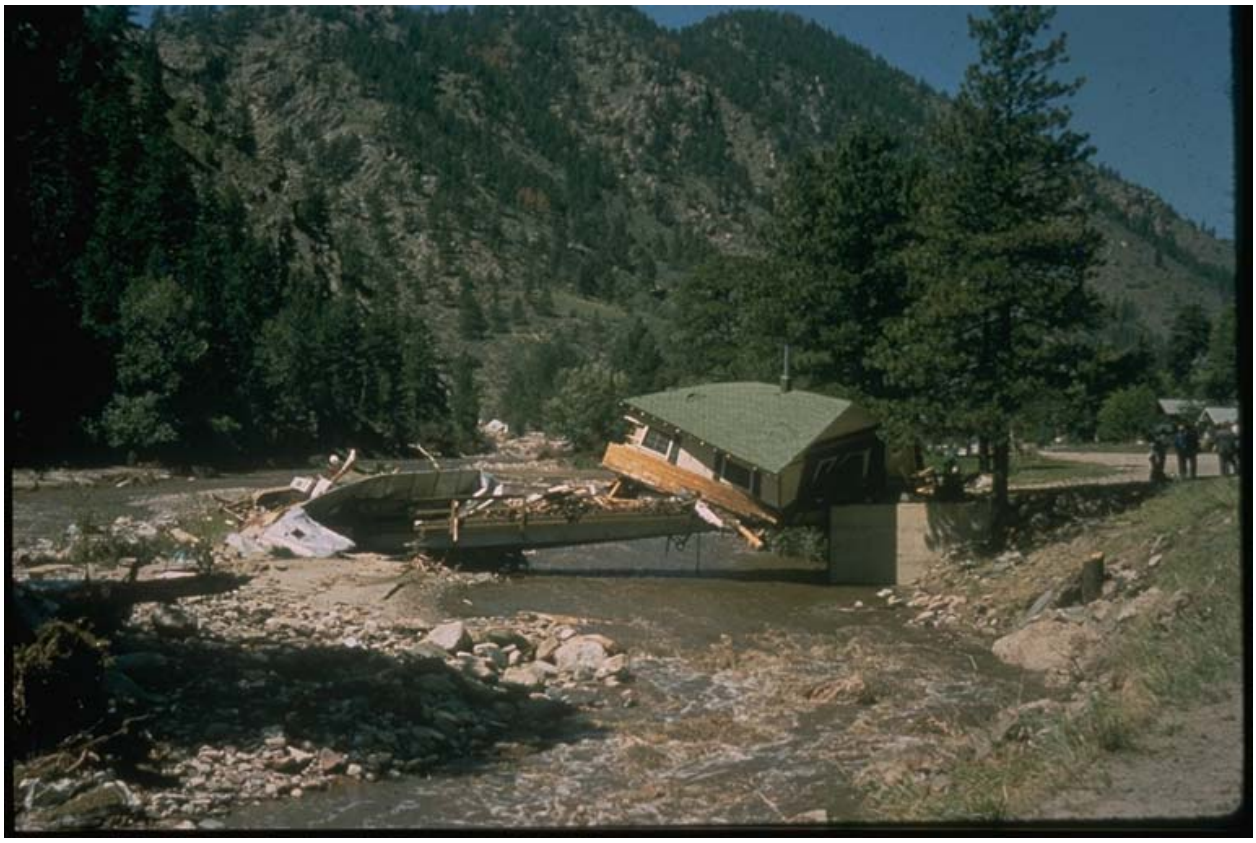
Guidelines For Determining 100-Year Flood Flows For Approximate Floodplains in Colorado

Version 6.0



Department of Natural Resources
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June 2004

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Prepared by:
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In cooperation with the Colorado Flood Hydrology Advisory Committee

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EXECUTIVE SUMMARY

The publication entitled ***Guidelines for Determining 100-Year Flood Flows for Approximate Floodplains in Colorado*** (***Guidelines***) was prepared by Colorado Water Conservation Board (CWCB) staff as a tool for estimating 100-year flood discharges for approximate floodplains where detailed engineering analyses are limited or unavailable. The ***Guidelines*** are designed to provide a streamlined hydrologic procedure for use in the review and designation of approximate floodplain studies and mapping in Colorado. The ***Guidelines*** facilitate the estimation of 100-year flood discharges for approximate floodplains as required by the CWCB's technical standards.

Many of the Flood Insurance Rate Maps (FIRM's) and Flood Hazard Boundary Maps (FHBM's) prepared by the Federal Emergency Management Agency (FEMA) and Flood Insurance Administration (FIA) include approximate floodplain delineations within Colorado. Those approximate delineations do not have detailed hydrologic information to accompany them and were therefore not previously designated and approved by the CWCB. However, Colorado statutes require that floodplain information to be used by local governments for land use and regulatory purposes must first be designated and approved by the CWCB. The ***Guidelines*** will permit fulfillment of that statutory requirement by allowing approximate floodplain delineations to meet the CWCB's hydrologic technical requirements for designation and approval.

The methodology in the ***Guidelines*** utilizes 100-year flow values and drainage areas from existing detailed floodplain studies. Due to the great hydrologic diversity of Colorado's streams, the state was divided into major river basins, and then further divided into subregions of hydrologic homogeneity. Regression equations were developed in order to relate 100-year peak flow values to the drainage areas for each hydrologic subregion within Colorado. By using these regression techniques, the ***Guidelines*** methodology allows hydrology for approximate floodplain delineations to be related to detailed published hydrology from floodplain studies that have already met the CWCB's technical requirements for designation and approval.

The use of the ***Guidelines*** is restricted to the estimation of 100-year flood discharge values for streams where only approximate floodplain information or no information is available. **The *Guidelines* are not to be used for the design of hydraulic structures or for the preparation of detailed floodplain studies. Detailed hydrologic and hydraulic analyses should be performed for any planned development involving residential subdivisions, commercial/industrial development, public infrastructure, and flood control facilities**. In the event that a detailed study is completed on a stream reach that has been previously studied by approximate methods, the new detailed floodplain information will supersede the approximate information.

TABLE OF CONTENTS

1.0 PURPOSE, PROCEDURES AND USE

1.1 INTRODUCTION

The Colorado Water Conservation Board (CWCB), Flood Protection Program, performs technical reviews for CWCB designation and approval of floodplain and drainageway studies. Through its process of designation and approval of floodplain studies, the CWCB staff prepares a numbered resolution for each study submitted for Board action. As of June 2004, this program has processed over 570 resolutions designating and approving floodplain reports. The resolutions and the accompanying studies are catalogued in the CWCB's library and data base system.

Until the development of these ***Guidelines for Determining 100-year Flood Flows for Approximate Floodplains in Colorado*** (***Guidelines***), the CWCB had no procedure for determining hydrology values for approximate floodplain mapping. Such approximate mapping could not, therefore, meet CWCB technical requirements for designation and approval. It was decided that a methodology linking the approximate floodplain delineations to existing detailed hydrologic analyses was needed in order to comply with CWCB requirements.

The regression equations included in these ***Guidelines*** were prepared using published 100-year hydrologic information in existing detailed floodplain reports that were already designated or soon to be designated. The CWCB prepared equations for hydrologic *drainage area vs. discharge* using a best-fit curve regression program. Data points from regional basins were grouped geographically and draft regression equations were developed. These draft equations were tested by graphical interpretation and through standard measures of regression validity. The CWCB staff will use these regression equations to estimate 100-year peak flow values for stream reaches that have only approximate floodplain information or no information at all. This process will fulfill the hydrologic requirements for the designation and approval of approximate floodplain information in Colorado. As described later in this document, the regression equations are subject to limitations in their application. For certain applications, a detailed hydrologic and hydraulic analysis will be needed.

Previous versions of the ***Guidelines*** were reviewed and endorsed by the CWCB's Colorado Flood Hydrology Advisory Committee (Committee). The Committee is made up of selected practicing hydrologists and engineers from the public and private sectors. The Committee members included representatives from federal, state, and local agencies, and from consulting engineering firms.

1.1.1 Acknowledgments

The ***Guidelines*** were completed under the direction of Larry F. Lang, P.E., and was facilitated by the help and guidance from the Colorado Flood Hydrology Advisory Committee. The author wishes to thank the entire Committee along with CWCB Flood Protection staff and Jim Wieger for their invaluable assistance. Additional input and guidance was provided by the Technical Advisory Committee (for the Colorado Floodplain and Stormwater Criteria Manual) regarding the use of USGS regional regression equations for certain geographic areas in Colorado.

1.1.2 Statutory Responsibilities

The CWCB's statutory responsibilities relating to designation and approval of flood water runoff channels or basins are as follows:

... "to devise and formulate methods, means, and plans for bringing about the greater utilization of the waters of the state and the prevention of flood damages therefrom, and to designate and approve storm or floodwater runoff channels or basins, and to make such designations available to legislative bodies of cities and incorporated towns, to county planning commissions, and to boards of adjustment of cities, incorporated towns, and counties of this state"..., Section 37-60-106(1)(c) of the Colorado Revised Statues (CRS).

Article 24-65.1-403.3.b of the Colorado Revised Statutes, Title 24, states that ..*"No floodplain shall be designated by any local government until such designation has been first approved by the Colorado water conservation board as provided in sections 30-28-111 and 31-23-301*.

The CWCB designates and approves the state's floodplains under the provisions of its "Rules and Regulations for the Designation and Approval of Floodplains and of Storm or Flood Runoff Channels in Colorado", dated January 30, 1988. The CWCB must comply with these "Rules and Regulations".

Rule 6.B.2. ("Other Requirements" for Hydrologic Analysis for Approximate Floodplain Information) states that *"The hydrology for approximate floodplain information shall, at a minimum, meet the hydrology standards... for detailed floodplain information"*. The ***Guidelines*** allow the development of hydrologic information for approximate floodplain maps so they can comply with Rule 6.B.2.

1.1.3 Limitations of This Publication

The limitations of this publication are as follows:

- This publication is intended to be used as a guideline to assist engineers with estimating peak flood flow values, and the methodology is not mandated by the State of Colorado. USGS and other hydrologic methods may be used for the purpose of determining 100-year flood discharges for streams in Colorado. Drainage criteria and hydrologic methodologies adopted and utilized by local governments and flood control agencies shall supersede these ***Guidelines***. For example, these ***Guidelines*** are not intended to supersede detailed hydrologic methods established by the Urban Drainage and Flood Control District, the City of Fort Collins, the City of Colorado Springs, or other such entities.

- The regression equations can be used to estimate peak flow values for the 100-year flood event for rural or largely undeveloped watersheds only.

- The regression equations are for unregulated natural streams, unless an adjustment can be made for effective drainage area in those situations where flood control reservoirs, detention ponds, or other man-made flood control facilities are present. Effects from non flood control reservoirs

may be ignored in hydrology studies utilizing these ***Guidelines***. Users must take caution when applying the ***Guidelines*** in watersheds having unusual drainage characteristics.

- The regression equations were developed using 100-year flow values that were obtained from published floodplain studies by FEMA, the Corps of Engineers, and other entities. The flow values in those previous studies were developed using various hydrologic methods such as rainfall-runoff models and frequency analyses of streamflow gaging station data.

- The ***Guidelines*** can be used for streams having no floodplain information or approximate floodplain information only. This publication should not be used for the preparation of detailed studies, for the design of hydraulic structures, for the evaluation of ditch and canal overflows, or for the evaluation of local storm drainage and ponding problems. A detailed hydrologic and hydraulic analysis should be performed for those cases and for any planned development involving residential subdivisions, commercial and industrial structures, public infrastructure, and flood control facilities.

- A detailed floodplain study will supersede a study that was completed using hydrology values generated using this publication.

- The subregional boundaries shown on the maps in this document for each major basin may be difficult to interpret due to the scale of the mapping. Study reaches that lie on or near a subregional boundary will require careful interpretation. In those cases, the CWCB may be contacted to assist in making a boundary determination.

1.2 METHODOLOGY

The first step in the development of the ***Guidelines*** was to collect existing hydrology information from all of the designated or soon to be designated Colorado floodplain studies (detailed) within the CWCB's floodplain information library. The state was divided into major drainage basins, and the available data was grouped by basin. The major basins, which are graphically presented in the PDF file located on the CWCB's website, are as follows:

1. Arkansas River
2. South Platte River
3. Republican River
4. Colorado River
5. Green River
6. Dolores River
7. San Juan River
8. Rio Grande
9. North Platte River

Each of the major drainage basins studied was divided into preliminary geographic/hydrologic subregions. Subregions in the eastern Colorado basins (Arkansas River, South Platte River, and Republican River) were divided using the generalized divisions of plains, foothills, and mountains, as appropriate. Basin divides, elevation limits, topographic breaks, stream confluences, and other features were used to define preliminary subregions. Subregions in the western Colorado are generally defined by major watershed boundaries. Parameters such as channel slope, geologic

conditions, vegetative cover, precipitation, and other hydrometeorological factors were assumed to have already been considered in the development of the previously published flow values.

During the data collection process, published 100-year flow values for studied streams were compiled along with their associated drainage areas for each of Colorado's major drainage basins. Those data pairs were entered into a spreadsheet, and then grouped into preliminary geographic/hydrologic subregions. The 100-year flow values and respective drainage areas were plotted for each subregion to evaluate trends and outliers.

Regression equations were then developed using a best-fit regression technique within a statistical software package entitled "GB-Stat" (Reference 1). The statistical routine fits values of X (i.e. drainage area) and Y (i.e. 100-year flow value) to several different equations and identifies the regression correlation for each equation. An acceptable correlation was assumed to be achieved when the standard error of estimate was 50% or less, or when the R squared for a regression was 0.80 or greater. For simplification purposes, the final equation selected was not necessarily the best-fit equation, but rather the simplest and most logical equation that still produced a reasonable correlation.

The subregional boundaries and data sets were refined during the course of the regional analysis. The subregional boundaries were also dictated by the availability of hydrology information from the detailed floodplain studies. Some preliminary subregions had to be split up or combined with other subregions because of data trends or other factors. Some subregions were deemed to be areas of "No Regression" due to lack of data points or lack of sufficient correlation of the data. The final data points used in the regression analyses are presented in graphical format in the technical addendum at the end of the report.

Due to limitations of the available data, the use of the regression equations is restricted by drainage basin size in each of the subregions. Extrapolation beyond the limits of the data set cannot be justified without a means of checking the accuracy.

The methodology and the draft equations were presented to the Committee for review and comment. Endorsement of the methodology was given by a majority of the Committee members, provided that the limitations and disclaimers were identified in this document. Recommendations made by the Committee were incorporated into these ***Guidelines*** to the extent possible.

1.3 INSTRUCTIONS ON *GUIDELINES* USE

The users of this methodology may apply the regression equations to stream reaches where only approximate or no floodplain mapping exists (where no detailed hydrologic data or floodplain studies are available). The procedure for using the equations in this document for a particular stream reach is as follows:

1. Establish the major drainage basin and the hydrologic subregion where the stream reach (hydrologic point of interest) is located by referencing the basin and subregion maps within this document.

2. Select the regression equation for the subregion where the hydrologic point of interest is located.

3. Establish the drainage area for the hydrologic point of interest by using GIS, planimetering the drainage basin on a topographic map, or obtaining a reliable published value for the drainage area.

4. Estimate the 100-year peak flow value for the hydrologic point of interest by applying the appropriate equation (or regression curve) to the drainage area found in step 3.

5. A weighted methodology may be used in cases where a hydrologic point of interest lies just downstream of a subregional boundary (see equation below). Compute the drainage area for each portion of the watershed that lies within a particular subregion, apply the appropriate regression equation to each portion of the watershed, and then sum the resulting 100-year flow values to obtain the total 100-year discharge for the point of interest. Discretion should be used when applying this methodology. The weighted results should be checked for reasonableness by comparing flow values obtained from using the downstream subregion equation only (applied to the entire watershed) along with values obtained from other available methodologies. Contact the CWCB for guidance if necessary.

$$Q_{100\ total} = Q_1 + Q_2$$

Where:
- Q_1 = 100-year flow value computed using portion of total drainage area within the subregion that lies upstream of the hydrologic point of interest.
- Q_2 = 100-year flow value computed using portion of total drainage area within the subregion where the hydrologic point of interest is located.

1.4 RELATED STUDIES

The TM-1 publication (Reference 2), which was prepared in 1976 by the CWCB in cooperation with the U.S. Geological Survey, has been used in many hydrologic analyses. TM-1 was developed to provide a simplified method for estimating approximate limits of flood-prone areas along streams in Colorado in response to House Bill 1041 (Local Government Land Use Control Enabling Act of 1974). The manual presents regional regression curves that were developed from stream gage data. Over the past 20 years, it has been discovered that the methods presented in TM-1 may not accurately estimate 100-year peak flow values in some geographic areas. Therefore, any usage of TM-1 should be checked by comparing results derived using other hydrologic methods. TM-1 has been essentially superseded by more recent USGS publications. Additional information regarding USGS publications can be obtained from www.usgs.gov.

Several USGS and other publications contain hydrologic methodologies for various regions of the state. For basins with drainage areas that fall outside of the applicability of the ***Guidelines***, the user should conduct a detailed hydrologic analysis or use other available methodologies.

1.5 UPDATING PROCEDURES

These ***Guidelines*** will be updated occasionally to revise the published information as necessary and to make revisions when additional information becomes available. The CWCB will generally invoke the updating process with assistance and endorsement from the Committee. The CWCB staff will gather additional data, review the subregional boundaries and regression equations, recommend revisions as needed. The Committee will review, discuss, and vote on any major changes that are proposed for the ***Guidelines***. Comments and questions related to these ***Guidelines*** may be directed to:

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1.6 REVISIONS

Version 1.0

Version 1.0 of the ***Guidelines*** was published in February 1996. Version 1.0 included two chapters: Chapter 1 provided general background information, and chapter 2 provided specific details regarding the regression methodology for the Arkansas River Basin.

Version 2.0

Version 2.0 was published in October 1996 and included revisions to chapters 1 and 2, and included new information for the South Platte River basin in chapter 3. The revisions to chapter 1 were editorial in nature, and did not include any substantial changes to the content or methodology. Revisions to chapter 2 included a change in the subbasin boundaries between the foothills areas and the mountains areas. The new boundary definition between the foothills and mountains is based on an elevation limit of generally 7,500 feet, except for in the northern part of the Arkansas Basin where the boundaries were essentially unchanged. In addition, the regression equation for subregion ARK-4b (foothills area to the east of Monument/Fountain Creeks) was changed to a power equation in lieu of a linear equation.

Version 3.0

Version 3.0 was published in July 1997 and included revisions to chapters 2 and 3, and included new information for the Republican River basin in chapter 4. The revisions to chapters 2 and 3 were minor, and did not include any substantial changes to the content or methodology. Revisions to chapter 3 included minor changes in the subbasin boundaries between the foothills subregions and the mountains subregion.

Version 4.0

Version 4.0 (draft) was published in December 1998 and included revisions to chapter 1, and included new information and equations for portions of western Colorado in chapters 5, 6, and 7. The revisions to chapter 1 were minor, and did not include any substantial changes to the content.

Version 5.0

Version 5.0 (draft) was published in December 2001 and included minor revisions to chapter 1 to update text only. No substantial content changes were made to chapter 1. Minor revisions to chapter 2 were made to renumber regional subareas: Subregion 4a was changed to 4, subregion 4b was changed to 5, subregion 5 was changed to 6, and subregion 6 was changed to 7.

Version 6.0

Version 6.0 (current version) was published in June 2004 and included minor text revisions to chapter 1. A weighted methodology for multi-subregion watersheds was added in Section 1.3 and one additional reference was added in Section 1.8. The recommendation to use USGS regression equations for watersheds located in western Colorado was added to chapters 5 through 9.

1.7 SELECTED REFERENCES

1. Chow, V. T., Maidment D. R., and Mays, L. W., Applied Hydrology, McGraw Hill Book Company, 1988.

2. Colorado Water Conservation Board in cooperation with U.S. Geological Survey, Jerald F. McCain and Robert D. Jarrett, Technical Manual No. 1, Manual for Estimating Flood Characteristics of Natural-Flow Streams in Colorado, 1976.

3. Colorado Water Conservation Board, Colorado Floodplain Information Index System, 2001.

4. Colorado Water Conservation Board, Colorado Floodplain Management and Drainage Criteria Manual (draft), June 2004.

5. Dynamic Microsystems, Inc., GB-STAT, Windows™ version computer program, 1990.

6. U.S. Geological Survey in cooperation with the Colorado Department of Transportation and the Bureau of Land Management, Analysis of the Magnitude and Frequency of Floods in Colorado, Water Resources Investigations Report 99-4190, 2000.

7. U.S. Geological Survey in cooperation with the Colorado Department of Highways and the Federal Highway Administration, Russell K. Livingston and Donald R. Minges, Techniques for Estimating Regional Flood Characteristics of Small Rural Watersheds in the Plains Region of Eastern Colorado, Water Resources Investigations 87-4094, 1987.

8. U.S. Soil Conservation Service, Procedures for determining peak flows in Colorado, including Technical Release No. 55, Urban Hydrology for Small Watersheds, 1980.

2.0 ARKANSAS RIVER BASIN

Hydrology data from designated and detailed floodplain reports within the CWCB floodplain library were obtained and analyzed for the Arkansas River Basin. The Arkansas River basin was divided into several subregions for the purpose of performing regional regression analyses. A description of each subregion along with the associated regression equation and application criteria are presented below. A hydrologic regions map showing the regional and subregional boundaries for Colorado is available on-line as a separate PDF file.

ARK-1: EASTERN PLAINS SUBREGION

This subregion includes stream reaches in the plains area of the Arkansas River basin. Some of the streams in this subregion originate in the foothills or mountains. The subregion is bounded as follows:

- On the south by the Colorado-New Mexico state line;
- On the east by the Colorado-Kansas state line;
- On the north by the Arkansas River-Republican River basin divide;
- And on the north by the Arkansas River-South Platte River basin divide;
- On the west (north of the Arkansas River mainstem) by the eastern basin boundary of the Chico Creek/Black Squirrel Creek basin;
- On the west (south of the Arkansas River mainstem) by the basin divide between:
    1. the Huerfano River basin
    2. streams flowing into the Arkansas River east of its confluence with the Huerfano River; and
- On the southwest by the basin divide between the following watersheds:
    1. streams flowing into the Apishapa River upstream of and including Salado Creek
    2. streams flowing into the Apishapa River downstream of its confluence with Salado Creek; and
- And on the southwest by the basin divide between the following watersheds:
    1. streams flowing into the Purgatoire River upstream of and including Trinchera Creek
    2. streams flowing into the Purgatoire River downstream of its confluence with Trinchera Creek

The regression equation for this subregion is only valid for tributary streams that have drainage areas between 25 mi^2 and 1125 mi^2. The mainstem of the Arkansas River is exempt from this subregion. A detailed study or other hydrologic analysis must be performed for projects involving the Arkansas River mainstem or streams with drainage areas that fall outside of the applicable range. For basins smaller than 25 mi^2, refer to section 1.4 of this document.

The equation for subregion ARK-1 is:

$$Q = 1572.8(A)^{.547}$$

Where:

A = Drainage Area, square miles (25<A<1125)

Q = 100 year peak flow, cfs

ARK-2: SOUTHERN FOOTHILLS SUBREGION

This subregion includes streams within the southern foothills area. The streams in this subregion may have part of their *drainage basins* above an elevation of 7500' MSL, but this subregion only includes *stream reaches* that are downstream of (east of) the 7500' elevation limit. The subregion is bounded as follows:

- On the south by the Colorado-New Mexico state line;
- And on the east by the basin divide between the following watersheds:
    1. streams flowing into the Purgatoire River upstream of and including Trinchera Creek
    2. streams flowing into the Purgatoire River downstream of its confluence with Trinchera Creek;
- And on the east by the basin divide between the following watersheds:
    1. streams flowing into the Apishapa River upstream of and including Salado Creek
    2. streams flowing into the Apishapa River downstream of its confluence with Salado Creek;
- And on the east by the Huerfano River-Apishapa River basin divide;
- On the northeast by the basin divide between the following watersheds;
    1. streams flowing into the Huerfano River upstream of and including the Cucharas River
    2. streams flowing into the Huerfano River downstream of its confluence with the Cucharas River;
- On the north by the Huerfano River-Greenhorn Creek basin divide; and
- On the west by an elevation line of generally 7500';

The regression equation for this subregion is only valid for streams that have drainage areas between 12 mi^2 and 280 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion ARK-2 is:

$$Q = 3959.20(A)^{0.366}$$

Where:

A = Drainage Area, square miles (12<A<280)

Q = 100 year peak flow, cfs

ARK-3: CENTRAL FOOTHILLS SUBREGION

This subregion includes streams within the central foothills area. The streams in this subregion may have part of their *drainage basins* above an elevation of 7500' MSL, but the subregion only includes *stream reaches* that are downstream of (east of) the 7500' elevation limit. This subregion is bounded as follows:

- On the south by the Greenhorn Creek-Huerfano River basin divide;
- And on the south by the basin divide between the following watersheds:
    1. streams flowing into the Huerfano River upstream of and including the Cucharas River
    2. streams flowing into the Huerfano River downstream of its confluence with the Cucharas River;
- On the east (south of the Arkansas River mainstem) by the Huerfano River-Apishapa River basin divide;
- On the northeast by the Arkansas River mainstem between its confluence with Huerfano Creek and its confluence with Chico Creek;
- And on the northeast by the basin divide between the following watersheds:
    1. streams flowing into the Arkansas River or Fountain Creek downstream of its confluence with Williams Creek; and
    2. the Chico Creek watershed
- And on the northeast by the basin divide between the following watersheds:
    1. streams flowing into Fountain Creek (from the west) upstream of and including Young Hollow; and
    2. streams flowing into the Arkansas River or Fountain Creek (from the west) downstream of its confluence with Young Hollow
- On the north by the Arkansas River-South Platte River Basin divide;
- On the northwest by the Fourmile Creek-Currant Creek basin divide; and
- On the southwest by an elevation line of generally 7500';

The Cripple Creek area was included in this subregion, despite its high elevation (about 10,000 feet), because the flow values from the Cripple Creek study fit much better with the other data used for this subregion. *The regression equation for this subregion is only valid for tributary streams that have drainage areas between 1 mi^2 and 930 mi^2. The mainstems of the Arkansas River and Fountain Creek are exempt from this subregion. A detailed study or other hydrologic analysis must be performed for projects involving the Arkansas River and Fountain Creek mainstems or streams with drainage areas that fall outside of the applicable range.*

The equation for subregion ARK-3 is:

$$\mathbf{Q = 1089.3(A)^{0.653}}$$

Where:

A = Drainage Area, square miles (1<A<930)
Q = 100 year peak flow, cfs

ARK-4: NORTHERN FOOTHILLS SUBREGION; WEST OF MONUMENT CREEK AND FOUNTAIN CREEK

This subregion includes streams in the northern foothills area which are tributary to and west of the Monument Creek and Fountain Creek (downstream of Monument Creek) mainstems. The subregion is bounded as follows:

- On the east by the Monument Creek mainstem;
- And on the east by the Fountain Creek mainstem (downstream of it confluence with Monument Creek);
- On the north by the Arkansas River-South Platte River basin divide;
- On the west by the basin divide between the following watersheds:
    1. streams flowing into Fountain Creek (from the west) upstream of and including Young Hollow; and
    2. streams flowing into the Arkansas River or Fountain Creek (from the west) downstream of its confluence with Young Hollow; and
- On the west by the basin divide between the following watersheds:
    1. streams flowing into the Arkansas River or Fountain Creek downstream of its confluence with Williams Creek
    2. the Chico Creek watershed

The Woodland Park/Rampart Range area was included in this subregion, despite its high elevation (up to about 9,000 feet), because the flow values from the study in that area fit much better with the other data used for this subregion. *The regression equation for this subregion is only valid for tributary streams that have drainage areas between 1 mi^2 and 26 mi^2. The mainstems of Fountain Creek and Monument Creek are exempt from this subregion due to available detailed hydrology information on these streams. Stream reaches within the incorporated area of Colorado Springs are also exempt from this subregion. Any future study in this subregion involving the Fountain Creek mainstem, Monument Creek mainstem, or streams within the City of Colorado Springs should be performed using detailed methods. A detailed study or other hydrologic analysis must be performed for project involving streams with drainage areas that fall outside of the applicable range.*

The equation for subregion ARK-4a is:

$$\mathbf{Q = 1408.2(A)^{.654}}$$

Where:

A = Drainage Area, square miles (1<A<26)
Q = 100 year peak flow, cfs

ARK-5: NORTHERN FOOTHILLS SUBREGION; EAST OF MONUMENT CREEK AND FOUNTAIN CREEK

This subregion includes streams which are tributary to and east of the Monument Creek and Fountain Creek (downstream of Monument Creek) mainstems. These tributary streams originate from the Black Forest/Palmer Divide area, the northeast portion of Colorado Springs, and the Black Squirrel Creek basin east of Colorado Springs. The subregion is bounded as follows:

- On the south by the basin divide between the following watersheds:
    1. streams flowing into the Arkansas River or Fountain Creek downstream of its confluence with Williams Creek; and
    2. the Chico Creek watershed;
- On the east by the eastern basin boundary of the Chico Creek/Black Squirrel Creek basin;
- On the north by the Arkansas River-South Platte River basin divide;
- On the west by the Monument Creek mainstem; and
- And on the west by the Fountain Creek mainstem (downstream of its confluence with Monument Creek)

The regression equation for this subregion is only valid for tributary streams that have drainage areas between 4 mi^2 and 75 mi^2. The mainstems of Fountain Creek and Monument Creek are exempt from this subregion due to available detailed hydrology information on these streams. Stream reaches within the incorporated area of Colorado Springs are also exempt from this subregion. Any future study in this subregion involving the Fountain Creek mainstem, Monument Creek mainstem, or streams within the City of Colorado Springs should be performed using detailed methods. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion ARK-4b is:

$$\mathbf{Q = 1343.4(A)^{.578}}$$

Where:
A = Drainage Area, square miles (4<A<75)
Q = 100 year peak flow, cfs

ARK-6: SOUTHERN MOUNTAINS SUBREGION (No Regression)

At the time of this publication, there was insufficient data to obtain a meaningful regression equation within the southern mountains subregion. The streams in the southern mountains subregion have 100% of their *drainage basins* above an elevation of about 7500' MSL. The southern mountains subregion is bounded as follows:

- On the south by the Colorado-New Mexico state line;
- On the east by an elevation line of generally 7500';
- On the north by the Grape Creek-Huerfano River basin divide; and
- On the west by the Arkansas River-Rio Grande basin divide.

Studies within the southern mountains subregion should be performed using detailed methods or appropriate USGS methodologies.

ARK-7: NORTHERN MOUNTAINS SUBREGION

This subregion includes streams within the northern mountains area. These streams have 100% of their *drainage basins* above an elevation of 7500' MSL. Chaffee County was included in its entirety within this subregion, despite the fact that portions of the county lie below the 7500' elevation limit. The subregion is bounded as follows:

- On the south by the Grape Creek-Huerfano River basin divide;
- On the east by an elevation line of generally 7500';
- And on the east by the Fourmile Creek-Currant Creek basin divide;
- On the north by the Arkansas River-South Platte River basin divide;
- On the northwest by the Continental Divide; and
- On the southwest by the Arkansas River-Rio Grande basin divide

The regression equation for this subregion is only valid for tributary streams that have drainage areas between 4 mi^2 and 330 mi^2. This equation is also valid for the Arkansas River mainstem upstream of the Lake Creek confluence only. The remainder of the Arkansas River mainstem (downstream of the Lake Creek confluence) is exempt from this subregion. A detailed study or other hydrologic analysis must be performed for projects involving most of the Arkansas River mainstem or streams with drainage areas that fall outside of the applicable range.

The equation for subregion ARK-6 is:

$$\mathbf{Q = 46.0(A)^{0.717}}$$

Where:

A = Drainage Area, square miles (4<A<330)

Q = 100 year peak flow, cfs

Arkansas River Basin

Regression Analysis Summary

Sub-region Name	Sub-region Description	Regression Equation	# of Data Points	Min. D.A.	Max. D.A.	R Squared (Regression Correlation)	Std Error of Estimate
ARK-1	*Eastern Plains*	$Q = 1572.8(A)^{.547}$	8	25	1125	.899	25%

ARK-2	*Southern Foothills*	$Q = 3959.20(A)^{\mathbf{0.366}}$	10	12	280	.835	16%
ARK-3	*Central Foothills*	$Q = 1089.3(A)^{0.653}$	25	1	930	.990	15%
ARK-4	*Northern Foothills*	$Q = 1408.2(A)^{\mathbf{.654}}$	29	1	26	.869	25%
ARK-5	*Northern Foothills*	$Q = 1343.4(A)^{\mathbf{.578}}$	25	4	75	.800	30%
ARK-6	*Southern Mountains*	N/A	N/A	N/A	N/A	N/A	N/A
ARK-7	*Northern Mountains*	$Q = 46.0(A)^{0.717}$	13	4	330	.997	6%

The following stream reaches and geographic areas are exempt from the Arkansas River Basin ***Guidelines:***

- Arkansas River mainstem from the Lake Creek confluence to the Colorado-Kansas state line
- Fountain Creek mainstem
- Monument Creek mainstem
- City of Colorado Springs incorporated areas
- Other areas where the local government prefers to use their own drainage criteria in lieu of the ***Guidelines***

3.0 SOUTH PLATTE RIVER BASIN

Hydrology data from designated and detailed floodplain reports within the CWCB floodplain information library were obtained and analyzed for the South Platte River Basin. The South Platte River basin was divided into several subregions for the purpose of performing regional regression analyses. A description of each subregion along with the associated regression equation and application criteria are presented below. A hydrologic regions map showing the regional and subregional boundaries for Colorado is available on-line as a separate PDF file.

SPL-1: EASTERN PLAINS SUBREGION

This subregion includes stream reaches in the plains area of the South Platte River basin. Some of the streams in this subregion originate in the foothills or mountains. The subregion is bounded as follows:

- On the south by the South Platte River-Arkansas River basin divide;
- On the east by the South Platte River-Republican River basin divide;
- On the north by the Colorado-Nebraska and the Colorado-Wyoming state lines;
- On the northwest by the Owl Creek-Lone Tree Creek basin divide;
- And on the northwest by an arc that passes through the following three locations:
    1. The confluence of Owl Creek and Lone Tree Creek
    2. The town of Bracewell
    3. The town of Dent
- And on the northwest by the South Platte River mainstem between the town of Dent and the northern boundary of the Urban Drainage and Flood Control District;
- On the west by the northern and eastern boundaries of the Urban Drainage and Flood Control District;
- On the southwest by the Box Elder Creek-Kiowa Creek basin divide (to the north of Elbert);
- And on the southwest by the Kiowa Creek-Comanche Creek basin divide (to the south of Elbert);
- And on the southwest by the Kiowa Creek-West Bijou Creek basin divide

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 2 mi^2 and 1090 mi^2. The mainstems of the South Platte River, Cache La Poudre River, Big Thompson River, and St. Vrain Creek are all exempt from this subregion. A detailed study or other hydrologic analysis must be performed for projects involving those mainstems, and for streams with drainage areas that fall outside of the applicable range. For drainage basins in extreme northeastern Colorado that are affected by sand hills areas, the regression equation may tend to overestimate peak flow values.

The equation for subregion SPL-1 is:

$$\mathbf{Q = 707.9(A)^{.654}}$$

Where:

A = Drainage Area, square miles (2<A<1090)
Q = 100 year peak flow, cfs

SPL-2: SOUTHERN FOOTHILLS SUBREGION

This subregion includes stream reaches in the southern foothills area of the South Platte River basin. The streams in this subregion may have part of their *drainage basins* above an elevation of 7500' MSL, but this subregion only includes *stream reaches* that are downstream of (below) the 7500' elevation limit. The subregion is bounded as follows:

- On the south by the South Platte River-Arkansas River basin divide;
- On the east by the Kiowa Creek-West Bijou Creek basin divide;
- And on the east by the Kiowa Creek-Comanche Creek basin divide (to the south of Elbert);
- And on the east by the Box Elder Creek-Kiowa Creek basin divide (to the north of Elbert);
- On the north by the southern boundary of the Urban Drainage and Flood Control District; and
- On the west by an elevation line that is generally 7500'

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 1 mi^2 and 170 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion SPL-2 is:

$$\mathbf{Q = 1005.5(A)^{.638}}$$

Where:

A = Drainage Area, square miles (1<A<170)
Q = 100 year peak flow, cfs

SPL-3: CENTRAL FOOTHILLS SUBREGION

This subregion includes stream reaches in the central foothills area of the South Platte River basin that are located to the west of the western boundary of the Urban Drainage and Flood Control District. The streams in this subregion may have part of their *drainage basins* above an elevation of 7500' MSL, but this subregion only includes *stream reaches* that are downstream of (below) the 7500' elevation limit. The subregion is bounded as follows:

- On the south by an elevation line that is generally 7500';
- On the east by the western boundary of the Urban Drainage and Flood Control District;
- On the north by the Lefthand Creek-St. Vrain Creek basin divide;
- On the west by an elevation line that is generally 7500'

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 1 mi^2 and 175 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams within the Urban Drainage and Flood Control District and streams with drainage areas that fall outside of the applicable range.

The equation for subregion SPL-3 is:

$$\mathbf{Q = 762.4(A)^{.546}}$$

Where:

A = Drainage Area, square miles (1<A<175)
Q = 100 year peak flow, cfs

SPL-4: NORTHERN FOOTHILLS SUBREGION

This subregion includes stream reaches in the northern foothills area of the South Platte River basin. The streams in this subregion may have part of their *drainage basins* above an elevation of 7500' MSL, but this subregion only includes *stream reaches* that are downstream of (below) the 7500' elevation limit. The subregion is bounded as follows:

- On the south by the northern boundary of the Urban Drainage and Flood Control District;
- On the southeast by the South Platte River mainstem between the northern boundary of the Urban Drainage and Flood Control District and the town of Dent;
- On the east by an arc that passes through the following three locations:
    1. The town of Dent
    2. The town of Bracewell
    3. The confluence of Owl Creek and Lone Tree Creek
- On the northeast by the Owl Creek-Lone Tree Creek basin divide;
- On the north by the Colorado-Wyoming state line;
- On the west by an elevation line that is generally 7500'

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 1 mi^2 and 445 mi^2. The mainstems of the South Platte River, Cache La Poudre River below Poudre Park, Big Thompson River below Drake,, and St. Vrain Creek below Lyons are all exempt from this subregion. The incorporated areas of Fort Collins are also exempt from this subregion. A detailed study or other hydrologic analysis must be performed for projects involving those streams and streams with drainage areas that fall outside of the applicable range.

The equation for subregion SPL-4 is:

$$Q = 800.8(A)^{.478}$$

Where:

A = Drainage Area, square miles (1<A<445)
Q = 100 year peak flow, cfs

SPL-5: MOUNTAINS SUBREGION

This subregion includes stream reaches in the mountains areas of the South Platte River basin, except for the South Park area. The streams in this subregion have 100% of their *drainage basins* and *stream reaches* above an elevation of 7500' MSL. The subregion is bounded as follows:

- On the south by the South Platte River-Arkansas River basin divide;
- On the east by an elevation line that is generally 7500';
- On the north by Colorado-Wyoming state line;
- On the west by the South Platte River-Laramie River basin divide;
- And on the west by the South Platte River-Colorado River basin divide;
- And on the west by the South Platte River-Arkansas River basin divide.

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 2 mi^2 and 480 mi^2. Streams within the incorporated areas of Blackhawk and Central City and the mainstem of the South Platte River are exempt from this subregion. The South Park area is not included in this subregion, and is an area of no regression. A detailed study or other hydrologic analysis must be performed for projects within the exempted areas and for streams with drainage areas that fall outside of the applicable range.

The equation for subregion SPL-5 is:

$$Q = 39.4(A)^{.776}$$

Where:

A = Drainage Area, square miles (2<A<480)
Q = 100 year peak flow, cfs

South Platte River Basin
Regression Analysis Summary

Sub-region Name	Sub-region Description	Regression Equation	# of Data Points	Min. D.A.	Max. D.A.	R Squared (Regression Correlation)	Std Error of Estimate
SPL-1	*Eastern Plains*	$Q = 707.9(A)^{.654}$	17	2	1090	.920	34%
SPL-2	*Southern Foothills*	$Q = 1005.5(A)^{.638}$	29	1	170	.968	18%
SPL-3	*Central Foothills*	$Q = 762.4(A)^{.546}$	67	1	175	.927	23%
SPL-4	*Northern Foothills*	$Q = 800.8(A)^{.478}$	81	1	445	.756	48%
SPL-5	*Mountains*	$Q = 39.4(A)^{.776}$	27	2	480	.938	29%

The following stream reaches and geographic areas are exempt from the South Platte River Basin ***Guidelines:***

- South Platte River mainstem
- St. Vrain Creek mainstem below Lyons
- Big Thompson River mainstem below Drake
- Cache La Poudre River mainstem below Poudre Park
- South Park
- Urban Drainage and Flood Control District
- City of Fort Collins incorporated areas
- Town of Wellington
- Blackhawk and Central City incorporated areas
- Other areas where the local government prefers to use their own drainage criteria in lieu of the ***Guidelines***

4.0 REPUBLICAN RIVER BASIN

Hydrology data from detailed floodplain analyses were obtained and analyzed for the Republican River basin. The Republican River basin was not divided into subregions as was the case for the Arkansas and the South Platte basins. A description of the single region along with the associated regression equation and application criteria are presented below. A hydrologic regions map showing the regional and subregional boundaries for Colorado is available on-line as a separate PDF file.

REP-1: REPUBLICAN RIVER BASIN

Thissubregion includes stream reaches in the plains area of eastern Colorado including areas within portions of Phillips County, Logan County, Washington County, Yuma County, and Kit Carson County. None of the streams in thissubregion originate in the foothills or mountains. The region is bounded as follows:

- On the south by the Republican River - Arkansas River basin divide;
- On the north by the Republican River - South Platte River basin divide;

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 1 mi^2 and 1300 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range. Users need to be cautioned that there is significant soil infiltration variability within this subregion. The regression equation may not appropriately estimate peak flow values depending on the watershed characteristics (especially for watersheds located in sand hills areas).

The equation for subregion REP-1 is:

$$\mathbf{Q = 289.1(A)^{.667}}$$

Where:

A = Drainage Area, square miles (1<A<1300)
Q = 100 year peak flow, cfs

Republican River Basin Regression Analysis Summary

Sub-region Name	Sub-region Description	Regression Equation	# of Data Points	Min. D.A.	Max. D.A.	R Squared (Regression Correlation)	Std Error of Estimate
REP-1	*Republican basin*	$Q = 289.1(A)^{.667}$	29	1	1300	.906	36%

5.0 COLORADO RIVER BASIN

The CWCB recommends that approximate peak flow values for this all watersheds within the Colorado River basin be computed using the USGS publication entitled U.S. Geological Survey in cooperation with the Colorado Department of Transportation and the Bureau of Land Management, Analysis of the Magnitude and Frequency of Floods in Colorado, Water Resources Investigations Report 99-4190, 2000.

For information purposes only, the CWCB has included the following equations for Subregions within the Colorado River basin that can be used for comparison of peak flow values at a site of interest.

Hydrology data from detailed floodplain analyses were obtained and analyzed for the Colorado River basin. The Colorado River basin was divided into subregions that are generally based on major watershed boundaries. A description of the various subregions along with the associated regression equation and application criteria are presented below. A hydrologic regions map showing the regional and subregional boundaries for Colorado is available on-line as a separate PDF file.

COL-1: UPPER COLORADO RIVER SUBREGION

This subregion includes the Colorado River mainstem and its tributaries in the watershed areas upstream of and including Glenwood Springs. Streams in this subregion are located to the west of the Continental Divide within Grand County, Summit County, Eagle County, and Pitkin County. Major tributaries in this subregion include the Fraser River, Blue River, Eagle River, and Roaring Fork River. The subregion is bounded as follows:

- On the north by the Colorado River - North Platte River basin divide;
- On the east by the Colorado River - South Platte River basin divide;
- On the south by the Colorado River - Arkansas River basin divide;
- On the southwest by the Colorado River - Gunnison River basin divide; and
- On the west/northwest by the Colorado River - Green River basin divide.

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 1 mi^2 and 950 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion COL-1 is:

$$\mathbf{Q = 79.5(A)^{.724}}$$

Where:

A = Drainage Area, square miles (1<A<950)
Q = 100 year peak flow, cfs

COL-2: LOWER COLORADO RIVER SUBREGION

This subregion includes the Colorado River mainstem and its tributaries in the watershed areas downstream of Glenwood Springs (downstream of the Colorado River confluence with the Roaring Fork River). Streams in this subregion are located to the west of the Continental Divide within Mesa County and Garfield County. Major tributaries in this subregion include the Roan Creek and Rifle Creek. The CWCB has not developed an equation for this Subregion. The USGS regional regression equations are recommended.

COL-3: LOWER GUNNISON RIVER SUBREGION

This subregion includes the Gunnison River mainstem and its tributaries downstream of the City of Gunnison. Streams in this subregion are located in portions of Gunnison County, Delta County, Mesa County, Montrose County, Ouray County, Hinsdale County, and Saguache County. Major tributaries in this subregion include the North Fork of the Gunnison River and Uncompahgre River. This subregion does not include the East River, Taylor River, Ohio Creek, and Tomichi Creek basins. The subregion is bounded as follows:

- On the north by the Gunnison River - Colorado River basin divide;
- On the east by the basin divide between the North Fork Gunnison River/Beaver Creek and Ohio Creek/East River;
- And on the east by the basin divide between Cebolla Creek/South Beaver Creek and Tomichi Creek;
- On the south by the Gunnison River - Rio Grande/San Juan River basin divides; and
- On the west by the Gunnison River - Dolores River basin divide.

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 2 mi^2 and 8,000 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion COL-3 is:

$$\mathbf{Q = 180.8(A)^{.578}}$$

Where:

A = Drainage Area, square miles ($2<A<8{,}000$)
Q = 100 year peak flow, cfs

COL-4: UPPER GUNNISON RIVER SUBREGION

This subregion includes the Gunnison River, East River, Taylor River, and Ohio Creek mainstems and their tributaries generally upstream of the City of Gunnison. Streams in this subregion are located in Gunnison County. This subregion does not include the Tomichi Creek basin. The subregion is bounded as follows:

- On the north by the Tomichi Creek - Taylor River basin divide;
- On the east by the Tomichi Creek - Arkansas River basin divide;
- On the south by the Tomichi Creek - Rio Grande basin divide; and
- On the west by the basin divide between Tomichi Creek and Cebolla Creek/South Beaver Creek.

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 20 mi^2 and 300 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion COL-4 is:

$$\mathbf{Q = 50.1(A)^{.838}}$$

Where:

A = Drainage Area, square miles (20<A<300)
Q = 100 year peak flow, cfs

COL-5: TOMICHI CREEK SUBREGION

This subregion includes the Tomichi Creek mainstem and its tributaries upstream of the City of Gunnison. Streams in this subregion are located in portions of Gunnison County and Saguache County. The subregion is bounded as follows:

- On the north by the Tomichi Creek - Taylor River basin divide;
- On the east by the Tomichi Creek - Arkansas River basin divide;
- On the south by the Tomichi Creek - Rio Grande basin divide; and
- On the west by the basin divide between Tomichi Creek and Cebolla Creek/South Beaver Creek.

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 100 mi^2 and 1,070 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion COL-5 is:

$$\mathbf{Q = 84.7(A)^{.487}}$$

Where:

A = Drainage Area, square miles ($100<A<1,070$)

Q = 100 year peak flow, cfs

Colorado River Basin
Regression Analysis Summary

Sub-region Name	Sub-region Description	Regression Equation	# of Data Points	Min. D.A.	Max. D.A.	R Squared (Regression Correlation)	Std Error of Estimate
COL-1	*Upper Colorado River basin*	$Q = 79.5(A)^{.724}$	142	1	950	.920	33%
COL-2	*Lower Colorado River basin*	Use USGS regression equation	n/a	n/a	n/a	n/a	n/a
COL-3	*Lower Gunnison River basin*	$Q = 180.8(A)^{.578}$	44	2	8000	.960	27%
COL-4	*Upper Gunnison River basin*	$Q = 50.1(A)^{.838}$	7	20	300	.889	30%
COL-5	*Tomichi Creek basin*	$Q = 84.7(A)^{.487}$	5	100	1070	.885	18%

6.0 GREEN RIVER BASIN

The CWCB recommends that approximate peak flow values for this all watersheds within the Green River basin be computed using the USGS publication entitled U.S. Geological Survey in cooperation with the Colorado Department of Transportation and the Bureau of Land Management, Analysis of the Magnitude and Frequency of Floods in Colorado, Water Resources Investigations Report 99-4190, 2000.

For information purposes only, the CWCB has included the following equation for the Green River basin that can be used for comparison of peak flow values at a site of interest.

Hydrology data from detailed floodplain analyses were obtained and analyzed for the Green River basin. The Green River basin was not divided into subregions. A description of the Green River region along with the associated regression equation and application criteria are presented below. A hydrologic regions map showing the regional and subregional boundaries for Colorado is available on-line as a separate PDF file.

GRN-1: GREEN RIVER SUBREGION

This subregion includes the Green River mainstem and its tributaries in northwestern Colorado. Streams in this subregion are located in Routt County, Moffat County, and Rio Blanco County. Major tributaries in this subregion include the Yampa River basin, Elk River basin, and White River basin. The subregion is bounded as follows:

- On the north by the Colorado - Wyoming state line;
- On the east by the Green River - North Platte River basin divide;
- On the south by the Green River - Colorado River basin divide; and
- On the west by the Colorado - Utah state line.

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 1 mi^2 and 3,300 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion GRN-1 is:

$$\mathbf{Q = 470.9(A)^{.417}}$$

Where:

A = Drainage Area, square miles (1<A<3,300)

Q = 100 year peak flow, cfs

Sub-region Name	Sub-region Description	Regression Equation	# of Data Points	Min. D.A.	Max. D.A.	R Squared (Regression Correlation)	Std Error of Estimate
GRN-1	*Green River Basin*	$Q = 470.9(A)^{.417}$	40	1	3300	.873	36%

7.0 DOLORES RIVER BASIN

The CWCB recommends that approximate peak flow values for this all watersheds within the Dolores River basin be computed using the USGS publication entitled U.S. Geological Survey in cooperation with the Colorado Department of Transportation and the Bureau of Land Management, Analysis of the Magnitude and Frequency of Floods in Colorado, Water Resources Investigations Report 99-4190, 2000.

For information purposes only, the CWCB has included the following equation for the Dolores River basin that can be used for comparison of peak flow values at a site of interest.

Hydrology data from detailed floodplain analyses were obtained and analyzed for the Dolores River basin. The Dolores River basin was not divided into subregions. A description of the Dolores River region along with the associated regression equation and application criteria are presented below. A hydrologic regions map showing the regional and subregional boundaries for Colorado is available on-line as a separate PDF file.

DLR-1: DOLORES RIVER SUBREGION

This subregion includes the Dolores River mainstem and its tributaries in southwestern Colorado. Streams in this subregion are located in portions of Dolores County, San Miguel County, Montrose County, and Mesa County. Major tributaries in this subregion include the San Miguel River, Naturita Creek, and West Dolores River. The subregion is bounded as follows:

- On the north by the Dolores River - Colorado River basin divide;
- On the east by the Dolores River - Gunnison River basin divide;
- On the south by the Dolores River - San Juan River basin divide; and
- On the west by the Colorado - Utah state line.

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 2 mi^2 and 1,080 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion DLR-1 is:

$$\mathbf{Q = 213.8(A)^{.601}}$$

Where:

A = Drainage Area, square miles ($2<A<1,080$)
Q = 100 year peak flow, cfs

Dolores River Basin
Regression Analysis Summary

Sub-region Name	Sub-region Description	Regression Equation	# of Data Points	Min. D.A.	Max. D.A.	R Squared (Regression Correlation)	Std Error of Estimate
DLR-1	*Dolores River Basin*	$Q = 213.8(A)^{.601}$	21	2	1080	.926	24%

8.0 SAN JUAN RIVER BASIN

The CWCB recommends that approximate peak flow values for this all watersheds within the San Juan River basin be computed using the USGS publication entitled U.S. Geological Survey in cooperation with the Colorado Department of Transportation and the Bureau of Land Management, Analysis of the Magnitude and Frequency of Floods in Colorado, Water Resources Investigations Report 99-4190, 2000.

For information purposes only, the CWCB has included the following equation for the San Juan River basin that can be used for comparison of peak flow values at a site of interest.

Hydrology data from detailed floodplain analyses were obtained and analyzed for the San Juan River basin. The San Juan River basin was divided into two subregions, an eastern subregion and a western subregion. The western subregion was determined to be an area of "No Regression" due to lack of available data. A description of the San Juan River region along with the associated regression equation and application criteria are presented below. A hydrologic regions map showing the regional and subregional boundaries for Colorado is available on-line as a separate PDF file.

SAN-1: EASTERN SAN JUAN RIVER SUBREGION

This subregion includes the San Juan River mainstem and its tributaries in southwestern Colorado. Streams in this subregion are located in portions of La Plata County, San Juan County, Archuleta County, Hinsdale County, and Mineral County. Major tributaries in this subregion include the San Juan River, Animas River, La Plata River, and Los Pinos River. The subregion is bounded as follows:

- On the north by the San Juan River - Gunnison River basin divide;
- On the east by the San Juan River - Gunnison River basin divide;
- On the south by the Colorado - New Mexico state line;
- On the west by La Plata River - Mancos River basin divide; and
- On the northwest by the Animas River - Dolores River basin divide

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 1 mi^2 and 760 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion SAN-1 is:

$$\mathbf{Q = 589.2(A)^{.512}}$$

Where:

A = Drainage Area, square miles (1<A<760)

Q = 100 year peak flow, cfs

SAN-2: WESTERN SAN JUAN RIVER SUBREGION

This subregion is an area of "No Regression" and includes the Mancos River mainstem and its tributaries in extreme southwestern Colorado. Streams in this subregion are located in Montezuma County and portions of Dolores County. There is insufficient data to produce a meaningful regression equation at this time. The CWCB recommends the use of the USGS regional regression equation for this subregion.

San Juan River Basin
Regression Analysis Summary

Sub-region Name	Sub-region Description	Regression Equation	# of Data Points	Min. D.A.	Max. D.A.	R Squared (Regression Correlation)	Std Error of Estimate
SAN-1	*Eastern San Juan River Basin*	$Q = 589.2(A)^{.512}$	30	1	760	.814	39%

9.0 RIO GRANDE BASIN

The CWCB recommends that approximate peak flow values for this all watersheds within the Rio Grande basin be computed using the USGS publication entitled U.S. Geological Survey in cooperation with the Colorado Department of Transportation and the Bureau of Land Management, Analysis of the Magnitude and Frequency of Floods in Colorado, Water Resources Investigations Report 99-4190, 2000.

For information purposes only, the CWCB has included the following equations for Subregions within the Rio Grande basin that can be used for comparison of peak flow values at a site of interest.

Hydrology data from detailed floodplain analyses were obtained and analyzed for the Rio Grande basin. The Rio Grande basin was divided into two subregions, a low elevation subregion and a high elevation subregion. A description of the Rio Grande along with the associated regression equations and application criteria are presented below. A hydrologic regions map showing the regional and subregional boundaries for Colorado is available on-line as a separate PDF file.

RIO-1: RIO GRANDE TRIBUTARIES (LOW ELEVATION)

This subregion includes lower elevation tributaries in the Rio Grande basin. Streams in this subregion are located in portions of Alamosa, Conejos, Costilla, Rio Grande, and Saguache Counties. Major tributaries in this subregion include Costilla Creek, Culebra Creek, Trinchera Creek, Trinchera Creek and Rito Seco. The subregion is bounded as follows:

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 4 mi^2 and 420 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion RIO-1 is:

$$\mathbf{Q = 83.1(A)^{.556}}$$

Where:

A = Drainage Area, square miles ($4<A<420$)
Q = 100 year peak flow, cfs

RIO-2: RIO GRANDE AND SOUTH FORK RIO GRANDE MAINSTEMS, AND HIGH ELEVATION TRIBUTARIES

This subregion includes the Rio Grande and South Fork Rio Grande mainstems and the higher elevation tributaries in the Rio Grande basin. Streams in this subregion are located in portions of Alamosa, Conejos, Costilla, Hinsdale, Mineral, Rio Grande, and Saguache Counties. Major tributaries in this subregion include Willow Creek, Beaver Creek, and Trout Creek. The subregion is bounded as follows:

The regression equation for this subregion is only valid for natural tributary streams that have drainage areas between 35 mi^2 and 1700 mi^2. A detailed study or other hydrologic analysis must be performed for projects involving streams with drainage areas that fall outside of the applicable range.

The equation for subregion RIO-2 is:

$$\mathbf{Q = 172.4(A)^{.592}}$$

Where:

A = Drainage Area, square miles (35<A<1700)
Q = 100 year peak flow, cfs

Rio Grande Basin
Regression Analysis Summary

Sub-region Name	Sub-region Description	Regression Equation	# of Data Points	Min. D.A.	Max. D.A.	R Squared (Regression Correlation)	Std Error of Estimate
RIO-1	*Low elevation tributaries*	$Q = 83.1(A)^{.556}$	17	4	420	0.992	6.3%
RIO-2	*Mainstem and high elevation tributaries*	$Q = 172.4(A)^{.592}$	8	35	1700	0.923	23%

A one-hundred-year flood is a flood event that has a 1 in 100 chance (1% probability) of being equaled or exceeded in any given year. The 100-year flood is also referred to as the 1% flood, since its annual exceedance probability is 1%. For coastal or lake flooding, the 100-year flood is generally expressed as a flood elevation or depth, and may include wave effects. For river systems, the 100-year flood is generally expressed as a flowrate. Based on the expected 100-year flood flow rate, the flood