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Estimating the Magnitude of Bankfull Flows for Streams in Idaho

Water-Resources Investigations Report 03–4261

U.S. Department of the Interior
U.S. Geological Survey

The following errors were corrected on June 16, 2004: Page 6, table 2, description of basin slope, "feet per mile" was changed to "percent"; Page 9, table 3, headnote, basin slope in "feet per mile" was changed to basin slope in "percent"; Page 17, appendix A, headnote, "feet per mile" was removed.

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Tables

Conversion Factors, Water Year Definition, and Vertical Datum

Multiply	**By**	**To obtain**
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
inch (in.)	2.54	centimeter (cm)
inch per year (in/yr)	2.54	centimeter per year (cm/yr)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

Water year: In U.S. Geological Survey reports dealing with surface-water supply, a water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends; thus, the water year ending September 30, 2001, is called the “2001 water year.”

Sea Level: In this report, “sea level” refers to the North American Vertical Datum of 1988 (NAVD of 1988)—a vertical control datum established by the minimum-constraint adjustment of Canadian-Mexican-United States leveling observations and held fixed at Father Point/Rimouski, Quebec, Canada.

Estimating the Magnitude of Bankfull Flows for Streams in Idaho

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Abstract

Methods for estimating magnitudes of peak flows with recurrence intervals of 1.5 and 2.33 years were developed for ungaged sites on streams throughout Idaho. These peak flows represent the magnitudes at and near bankfull stage and are needed for quantification of water rights required to maintain or restore fish and wildlife habitats and riparian vegetation. Data from a previous report detailing methods for estimating magnitudes with recurrence intervals of 2 to 500 years were used in this study.

Generalized least-squares regression techniques were used to calculate the final coefficients and measures of accuracy for the regression equations for each of nine regions. The equations relate basin and climatic characteristics to peak flows with recurrence intervals of 1.5 and 2.33 years. The basin and climatic characteristics used to develop the equations included drainage area, mean basin elevation, forested area, mean annual precipitation, basin slope, north-facing slopes greater than 30 percent, and slopes greater than 30 percent. Average standard errors of the regression model ranged from +150 to -60.1 percent, and average standard errors of prediction ranged from +165 to -62.2 percent. The range of prediction errors was narrowest, -48.9 to-32.9 percent, for region 5.

A computer program was developed to automate the calculations required for the regional regression calculations. Results from this program comprised calculated peak flows, site-specific standard errors of prediction, and the 90-percent confidence intervals for the estimates.

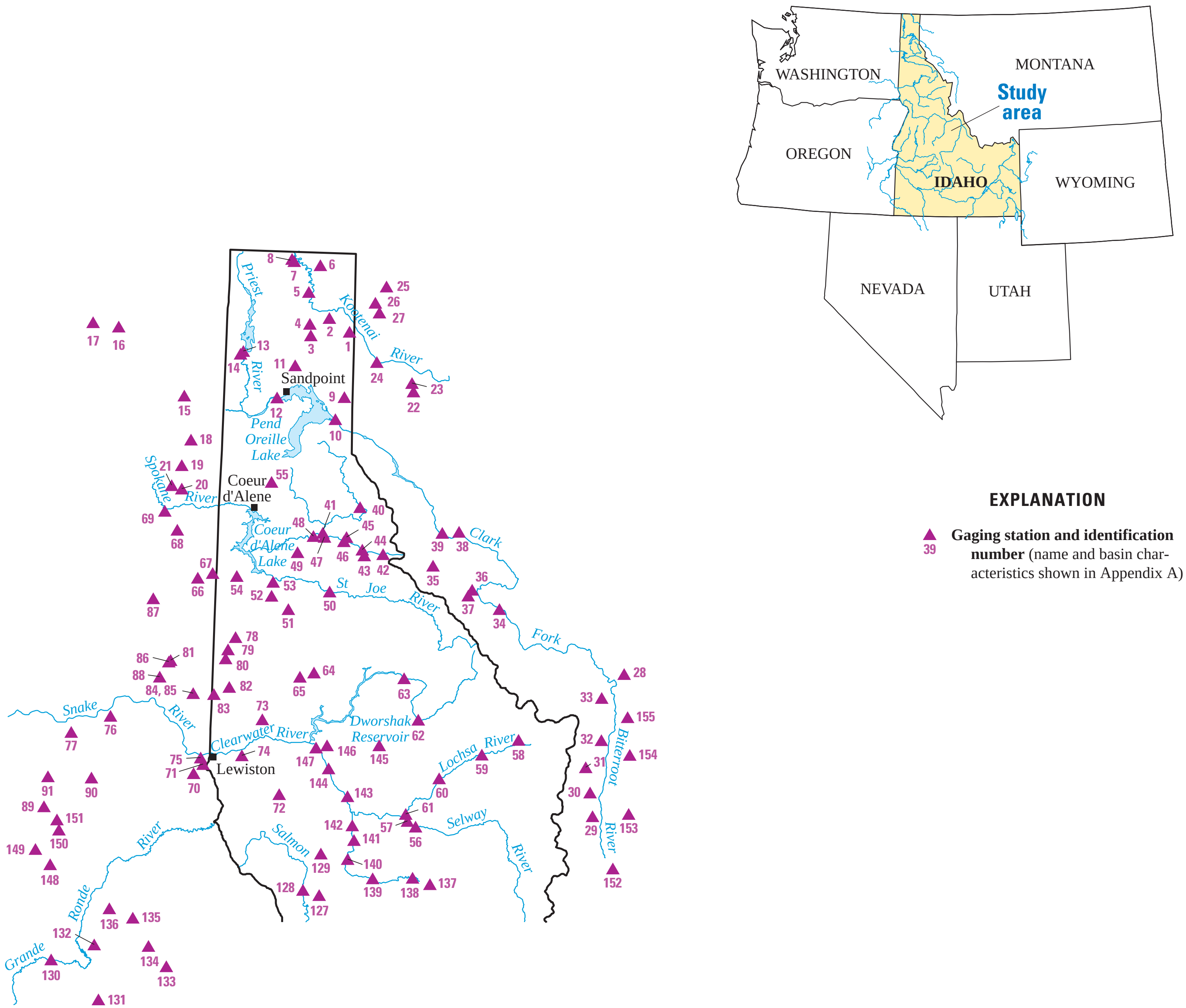
INTRODUCTION

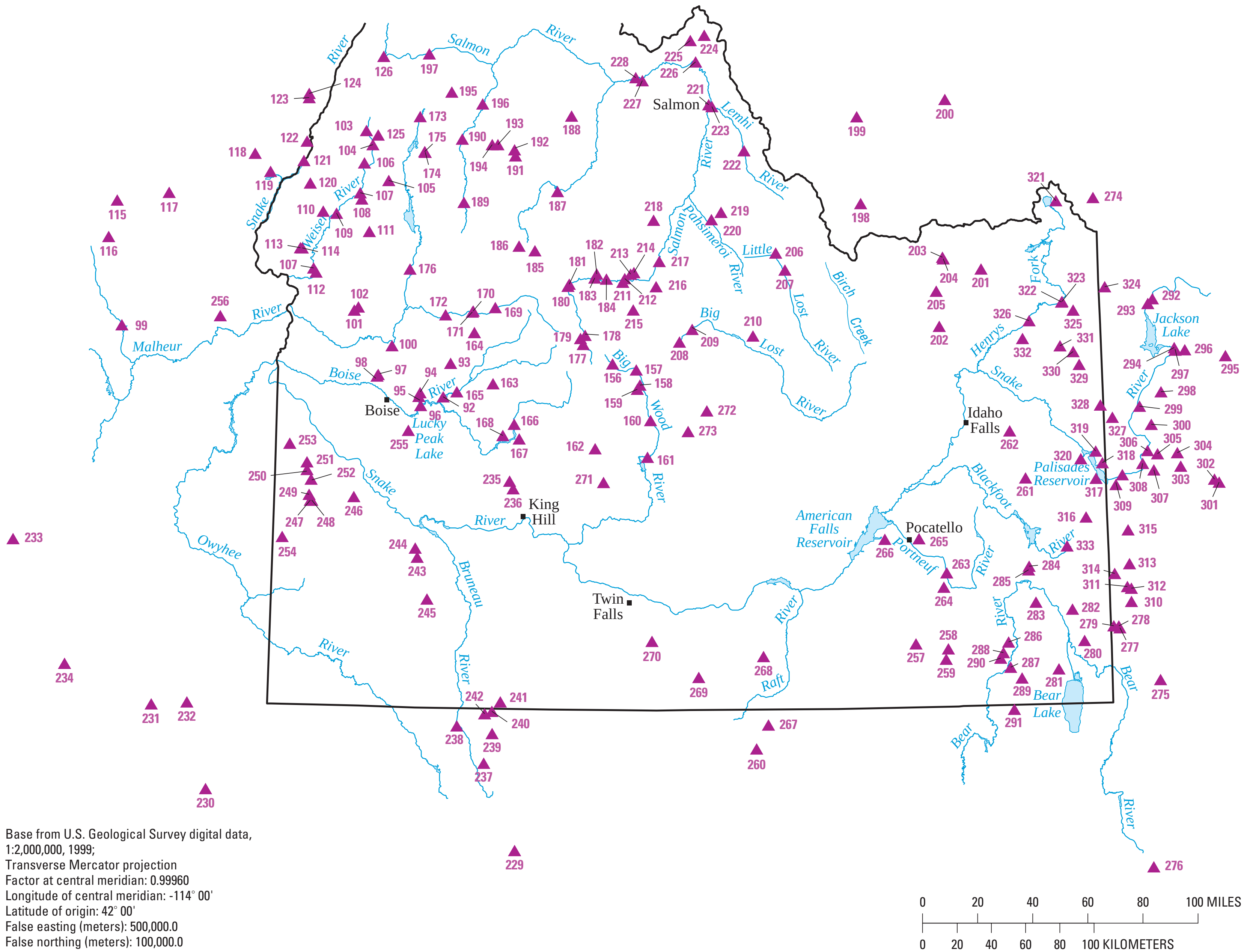
Estimates of the magnitude and frequency of peak flows are used for a variety of purposes, such as the design of bridges, culverts, and flood-control structures, and the management and regulation of flood plains. For these purposes, peak-flow recurrence intervals generally are 50 years or greater. However, there is increasing interest in peak flows with a more frequent recurrence interval and their role in maintaining aquatic and riparian ecosystems. Of particular interest are those peak flows necessary for mobilization of streambed sediments to maintain long-term fish habitat and channel capacity.

The U.S. Forest Service (USFS) in Idaho has been involved in the quantification of instream flows as part of the ongoing Snake River Basin Adjudication, as well as for general planning and administrative purposes. One key component of instream flows proposed by the Forest Service is the high flow regime necessary to sustain long-term aquatic and riparian ecosystems. Methods used to estimate the range of flows that constitute this high flow regime include using bankfull discharge or a percentage of bankfull discharge.

Most hydrologists agree that peak flows with a recurrence interval of about 1.5 years best represent bankfull flows. Leopold (1994) stated that the recurrence interval of bankfull discharges generally ranges from 1 to 2.5 years and that the 1.5-year peak flow is a reasonable average. Similarly, a regional study completed by Castro and Jackson (2001) suggests that the average recurrence interval for bankfull flows in the Pacific Northwest States (Oregon, Washington, and Idaho) is 1.4 years, and the 1.5-year interval is suggested for use in Idaho. Emmett (1975) also found that the average recurrence interval for bankfull discharges in the upper Salmon River Basin is about 1.5 years.

Currently, peak-flow recurrence interval information is available only for gaged sites (sites where streamflow-gaging stations, or gages, have been established) that have at least 10 years of annual peak-flow record. Berenbrock (2002) developed regional peak-flow regression equations for ungaged streams in Idaho; however, the minimum recurrence interval for


WASHINGTON
MONTANA
Study area
OREGON
IDAHO
WYOMING
NEVADA
UTAH
Sandpoint
Coeur d'Alene
Lewiston
Priest River
Kootenai River
Pend Oreille Lake
Spokane River
Coeur d'Alene Lake
St Joe River
Clark Fork
Snake River
Clearwater River
Dworshak Reservoir
Lochsa River
Selway River
Salmon River
Bitterroot River
Grande Ronde River
EXPLANATION
Gaging station and identification number (name and basin characteristics shown in Appendix A)



Base from U.S. Geological Survey digital data,
1:2,000,000, 1999;
Transverse Mercator projection
Factor at central meridian: 0.99960
Longitude of central meridian: -114° 00'
Latitude of origin: 42° 00'
False easting (meters): 500,000.0
False northing (meters): 100,000.0

Figure 1. Locations of streamflow-gaging stations in Idaho and bordering States used in regional regression analysis.

these equations was 2 years and did not include the 2.33-year recurrence interval, which is also a standard output from the U.S. Geological Survey (USGS) flood-frequency program.

In 2003, using data obtained for Berenbrock's 2002 study, the USGS conducted a study in cooperation with the USFS to develop additional regional regression equations that can be used to estimate bankfull flows. The equations developed in this study will provide more accurate estimates of bankfull flows for ungaged streams in Idaho.

Purpose and Scope

This report documents the development of regression equations used for estimating the magnitude of peak flows with recurrence intervals of 1.5 and 2.33 years. Equations for peak flows with a 2-year recurrence interval estimated previously by Berenbrock (2002) also are presented. Data from Berenbrock's study of 333 gaging stations with at least 10 years of record through water year 1997 were used to develop the regression equations for this study. The equations are in the same format and were developed for the same regions as those provided in Berenbrock's study. Standard errors of estimates are included to help predict the reliability and accuracy of each equation.

Description of Study Area

The study area (fig. 1) is the entire State of Idaho and areas of adjacent States where particular drainage basins cross over State boundaries. The adjacent States partially included in the study area are Washington, Oregon, Nevada, Utah, Wyoming, and Montana. The northern and central parts of the area comprise mainly rugged, mountainous terrain; broad plains and mildly sloping valleys and hills predominate in the south. Geologic features across the study area consist of sedimentary, igneous, and metamorphic rocks ranging in age from Precambrian to Holocene (Bond, 1978). The granitic Idaho batholith is the major structural feature in the central part of the study area, and basalt covers much of the southern and western parts (Ross and Savage, 1967).

Most precipitation in the study area results from storms moving inland from the Pacific Ocean. The amount of precipitation varies widely and is greatly affected by topography. Precipitation ranges from less than 10 in/yr on the Snake River Plain in south-central Idaho to 60 to 70 in/yr in the central mountains of Idaho (Molnau, 1995). Precipitation is greatest during the winter and the most significant amounts are a direct result of orographic effects. Spring and summer thunderstorms in the southern part of the study area sometimes produce large amounts of precipitation. Resulting streamflow varies geographically and seasonally and can be affected by land use and vegetation. During much of the year, streamflow in most unregulated streams in the study area is minimal base flow; during April, May, June, and July, streamflow is significantly higher, primarily as a result of snowmelt. Occasionally during the winter months, large frontal systems carrying warmer air release moisture as rain on the snowpack and frozen ground, which results in rapid snowmelt and high runoff rates, particularly at elevations less than 6,000 ft above sea level (National Oceanic and Atmospheric Administration, 1971).

Acknowledgments

The authors recognize the hard work and dedication of the many USGS hydrologic technicians and hydrologists in collecting, processing, and storing the peak-flow data necessary for the completion of this report. Also, the authors appreciate the assistance of the many Federal, State, and local agencies that financially support operations of streamflow-gaging stations throughout Idaho where peak-flow data are collected.

PREVIOUS INVESTIGATIONS

Emmett (1975) developed equations that related bankfull discharge to other channel-geometry and flow characteristics in the upper Salmon River Basin in south-central Idaho. The main assumption in the study was that river channels are shaped by the dominant flow, which was defined as the bankfull flow. Only equations for the 1.5-year recurrence interval flood (assumed to be the bankfull flow) were developed during Emmett's study.

Harenberg (1980) developed several sets of regression equations for Idaho on the basis of channel-geometry and basin characteristics. He developed equations to predict the 1.25-, 2-, 5-, 10-, 25-, 50-, and 100-year peak flows at ungaged sites. The characteristics in the final equations were bankfull width, drainage area, and 24-hour rainfall intensity for the 2-year recurrence interval. He used fewer gaging stations than previous flood-frequency studies because channel-geometry characteristics could not be determined at every gaging station. He demonstrated that standard errors were smaller when channel-geometry variables were included with basin characteristics in regression equations, but standard errors in his study were 20 to 30 percent larger than those in Berenbrock's (2002) study; Berenbrock's dataset was approximately twice as large as Harenberg's. Regional regression equations for estimating streamflow statistics in the Western United States were developed by Hedman and Osterkamp (1982). The regression equations were developed for various streamflow statistics using channel geometry. However, data from only three gages in Idaho (located on tributaries to the Snake River) were used in their analysis.

COMPILATION OF DATA

All data used to develop regression equations for estimating peak flows with recurrence intervals of 1.5 and 2.33 years were obtained from the report by Berenbrock (2002). These data consisted of basin and climatic characteristics and peak-flow records for each of the relevant gaging stations. In addition, the regional boundaries determined by Berenbrock (2002) also were used in this study.

Basin and Climatic Characteristics

Use of the same independent variables in each of the peak-flow equations for a specific region ensures that the correlation structure among the streamflow statistics for each region is preserved so that estimates of the statistics are stable and consistent (Haan, 1977). For this reason, equations developed in this study use the same independent variables (basin and climatic characteristics) as the equations developed by Berenbrock (2002) for each region. Thus, the same seven basin and climatic characteristics used by Berenbrock—drainage area (DA), mean basin elevation (E), forested area (F), mean annual precipitation (P), basin slope (BS), north-facing slopes greater than 30 percent (NF30), and slopes greater than 30 percent (S30)—also were used in this analysis. Data sources used to obtain these characteristics are listed in table 1, general descriptions of the seven characteristics used in the final equations are listed in table 2, and basin and climatic characteristic values obtained for each gaging station are listed in appendix A (back of report; table 4

Table 1. Selected data sources used to obtain basin and climatic characteristics for regional regression analysis

[Multiply meter by 3.281 to obtain foot; multiply kilometer (km) by 0.6214 to obtain mile]

Dataset name	Source description
National Elevation Dataset (NED)	Basin characteristics were calculated using 30-meter resolution digital elevation data; http://gisdata.usgs.gov/ned/default.asp
National Elevation Dataset Hydrologic Derivatives (NED-H)	Hydrologic derivatives of NED data were developed using procedures similar to those in Stage 1 processing, using a custom projection for Idaho; http://edcnts12.cr.usgs.gov/ned-h/about/Stage1.html
National Land Cover Dataset (NLCD)	Vogelmann, J.E., Sohl, T.L., Campbell, P.V., and Shaw, D.M., 1998, Regional land cover characterization using Landsat Thematic Mapper data and ancillary data sources: Environmental Monitoring and Assessment, v. 51, p. 415–428 (http://edcwww.cr.usgs.gov/programs/lccp)
Idaho map of mean annual precipitation[1]	Molnau, M., 1995, Mean annual precipitation, 1961–1990, Idaho: Moscow, University of Idaho, Agricultural Engineering Department, State Climate Program, scale 1:1,000,000 (http://snow.ag.uidaho.edu/Climate/reports.html)
Western United States average monthly or annual precipitation[2]	Daly, C., and Taylor, G., 1998, Western United States average monthly or annual precipitation, 1961–90, Oregon: Portland, Water and Climate Center of the Natural Resources Conservation Service, grid-cell resolution 4 km (http://www.ocs.orst.edu/prism/prism_new.html)

[1] Used for areas in Idaho.
[2] Used for areas outside of Idaho.

Table 2. Description of selected basin and climatic characteristics used in the final predictive equations

[Multiply meter by 3.281 to obtain foot; multiply kilometer (km) by 0.6214 to obtain mile]

Characteristic	Description
Drainage area (DA)	Drainage area of the basin that contributes surface runoff, in square miles; estimated using Arc/Info Grid with 30-meter resolution digital elevation models (DEMs)
Mean basin elevation (E)	Mean elevation of the basin, in feet above sea level; estimated using Arc/Info Grid and averaging elevations using 30-meter resolution DEMs
Forested area (F)	Area of the basin containing forest, in percent of total drainage area; estimated using Arc/Info Grid with a 37-meter resolution land cover grid
Mean annual precipitation (P)	Mean annual precipitation over the entire drainage area, in inches; estimated using Arc/Info Grid with a combination of 500-meter (within Idaho) and 4-km (outside of Idaho) resolution precipitation grids
Basin slope (BS)	Average slope of the basin, in percent; estimated using the "average maximum technique" in Arc/Info Grid with 30-meter resolution DEMs
North-facing slopes greater than 30 percent (NF30)	Area of north-facing slopes with slopes greater than 30 percent, in percent of drainage area; estimated using the "average maximum technique" in Arc/Info Grid with 30-meter resolution DEMs
Slopes greater than 30 percent (S30)	Area with slopes greater than 30 percent, in percent of drainage area; estimated using the "average maximum technique" in Arc/Info Grid with 30-meter resolution DEMs

in Berenbrock, 2002). Detailed information concerning how these values were obtained can be found in Berenbrock's report (2002, p. 5).

Peak-Flow Data

Peak-flow data from 333 gaging stations (fig. 1; appendix B, back of report) with at least 10 years of record through water year 1997 (Berenbrock, 2002) were used in this analysis. These data represented naturally occurring flows that were not affected by regulation or large irrigation diversions. Most data were from continuous-record sites where stage is recorded at a fixed interval, typically ranging from 15 to 60 minutes. Some data were collected at crest-stage sites where only the peak, or highest stage that occurs between site visits (usually several months), is recorded.

Determination of Regions

Because of the need for stable and consistent estimates at a specific site, the same region boundaries defined by Berenbrock (2002) also were used in this analysis. This resulted in nine separate study regions and one undefined region (fig. 2). The undefined region is almost entirely made up of the area commonly referred to as the eastern Snake River Plain. This area includes several dams, major irrigation diversions, springs with extremely large discharges, and channel bottoms with very high infiltration rates. Because flows influenced by these conditions cannot be characterized by a regional regression approach, this area was not included in the analysis. More detailed information on how the regional boundaries were determined can be found in previous reports by Berenbrock (2002, p. 8) and Hortness and Berenbrock (2001, p. 6).

ESTIMATION METHODS

Regional regression equations that can be used to estimate the magnitude of peak flows with recurrence intervals of 1.5 and 2.33 years at ungaged sites were developed during this study. Equations for estimating peak flows with a recurrence interval of 2 years that were developed by Berenbrock (2002) also are included for comparison.

Regression techniques were used to define a set of predictive equations that related peak flows with recur-

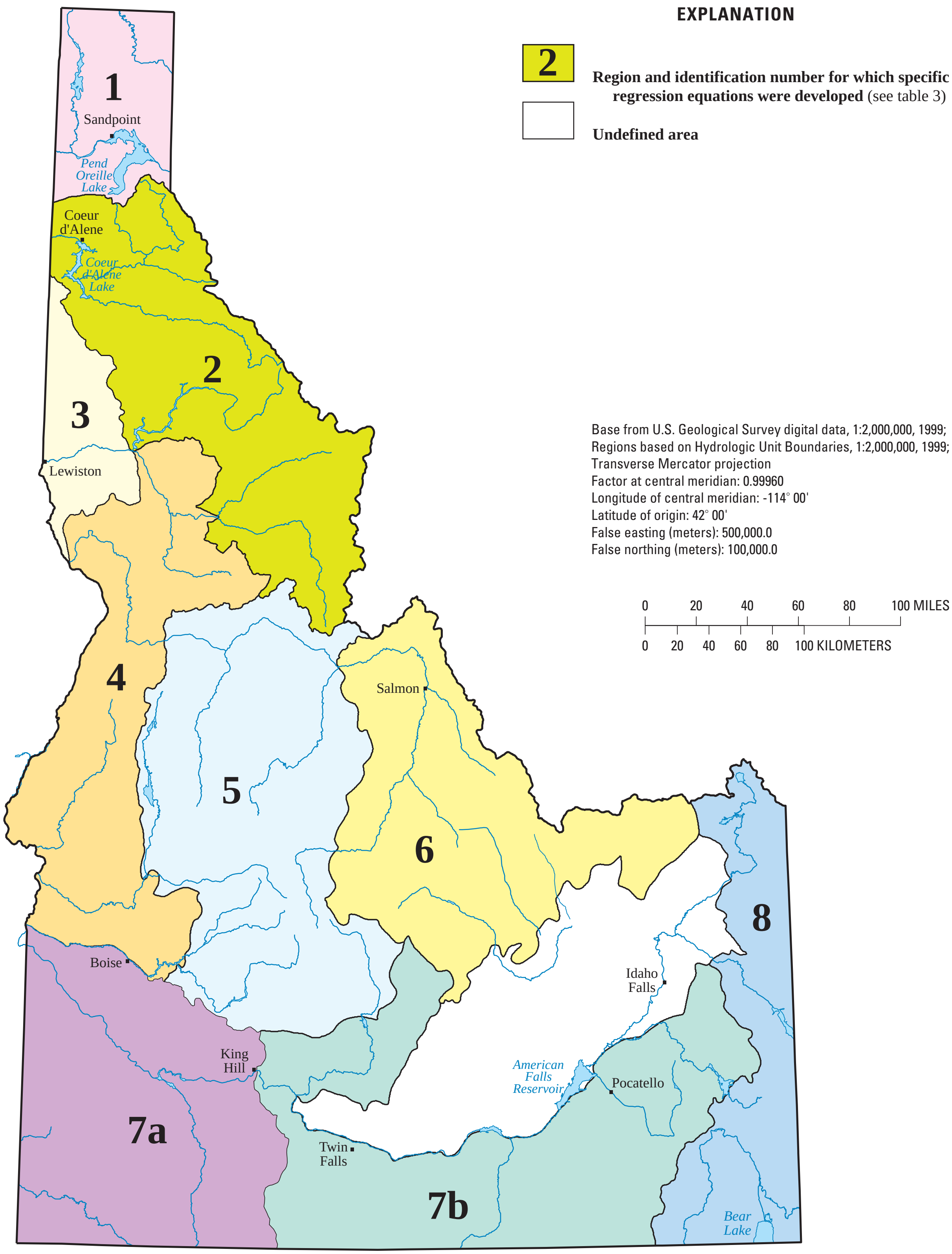


Figure 2. Locations of regions in Idaho used in regional regression analysis.

rence intervals of 1.5 and 2.33 years to selected basin and climatic characteristics for each region in Idaho. The initial step involved performing a flood-frequency analysis of the peak-flow data for each gaging station to determine the peak-flow values for selected recurrence intervals. Next, all the peak-flow, basin, and climatic characteristic data were transformed to base-10 logarithms to obtain a linear regression model and to achieve equal variance about the regression line. Equal variance about the regression line satisfies the basic assumption that the distribution of errors is normal and constant throughout the range (Riggs, 1968). Prior to the transformation, a value of 1 was added to data that were a measure of percentage (such as forest cover) to ensure that no 0 values, which cannot be transformed, were present. Also, mean basin elevation (E) values were divided by 1,000 to allow for more convenient coefficients in the final equations.

Finally, using the same explanatory variables for each region as defined by Berenbrock (2002), generalized least-squares (GLS) regression techniques were used to calculate the final coefficients and measures of accuracy for the regression equations for each region. GLS techniques (Stedinger and Tasker, 1985) can account for correlation between sites, differences in record lengths, and variability of peak flows at gaged sites. These factors are accounted for by assigning different weights to each observation of the peak flow on the basis of its contribution to the total variance of the sample flow statistic. A more detailed discussion of how GLS accounts these factors can be found in Berenbrock's (2002, p. 13) report.

RESULTS

Drainage area (DA), mean basin elevation (E), mean annual precipitation (P), forest cover (F), north-facing slopes greater than 30 percent (NF30), basin slope (BS), and slopes greater than 30 percent (S30) were the explanatory variables that were included in regression equations. No equation included more than three explanatory variables, and region 7b was the only region that included only one explanatory variable (DA).

The standard error of the regression model and the average standard error of prediction also are listed in table 3. The standard error of the regression analysis (model) is a measure of how well the regression model fits the data used to construct it. This error term also is often referred to as the standard error of estimate. The average standard error of prediction is the sum of two components—model error plus sampling error—which results from estimating model parameters from samples of the population. The model error is a characteristic of the model and is a constant for all sites. The sampling error for a given site, however, depends on the values of the explanatory variables used to develop the peak-flow estimate at that site and, thus, varies from site to site. The standard error of prediction provides a better overall measure of a model's predictive reliability than does the model error. A more rigorous mathematical description of these errors and how to convert them from logarithms (base-10 units) to percent errors is given in a report by Pope and Tasker (1999, p. 12).

Standard errors of the model were different for each region and for each recurrence interval (table 3). The largest and smallest average standard errors of the model were +150 and −60.1 percent (region 7b, Q1.5) and +42.9 and −30.0 percent (region 5, Q2.33), respectively. Similarly, the largest and smallest average standard errors of prediction were +165 and −62.2 percent (region 7b, Q1.5) and +45.9 and −31.5 percent (region 5, Q2.33), respectively (table 3). Overall, region 5 equations would be expected to have the smallest error and region 7b equations would be expected to have the largest error. The larger errors associated with the region 7b equations likely result from use of a small number of gaging stations (17) in a region of more diverse geology, which can have unknown effects on small peak flows.

LIMITATIONS

The average standard errors of prediction given in table 3 represent the general measure of how well the regional regression equations will estimate peak flows when they are applied to ungaged sites. The accuracy of the equations will be reduced if the values of explanatory variables are outside the range of the values used to develop the equations. The magnitude of this reduction in accuracy is unknown. Standard errors of prediction vary from site to site, depending on the values of the explanatory variables for each site. The standard errors of prediction will be smaller for sites where values of the explanatory variables are near the mean of their range. If the value of an explanatory variable used

Table 3. Predictive regression equations and their accuracy in estimating peak flows for ungaged sites on unregulated and undiverted streams in Idaho

[Q, peak flow, in cubic feet per second; DA, drainage area, in square miles; E, mean basin elevation, in feet; F, percentage of forest cover in the basin; P, mean annual precipitation, in inches; NF30, percentage of north-facing slopes greater than 30 percent; S30, percentage of slopes greater than 30 percent; and BS, average basin slope, in percent]

Peak-flow regression equations for given recurrence interval	Standard error of model (percent)	Standard error of prediction (percent)
Region 1 (Data were based on 21 gaging stations)		
$Q_{1.5} = 0.748\ DA^{0.802}\ (E/1{,}000)^{3.28}\ (F + 1)^{-0.283}$	+76.7 to −43.4	+87.1 to −46.5
[1]$Q_2 = 2.52\ DA^{0.775}\ (E/1{,}000)^{3.32}\ (F + 1)^{-0.504}$	+69.0 to −40.8	+78.4 to −43.9
$Q_{2.33} = 3.90\ DA^{0.764}\ (E/1{,}000)^{3.32}\ (F + 1)^{-0.577}$	+65.1 to −39.4	+73.9 to −42.5
Region 2 (Data were based on 44 gaging stations)		
$Q_{1.5} = 0.508\ DA^{0.901}\ (E/1{,}000)^{0.132}\ P^{0.926}$	+61.4 to −38.1	+65.5 to −39.6
[2]$Q_2 = 0.742\ DA^{0.897}\ P^{0.935}$	+60.2 to −37.6	+64.2 to −39.1
$Q_{2.33} = 0.863\ DA^{0.894}\ (E/1{,}000)^{-0.0587}\ P^{0.941}$	+59.9 to −37.4	+63.9 to −39.0
Region 3 (Data were based on 26 gaging stations)		
$Q_{1.5} = 12.6\ DA^{0.879}\ (E/1{,}000)^{-0.161}$	+98.1 to −49.5	+108 to −52.0
[1]$Q_2 = 26.3\ DA^{0.864}\ (E/1{,}000)^{-0.502}$	+78.3 to −43.9	+86.4 to −46.4
$Q_{2.33} = 45.0\ DA^{0.856}\ (E/1{,}000)^{-0.849}$	+70.5 to −41.3	+77.9 to −43.8
Region 4 (Data were based on 60 gaging stations)		
$Q_{1.5} = 9.49\ DA^{0.903}\ (E/1{,}000)^{0.055}$	+89.2 to −47.2	+92.6 to −48.1
[1]$Q_2 = 16.3\ DA^{0.893}\ (E/1{,}000)^{-0.121}$	+80.5 to −44.6	+83.5 to −45.5
$Q_{2.33} = 20.3\ DA^{0.890}\ (E/1{,}000)^{-0.193}$	+77.2 to −43.6	+80.1 to −44.5
Region 5 (Data were based on 46 gaging stations)		
$Q_{1.5} = 0.0157\ DA^{1.01}\ P^{2.34}\ (NF30 + 1)^{-0.696}$	+45.6 to −31.3	+48.9 to −32.9
[1]$Q_2 = 0.0297\ DA^{0.995}\ P^{2.20}\ (NF30 + 1)^{-0.664}$	+43.6 to −30.4	+46.7 to −31.8
$Q_{2.33} = 0.0388\ DA^{0.990}\ P^{2.13}\ (NF30 + 1)^{-0.651}$	+42.9 to −30.0	+45.9 to −31.5
Region 6 (Data were based on 31 gaging stations)		
[3]$Q_{1.5} = 1.41 \cdot 10^{-4}\ DA^{0.904}\ P^{3.25}$	+72.4 to −42.0	+78.1 to −43.8
[1]$Q_2 = 2.58 \cdot 10^{-4}\ DA^{0.893}\ P^{3.15}$	+71.2 to −41.6	+76.5 to −43.4
$Q_{2.33} = 4.16 \cdot 10^{-4}\ DA^{0.882}\ P^{3.04}$	+68.9 to −40.8	+74.2 to −43.6
Region 7a (Data were based on 28 gaging stations)		
[4]$Q_{1.5} = 0.699\ DA^{0.758}\ (E/1{,}000)^{1.213}$	+86.9 to −46.5	+95.6 to −48.9
[1]$Q_2 = 2.28\ DA^{0.759}\ (E/1{,}000)^{0.769}$	+74.8 to −42.8	+82.3 to −45.2
$Q_{2.33} = 3.99\ DA^{0.760}\ (E/1{,}000)^{0.544}$	+71.1 to −41.6	+78.3 to −43.9
Region 7b (Data were based on 17 gaging stations)		
$Q_{1.5} = 7.82\ DA^{0.606}$	+150 to −60.1	+165 to −62.2
[1]$Q_2 = 10.2\ DA^{0.611}$	+131 to −56.6	+143 to −58.8
$Q_{2.33} = 11.4\ DA^{0.613}$	+123 to −55.1	+134 to −57.3
Region 8 (Data were based on 60 gaging stations)		
$Q_{1.5} = 1.23\ DA^{0.958}\ BS^{0.984}\ (S30 + 1)^{-0.421}$	+88.7 to −47.0	+93.0 to −48.2
[1]$Q_2 = 1.49\ DA^{0.942}\ BS^{1.15}\ (S30 + 1)^{-0.563}$	+82.9 to −45.3	+86.9 to −46.5
$Q_{2.33} = 1.59\ DA^{0.936}\ BS^{1.23}\ (S30 + 1)^{-0.623}$	+81.0 to −44.7	+84.8 to −45.9

[1] From Berenbrock (2002, table 7, p. 16–18).
[2] Exponent for (E/1,000) is zero which is equivalent to multiplying by one; $(E/1{,}000)^0 = 1$.
[3] Data were based on 30 gaging stations. The 1.5-year peak flow was below the base flow for gaging station 13301800, and thus was excluded from the analysis.
[4] Data were based on 27 gaging stations. The 1.5-year peak flow was below the base flow for gaging station 13172200, and thus was excluded from the analysis.

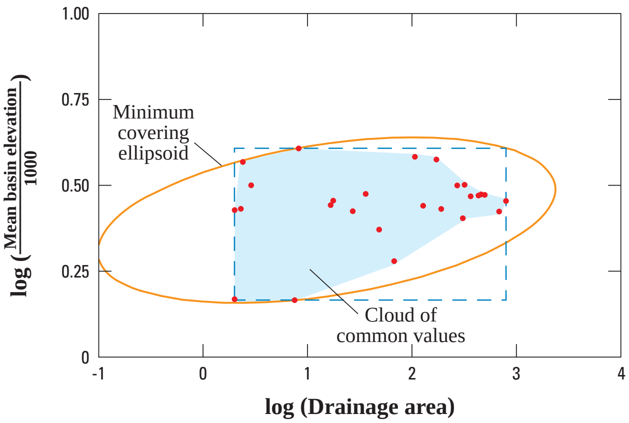


Figure 3. Joint distribution of drainage area and mean basin elevation, and minimum covering ellipsoid for gaged sites in region 3, Idaho.

in the regression equations is near its extreme (maximum or minimum, appendix A), the equations might result in unreliable and erroneous estimates. For example, figure 3 shows a “cloud of common values” for the two explanatory variables used in regression equations for region 3. If the maximum value for drainage area and the minimum value for mean basin elevation were used, this combination would plot outside the cloud of common values and, thus, any equations used might result in unreliable estimates.

Generating basin characteristic values using source datasets or methods other than those described in this study also will result in estimates of unknown reliability. The standard errors for each equation are applicable only if the datasets presented in table 1 and methods described in table 2 are used to obtain the required basin characteristics.

The regression equations are not applicable for streams that exhibit significant gains and (or) losses as a result of flow from springs or seepage through highly permeable streambeds. The equations also are not applicable for streams affected by irrigation diversions or large dams that regulate streamflow. The Boise River downstream from Lucky Peak Lake, the Clearwater River downstream from Dworshak Reservoir, and the entire Snake River in Idaho are examples of stream reaches within the study area for which the regional regression equations are not applicable.

Finally, the regional regression equations might not be reliable for sites in heavily urbanized basins. Techniques for estimating peak flows for urban streams are presented in a report by Sauer and others (1983).

APPLICATION OF METHODS

In the subsequent paragraphs, specific examples are given for calculating peak flows. The first example addresses the situation where the drainage area for an ungaged site is located completely within one region. The second example addresses the situation where the drainage area of the specified site encompasses parts of two separate regions. It is important to note that the coefficients and exponents in the predictive equations are rounded to three significant figures. Thus, the final peak-flow estimate derived from these equations will have an accuracy no greater than to three significant figures.

Example 1

A 1.5-year peak-flow estimate for an ungaged site in region 5 is needed. The required basin characteristics for region 5 regional regression equations were determined to be the following: DA = 480.5 mi^2; P = 28.33 in.; and NF30 = 21.5 percent. Then

$$Q1.5 = 0.0157\ DA^{1.01}\ P^{2.34}\ (NF30 + 1)^{-0.696} \quad (1)$$
$$Q1.5 = 0.0157\ (480.5)^{1.01}\ (28.33)^{2.34}\ (21.5 + 1)^{-0.696}$$
$$Q1.5 = 2{,}300\ ft^3/s$$

On the basis of the range of the average standard errors of prediction given in table 3, about 67 percent of all estimates at this site will be between 1,580 and 3,360 ft^3/s (−31.5 to +45.9 percent). Put another way, there is about a 67-percent certainty that the “true” value of Q1.5 is between 1,580 and 3,360 ft^3/s. Instead of calculating these equations (table 3) manually, a computer program explained in the section titled “Computer Program for Regional Regression Equations” can be used. This computer program also calculates the error of prediction and the 90-percent confidence interval for individual estimates for each recurrence interval and for each region.

Example 2

A 1.5-year peak-flow estimate is needed for an ungaged site in region 4 with a drainage basin encompassing parts of regions 4 and 5. The procedure is similar to that given in example 1, except the regional regression equations need to be solved for each of the associated regions and the results averaged or apportioned according to the fraction of the contributing drainage area that is in each region (Sando, 1998). The required basin characteristics for region 4 and 5 equations were determined to be the following: DA = 853.0 mi^2; P = 35.4 in.; E = 5,125.6 ft; and NF30 = 23.6 percent. The part of the drainage area in region 4 is 622.0 mi^2 and the part in region 5 is 231.0 mi^2.

(1) REGION 4 EQUATION

$$Q1.5 = 9.49DA^{0.903} (E/1,000)^{-0.055} \qquad (2)$$
$$Q1.5 = 9.49\ (853.0)^{0.903}\ (5,125.6/1,000)^{-0.055}$$
$$Q1.5 = 3,845\ ft^3/s$$

(2) REGION 5 EQUATION

$$Q1.5 = 0.0157\ DA^{1.01}\ P^{2.34}\ (NF30 + 1)^{-0.696} \qquad (3)$$
$$Q1.5 = 0.0157\ (853.0)^{1.01}\ (35.4)^{2.34}\ (23.6 + 1)^{-0.696}$$
$$Q1.5 = 6,497\ ft^3/s$$

(3) AREA-WEIGHTED AVERAGE OF THE 1.5-YEAR PEAK FLOWS

$$Q_u = Q_{x_n}\left(\frac{DA_{x_n}}{DA}\right) + Q_{x_n}\left(\frac{DA_{x_n}}{DA}\right) \qquad (4)$$

where

- Q_u *is* peak flow for the selected flood frequency for the ungaged site,
- Q_x *is* estimated peak flow using the equation for the selected region,
- DA_x *is* drainage area for the selected region,
- DA *is* total drainage area upstream from the ungaged site, and
- x_n *is* selected region where n = 1 through 9.

$$Q1.5 = 3,845\ (622.0/853.0) + 6,497\ (231.0/853.0)$$
$$Q1.5 = 4,560\ ft^3/s$$

The regional regression equation computer program also can be used to estimate the peak-flow values in this example. The program would need to be executed twice, once for region 4 and once for region 5. Then, the average value would need to be estimated manually by weighting according to drainage area (area-weighted average), as shown in equation 4.

COMPUTER PROGRAM FOR REGIONAL REGRESSION EQUATIONS

As part of the previous peak-flow study by Berenbrock (2002), a computer program was adapted to calculate peak flows using regional regression equations. The program also calculates the associated site-specific errors of prediction for ungaged sites. Regression equations for 1.5 and 2.33 recurrence interval peak flows developed during this study (table 3) have been added to this program. The computer software package includes an executable program file and other supporting files. The software package and instructions for downloading, installing, and executing the program are available from the Idaho District home page on the World Wide Web at http://idaho.usgs.gov/PDF/wri024170/program.html The executable program *idregeq.exe* will calculate estimated peak flows for the regional regression equations presented in table 3 of this report and in table 7 of Berenbrock's (2002) report. This program must be executed in a disk operating system (DOS) and the user will be prompted to input data for ungaged sites.

The regional regression equations can be calculated manually, but the program allows more convenient and efficient calculation of the errors of prediction. The errors of prediction for ungaged sites are calculated by matrix algebra using the weighted matrix $(X^T \Lambda^{-1} X)^{-1}$ obtained from GLS analysis. Further explanation for computing the error of prediction is given in a report by Hodgkins (1999), and the $(X^T \Lambda^{-1} X)^{-1}$ matrices for each recurrence interval and region are shown in appendix C of this report (back of report) and in table 9 of Berenbrock's (2002) report.

To execute the regional regression program, enter the program's name (*idregeq.exe*) in a DOS window. The program will ask for the name of an output file to save program results, an identifier (name and/or number) of the ungaged site, the region number where the ungaged site is located, and the value for each explanatory variable used in the region's regional regression equations. Results will be displayed on the screen, and all program results will be saved in a single output file no matter how many times the program repeats. Results from each program execution comprise calculated peak flows, site-specific standard errors of prediction (SE), and 90-percent confidence intervals for the estimates. A more detailed discussion explaining the use of the regional regression program, how to interpret the results, and cautions to be aware of can be found in the previous report by Berenbrock (2002, p. 22).

SUMMARY

Recent increased interest in the biological, geomorphic, and environmental effects of varying river flows has highlighted the need for information regarding annual peak flows with relatively short recurrence intervals. Peak flows with recurrence intervals between 1.5 and 2.33 years, often referred to as bankfull flows, are important for mobilization of streambed sediments (cleansing), maintenance of width and depth features of the channel, and maintenance of riparian vegetation. Currently, this information is available only for gaged sites that have at least 10 years of annual peak-flow record. Berenbrock (2002) developed regional peak-flow regression equations for ungaged streams in Idaho; however, the minimum recurrence interval for these equations was 2 years and did not include the 2.33-year recurrence interval. Recognizing the need for this additional information, the U.S. Geological Survey, in cooperation with the U.S. Forest Service, conducted a study to develop additional regional regression equations that can be used to estimate bankfull flows.

Basin and climatic characteristics, peak-flow records, and regional boundaries presented by Berenbrock (2002) were used in this study to develop regional regression equations for estimating peak flows with recurrence intervals of 1.5 and 2.33 years. Basin and climatic characteristics and peak-flow records were included for 333 gaging stations with at least 10 years of record through water year 1997. The State was divided into 10 regions, which included one undefined region in the area of the eastern Snake River Plain.

Because of the need for stable and consistent estimates of peak flows in each region, the same explanatory variables used by Berenbrock (2002) also were used in this study for each region. Generalized least-squares regression techniques then were used to calculate the final coefficients and measures of accuracy for the regression equations for each region. Average standard errors of the model ranged from +150 to −60.1 percent, and average standard errors of prediction ranged from +165 to −62.2 percent. As the recurrence intervals increased, the magnitude and the range between the errors decreased. The ranges of standard errors of the model and standard errors of prediction were narrowest for region 5.

The estimating equations might not yield reliable results for sites with basin characteristic values outside of the range of values used to develop the equations. The equations are not applicable for regulated streams or those affected by significant gains and (or) losses owing to spring flow, seepage through highly permeable streambeds, or irrigation diversions.

A computer program (*idregeq.exe*) automates the calculations required for the regional regression calculations. Results from this program comprise calculated peak flows, site-specific standard errors of prediction, and the 90-percent confidence intervals for the estimates.

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Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis

[DA, drainage area; E, mean basin elevation; F, percentage of forest cover in the basin; P, mean annual precipitation; BS, average basin slope; NF30, percentage of north-facing slopes greater than 30 percent; S30, percentage of slopes greater than 30 percent; mi^2, square miles; ft, feet; in., inches; ID, Idaho; MT, Montana; NV, Nevada; OR, Oregon; WA, Washington; WY, Wyoming; Y.N.P., Yellowstone National Park]

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 1							
1	12305500	Boulder Creek near Leonia, ID	55.3	4,686.9	92.0	48.30	37.1	21.8	69.4
2	12309000	Cow Creek near Bonners Ferry, ID	17.6	3,189.5	77.1	30.05	26.7	28.8	40.8
3	12310800	Trail Creek at Naples, ID	16.0	3,498.6	92.6	31.27	24.3	13.7	27.8
4	12311000	Deep Creek at Moravia, ID	133.1	3,257.0	72.6	30.36	21.2	9.7	27.0
5	12313500	Ball Creek near Bonners Ferry, ID	26.6	5,194.4	78.7	42.20	40.6	18.3	70.2
6	12316800	Mission Creek near Copeland, ID	12.5	4,084.4	94.5	29.15	25.4	5.8	33.2
7	12320500	Long Canyon Creek near Porthill, ID	29.9	5,347.3	89.5	41.32	46.4	22.7	81.4
8	12321000	Smith Creek near Porthill, ID	71.1	5,054.2	70.4	46.14	37.0	19.8	62.3
9	12392100	Trapper Creek near Clark Fork, ID	1.1	4,844.3	96.1	57.78	50.2	9.1	91.6
10	12392155	Lightning Creek at Clark Fork, ID	115.1	4,648.5	82.4	54.32	43.2	20.3	71.8
11	12392300	Pack River near Colburn, ID	121.4	4,280.6	62.6	38.15	32.2	15.9	52.4
12	12392800	Hornby Creek near Dover, ID	3.1	2,519.6	89.4	30.00	17.9	3.7	11.9
13	12393500	Priest River at outlet of Priest Lake near Coolin, ID	596.6	3,941.3	79.0	38.79	28.9	13.7	46.3
14	12393600	Binarch Creek near Coolin, ID	10.6	3,258.6	97.6	30.58	35.0	16.6	59.3
15	12396000	Calispell Creek near Dalkena, WA	68.2	3,622.5	79.6	36.71	30.1	20.0	51.8
16	12408500	Mill Creek near Colville, WA	82.5	3,520.8	89.4	37.74	29.6	13.9	46.2
17	12409000	Colville River at Kettle Falls, WA	1,011.0	2,904.3	77.0	27.57	22.3	9.0	28.2
18	12427000	Little Spokane River at Elk, WA	84.4	2,459.0	65.2	28.22	13.2	4.1	10.4
19	12429600	Deer Creek near Chattaroy, WA	31.0	2,683.7	65.3	27.61	15.3	4.4	9.0
20	12430370	Bigelow Gulch near Spokane, WA	4.4	2,245.2	23.9	19.37	9.7	0.6	2.6
21	12431000	Little Spokane River at Dartford, WA	634.9	2,397.7	54.6	25.11	12.2	2.8	9.4
		REGION 2							
22	12302500	Granite Creek near Libby, MT	23.7	5,275.3	66.4	52.96	54.1	26.7	82.4
23	12303100	Flower Creek near Libby, MT	11.3	5,466.8	76.7	52.64	48.3	30.0	71.2
24	12303500	Lake Creek at Troy, MT	125.0	4,069.2	87.3	43.94	38.5	21.0	62.8
25	12304250	Whitetail Creek near Yaak, MT	2.4	4,299.5	81.5	31.61	27.4	0.5	37.2
26	12304300	Cyclone Creek near Yaak, MT	5.7	4,627.2	96.9	40.99	33.9	30.1	63.5
27	12304400	Fourth of July Creek near Yaak, MT	7.8	4,468.8	96.7	38.86	35.9	26.7	72.6
28	12341000	Rattlesnake Creek at Missoula, MT	79.9	5,708.4	79.3	37.04	36.9	16.7	57.6
29	12345800	Camas Creek near Hamilton, MT	5.1	7,064.0	51.8	50.32	42.5	19.5	73.4
30	12347500	Blodgett Creek near Corvallis, MT	26.1	6,649.7	50.4	60.87	57.0	32.1	82.8
31	12350200	Gash Creek near Victor, MT	3.3	6,684.3	73.4	54.70	37.9	22.0	69.2
32	12350500	Kootenai Creek near Stevensville, MT	29.0	6,557.7	60.4	55.58	58.8	28.8	89.6
33	12352000	Lolo Creek above Sleeman Creek, near Lolo, MT	249.2	5,272.8	84.7	46.82	35.3	19.1	58.9

Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 2 -- Continued							
34	12353800	Thompson Creek near Superior, MT	12.0	4,648.3	88.2	39.04	41.2	27.3	76.2
35	12353850	East Fork Timber Creek near Haugan, MT	2.6	4,669.2	96.0	48.34	32.8	1.6	54.3
36	12354000	St. Regis River near St. Regis, MT	43.6	4,843.4	88.3	44.49	47.2	30.4	84.6
37	12354100	North Fork Little Joe Creek near St. Regis, MT	14.4	4,854.3	89.8	42.42	45.6	28.5	83.1
38	12389500	Thompson River near Thompson Falls, MT	641.5	4,567.1	85.8	29.56	30.0	15.9	47.0
39	12390700	Prospect Creek at Thompson Falls, MT	181.5	4,437.3	93.1	43.68	43.5	27.8	79.6
40	12411000	North Fork Coeur d'Alene River above Shoshone Creek, near Prichard, ID	334.0	3,947.0	89.7	48.25	40.8	24.7	75.6
41	12413000	North Fork Coeur d'Alene River at Enaville, ID	893.7	3,835.9	88.9	45.38	41.9	25.4	77.6
42	12413100	Boulder Creek at Mullan, ID	3.1	5,212.4	93.2	49.41	46.7	33.1	83.0
43	12413140	Placer Creek at Wallace, ID	15.0	4,411.0	94.2	41.53	49.6	31.2	88.8
44	12413150	South Fork Coeur d'Alene River at Silverton, ID	105.6	4,615.4	89.8	42.52	45.8	27.5	82.3
45	12413200	Montgomery Creek near Kellogg, ID	4.5	3,648.3	91.8	40.23	48.0	13.6	89.3
46	12413210	South Fork Coeur d'Alene at Elizabeth Park near Kellogg, ID	181.8	4,301.2	88.5	43.34	45.8	27.2	82.5
47	12413470	South Fork Coeur d'Alene River near Pinehurst, ID	287.1	4,096.4	83.5	45.09	44.6	26.9	80.7
48	12413500	Coeur d'Alene River at Cataldo, ID	1,207.4	3,878.0	87.3	45.01	42.3	25.5	77.8
49	12413700	Latour Creek near Cataldo, ID	24.8	4,316.0	85.6	54.84	41.8	27.9	81.6
50	12414500	St. Joe River at Calder, ID	1,024.5	4,545.6	89.8	46.95	41.3	24.7	74.4
51	12414900	St. Maries River near Santa, ID	272.6	3,592.6	80.6	37.73	25.1	12.5	34.9
52	12415000	St. Maries River at Lotus, ID	434.5	3,465.5	82.2	35.63	23.8	11.4	31.7
53	12415100	Cherry Creek near St. Maries, ID	7.1	3,308.1	86.4	31.71	30.3	23.5	51.3
54	12415200	Plummer Creek Tributary at Plummer, ID	2.0	2,966.3	35.9	20.00	15.2	1.5	9.9
55	12416000	Hayden Creek below North Fork, near Hayden Lake, ID	21.5	3,564.7	95.1	38.75	41.8	25.3	81.2
56	13336500	Selway River near Lowell, ID	1,913.1	5,511.8	82.8	40.58	44.2	24.1	785.6
57	13336600	Swiftwater Creek near Lowell, ID	6.2	3,814.8	93.7	33.22	42.7	39.6	80.2
58	13336650	East Fork Papoose Creek near Powell Ranger Station, ID	4.5	4,832.2	82.4	47.61	47.2	17.1	87.9
59	13336850	Weir Creek near Powell Ranger Station, ID	12.2	4,817.1	86.5	48.18	48.7	13.9	88.5
60	13336900	Fish Creek near Lowell, ID	88.3	4,467.2	91.3	46.34	34.7	13.7	55.7
61	13337000	Lochsa River near Lowell, ID	1,179.4	5,197.2	88.2	46.62	38.5	20.4	63.5
62	13340500	North Fork Clearwater River at Bungalow Ranger Station, ID	997.5	4,888.8	82.2	52.47	39.0	22.1	68.1
63	13340600	North Fork Clearwater River near Canyon Ranger Station, ID	1,294.2	4,732.9	82.9	51.40	40.4	22.7	69.9
64	13341300	Bloom Creek near Bovill, ID	3.0	3,716.0	86.8	48.07	32.0	27.6	55.6
65	13341400	East Fork Potlatch River near Bovill, ID	42.7	3,617.2	86.0	42.67	26.3	14.0	36.4
		REGION 3							
66	12423550	Hangman Creek Tributary near Latah, WA	2.3	2,693.4	1.1	20.41	11.4	1.7	1.9
67	12423700	South Fork Rock Creek Tributary near Fairfield, WA	0.6	2,720.9	7.9	19.91	11.0	2.6	3.2
68	12423900	Stevens Creek Tributary near Moran, WA	2.0	2,671.8	9.9	18.97	17.2	0.9	2.0
69	12424000	Hangman Creek at Spokane, WA	674.9	2,647.1	19.4	20.83	10.5	2.3	6.7

Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 3 -- Continued							
70	13334700	Asotin Creek below Kearney Gulch near Asotin, WA	170.5	3,752.2	30.5	23.01	35.4	20.7	57.5
71	13335200	Critchfield Draw near Clarkston, WA	2.0	1,472.6	0.2	11.90	12.7	0.9	3.9
72	13341100	Cold Springs Creek near Craigmont, ID	8.2	4,040.1	10.7	20.00	8.9	0.2	1.0
73	13341500	Potlatch River at Kendrick, ID	453.7	2,969.1	59.8	29.51	18.2	5.5	17.8
74	13342450	Lapwai Creek near Lapwai, ID	268.9	3,149.2	30.7	19.31	18.9	7.7	22.2
75	13343450	Dry Creek at mouth near Clarkston, WA	7.5	1,458.4	0.2	12.08	8.6	0.1	1.4
76	13343800	Meadow Creek near Central Ferry, WA	67.2	1,898.5	0.0	16.12	14.2	2.3	6.7
77	13344500	Tucannon River near Starbuck, WA	431.8	2,943.7	23.7	23.98	26.4	11.9	36.0
78	13344700	Deep Creek Tributary near Polatch, ID	2.9	3,156.8	87.6	28.67	24.3	17.8	27.1
79	13344800	Deep Creek near Potlatch, ID	35.8	2,977.9	46.4	24.92	18.7	5.0	19.8
80	13345000	Palouse River near Potlatch, ID	316.0	3,165.1	63.4	30.07	21.2	9.0	25.8
81	13346100	Palouse River at Colfax, WA	491.7	2,963.6	41.7	26.93	17.7	6.2	17.8
82	13346300	Crumarine Creek near Moscow, ID	2.4	3,694.1	79.3	29.55	27.4	10.0	41.1
83	13346800	Paradise Creek at University of Idaho, at Moscow, ID	17.6	2,844.2	12.5	24.53	11.8	1.0	6.0
84	13348000	South Fork Palouse River at Pullman, WA	126.9	2,745.5	6.9	23.76	11.9	0.8	3.3
85	13348500	Missouri Flat Creek at Pullman, WA	27.1	2,652.2	0.6	23.23	10.0	0.0	0.0
86	13349210	Palouse River below South Fork at Colfax, WA	788.7	2,842.0	27.4	25.33	15.5	4.2	12.1
87	13349400	Pine Creek at Pine City, WA	304.6	2,527.0	1.6	19.00	9.1	0.5	1.2
88	13350500	Union Flat Creek near Colfax, WA	189.8	2,691.9	0.0	20.97	10.5	0.5	1.1
89	14016000	Dry Creek near Walla Walla, WA	48.5	2,342.9	18.4	30.10	21.4	8.9	23.7
90	14016500	East Fork Touchet River near Dayton, WA	106.2	3,820.0	59.8	42.10	38.9	21.0	65.9
91	14017000	Touchet River at Bolles, WA	363.3	2,928.8	31.7	30.50	27.3	13.4	38.5
		REGION 4							
92	13185500	Cottonwood Creek at Arrowrock Reservoir, ID	20.8	5,198.1	36.8	19.08	39.8	18.4	70.7
93	13196500	Bannock Creek near Idaho City, ID	4.8	5,313.2	60.4	22.08	32.9	26.2	57.4
94	13200000	Mores Creek above Robie Creek, near Arrowrock Dam, ID	397.0	5,070.8	66.3	24.76	31.3	16.7	51.0
95	13200500	Robie Creek near Arrowrock Dam, ID	16.0	4,680.6	65.0	23.34	39.8	23.4	70.6
96	13201000	Mores Creek near Arrowrock, ID	424.4	5,024.2	65.0	24.48	31.7	17.0	52.0
97	13207000	Spring Valley Creek near Eagle, ID	19.2	4,017.4	8.0	19.42	24.3	9.3	30.2
98	13207500	Dry Creek near Eagle, ID	59.4	3,963.4	11.7	20.39	25.3	8.8	34.3
99	13216500	North Fork Malheur River above Beulah Reservoir near Beulah, OR	342.5	5,360.8	52.7	23.79	21.6	6.0	23.2
100	13248900	Cottonwood Creek near Horseshoe Bend, ID	7.0	3,882.5	0.0	17.16	23.9	15.2	26.3
101	13250600	Big Willow Creek near Emmett, ID	55.2	4,099.3	4.8	15.88	23.6	7.3	28.0
102	13250650	Fourmile Creek near Emmett, ID	6.2	3,804.1	1.7	12.88	22.9	2.9	21.4
103	13251300	West Branch Weiser River near Tamarack, ID	4.0	4,947.6	81.5	39.75	27.3	3.2	41.5
104	13251500	Weiser River at Tamarack, ID	36.6	4,654.2	87.8	34.61	22.3	4.9	27.1
105	13252500	East Fork Weiser River near Council, ID	2.3	6,883.5	76.0	40.00	27.0	16.9	36.5

Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 4 -- Continued							
106	13253500	Weiser River at Starkey, ID	105.4	4,969.7	88.1	32.34	26.5	10.7	38.0
107	13256000	Weiser River near Council, ID	391.9	4,668.2	64.6	29.64	24.2	9.6	32.7
108	13257000	Middle Fork Weiser River near Mesa, ID	86.1	5,430.2	74.1	34.00	27.4	11.1	38.3
109	13258500	Weiser River near Cambridge, ID	596.4	4,636.5	58.2	29.23	23.5	8.7	30.6
110	13260000	Pine Creek near Cambridge, ID	55.3	4,751.8	42.3	22.43	26.4	10.0	37.9
111	13261000	Little Weiser River near Indian Valley, ID	79.5	5,313.9	67.1	28.23	26.9	11.2	36.5
112	13266000	Weiser River near Weiser, ID	1,448.3	4,141.3	32.7	22.23	19.3	6.4	22.1
113	13267000	Mann Creek near Weiser, ID	56.8	4,846.2	55.4	22.12	31.6	10.6	53.4
114	13267100	Deer Creek near Midvale, ID	4.3	3,233.7	1.1	10.00	15.7	0.5	6.1
115	13269300	North Fork Burnt River near Whitney, OR	110.8	4,901.1	81.6	25.11	18.7	4.5	17.7
116	13270800	South Fork Burnt River above Barney Creek near Unity, OR	38.9	5,823.5	91.6	28.59	28.2	16.9	42.0
117	13275500	Powder River near Baker, OR	205.2	5,224.6	74.5	24.67	26.5	9.6	40.8
118	13288200	Eagle Creek above Skull Creek near New Bridge, OR	155.7	5,742.6	67.6	47.53	40.5	14.5	63.7
119	13289100	Immigrant Gulch near Richlavel, OR	6.7	3,581.4	1.4	24.97	25.4	3.1	32.3
120	13289600	East Brownlee Creek at Brownlee Ranger Station, ID	7.4	5,913.0	79.2	30.00	44.9	18.5	78.9
121	13289960	Wildhorse River at Brownlee Dam, ID	177.1	5,037.5	62.2	27.53	29.4	14.3	43.3
122	13290190	Pine Creek near Oxbow, OR	298.5	4,287.7	50.2	33.71	27.4	9.8	40.0
123	13291000	Imnaha River above Gumboot Creek, OR	99.8	6,374.4	64.6	56.25	37.0	21.0	58.7
124	13291200	Mahogany Creek near Homestead, OR	4.1	5,192.1	75.4	37.19	33.5	18.5	53.2
125	13315500	Mud Creek near Tamarack, ID	15.1	4,742.2	93.0	35.36	27.4	6.7	45.0
126	13316500	Little Salmon River at Riggins, ID	576.1	5,421.1	71.8	29.61	33.4	15.5	51.5
127	13316800	North Fork Skookumchuck Creek near White Bird, ID	15.3	5,031.2	69.3	30.22	30.6	15.8	44.2
128	13317000	Salmon River at White Bird, ID	13,418.3	6,753.8	58.3	24.72	37.7	19.1	60.3
129	13317200	Johns Creek near Grangeville, ID	5.0	3,961.5	33.1	24.22	11.7	8.5	10.9
130	13319000	Grande Ronde River at La Grande, OR	687.4	4,582.0	68.4	27.57	20.3	6.5	21.8
131	13320000	Catherine Creek near Union, OR	104.1	5,263.8	85.9	39.66	28.6	10.6	40.8
132	13323600	Indian Creek near Imbler, OR	24.8	5,515.7	77.1	43.58	21.3	6.3	20.8
133	13329500	Hurricane Creek near Joseph, OR	29.6	7,461.3	47.0	64.64	57.2	22.9	87.0
134	13330000	Lostine River near Lostine, OR	71.5	6,893.5	52.1	56.69	49.2	22.1	77.2
135	13330500	Bear Creek near Wallowa, OR	72.1	5,804.7	67.2	44.74	45.6	23.2	75.0
136	13331500	Minam River at Minam, OR	239.2	5,699.5	66.4	46.47	43.5	21.3	70.5
137	13337200	Red Horse Creek near Elk City, ID	9.1	5,052.5	93.9	36.37	27.9	11.9	42.3
138	13337500	South Fork Clearwater River near Elk City, ID	260.8	5,095.1	91.7	35.30	24.1	10.1	28.8
139	13337700	Peasley Creek near Golden, ID	14.2	4,880.8	94.3	35.81	35.0	9.5	57.9
140	13338000	South Fork Clearwater River near Grangeville, ID	843.4	5,116.5	91.8	34.88	29.7	14.0	42.4
141	13338200	Sally Ann Creek near Stites, ID	13.8	3,142.8	57.6	31.08	24.8	16.6	32.0
142	13338500	South Fork Clearwater River at Stites, ID	1,168.3	4,546.6	70.5	31.31	25.7	11.9	35.1
143	13339000	Clearwater River at Kamiah, ID	4,827.4	4,956.2	77.4	38.29	36.2	19.1	58.6

Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 4 -- Continued							
144	13339500	Lolo Creek near Greer, ID	241.4	3,528.6	84.1	31.53	22.6	8.4	25.5
145	13339700	Canal Gulch Creek at Pierce Ranger Station, ID	6.4	3,539.5	92.2	40.00	17.5	1.1	8.5
146	13339900	Deer Creek near Orofino, ID	5.2	2,955.8	82.6	29.82	18.0	7.2	17.7
147	13340000	Clearwater River at Orofino, ID	5,507.9	4,736.4	76.6	37.36	34.4	17.7	54.5
148	14010000	South Fork Walla Walla River near Milton, OR	61.9	4,273.1	68.3	46.44	46.3	21.9	74.7
149	14011000	North Fork Walla Walla River near Milton, OR	42.6	3,640.0	57.2	42.17	42.1	23.9	71.2
150	14013000	Mill Creek near Walla Walla, WA	58.8	3,933.2	68.6	47.97	50.5	28.8	85.5
151	14013500	Blue Creek near Walla Walla, WA	17.1	3,136.4	45.7	40.52	38.3	24.9	68.8
		REGION 5							
152	12343400	East Fork Bitterroot River near Conner, MT	379.3	6,361.7	78.6	28.42	33.2	18.1	55.1
153	12346500	Skalkaho Creek near Hamilton, MT	88.1	6,676.0	86.4	29.55	38.8	22.5	67.5
154	12351000	Burnt Fork Bitterroot River near Stevensville, MT	73.0	6,495.2	79.6	30.60	36.5	21.3	62.0
155	12351400	Eightmile Creek near Florence, MT	20.8	5,389.4	62.1	24.51	39.1	24.2	69.3
156	13135200	Prairie Creek near Ketchum, ID	17.3	8,558.1	59.0	34.44	45.9	24.1	72.1
157	13135500	Big Wood River near Ketchum, ID	137.5	8,204.0	55.8	31.42	40.6	20.8	67.5
158	13135800	Adams Gulch near Ketchum, ID	10.5	7,373.5	61.5	30.69	42.5	32.9	79.2
159	13136500	Warm Springs Creek at Guyer Hot Springs, near Ketchum, ID	92.6	7,696.0	59.7	35.77	42.6	23.1	77.8
160	13139500	Big Wood River at Hailey, ID	627.6	7,685.6	43.2	29.35	42.7	22.1	74.0
161	13141000	Big Wood River near Bellevue, ID	786.2	7,347.3	35.5	26.45	40.2	20.8	69.3
162	13141400	Deer Creek near Fairfield, ID	11.8	6,496.3	30.1	19.80	33.4	13.1	62.2
163	13184200	Roaring River near Rocky Bar, ID	22.1	7,274.7	61.3	41.26	32.6	15.7	46.8
164	13184800	Beaver Creek near Lowman, ID	10.0	5,796.4	52.1	32.14	24.2	7.8	29.9
165	13185000	Boise River near Twin Springs, ID	831.6	6,415.7	50.2	32.42	44.3	23.2	75.1
166	13186000	South Fork Boise River near Featherville, ID	641.6	7,025.2	50.6	34.72	42.1	21.5	74.4
167	13186500	Lime Creek near Bennett, ID	133.6	6,276.7	22.4	22.40	29.3	11.4	47.3
168	13187000	Fall Creek near Anderson Ranch Dam, ID	55.6	6,171.1	59.2	32.16	33.6	14.0	59.3
169	13234300	Fivemile Creek nr Lowman, ID	11.3	6,623.7	49.9	32.33	44.6	14.7	76.2
170	13235000	South Fork Payette River at Lowman, ID	449.3	6,824.5	54.3	34.51	46.7	23.2	76.6
171	13235100	Rock Creek at Lowman, ID	16.5	5,793.4	63.3	31.40	39.5	25.9	72.2
172	13237300	Danskin Creek near Crimes Pass, ID	10.0	4,779.2	68.8	26.49	46.3	16.1	83.7
173	13238300	Deep Creek near McCall, ID	3.6	7,255.3	60.3	49.73	22.5	2.5	23.4
174	13240000	Lake Fork Payette River above Jumbo Creek, near McCall, ID	48.7	6,921.9	71.6	37.22	42.1	16.5	67.9
175	13240500	Lake Fork Payette River above Reservoir near McCall, ID	51.7	6,905.7	72.6	36.82	41.0	15.7	65.6
176	13245400	Tripod Creek at Smiths Ferry, ID	8.6	5,514.1	87.7	28.13	19.8	3.6	18.3
177	13292400	Beaver Creek near Stanley, ID	14.9	8,255.9	57.7	41.59	35.4	22.1	56.9
178	13292500	Salmon River near Obsidian, ID	93.9	8,181.1	56.9	34.66	32.8	17.8	53.1
179	13293000	Alturas Lake Creek near Obsidian, ID	35.6	8,161.5	47.1	44.47	37.6	19.0	60.4
180	13295000	Valley Creek at Stanley, ID	148.9	7,318.8	63.0	23.94	26.1	12.0	37.0

Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 5 -- Continued							
181	13295500	Salmon River below Valley Creek, at Stanley, ID	510.4	7,786.2	54.9	29.61	30.4	14.6	45.2
182	13296000	Yankee Fork Salmon River near Clayton, ID	187.3	7,992.1	74.5	27.11	41.0	22.7	71.1
183	13296500	Salmon River below Yankee Fork, near Clayton, ID	811.1	7,791.6	61.9	27.95	33.6	17.1	53.7
184	13297100	Peach Creek near Clayton, ID	7.6	7,809.8	78.1	22.53	47.1	16.6	87.1
185	13308500	Middle Fork Salmon River near Cape Horn, ID	133.8	7,482.6	70.8	28.40	26.6	11.6	40.2
186	13309000	Bear Valley Creek near Cape Horn, ID	181.7	7,060.3	70.1	30.02	20.2	7.6	24.7
187	13309220	Middle Fork Salmon River near Yellow Pine, ID	1,038.7	7,189.7	68.9	29.00	38.4	20.3	64.1
188	13310000	Big Creek near Big Creek, ID	451.5	6,981.2	78.6	28.71	44.3	24.6	74.0
189	13310500	South Fork Salmon River near Knox, ID	91.7	6,631.3	88.7	37.46	31.7	18.3	52.9
190	13310700	South Fork Salmon River near Krassel Ranger Station, ID	329.3	6,381.8	83.7	33.62	38.0	19.9	63.8
191	13311000	East Fork South Fork Salmon River at Stibnite, ID	19.3	7,724.4	83.7	34.05	35.3	20.4	62.6
192	13311500	East Fork South Fork Salmon River near Stibnite, ID	42.9	7,619.9	77.3	30.88	40.8	22.8	72.5
193	13312000	East Fork South Fork Salmon River near Yellow Pine, ID	106.9	7,404.6	78.2	30.02	41.7	22.2	73.0
194	13313000	Johnson Creek at Yellow Pine, ID	216.4	7,135.2	91.7	34.31	28.2	11.3	40.7
195	13313500	Secesh River near Burgdorf, ID	100.5	6,963.9	82.7	43.91	24.8	10.7	61.8
196	13314000	South Fork Salmon River near Warren, ID	1,164.0	6,696.9	81.2	33.15	37.4	18.4	60.5
197	13315000	Salmon River near French Creek, ID	12,228.0	6,913.7	57.4	24.41	37.8	19.3	60.4
		REGION 6							
198	06013500	Big Sheep Creek below Muddy Creek near Dell, MT	277.0	7,928.2	14.5	18.82	24.1	10.1	31.8
199	06015500	Grasshopper Creek near Dillon, MT	349.0	6,940.1	28.9	19.22	18.8	5.6	19.6
200	06019500	Ruby River above reservoir near Alder, MT	525.5	7,235.2	26.0	22.93	20.1	6.2	20.5
201	13108500	Camas Creek at Eighteenmile Shearing Corral, near Kilgore, II	228.4	6,943.3	39.4	26.84	12.8	3.2	12.8
202	13112000	Camas Creek at Camas, ID	393.9	6,428.8	22.9	21.10	8.6	1.9	7.5
203	13112900	Huntley Canyon at Spencer, ID	4.0	6,820.0	58.0	17.33	24.8	11.2	33.1
204	13113000	Beaver Creek at Spencer, ID	123.2	7,027.5	29.9	20.29	19.6	7.9	23.5
205	13113500	Beaver Creek at Dubois, ID	238.7	6,696.9	24.4	19.42	16.7	5.1	18.8
206	13117200	Main Fork near Goldburg, ID	16.2	8,734.8	49.7	26.30	32.6	10.9	53.0
207	13117300	Sawmill Creek near Goldburg, ID	74.2	8,380.5	54.1	23.79	32.7	14.2	53.7
208	13120000	North Fork Big Lost River at Wild Horse, near Chilly, ID	114.7	8,659.7	58.1	29.80	43.1	22.0	72.1
209	13120500	Big Lost River at Howell Ranch, near Chilly, ID	440.4	8,626.3	37.9	26.96	37.8	17.9	60.8
210	13128900	Lower Cedar Creek above Diversion 3, near Mackay, ID	8.4	9,461.0	21.0	26.61	66.2	17.1	94.2
211	13297300	Holman Creek near Clayton, ID	6.1	7,298.7	69.6	20.81	36.6	24.9	61.5
212	13297330	Thompson Creek near Clayton, ID	29.5	7,618.4	68.9	22.60	47.7	23.5	85.8
213	13297350	Bruno Creek near Clayton, ID	6.4	7,520.2	66.3	21.74	40.8	21.2	68.3
214	13297355	Squaw Creek below Bruno Creek, near Clayton, ID	71.6	7,729.2	73.0	25.17	36.3	16.3	60.2
215	13297450	Little Boulder Creek near Clayton, ID	18.3	8,951.8	39.2	31.98	41.3	23.5	64.3
216	13298000	East Fork Salmon River near Clayton, ID	540.2	8,092.5	31.7	26.00	38.2	20.6	62.7
217	13298300	Malm Gulch near Clayton, ID	9.3	7,015.7	9.4	20.99	36.3	16.8	63.5

Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 6 -- Continued							
218	13299000	Challis Creek near Challis, ID	84.6	7,780.8	62.4	25.59	37.2	18.3	62.0
219	13301700	Morse Creek above Diversion near May, ID	17.9	8,178.6	45.4	21.25	51.4	26.7	87.5
220	13301800	Morse Creek near May, ID	20.0	7,926.5	40.7	20.24	47.9	24.1	80.6
221	13302500	Salmon River at Salmon, ID	3,746.1	7,397.5	37.3	21.63	33.4	16.7	52.9
222	13305000	Lemhi River near Lemhi, ID	907.1	7,430.9	24.3	15.62	25.2	11.9	36.9
223	13305500	Lemhi River at Salmon, ID	1,258.0	7,108.2	24.9	15.26	26.4	12.4	39.1
224	13305700	Dahlonega Creek at Gibbonsville, ID	32.5	6,184.7	90.9	25.32	45.2	18.8	86.3
225	13305800	Hughes Creek near North Fork, ID	20.5	6,707.4	83.9	27.88	41.3	20.7	75.8
226	13306000	North Fork Salmon River at North Fork, ID	210.3	6,258.1	77.8	22.87	43.6	23.1	78.0
227	13306500	Panther Creek near Shoup, ID	520.7	7,028.2	80.2	24.00	38.6	20.9	62.2
228	13307000	Salmon River near Shoup, ID	6,236.7	7,154.3	41.1	20.37	33.3	16.6	52.8
		REGION 7a							
229	10315500	Marys River above Hot Springs Creek near Deeth, NV	389.8	6,589.8	2.3	15.19	17.5	5.3	21.8
230	10329500	Martin Creek near Paradise Valley, NV	176.2	6,210.4	4.1	21.88	21.0	8.3	26.4
231	10352500	McDermitt Creek near Mc Dermitt, NV	225.4	5,890.4	1.4	17.00	17.3	4.3	17.2
232	10353000	East Fork Quinn River near McDermitt, NV	137.9	6,117.4	2.1	22.24	22.2	10.0	28.0
233	10396000	Donner And Blitzen River near Frenchglen, OR	204.7	6,197.6	22.4	29.07	16.2	5.5	15.2
234	10406500	Trout Creek near Denio, NV	86.7	6,025.9	3.9	16.86	23.1	9.0	31.2
235	13155200	Burns Gulch near Glenns Ferry, ID	0.7	6,089.9	1.3	25.00	30.7	1.7	53.2
236	13155300	Little Canyon Creek at Stout Crossing near Glenns Ferry, ID	14.2	5,927.8	3.0	23.47	25.2	8.3	36.8
237	13161200	Seventy Six Creek near Charleston, NV	3.6	7,067.5	1.3	24.49	27.4	6.6	38.9
238	13161300	Meadow Creek near Rowland, NV	57.6	6,597.0	3.6	19.58	25.7	11.9	35.2
239	13162200	Jarbidge River at Jarbidge, NV	22.6	8,260.7	37.8	33.79	48.8	22.7	85.8
240	13162400	Buck Creek near Jarbidge, NV	25.8	7,069.6	13.7	22.42	17.9	7.7	18.8
241	13162500	East Fork Jarbidge River near Three Creek, ID	84.9	7,603.0	24.5	24.77	35.3	16.1	55.2
242	13162600	Columbet Creek near Jarbidge, NV	3.5	7,028.8	8.4	22.15	16.8	7.1	14.1
243	13169500	Big Jacks Creek near Bruneau, ID	243.7	5,170.0	0.0	13.81	10.1	2.3	7.4
244	13170000	Little Jacks Creek near Bruneau, ID	103.4	5,067.4	0.1	14.22	13.2	3.8	11.5
245	13170100	Sugar Creek Tributary near Grasmere, ID	4.5	4,856.2	0.0	10.00	8.0	0.0	0.2
246	13172200	Fossil Creek near Oreana, ID	16.7	3,879.7	2.1	9.79	11.4	4.2	11.0
247	13172666	West Fork Reynolds Creek near Reynolds, ID	0.4	6,821.4	40.2	15.00	17.5	6.0	10.4
248	13172668	East Fork Reynolds Creek near Reynolds, ID	0.2	6,810.7	3.3	25.00	13.3	0.4	0.6
249	13172680	Reynolds Creek at Toolgate Weir near Reynolds, ID	18.7	6,133.6	38.4	21.22	23.0	11.1	24.9
250	13172720	Macks Creek near Reynolds, ID	12.5	4,883.0	11.1	13.64	21.1	7.7	21.6
251	13172735	Salmon Creek near Reynolds, ID	13.1	5,001.8	5.5	14.66	26.1	9.7	36.3
252	13172740	Reynolds Creek at Outlet Weir near Reynolds, ID	91.8	5,015.7	12.4	14.83	20.2	7.2	20.7
253	13172800	Little Squaw Creek Tributary near Marsing, ID	1.8	4,447.6	0.0	10.00	14.3	0.1	8.3
254	13178000	Jordan Creek above Lone Tree Creek, near Jordan Vallley, ID	454.2	5,781.8	38.9	26.15	19.5	5.8	21.8

Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 7a -- Continued							
255	13210300	Bryans Run near Boise, ID	9.1	3,605.5	0.0	10.23	3.2	0.0	0.0
256	13226500	Bully Creek at Warmsprings near Vale, OR	535.3	4,133.8	0.8	12.26	17.4	3.7	15.3
		REGION 7b							
257	10119000	Little Malad River above Elkhorn Reservoir, near Malad City,	107.1	6,070.2	8.1	13.20	17.7	6.1	17.8
258	10122500	Devil Creek above Campbell Creek, near Malad City, ID	12.5	5,986.6	9.4	15.08	17.5	4.7	17.9
259	10123000	Devil Creek above Evans Dividers, near Malad City, ID	34.0	5,883.8	11.1	16.79	20.8	6.6	24.4
260	10172940	Dove Creek near Park Valley, UT	28.7	6,681.4	0.7	17.00	17.5	3.7	13.7
261	13057600	Homer Creek near Herman, ID	26.7	6,477.2	14.9	15.65	9.0	0.6	1.4
262	13057940	Willow Creek below Tex Creek near Ririe, ID	431.4	6,422.9	19.2	16.61	13.3	2.8	8.4
263	13073700	Robbers Roost Creek near McCammon, ID	3.9	6,767.0	41.5	24.88	42.4	21.8	77.0
264	13075000	Marsh Creek near McCammon, ID	367.4	5,587.7	9.0	14.30	16.8	6.4	20.2
265	13075600	North Fork Pocatello Creek near Pocatello, ID	14.0	5,756.2	7.7	15.00	21.2	8.0	17.3
266	13076200	Bannock Creek near Pocatello, ID	407.3	5,545.4	7.3	16.28	16.4	6.9	18.7
267	13077700	George Creek near Yost, UT	7.9	8,483.9	40.7	23.66	32.3	29.7	51.8
268	13079200	Cassia Creek near Elba, ID	81.2	6,460.8	16.3	17.39	23.5	12.2	33.0
269	13083000	Trapper Creek near Oakley, ID	52.4	6,339.4	6.2	17.39	28.1	14.4	41.3
270	13092000	Rock Creek near Rock Creek, ID	81.6	6,350.2	9.4	14.46	31.6	13.8	48.7
271	13145700	Schooler Screek near Gooding, ID	2.1	5,624.1	0.0	10.00	10.1	0.2	2.0
272	13147300	Muldoon Creek near Garfield Guard Station, ID	12.3	8,395.8	30.8	25.00	47.4	12.7	79.0
273	13148000	Little Wood River at Campbell Ranch near Carey, ID	263.4	7,045.9	17.9	22.03	34.9	13.5	57.5
		REGION 8							
274	06037500	Madison River near West Yellowstone, MT	434.9	7,900.0	93.9	42.30	11.3	2.4	7.9
275	09223000	Hams Fork below Pole Creek near Frontier, WY	128.6	8,466.6	72.8	31.97	20.4	5.0	19.5
276	10015700	Sulphur Creek above reservoir, below La Chapelle Creek, near Evanston, WY	58.5	7,971.5	25.4	21.62	9.6	0.3	1.2
277	10040000	Thomas Fork near Geneva, ID	45.4	7,243.6	24.8	23.80	26.5	8.1	36.9
278	10040500	Salt Creek near Geneva, ID	38.1	7,448.4	51.3	26.84	27.9	8.3	42.9
279	10041000	Thomas Fork near Wyoming-Idaho State Line, WY	113.8	7,330.7	36.5	25.13	27.4	8.7	40.7
280	10047500	Montpelier Creek at Irrigators Weir, near Montpelier, ID	50.6	7,360.5	28.5	21.49	32.0	14.1	52.6
281	10058600	Bloomington Creek at Bloomington, ID	24.3	7,684.3	37.6	35.10	27.4	15.7	40.5
282	10069000	Georgetown Creek near Georgetown, ID	21.9	7,824.2	55.4	26.14	40.6	19.6	70.8
283	10072800	Eightmile Creek near Soda Springs, ID	17.2	7,598.6	75.5	30.73	29.9	15.1	47.3
284	10076400	Soda Creek at Fivemile Meadows, near Soda Springs, ID	42.5	6,193.0	1.2	18.42	5.1	0.8	3.4
285	10077000	Soda Creek near Soda Springs, ID	50.9	6,184.9	2.3	18.19	6.1	1.7	5.5
286	10084500	Cottonwood Creek near Cleveland, ID	62.4	6,720.9	40.4	23.61	20.9	5.8	21.8
287	10089500	Mink Creek near Mink Creek, ID	68.4	6,534.7	40.0	26.57	28.6	14.9	42.4
288	10090800	Battle Creek Tributary near Treasureton, ID	4.7	5,837.2	2.2	15.10	17.4	4.8	10.3
289	10093000	Cub River near Preston, ID	30.4	7,384.3	53.7	36.05	31.3	13.9	49.4

Appendix A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 8 -- Continued							
290	10096000	Cub River above Maple Creek near Franklin, ID	23.2	5,691.9	2.5	14.22	19.8	5.1	18.0
291	10099000	High Creek near Richmond, UT	16.3	7,655.4	62.2	40.94	49.4	30.6	86.6
292	13010000	Snake River at south boundary of Y.N.P., WY	477.4	7,232.2	82.6	47.68	15.9	5.6	14.8
293	13010065	Snake River above Jackson Lake at Flagg Ranch, WY	502.5	8,199.4	82.8	47.42	15.8	5.5	14.7
294	13011500	Pacific Creek at Moran, WY	162.7	8,134.7	72.4	36.25	20.3	6.1	20.8
295	13011800	Blackrock Creek Tributary near Moran, WY	2.5	9,690.1	39.2	39.20	22.8	2.8	23.2
296	13011900	Buffalo Fork above Lava Creek near Moran, WY	330.1	8,951.0	59.7	37.05	27.0	12.1	33.9
297	13012000	Buffalo Fork near Moran, WY	370.2	8,815.8	60.2	35.58	26.3	11.5	32.8
298	13014500	Gros Ventre River at Kelly, WY	608.0	8,863.0	62.6	31.62	23.3	8.3	26.9
299	13015000	Gros Ventre River at Zenith, WY	627.2	8,792.9	61.5	31.27	22.8	8.1	26.3
300	13018300	Cache Creek near Jackson, WY	10.7	8,291.9	75.7	34.72	40.3	21.0	71.2
301	13019210	Rim Draw near Bondurant, WY	4.7	8,030.8	94.9	26.96	26.5	7.6	38.8
302	13019220	Sour Moose Creek near Bondurant, WY	2.8	7,773.4	82.4	25.46	22.8	6.7	25.2
303	13019400	Cliff Creek near Bondurant, WY	58.2	8,078.6	71.6	28.09	35.1	17.7	55.5
304	13019438	Little Granite Creek at mouth near Bondurant, WY	82.7	8,559.5	54.5	31.02	38.6	16.1	60.8
305	13019500	Hoback River near Jackson, WY	561.3	7,961.5	60.9	26.68	30.3	12.7	42.6
306	13020000	Fall Creek near Jackson, WY	46.9	7,459.6	65.6	28.89	32.7	18.4	50.5
307	13021000	Cabin Creek near Jackson, WY	9.0	7,274.0	72.5	23.64	35.6	26.5	64.7
308	13022550	Red Creek near Alpine, WY	3.9	7,938.7	38.8	30.63	53.6	7.7	88.7
309	13023000	Greys River above reservoir, near Alpine, WY	448.8	8,105.3	72.2	34.91	35.1	16.7	54.5
310	13023800	Fish Creek near Smoot, WY	3.2	7,568.8	68.8	27.87	18.7	3.2	11.9
311	13024000	Salt River near Smoot, WY	48.2	8,010.1	73.4	32.89	28.0	9.3	40.5
312	13024500	Cottonwood Creek near Smoot, WY	25.7	8,647.5	73.4	39.48	45.1	21.6	81.3
313	13025000	Swift Creek near Afton, WY	27.7	8,496.0	72.3	39.33	49.3	20.7	84.9
314	13025500	Crow Creek near Fairview, WY	113.8	8,441.5	34.5	29.44	24.9	9.9	33.2
315	13027000	Strawberry Creek near Bedford, WY	20.1	8,469.4	54.0	40.81	49.7	20.1	80.7
316	13027200	Bear Canyon near Freedom, WY	3.3	7,087.4	50.8	28.44	27.9	4.5	40.2
317	13029500	McCoy Creek above reservoir near Alpine, WY	108.1	7,017.8	59.3	26.69	27.5	12.4	40.4
318	13030000	Indian Creek above reservoir near Alpine, WY	36.5	7,962.0	46.8	31.08	51.5	25.2	83.1
319	13030500	Elk Creek above reservoir near Irwin, ID	58.5	7,908.8	59.5	34.15	49.8	26.6	81.4
320	13032000	Bear Creek above reservoir near Irwin, ID	78.3	7,187.5	56.1	26.74	38.8	22.6	69.7
321	13038900	Targhee Creek near Macks Inn, ID	20.9	8,273.4	57.8	30.06	34.6	11.8	49.3
322	13044500	Warm River at Warm River, ID	131.1	6,675.6	69.3	31.78	9.1	1.5	5.5
323	13045500	Robinson Creek at Warm River, ID	123.7	6,418.3	65.4	35.26	10.6	1.3	5.4
324	13046680	Boundary Creek near Bechler Ranger Station Y.N.P., ID	85.4	7,912.5	87.7	56.03	6.9	0.2	3.3
325	13047500	Falls River near Squirrel, ID	333.6	7,540.3	83.6	52.87	11.0	2.4	7.8
326	13049500	Falls River near Chester, ID	512.9	6,974.2	63.3	42.64	9.9	2.1	6.4
327	13050700	Mail Cabin Creek near Victor, ID	3.0	8,287.6	77.8	40.89	45.1	37.0	86.6

APPENDIX A. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 8 -- Continued							
328	13050800	Moose Creek near Victor, ID	21.8	8,499.6	65.1	54.17	41.7	23.4	68.3
329	13052200	Teton River above South Leigh Creek, near Driggs, ID	341.4	7,302.9	39.7	31.73	23.6	13.3	34.5
330	13054000	Teton River near Tetonia, ID	479.2	7,200.1	38.2	30.33	21.5	11.5	30.0
331	13054400	Milk Creek near Tetonia, ID	17.5	6,551.9	15.7	16.55	9.2	0.4	1.8
332	13055000	Teton River near St. Anthony, ID	874.8	6,920.9	36.1	27.65	19.0	9.1	24.3
333	13062700	Angus Creek near Henry, ID	14.3	6,881.2	28.3	20.00	18.0	5.3	18.2

Appendix B. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis

[ND, not determined because peak flow is below base flow]

Peak flow, in cubic feet per second, for given recurrence intervals, in years 1.5	[1]2	2.33	Period of known peak flows	Number of years of known peak
			REGION 1	
1,050	1,240	1,330	1929-80	50
29	42	49	1928-31, 33, 35-38, 74	11
127	154	167	1961-80	19
773	929	1,000	1928-74	45
407	524	583	1928-34, 72-79	15
298	338	356	1959-81	23
524	602	637	1928-59	32
1,680	1,930	2,040	1928-71	43
29	42	51	1962-81	20
2,880	3,140	3,260	1989-99	11
2,240	2,580	2,740	1959-82	24
33	36	38	1961-71	11
4,240	4,830	5,100	1913-48	35
51	64	70	1962-71	18
405	506	556	1951-97	47
324	298	328	1940-86	47
881	1,150	1,280	1923-97	75
99	109	114	1949-79	31
117	137	146	1962-75	14
14	22	27	1950, 62-75	15
1,030	1,290	1,410	1929-32, 47-97	55
			REGION 2	
530	642	696	1933, 37-44, 48, 54, 59-69, 74	23
191	226	243	1960-92	33
1,850	2,170	2,330	1945-57, 74, 83-96	28
22	27	30	1960-74	15
109	128	137	1960-78	19
141	170	184	1960-74	15
1,100	1,270	1,350	1899, 1948, 58-59, 61-64, 66-67	10
123	148	160	1958-73	16
572	627	651	1947-69, 72	24
89	109	119	1958-73	16
701	810	860	1948-53, 58-73	22
1,470	1,670	1,760	1951-60, 72, 74	12
50	67	76	1961-79, 82	20
31	39	43	1961-75, 79	16
3,420	4,410	4,900	1911-17, 34, 48, 54, 59-75	27
154	180	192	1960-74	15
1,830	2,310	2,550	1948, 56-97	43
1,310	1,590	1,720	1956-97	42
4,840	6,040	6,620	1951-97	47
12,000	15,100	16,600	1940-97	58
88	104	111	1961-71, 73-80	19
281	376	425	1968-97	30
1,390	1,660	1,790	1968-88	21
56	73	81	1962-71	10
1,500	1,940	2,160	1987-99	13
2,820	3,660	4,080	1988-97	10

Appendix B. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Peak flow, in cubic feet per second, for given recurrence intervals, in years				
1.5	[1]2	2.33	Period of known peak flows	Number of years of known peak
			REGION 2--Continued	
15,200	18,800	20,600	1911-97	66
476	587	641	1967-71, 73-81	14
12,900	15,500	16,800	1911-12, 21 -97	79
2,350	3,060	3,420	1966-97	32
3,750	4,780	5,290	1912, 21-66	45
97	113	121	1961-71, 74	12
56	67	73	1961-81	21
239	319	360	1948-97	43
22,400	25,500	27,000	1911, 30-99	71
57	73	81	1962-71	10
67	78	84	1962-71	10
212	267	294	1962-71	10
1,570	1,710	1,770	1958-67	10
16,400	18,700	19,800	1911-12, 30-99	72
14,600	16,300	17,100	1945-69	25
16,300	18,800	19,900	1967-97	33
46	58	64	1960-71, 73-79	19
539	644	694	1960-71	12
			REGION 3	
35	55	66	1961-70, 72-76	16
22	25	27	1962-76	15
11	18	22	1954-73	20
4,950	6,510	7,270	1948-97	50
276	405	476	1960-82, 91-96	30
6	17	26	1959-76	18
31	47	56	1961-65, 67-71, 74-81	18
5,130	6,210	6,720	1945-71	26
527	816	977	1975-97	23
55	78	158	1963-77	15
452	651	757	1964-78	15
1,010	1,490	1,750	1915-17, 29-31, 59-90, 95-97	41
46	56	61	1961-71	11
631	799	882	1961-71, 74-81	19
2,810	3,580	3,970	1915-19, 67-97	36
3,690	4,530	4,930	1956-79	24
10	12	13	1956-59, 61, 63-64, 66-71	13
261	331	365	1979-97	19
797	1,040	1,170	1934-42, 48, 59-81	33
316	396	435	1935-40, 48, 60-79	27
4,420	5,600	6,180	1963-95	33
1,310	1,840	2,120	1962-79	18
646	865	976	1954-79	26
359	522	610	1949-53, 55-67	18
657	858	959	1944-51, 56-68	21
2,190	2,770	3,060	1906-89	84
			REGION 4	
63	91	107	1914-18, 39-43, 55	11
10	13	15	1939-41, 51-71	24
1,220	1,650	1,860	1951-97	47

Appendix B. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Peak flow, in cubic feet per second, for given recurrence intervals, in years				Number of years of known peak
1.5	[1]2	2.33	Period of known peak flows	
			REGION 4--Continued	
47	62	70	1951-71	21
1,510	1,930	2,130	1916-54	39
32	51	62	1955-59, 61-71	16
58	94	114	1955-68	14
647	882	1,000	1904-82, 84-94	90
61	78	87	1961-71, 73-80	19
753	938	1,030	1957, 62-82, 97	23
55	92	114	1962-71	10
32	39	42	1960-77	18
395	484	527	1937-71, 74-75, 97	38
51	55	57	1933-35, 37-43	10
793	991	1,090	1939-49, 56	12
2,390	2,910	3,160	1937-41, 43-53, 56	17
668	817	880	1911-13, 20-21, 37-49, 56, 81-82, 85-88, 97	26
3,840	4,770	5,220	1939-97	59
210	266	293	1939-62, 97	25
601	729	791	1923-27, 38-71, 97	40
7,600	9,720	10,800	1890-91, 1895-1904, 11-14, 53-97	61
337	420	461	1911-13, 19337-65	32
53	67	73	1962-71	10
583	686	734	1967-80	16
59	73	79	1964-81	18
568	708	775	1904-16, 20-25, 27-68	61
1,760	2,020	2,140	1958-97	40
71	89	98	1964-65, 67-81	17
66	91	103	1962-71	10
692	903	1,010	1979-96	18
2,010	2,570	2,840	1967-96	30
1,510	1,640	1,700	1945-53	9
60	72	78	1965-75	11
167	199	214	1937-38, 46-59, 62-71	26
4,160	4,900	5,240	1948, 51-99	48
110	138	151	1960-71	12
52,200	61,600	66,000	1894, 1911-99	88
66	98	115	1961-72	12
2,670	3,260	3,540	1904-09, 11-15, 18-23, 26-89	81
640	749	800	1912, 15, 18-19, 26, 97	75
348	405	431	1938-50	13
459	540	578	1915, 24-78	56
1,420	1,580	1,650	1913, 26-91, 95-97	70
801	923	979	1915, 24-85, 95-97	66
2,700	3,110	3,290	1913, 66-97	33
71	90	99	1962-71	10
1,660	1,930	2,050	1945-74	30
74	91	98	1962-81	16
4,330	5,000	5,310	1911-20, 23-63	51
159	186	198	1961-71	11
5,360	6,560	7,120	1964-99	36

Appendix B. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Peak flow, in cubic feet per second, for given recurrence intervals, in years				Number of years of known
1.5	[1]2	2.33	Period of known peak flows	peak
			REGION 4--Continued	
46,500	53,000	55,900	1911-65	55
1,710	2,140	2,340	1980-99	20
104	123	133	1962-81	19
74	109	127	1962-71, 74-81	18
47,600	54,200	57,100	1931-33, 35-38, 65-99	42
637	776	844	1903, 07, 09-16, 32-91	70
385	489	541	1930, 33-69	38
686	890	994	1914-17, 40-97	62
240	317	356	1940-42, 44-71	31
			REGION 5	
1,950	2,340	2,520	1956-73	18
572	659	699	1948-54, 58-79	29
275	342	373	1920, 22-24, 38-73	40
41	51	55	1958-73	16
139	170	184	1962-71	10
762	905	972	1948-71	24
27	40	47	1962-71	10
427	495	526	1941-58	18
1,800	2,290	2,520	1915-97	83
1,230	1,660	1,880	1912-96	85
42	54	60	1961-72	11
279	332	357	1958, 63-71, 73-76, 78-80	17
84	102	111	1962-71	10
5,520	6,610	7,120	1871-72, 1911-99	91
3,670	4,400	4,730	1945-97	53
536	655	712	1946-56	11
439	513	548	1945-56	12
123	151	165	1962-71, 73-80	18
3,620	4,230	4,510	1941-99	59
116	148	164	1962-71	10
27	35	38	1962-71	10
309	346	363	1962-71	10
1,160	1,340	1,430	1946-97	52
1,080	1,280	1,370	1926-45	20
71	89	97	1962-71, 73-80	18
125	143	151	1963-71	9
460	517	542	1941-52	12
436	482	503	1941-52	12
848	1,000	1,070	1911-13, 21-74, 93-99	63
2,620	3,070	3,270	1926-60, 74	36
1,180	1,470	1,610	1921-49, 74	29
4,180	4,970	5,330	1922-91	70
24	33	38	1963-72	10
1,420	1,660	1,760	1929-72, 74	45
1,800	2,110	2,250	1922-60	39
7,390	8,870	9,570	1973-81	9
3,300	3,780	3,990	1945-58	14
893	1,030	1,090	1929, 31-60	31
2,800	3,330	3,580	1967-99	29

Appendix B. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Peak flow, in cubic feet per second, for given recurrence intervals, in years				
1.5	**2**[1]	**2.33**	**Period of known peak flows**	**Number of years of known peak**
			REGION 5--Continued	
143	173	188	1929-42, 83-97	29
293	352	380	1929-40	12
823	953	1,010	1929-43	15
2,510	2,930	3,130	1929-99	71
1,230	1,400	1,480	1943-52	10
9,880	11,400	12,100	1932-48	13
55,000	61,500	64,300	1945-56	12
			REGION 6	
262	331	365	1946-53, 60-91	40
290	393	444	1921-32, 46-53, 55-58, 60-73, 75	39
822	968	1,040	1939-97	59
628	808	897	1937-53, 69-73	22
336	454	513	1925-97	73
7.3	9.8	11	1962-71	10
233	307	344	1941-52, 69-93	35
197	264	297	1921-73, 83-87	57
109	135	147	1962-71	10
319	379	407	1961-73	13
611	742	803	1944-97	54
1,780	2,150	2,320	1904-14, 20-97	89
163	183	192	1963-73, 80-84	16
6.7	8.9	10	1963-71, 74	10
86	123	143	1973-97	25
4.4	7.4	9.2	1971-97	27
178	252	291	1973-97	25
161	206	227	1970-86	17
1,280	1,590	1,730	1929-38, 73-81	19
49	85	107	1962-71	10
206	246	265	1944-63	20
123	147	158	1962-71, 73-76, 78-80	17
ND	21	26	1962-71	10
6,930	8,490	9,220	1912-16, 20-97	83
702	910	1,010	1956-97	42
747	988	1,110	1929-43	15
74	97	109	1962-71	10
116	139	150	1962-80	19
476	556	592	1930-39	10
1,440	1,760	1,910	1945-77	33
11,400	13,500	14,400	1945-81	37
			REGION 7a	
273	375	429	1943-80, 82-97	54
242	393	483	1922-27, 29-33, 35-97	74
268	454	564	1949-97	49
307	407	457	1949-81	33
1,040	1,380	1,540	1911-16, 18-21, 30, 38-98	72
84	111	124	1911, 22-23, 25-91	70
3.8	5.7	6.5	1960-71	12
68	87	97	1961-71, 73-80	19
15	23	27	1963-79	17

Appendix B. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Peak flow, in cubic feet per second, for given recurrence intervals, in years				Number of years of known
1.5	[1]2	2.33	Period of known peak flows	peak
			REGION 7a--Continued	
127	188	221	1964-78	15
240	302	333	1963-78	16
55	81	96	1929-32, 54-71	22
373	444	478	1963-78	16
8.1	12	14	1939-49, 63, 66-97	44
81	165	219	1939-49	11
80	140	177	1961-71, 73-80	19
16	23	27	1961-71, 74-76, 78-80	17
ND	43	56	1965-78	14
3.8	5.1	5.8	1963-93	31
3.2	4.2	4.6	1966-93	28
125	169	191	1964-90	27
51	85	105	1964-93	30
35	63	81	1963-93	31
184	322	404	1961-71, 73-80	19
5.4	10	13	1946-52, 55-71	24
1,560	1,960	2,160	1961-80	19
33	59	75	1904-06, 10-17, 22-23, 38-62, 64-85	59
862	1,470	1,820	1963-79	17
			REGION 7b	
74	109	129	1912-13, 32, 41-69	32
50	65	73	1939-61	23
100	120	129	1941-43, 47-52	9
5.1	10	13	1959-73	15
165	208	228	1963-71	9
595	787	883	1978-79, 86-97	14
11	14	15	1961-71	11
250	298	321	1955-97	43
17	22	25	1961-1971	11
154	214	246	1985-94	10
56	69	75	1960-89	30
127	176	202	1957-67, 71	12
39	50	56	1911-16, 19-30, 32-97	84
150	200	224	1910-13, 39, 44-74	36
17	23	26	1961-76, 78-80	19
90	106	113	1963-71	9
689	880	974	1920-26, 41-58	25
			REGION 8	
1,210	1,360	1,430	1914-17, 19-73, 84-96	70
601	771	852	1953-98	46
233	335	390	1958-97	39
110	147	165	1940-51	12
119	165	188	1940-51	12
271	400	469	1950-92	43
82	99	107	1943-79	37
124	150	162	1961-86	26
43	50	53	1940-56	17
103	121	130	1961-86	26
57	73	80	1965-86	22

Appendix B. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Peak flow, in cubic feet per second, for given recurrence intervals, in years				
1.5	[1]2	2.33	Period of known peak flows	Number of years of known peak
			REGION 8--Continued	
161	187	198	1913-26	14
300	372	407	1939-86	48
334	355	364	1943-52	10
30	45	53	1961-80	20
536	591	616	1947-52, 56-62, 70-84, 86	37
527	558	571	1940-1952	13
187	200	206	1944-52, 71-72, 79-89	22
4,960	5,360	5,530	1914-15, 19-25	9
6,490	8,030	8,760	1984-97	14
2,120	2,510	2,680	1918, 45-97	52
35	41	44	1964-74	11
3,690	4,080	4,250	1966-97	32
3,800	4,090	4,210	1918, 45-60	17
2,900	3,180	3,310	1918, 45-58	15
2,240	2,700	2,920	1917, 88-97	12
62	79	86	1945-97	53
12	13	14	1950-92	43
13	15	16	1943-79	37
520	612	655	1961-86	26
213	292	333	1982-92	11
3,320	3,750	3,950	1918, 45-58	15
341	391	413	1965-86	22
111	128	135	1914-17, 19-73, 84-96	70
18	21	23	1953-98	46
2,800	3,290	3,510	1918, 37-38, 54-97	47
36	47	52	1940-51	12
213	250	266	1932-57	25
210	242	256	1933-57	24
453	505	528	1943-80	38
197	227	241	1946-49, 62-67	10
236	263	274	1932-43	12
32	44	51	1961-71	11
800	924	980	1954-71, 74	19
175	200	211	1918, 54-71	19
407	464	490	1918, 1954-71	19
447	517	549	1918, 34-36, 54-71	22
227	258	272	1963-80	18
392	461	493	1912-14, 18-32	18
500	605	653	1912-14, 18-32	18
429	502	535	1984-97	14
3,150	3,550	3,730	1905-09, 18-97	85
3,120	3,540	3,730	1920-97	78
33	38	41	1962-71	10
253	280	292	1962-71	10
1,260	1,460	1,550	1962-97	36
1,070	1,270	1,350	1930-32, 34, 40-57	22
47	84	107	1962-80	19
2,890	3,380	3,610	1890-93, 1903-09, 20-97	88
206	283	322	1963-71, 74-80	16

[1]From Berenbrock (2002, table 7, p. 16-18).

Appendix C. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 1.5, 2, and 2.33) regional regression equations for Idaho

[Some numbers are in scientific notation; DA, Drainage area; E, mean basin elevation; F, percentage of forest cover in the basin; P, mean annual precipitation; NF30, percentage of north-facing slopes greater than 30 percent; BS, average basin slope; and S30, percentage of slopes greater than 30 percent]

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 1

1.5-year recurrence interval

CONSTANT	DA	E	F
0.81690	-0.15522E-01	0.89824E-01	-0.44334
-0.15522E-01	0.58304E-02	0.23381E-02	0.23234E-02
0.89824E-01	0.23381E-02	0.30674	-0.14033
-0.44334	0.23234E-02	-0.14033	0.27410

2-year recurrence interval

CONSTANT	DA	E	F
0.70947	-0.13937E-01	0.74767E-01	-0.38336
-0.13937E-01	0.50165E-02	0.20736E-02	0.22620E-02
0.74767E-01	0.20736E-02	0.26166	-0.11881
-0.38336	0.22620E-02	-0.11881	0.23590

2.33-year recurrence interval

CONSTANT	DA	E	F
0.66262	-0.13362E-01	0.66824E-01	-0.35660
-0.13362E-01	0.46295E-02	0.19920E-02	0.23076E-02
0.66824E-01	0.19920E-02	0.23977	-0.10808
-0.35660	0.23076E-02	-0.10808	0.21843

REGION 2

1.5-year recurrence interval

CONSTANT	DA	E	P
0.41277	0.10637E-02	0.75114E-01	-0.28223
0.10637E-02	0.13788E-02	0.31021E-02	-0.33895E-02
0.75114E-01	0.31021E-02	0.26254	-0.15515
-0.28223	-0.33895E-02	-0.15515	0.23833

2-year recurrence interval

CONSTANT	DA	E	P
0.39901	0.98739E-03	0.72212E-01	-0.27258
0.98739E-03	0.13325E-02	0.30477E-02	-0.32694E-02
0.72212E-01	0.30477E-02	0.25340	-0.14973
-0.27258	-0.32694E-02	-0.14973	0.23015

2.33-year recurrence interval

CONSTANT	DA	E	P
0.39651	0.94449E-03	0.71247E-01	-0.27060
0.94449E-03	0.13240E-02	0.30554E-02	-0.32384E-02
0.71247E-01	0.30554E-02	0.25199	-0.14864
-0.27060	-0.32384E-02	-0.14864	0.22848

REGION 3

1.5-year recurrence interval

CONSTANT	DA	E
0.97938E-01	-0.54908E-02	-0.17862
-0.54908E-02	0.43918E-02	-0.54067E-02
-0.17862	-0.54067E-02	0.40646

2-year recurrence interval

CONSTANT	DA	E
0.72994E-01	-0.40438E-02	-0.13200
-0.40438E-02	0.31745E-02	-0.38284E-02
-0.13200	-0.38284E-02	0.29798

Appendix C. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 1.5, 2, and 2.33) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 3 – Continued

2.33-year recurrence interval

CONSTANT	DA	E
0.64627E-01	-0.35647E-02	-0.11614
-0.35647E-02	0.27364E-02	-0.31926E-02
-0.11614	-0.31926E-02	0.26035

REGION 4

1.5-year recurrence interval

CONSTANT	DA	E
0.88119E-01	-0.81369E-03	-0.12446
-0.81369E-03	0.19964E-02	-0.43262E-02
-0.12446	-0.43262E-02	0.19417

2-year recurrence interval

CONSTANT	DA	E
0.76068E-01	-0.75066E-03	-0.10719
-0.75066E-03	0.17192E-02	-0.36670E-02
-0.10719	-0.36670E-02	0.16698

2.33-year recurrence interval

CONSTANT	DA	E
0.71908E-01	-0.73895E-03	-0.10117
-0.73895E-03	0.16203E-02	-0.34200E-02
-0.10117	-0.34200E-02	0.15742

REGION 5

1.5-year recurrence interval

CONSTANT	DA	P	NF30
0.30088	-0.68338E-02	-0.17085	-0.22671E-01
-0.68338E-02	0.17285E-02	0.37080E-02	-0.19055E-02
-0.17085	0.37080E-02	0.10729	0.12335E-02
-0.22671E-01	-0.19055E-02	0.12335E-02	0.19957E-01

2-year recurrence interval

CONSTANT	DA	P	NF30
0.27767	-0.62717E-02	-0.15755	-0.21191E-01
-0.62717E-02	0.15842E-02	0.33900E-02	-0.17302E-02
-0.15755	0.33900E-02	0.98903E-01	0.12712E-02
-0.21191E-01	-0.17302E-02	0.12712E-02	0.18410E-01

2.33-year recurrence interval

CONSTANT	DA	P	NF30
0.27113	-0.61759E-02	-0.15377	-0.20656E-01
-0.61759E-02	0.15500E-02	0.33331E-02	-0.16851E-02
-0.15377	0.33331E-02	0.96490E-01	0.12389E-02
-0.20656E-01	-0.16851E-02	0.12389E-02	0.17942E-01

REGION 6

1.5-year recurrence interval

CONSTANT	DA	P
0.77207	-0.21098E-01	-0.53388
-0.21098E-01	0.34260E-02	0.10154E-01
-0.53388	0.10154E-01	0.37746

2-year recurrence interval

CONSTANT	DA	P
0.73182	-0.19589E-01	-0.50715
-0.19589E-01	0.32568E-02	0.93413E-02
-0.50715	0.93413E-02	0.35932

Appendix C. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 1.5, 2, and 2.33) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 6 – Continued

2.33-year recurrence interval

CONSTANT	DA	P
0.69863	-0.18807E-01	-0.48392
-0.18807E-01	0.31155E-02	0.89783E-02
-0.48392	0.89783E-02	0.34272

REGION 7a

1.5-year recurrence interval

CONSTANT	DA	E
0.36664	-0.12482E-01	-0.44083
-0.12482E-01	0.36699E-02	0.87481E-02
-0.44083	0.87481E-02	0.54890

2-year recurrence interval

CONSTANT	DA	E
0.27535	-0.10043E-01	-0.32931
-0.10043E-01	0.29644E-02	0.69738E-02
-0.32931	0.69738E-02	0.40923

2.33-year recurrence interval

CONSTANT	DA	E
0.26053	-0.95514E-02	-0.31118
-0.95514E-02	0.27689E-02	0.67052E-02
-0.31118	0.67052E-02	0.38613

REGION 7b

1.5-year recurrence interval

CONSTANT	DA
0.63666E-01	-0.33265E-01
-0.33265E-01	0.20590E-01

2-year recurrence interval

CONSTANT	DA
0.52959E-01	-0.27639E-01
-0.27639E-01	0.17103E-01

2.33-year recurrence interval

CONSTANT	DA
0.48930E-01	-0.25516E-01
-0.25516E-01	0.15787E-01

REGION 8

1.5-year recurrence interval

CONSTANT	DA	BS	S30
0.15000	-0.11962E-01	-0.19540	0.96505E-01
-0.11962E-01	0.32557E-02	0.83896E-02	-0.36495E-02
-0.19540	0.83896E-02	0.33323	-0.18960
0.96505E-01	-0.36495E-02	-0.18960	0.11656

2-year recurrence interval

CONSTANT	DA	BS	S30
0.13509	-0.10754E-01	-0.17622	0.87079E-01
-0.10754E-01	0.29289E-02	0.75498E-02	-0.32850E-02
-0.17622	0.75498E-02	0.30082	-0.17123
0.87079E-01	-0.32850E-02	-0.17123	0.10528

2.33-year recurrence interval

CONSTANT	DA	BS	S30
0.13042	-0.10377E-01	-0.17020	0.84129E-01
-0.10377E-01	0.28276E-02	0.72849E-02	-0.31706E-02
-0.17020	0.72849E-02	0.29073	-0.16553
0.84129E-01	-0.31706E-02	-0.16553	0.10180

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