A METHOD FOR ESTIMATING MEAN AND LOW FLOWS OF STREAMS IN NATIONAL FORESTS OF MONTANA

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UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

The following factors can be used to convert inch-pound units in this report to the International System of units (SI).

Multiply inch-pound unit	By	To obtain SI unit
cubic foot per second	0.02832	cubic meter per second
foot	0.3048	meter
inch	25.40	millimeter
mile	1.609	kilometer
square mile	2.590	square kilometer

A METHOD FOR ESTIMATING MEAN AND LOW FLOWS OF STREAMS IN NATIONAL FORESTS OF MONTANA

By

Charles Parrett and J. A. Hull

ABSTRACT

Equations were developed for estimating mean annual discharge, 80-percent exceedance discharge, and 95-percent exceedance discharge for ungaged streams on national forest lands in Montana. The equations for mean annual discharge used active-channel width, drainage area, and mean annual precipitation as independent variables, with active-channel width being most significant. The equations for 80-percent exceedance discharge and 95-percent exceedance discharge used only active-channel width as an independent variable.

The standard error of estimate for the best equation for estimating mean annual discharge was 27 percent. The standard errors of estimate for the equations were 67 percent for estimating 80-percent exceedance discharge and 75 percent for estimating 95-percent exceedance discharge.

INTRODUCTION

To quantify the federally reserved water right on Federal lands in Montana, a Reserved Water Rights Compact Commission was established by the Montana legislature. The Commission is charged with negotiating equitable water quantities necessary for national forest management by July 1985. The identification of the water needs on Federal lands is thus an important prerequisite to the negotiation process.

On national forest lands in Montana, forest hydrologists have identified various key levels of streamflow required for channel maintenance and other forestry purposes. Included among those key levels of streamflow are the bankfull discharge[1], mean annual discharge, 80-percent exceedance discharge[2], and 95-percent exceedance discharge[2].

The purpose of this report is to describe a method for estimating mean annual discharge, 80-percent exceedance discharge, and 95-percent exceedance discharge for ungaged streams on national forest lands in Montana. Estimating equations were developed by multiple-regression techniques and relate the streamflow characteristics to drainage area, mean annual precipitation, and active-channel width.

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[1] Defined for U.S. Forest Service purposes as the annual peak discharge with a 50-percent chance of exceedance.

[2] In this report, 80-percent or 95-percent exceedance discharge is equivalent to the daily mean discharge that is exceeded 80 percent or 95 percent of the time.

The equations were developed using data from streamflow-gaging stations and estimates of streamflow made for miscellaneous streamflow-measurement sites in the Columbia River basin and the upper Yellowstone River basin. Long-term streamflow characteristics at the miscellaneous measurement sites had been estimated and described in previous reports. A report by Parrett and Hull (1984) described equations for estimating mean annual discharge and 80-percent exceedance discharge for ungaged streams in the mountains of western Montana, but the estimating equations did not include channel-geometry measurements. Likewise, a report by Parrett (1984) provides estimating equations for mean annual discharge, 80-percent exceedance discharge, and 95-percent exceedance discharge for ungaged streams in the upper Yellowstone River basin in Montana, but channel-geometry measurements were not used. Channel-geometry measurements were used to develop estimating equations for mean annual discharge in western Montana in an earlier study by Parrett and others (1983), but that study used only streamflow-gaging-station data. The data base for the present study is much larger and includes many smaller streams for which gaged data are not available.

This report does not include estimating equations for bankfull discharge, because bankfull discharge was not one of the streamflow characteristics determined at the miscellaneous streamflow-measurement sites. Therefore, estimating equations for bankfull discharge based on channel-geometry measurements must be obtained from the study by Parrett and others (1983).

This report was prepared in cooperation with the Montana Reserved Water Rights Compact Commission and the U.S. Department of Agriculture, Forest Service. The estimating equations are intended to provide streamflow information that can be used by those agencies in future negotiation of equitable quantities of water for the national forests in Montana. The report also will be useful to designers, land-use managers, foresters, and others who require flow information on streams in forested areas of Montana.

ESTIMATING MEAN AND LOW FLOWS

Data used

Data from 33 streamflow-gaging stations and estimates of streamflow for 66 miscellaneous streamflow-measurement sites were used to develop the estimating equations in this report. The location of the gaging stations and measurement sites is shown in figure 1. The streamflow data, streamflow estimates, drainage area, mean annual precipitation, and active-channel width at each gaging station and measurement site are listed in table 4 at the end of the report.

Although the estimating equations were derived from streamflow information collected only in the Columbia River basin and the upper Yellowstone River basin, the equations were tested using data from 15 gaging stations located on or adjacent to national forest land outside those two basins. Based on those tests, the equations are considered to be applicable to all national forests in Montana. The national forest boundaries and the location of the 15 gaging stations used to test the accuracy of the estimating equations are shown in figure 1. Data for the 15 stations are given in table 5 at the end of the report.

The streamflow information used to develop the estimating equations was previously compiled and used in the reports by Parrett and Hull (1984) and Parrett (1984). The streamflow information in the report by Parrett and Hull was developed using a common base period, water years 1938-82. The streamflow information in the report by Parrett was developed using a common base period, water years 1934-83, but was based on only one long-term station. The equations presented in this report are thus considered to be representative of the base period, water years 1938-82. Data from the gaging station having the longest period of record in Montana (Missouri River at Fort Benton, station 06090800) indicate that streamflow for the period 1938-82 is about the same as for the much longer period, 1881-1982.

Drainage areas were determined at each site by planimetering the outline of the basin on the best available topographic map. Mean annual precipitation is the basin average and was determined from maps contained in the report of the U.S. Soil Conservation Service (1977). The basin mean precipitation was determined by placing a clear grid overlay on the appropriate map, finding the precipitation value at each grid intersection within the basin, and averaging the results. Active-channel width was measured at each site using techniques previously described by Parrett and others (1983) and Omang and others (1983).

Regression analysis

Prediction equations for mean annual discharge, 80-percent exceedance discharge, and 95-percent exceedance discharge were determined by a multiple-regression analysis of the data at the 99 sites listed in table 4. The regressions were performed using a digital computer program (SAS Institute, Inc., 1979), and equations of the following log-linear form were derived:

$$\text{Log } Q = \log a + b_1 \log B + b_2 \log C + \ldots + b_m \log M \quad (1)$$

where:

- Q, the dependent variable, is the streamflow characteristic being estimated, in cubic feet per second;
- a is the regression constant;
- $b_1, b_2, \ldots b_m$ are the regression coefficients; and
- $B, C, \ldots M$ are values for drainage-basin or channel geometry characteristics (independent variables).

The log equations also can be expressed in the following non-linear form:

$$Q = a \cdot B^{b_1} \cdot C^{b_2} \ldots M^{b_m} \quad (2)$$

The regression analysis considered active-channel width (W), in feet, drainage area (A), in square miles, and average annual precipitation (P), in inches, as independent variables. A "maximum R^2 improvement" routine was used to select independent variables for inclusion in the regression equations. A variable was included in the equations only if the statistical test for significance was 1 percent or less. In general, the smaller the test statistic for significance, the more significant is the variable in the equation.

The results of the regression analysis for mean annual discharge (Q_A), 80-percent exceedance discharge (Q_{80}) and 95-percent exceedance discharge (Q_{95}) are given in table 1. The table is arranged to show the effects of adding each new

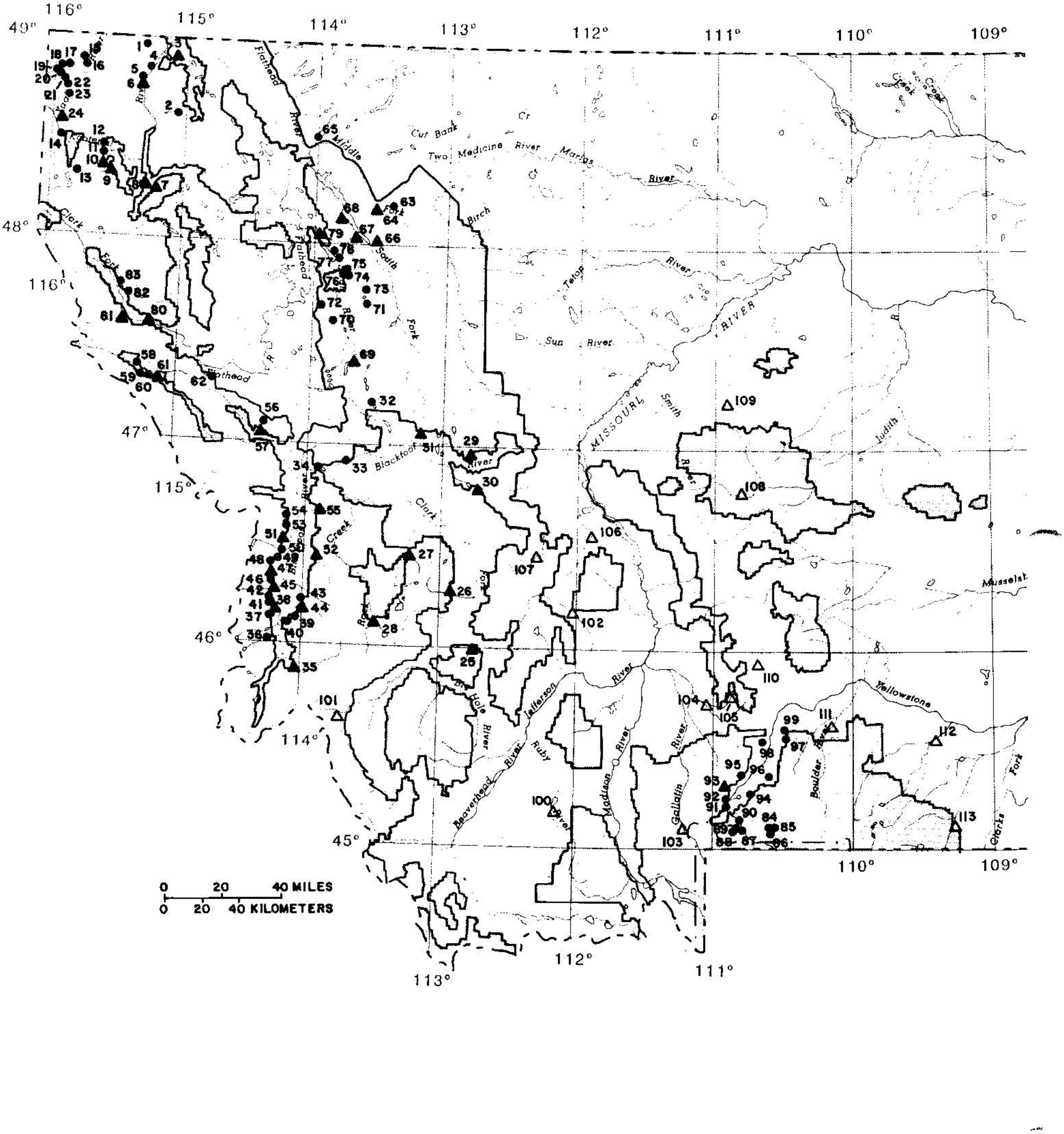
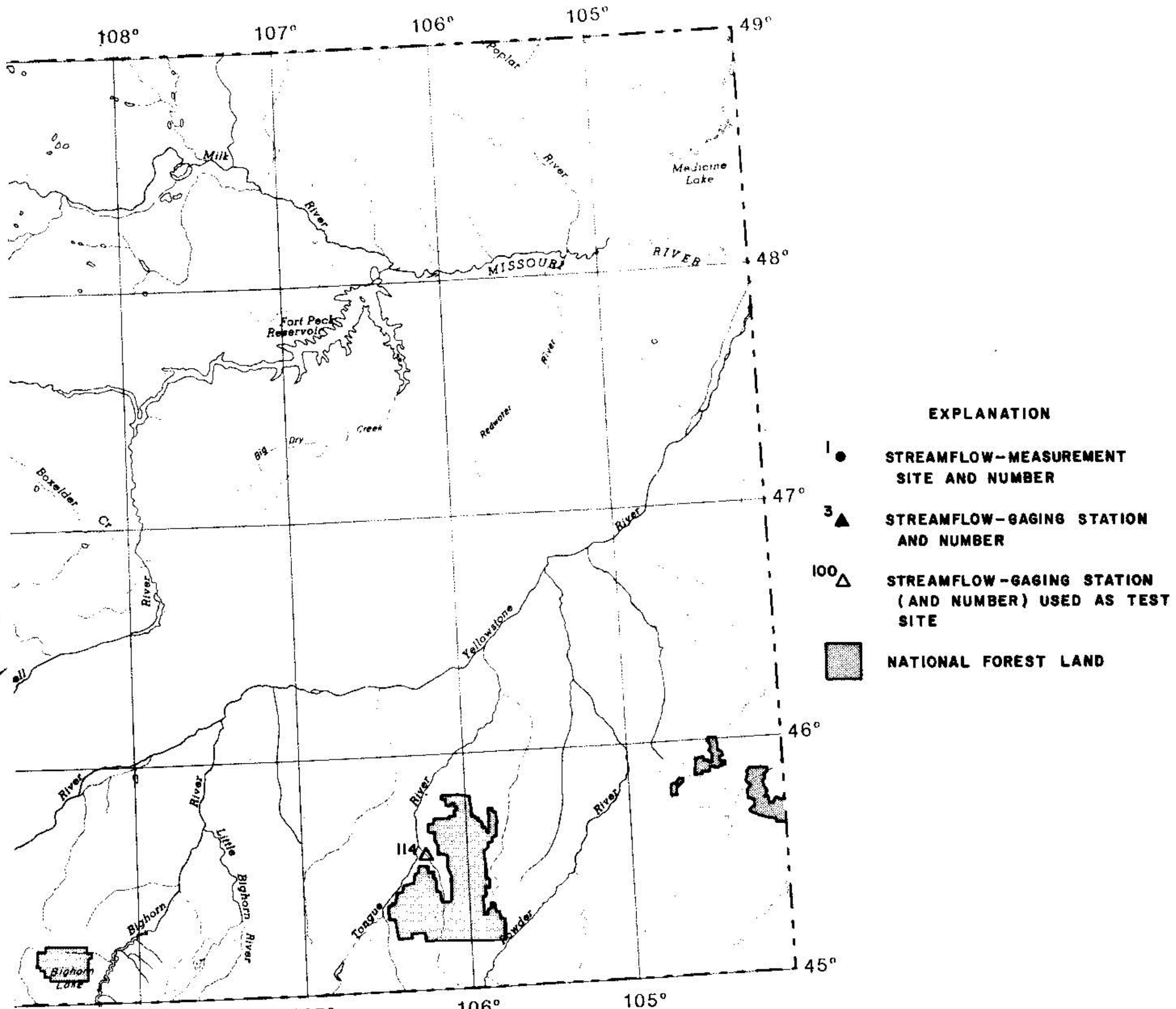


Figure 1.--Location of streamflow-measurement sites



and streamflow-gaging stations.

Table 1.--*Results of regression analysis*

Discharge (cubic feet per second)		Equation	Coefficient of determination (R^2)	Standard error of estimate (percent)
		(99 sites)		
Q_A	=	$0.125W^{1.772}$	0.93	33
Q_A	=	$0.186W^{1.419}A^{0.222}$	.95	29
Q_A	=	$0.025W^{0.956}A^{0.486}P^{0.699}$	.97	27
		(92 sites)		
Q_{80}	=	$0.035W^{1.673}$	.77	67
		(92 sites)		
Q_{95}	=	$0.026W^{1.667}$	.73	75

independent variable to the equation using the "maximum R^2 improvement" routine. For example, the first equation for Q_A shows that W was the most significant independent variable. Adding A to the equation improved the R^2 somewhat, and adding P further improved the R^2 although by less than A. All three independent variables were significant at the 1-percent level of significance.

The regression equations for the 80-percent exceedance discharge and the 95-percent exceedance discharge are based on data from only 92 of the sites listed in table 4. Seven sites were excluded because the low-flow characteristics either were greatly affected by springs or were zero as a result of the streams being dry.

Although all three independent variables were significant in the equation for estimating mean annual discharge, only active-channel width was significant in the equation for estimating 80-percent-exceedance discharge and 95-percent-exceedance discharge. In addition, table 1 indicates that the expected accuracy of the estimating equations (as measured by the coefficient of determination and the standard error of estimate) decreases as the dependent variable changes from mean annual discharge to 80-percent-exceedance discharge to 95-percent-exceedance discharge. This successive decrease in the predictive accuracy is not unexpected, however, for the reason that low flows (discharges less than the mean) are more sensitive to the local geologic and hydrologic conditions than are mean flows.

Because the study area for this report includes the areas previously studied and described in the reports by Parrett and Hull (1984) and Parrett (1984), separate regression analyses were made for each of the three regions used in those reports. In this instance, however, the regional differences in the prediction equations were not significant. Apparently, the inclusion of channel width as an independent variable accounts for the regional variation in equations required when only drainage area and mean annual precipitation are used as independent variables.

Accuracy appraisal

The accuracy of the prediction equations derived for this report is generally comparable to the accuracy of the equations previously described in Parrett and Hull (1984) and in Parrett (1984). For example, the coefficient of determination (R^2) ranges from 0.90 to 0.97 and the standard error ranges from 17 to 33 percent for the equations for estimating mean annual discharge in the three different regions previously described. In this report, the coefficient of determination (R^2) is 0.97 and the standard error is 27 percent for the equation for estimating mean annual discharge using all independent variables.

The equations for estimating the 80-percent exceedance discharge and the 95-percent exceedance discharge cannot be compared directly with equations previously derived, because the equations in the previous reports used mean annual discharge as the only independent variable. The writers believe that the equations presented in this report will estimate the 80-percent or 95-percent exceedance discharge as accurately as the equations previously reported because of the comparability of the mean annual discharge estimates from the current equations and the previously derived equations.

Because the streamflow information used to derive the equations was all from within the Columbia River basin or the upper Yellowstone River basin, a test was made to determine if the equations would be applicable to other national forest lands in Montana. Thus, 15 gaging stations on streams with essentially unregulated flow that traverse or are adjacent to national forest areas were used to test the derived equations. The equations in table 1 were used to compute the mean annual discharge, 80-percent exceedance discharge, and 95-percent exceedance discharge at the 15 test sites, and the computed results were compared with the results obtained from the actual flow record. The standard deviation of the residuals (the differences between the estimated and actual discharges) is analagous to the standard error of the regression equations, and the two are compared in table 2.

As indicated in table 2, the standard deviation of residuals for the estimating equation for mean annual discharge using only active-channel width is about the same as the standard error of estimate. This equation thus appears to provide reliable estimates of mean annual discharge anywhere within national forest lands in Montana. The equations for estimating mean annual discharge, using drainage area and drainage area together with mean annual precipitation as additional independent variables, both have significantly larger standard deviations of residuals than standard errors of estimate. If the one test site (Otter Creek, station 114) located east of longitude 109° is excluded, however, the standard deviations of residuals for the two equations using the additional variables decrease to 18 and 17 percent. Thus, the equations for estimating mean annual discharge that use drainage area or drainage area and mean annual precipitation are considered to be valid only for areas west of longitude 109°.

Table 2.--*Comparison of standard error of estimate with standard deviation of residuals at test sites*

Equation	Standard error of estimate (percent)	Standard deviation of residuals at test sites (percent)
$Q_A = 0.125W^{1.772}$	33	32
$Q_A = 0.186W^{1.419}A^{0.222}$	29	47
$Q_A = 0.025W^{0.956}A^{0.486}P^{0.699}$	27	59
$Q_{80} = 0.035W^{1.673}$	67	91
$Q_{95} = 0.026W^{1.667}$	75	147

The standard deviations of residuals for the estimating equations for the 80-percent exceedance discharge and the 95-percent exceedance discharge are both substantially larger than the standard errors of estimate. A large part of the difference between the standard error of estimate and the standard deviation of residuals for the 80-percent exceedance discharge is attributable to one test site where the 80-percent exceedance discharge is less than 1 cubic foot per second. Excluding this test site (Tenmile Creek, station 107) from the analysis decreases the standard deviation of residuals for the 80-percent exceedance discharge to 68 percent, which is almost identical to the standard error of estimate. Similarly, two test sites (Tenmile Creek and Otter Creek), had very small (less than 1 cubic foot per second) 95-percent exceedance discharges. Excluding both sites from the analysis decreases the standard deviation of residuals for the 95-percent exceedance discharge to 78 percent, which is also close to the standard error of estimate. Thus, the estimating equations for the 80-percent exceedance discharge and the 95-percent exceedance discharge are both applicable to all national forest lands in Montana, but only when it is known that the streams do not periodically become dry or have very small base flows.

Limitations

Using the estimating equations outside the national forests or for sites where the values of the independent variables are outside the range of values used to derive the equations may give erroneous results. The range of values of independent variables used to derive the equations is listed in table 3 and can be used as a guide in deciding when the equations are applicable.

Table 3.--*Range of values of independent variables*

Variable	Range of values
Active-channel width (W), feet	6 - 172
Drainage area (A), square miles	2.88 - 780
Average annual precipitation (P), inches	15 - 72

The estimating equations for the 80-percent exceedance discharge and the 95-percent exceedance discharge are not applicable to streams that receive water from springs or that periodically become dry because of localized geologic or hydrologic conditions. The equation for mean annual discharge using active-channel width as the only independent variable can provide reliable estimates in such instances, but the results need to be carefully examined for reasonableness. Likewise, the equation for mean annual discharge using active-channel width as the only independent variable is the only equation applicable to national forest lands east of longitude 109°. The inclusion of drainage area and mean annual precipitation as independent variables improves the reliability of the mean annual discharge estimates only in the western forest areas (west of longitude 109°).

Using active-channel width as an independent variable requires an onsite visit before discharge can be estimated. For reconnaissance-level flow investigations, the cost and effort required for a field measurement of channel width may not be justified. An onsite investigation commonly will reveal anomalies in the flow regimen, or local geology, however, so the requirement for a field visit generally will lead to more reliable results. As explained in previous reports by Omang and others (1983) and Parrett and others (1983), training and experience are requisites for making consistent measurements of active-channel width.

SUMMARY

Multiple regression equations were developed for estimating mean annual discharge, the 80-percent exceedance discharge, and the 95-percent exceedance discharge for streams on national forest lands in Montana. The equations for estimating mean annual discharge used active-channel width, drainage area, and average annual precipitation as independent variables, with active-channel width being the most significant. The standard error of estimate for the best equation for estimating mean annual discharge was 27 percent. The equations for estimating the 80-percent exceedance discharge and 95-percent exceedance discharge used active-channel width as the only independent variable and had standard errors of estimate of 67 and 75 percent, respectively.

The equations derived for this report were comparable in accuracy to equations previously derived that were based only on drainage basin and climatic variables. A test of the prediction accuracy of the equations when applied to national forest lands outside the Columbia River basin and the upper Yellowstone River basin was made using 15 streamflow stations outside those basins. For mean annual discharge, the equation using active-channel width as the only independent variable resulted in a standard deviation of residuals at the 15 test sites about equal to the standard error of estimate of the regression equation. The equations using drainage area and mean annual precipitation as additional independent variables had larger standard deviations of residuals than the standard errors of estimate at the 15 test sites. Eliminating one test site, which limited the applicability of the two equations using drainage area and average annual precipitation to national forest lands west of longitude 109°, resulted in standard deviations of residuals less than the standard errors of estimate. The standard deviation of the residuals was greater than the standard error of estimate for both the 80-percent exceedance discharge and the 95-percent exceedance discharge, but the differences did not appear to be significant when two sites having very small discharges were excluded from the analysis. The estimating equations for mean annual discharge, 80-percent exceedance discharge, and 95-percent exceedance discharge thus are presumed to be applicable to all national forest lands in Montana, as long as the expressed limitations and general constraints on the use of the regression equations are not ignored.

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Table 4.--*Hydrologic information from streamflow sites and stations used to develop equations*

Site or station No. (fig. 1)	Stream name and gaging-station number	Drainage area, (square miles)	Mean annual precipitation (inches)	Active-channel width (feet)	Mean annual discharge[1] (cubic feet per second)	80-percent exceedance discharge[1] (cubic feet per second)	95-percent exceedance discharge[1] (cubic feet per second)
1	Young Creek below South Fork	19.0	31	17	15.1	5.1	3.6
2	Cayuse Creek	5.29	28	11	6.6	.4	.3
3	Tobacco River (12301300)	440	31	48	268	86.0	66.0
4	Sullivan Creek	14.1	33	16	10.1	2.9	1.7
5	Boulder Creek	18.1	34	23	19.4	3.9	2.4
6	Big Creek near Rexford (12301810)	139	37	44	149	19.0	13.0
7	Wolf Creek near Libby (12301999)	216	27	40	67.0	8.2	6.3
8	Fisher River near Jennings (12302000)	780	32	111	510	127	97.0
9	Granite Creek (12302500)	23.6	67	32	71.0	14.0	8.6
10	Flower Creek (12303100)	11.1	67	17	27.0	6.5	5.1
11	Cedar Creek	12.9	61	20	23.8	4.8	3.6
12	Quartz Creek	35.4	47	28	69.0	19.0	15
13	Camp Creek	11.3	63	19	19.3	4.4	3.8
14	Ruby Creek	15.8	64	19	26.8	3.7	2.7
15	Pete Creek below Hensley Creek	29.8	35	26	34.7	3.1	1.9
16	Pete Creek at mouth	33.8	34	25	39.4	3.1	1.9
17	Spread Creek	37.3	50	50	80.5	15.0	12.0
18	Hellroaring Creek at U.S. Forest Service bridge	9.65	70	30	27.0	4.0	3.5
19	North Fork Meadow Creek	6.33	72	19	13.6	2.2	1.6
20	Meadow Creek	20.4	68	30	42.6	4.4	3.0
21	Red Top Creek	9.96	69	18	19.7	3.2	2.5
22	Cyclone Creek	5.71	67	9	10.7	2.2	1.7
23	Fourth of July Creek	7.84	64	13	13.1	2.2	1.8
24	Yaak River (12304500)	766	43	136	888	158	120
25	German Gulch (12323500)	40.6	18	20	21.0	6.4	5.4
26	Racetrack Creek (12324100)	39.5	35	22	59.0	20.0	17.0
27	Boulder Creek (12330000)	71.3	31	28	48.0	17.0	12.0
28	Middle Fork Rock Creek (12332000)	123	35	56	123	33.0	24.0
29	Blackfoot River near Helmville (12335000)	481	15	100	342	115	94.0
30	Nevada Creek (12335500)	116	23	28	38.0	8.8	5.6
31	Monture Creek (12338690)	140	35	52	184	35.0	29.0
32	Deer Creek	19.8	39	23	21.1	2.5	2.0
33	West Twin Creek	7.33	25	15	11.3	1.9	1.2
34	Marshall Creek	5.63	23	6	2.3	1.1	.7
35	East Fork Bitterroot River (12343400)	381	32	70	282	83.0	68.0
36	Tin Cup Creek	33.4	65	38	91.0	13.6	8.5
37	Lost Horse Creek	66.3	68	53	190	25.0	20.0
38	Camas Creek (12345800)	6.01	62	15	15.2	1.3	1.0
39	Sleeping Child Creek	64.7	31	33	58.6	12.0	10.0
40	Little Sleeping Child Creek	11.2	21	7	3.3	.6	.5
41	Roaring Lion Creek	23.9	67	32	63.5	6.6	3.8
42	Sawtooth Creek	22.6	63	32	60.3	7.7	5.8
43	Gird Creek	28.8	23	11	17.1	6.3	5.5
44	Skalkaho Creek (12346500)	87.8	36	34	91.0	26.0	22.0
45	Blodgett Creek (12347500)	26.4	64	37	68.0	9.2	4.8
46	Mill Creek	17.6	62	27	50.3	5.0	4.5
47	Bear Creek (12350000)	26.8	63	41	70.0	8.5	4.3
48	Sweat House Creek	10.2	62	23	25.3	3.5	2.2
49	Gash Creek	3.37	60	11	10.7	1.5	1.3
50	Big Creek	32.9	61	39	93.3	16.0	13.0
51	Kootenai Creek (12350500)	28.9	64	38	78.0	12.0	7.4
52	Burnt Fork Bitterroot River (12351000)	74.0	32	20	50.0	17.0	13.0

Table 4.--*Hydrologic information from streamflow sites and stations used to develop equations*--Continued

Site or station No. (fig. 1)	Stream name and gaging-station number	Drainage area, (square miles)	Mean annual precipitation (inches)	Active-channel width (feet)	Mean annual discharge[1] (cubic feet per second)	80-percent exceedance discharge[1] (cubic feet per second)	95-percent exceedance discharge[1] (cubic feet per second)
53	Bass Creek	13.1	58	18	27.3	8.2	5.3
54	Sweeney Creek	16.4	60	26	31.0	7.1	4.3
55	Eightmile Creek (12351400)	20.6	21	10	8.0	3.5	2.9
56	Butler Creek	10.7	38	15	11.9	1.7	1.4
57	Ninemile Creek (12353280)	170	38	48	124	27.0	21.0
58	Twelvemile Creek	40.7	50	23	44.4	8.8	7.6
59	Ward Creek	22.8	57	22	40.9	8.4	6.9
60	Twomile Creek	17.1	52	20	23.0	5.4	4.6
61	St. Regis River (12354000)	303	52	130	541	112	83.0
62	Siegel Creek	14.2	40	12	10.5	3.4	3.0
63	Bear Creek	20.4	47	25	43.0	8.4	6.2
64	Middle Fork Flathead River at Essex (12357000)	510	52	172	1,100	188	128
65	Fish Creek	15.3	44	19	24.7	7.5	6.4
66	Twin Creek (12360000)	47.0	53	41	112	14.0	8.4
67	Sullivan Creek (12361000)	71.3	53	63	210	34.0	22.0
68	Graves Creek near Hungry Horse (12361500)	27.0	67	40	127	20.0	14.0
69	Swan River near Condon (12369200)	69.1	54	72	160	41.0	33.0
70	Piper Creek	11.8	55	27	22.2	4.7	3.0
71	Goat Creek above Scout Creek	8.27	72	20	24.2	.0	.0
72	South Woodward Creek above Fatty Creek road	2.88	60	10	6.2	5.0	3.9
73	Soup Creek above Soup Creek Campground	4.5	67	15	12.2	2.6	1.7
74	South Fork Lost Creek	14.8	61	25	42.9	6.7	5.3
75	North Fork Lost Creek	13.0	60	25	30.7	5.3	4.0
76	Lost Creek	31.7	58	40	61.5	8.3	6.2
77	Bond Creek	7.58	53	11	12.8	1.2	.8
78	Hall Creek	4.66	54	15	12.7	3.1	2.1
79	Swan River near Big Fork (12370000)	671	46	165	1,180	417	330
80	Thompson River (12389500)	642	41	95	480	176	144
81	Prospect Creek (12390700)	182	54	53	258	57.0	43.0
82	Graves Creek	28.3	56	26	42.9	1.0	.2
83	Deep Creek	12.6	56	18	18.2	2.8	2.0
84	North Fork Bear Creek	13.4	33	24	22.6	4.2	2.2
85	Bear Creek above North Fork Bear Creek	13.8	33	32	37.3	4.1	2.3
86	Bear Creek at Jardine	27.2	33	39	60.0	7.0	4.7
87	Mol Heron Creek	18.1	34	15	24.4	8.4	6.0
88	Cinnabar Creek above Cottonwood Creek	14.5	38	11	10.7	4.7	3.7
89	Cinnabar Creek at mouth	23.9	34	11	12.7	6.5	5.2
90	Cedar Creek near Corwin Springs	21.3	27	12	9.2	2.4	1.1
91	Tom Miner Creek at mouth	65.8	35	30	57.2	22.5	14.5
92	Rock Creek near Corwin Springs	28.8	37	21	23.3	4.6	3.7
93	Big Creek near Emigrant (06191800)	60.9	36	29	62.0	23.2	20.0
94	Sixmile Creek	33.8	28	20	34.0	7.9	6.0
95	Fridley Creek	17.2	37	17	19.8	6.7	4.9
96	Mill Creek above national forest boundary	148	33	54	160	26.0	17.5
97	Deep Creek near Livingston	18.8	30	22	12.7	.5	.3
98	Trail Creek	41.8	26	16	20.7	6.1	3.9
99	Suce Creek	9.77	23	12	6.4	.7	.6

[1] All discharge data from gage record at gaging stations; all other discharge information is estimated.

Table 5.--*Hydrologic data from streamflow stations used to test equations*

Station No. (fig. 1)	Stream name	Drainage area (square miles)	Mean annual precipitation (inches)	Active-channel width (feet)	Mean annual discharge[1] (cubic feet per second)	80-percent exceedance discharge[1] (cubic feet per second)	95-percent exceedance discharge[1] (cubic feet per second)
100	Ruby River (06019500)	538	18	44	177	98.0	82.0
101	Trail Creek (06024500)	71	30	39	85.0	15.0	11.0
102	Boulder River near Boulder (06033000)	381	19	45	121	21.0	11.0
103	Taylor Creek (06043000)	98	40	39	98.0	19.0	15.0
104	East Gallatin River (06048000)	148	26	35	84.7	38.0	28.0
105	Bridger Creek (06048500)	62	33	22	36.6	6.7	4.5
106	Prickly Pear Creek (06061500)	192	19	27	48.7	20.0	14.0
107	Tenmile Creek (06062500)	32.7	24	16	18.0	.67	.32
108	Sheep Creek (06077000)	54.4	30	26	31.9	9.3	6.8
109	Belt Creek (06090500)	368	25	62	189	30.0	16.0
110	Brackett Creek (06194000)	57.9	26	23	28.0	5.8	3.2
111	Boulder River near Contact (06197500)	226	37	80	385	61.0	48.0
112	Stillwater River (06205000)	975	32	140	970	282	201
113	Rock Creek (06209500)	124	40	65	174	34.0	27.0
114	Otter Creek (06307740)	707	15	16	7.3	1.5	.24

[1]All discharge data from gage record.