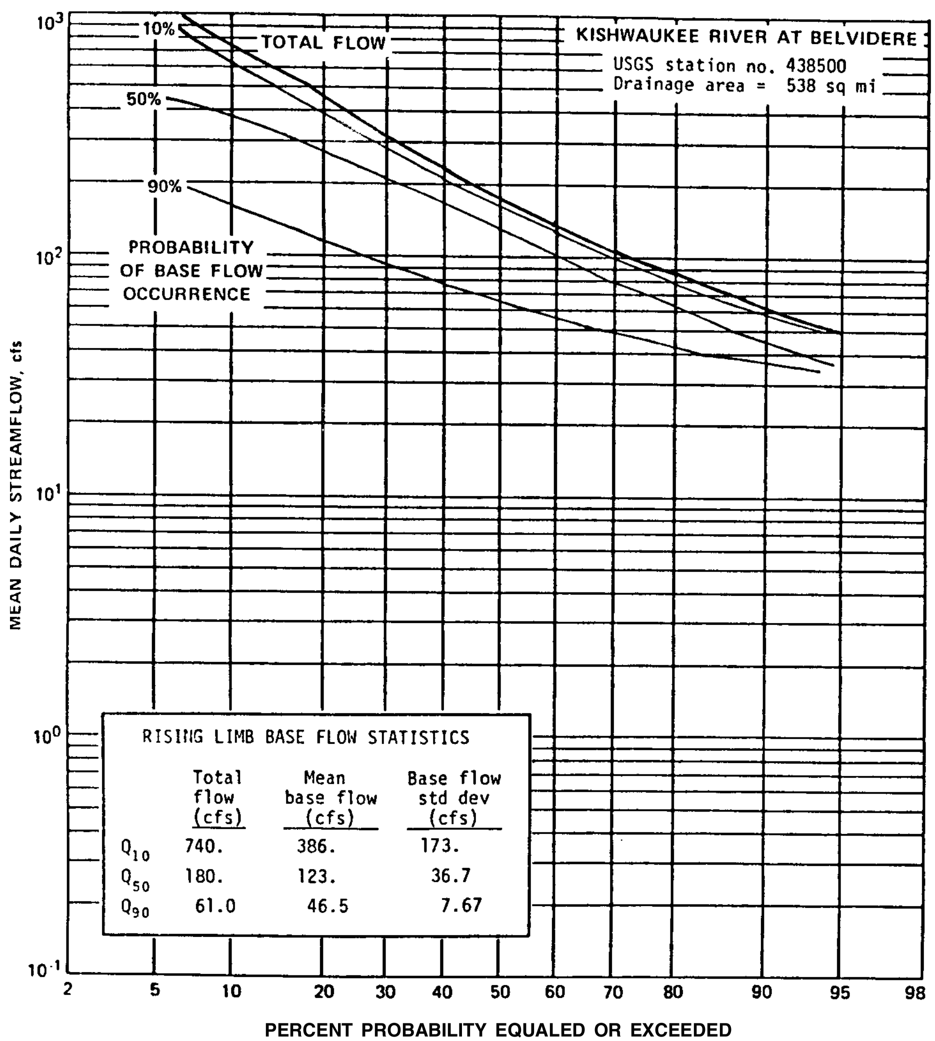
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	120.	52.0	33.0
Q_{50}	24.0	14.5	5.54
Q_{90}	5.80	4.63	0.78



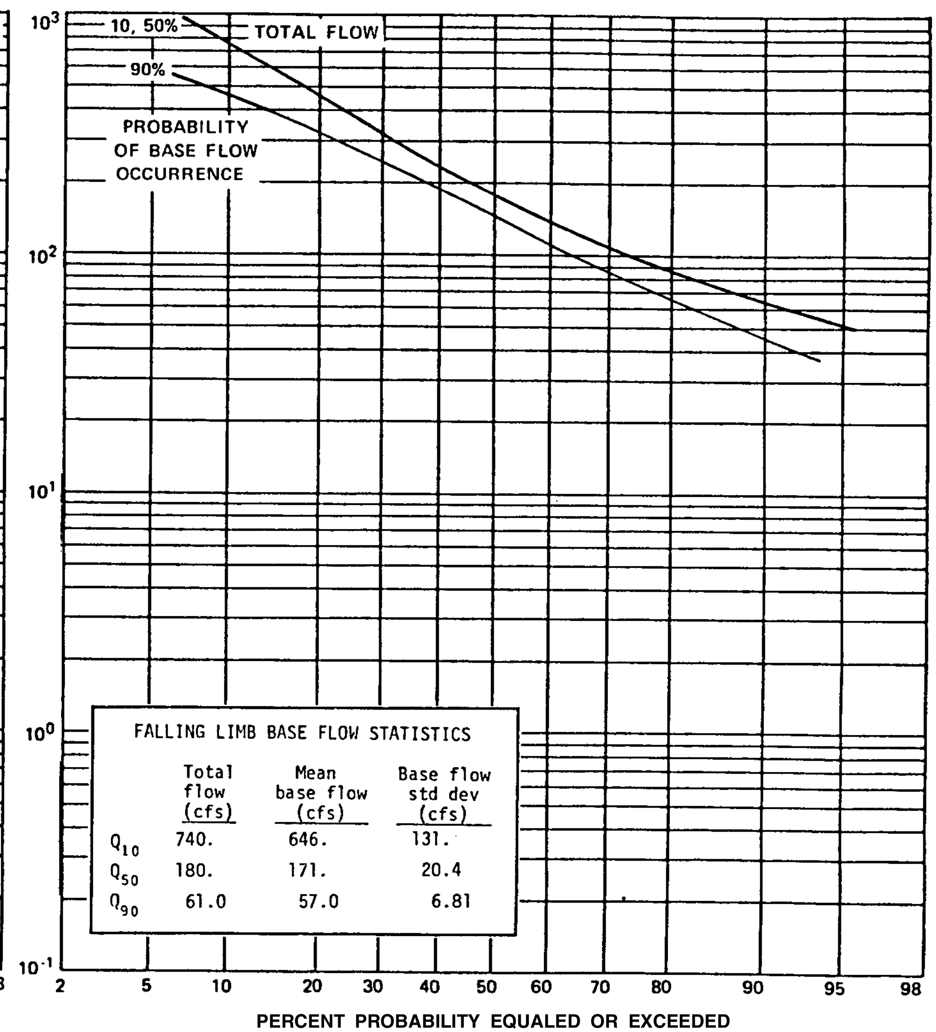
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	120.	94.0	33.4
Q_{50}	24.0	22.2	3.67
Q_{90}	5.80	5.49	0.59



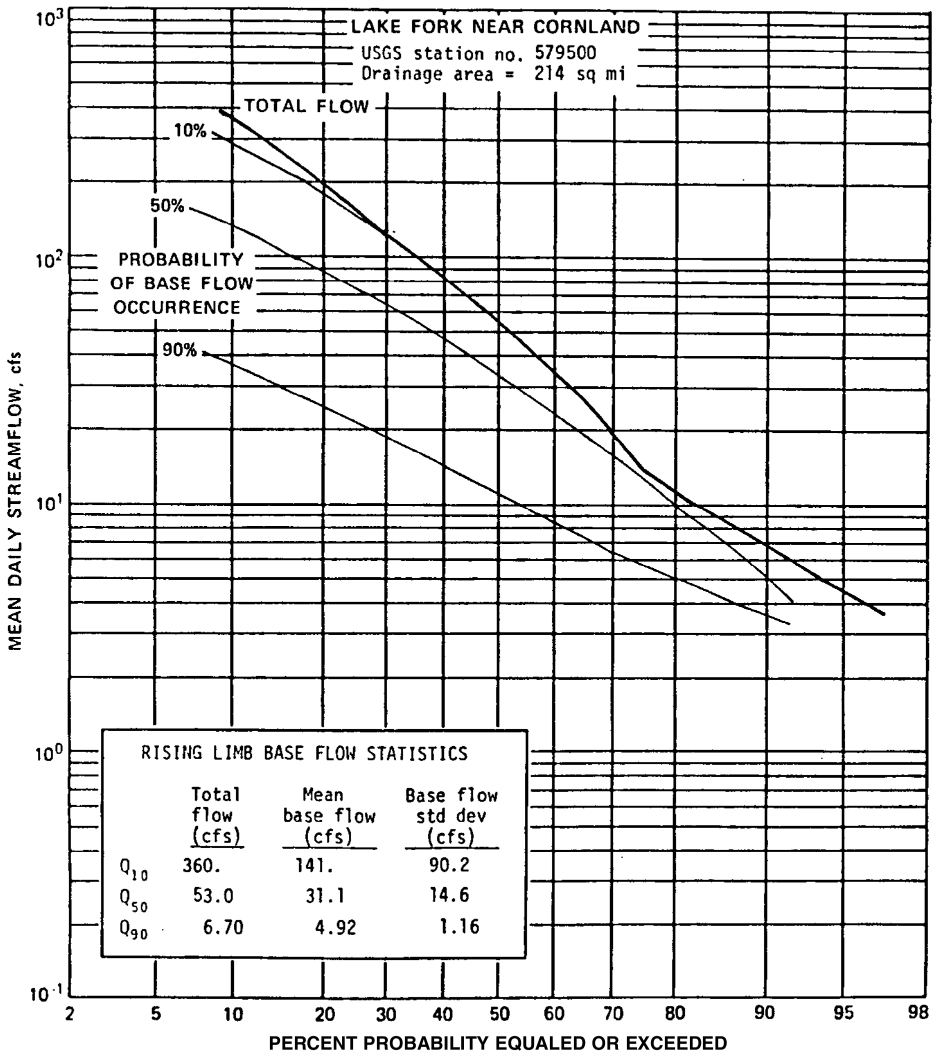
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	740.	386.	173.
Q_{50}	180.	123.	36.7
Q_{90}	61.0	46.5	7.67



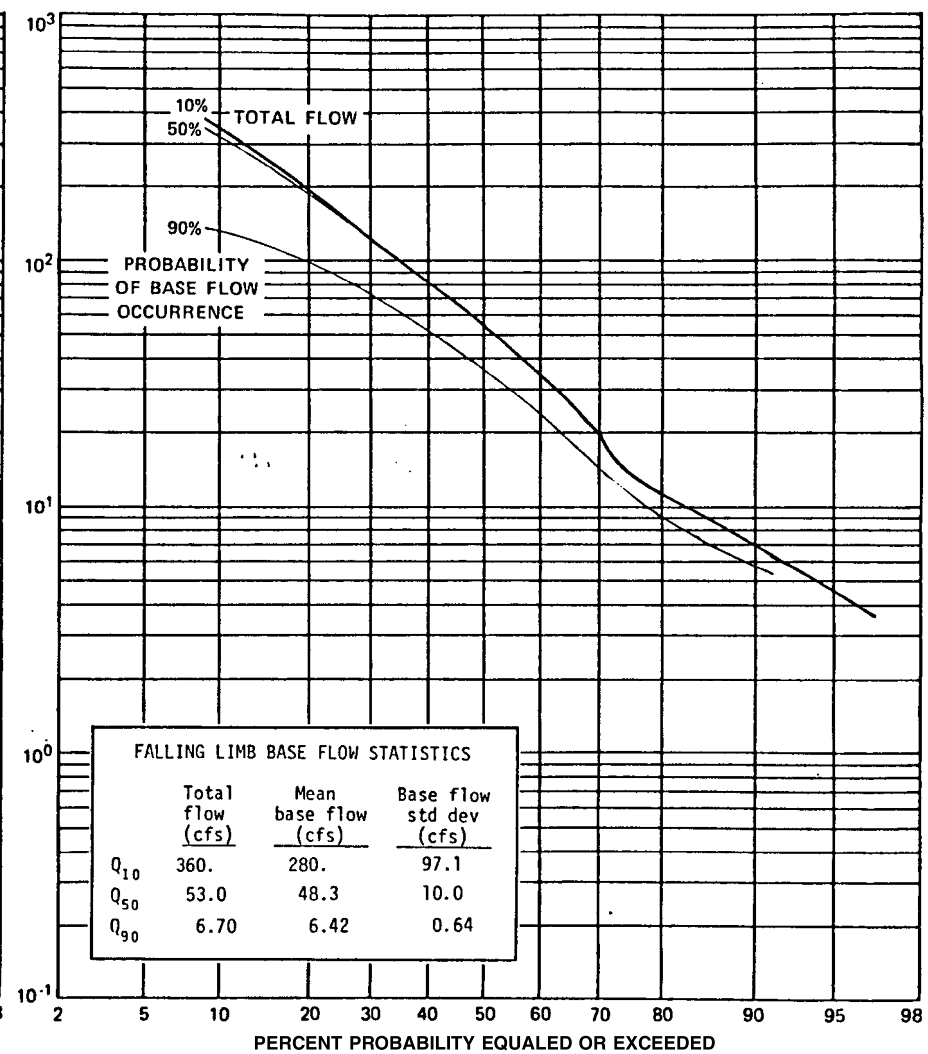
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	740.	646.	131.
Q_{50}	180.	171.	20.4
Q_{90}	61.0	57.0	6.81



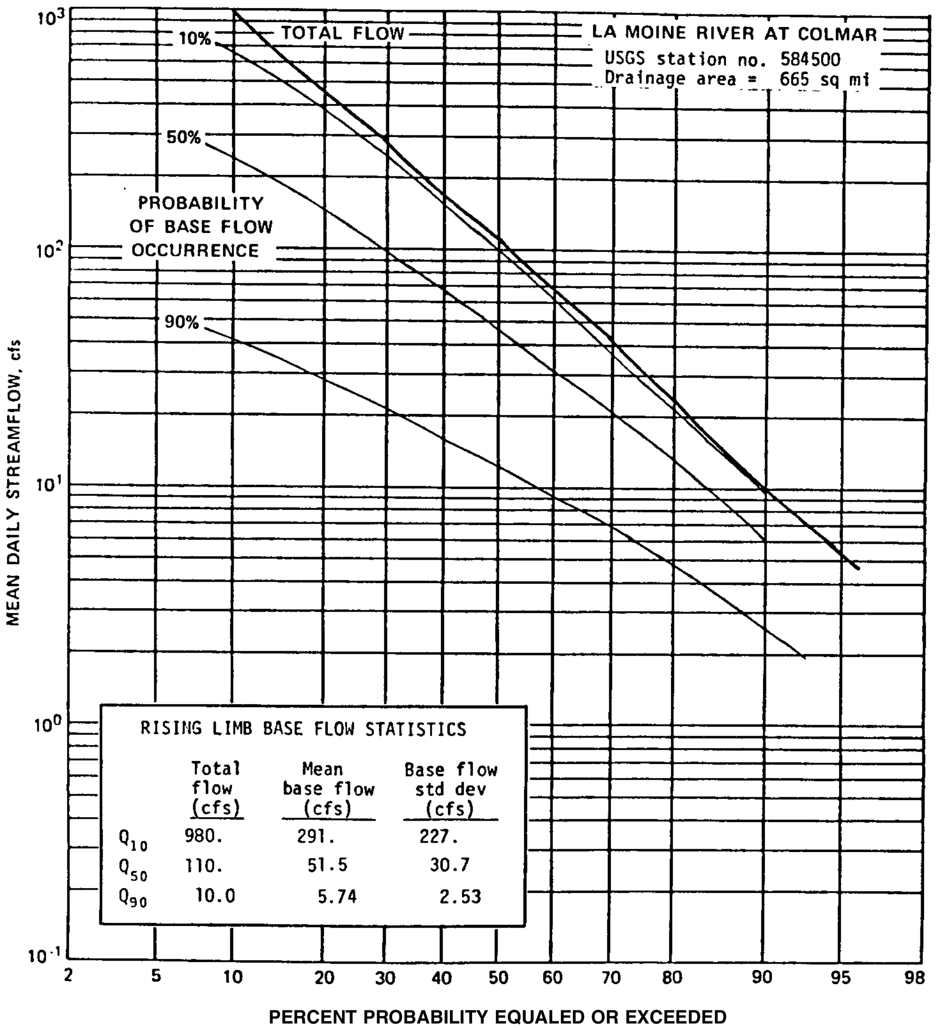
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	360.	141.	90.2
Q_{50}	53.0	31.1	14.6
Q_{90}	6.70	4.92	1.16



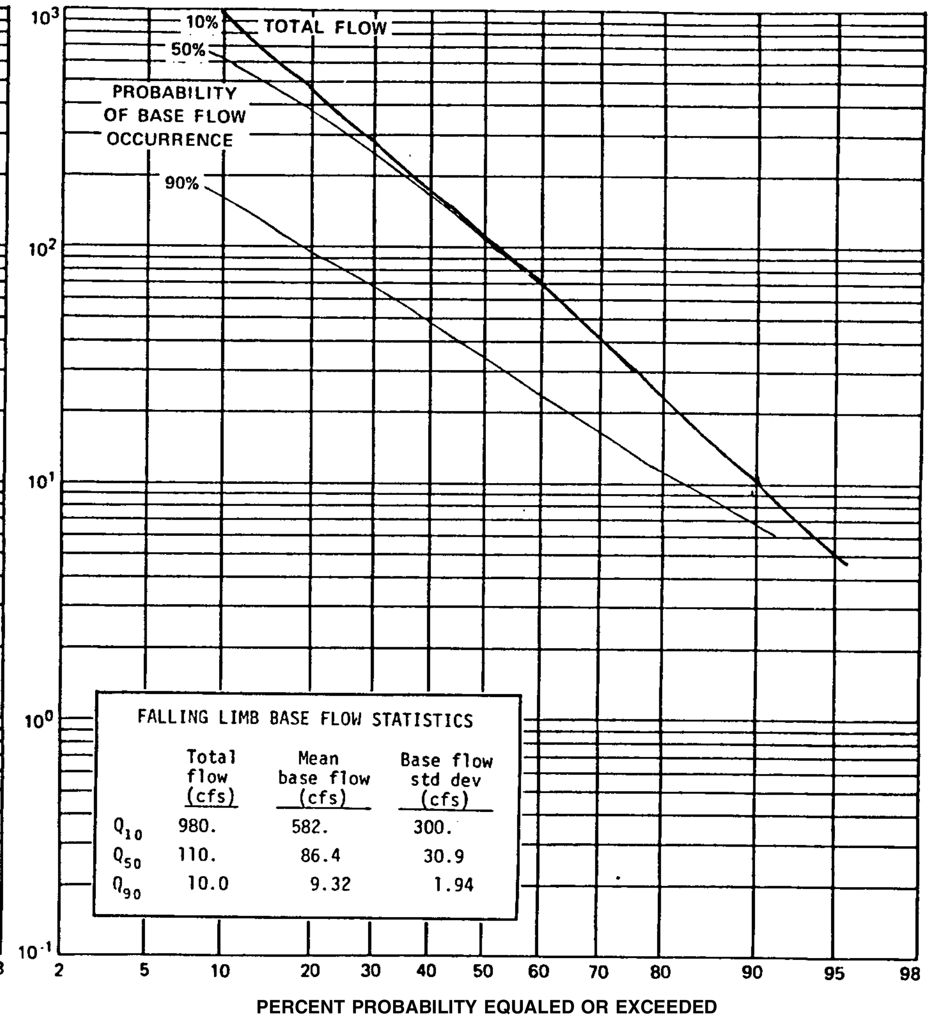
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	360.	280.	97.1
Q_{50}	53.0	48.3	10.0
Q_{90}	6.70	6.42	0.64



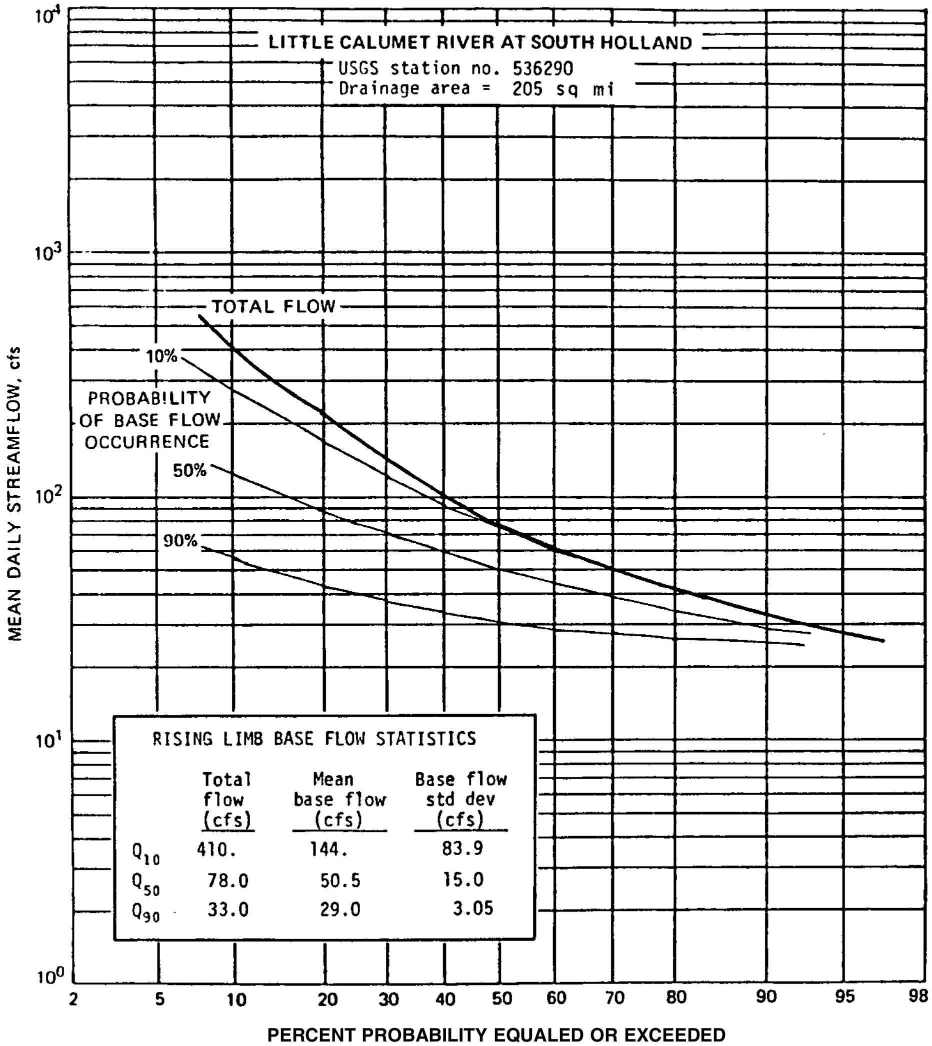
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	980.	291.	227.
Q_{50}	110.	51.5	30.7
Q_{90}	10.0	5.74	2.53



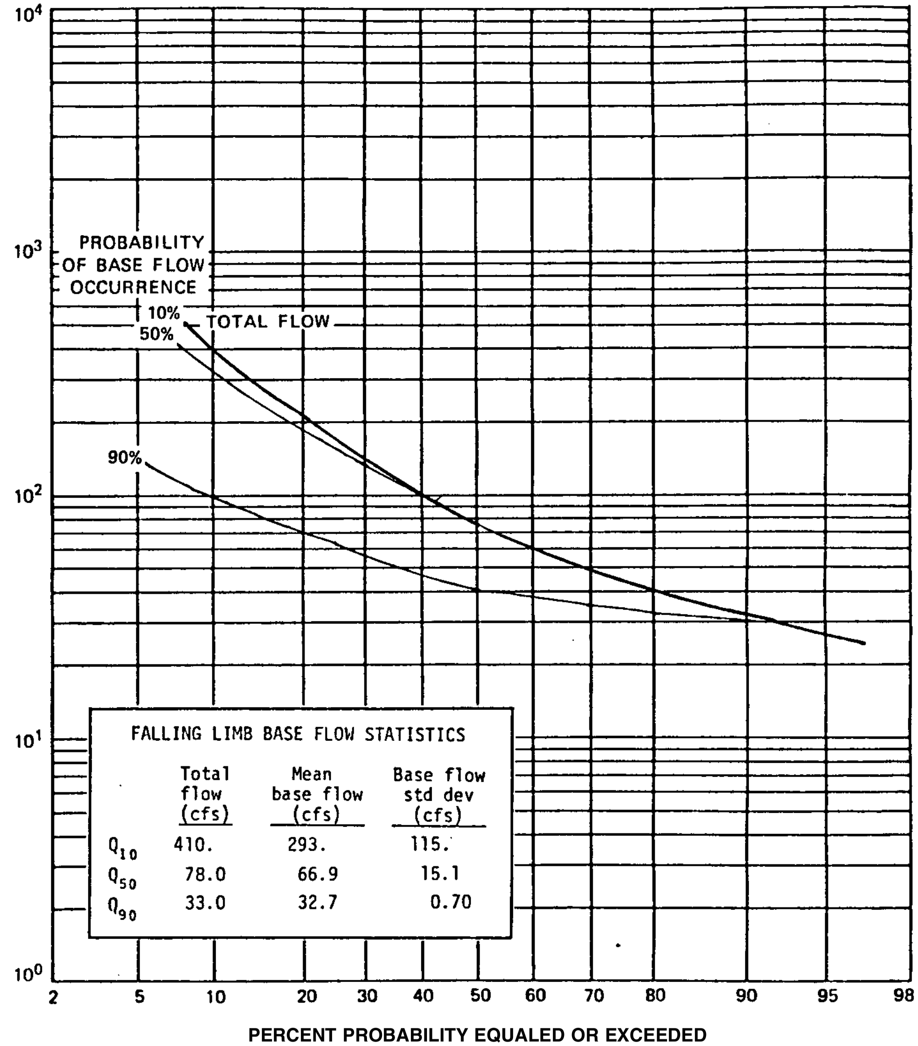
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	980.	582.	300.
Q_{50}	110.	86.4	30.9
Q_{90}	10.0	9.32	1.94



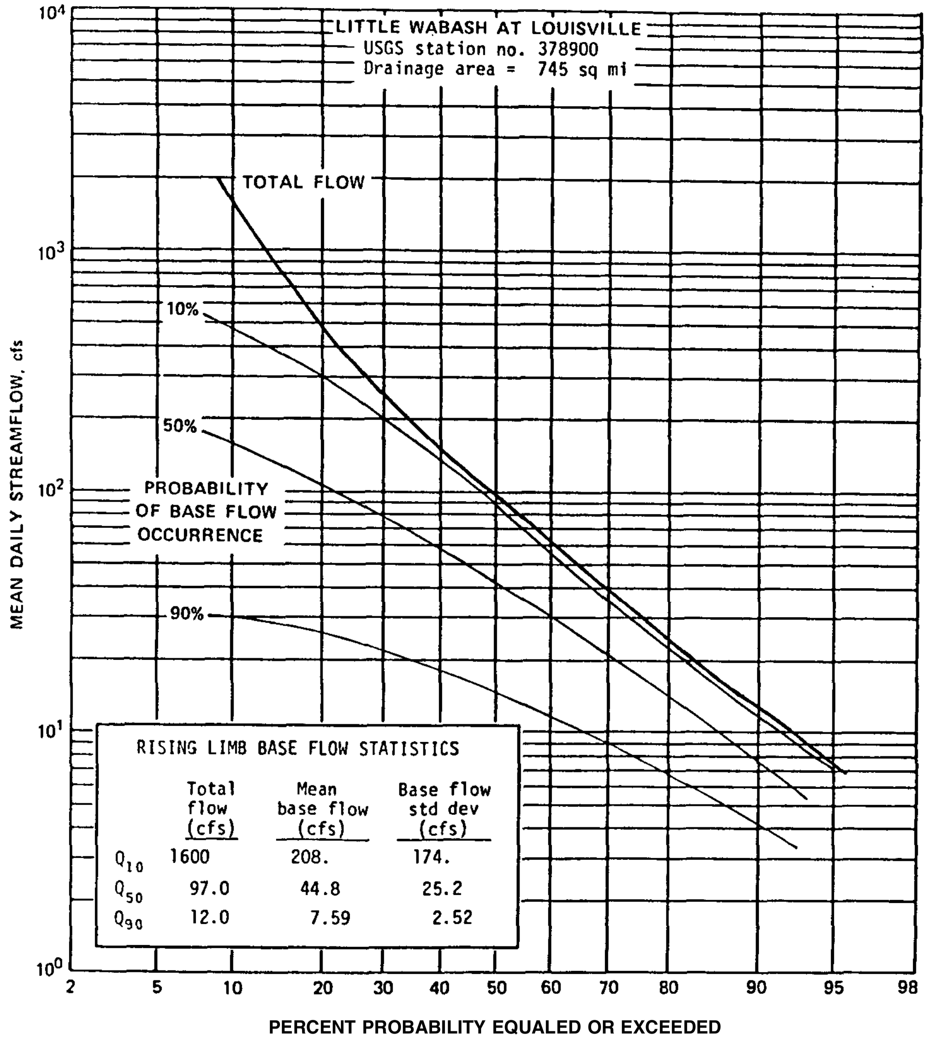
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	410.	144.	83.9
Q_{50}	78.0	50.5	15.0
Q_{90}	33.0	29.0	3.05

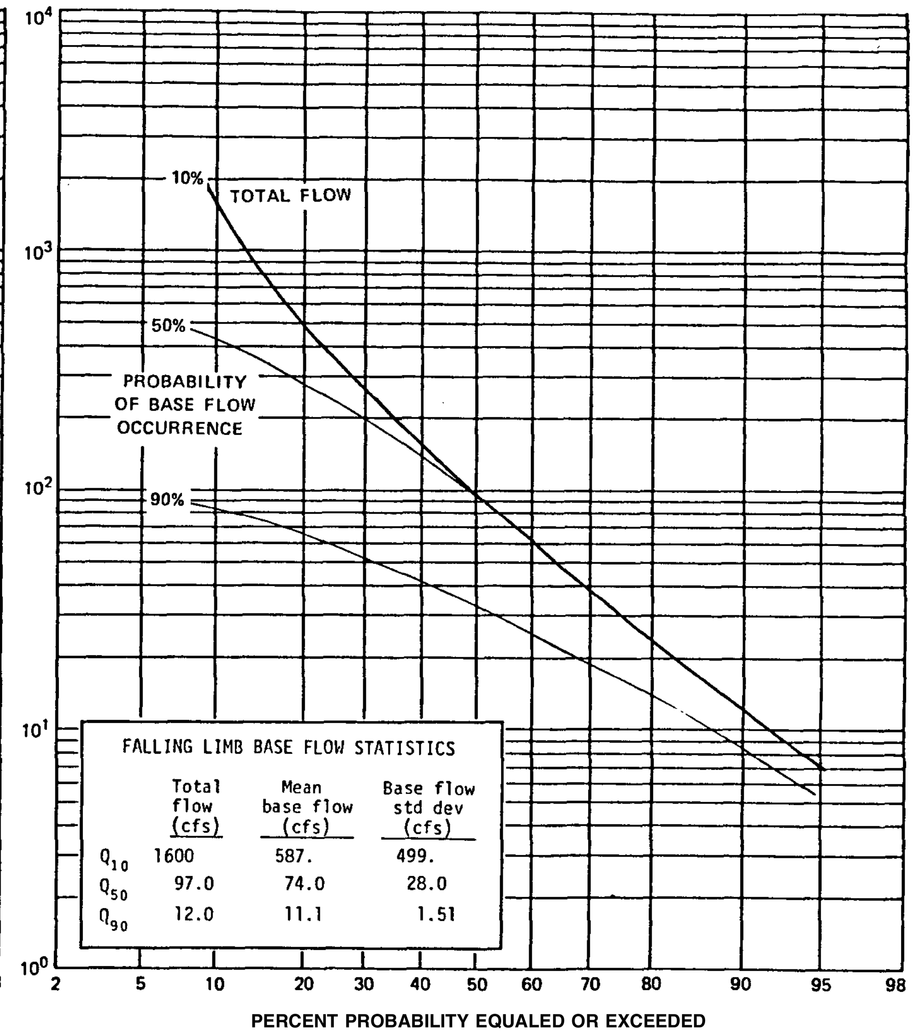


FALLING LIMB BASE FLOW STATISTICS

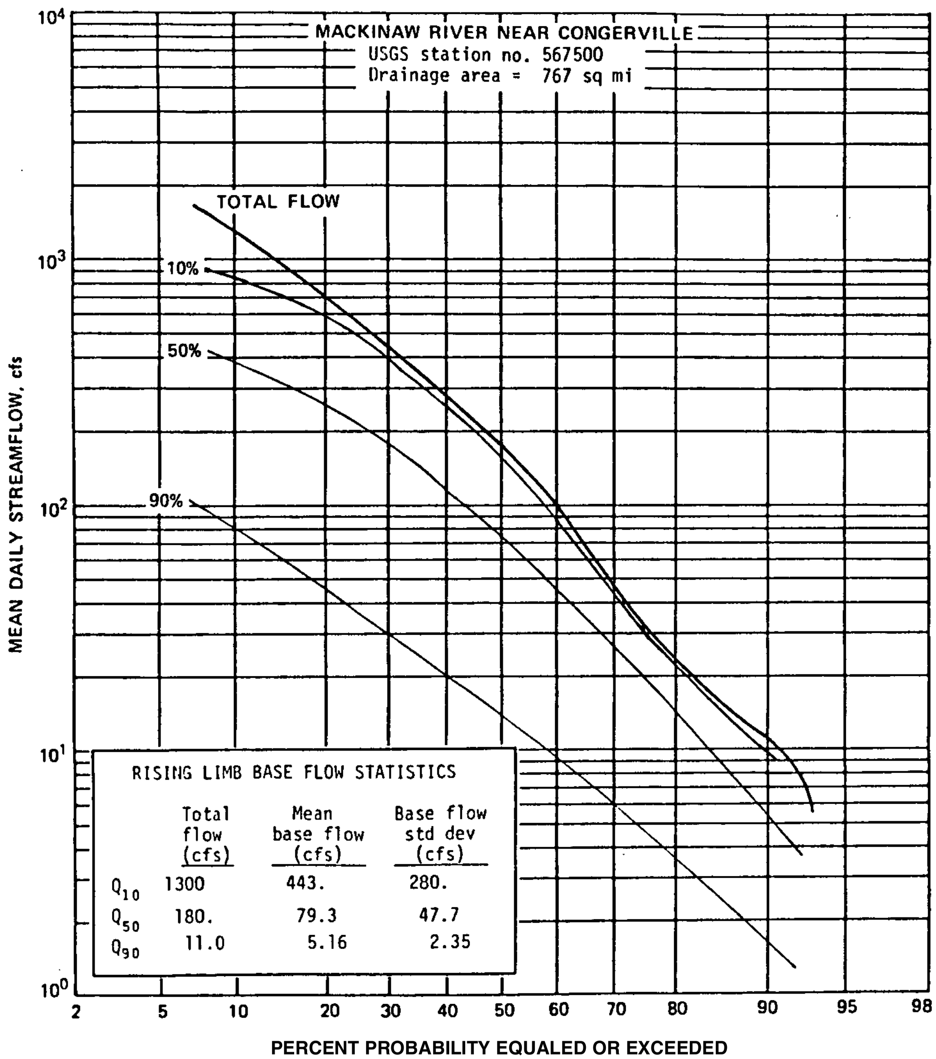
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	410.	293.	115.
Q_{50}	78.0	66.9	15.1
Q_{90}	33.0	32.7	0.70



LITTLE WABASH AT LOUISVILLE
USGS station no. 378900
Drainage area = 745 sq mi
TOTAL FLOW
10%
50%
90%
PROBABILITY
OF BASE FLOW
OCCURRENCE
MEAN DAILY STREAMFLOW, cfs
PERCENT PROBABILITY EQUALED OR EXCEEDED
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 1600 208. 174.
Q50 97.0 44.8 25.2
Q90 12.0 7.59 2.52

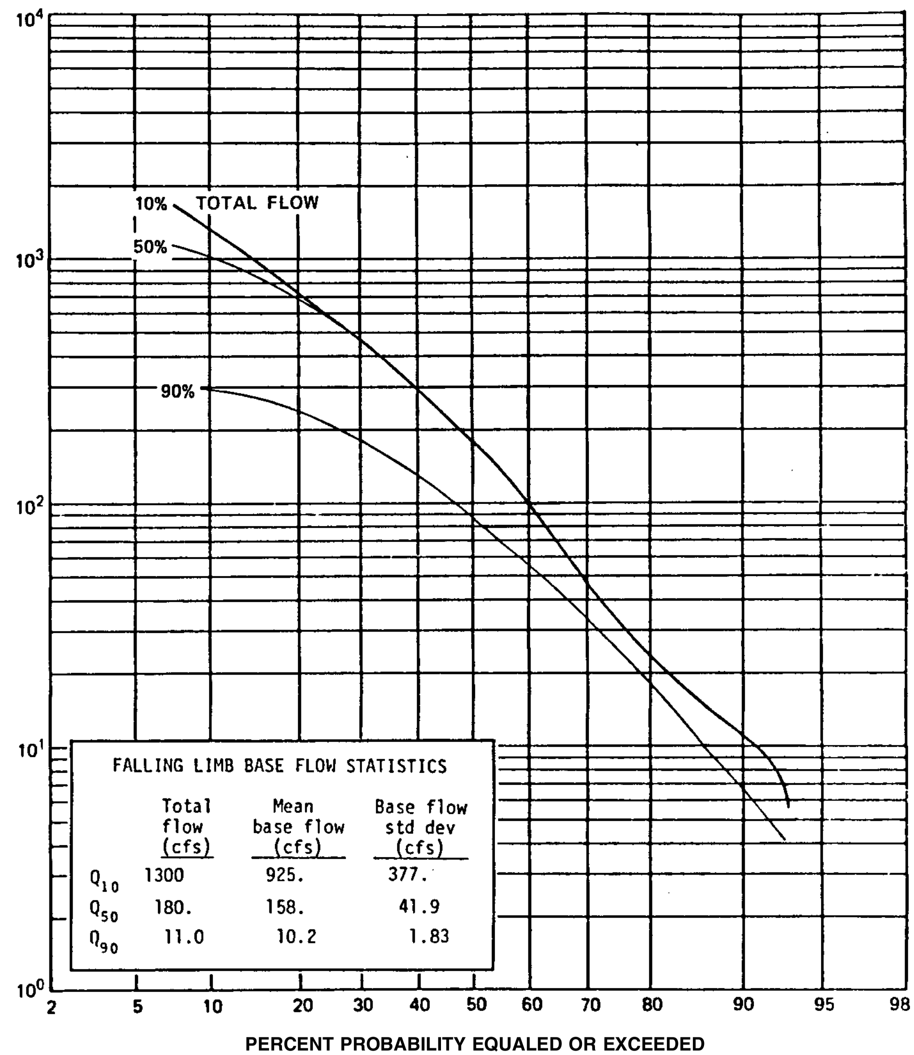


TOTAL FLOW
10%
50%
90%
PROBABILITY
OF BASE FLOW
OCCURRENCE
PERCENT PROBABILITY EQUALED OR EXCEEDED
FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 1600 587. 499.
Q50 97.0 74.0 28.0
Q90 12.0 11.1 1.51



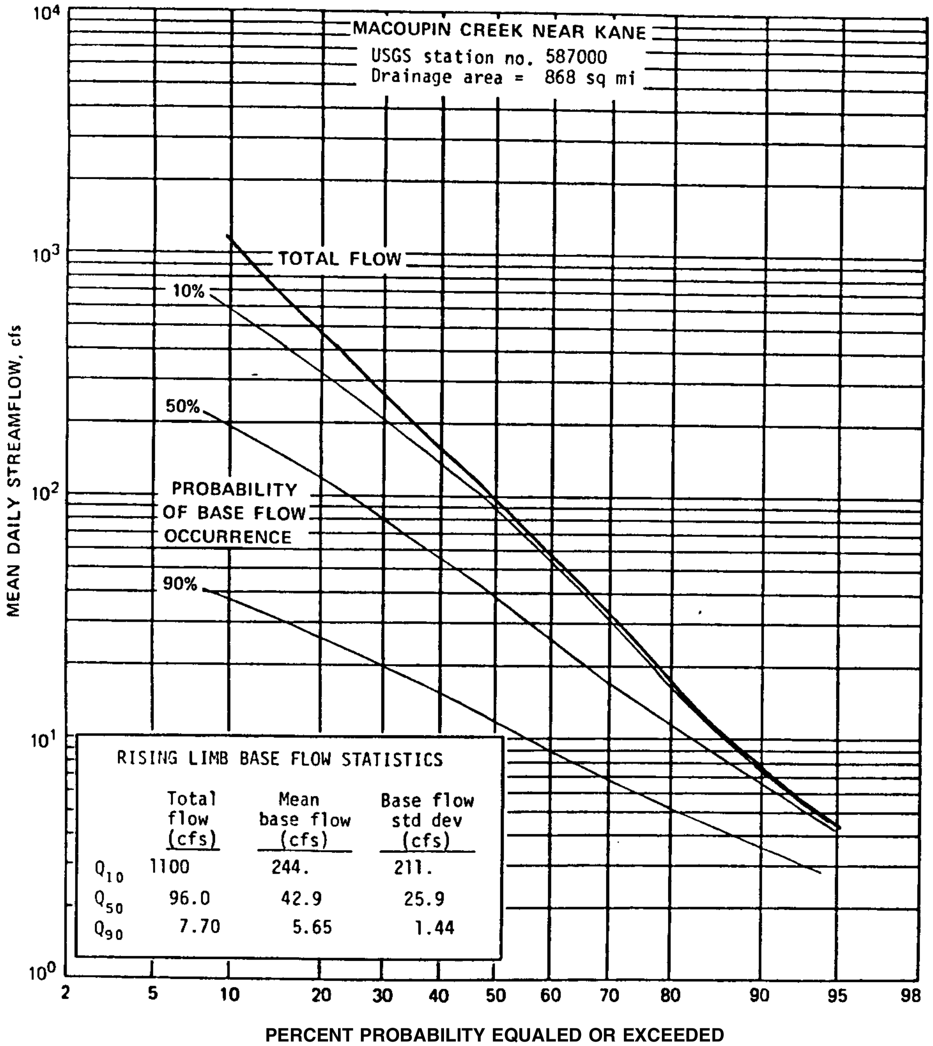
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1300	443.	280.
Q_{50}	180.	79.3	47.7
Q_{90}	11.0	5.16	2.35



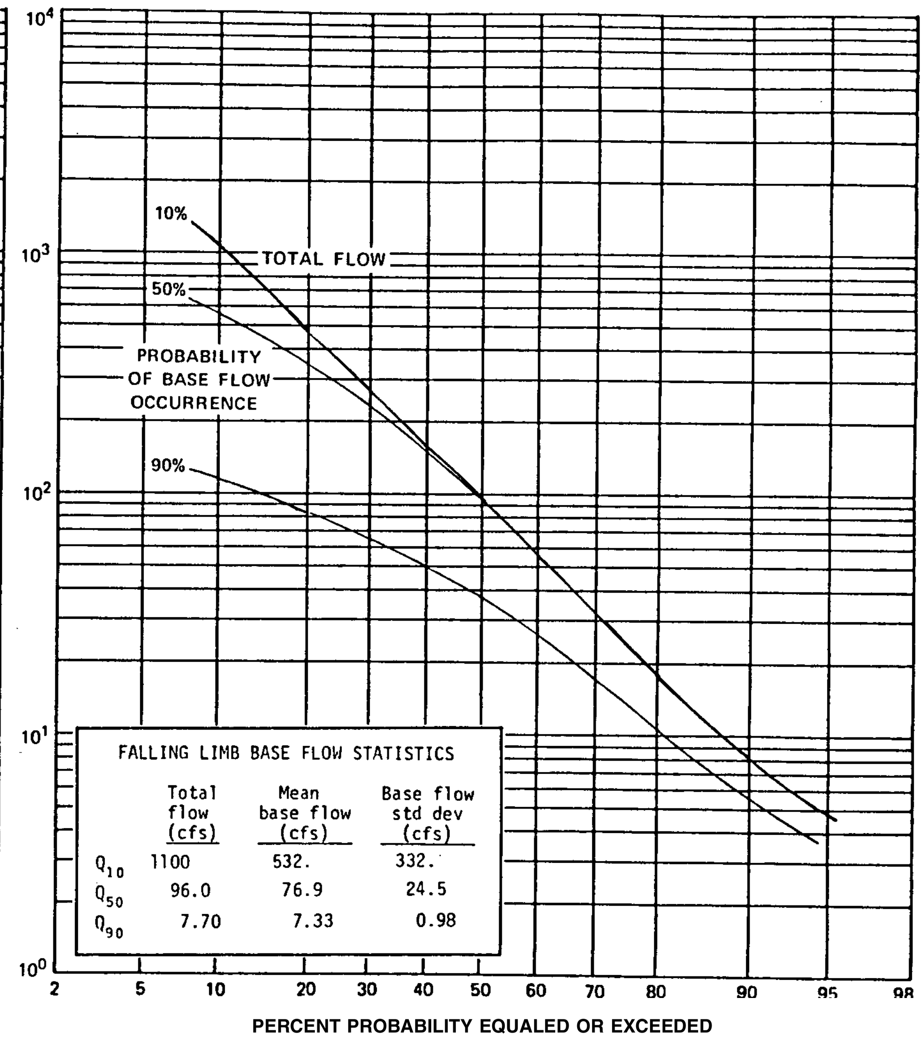
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1300	925.	377.
Q_{50}	180.	158.	41.9
Q_{90}	11.0	10.2	1.83



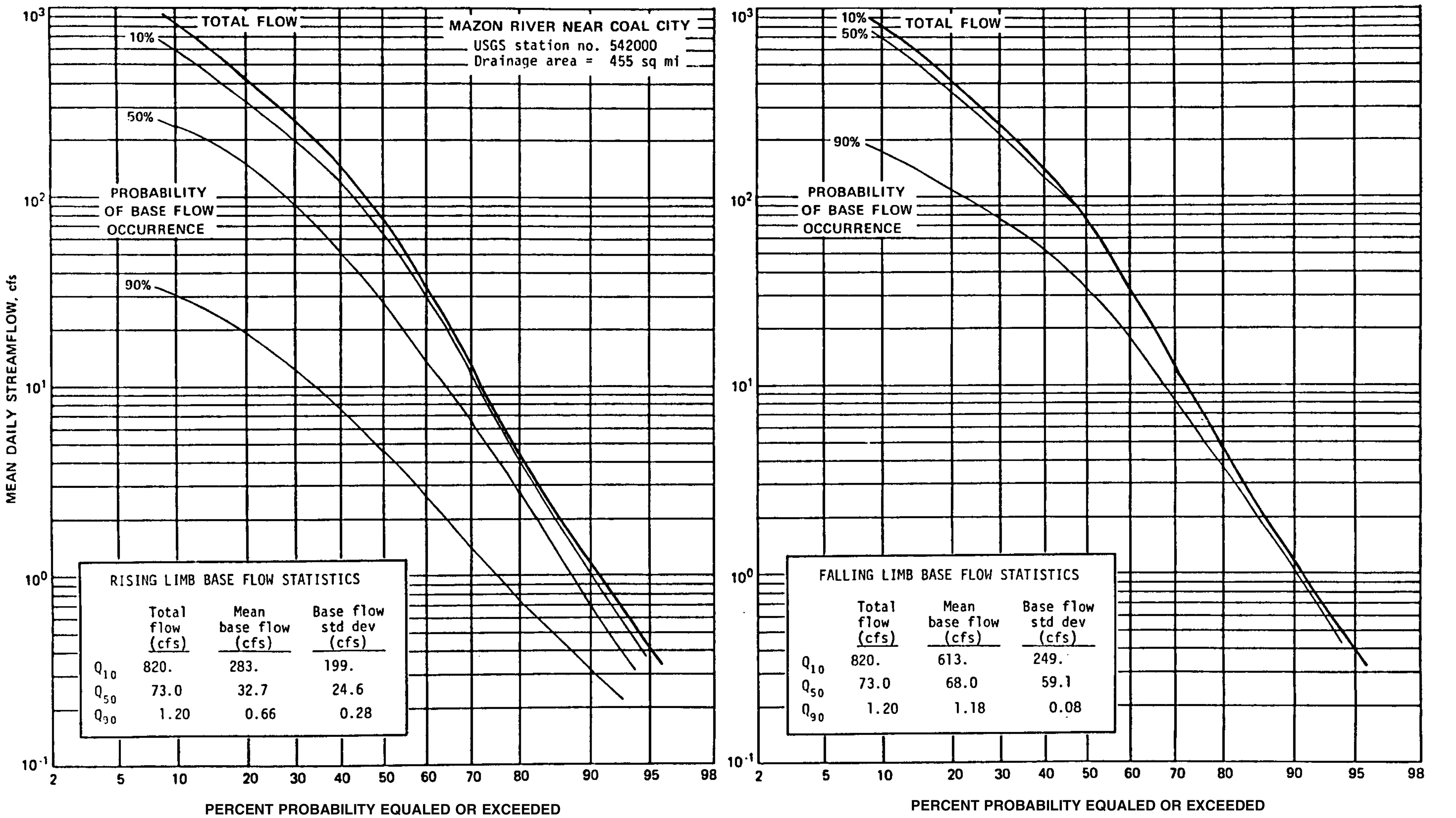
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1100	244.	211.
Q_{50}	96.0	42.9	25.9
Q_{90}	7.70	5.65	1.44



FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1100	532.	332.
Q_{50}	96.0	76.9	24.5
Q_{90}	7.70	7.33	0.98

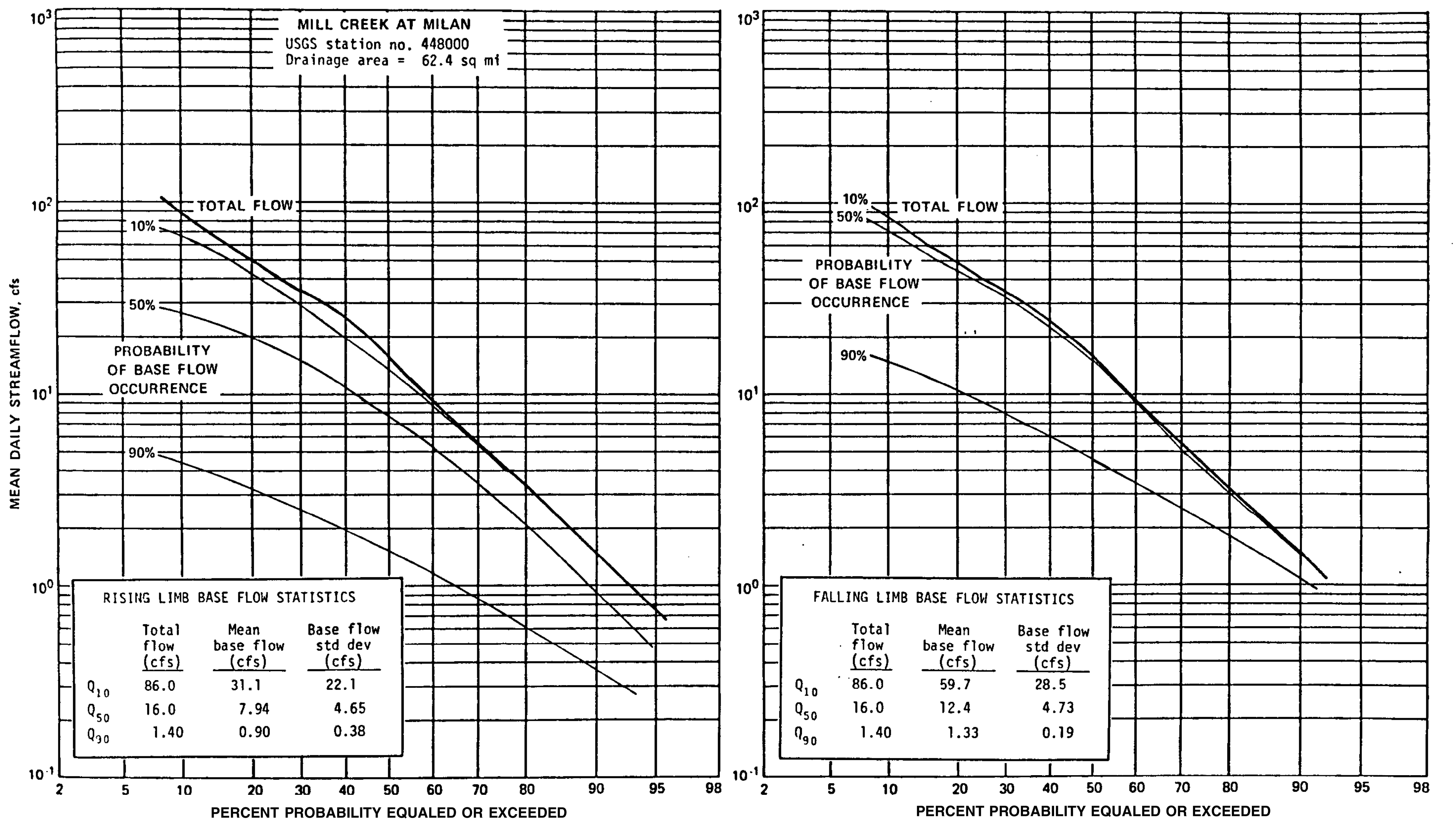


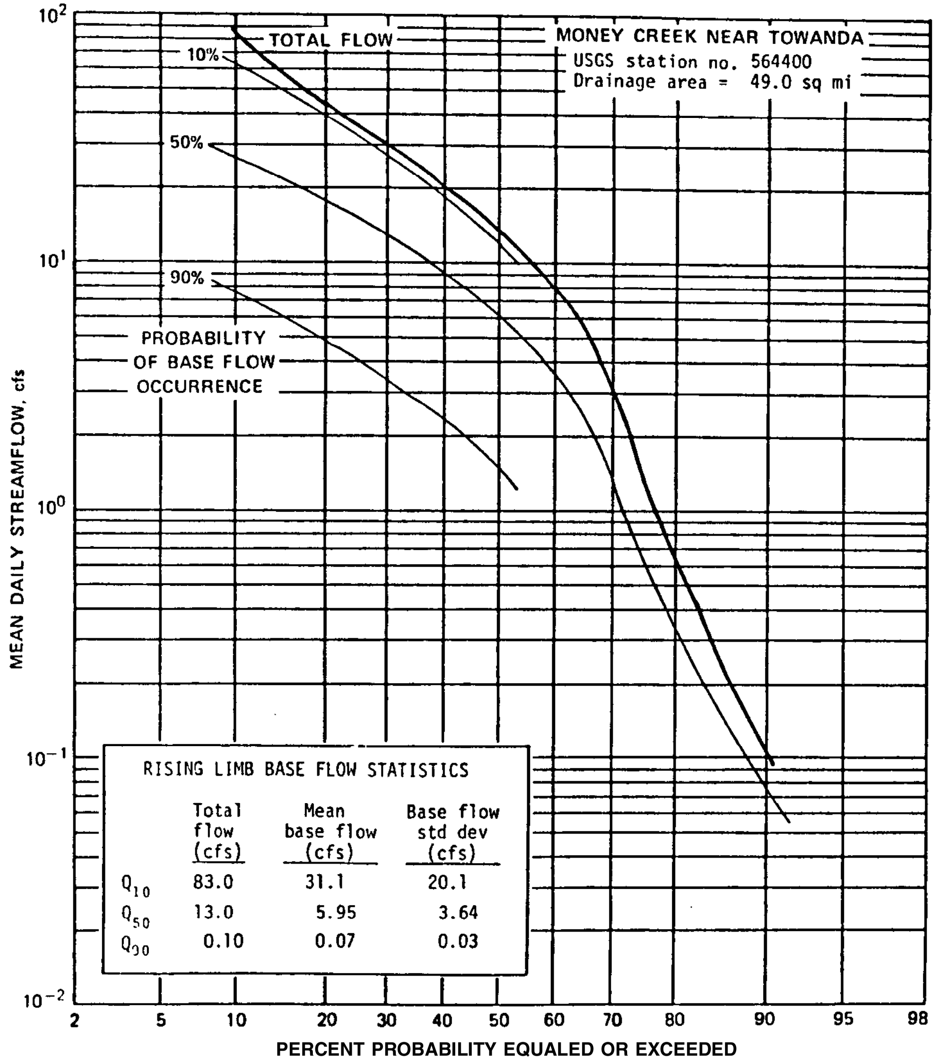
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	820.	283.	199.
Q_{50}	73.0	32.7	24.6
Q_{90}	1.20	0.66	0.28

FALLING LIMB BASE FLOW STATISTICS

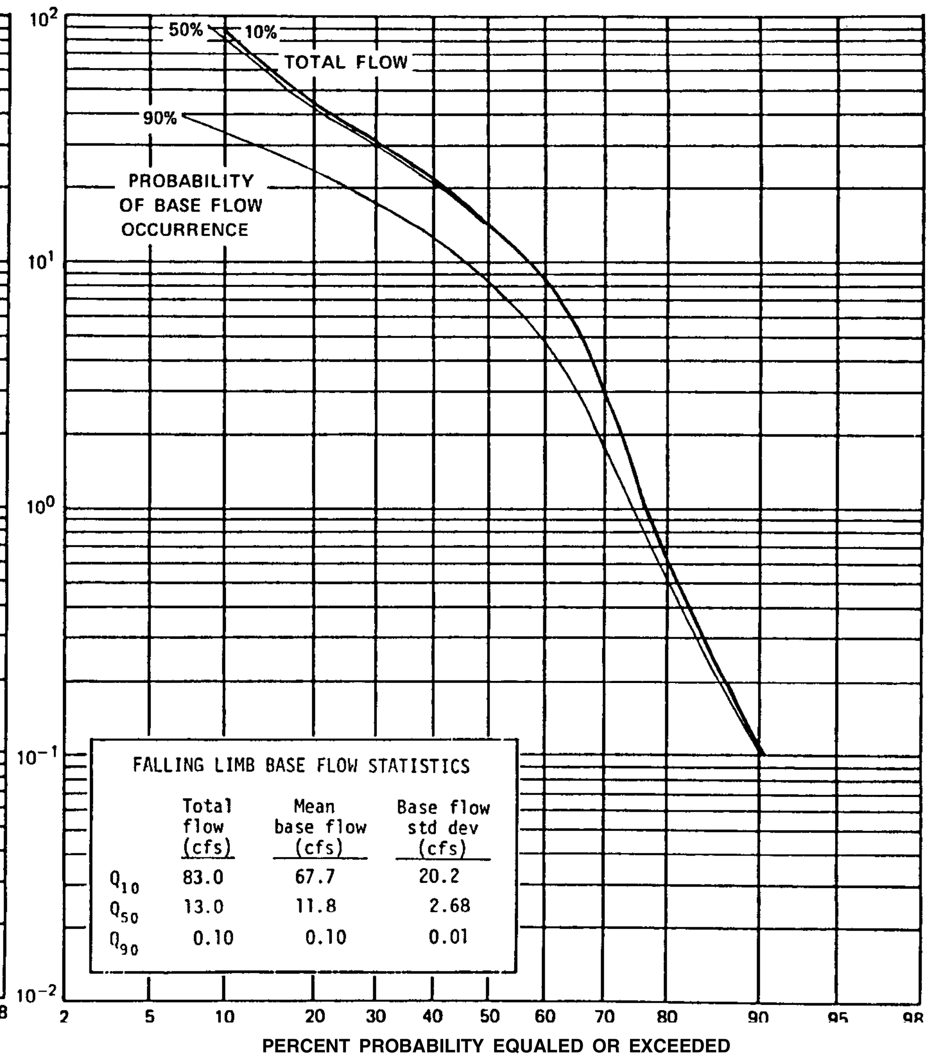
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	820.	613.	249.
Q_{50}	73.0	68.0	59.1
Q_{90}	1.20	1.18	0.08


MILL CREEK AT MILAN
USGS station no. 448000
Drainage area = 62.4 sq mi
MEAN DAILY STREAMFLOW, cfs
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 86.0 31.1 22.1
Q50 16.0 7.94 4.65
Q90 1.40 0.90 0.38
PERCENT PROBABILITY EQUALED OR EXCEEDED
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 86.0 59.7 28.5
Q50 16.0 12.4 4.73
Q90 1.40 1.33 0.19
PERCENT PROBABILITY EQUALED OR EXCEEDED



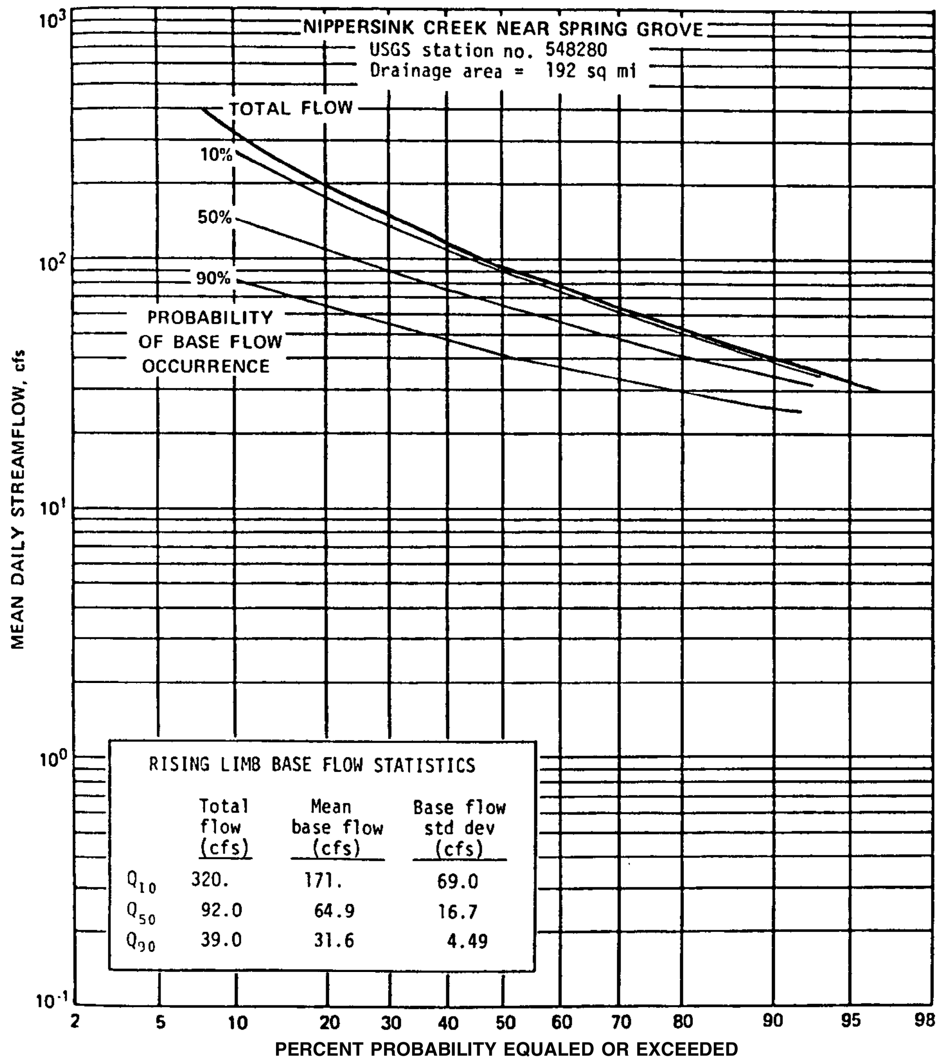
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	83.0	31.1	20.1
Q_{50}	13.0	5.95	3.64
Q_{90}	0.10	0.07	0.03



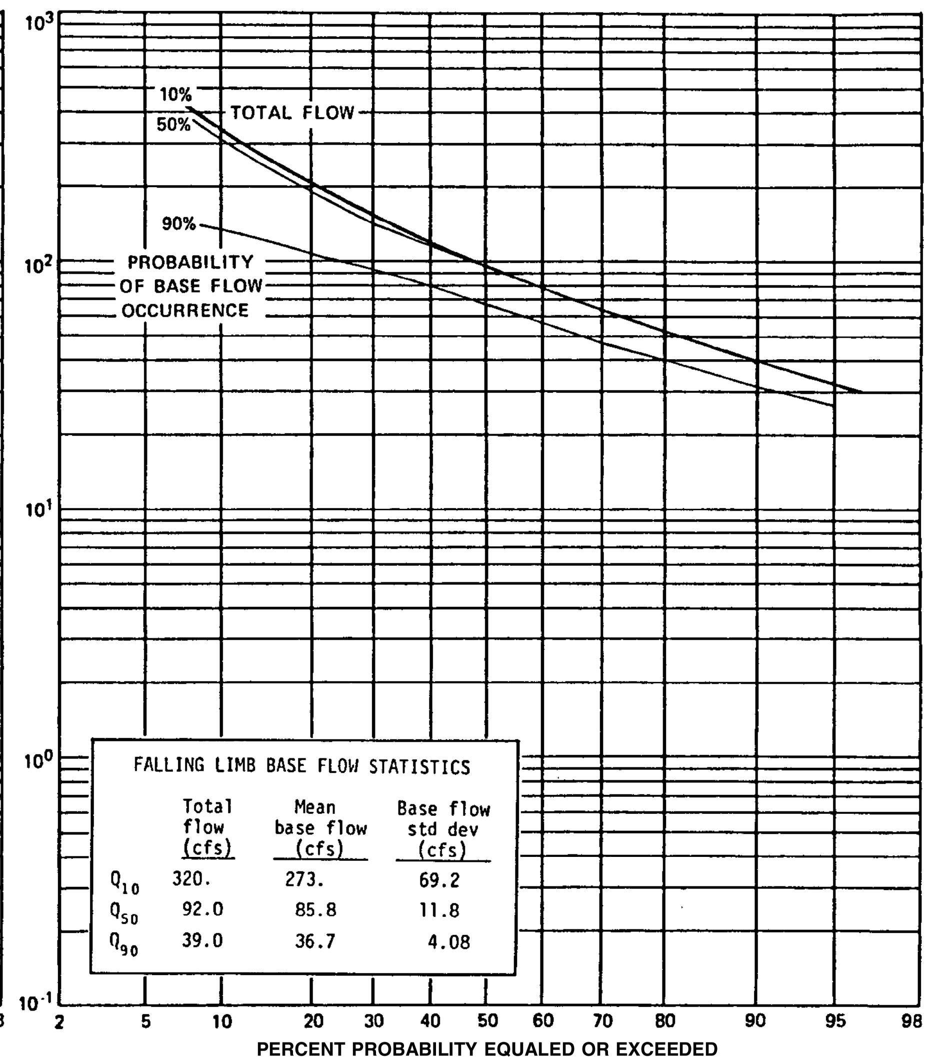
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	83.0	67.7	20.2
Q_{50}	13.0	11.8	2.68
Q_{90}	0.10	0.10	0.01



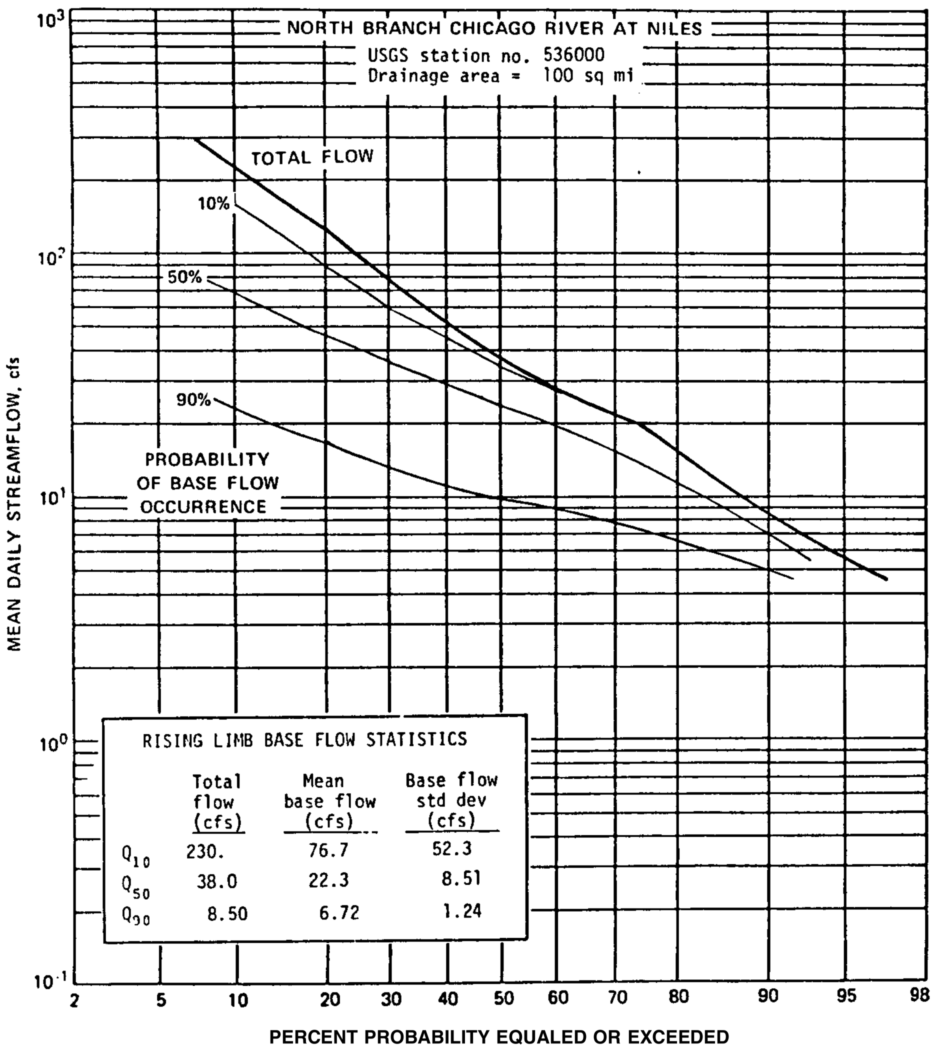
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	320.	171.	69.0
Q_{50}	92.0	64.9	16.7
Q_{90}	39.0	31.6	4.49



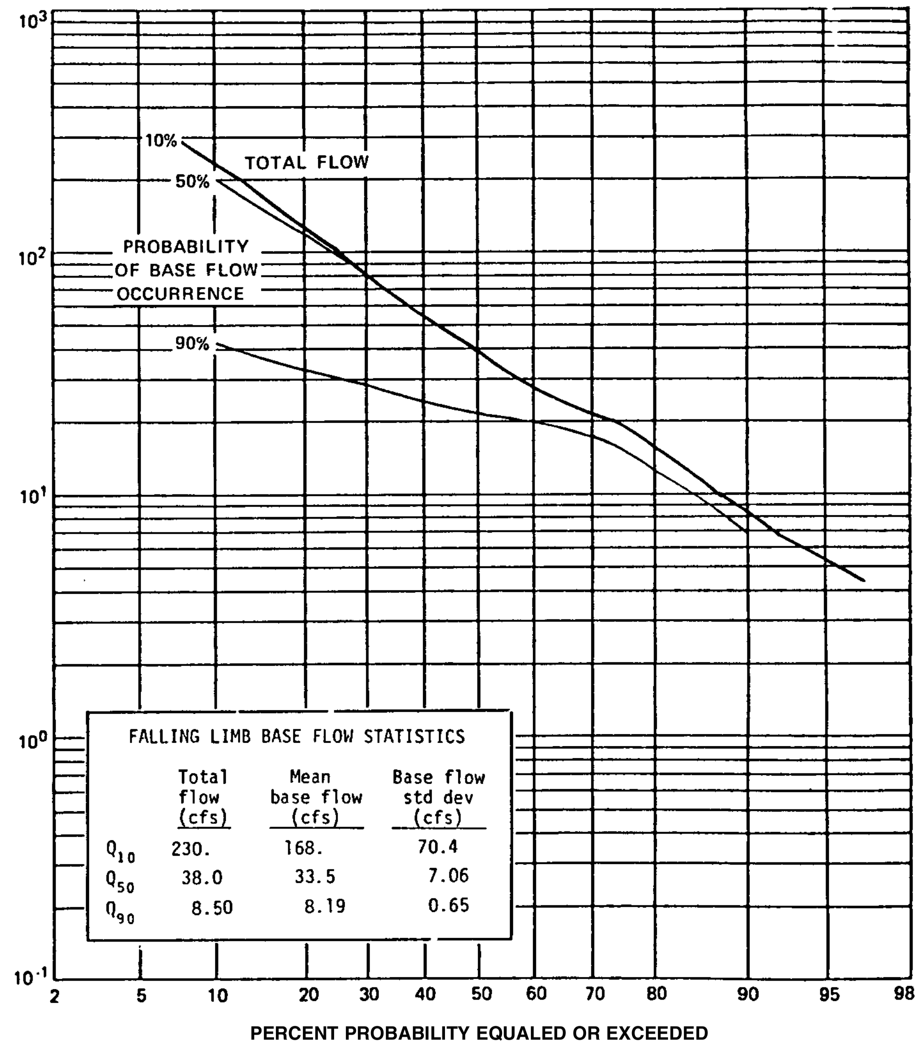
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	320.	273.	69.2
Q_{50}	92.0	85.8	11.8
Q_{90}	39.0	36.7	4.08



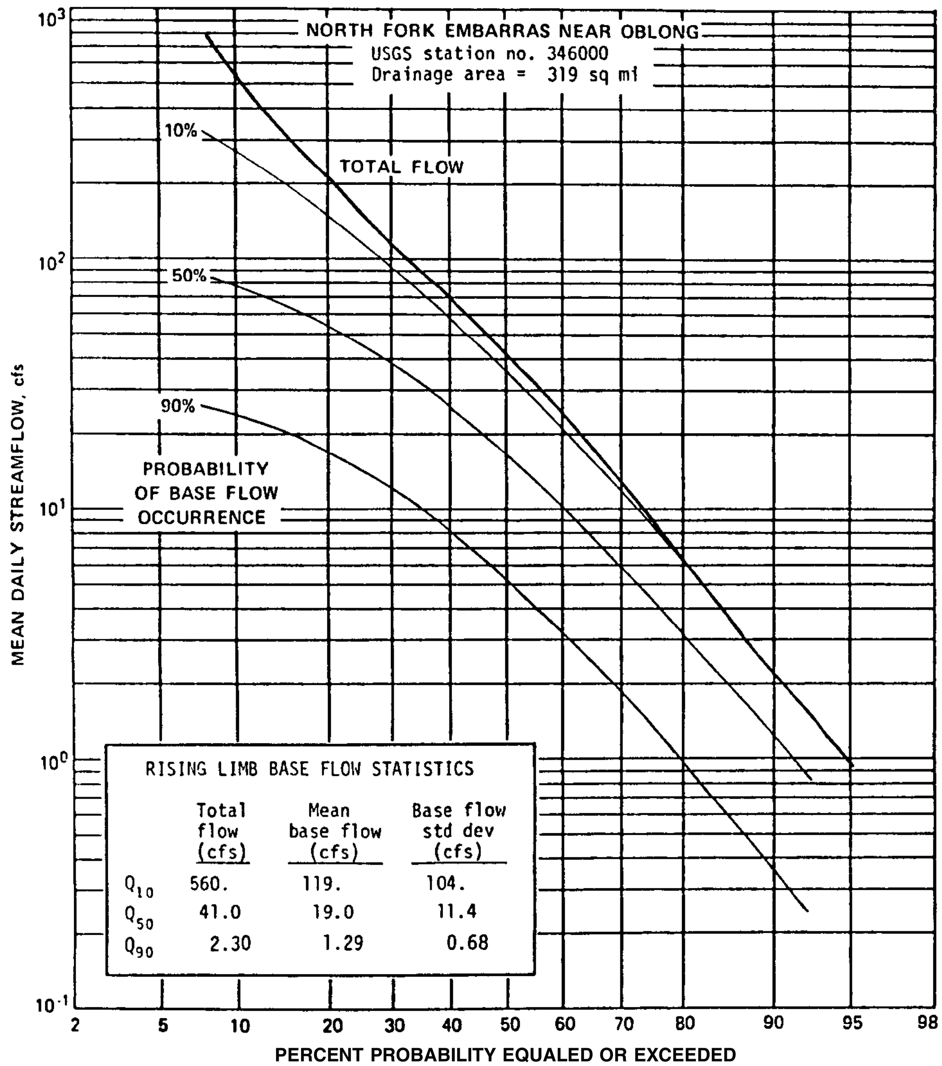
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	230.	76.7	52.3
Q_{50}	38.0	22.3	8.51
Q_{90}	8.50	6.72	1.24



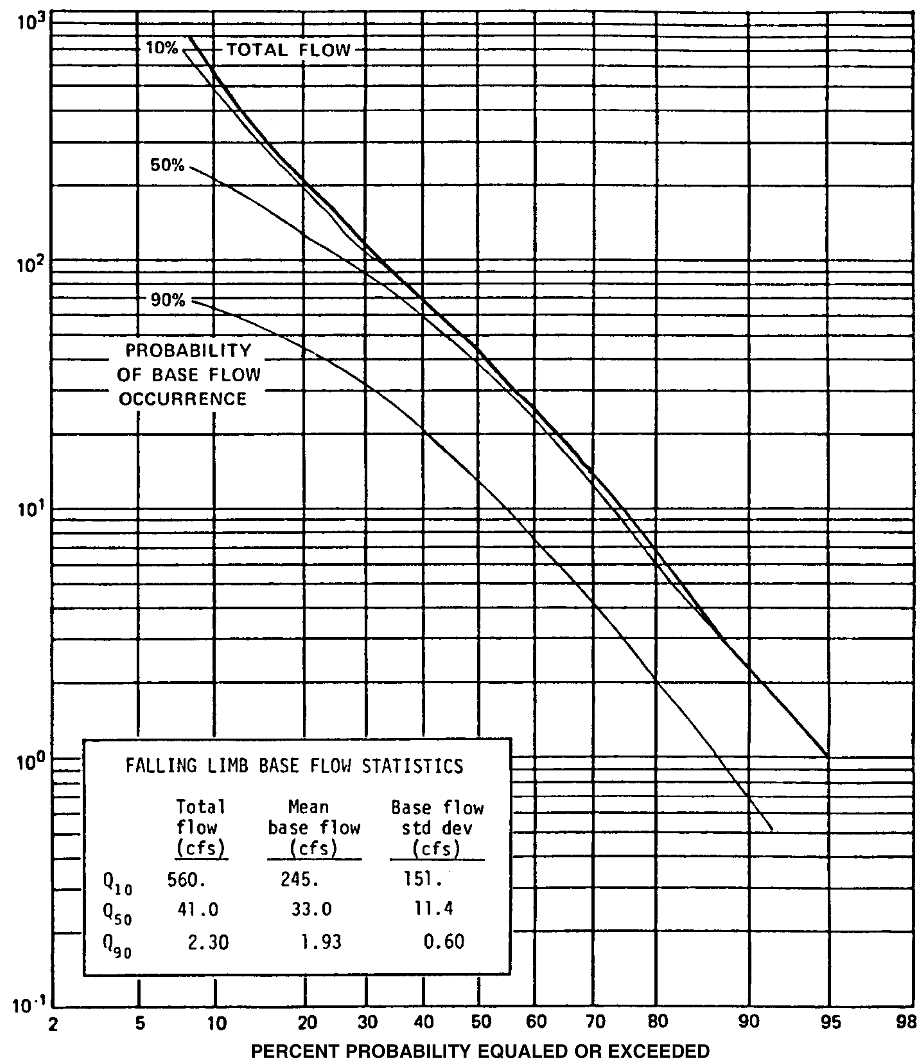
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	230.	168.	70.4
Q_{50}	38.0	33.5	7.06
Q_{90}	8.50	8.19	0.65



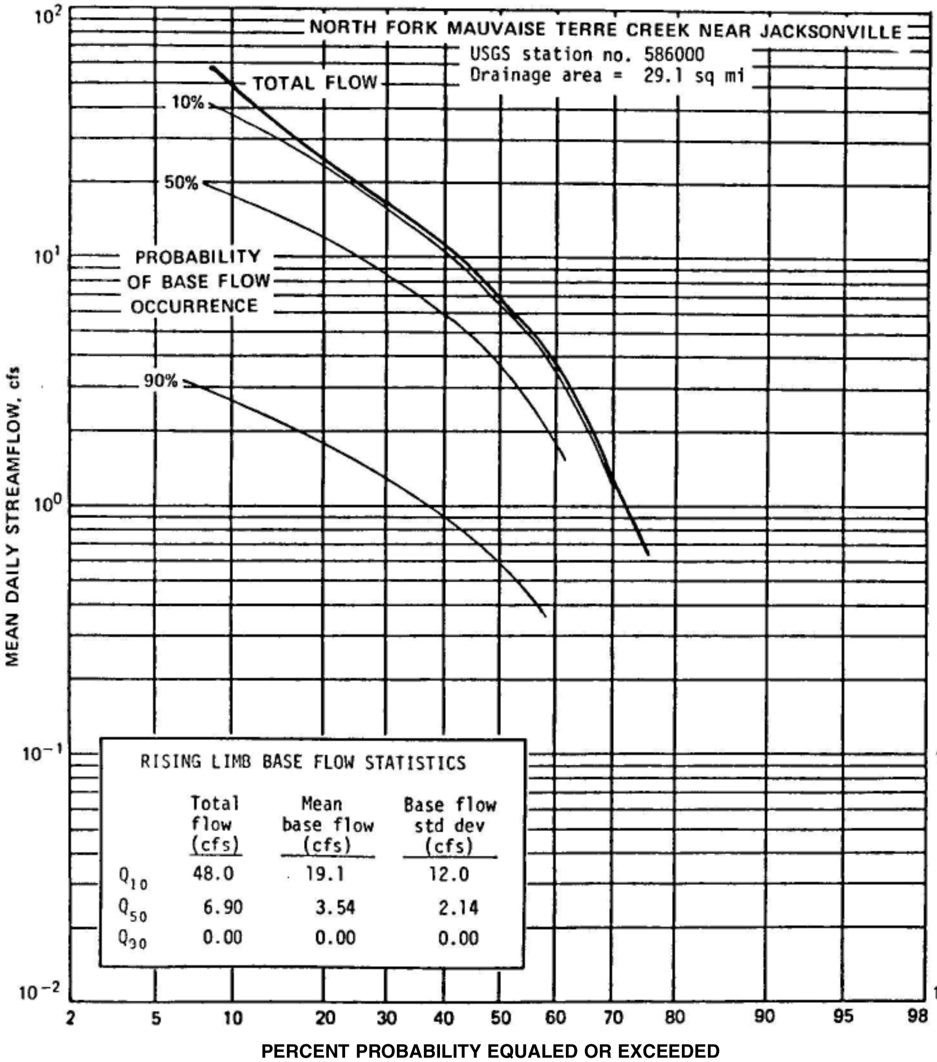
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	560.	119.	104.
Q_{50}	41.0	19.0	11.4
Q_{90}	2.30	1.29	0.68



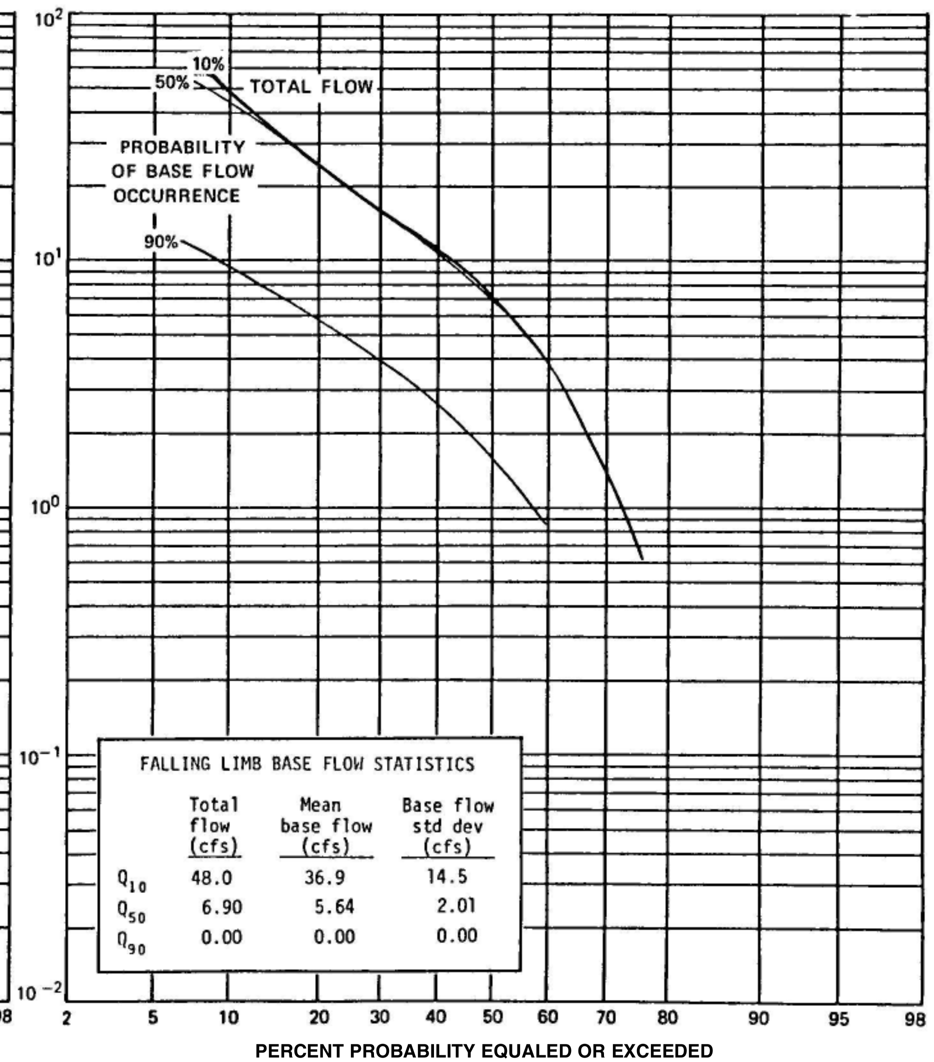
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	560.	245.	151.
Q_{50}	41.0	33.0	11.4
Q_{90}	2.30	1.93	0.60



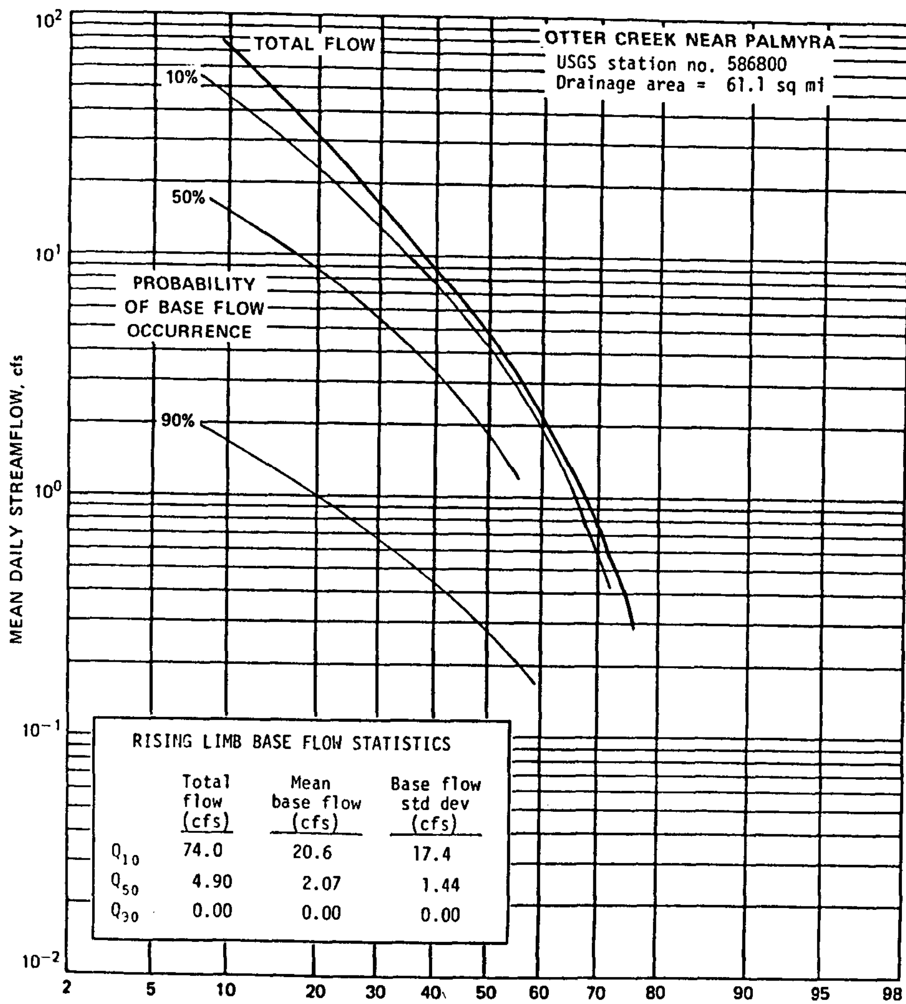
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	48.0	19.1	12.0
Q_{50}	6.90	3.54	2.14
Q_{90}	0.00	0.00	0.00



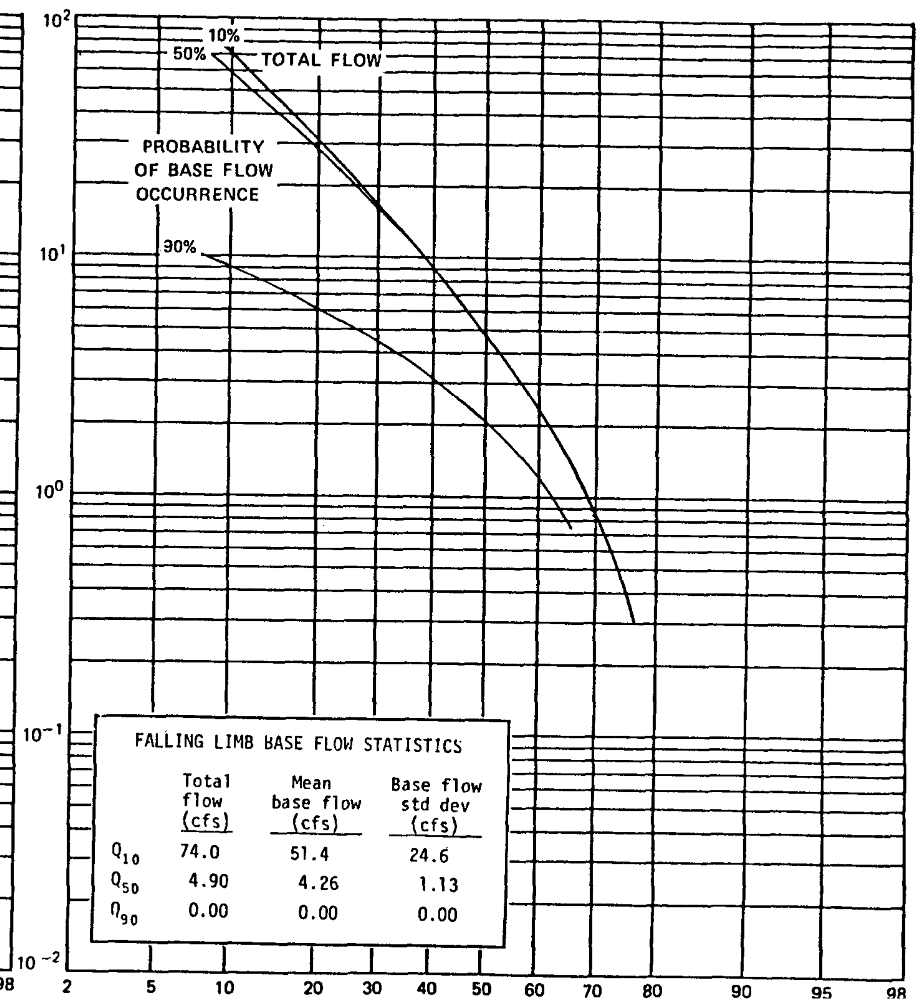
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	48.0	36.9	14.5
Q_{50}	6.90	5.64	2.01
Q_{90}	0.00	0.00	0.00



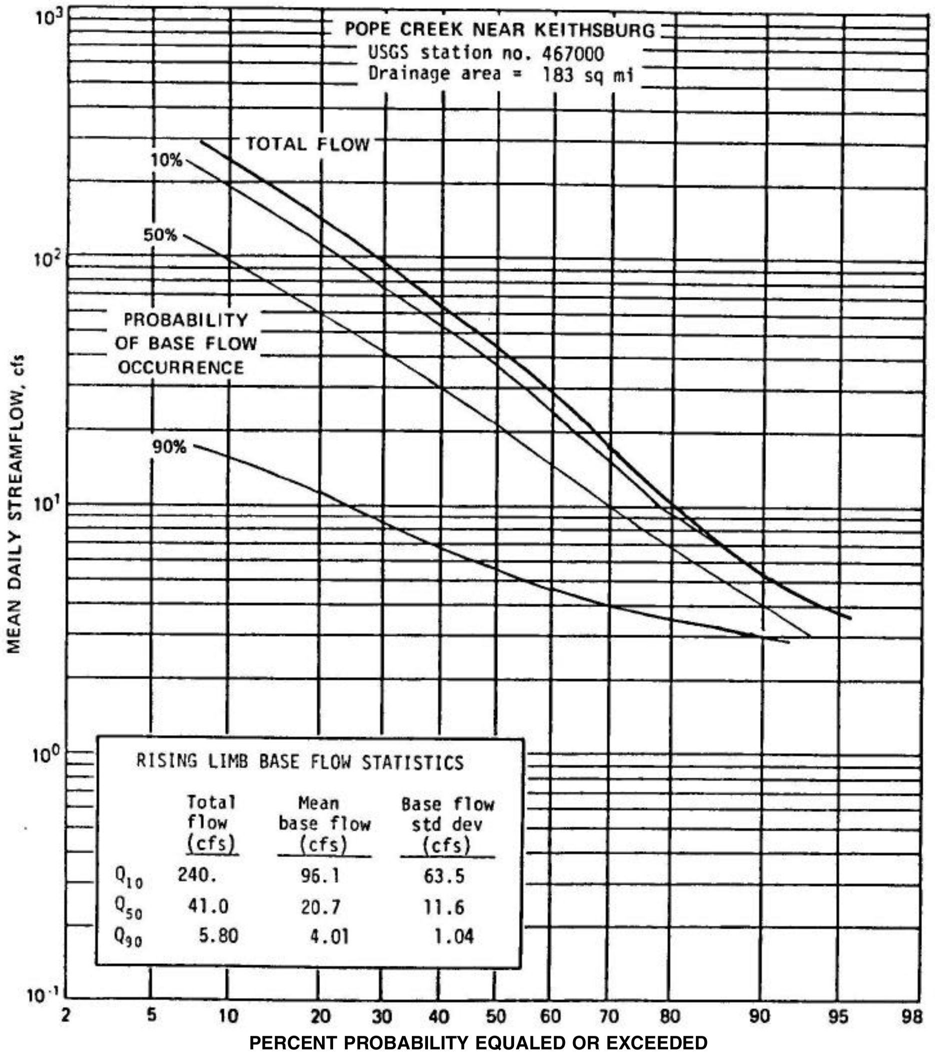
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	74.0	20.6	17.4
Q_{50}	4.90	2.07	1.44
Q_{30}	0.00	0.00	0.00



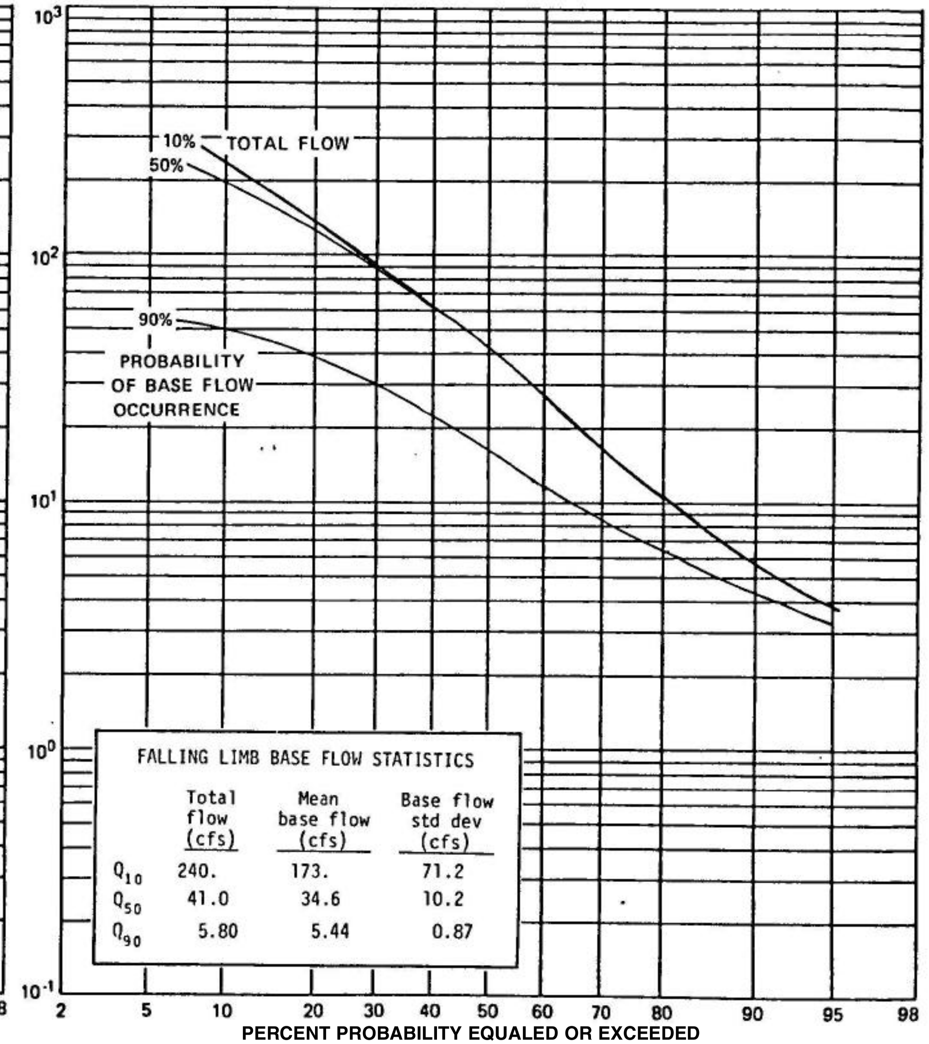
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	74.0	51.4	24.6
Q_{50}	4.90	4.26	1.13
Q_{90}	0.00	0.00	0.00



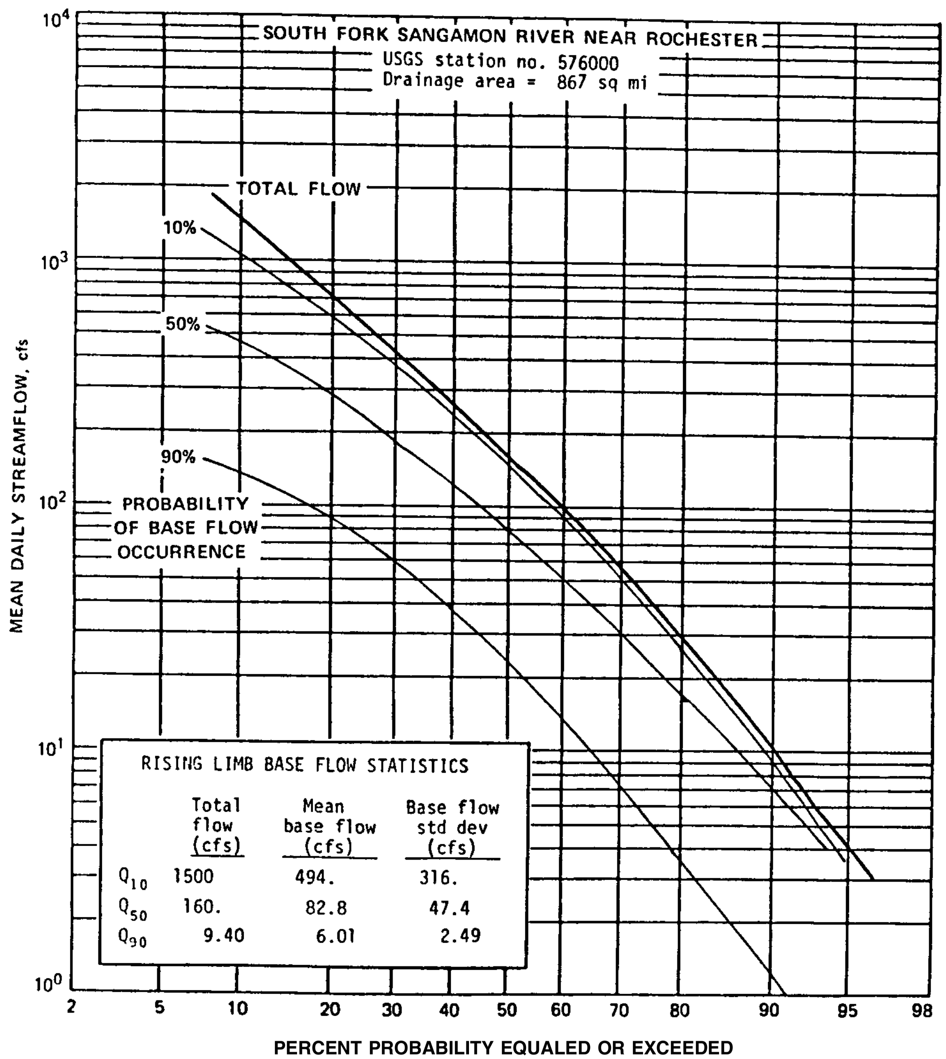
RISING LIMB BASE FLOW STATISTICS

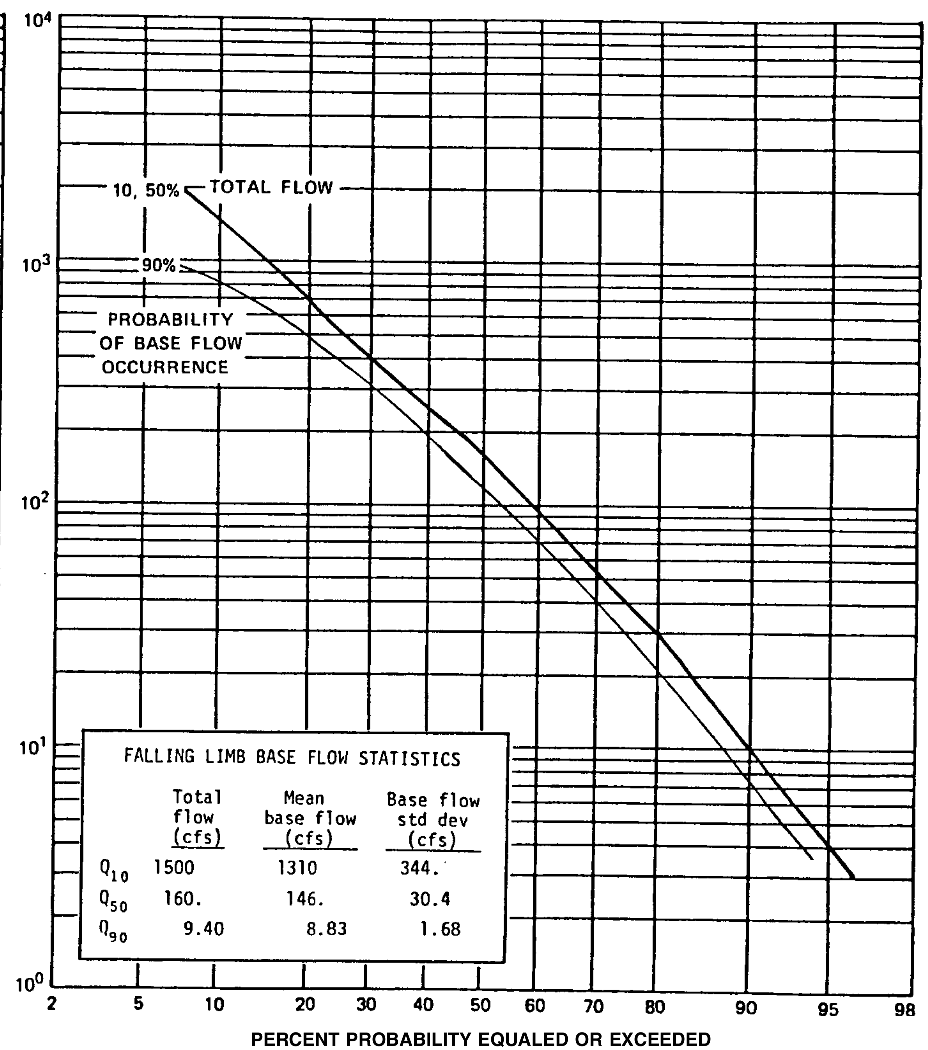
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	240.	96.1	63.5
Q_{50}	41.0	20.7	11.6
Q_{90}	5.80	4.01	1.04

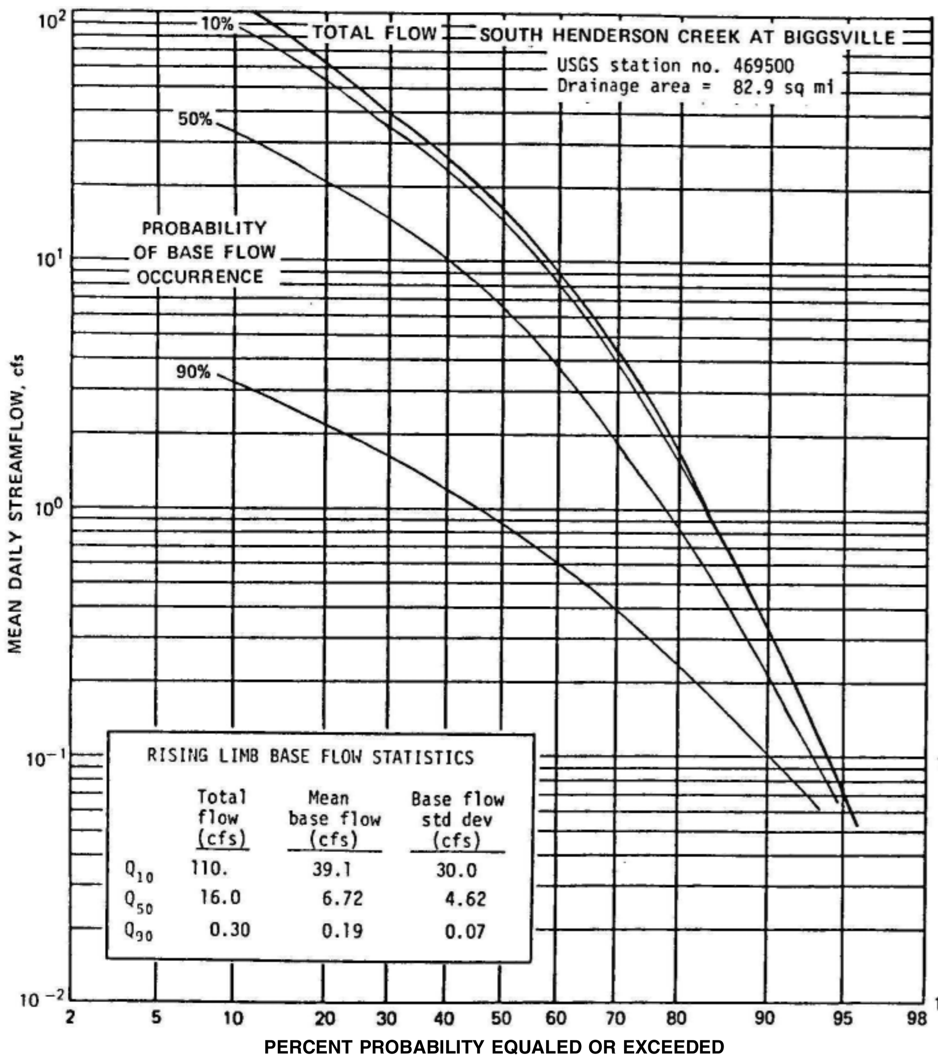


FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	240.	173.	71.2
Q_{50}	41.0	34.6	10.2
Q_{90}	5.80	5.44	0.87

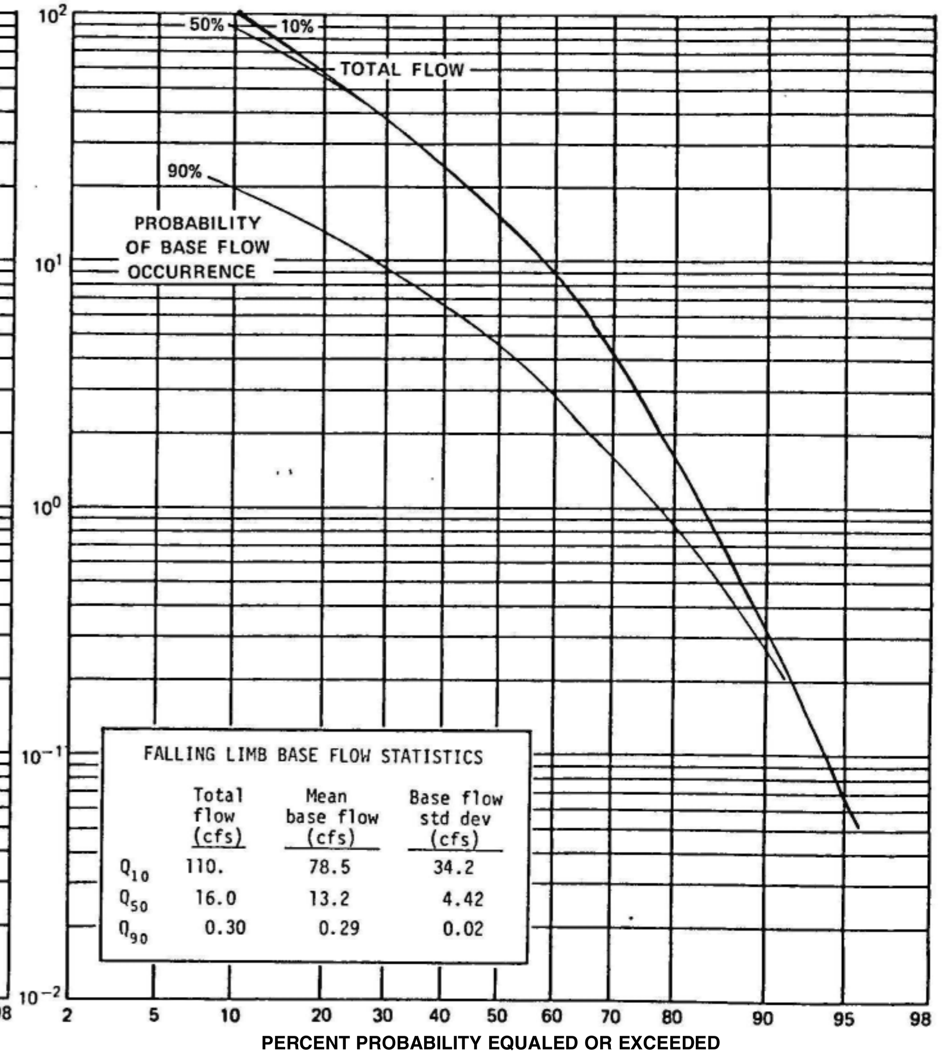

SOUTH FORK SANGAMON RIVER NEAR ROCHESTER
USGS station no. 576000
Drainage area = 867 sq mi
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
MEAN DAILY STREAMFLOW, cfs
PERCENT PROBABILITY EQUALED OR EXCEEDED
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 1500 494. 316.
Q50 160. 82.8 47.4
Q90 9.40 6.01 2.49


10, 50%
TOTAL FLOW
90%
PROBABILITY OF BASE FLOW OCCURRENCE
PERCENT PROBABILITY EQUALED OR EXCEEDED
FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 1500 1310 344.
Q50 160. 146. 30.4
Q90 9.40 8.83 1.68



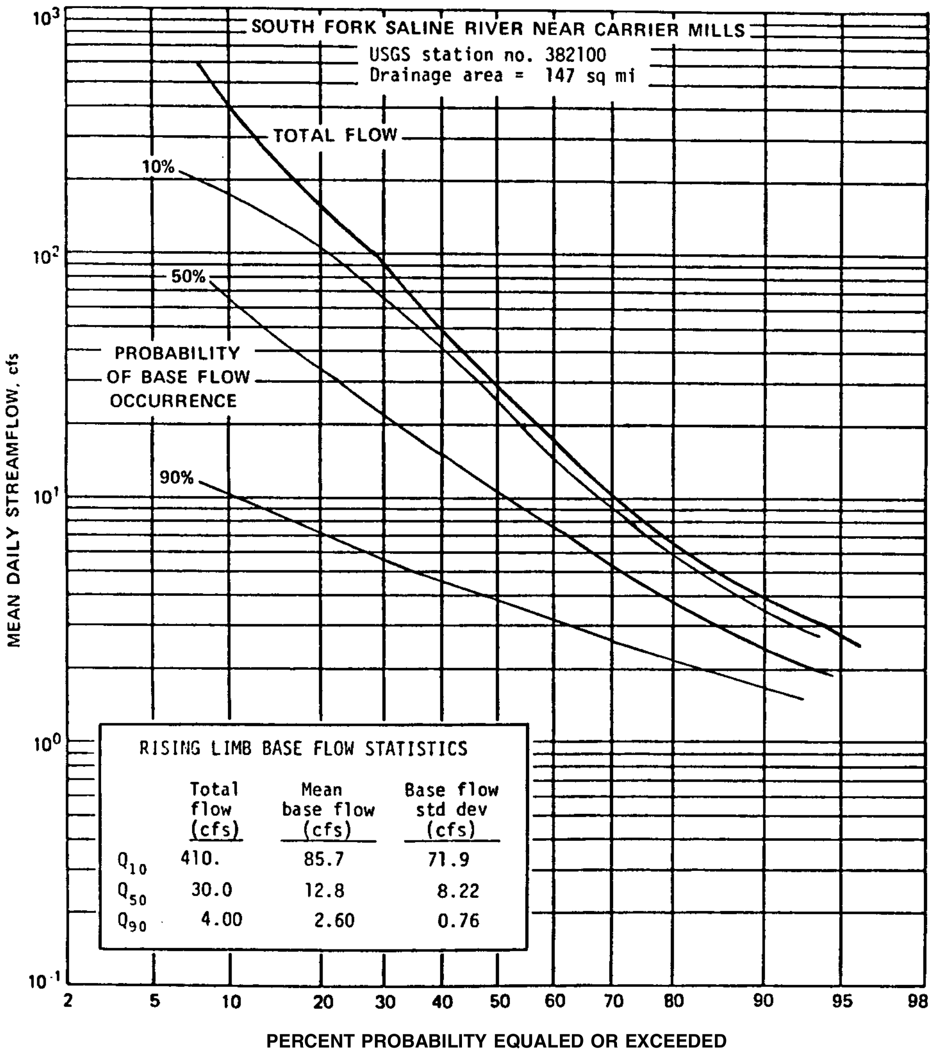
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	110.	39.1	30.0
Q_{50}	16.0	6.72	4.62
Q_{90}	0.30	0.19	0.07



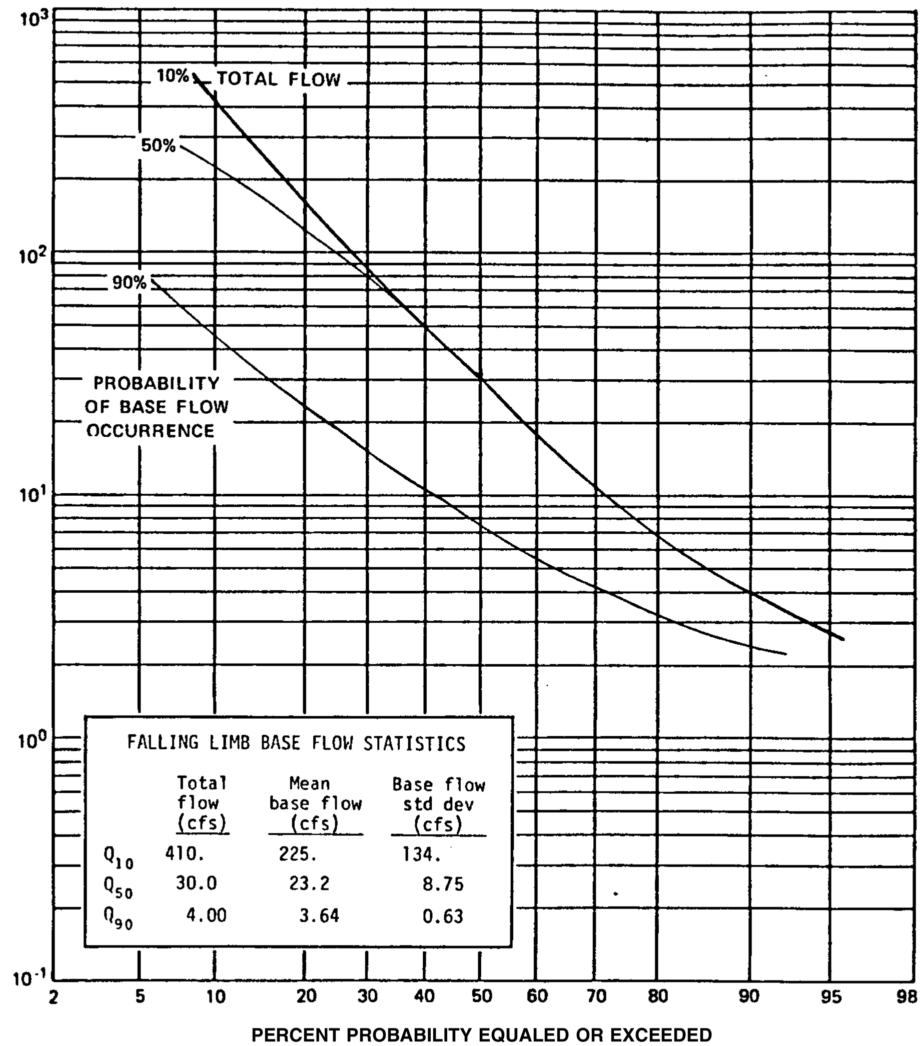
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	110.	78.5	34.2
Q_{50}	16.0	13.2	4.42
Q_{90}	0.30	0.29	0.02



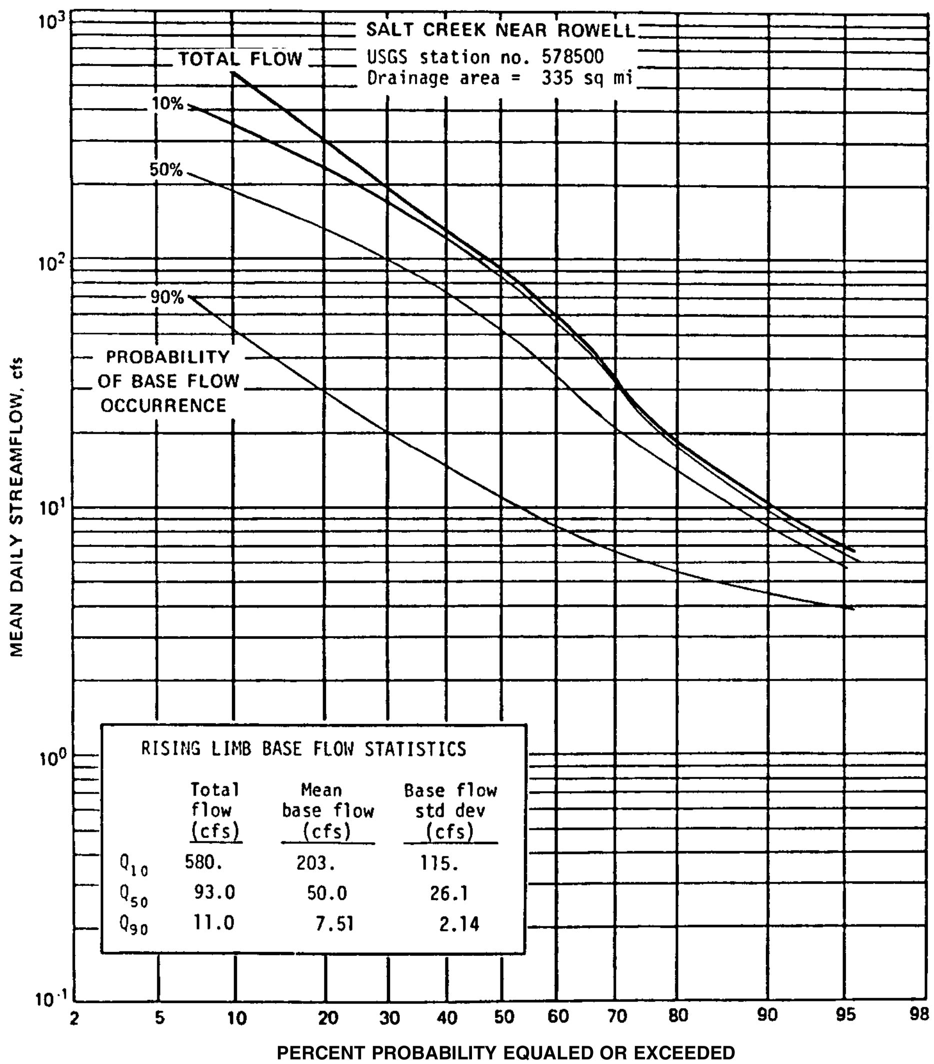
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	410.	85.7	71.9
Q_{50}	30.0	12.8	8.22
Q_{90}	4.00	2.60	0.76



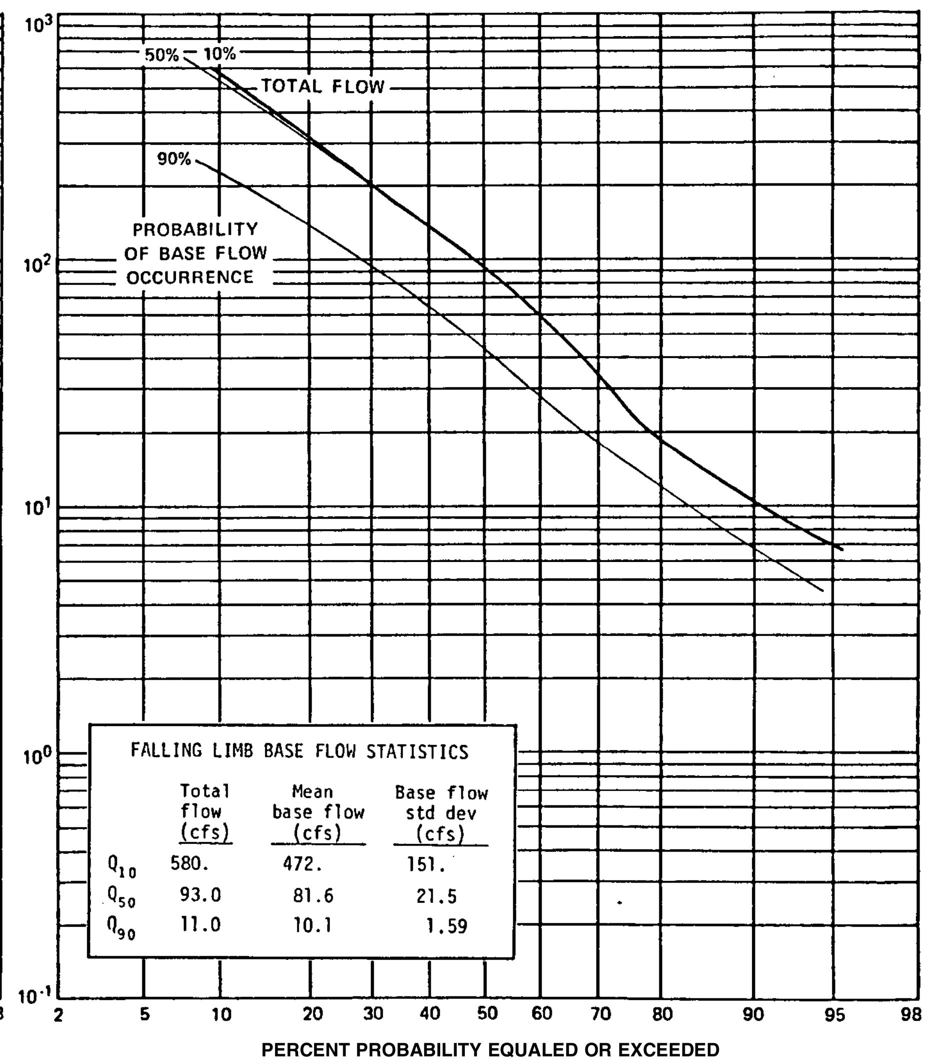
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	410.	225.	134.
Q_{50}	30.0	23.2	8.75
Q_{90}	4.00	3.64	0.63



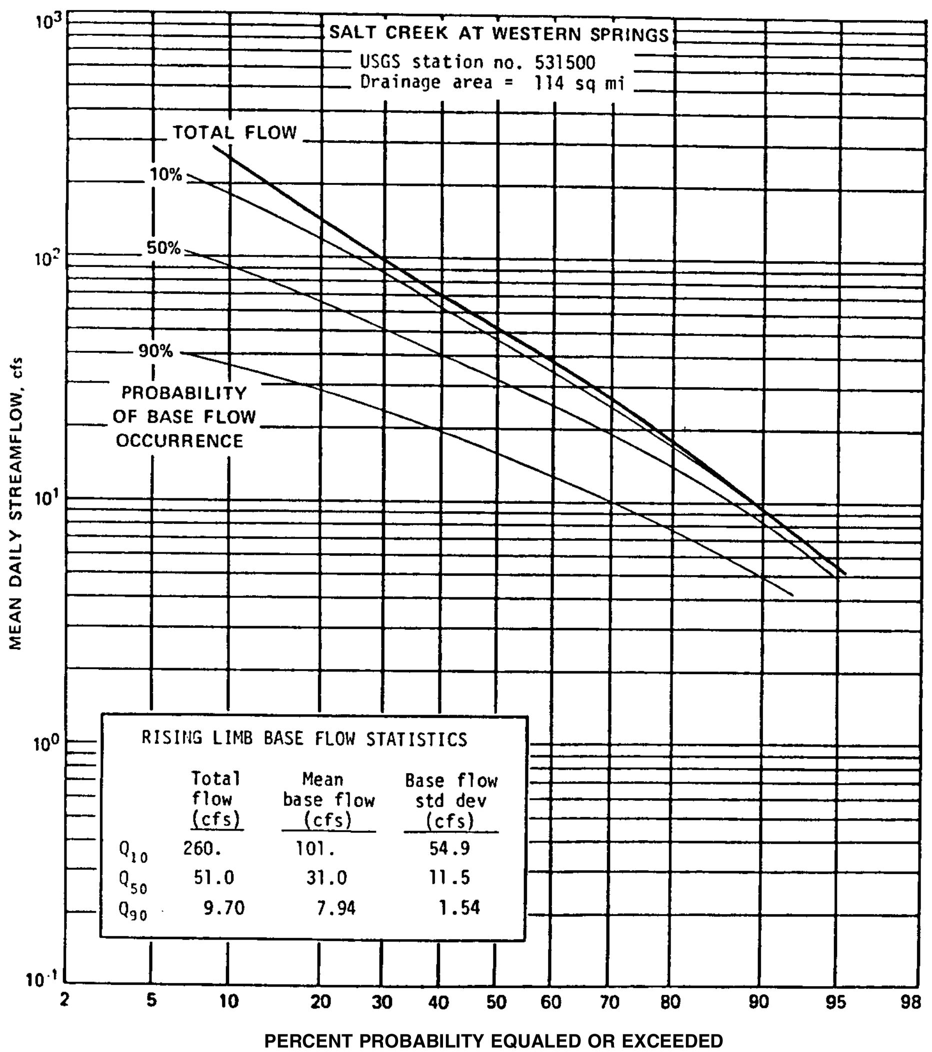
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	580.	203.	115.
Q_{50}	93.0	50.0	26.1
Q_{90}	11.0	7.51	2.14



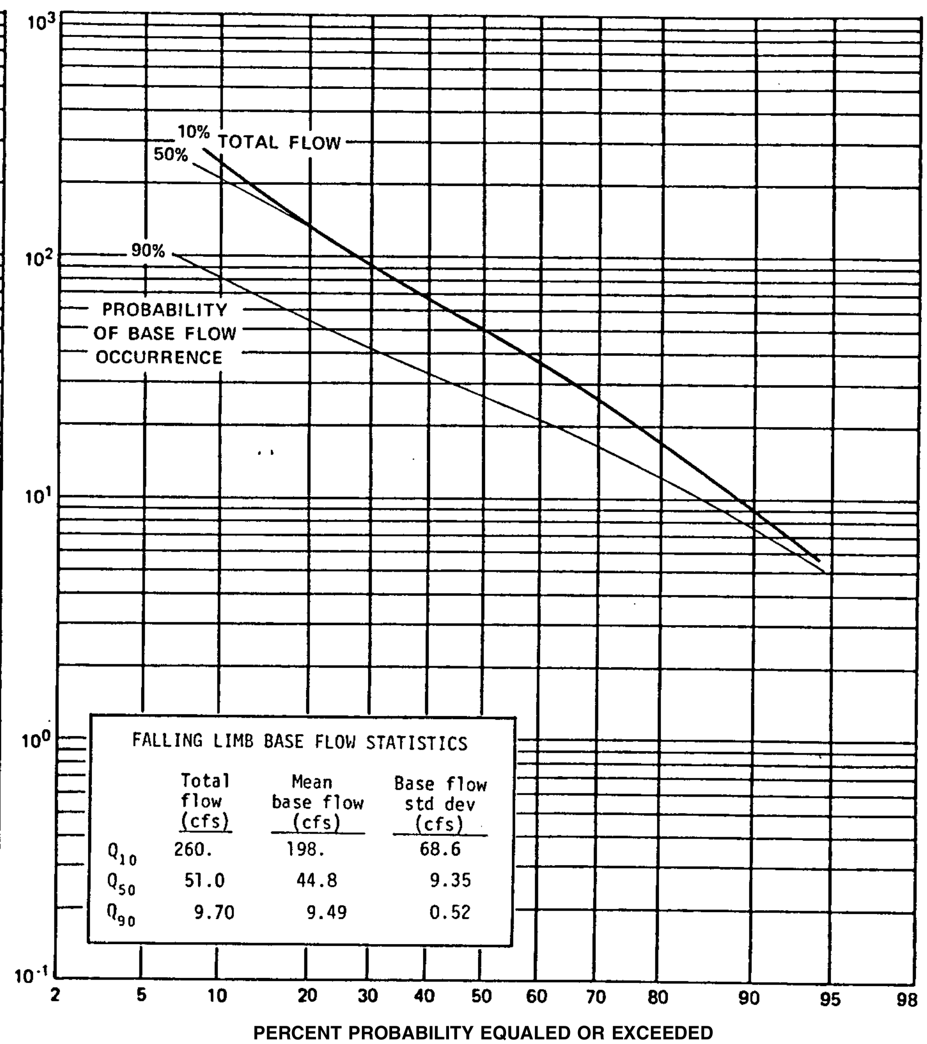
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	580.	472.	151.
Q_{50}	93.0	81.6	21.5
Q_{90}	11.0	10.1	1.59



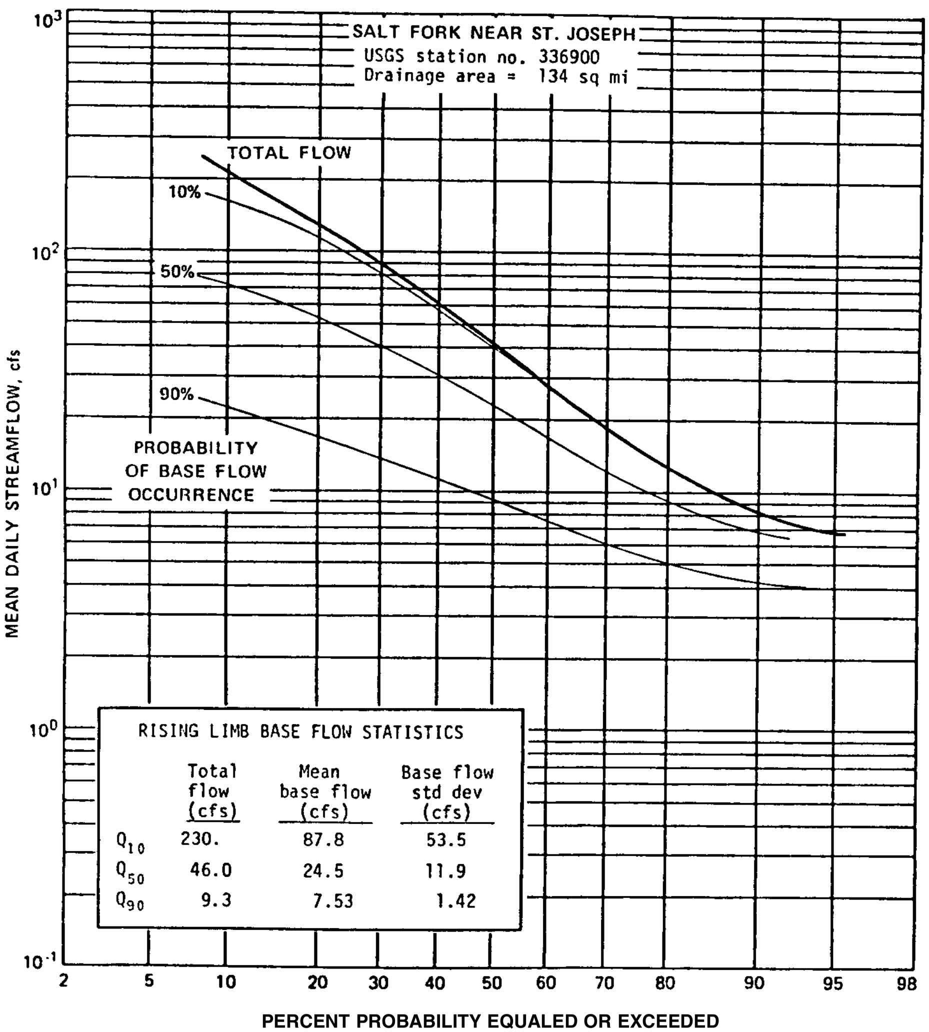
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	260.	101.	54.9
Q_{50}	51.0	31.0	11.5
Q_{90}	9.70	7.94	1.54



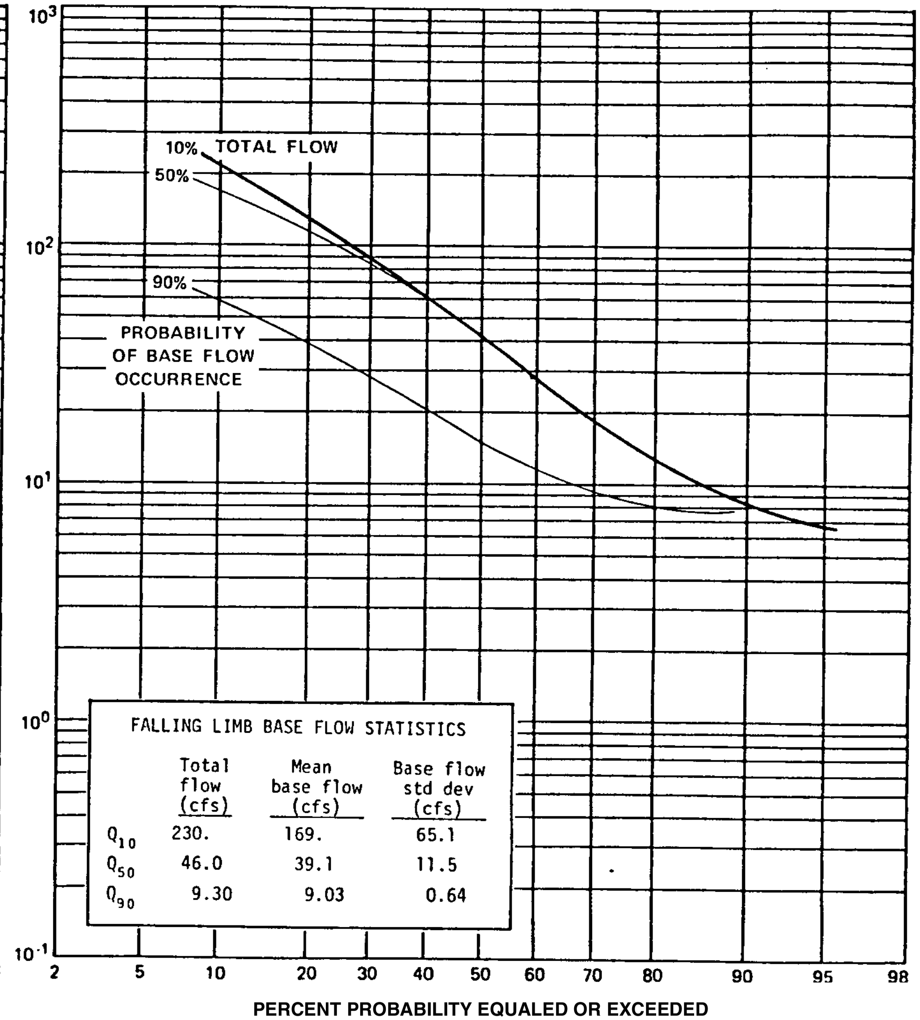
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	260.	198.	68.6
Q_{50}	51.0	44.8	9.35
Q_{90}	9.70	9.49	0.52



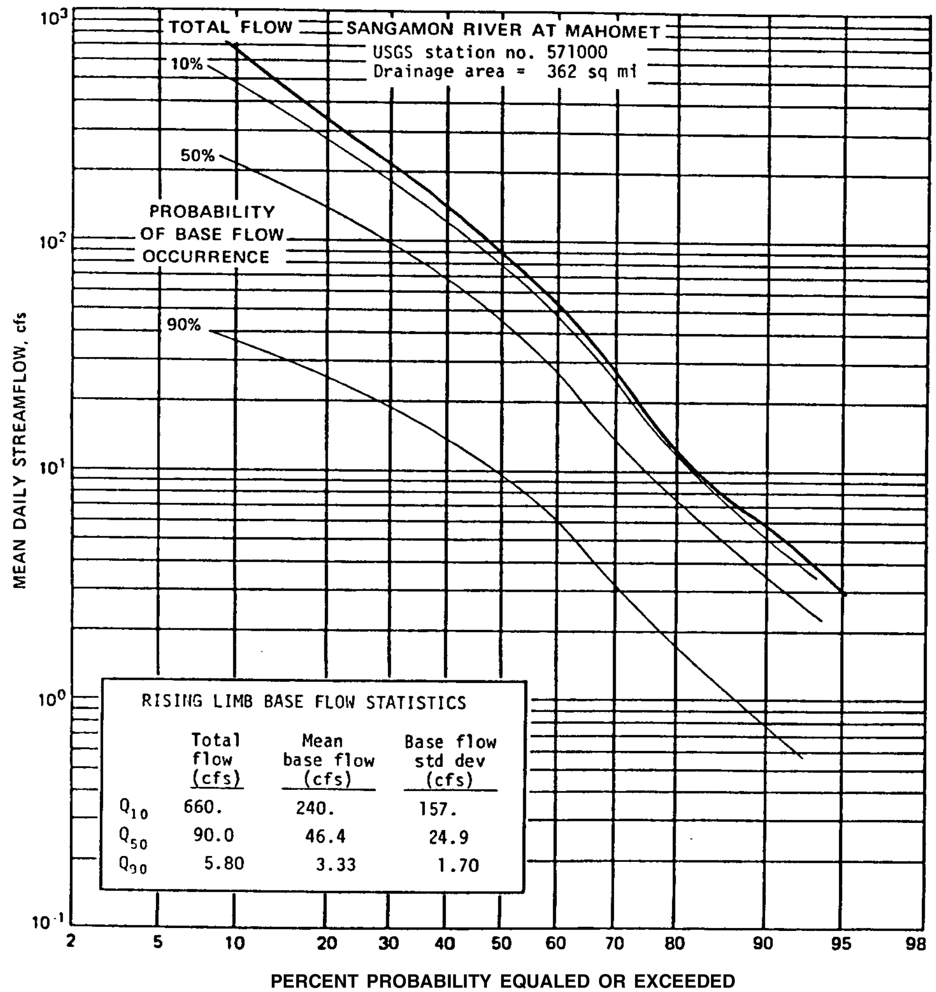
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	230.	87.8	53.5
Q_{50}	46.0	24.5	11.9
Q_{90}	9.3	7.53	1.42



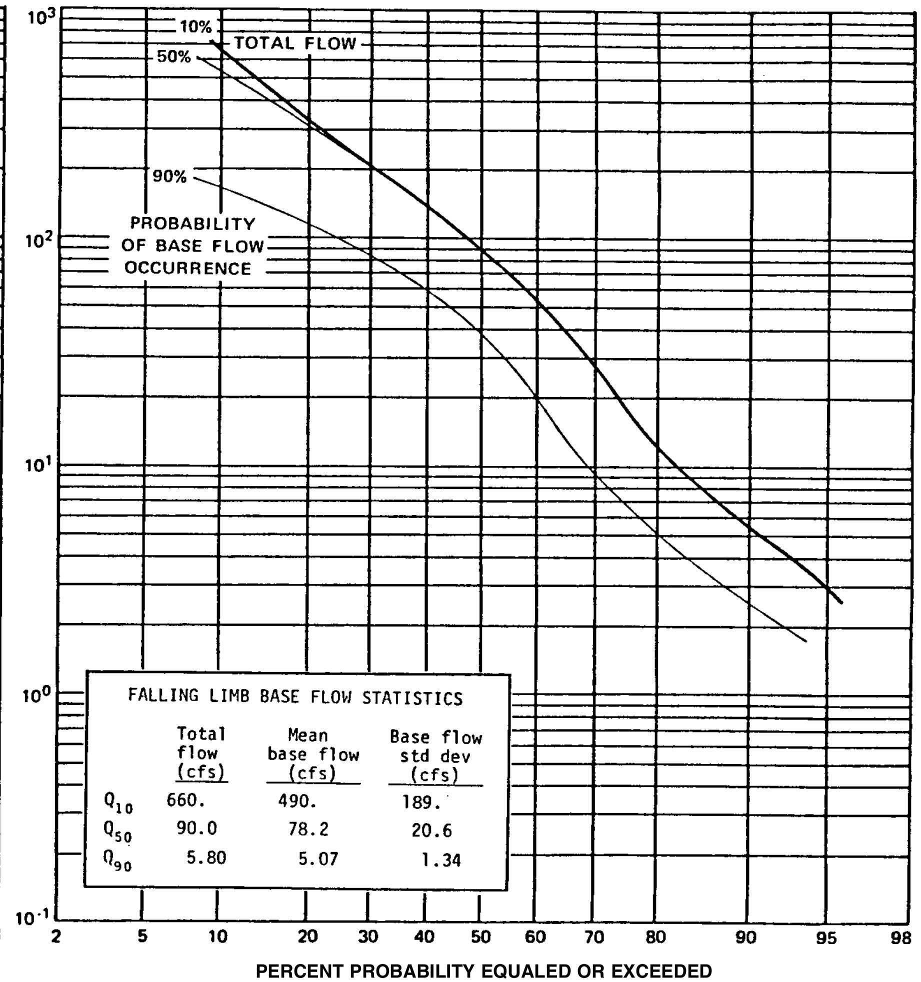
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	230.	169.	65.1
Q_{50}	46.0	39.1	11.5
Q_{90}	9.30	9.03	0.64



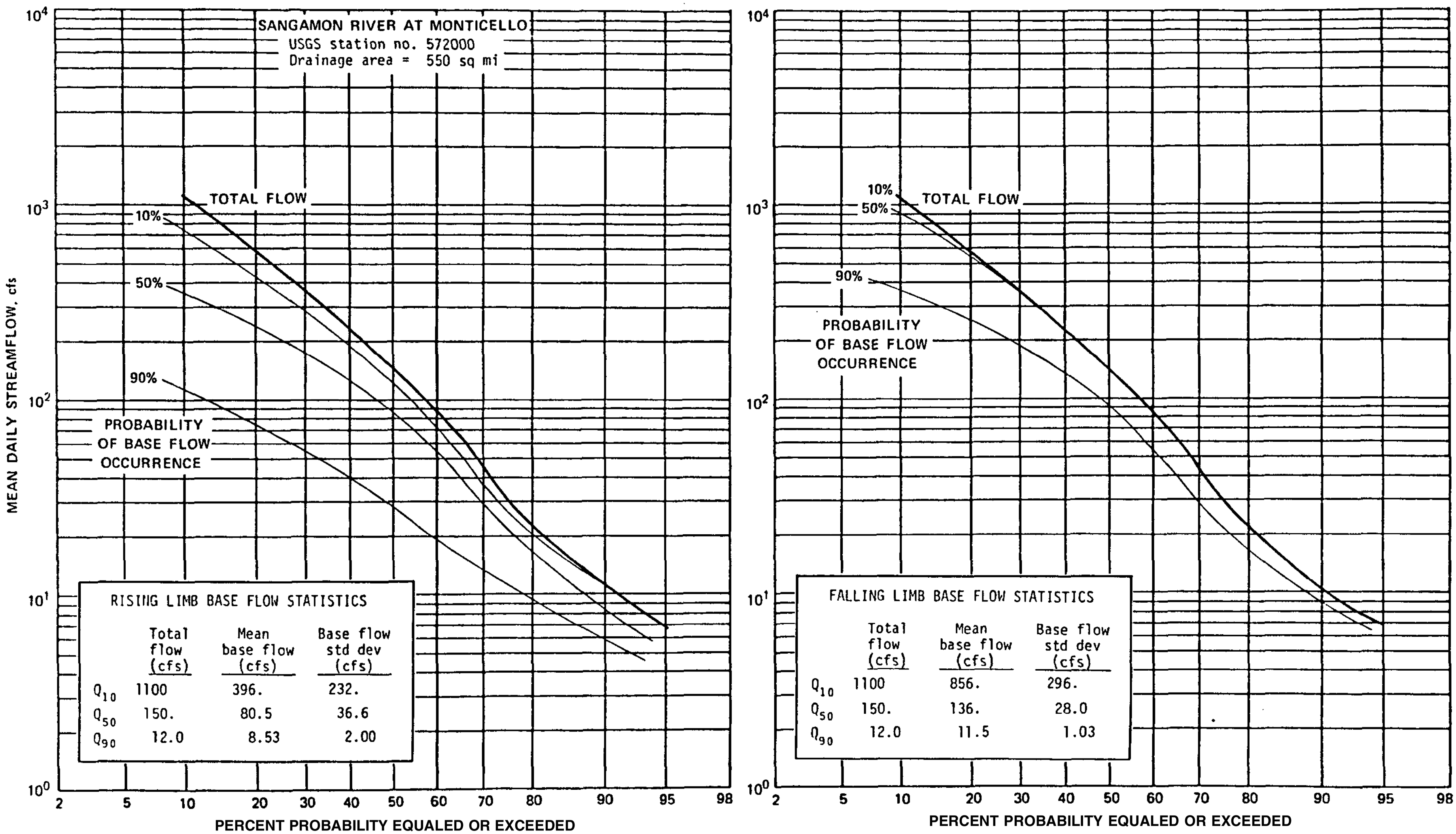
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	660.	240.	157.
Q_{50}	90.0	46.4	24.9
Q_{90}	5.80	3.33	1.70



FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	660.	490.	189.
Q_{50}	90.0	78.2	20.6
Q_{90}	5.80	5.07	1.34

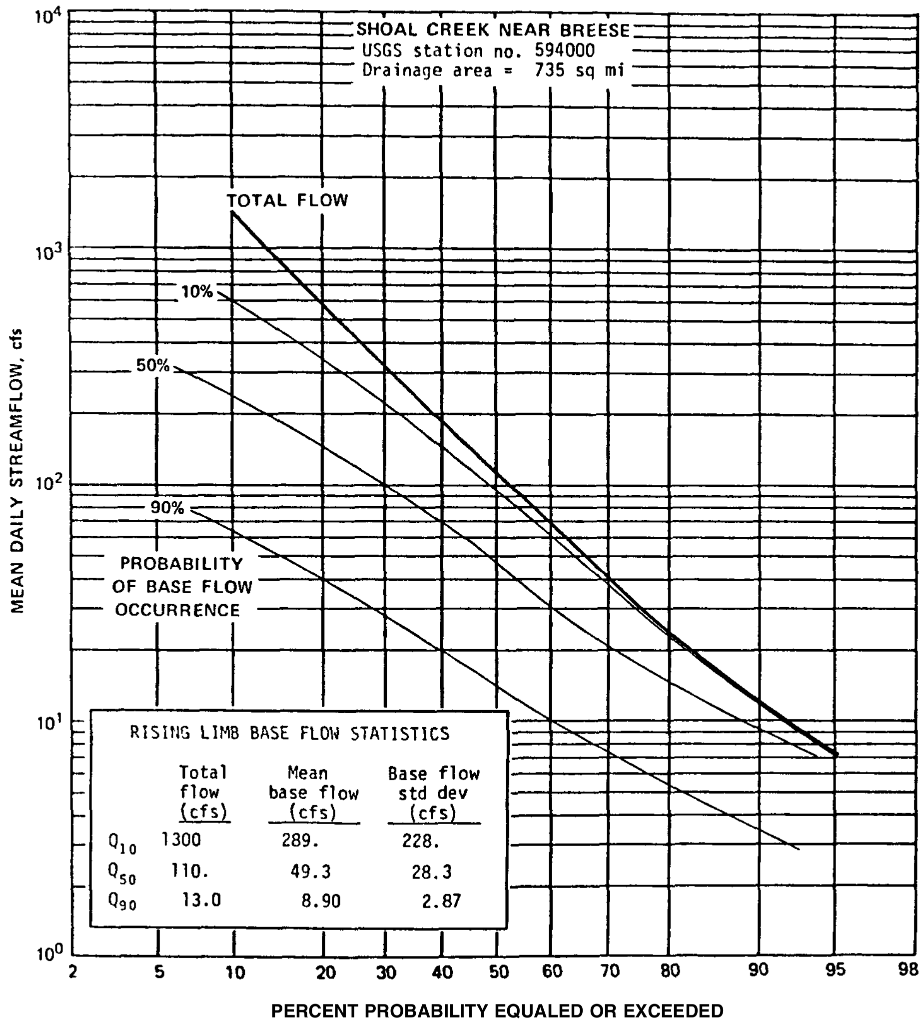


RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1100	396.	232.
Q_{50}	150.	80.5	36.6
Q_{90}	12.0	8.53	2.00

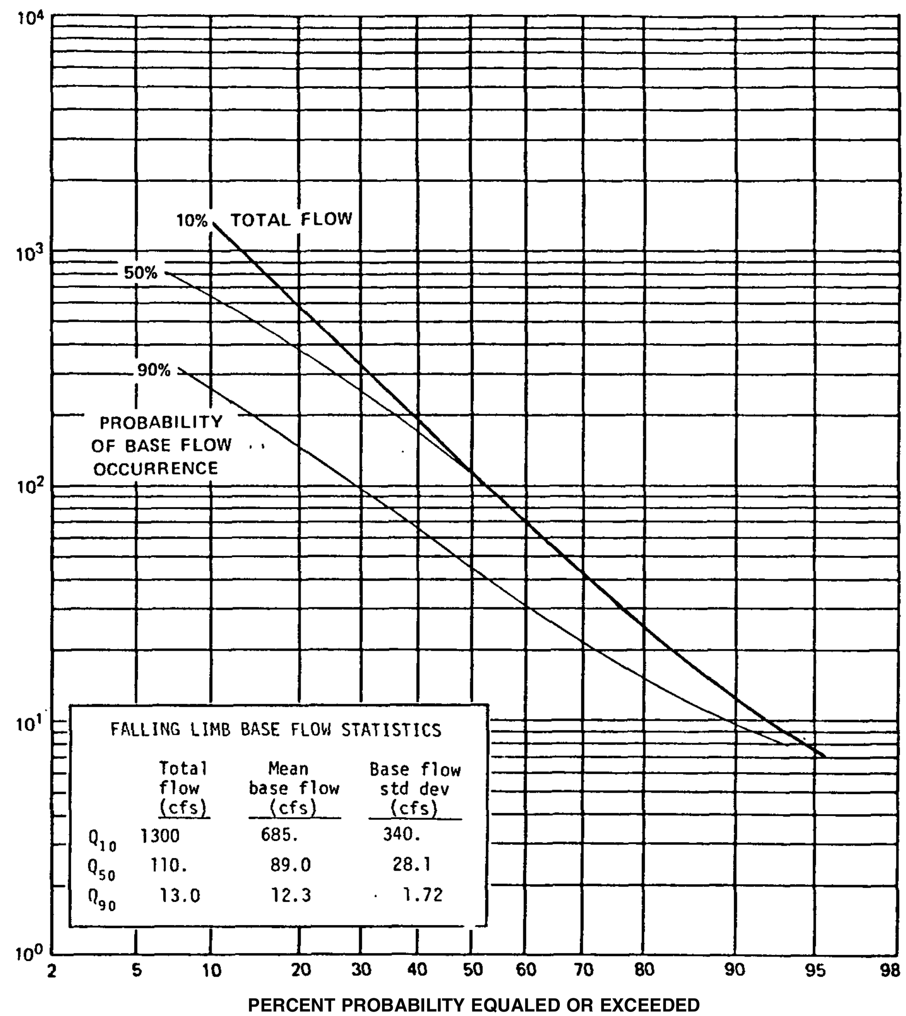
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1100	856.	296.
Q_{50}	150.	136.	28.0
Q_{90}	12.0	11.5	1.03



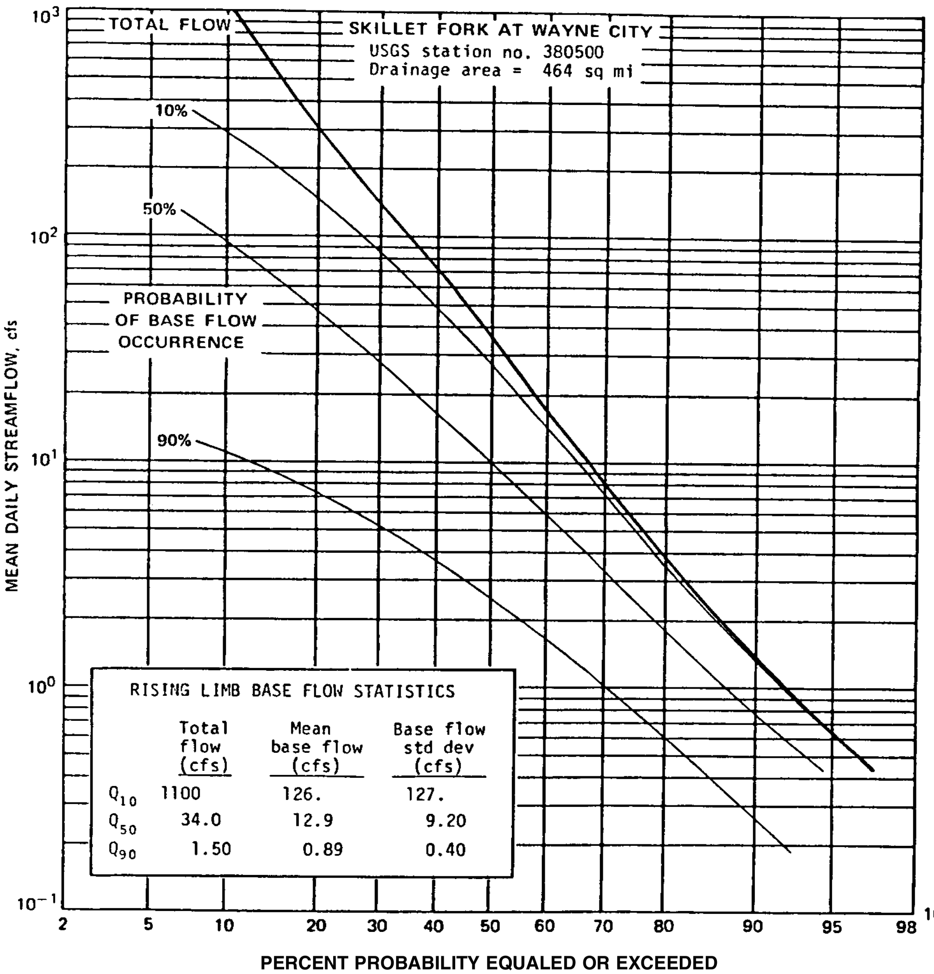
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1300	289.	228.
Q_{50}	110.	49.3	28.3
Q_{90}	13.0	8.90	2.87

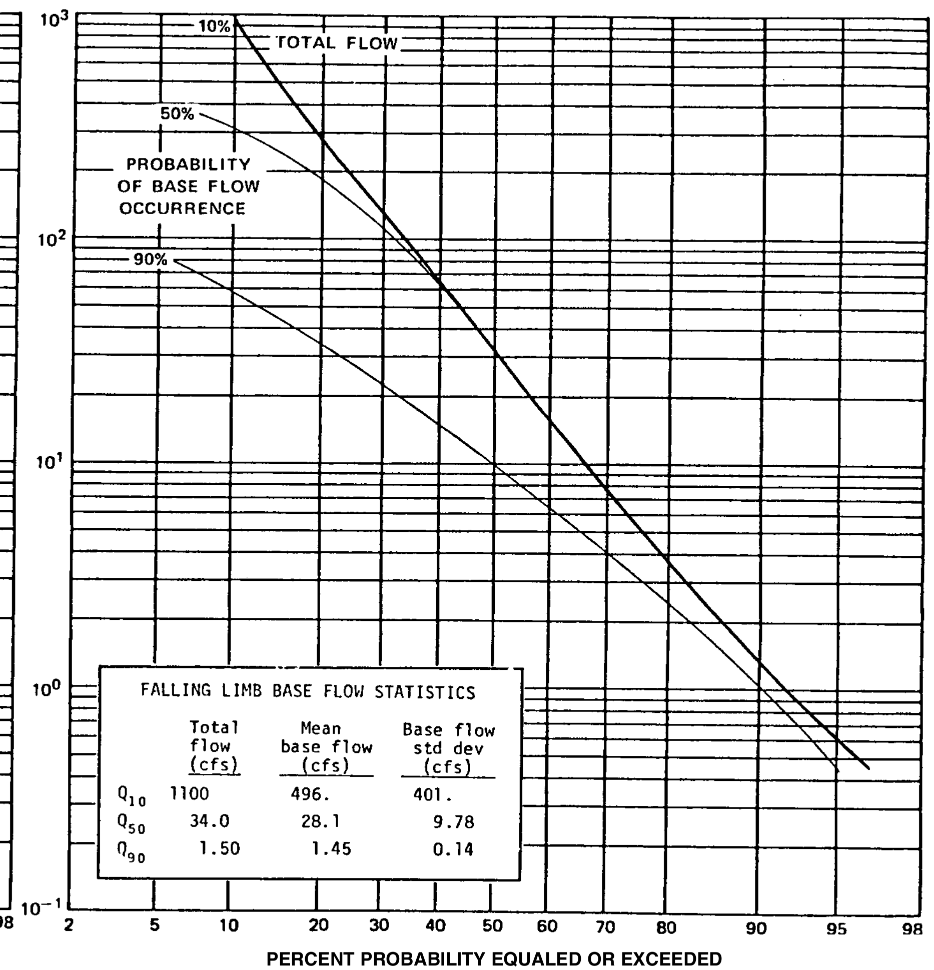


FALLING LIMB BASE FLOW STATISTICS

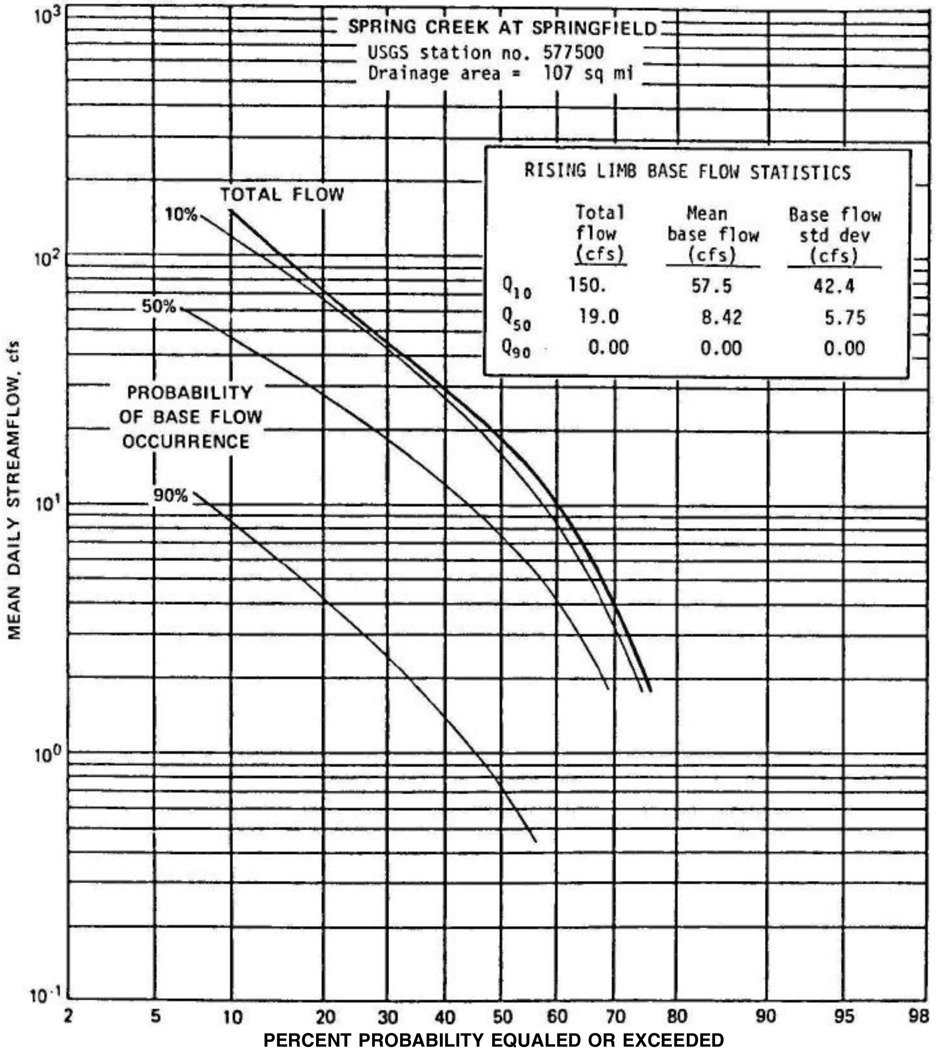
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1300	685.	340.
Q_{50}	110.	89.0	28.1
Q_{90}	13.0	12.3	1.72

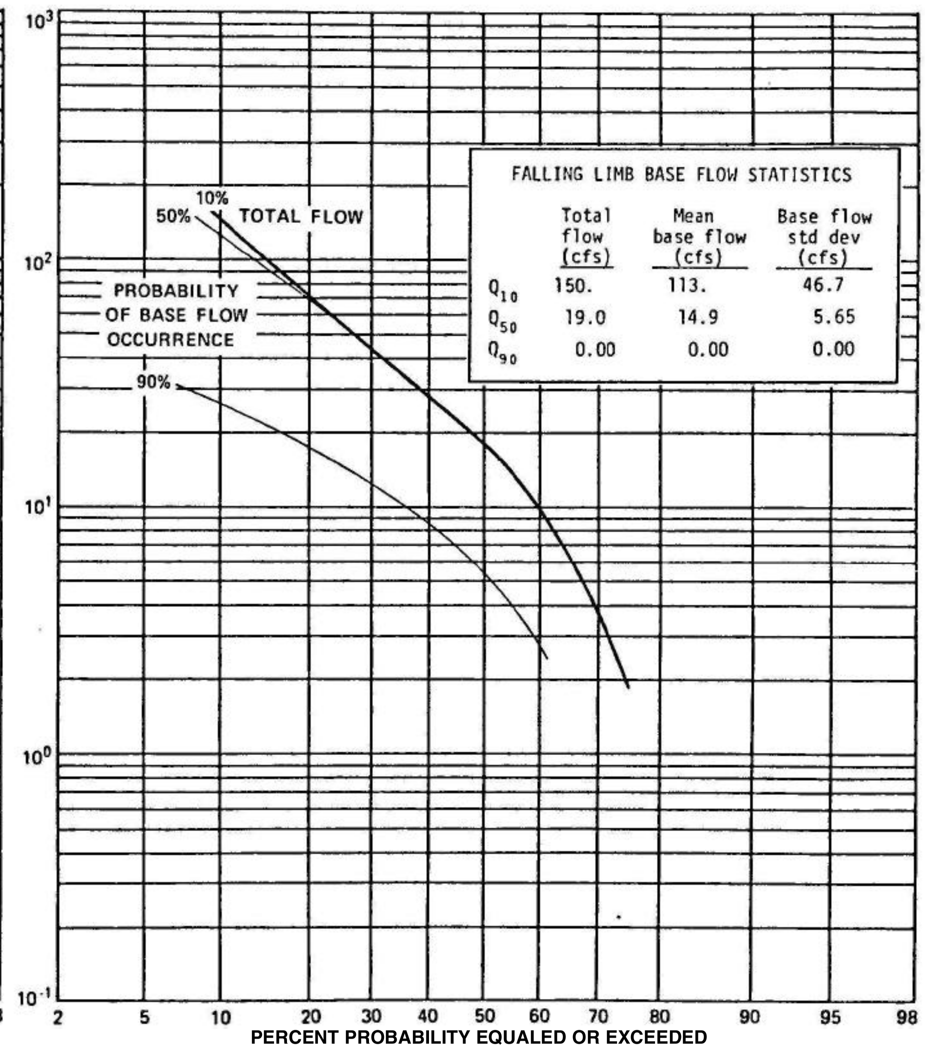


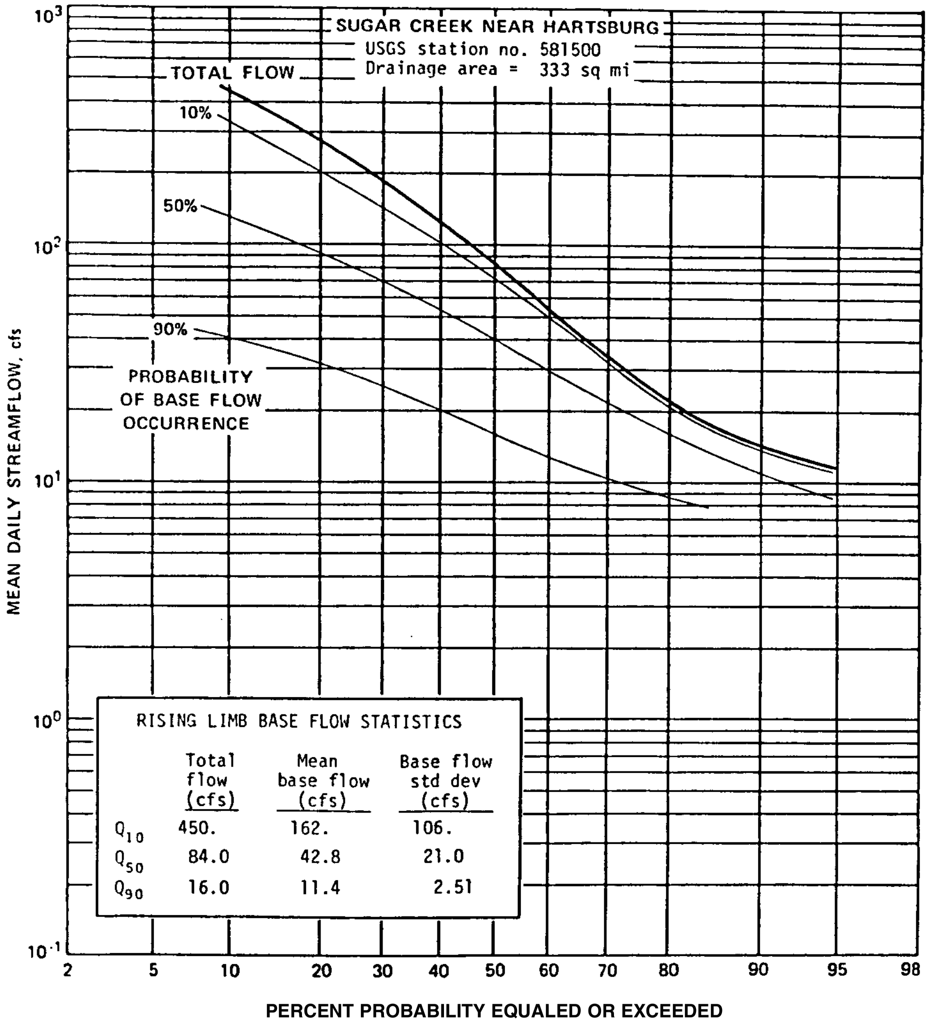
SKILLET FORK AT WAYNE CITY
USGS station no. 380500
Drainage area = 464 sq mi
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs)
Mean base flow (cfs)
Base flow std dev (cfs)
Q10 1100 126. 127.
Q50 34.0 12.9 9.20
Q90 1.50 0.89 0.40
MEAN DAILY STREAMFLOW, cfs
PERCENT PROBABILITY EQUALED OR EXCEEDED



TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs)
Mean base flow (cfs)
Base flow std dev (cfs)
Q10 1100 496. 401.
Q50 34.0 28.1 9.78
Q90 1.50 1.45 0.14
PERCENT PROBABILITY EQUALED OR EXCEEDED

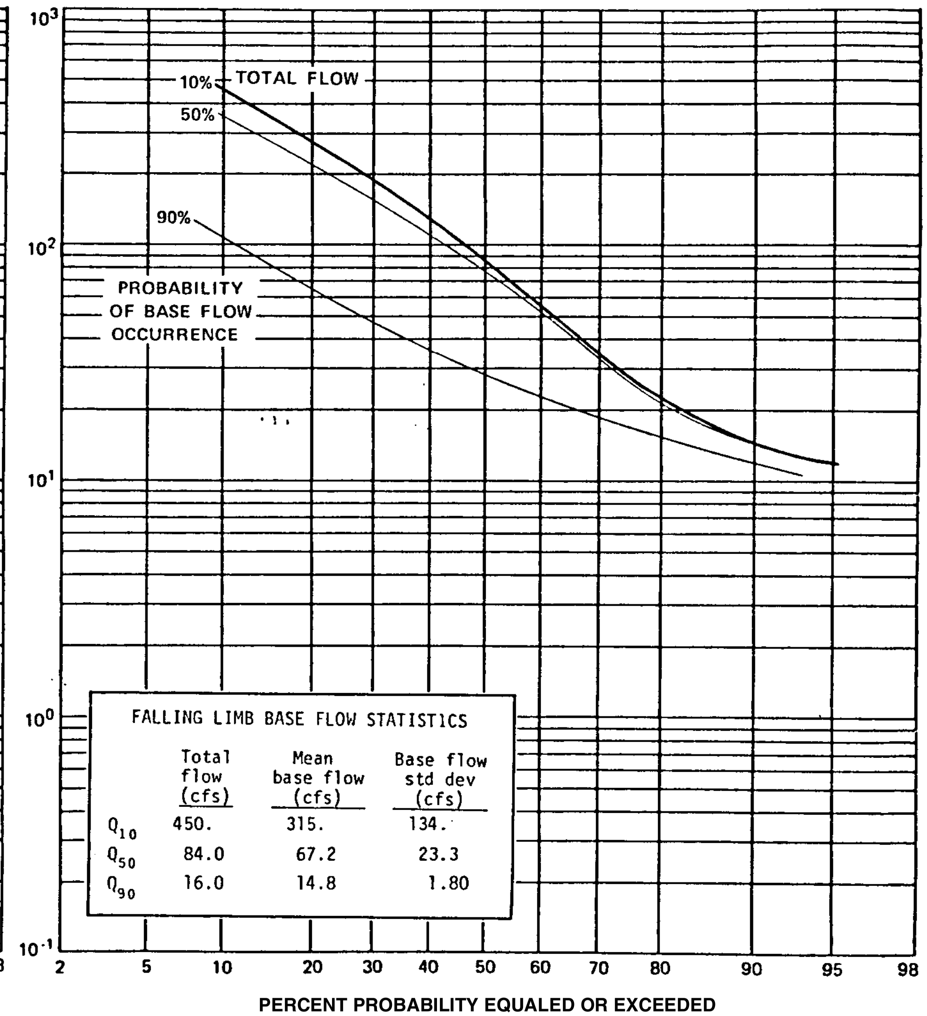

SPRING CREEK AT SPRINGFIELD
USGS station no. 577500
Drainage area = 107 sq mi
RISING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 150. 57.5 42.4
Q50 19.0 8.42 5.75
Q90 0.00 0.00 0.00
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
MEAN DAILY STREAMFLOW, cfs
PERCENT PROBABILITY EQUALED OR EXCEEDED


FALLING LIMB BASE FLOW STATISTICS
Total flow (cfs) | Mean base flow (cfs) | Base flow std dev (cfs)
Q10 150. 113. 46.7
Q50 19.0 14.9 5.65
Q90 0.00 0.00 0.00
TOTAL FLOW
10%
50%
90%
PROBABILITY OF BASE FLOW OCCURRENCE
PERCENT PROBABILITY EQUALED OR EXCEEDED



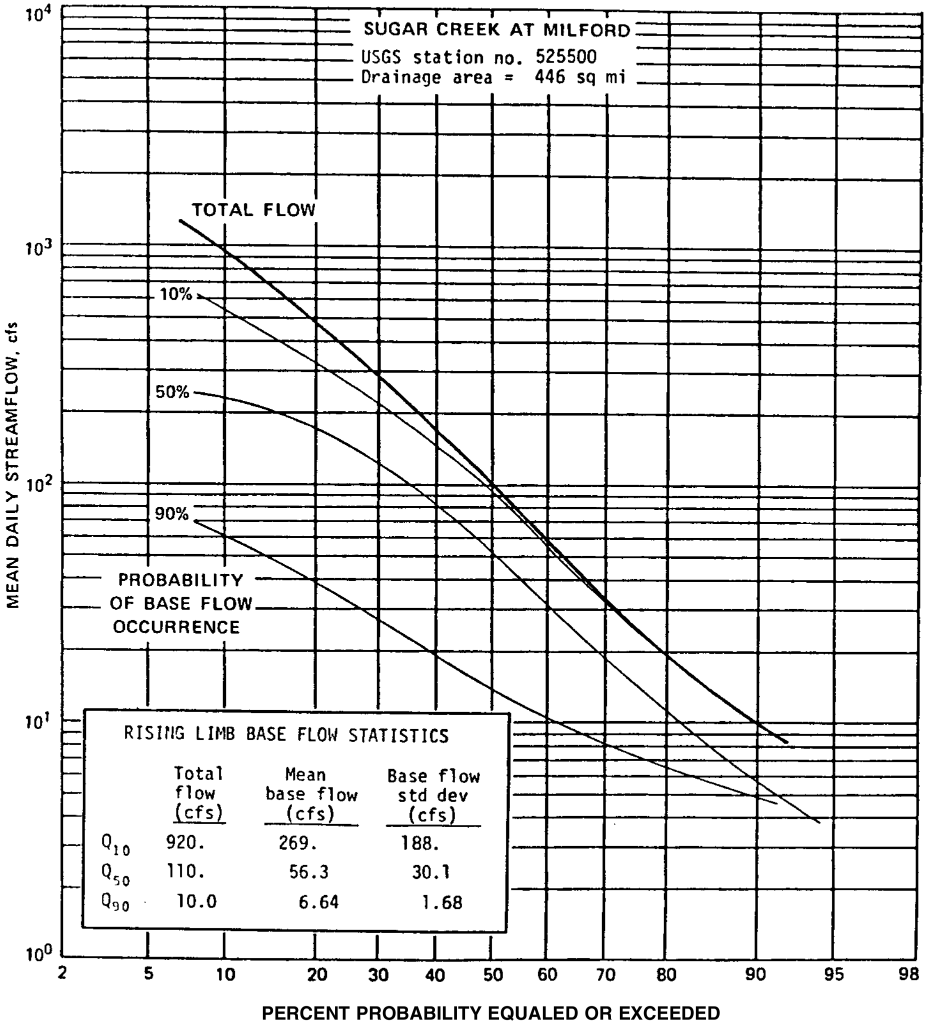
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	450.	162.	106.
Q_{50}	84.0	42.8	21.0
Q_{90}	16.0	11.4	2.51



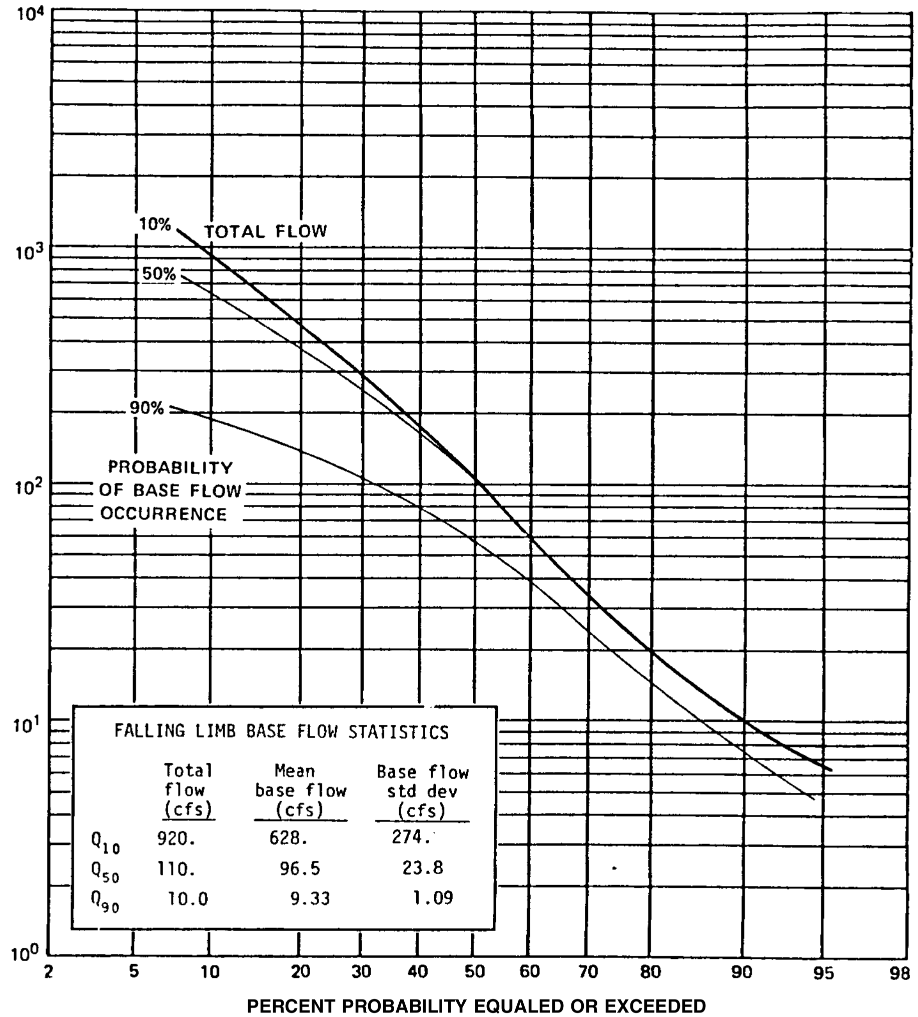
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	450.	315.	134.
Q_{50}	84.0	67.2	23.3
Q_{90}	16.0	14.8	1.80



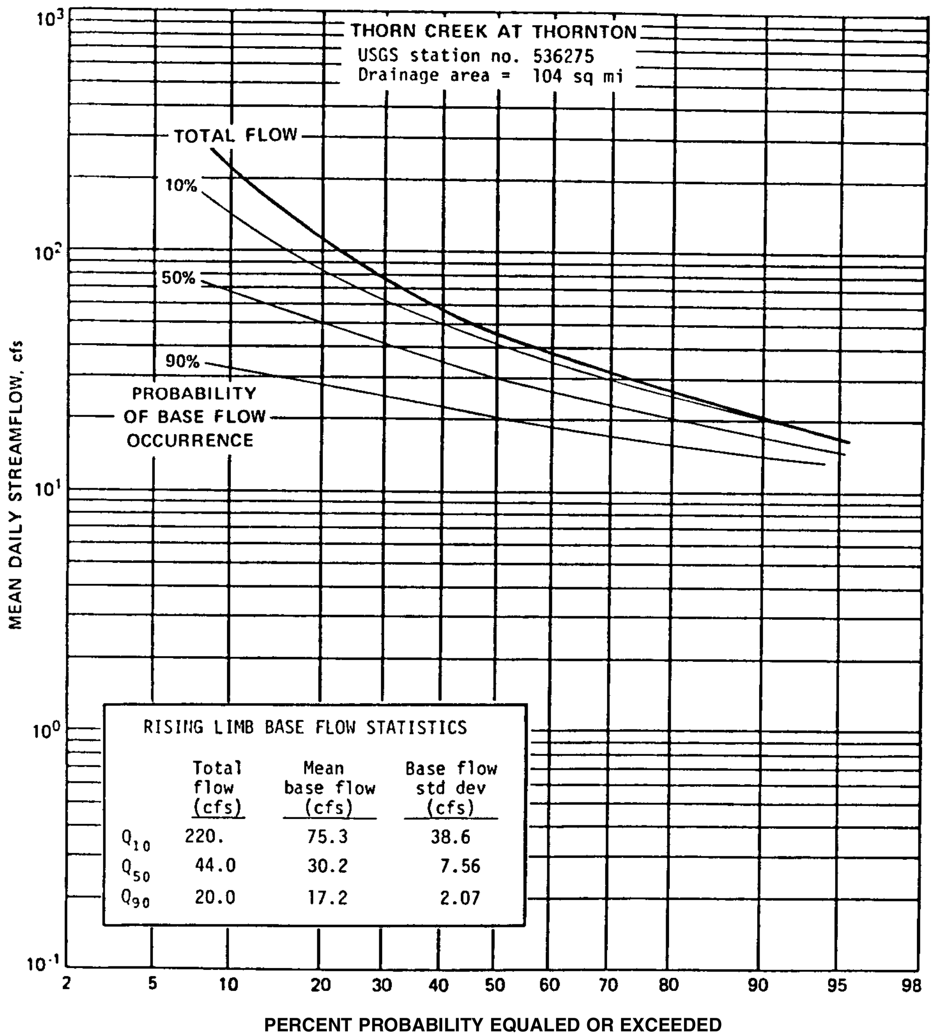
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	920.	269.	188.
Q_{50}	110.	56.3	30.1
Q_{90}	10.0	6.64	1.68



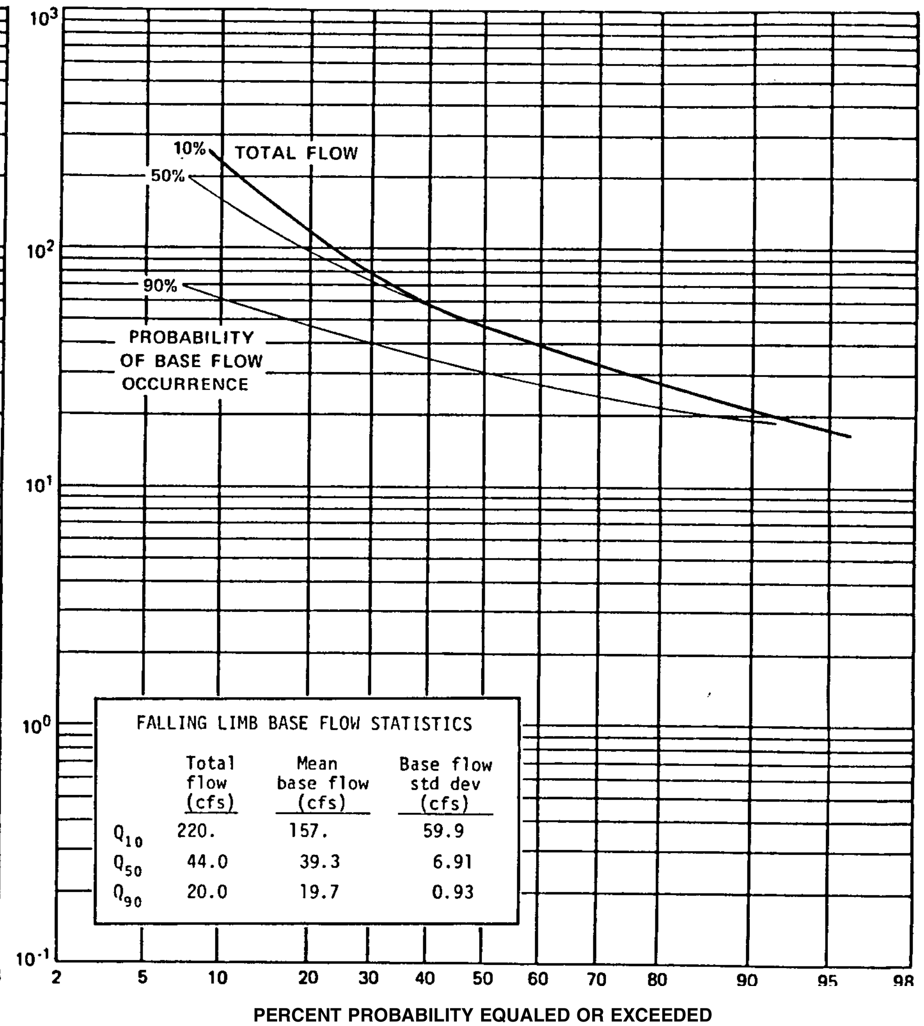
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	920.	628.	274.
Q_{50}	110.	96.5	23.8
Q_{90}	10.0	9.33	1.09



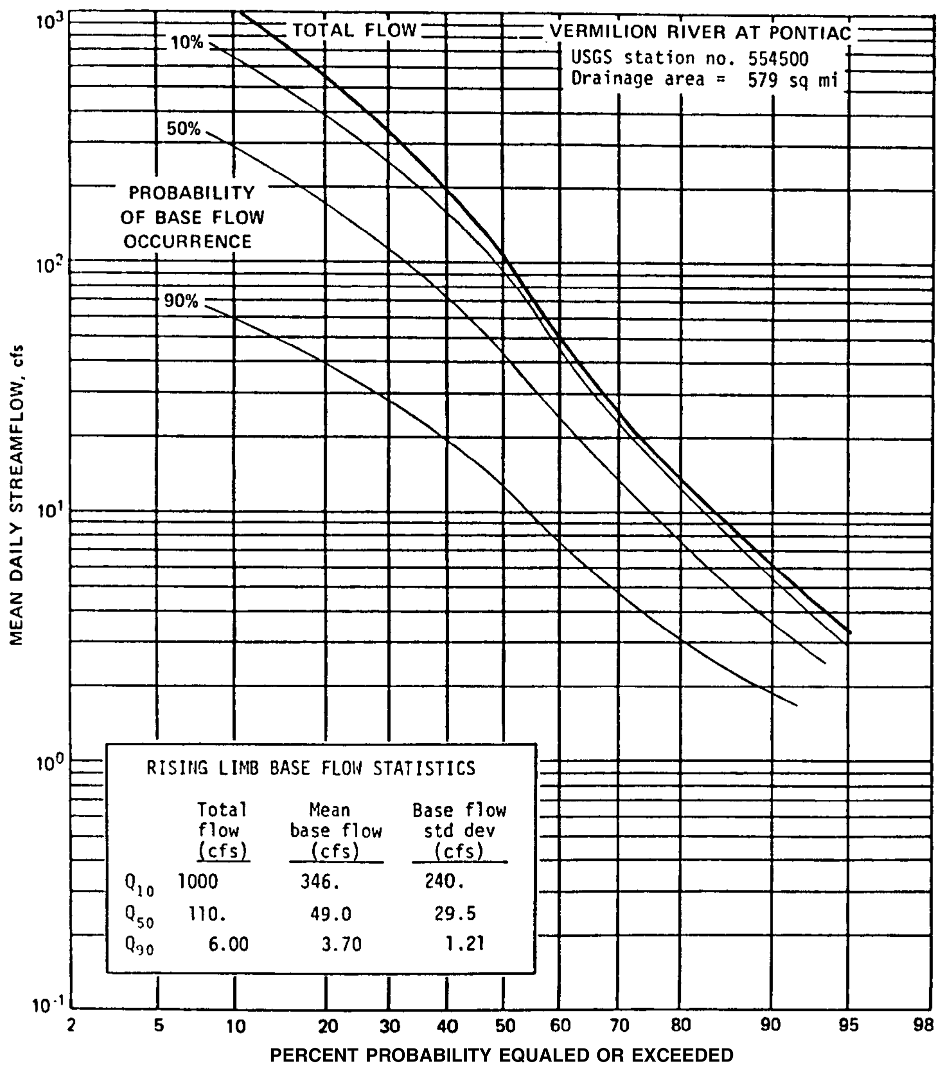
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	220.	75.3	38.6
Q_{50}	44.0	30.2	7.56
Q_{90}	20.0	17.2	2.07



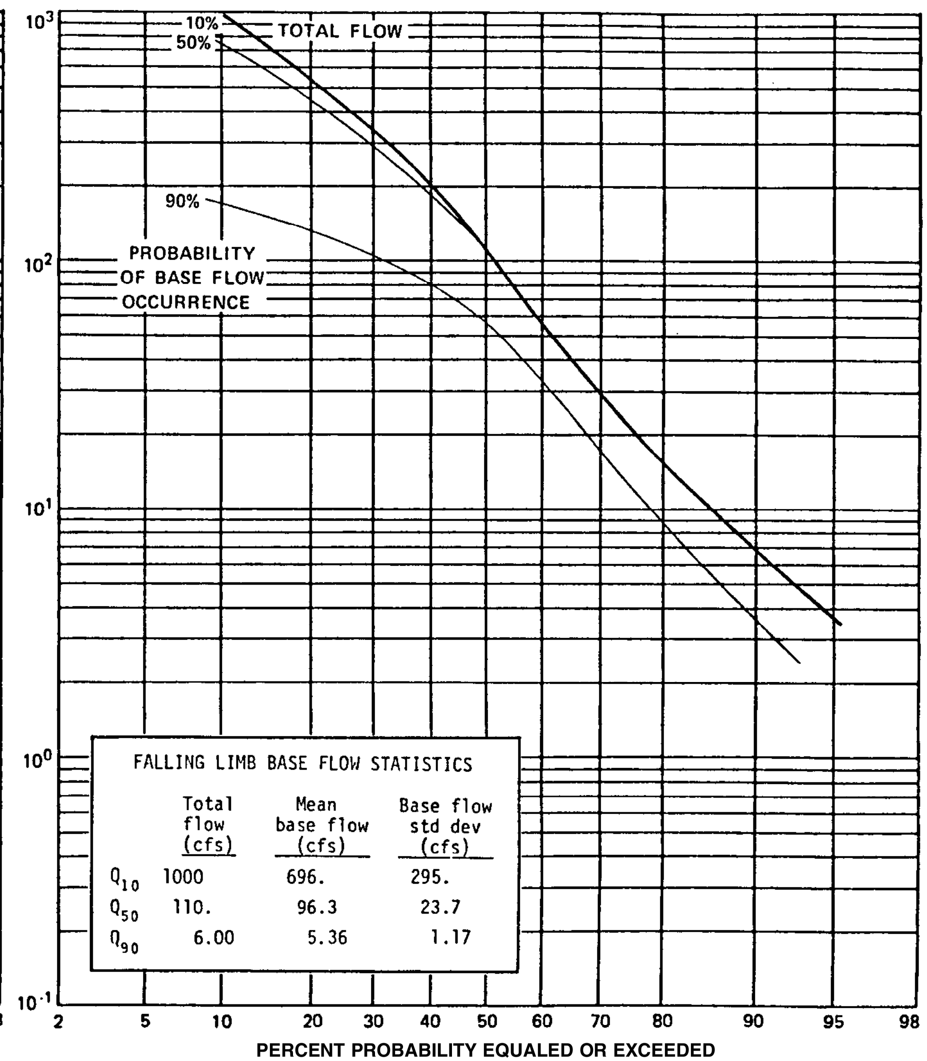
FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	220.	157.	59.9
Q_{50}	44.0	39.3	6.91
Q_{90}	20.0	19.7	0.93



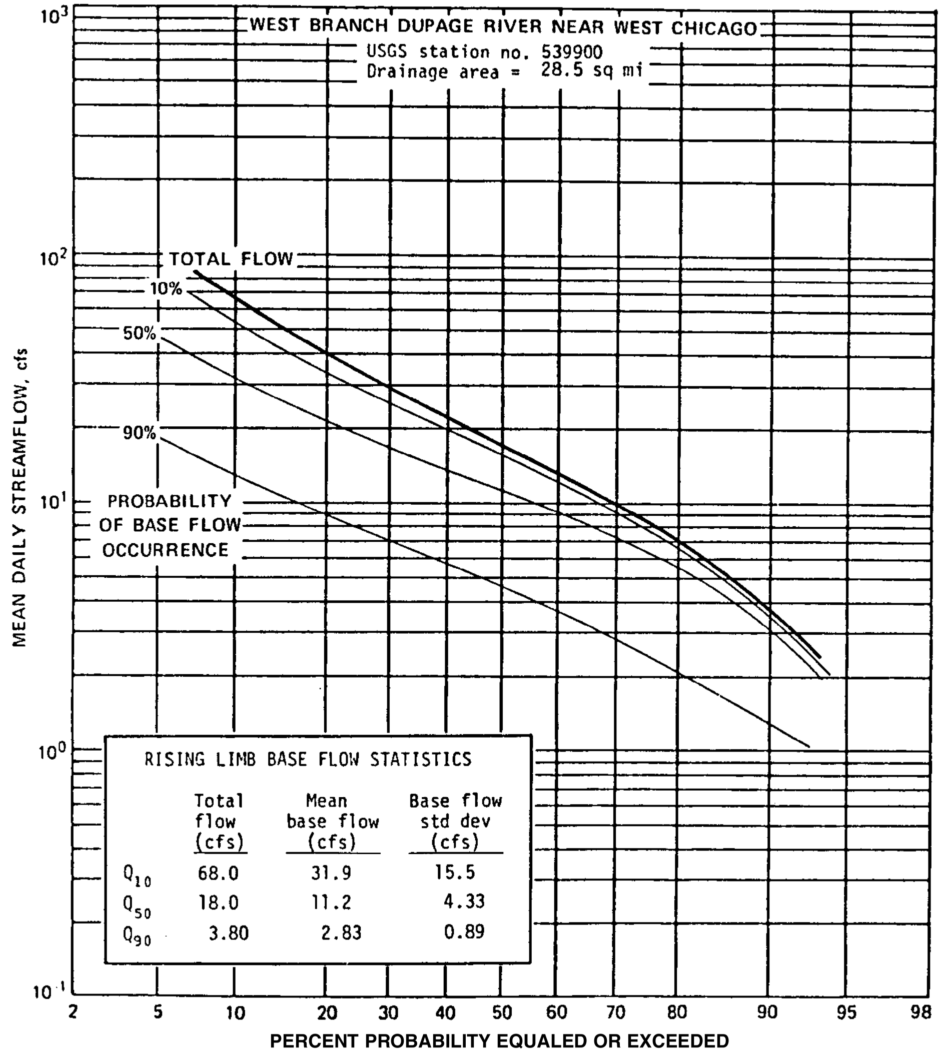
RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1000	346.	240.
Q_{50}	110.	49.0	29.5
Q_{90}	6.00	3.70	1.21

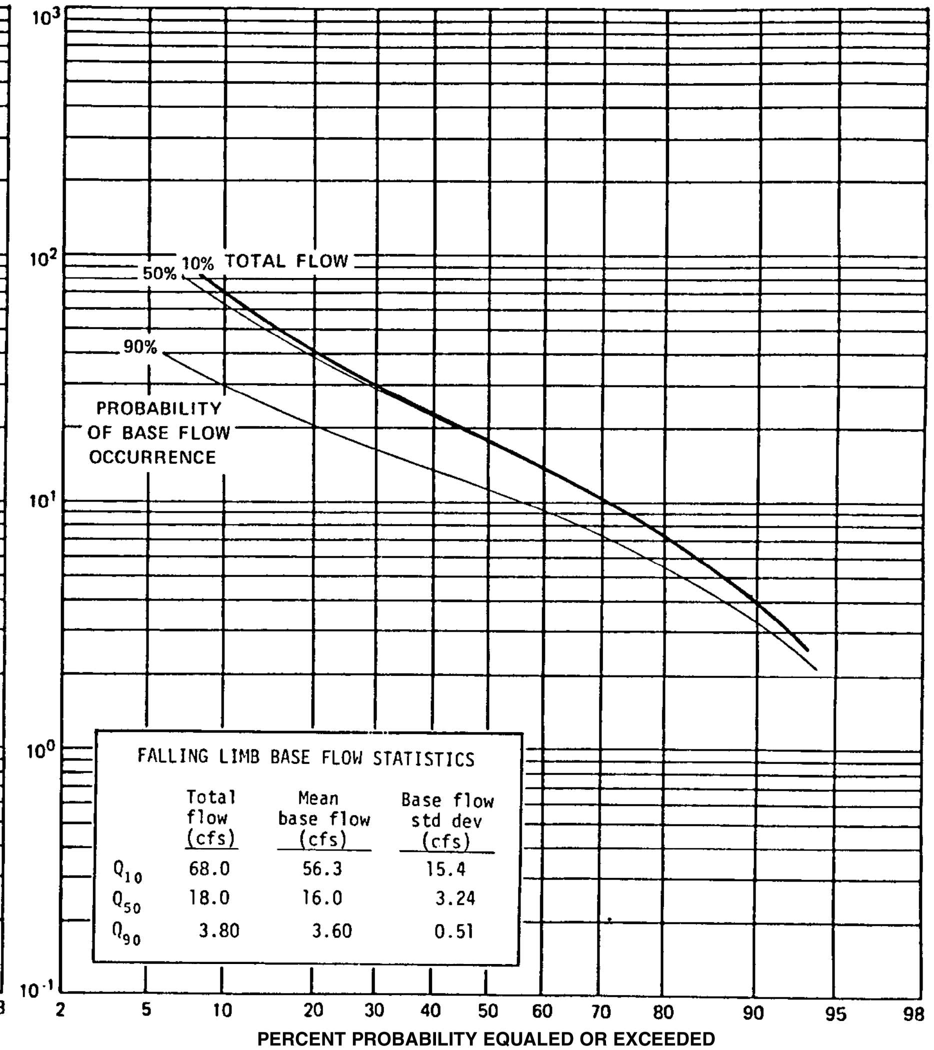


FALLING LIMB BASE FLOW STATISTICS

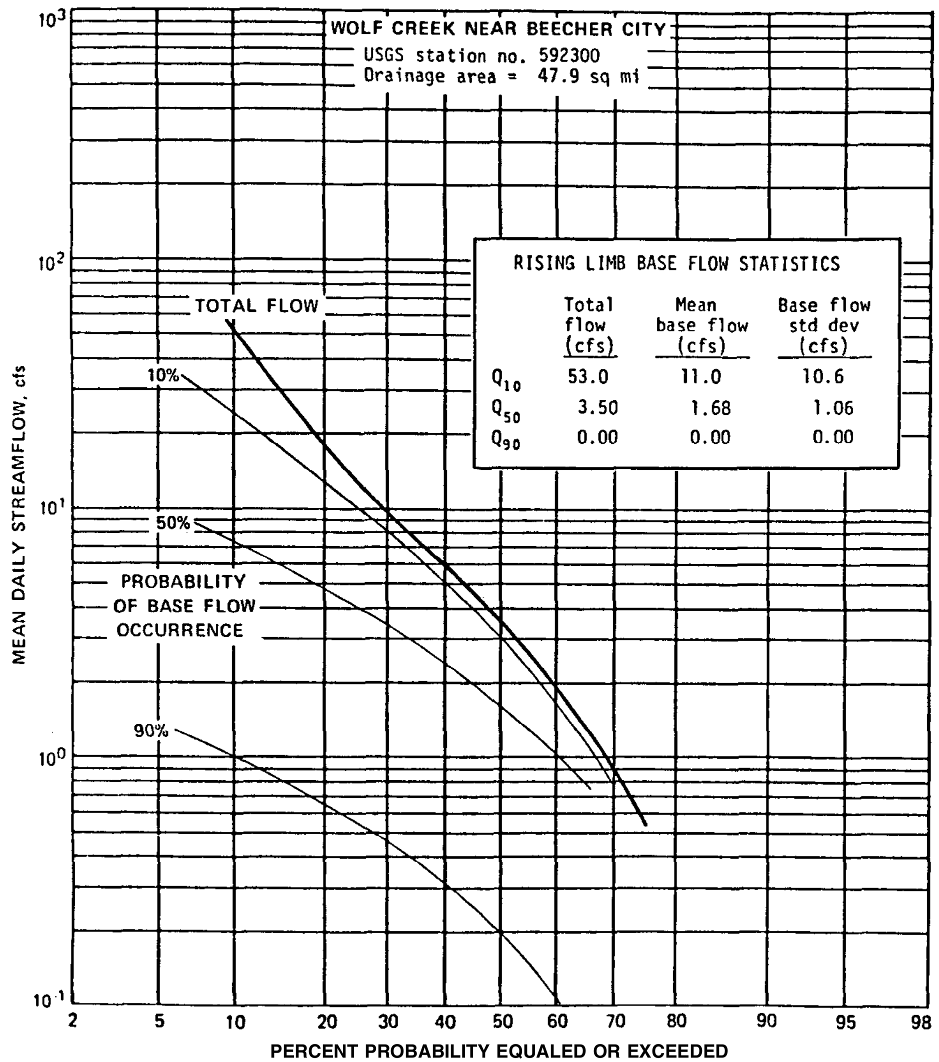
	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	1000	696.	295.
Q_{50}	110.	96.3	23.7
Q_{90}	6.00	5.36	1.17



	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	68.0	31.9	15.5
Q_{50}	18.0	11.2	4.33
Q_{90}	3.80	2.83	0.89

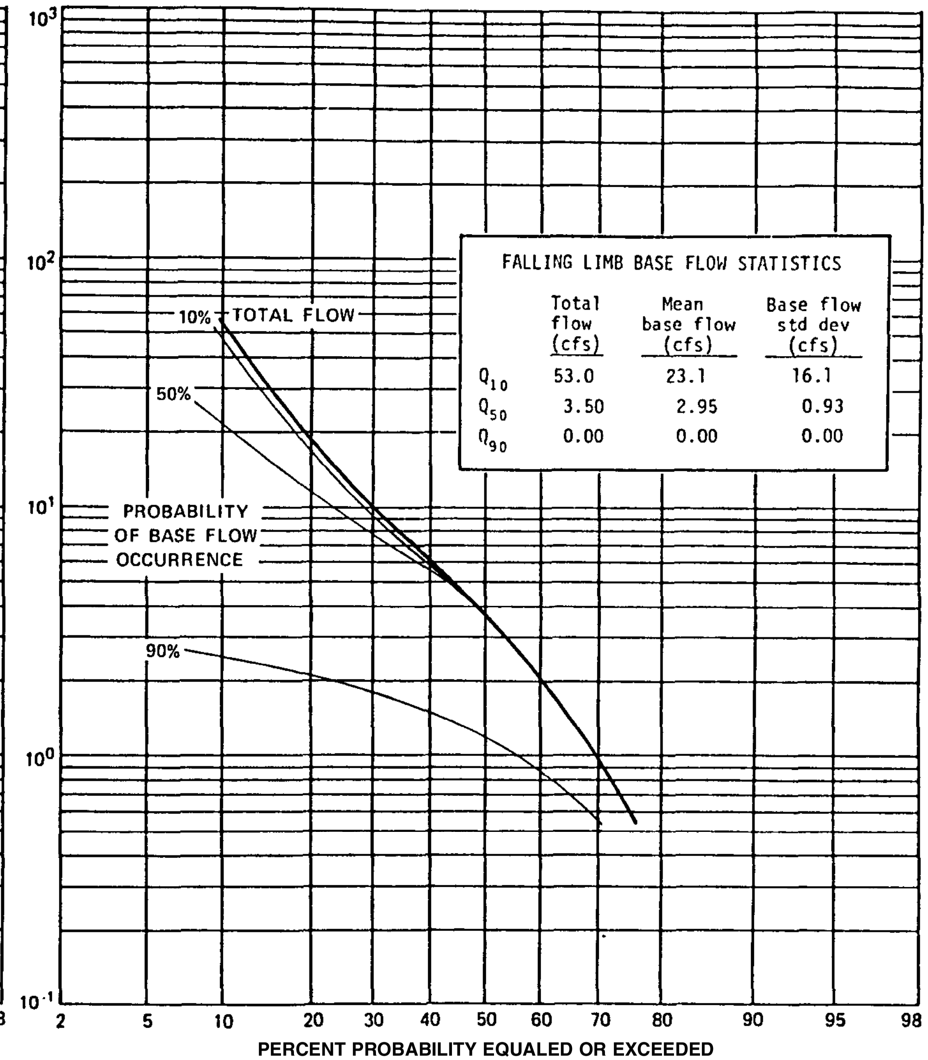


	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	68.0	56.3	15.4
Q_{50}	18.0	16.0	3.24
Q_{90}	3.80	3.60	0.51



RISING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	53.0	11.0	10.6
Q_{50}	3.50	1.68	1.06
Q_{90}	0.00	0.00	0.00



FALLING LIMB BASE FLOW STATISTICS

	Total flow (cfs)	Mean base flow (cfs)	Base flow std dev (cfs)
Q_{10}	53.0	23.1	16.1
Q_{50}	3.50	2.95	0.93
Q_{90}	0.00	0.00	0.00