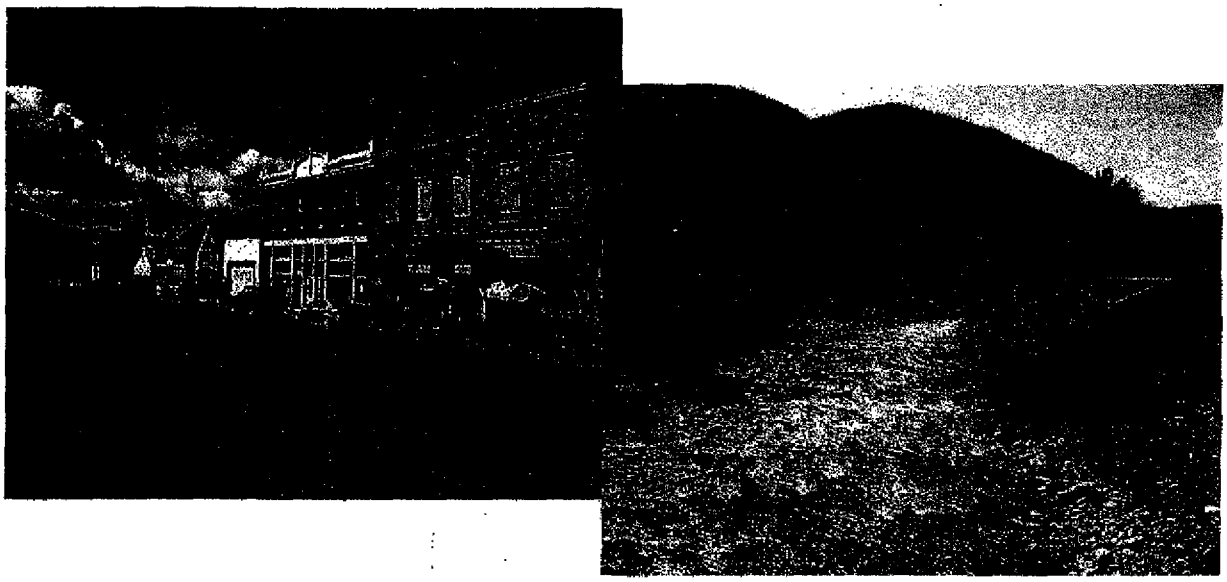
00-528

FLOODPLAIN INFORMATION REPORT

Rico, Colorado



Prepared for:

Town of Rico, Colorado

- and -

Department of Natural Resources
Colorado Water Conservation Board
Flood Control and Floodplain Management Section
1313 Sherman Street, Room 721
Denver, Colorado 80203

Prepared by:

MONTGOMERY WATSON

September 2000

PREFACE

This Floodplain Information Report (FIR) is part of a program by the Colorado Water Conservation Board (CWCB) to make approximate floodplain maps prepared by the Federal Emergency Management Agency (FEMA) easier for local governments to use. This CWCB report provides limited engineering information to support the approximate delineations on the FEMA maps, and it provides floodplain management information to guide the local governments in the use of the maps.

The official floodplain information for Rico is the Flood Insurance Rate Map (FIRM), dated August 5, 1986. The FIRM was prepared by FEMA and contains approximate floodplain delineations. In addition, a flood hazard study containing flood hazard maps was prepared for the Town in 1995 by Wilbur Engineering, Inc. This study contains both detailed and approximate floodplain delineations. The approximate floodplains in the FEMA analysis do not include any engineering information to describe basis of the approximate floodplain mapping. However, the approximate floodplains in the Wilbur Engineering report contain some hydrology and hydraulics information. Therefore, the initial purpose of this report is to provide the Town with limited supporting information for the approximate floodplain delineations and verification of the Wilbur Engineering report. This FIR includes a description of available hydrologic information for major flooding sources within or adjacent to the Town. In addition, the FIR gives the Town some basic information about floodplain management and it provides some alternatives that could be considered in formulating and implementing floodplain management objectives.

A second function of this report is to assure that the FIRM meets the basic technical requirements for designation and approval by the CWCB. Without the inclusion of basic engineering information, the approximate floodplain delineations shown on the Rico Flood Insurance Rate Maps cannot qualify for CWCB designation. Colorado statutes require that local governments obtain from the CWCB the designation and approval of floodplain information for its use in regulatory purposes. This FIR provides a means for the FIRM to meet that statutory objective. As new and more detailed floodplain information becomes available, the approximate floodplain areas shown on the FIRM panels will become superseded. The CWCB will designate and approve new information, and rescind old information as appropriate.

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INTRODUCTION

Purpose and Scope

This Floodplain Information Report was prepared to provide supporting documentation for the approximate 100-year floodplain boundaries shown in the Town of Rico FIRM, dated August 5, 1986 and the 1995 flood hazard study by Wilbur Engineering. The FIRMs were prepared using approximate floodplain mapping techniques. Engineering information was not provided by FEMA to support the approximate floodplain delineations shown on the FIRMs. This FIR provides limited engineering information to fulfill that need.

This FIR includes:

1. Authorization for the report and its purpose and scope;

2. Study area description including information on the community, the watershed, any known flooding history/flooding problems, previous studies and projects, and community response to the CWCB designation and approval process;

3. Description of hydrologic and hydraulic information; and

4. Floodplain management program.

Authorization

The CWCB has certain statutory responsibilities relating to the designation and approval of floodwater runoff channels or basins 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 Counties, to County planning commissions, and to boards of adjustment of cities, incorporated Counties, and counties of this state"... Section 37-60-106(1)(c) of the Colorado Revised Statues (CRS).

A CWCB designation and approval of current floodplain information is needed for the Town of Rico, Colorado. The CWCB has prepared this FIR as a means of designating Rico's FIRMs so that the community can better implement its floodplain management program.

STUDY AREA DESCRIPTION

Community Description

The Town of Rico is located in eastern Dolores County, which is bordered by San Miguel County on the north, San Juan County on the east, Montezuma County on the south and the state of Utah on the west. Dove Creek is the County Seat of Dolores County. The population of Rico was estimated at 185 in July 1999 by the Demography Section of the Colorado Division of Local Government. The area mapped in the FIRM includes the incorporation boundaries as of 1986.

Watershed Description

The Town of Rico is located in the Dolores River basin on the western slope of the Continental Divide. The Dolores River is the primary stream flowing through the incorporation limits of the Town, and generally flows from north to south. There are several smaller streams that flow through and have their confluence point within the incorporation limits, including Silver Creek, Iron Draw, Spear Creek and Sulphur Creek. The watersheds for Iron Draw, Spear Creek and Sulphur creek are all less than 1 square mile, and are not included in this designation.

The Dolores River watershed above Rico extends from the Continental Divide south and west to the town. Elevations of the watershed range from over 14,000 feet Mount Wilson to about 9000 feet at the Town of Rico. The Dolores River Below Rico gaging station (09165000) is located approximately 4 miles south of Rico. With the exception of the town itself, the Dolores River watershed upstream of the town is generally agricultural and forested lands.

Flooding Problems and Flooding History

Floods in the subject watersheds normally occur during late summer and early autumn and are caused primarily by intense localized cloudbursts or thunderstorms. Typically, these floods have high peak discharges with low volumes over short durations and there is usually a very short window of opportunity for flood warning and evacuation once a major storms hits the area. Less damaging floods can also result from rapid melting of mountain snowpack in the spring and early summer months, especially on the Dolores River. A combination of rainfall and snowmelt can sometimes prove to be the worst flooding scenario for Colorado's mountain streams.

According to the town, flooding is much more common on the smaller tributary streams than the Dolores River. However, a devastating flood occurred in October of 1911 on both Silver Creek and the Dolores River. Flood flow contained a significant amount of debris, including rocks, trees and other dislodged materials. May houses and commercial buildings were destroyed, and most of the railroad was either damaged or completely destroyed.

Previous Studies

No studies were completed prior to the current FIRM for the Town of Rico. However, in 1995, the town contracted with Wilbur Engineering, Inc. in Durango to update the flood hazard maps, documented in the report "Documentation for Hazard and Constraint Maps, Town of Rico, Colorado." A detailed analysis of the Dolores River and Silver Creek was conducted. A new flood hazard map was prepared during the study. The flood hazard portion of the study and flood

hazard maps is contained in the Appendices. The information contained in the Wilbur Engineering report is discussed in the "Engineering Methods" section of this report.

Community Response to the CWCB Designation and Approval Process

A letter from the CWCB was transmitted to the Town of Rico regarding the Board's proposed action for designation and approval of the Rico FIRMs. Local officials confirmed that there have been minor to severe flooding problems in the town, especially along Silver Creek. The town was receptive to the Board's proposed designation action, and sent an official letter requesting that the CWCB designate and approve the floodplain information currently available to the community. A copy of the request letter is included in the Appendix of this report.

A meeting was held with the town supervisor and on August 22, 2000, to explain the designation process, to review the FHBMs and to solicit comments regarding the maps and general flooding conditions in the town. A field tour of the floodplains in Rico was also conducted at this time.

ENGINEERING METHODS

Hydrologic Analysis

The Rico FIRM presents approximate floodplain delineations. Hydrologic information used for the FEMA approximate floodplain delineations are not available or were not documented by FEMA. The Wilbur Engineering report contains a detailed floodplain for the Dolores River and an approximate floodplain for Silver Creek. The 100-year discharge for the Dolores River is based on a gage analysis while the 100-year discharge for Silver Creek is based on a regional comparison of other gages. In order to verify discharges in the Wilbur Engineering report, the discharges were compared to those calculated using CWCB methods described below.

The CWCB has developed acceptable hydrologic information for undeveloped basins using regional regression methodologies for computing 100-year flood-flow values. The CWCB methodology is fully described in a publication by the CWCB entitled "Guidelines for Determining 100-year Flood Flows for Approximate Floodplains in Colorado". The Dolores River Subregion (DLR-1) is used for streams in the Dolores River basin. The CWCB equation is:

Equation 1
Regional Regression Equation for Dolores River Basin

$$Q_{100} = 213.8(A)^{0.601}$$ (Only for drainage areas between 2 and 1080 square miles)

For Equation 1, the Q_{100} is the 100-year peak flow in cubic feet per second, and **A** is the upstream (contributing) drainage area in square miles. The regression equation equations are only valid for the range of drainage areas as shown next to each equation.

The 100-year flow for Rico within the Town Limits were estimated by utilizing the regional regression equations shown in Equation 1. Table 1 presents 100-year flow estimate for these locations. As shown, three of the watersheds are too small to utilized the CWCB equations. For these watersheds, other methods should be used in development of flood discharges.

Table 1
Estimated Discharges for Rico

Drainage Area Description	Drainage Area (mi^2)	100-year Discharge (cfs)	
		CWCB Method	Wilbur Report
Dolores River – Upstream of Silver Creek	72.43	2,800	
Dolores River – At Rico Downstream Incorporation Limits	82.75	3,000	2,800
Silver Creek – Upstream of Mouth	7.13	700	350
Iron Draw - Upstream of Mouth	0.84	Outside Bounds [1]	
Spear Creek – Upstream of Mouth	0.30	Outside Bounds [1]	
Sulfur Creek – Upstream of Mouth	0.83	Outside Bounds [1]	

Notes:
[1] Streams are shown on the FHBMs. However, because the watersheds are less than 1 square mile, these streams are not included in the CWCB floodplain designation.

Table 1 also shows those discharges calculated by Wilbur Engineering for mapping of the flood hazard boundaries. As previously stated, the Dolores River peak discharge was estimated using USGS 17B procedures and adjusted based on historical data, while Silver Creek peak discharge was based on area/discharge relationships for similar basins in the area. The Dolores River peak discharge agrees well with the peak discharge found in this study. However, the Silver Creek discharge is half of that found in this study. The Silver Creek basin area is nearly three times smaller than the smallest basin in the area/discharge relationship. In general, peak discharges increase as basin size decreases. Therefore, the area/discharge relationship used in the Wilbur Engineering study is likely underestimating peak discharge. Therefore, it is recommended that the discharge calculated in this study of 700 cfs be utilized for planning purposes. Because Silver Creek is only shown as an approximate floodplain on the flood hazard map, no changes to the map are required at this time. However, it should be recognized that utilization of the higher discharge will increase the floodplain width from lower discharges, and development near the floodplain may require additional analysis to determine more accurate floodplain boundaries.

Peak flow records are available at the Dolores River Below Rico gage (USGS Gage No. 09165000) from 1952 through 1996. Using the gage records, USGS Bulletin 17B procedures were used to calculate discharges for specific return intervals at the gage. These discharges were then used to estimate peak flows for the Dolores River at the Incorporation Limits using CWCB Technical Memorandum No. 1 procedures. The estimated 100-year discharge using these procedures is 2,200 cfs. This is 20 percent less than the estimate of 2,800 cfs using the regression equations. Due to the relatively short period-of- record, it is recommended that 2,800 cfs be used for planning purposes.

Table 2 presents the recommended planning level discharges for the Dolores River and Silver Creek in the Town of Rico. Rico should regulate the approximate floodplains on a case-by-case basis. FEMA requires that a detailed floodplain analysis must be performed by a professional engineer and submitted by the developer or development proponent for development projects involving more 5 acres or more than 50 units (whichever is more restrictive).

Table 2. Recommended Planning Discharges for Rico

Location	100-year Peak Discharge (cfs)
Dolores River	2,800
Silver Creek	700

Hydraulic Analysis

Hydraulic methods used for the approximate floodplain delineations shown on the Rico FIRM panels are not available or have not been documented by FEMA. The Wilbur Engineering study has performed hydraulic calculations using the Corps of Engineers' HEC-2 computer program. For future studies where the floodplains may be affected, the HEC-2 computer model should be updated with the new information. Channel and floodplain cross-sections may be obtained from detailed topographic mapping or from field surveys. Cross-sections obtained from USGS quadrangle maps are not advised.

Floodplain Mapping

The existing FIRM for Rico depicts areas subject to 100-year flooding based on approximate technical methods. The map does not show flood profiles, base flood elevations, or sufficient detail in order for County officials, engineers, developers, and land owners to make floodplain determinations with any certainty.

The flood hazard map prepared by Wilbur Engineering shows Zone AE, X and Y floodplains for the Dolores River and Zone A floodplain for Silver Creek. A comparison of the new Flood Hazard map with the older FIRM shows some lateral migration of the Dolores River. Based on field observation, it appears that the new flood hazard map accurately depicts the floodplains. CWCB's floodplain designation will utilize this new map as the official floodplain map for the Town of Rico for floodplain management, regulation and land use purposes subject to previous discussions in this report. A copy of the flood hazard map is included in the appendices. It should be noted that the current the 1986 FIRM shall be used for flood insurance purposes until the newer map is recognized by FEMA.

The Colorado Water Conservation Board can be contacted to request technical assistance for approximate floodplain analyses as needed.

FLOODPLAIN MANAGEMENT

Local Ordinance Requirements

Communities that manage their floodplains in Colorado do so most often through the local regulatory process. This requires a community to adopt an ordinance or regulation, which sets forth the performance standards by which development will occur in identified flood hazard areas. Nationwide and in Colorado, regulations are enforced within the area of the 100-year floodplain.

The basic requirement of these regulations is that new development and significant improvement of existing development cannot occur in the 100-year floodplain without a floodplain development permit being obtained. Obtaining such a permit requires compliance with engineering standards. In communities like Rico that have approximate floodplain information, the engineering standards have been more general. Structures must be built with materials and techniques that "minimize flood damages". For communities that have detailed floodplain information, more specific regulations would apply. The use of engineering techniques presented in this report can help the Town to better regulate its approximate floodplain areas.

Flood Insurance

Flood insurance is made available to owners and occupants of floodprone property through the federal government's National Flood Insurance Program (NFIP). The federally backed flood insurance is available to anyone in any community that participates in the NFIP. At the time of this publication, the Town of Rico is currently participating in the NFIP, and officially joined the regular program of the NFIP on August 5, 1986. Communities become participants by adopting floodplain regulations, adopting an NFIP map (if one exists) and agreeing to cooperate with the federal government in the local implementation of the NFIP. Property owners and occupants can then contact an insurance agent familiar with the NFIP (perhaps their own agent) and purchase insurance through that agent, much like they would purchase homeowner's insurance. Brochures and other information regarding the National Flood Insurance Program can be obtained by calling the Regional Office of the Federal Emergency Management Agency (FEMA) in Denver at (303) 235-4830.

Floodplain Management Alternatives

Besides floodplain regulations and flood insurance, there are many actions that can reduce the risk of flood damage in a community. Generally these actions fall into two classes, structural actions and non-structural actions. Structural actions involve the construction of facilities to separate floodwaters from property that is at risk. They include construction of improved channels, enlargement of crossing structures (bridges and culverts), levees and floodwalls, reservoirs and ponds to detain floodwaters and diversion channels and pipes to direct waters elsewhere. Non-structural actions usually involve removing people and/or structures from the risk area without physically altering the floodplain. Actions include regulation of new development, the adoption and enforcement of specific building code requirements, floodproofing of existing buildings, relocation of structures to safer sites, acquisition of floodplain (including buildings) for open space or other appropriate land uses, public education, flood warning systems and emergency response programs.

Colorado communities interested in examining or pursuing possible floodplain management alternatives should contact the Colorado Water Conservation Board. Knowing the full range of alternatives can allow a community to develop a program that best addresses its particular flood and storm drainage situation.

APPENDIX

ERIC JAMES HEIL
RICO TOWN MANAGER AND ATTORNEY

10-27-00

Mr. Larry Lang
Chief, Flood Control and Floodplain Management Section
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203

RE: Updating flood plain maps for Rico, Colorado

Dear Mr. Lang,

In accordance with §37-60-106(1)(c) C.R.S., as amended, the Town of Rico is requesting that the Colorado Water Conservation Board consider the designation and approval of flood hasard areas with the Town of Rico.

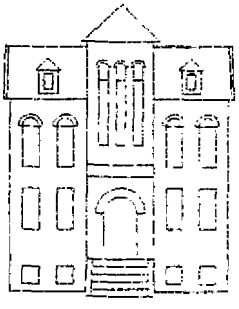
We would like for CWCB staff to review the floodplain information prepared by Chris Wilbur and Douglas Bradley in 1995 for possible designation and approval by CWCB. Please call me if you have any questions. Thank you for your consideration on this matter.

Sincerely,

Eric James Heil

P.O. BOX 189 2 COMMERCIAL STREET RICO, CO 81332
OFFICE (970) 967-2863 TELECOPIER (970) 967-2864 E-MAIL erichell@frontier.net

DOCUMENTATION FOR HAZARD & CONSTRAINT MAPS



TOWN OF RICO, COLORADO

prepared by

Chris Wilbur, P.E.
Doug Bradley
Durango, Colorado
(970) 247-1488

September 1995

RECEIVED
SEP 25 2000
MONTGOMERY WATSON
AMERICAS
DENVER-1

FORWARD

The purpose of this documentation is to describe the methods used to create the accompanying Hazard and Constraint Maps. Recommendations are made concerning hazard mitigation and avoidance. The Hazard and Constraint Maps and accompanying documentation should be updated periodically to reflect additional or improved information as it becomes available.

All maps, except the flood hazard map were done at a scale of 1:4,800. The flood hazard map was originally done at a scale of 1:1,200, but is presented at 1:2,400. The hazard boundaries were digitized in AutoCAD™ Version 12.0 by INDACAD of Durango Colorado. All hazard and constraint boundaries are approximate. Many of the boundaries are transitional over considerable distances. Plotting at different scales should not be permitted to imply accuracy beyond scales at which the maps were originally presented. These maps are not intended for evaluating individual sites, lots or properties. They are intended for planning purposes only.

Chris Wilbur
Douglas Bradley

September 12, 1995

FLOOD HAZARDS

Introduction

The purpose of the flood study is to evaluate flood elevations and areas likely to be impacted by floods within the Town of Rico. Flood events of magnitudes which are expected to be equaled or exceeded once on the average during any 100- or 500-year period were analyzed. Cross-sections and roughness parameters were selected based on flows of these magnitudes. All elevations in this study are referenced to the National Geodetic Vertical Datum of 1929 (NGVD).

Three methods were employed to evaluate peak flood discharges for the Dolores River and Silver Creek in this study. A statistical frequency analysis was performed using data for the Dolores River. Historical accounts and photographs of high water elevations and damage caused by flood events without flow measurements were also used to determine flood discharges. Additionally, data from similar drainage basins in the region were considered, particularly for Silver Creek which is an ungaged basin.

Frequency Analyses

Peak discharges for the Dolores River were evaluated by applying The U.S. Geological Survey (USGS) Annual Peak Flow Frequency Analyses Program J477 Version 3.7, revised 11-5-81. The reference gage station (USGS 09165000) is located near the Dolores-Montezuma County Line approximately four miles south of Rico. Scotch Creek is the only significant tributary to the Dolores River between Rico and the gage. Silver Creek is another significant tributary which joins the Dolores River near the north Town Limit. Incomplete flow data from a gage located at Rico between 1914 and 1921 were not included in the analysis because these data do not include peak flows. The USGS program generates curve parameters using a log-Pearson Type III

distribution. Input data for the program consisted of 43 years of uninterrupted data collected at the gage station below Rico. The 100-year and 500-year peak annual discharges determined by this method are 2655 cubic feet per second (cfs) and 3183 cfs, respectively. It is likely that the flood magnitudes determined by this method underestimate the true magnitude-probability relationship because the relatively short time period of the data does not include the two largest historic floods from an observation period of about 120 years.

Flood History

The largest flood events in Rico's history occurred in June 1884 and October 1911. Flooding on these dates was widespread throughout the San Juan region. Neither of these floods are represented by discharge data. Information on the 1884 flood is scarce. Newspaper accounts describe farmers coops floating down the river (ref. 1). The 1911 flood destroyed 11 houses, 1 stable, the city feed yards and every bridge in Rico (ref. 2). The railroad yards were "badly washed, cars overturned and other damage done" (ref. 3). Photographs show that both the Dolores River and Silver Creek caused extensive damage (ref. 4). Hydraulic analyses indicate Dolores River discharges of at least 8000 cfs would be required to inundate the former location of the train depot.

Comparison with Other Basins

Drainage area-discharge relationships from similar basins were used to estimate peak discharges for Silver Creek because discharge data are unavailable. Area-discharge relationships were also used to help estimate the 500-year flood discharge for the Dolores River due to data limitations. Table 1-1 shows the peak discharges reported in FEMA flood studies from other regional basins. The ratios of peak discharge to area for the Dolores River Basin also shown in Table 1-1 are relatively consistent. The higher discharge-area ratios for Chicken Creek and Junction Creek can be explained by

Table 1-1. Area-Discharge Data for Dolores River and Similar Basins

Location	Area (A) (sq mi)	Peak Discharge, Q (cfs) 100-year	Q/A	500-year	Q/A	Q_{500}/Q_{100}
Lost Canyon Creek at Dolores	72	2,500	35	4,500	63	1.8
Dolores River above West Dolores River	270	7,500	28	20,000	74	2.7
Dolores River at Dolores	567	14,500	26	36,000	63	2.5
Mancos River at Mancos	83	2,750	33	4,420	53	1.6
Chicken Creek at Mancos	22	950	43	1,370	62	1.4
Junction Creek at Durango	39	4,350	112	7,700	197	1.8

Sources: references 5, 6 and 7

large areas of shale which has a very small runoff storage capacity.

Peak Discharges

Table 1-2 shows the 100-year and 500-year discharges used in this study along with the results of the frequency analysis for the Dolores River below Rico. The 100-year peak discharge for the Dolores River at Rico was based on the results of the frequency analysis with adjustments made based on area-discharge ratios and knowledge of unrecorded historic floods. Peak discharges for Silver Creek and the 500-year flood discharge for the Dolores River were determined primarily by comparisons with other drainage basins and known high-water elevations from historic floods.

Table 1-2. Peak Discharges and Area-discharge Data for this Study

Location	Area (A) (sq mi)	Peak Discharge, Q (cfs) 100-year	Q/A	500-year	Q/A	Q_{500}/Q_{100}
Dolores River at Rico	85	2800	33	6000	71	2.1
Dolores River below Rico freq. analysis	105	2655	25	3183	30	1.2
Scotch Creek	11	400	36	700	63	1.7
Silver Creek	7	350	50	500	71	1.4

Hydraulic Analyses

Water surface profiles were computed using the Army Corp of Engineers' HEC-2 computer program (ref. 8). The iterative program applies the standard step method to solve energy and head-loss equations for one-dimensional steady or gradually varied flow. Subcritical conditions were assumed.

Cross-section geometry for this study was determined from recent 1:1,200 scale topographic maps with 2-foot contour intervals (ref. 9). The data was refined and verified by field measurements. Bridges and culverts were measured in the field. Cross section locations are indicated by flood water elevations on the flood map.

Initially, Manning's roughness coefficients ("n-values") were estimated based on field observations and standard ranges of values (ref. 10). However, due to the high gradients of the channels, roughness coefficients were adjusted to conform with data from similar high-gradient streams in Colorado (ref. 11). The previous study found a strong correlation between slope and hydraulic radius with roughness for high-gradient

streams. The relationship developed is:

$$n = 0.39 S^{0.38} R_h^{-0.16}$$

where S is slope, (about 0.012 for the Dolores River at Rico)

R_h is hydraulic radius (in feet)

Data from this study also support the assumption of subcritical flow conditions. Ranges of roughness values for the main channels and flood plains are presented in Table 1-3.

Table 1-3. Manning's n-values used in this Study

	typical	Manning's "n" maximum	Manning's "n" minimum
Dolores River			
main channel	0.055	0.034	0.070
flood plain	0.080	0.060	0.080
Silver Creek	0.120	0.120	0.120

The flood profiles determined in this study assume that the channels and flood plains remain unobstructed. Appendix A presents the input HEC-2 file and a summary of the output.

References

1. The Early History of Rico - 1869-1886, The Dolores Star Press, 1964.
2. The Durango Herald, October 12, 1911.
3. The Dove Creek Press, October 13, 1911.
4. Colorado Historical Society negative #F36413, October 1911, reproduced in *A Historic Touring Guide to the San Juan Skyway*, by Ian Thompson, Fort Lewis College, 1994.

5. Federal Emergency Management Agency, *Flood Insurance Study, Town of Dolores, Colorado, Montezuma County,* September 1989.

6. Federal Emergency Management Agency, *Flood Insurance Study, Town of Mancos, Colorado, Montezuma County,* September 1986.

7. Federal Emergency Management Agency, *Flood Insurance Study, City of Durango, Colorado, La Plata County,* December 1989.

8. Hydrologic Engineering Center, *HEC-2 Water Surface Profiles, Version 4.6.2, Generalized Computer Program*, U.S. Army Corp of Engineers, Davis, CA, May 1991.

9. Olympus Aerial Surveys, Inc., Topographic map of the Town of Rico, Colorado, Scale 1:1,200, Contour Interval 2 feet: Rico, Colorado, October 1994.

10. Chow, Ven Te, *Open Channel Hydraulics*, McGraw-Hill, New York, 1959.

11. Jarrett, Robert D., *Hydraulics of High-Gradient Streams,* Journal of Hydraulic Engineering, Vol. 110, No. 11, November 1984.

12. Hoggan, Daniel H., *Computer-Assisted Floodplain Hydrology and Hydraulics*, McGraw-Hill, New York, 1989.

CWCB Hydrology Worksheet

Title of Study: FIRM - Town of Rico
County: Dolores
Calculations By: jag Date: August 15, 2000

Documentation

This workbook estimates 100-year discharges for approximate floodplains in Colorado using the following source:

Browning, T.W. 1999. Guidelines for Determining 100-year Flood Flows for Approximate Floodplains in Colorado, Version 4.0. Colorado Water Conservation Board. January.

River Basin

DLR-1: Dolores, Dolores River Subregion

Status of Regression Equations for this sub-region: Draft

Regression Equation Data

$$Q = aA^{b}$$

Where:

Q = Discharge (cfs)
A = Drainage Area (square miles)
a = coefficient = 213.8
b = coefficient = 0.601

Limited by:

Minimum Drainage Area = 2 square miles
Maximum Drainage Area = 1080 square miles

Discharge Calculations

Drainage Area ID	Drainage Area Description	Drainage Area (mi^2)	100-year Discharge (cfs)
D1	Dolores - Upstream of Silver Creek	72.43	2,804
D2	Dolores - At Rico Incorporated Limits	82.75	3,038
D3	Silver Creek - Upstream of Mouth	7.13	696
D4	Iron Draw - Upstream of Mouth	0.84	Outside Bounds
D5	Spear Creek - Upstream of Mouth	0.30	Outside Bounds
D6	Sulfur Creek - Upstream of Mouth	0.83	Outside Bounds

Peak Discharge at Ungaged Sites

Title of Study:	FHBM - Town of Rico			
County:	Dolores			
Gage No.	09165000	Gage: Dolores River Below Rico, CO		
Calculations By:	jag		Date:	August 25, 2000

Documentation

This workbook calculates peak discharges at ungaged sites based on peak discharges at gaged sites on the same stream. The methodology is based on the following source:

CWCB. 1976. Manual for Estimating Flood Characteristics of Natural-Flow Streams in Colorado. Technical Memorandum No. 1. Prepared in Cooperation with USGS.

Regression Equation Data

$$Q_{T(U)} = \left(\frac{A_U}{A_G}\right)^X Q_{T(G)}$$

Where:

$Q_{T(U)}$ = peak discharge at ungaged site for recurrance interval T

$Q_{T(G)}$ = weighted average discharge at gage site for recurrance interval T

A_U = drainage area at ungaged site

A_G = drainage area at gaged site

X = exponent for each flood region

Mountains

Limited by:

$$0.5 < A_U/A_G < 2.0$$

Discharge Calculations

A_U = 82.75 square miles

A_G = 105 square miles

X = 0.79

Return Period	Percent Exceedance	Gaged Dis. $Q_{T(G)}$ =	Ungaged Dis. $Q_{T(U)}$ =
500	0.2	2,890	2,394
200	0.5	2,710	2,245
100	1	2,560	2,121
50	2	2,390	1,980
20	5	2,150	1,781
10	10	1,930	1,599
5	20	1,670	1,384
2	50	1,220	1,011
1.25	80	839	695
1.11	90	673	558
1.05	95	554	459
1.01	99	372	308

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*              FFA                 *      *                                  *
*     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS   *
*     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1           *      *         609 SECOND STREET        *
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**TITLE RECORD(S)**
TT   CWCB Floodplain Designation Program - Peak Flow Analysis
TT   Town of Rico, Colorado

**STATION IDENTIFICATION**
ID   09165000  Dolores River Below Rico, Co.   DA  =  105 sq.mi.   1952 - 1996

**HP PLOT **
     HP PLOT FILE                    IHPCV  KLIMIT    IPER    BAREA
HP plot6.pcl                             0       0       0          105 sq.mi.

     SELECTED CURVES ON HPPLOT
          EXPECTED PROBABILITY CURVE
          CONFIDENCE LIMITS

HP USGS Gage No. 09165000
HP Dolores River Below Rico, Co.

**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   5000    .000    -.10

**SYSTEMATIC EVENTS**
     45 EVENTS TO BE ANALYZED

**END OF INPUT DATA**
ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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----------------------PRELIMINARY RESULTS ----------------------


-SKEW WEIGHTING -
---------------------------------------------------------------
BASED ON  45 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =   .190
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =   .302
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PRELIMINARY RESULTS

-FREQUENCY CURVE- 09165000 Dolores River Below Rico, Co. DA

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	.95
2890.	3000.	.2	3600.	2450.
2710.	2790.	.5	3340.	2310.
2560.	2630.	1.0	3130.	2200.
2390.	2450.	2.0	2890.	2080.
2150.	2180.	5.0	2550.	1880.
1930.	1950.	10.0	2250.	1710.
1670.	1680.	20.0	1910.	1500.
1220.	1220.	50.0	1360.	1100.
839.	832.	80.0	936.	736.
673.	661.	90.0	764.	573.
554.	538.	95.0	642.	456.
372.	346.	99.0	452.	284.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	3.0683	HISTORIC EVENTS	0
STANDARD DEV	.1807	HIGH OUTLIERS	0
COMPUTED SKEW	-.8903	LOW OUTLIERS	0
REGIONAL SKEW	-.1000	ZERO OR MISSING	0
ADOPTED SKEW	-.6000	SYSTEMATIC EVENTS	45

FINAL RESULTS

-PLOTTING POSITIONS- 09165000 Dolores River Below Rico, Co. DA

EVENTS ANALYZED MON	DAY	YEAR	FLOW CFS	ORDERED EVENTS RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
6	10	1952	2120.	1	1984	2170.	2.17
5	28	1953	1460.	2	1995	2140.	4.35
5	21	1954	786.	3	1952	2120.	6.52
6	8	1955	1360.	4	1957	2080.	8.70
5	31	1956	1020.	5	1970	1930.	10.87
6	5	1957	2080.	6	1958	1900.	13.04
5	27	1958	1900.	7	1985	1830.	15.22
5	15	1959	585.	8	1973	1810.	17.39
6	3	1960	1170.	9	1980	1770.	19.57
5	19	1961	1020.	10	1975	1620.	21.74
5	9	1962	1190.	11	1982	1610.	23.91
5	8	1963	867.	12	1979	1600.	26.09

5	26	1964	1220.	13	1983	1590.	28.26
5	21	1965	1330.	14	1986	1590.	30.43
5	9	1966	951.	15	1993	1490.	32.61
5	21	1967	769.	16	1953	1460.	34.78
6	4	1968	1360.	17	1968	1360.	36.96
5	30	1969	1210.	18	1955	1360.	39.13
9	6	1970	1930.	19	1978	1330.	41.30
6	17	1971	1100.	20	1965	1330.	43.48
6	8	1972	776.	21	1964	1220.	45.65
6	11	1973	1810.	22	1969	1210.	47.83
5	10	1974	783.	23	1962	1190.	50.00
6	5	1975	1620.	24	1960	1170.	52.17
6	4	1976	958.	25	1987	1150.	54.35
5	9	1977	270.	26	1971	1100.	56.52
6	10	1978	1330.	27	1996	1060.	58.70
6	13	1979	1600.	28	1961	1020.	60.87
6	10	1980	1770.	29	1956	1020.	63.04
6	7	1981	878.	30	1994	980.	65.22
8	25	1982	1610.	31	1976	958.	67.39
6	19	1983	1590.	32	1966	951.	69.57
5	24	1984	2170.	33	1990	938.	71.74
6	8	1985	1830.	34	1981	878.	73.91
6	6	1986	1590.	35	1963	867.	76.09
6	9	1987	1150.	36	1992	866.	78.26
6	6	1988	764.	37	1991	794.	80.43
5	10	1989	644.	38	1954	786.	82.61
6	5	1990	938.	39	1974	783.	84.78
5	20	1991	794.	40	1972	776.	86.96
5	20	1992	866.	41	1967	769.	89.13
6	16	1993	1490.	42	1988	764.	91.30
6	3	1994	980.	43	1989	644.	93.48
6	17	1995	2140.	44	1959	585.	95.65
5	16	1996	1060.	45	1977	270.	97.83

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 45 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.727

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 376.2

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

HIGH OUTLIER TEST

BASED ON 44 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.719

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 3177.

-SKEW WEIGHTING -

BASED ON 45 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .115
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- 09165000 Dolores River Below Rico, Co. DA

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	.95
3330.	3570.	.2	4220.	2800.
2990.	3150.	.5	3710.	2550.
2740.	2850.	1.0	3340.	2360.
2490.	2560.	2.0	2980.	2170.
2150.	2190.	5.0	2510.	1910.
1890.	1910.	10.0	2160.	1700.
1620.	1630.	20.0	1810.	1470.
1200.	1200.	50.0	1310.	1100.
890.	884.	80.0	978.	795.
761.	752.	90.0	847.	665.
669.	657.	95.0	754.	572.
525.	505.	99.0	609.	430.

SYNTHETIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	3.0790	HISTORIC EVENTS	0
STANDARD DEV	.1541	HIGH OUTLIERS	0
COMPUTED SKEW	-.0233	LOW OUTLIERS	1
REGIONAL SKEW	-.1000	ZERO OR MISSING	0
ADOPTED SKEW	.0000	SYSTEMATIC EVENTS	45

HP PLOT WRITTEN TO THE FILE: plot6.pcl

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++++++++++++++++++++++++++
+ END OF RUN             +
+ NORMAL STOP IN FFA     +
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AE
X
A
AE
X
X
Y
AE
Y
AE
X
X
Y
AE
AE
LEGEND
ZONE AE Base Flood with Elevations Determined
ZONE A No Base Flood Elevations Determined
ZONE X Areas of 500-year flood; areas of 100-year flood with average depths <1'
ZONE Y Erodable material within the 100-year or 500-year flood area.
• 8650.5 Base flood elevation in main channel in feet.
Notes.
1. This map is subject to approval of the Colorado Water Conservation Board.
2. All elevations in feet above mean sea level.
3. Debris fan hazards and flood hazards on tributary streams not shown; refer to Map 3 - Geologic Hazards
4. This map not intended for insurance rating purposes.
N
SCALE: 1" = 200'
0 50 100 200 400
by
Chris Wilbur, P.E.
August 1995
MAP 1
Flood Hazards