USE OF SELECTED BASIN CHARACTERISTICS TO ESTIMATE MEAN ANNUAL RUNOFF AND PEAK DISCHARGES FOR UNGAGED STREAMS IN DRAINAGE BASINS CONTAINING STRIPPABLE COAL RESOURCES, NORTHWESTERN NEW MEXICO

By H. R. Hejl, Jr.

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CONVERSION FACTORS

In this report, values for measurements are given in inch-pound units only. The following table contains factors for converting to metric units.

Multiply inch-pound units	By	To obtain metric units
inch	25.4	millimeter
foot	0.3048	meter
cubic foot per second	0.02832	cubic meter per second
acre-foot	1,233	cubic meter
mile	1.609	kilometer
square mile	2.590	square kilometer
foot per mile	0.1894	meter per kilometer

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ABSTRACT

Equations in this report can be used to estimate mean annual runoff and peak discharges for 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals for ungaged streams in drainage basins containing strippable coal resources in northwestern New Mexico. These streamflow characteristics are related to basin characteristics that were found to be significant using regression techniques. Mean annual runoff for ephemeral streams is related to drainage area, active-channel width, main-channel slope, basin slope, and silt-clay percentage in active-channel banks. Peak discharges for ephemeral, intermittent, and perennial streams are related to drainage area, active-channel width, main-channel length, basin slope, and silt-clay percentage in active-channel banks.

INTRODUCTION

The purpose of this study was to develop equations to estimate mean annual runoff and peak discharges for ungaged streams in drainage basins containing strippable coal resources in northwestern New Mexico. Mean annual runoff and peak discharges for 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals were related to selected basin characteristics using regression equations. This report may be useful to Federal and State agencies in defining streamflow characteristics in areas underlain by strippable coal deposits, so that reasonable stipulations can be developed for lease-permit mining applications by agencies charged with enforcing the Surface Mining Control and Reclamation Act of 1977. In addition, the hydrologic information may assist coal companies in the development of mining plans.

The study area is characterized by mesas, rolling plains, and badlands. Soils vary from very permeable sand to almost impermeable shale. The arid to semiarid climate supports various species of trees, shrubs, grasses, and other vegetation adapted to a desert environment. Badland areas, however, are virtually devoid of vegetation. The annual precipitation throughout the study area averages 8 to 12 inches except for a small area along the eastern boundary that receives more than 12 inches (U.S. Weather Bureau, no date). About one-half of the annual precipitation, mainly in the form of thunderstorms, occurs from May through September. Precipitation during the remainder of the year can occur in the form of rain, sleet, or snow.

This report was prepared in cooperation with the U.S. Bureau of Land Management. The part of this report pertaining to active-channel width was closely coordinated with a study relating streamflow characteristics to channel geometry of streams in the Western United States (Hedman and Osterkamp, 1982).

DATA BASE

Basin Characteristics

Drainage area--Drainage area, in square miles, is the area of the horizontal projection onto a flat plane of an area whose surface directs water toward a stream upstream from a specified point on that stream.

Length of main channel--Length of main channel, in miles, is the distance measured along the main channel from a specified point to the drainage-basin divide.

Slope of main channel--Slope of main channel, in feet per mile, is the altitude difference, in feet, between points on the main channel that are 10 and 85 percent of the distance, in miles, from the gaged site to the drainage-basin divide.

Slope of basin--Slope of basin, in feet per mile, is the average slope of a drainage basin obtained by measuring the total length, in miles, of land-surface contours within the basin, multiplying by the altitude difference, in feet, of the contours, and dividing by the basin area, in square miles. For this study, contour length was measured at: 20-foot intervals when basin area was less than 2 square miles; 100-foot intervals when the area ranged from 2 to 200 square miles; 200-foot intervals when area ranged from 200 to 500 square miles; and 500-foot intervals when the area was greater than 500 square miles. Small differences (less than 5 percent) were found in basin slope with additional refinement in the measurement of contours within these groups.

Width of active channel--Width of active channel, in feet, is the distance between points on opposite banks at the lowest, stable part of the bank where the slope abruptly changes from a steep slope to a slighter or flatter slope. A line connecting the points would be level, or almost level, and perpendicular to the flow at that stage. The banks below the points identifying the active channel may show evidence of minor scour or may be masked by a thin layer of sediment, which is evidence of the forming processes in quasi-equilibrium. The streambed at the bottom of the banks is subject to alteration with each occurrence of flow. The active-channel width may be coincident with the lower limit of permanent vegetation; however, not all channels in the study area support vegetation.

Examples of the active-channel reference points used in this report are shown in figure 1. The best locations to measure the width of an active channel are in the straightest reaches available, which generally are located between bends in the channel near the outflow from the drainage basin. The active-channel width approximately repeats itself along the channel and the average of three or more measurements is used for determining the final value.

The time required to recognize this geomorphic feature can be decreased significantly with onsite training by an experienced person. Additional information about active-channel width can be found in reports by Hedman, Kastner, and Hejl (1974, p. 3-4), Hedman and Kastner (1977, p. 286), and Hedman and Osterkamp (1982, p. 2-4).

Figure 1.--Reference points for determining active-channel width in reaches of ephemeral-stream channels.

Silt-clay percentage of active-channel bank--Silt-clay percentage of active-channel bank is the percentage of the fine-grained material (particle size smaller than 62 micrometers in diameter) in samples of the active-channel bank. Samples of bank material were collected within 1 inch of the surface at three or four equally spaced intervals on the part of the bank between the streambed and the top of the active channel. The composite samples for the bank on each side of the streambed were analyzed separately. The composite sample with the larger percentage of silt-clay was found to be more significant and was used in the regression analyses.

Streamflow Characteristics

Mean annual runoff--Mean annual runoff, in acre-feet, was computed from published records collected for ephemeral streams through the 1981 water year at continuous-record, streamflow-gaging stations (map numbers 1-10 in fig. 2; table 1). These streamflow-gaging stations were established for the purpose of collecting streamflow data prior to the start of mining along the band of the Fruitland Formation containing strippable coal resources in the San Juan Basin, northwestern New Mexico. Prior to the "energy crisis" in 1974 and the subsequent increased concern about energy-resource development, few hydrologic data had been collected in the area. Thus, only 4 to 6 years of data are available to calculate mean annual runoff. These values may not be representative of long-term means.

Peak discharges--Peak discharges for 2-, 5-, 10-, 25-, 50-, or 100-year recurrence intervals, in cubic feet per second, were determined from published records of annual maximum discharges collected through the 1981 water year at streamflow-gaging stations on ephemeral, intermittent, and perennial streams (map numbers 11-19 in fig. 2; table 2). Most of these gaging stations were established to determine only the annual maximum discharges. Data available for analyses range from 11 to 38 years of record. The peak discharges for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals for gaging stations were defined from flood-frequency curves developed by applying a log-Pearson Type III distribution to annual maximum discharges and modifying the station skew coefficient using generalized relations as recommended by the U.S. Water Resources Council (1981). Four of the sites did not meet the Water Resources Council's recommended specifications for the ratio of peaks above the gage base to years of record. However, the above-gage-base statistics were reviewed and after the conditional probability adjustments were applied, the estimates of peaks appeared reasonable.

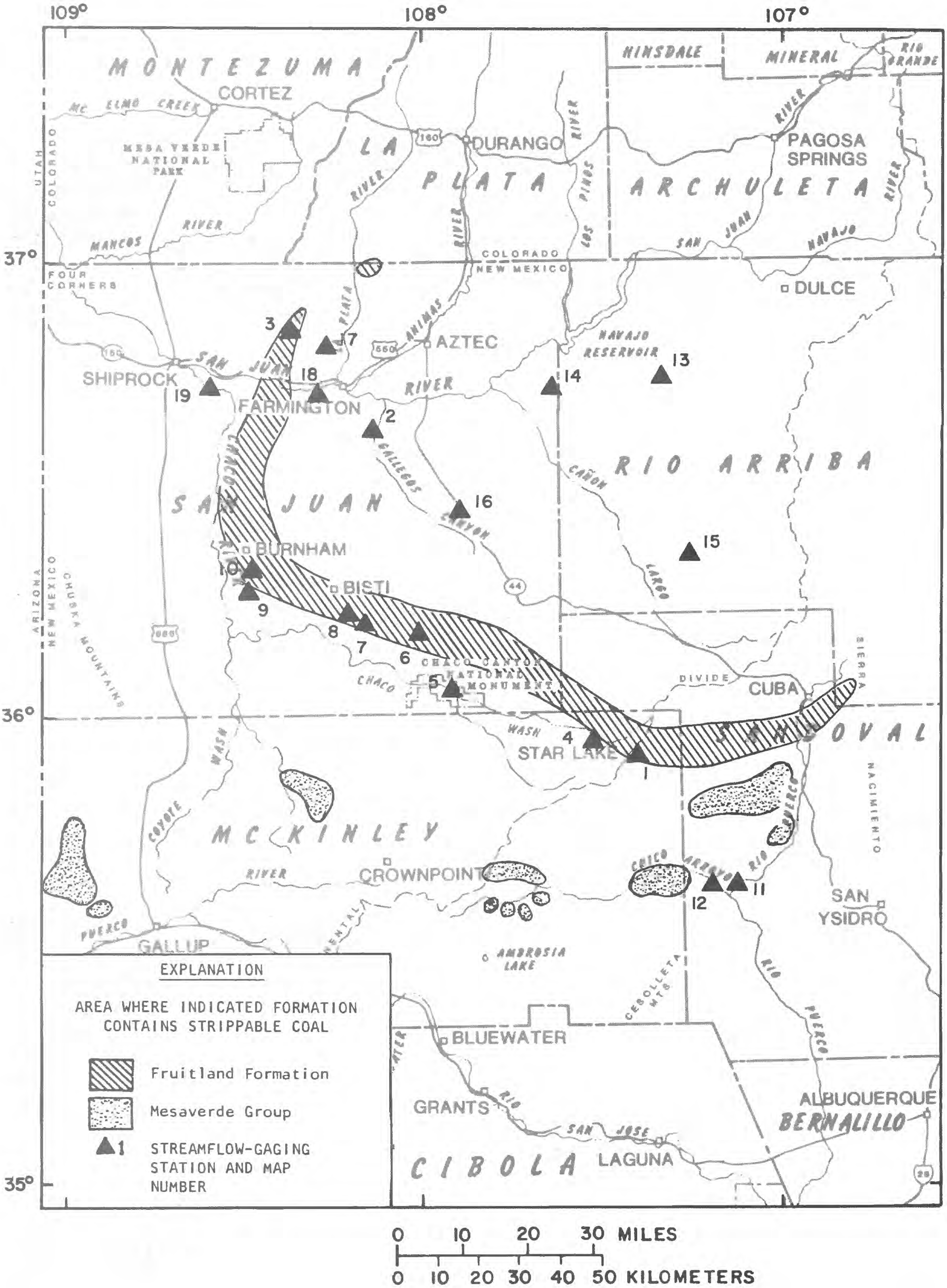

Figure 2.--Location of strippable coal and streamflow-gaging stations used in the analyses.

Table 1. Basin characteristics and mean annual runoff at ten streamflow-gaging stations.

[A, drainage area, in square miles; W_{AC}, width of active channel, in feet; $S_{10/85}$, main channel slope, in feet per mile; S_B, basin slope, in feet per mile; B_{SC}, bank silt-clay percentage; Q_A, mean annual runoff, in acre-feet.]

Map number	Station number	Station name	A	W_{AC}	$S_{10/85}$	S_B	B_{SC}	Period of record (years)	Q_A
1	08334300	Papers Wash near Star Lake Trading Post, New Mexico	20.3	3.4	60.4	311	82	4	108
2	09357250	Gallegos Canyon Wash near Farmington, New Mexico	290	198	37.4	304	12	4	544
3	09367555	Shumway Arroyo near Fruitland, New Mexico	62.8	10	61.7	779	36	6	456
4	09367660	Chaco Wash near Star Lake, New Mexico	59.0	4.6	24.3	238	75	4	601
5	09367680	Chaco Wash at Chaco Canyon National Monument, New Mexico	578	17	19.7	324	54	5	3620
6	09367685	Ah-shi-sle-pah Wash near Kimbeto, New Mexico	8.21	21	49.9	647	22	4	838
7	09367710	De-na-zin Wash near Bisti Trading Post, New Mexico	184	224	36.6	195	70	5	3660
8	09367930	Hunter Wash at Bisti Trading Post, New Mexico	45.6	68	37.0	234	32	6	565
9	09367934	Teec-ni-di-tso Wash near Burnham, New Mexico	7.20	54	72.9	275	16	4	78
10	09367936	Burnham Wash, near Burnham, New Mexico	8.60	14	56.2	230	32	4	214

Table 2. Basin characteristics and peak discharges at specified recurrence intervals at nine streamflow-gaging stations.

[Type of stream—e, ephemeral; i, intermittent; p, perennial. A, drainage area, in square miles; W_{AC}, width of active channel, in feet; L, length of main channel, in miles; B_{SC}, bank silt-clay percentage; S_B, slope of basin, in feet per mile; P_{2-100}, flood discharge of specific recurrence interval from 2 to 100 years, in cubic feet per second.]

Map number	Station number	Station name	Type of stream	A	W_{AC}	L*	B_{SC}	S_B	Period of record (years)	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}
11	08334000	Rio Puerco above Arroyo Chico, above Guadalupe, New Mexico	i	420	34	58.8	53	750	30	1,940	3,550	4,730	6,280	7,450	8,6
12	08340500	Arroyo Chico near Guadalupe, New Mexico	p	1,390	96	51.8	53	-	38	4,500	7,630	9,850	12,800	14,900	17,1
13	09355700	Gobernador Canyon near Gobernador, New Mexico	e	19.8	15	6.1	70	797	26	577	1,040	1,430	2,040	2,580	3,2
14	09356400	Manzanares Canyon, near Turley, New Mexico	e	3.20	14	2.0	26	1,660	26	380	715	1,050	1,600	2,100	2,
15	09356520	Burro Canyon near Lindrith, New Mexico	e	9.11	6.2	4.0	30	566	11	70	237	443	850	1,290	1,8
16	09357200	Gallegos Canyon tributary near Nageezi, New Mexico	e	.20	6.6	1.1	16	819	30	126	254	364	535	684	8
17	09367400	La Plata River tributary near Farmington, New Mexico	e	1.03	14	3.3	15	1,020	12	62	221	433	892	1,430	2,1
18	09367530	Locke Arroyo near Kirtland, New Mexico	e	2.96	9.7	5.4	28	562	31	92	251	415	697	967	1,2
19	09367950	Chaco River near Waterflow, New Mexico	p	4350	51	55.0	45	-	17	2,790	5,800	8,220	11,700	14,400	17,3

*Values from Thomas and Dunne, 1981.

ESTIMATION OF MEAN ANNUAL RUNOFF AND PEAK DISCHARGE

Regression Analyses

Regression analyses were used to determine relationships between selected streamflow characteristics (mean annual runoff and peak discharge at specified recurrence intervals) and selected basin characteristics in gaged basins. The objective was to develop equations that could be used to estimate streamflow characteristics in ungaged drainage basins.

The mathematical model used to develop equations to estimate streamflow characteristics is of the form:

$$Y = aX_1^{b_1} X_2^{b_2} \ldots X_n^{b_n} \qquad (1)$$

where Y is a dependent variable (streamflow characteristics);
a is a constant determined by statistical analysis;
X_1, X_2,...X_n are independent variables (basin characteristics); and
b_1, b_2,...b_n are coefficients of regression (exponents).

The logarithmic transform of equation 1 reduces to a regression model of the form:

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + \ldots + b_n \log X_n. \qquad (2)$$

Equation 2 can be the result of a simple-regression analysis (which includes only one independent variable) or multiple-linear-regression analysis (which includes two or more independent variables). Regression analyses were made by digital computer using the Statistical Package for Social Sciences (SPSS)* developed at the University of Chicago (Nie and others, 1975).

Equations For Estimating Mean Annual Runoff

Selected basin characteristics upstream from 10 streamflow-gaging stations are listed in table 1. The streams are not significantly affected by man's activities and are ephemeral (they flow only in direct response to precipitation, and the water table is below the stream channel at all times).

Simple-regression analyses of the data in table 1 indicated that drainage area is the only independent variable that is significant by itself for estimating mean annual runoff for ephemeral streams. The equation resulting from these analyses is:

$$Q_A = 51.4 A^{0.605} \qquad SE = 105 \qquad (3)$$

where Q_A is mean annual runoff, in acre-feet;
A is drainage area, in square miles; and
SE is the standard error of estimate, in percent.

*The use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

The exponent of equation 3 is significant at the 2-percent level (2 chances in 100 the exponent equals zero, no correlation), and the correlation coefficient is 0.74.

Multiple-regression analyses using forward (stepwise) inclusion of independent variables indicated that only one combination of independent variables was statistically significant in estimating mean annual runoff. The equation resulting from the multiple-regression analysis is:

$$Q_A = 0.249\ (W_{AC})^{0.682}\ (S_{10/85})^{-2.03}\ (S_B)^{1.56}\ (B_{SC})^{1.12} \qquad SE = 50 \qquad (4)$$

where Q_A is mean annual runoff, in acre-feet;
W_{AC} is width of active channel, in feet;
$S_{10/85}$ is slope of main channel, in feet per mile;
S_B is slope of basin, in feet per mile;
B_{SC} is silt-clay percentage of active-channel bank having the larger silt-clay percentage; and
SE is the standard error of estimate, in percent.

The partial regression coefficients of the independent variables, active-channel width and main-channel slope, are significant at the 1-percent level, whereas basin slope is significant at the 2-percent level and silt-clay percentage of active-channel bank is significant at the 5-percent level. The multiple-correlation coefficient of equation 4 is 0.96. However, the small sample size (ten) and small number of number of degrees of freedom (five) of the multiple-regression equation probably result in overstating both the correlation and the accuracy of the equation.

Silt-clay percentage and median particle size of opposite active-channel banks were tested in multiple-regression analyses. Both were found to be significant and correlated. However, the silt-clay percentage of the active-channel bank containing the larger silt-clay percentage at each site was more significant, and this value was used in equation 4 and is shown in table 1. Mean annual precipitation, altitude, and streambed material (silt-clay percentage and median particle size) were found to have little significance in multiple-regression analyses when estimating mean annual runoff.

The degree of significance of regression and partial-regression coefficients are dependent on degrees of freedom. Because of the small number of gaged sites available and short period of record for these and subsequent analyses, a Student's "t" distribution was used rather than a normal distribution to test the degree of significance of the regression coefficients. Also, plotting the residuals (the difference between the estimated and measured mean annual runoff) of equations 3 and 4 on a map shows no apparent trends of positive and negative values based on location of streamflow-gaging stations.

Equations For Estimating Peak Dishcarges

Regression analyses were used to develop equations for estimating peak discharges for 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals for ungaged streams. Data from nine gaged streams in different basins were available for regression analyses. Selected basin characteristics from these basins and results of frequency analysis of flood discharges are listed in table 2. The streams in table 2 consist of six ephemeral, one intermittent, and two perennial streams. Mine dewatering and powerplant discharges into the two perennial streams (sites 12 and 19) are assumed to have negligible effect on peak discharges.

Simple-regression analyses indicated that three independent variables were significant by themselves in estimating peak discharges of specified recurrence intervals. The equations resulting from these regression analyses are as follows:

$$P_2 = 107(A)^{0.433} \qquad SE = 91 \qquad (5)$$
$$P_5 = 268(A)^{0.396} \qquad SE = 60 \qquad (6)$$
$$P_{10} = 437(A)^{0.373} \qquad SE = 48 \qquad (7)$$
$$P_{25} = 738(A)^{0.345} \qquad SE = 38 \qquad (8)$$
$$P_{50} = 1030(A)^{0.326} \qquad SE = 33 \qquad (9)$$
$$P_{100} = 1400(A)^{0.307} \qquad SE = 32 \qquad (10)$$
$$P_2 = 3.55(W_{AC})^{1.64} \qquad SE = 78 \qquad (11)$$
$$P_5 = 12.9(W_{AC})^{1.47} \qquad SE = 54 \qquad (12)$$
$$P_{10} = 25.9(W_{AC})^{1.37} \qquad SE = 45 \qquad (13)$$
$$P_{25} = 55.1(W_{AC})^{1.26} \qquad SE = 38 \qquad (14)$$
$$P_{50} = 90.9(W_{AC})^{1.19} \qquad SE = 36 \qquad (15)$$
$$P_{100} = 142(W_{AC})^{1.12} \qquad SE = 35 \qquad (16)$$
$$P_2 = 57.7(L)^{0.924} \qquad SE = 112 \qquad (17)$$
$$P_5 = 151(L)^{0.852} \qquad SE = 77 \qquad (18)$$
$$P_{10} = 254(L)^{0.802} \qquad SE = 64 \qquad (19)$$
$$P_{25} = 445(L)^{0.744} \qquad SE = 54 \qquad (20)$$
$$P_{50} = 642(L)^{0.701} \qquad SE = 49 \qquad (21)$$
$$P_{100} = 893(L)^{0.662} \qquad SE = 47 \qquad (22)$$

where P_N is peak discharge at 2-, 5-, 10-, 25-, 50- or 100-year recurrence intervals, in cubic feet per second;
A is drainage area, in square miles;
W_{AC} is width of active channel, in feet;
L is length of main channel, in miles; and
SE is the standard error of estimate, in percent.

The coefficients of regression for equations 5 through 22 are significant at the 1-percent level. The correlation coefficients range from 0.89 to 0.96 for drainage area, 0.92 to 0.96 for width of active channel, and 0.84 to 0.92 for length of main channel.

Multiple-regression analyses using forward (stepwise) inclusion were made by initially including the independent variables found to be significant in the simple-regression analyses. The inclusion of more than two independent variables did not improve the equations for estimating peak discharges of the specified recurrence intervals. Equations resulting from these analyses are as follows:

$P_5 = 43.0(A)^{0.192}(W_{AC})^{0.850}$	SE = 44	(23)
$P_{10} = 86.0(A)^{0.192}(W_{AC})^{0.755}$	SE = 31	(24)
$P_{25} = 176(A)^{0.186}(W_{AC})^{0.664}$	SE = 20	(25)
$P_{50} = 280(A)^{0.180}(W_{AC})^{0.606}$	SE = 17	(26)
$P_{100} = 419(A)^{0.173}(W_{AC})^{0.560}$	SE = 18	(27)
$P_2 = 0.307(W_{AC})^{1.29}(B_{SC})^{0.988}$	SE = 63	(28)
$P_5 = 1.92(W_{AC})^{1.20}(B_{SC})^{0.769}$	SE = 43	(29)
$P_{10} = 5.22(W_{AC})^{1.14}(B_{SC})^{0.648}$	SE = 36	(30)
$P_{25} = 15.3(W_{AC})^{1.08}(B_{SC})^{0.518}$	SE = 32	(31)
$P_{10} = 0.0764(L)^{0.726}(S_B)^{1.21}$	SE = 44	(32)
$P_{25} = 0.298(L)^{0.667}(S_B)^{1.09}$	SE = 30	(33)
$P_{50} = 0.696(L)^{0.627}(S_B)^{1.02}$	SE = 24	(34)
$P_{100} = 1.43(L)^{0.589}(S_B)^{0.961}$	SE = 23	(35)

where P_N is peak discharge at the specified recurrence interval, in cubic feet per second;
A is drainage area, in square miles;
W_{AC} is width of active channel, in feet;
B_{SC} is bank silt-clay percentage of active-channel bank having the larger silt-clay percentage;
L is length of main channel, in miles;
S_B is slope of basin, in feet per mile; and
SE is standard error of estimate, in percent.

The degree of significance of the exponents of the independent variables in equations 23 to 35 ranges from 1 to 10 percent. The independent variable having the more significant partial-coefficient of regression is entered in the regression equation first. In general, the degree of significance of the coefficients of regression increases with increases in the flood magnitude. The multiple-correlation coefficients range from 0.90 to 0.98.

The silt-clay percentage and the median particle size of opposite banks were tested in multiple-regression analyses. The larger silt-clay percentage was determined to be slightly more significant than the smaller silt-clay percentage; the larger values were used in the equations and are shown in tables 1 and 2. Median particle size was found to be slightly less significant than silt-clay percentage.

Equations based on certain combinations of independent variables for some recurrence intervals are not presented because the coefficients of regression for these variables were not significant at the 10-percent level. These variables are (1) drainage area and width of active channel for predicting peak discharge for 2-year recurrence interval, (2) silt-clay percentage of active-channel bank and width of active channel for predicting peak discharges for 50- and 100-year recurrence intervals, and (3) slope of basin for predicting peak discharges for 2- and 5-year recurrence intervals.

Basin characteristics found not to be significant at the 10-percent level in multiple-regression analyses when estimating peak discharges were average annual precipitation, altitude, streambed material (silt-clay percentage and median-particle size of the streambed), flow duration, and slope of main channel.

The residuals of equations 5 to 35 were plotted on a map. There were no apparent trends of positive and negative values based on location of streamflow-gaging station.

Limitations of Equations

The equations in this report define relations only in the vicinity of the basins with streamflow gages and reflect the range in data used in the regression analyses. Caution needs to be exercised when estimating streamflow characteristics outside this area. Equations 3 and 4 were developed for estimating mean annual runoff based on only 4 to 6 years of streamflow record on ephemeral streams (table 1), which may not be representative of long-term means. Equations 5 to 35 were developed for estimating peak discharges for specified recurrence intervals based on data from ephemeral, intermittent, and perennial streams (table 2). It is assumed that the effect of man's activities on streamflow is negligible. Because of the length of records and number of peaks below the gage base at some of the sites, the peak-discharge estimates may not be well defined, particularly for the 50- and 100-year recurrence intervals. Note that the geographical area used to develop peak-discharge equations for specified recurrence intervals (stations 11-19 on fig. 2) is larger than the geographical area used in the analyses for developing equations for mean annual runoff (stations 1-10 on fig. 2).

Because of the small sample sizes, the degrees of freedom of the equations are quite limited. This undoubtedly causes correlation coefficients and standard errors of estimate to be overstated. The user needs to recognize that the errors in applying these relations at ungaged sites will probably be significantly larger than the standard errors of estimate shown with the equations.

Applications of Equations

The equations were developed to estimate selected streamflow characteristics at ungaged basins and are applicable as specified in the previous section. For example, assume mean annual runoff and the 100-year peak discharge need to be determined for an ungaged drainage basin in the study area that has a drainage area of 100 square miles, an active-channel width at the outlet of the basin of 30 feet, slope of main channel of 40 feet per mile, slope of basin of 300 feet per mile, and silt-clay percentage of active-channel bank of 40 percent. The computations follow:

$$Q_A = 51.4\ A^{0.605} \qquad SE = 105 \qquad (3)$$
$$Q_A = 51.4\ (100)^{0.605}$$
$$Q_A = 834 \text{ acre-feet}$$

$$Q_A = 0.249(W_{AC})^{0.682}(S_{10/85})^{-2.03}(S_B)^{1.56}(B_{SC})^{1.12} \qquad SE = 50 \qquad (4)$$
$$Q_A = 0.249\ (30)^{0.682}\ (40)^{-2.03}\ (300)^{1.56}\ (40)^{1.12}$$
$$Q_A = 646 \text{ acre-feet}$$

$$P_{100} = 1{,}400\ A^{0.307} \qquad SE = 32 \qquad (10)$$
$$P_{100} = 1{,}400\ (100)^{0.307}$$
$$P_{100} = 5{,}760 \text{ cubic feet per second}$$

$$P_{100} = 142(W_{AC})^{1.12} \qquad SE = 35 \qquad (16)$$
$$P_{100} = 142\ (30)^{1.12}$$
$$P_{100} = 6{,}410 \text{ cubic feet per second}$$

$$P_{100} = 419\ A^{0.173}\ (W_{AC})^{0.560} \qquad SE = 18 \qquad (27)$$
$$P_{100} = 419\ (100)^{0.173}\ (30)^{0.560}$$
$$P_{100} = 6{,}240 \text{ cubic feet per second}$$

Two values may be obtained for mean annual runoff and three values may be obtained for estimating the 100-year peak discharge with the information available. Because of the small sample sizes used to define the equations, the standard error of estimate is a poor measure of the standard error of prediction (error in application at sites not used in defining the equation). Therefore, the separate estimates of standard error need to be averaged.

Comparison with Previously Developed Equations

Equations to estimate selected streamflow characteristics for northwestern New Mexico were presented in a preliminary report (Hejl, 1980). However, the equations in the present report are restricted to a smaller region within the study area of the previous report (Hejl, 1980) and should be more representative of the streamflow characteristics found in the strippable coal-resource area of northwestern New Mexico. The equations presented here resulted in smaller standard errors of estimate and greater significance levels for identical independent variables than the previous equations.

Peak discharges estimated from the equations in this report generally are larger than those estimated from the equations in Hejl (1980). The equation presented here for estimating mean annual runoff based on drainage area also results in a larger value than the equation in Hejl (1980).

SUMMARY

Equations are presented in this report for estimating mean annual runoff and peak discharges for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals for ungaged streams in drainage basins containing strippable coal resources in northwestern New Mexico. The relationships of these streamflow characteristics to basin characteristics were determined using regression techniques.

In the estimation of mean annual runoff, simple-regression analyses indicated drainage area to be the most significant basin characteristic. Multiple-regression analyses indicated the combination of active-channel width, main-channel slope, basin slope, and silt-clay percentage of active-channel bank to be most significant.

In the estimation of peak discharges at specified recurrence intervals, simple-regression analyses indicated drainage area, active-channel width, and main-channel length to be the most significant basin characteristics. Multiple-regression analyses indicated the following combinations to be most significant: (1) Drainage area and active-channel width; (2) active-channel width and silt-clay percentage of active-channel bank; and (3) main-channel length and basin slope.

The basin characteristics determined in this study not to be significant at the 10-percent level when related to peak discharge characteristics were average annual precipitation, altitude, streambed median particle size and silt-clay percentage, slope of main channel, and flow duration. Precipitation, altitude, and streambed material were found to have significance when estimating mean annual runoff.

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