State of Colorado
2002 Flood Documentation Report

Wiley, Colorado flood of August 28, 2002. Courtesy of Southeastern Land & Environment in Lamar, Colorado.

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COLORADO
DEPARTMENT OF
NATURAL
RESOURCES

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COLORADO WATER CONSERVATION BOARD
STATE OF COLORADO
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EXECUTIVE REPORT SUMMARY

During the months of July and August of 2002, various flood events occurred throughout the state of Colorado (see table below). Counties that were affected include: Chaffee, Douglas, Garfield, La Plata, Prowers, and Keith County in Nebraska. Keith County had a serious flood event in July, and since it is close to the state of Colorado, it has been included in this report. After the "Authority" section of this report, there are maps of both Colorado and Nebraska counties, and highlighted maps, detailing the counties where each flood event took place.

Each county experienced various degrees of flooding and damage. Keith County, in Nebraska, had the most severe event of all counties that were studied. This event was the only one to involve a death. The heavy precipitation caused different levels of damage to each area. Most counties had: damage to structures, roads, culverts, bridges, public facilities such as parks, crop damage, and personal property damage.

This report summarizes the 2002 flood events that took place in the state of Colorado and surrounding areas. In no way is this report intended to review every event that took place during the year, but specific events that the Colorado Water Conservation Board wanted a closer look at. It investigates the key factors of a flood event such as: hydrologic and hydraulic characteristics, storm facts and location, estimated flood damages, mitigation, and a description of any areas that were underwater or impacted by the flood. Additional support information found, such as pictures, maps, etc, was also included in each chapter.

Summary of Documented Flood Events

Community	Flood Event Date(s)	Effected Watershed	Estimated Storm Frequency
Deckers (Douglas County)	7/10 and 7/21/02	Hayman Burn Area (South Platte Basin)	2-YR
Rifle (Garfield County)	7/18 and 7/19/02	Government and Rifle Creeks	20-YR
Buena Vista (Chaffee County)	7/22/02	Cottonwood Pass	10-YR
Durango (La Plata County)	7/23 and 8/03/02	Missionary Ridge Burn Area	2-YR
Glenwood Springs (Garfield County)	8/05/02	Mitchell Creek	2-YR
Wiley/Lamar (Prowers County)	8/28/02	Wiley Drainage Ditch and Willow Creek	10-YR / 50-YR*
Ogallala, Nebraska (Keith County)	7/06/02	Interstate 80 Drainage Ditch	More Than 2X the 100-YR

* Frequency estimate given is for Wiley / Lamar respectively.

INTRODUCTION

The following chapters discuss the seven significant flood events that occurred in 2002 around the state of Colorado. The seventh chapter reports on a flood event that occurred near Ogallala Nebraska in July. Each chapter follows a specific presentation format of gathered information that was outlined before the project commenced. However, the amount and type of information that could be gathered for each event varies greatly due, in most part, to the quantity of available contacts, and the amount of information gathered by local, state and federal agencies. The general trend seems to imply that the more severe the event, the more contacts and information available. Thus, the levels of detail and discussion depth for each chapter also differ accordingly.

PURPOSE OF STUDY

The intended purpose of this study is to gather information on specific flood events throughout the state and present that information to all interested parties in an organized and presentable fashion. This study is also being done to help inform government officials, and private citizens, on the effects and damage that floods can cause in order to help prepare them for future occurrences. After reading each chapter, one will be able to identify problem spots and areas where flood mitigation projects assisted in minimizing the impacts to the surrounding area.

AUTHORITY AND ACKNOWLEDGEMENTS

Authority

It is the responsibility of the CWCB (Colorado Water Conservation Board) 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. By this authorization, work on this project was sanctioned and funded by the CWCB through several contracts dated, August 1st, and August 29th, 2002 with ICON Engineering, Inc. In consultation with the Colorado Water Conservation Board and a variety of federal, state, and local agencies, ICON Engineering, Inc. conducted the study and produced the following document to be used statewide.

Acknowledgements

This report was made possible by funding made available through the CWCB's Flood Response Program, which includes an element for flood documentation services. The following staff played a key role in the completion of this report:

- Tom Browning, CWCB, Flood Protection Program
- Penn Gildersleeve, ICON Engineering, Inc.
- Justen Hamann, ICON Engineering, Inc.
- Mike Vinson, ICON Engineering, Inc.

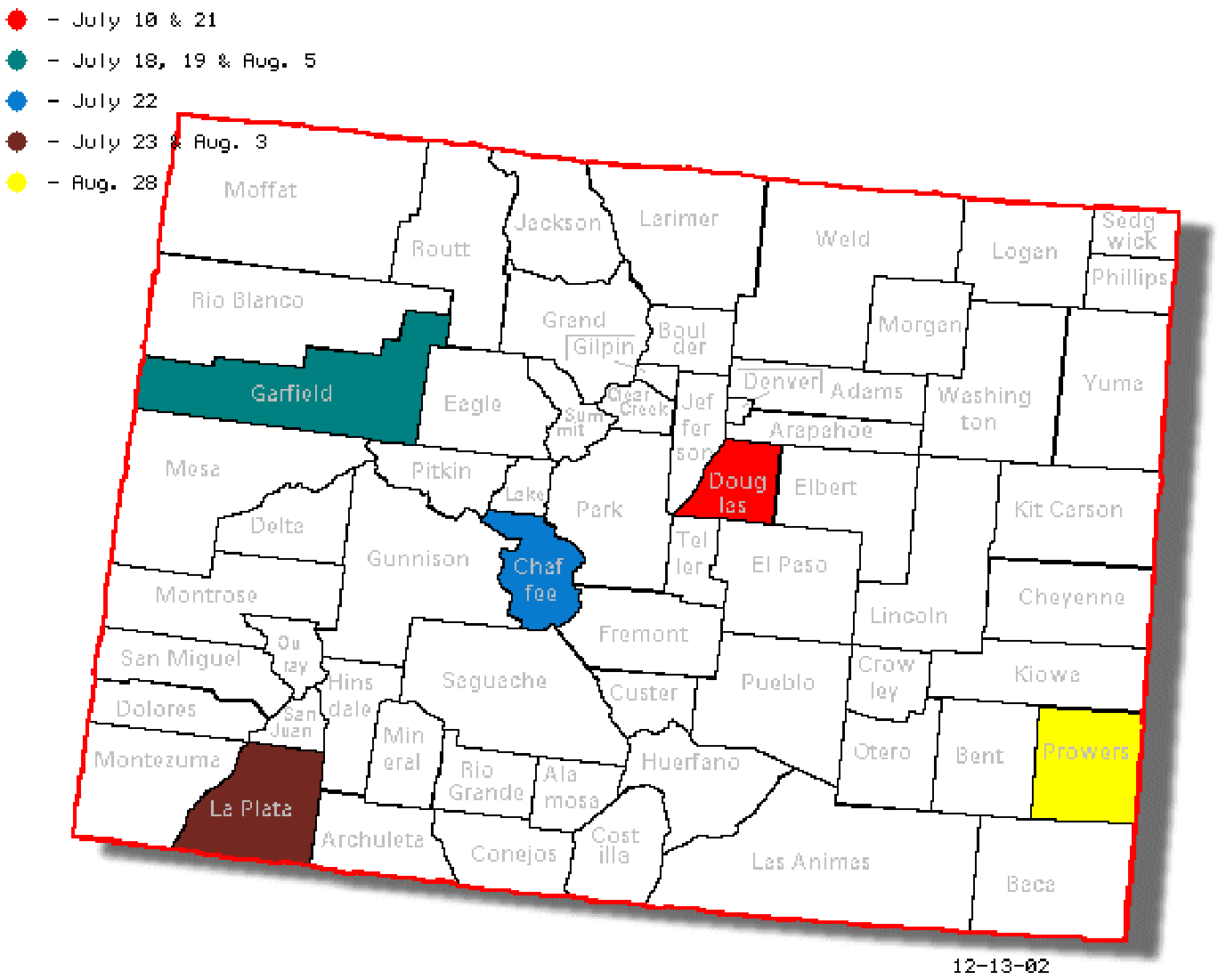


Figure A – Colorado Flood Locations by County & Event Date(s).
Obtained from Texas A&M University's "Do it Yourself Color-Coded State Maps."

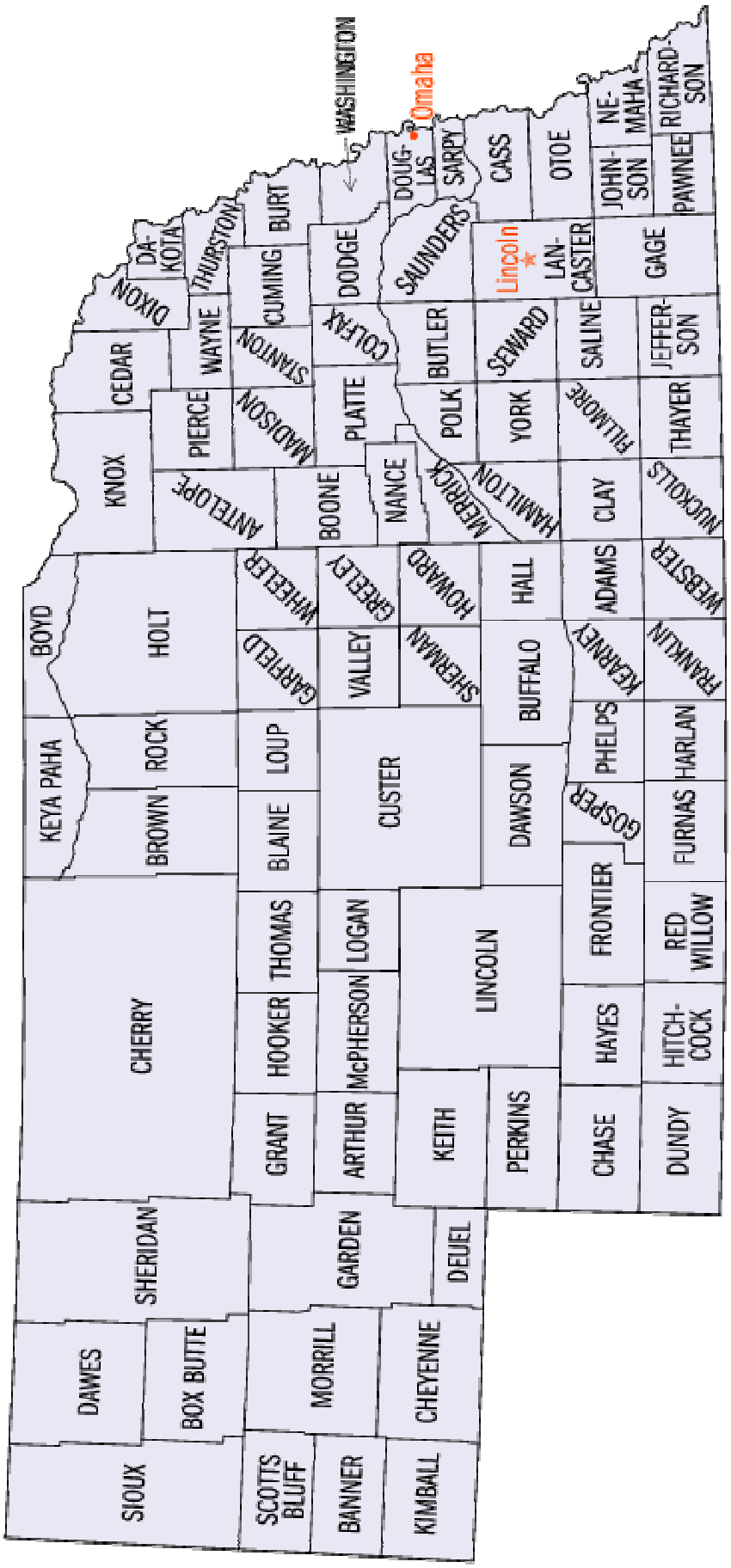


Figure B – State of Nebraska County Map.
Courtesy United States Census Bureau's "State & County QuickFacts" website.

Figure C – Mapquest Map Legend
Obtained from www.mapquest.com.

CHAPTER 1

Deckers, Colorado Floods of July 10th and 21st, 2002
Hayman Burn Area / South Platte Basin
(Douglas County)

Introduction

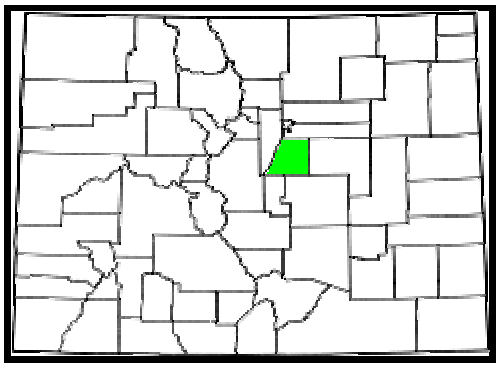


Figure 1.1 – Douglas County Location in the State of Colorado.
Map courtesy of the Colorado Herpetological Society.

On Wednesday, July 10th and Sunday, July 21st, two storms produced significant amounts of rainfall that fell on the Hayman Burn area, or what is formally known as the South Platte Basin. The community of Deckers Colorado, which resides in this area, experienced minor flooding and several mudslides as a result of the storm. According to various sources, as much as 0.6 inches of rain fell on July 10th, and as much as 0.33 inches of precipitation was recorded for the July 22nd event. Most of the reported storm damage was minor with the most severe impact being the closing of South Deckers Road due to a four-foot deep river of mud, water, and debris that crossed the highway during, and after, the July 21st event.

Location and Description

Deckers, Colorado is located approximately 32 miles southwest of Denver, at the intersection of State Highway 67 and CR 126 in Douglas County (see Figure 1.3 on the next page). The border between Douglas and Jefferson County lies just to the west of this small community. Deckers is considered a part of unincorporated Douglas County.

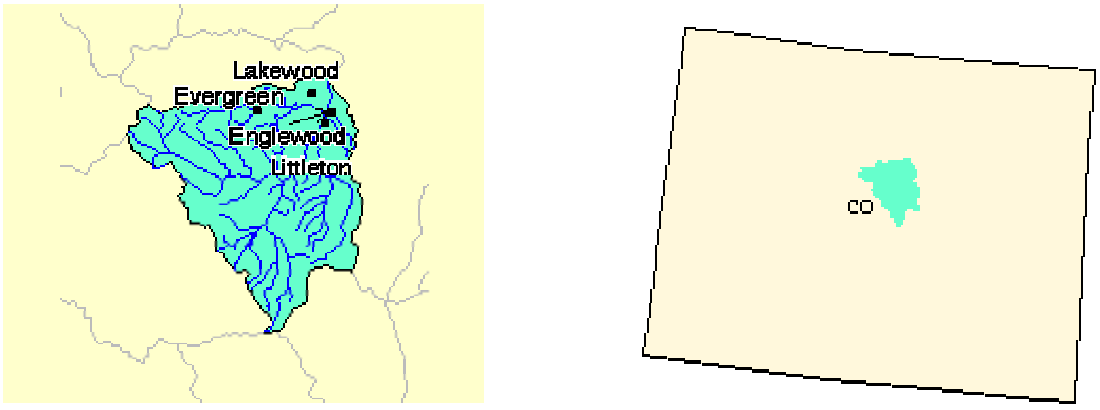


Figure 1.2 – Upper South Platte Watershed and Location
Obtained from Environmental Protection Agency's "Surf Your Watershed" website.

According to the 2000 Census, Douglas County's population is 175,766 (U.S. Census Bureau, "Factfinder" website). The County Seat is located in Castle Rock, which is approximately 20 miles to the northeast.

The Deckers community lies within the Upper South Platte watershed along with several other towns and cities. Downstream towns include Littleton, Lakewood, and Englewood to name a few. This watershed spans nine counties including Jefferson, Douglas, and Denver.

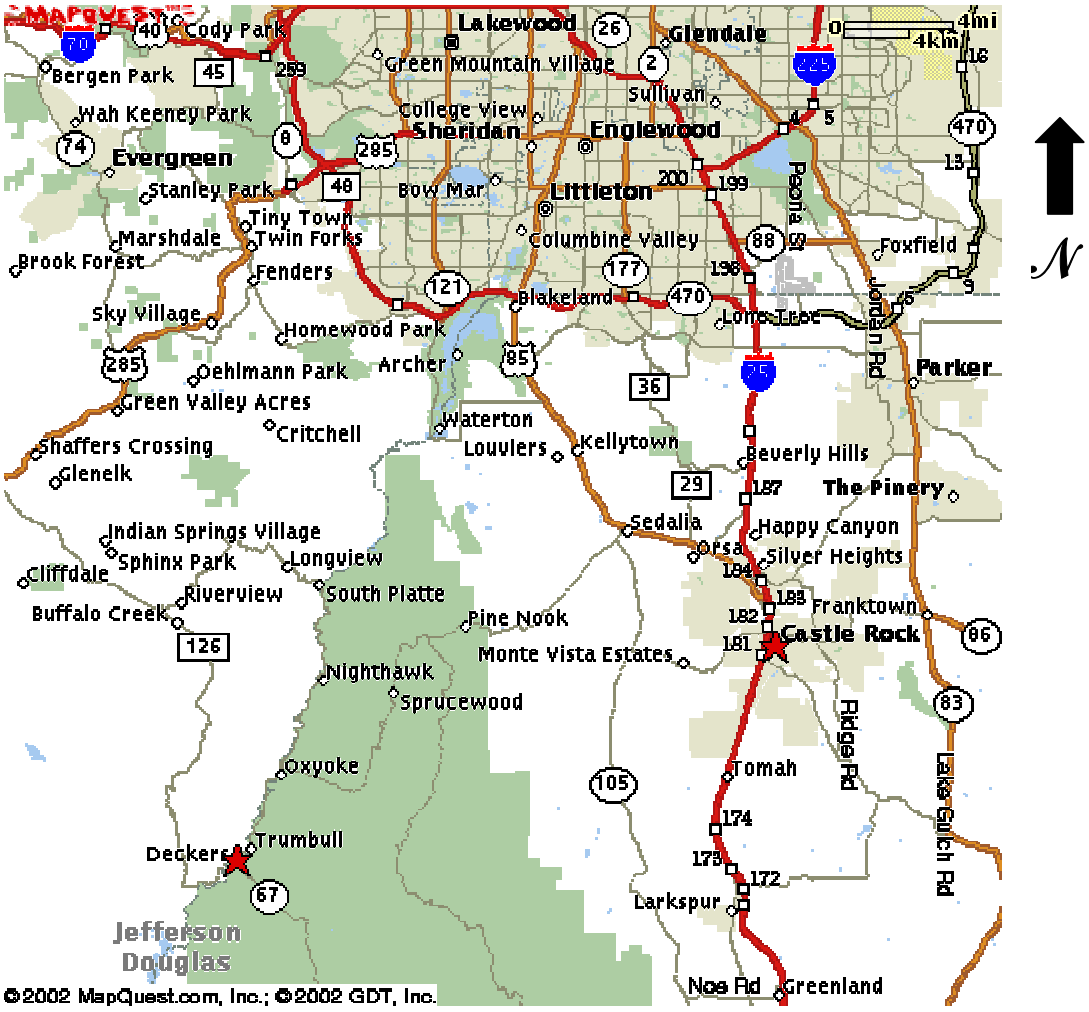


Figure 1.3 – Map of Deckers, Colorado in Relation to Nearby Castle Rock and Denver Area.

Storm Characteristics and Information

Finding rainfall information and storm characteristics for the two events in the Deckers area was difficult. Because the two storms were relatively minor events and therefore indistinguishable from many other storms that occurred during the 2002 flood season, most contacts could not separate defining traits for these storms. However, one clear difference that separated them was the closing of South Deckers Road during the second event. Information could be obtained about the effects of the Hayman fire and the

rehabilitation of the burned area, but facts concerning two specific storms were unavailable. In addition, since the storms did not cause significant damage to the community and surrounding area, or any injuries, there was no federal flood mitigation. In other words, officials did not make it a priority to collect and assemble data about these two events.

Total precipitation amounts varied according to different sources and different locations throughout the burn area. This variation is expected and normal for storm fronts in the state. The National Weather Service reported that 0.13 inches of rain fell in Lake George (a nearby community to the south of Deckers), and 0.06 inches of precipitation was recorded at Cheesman Reservoir (approximately 6 miles southwest of Deckers on the South Platte River) during the July 10th storm. A local dude ranch owner told the Denver Post that according to a rain gage, 0.6 inches of rain fell on his property including some small hail.

A wide variance in precipitation amounts was also reported for the July 22nd storm. The

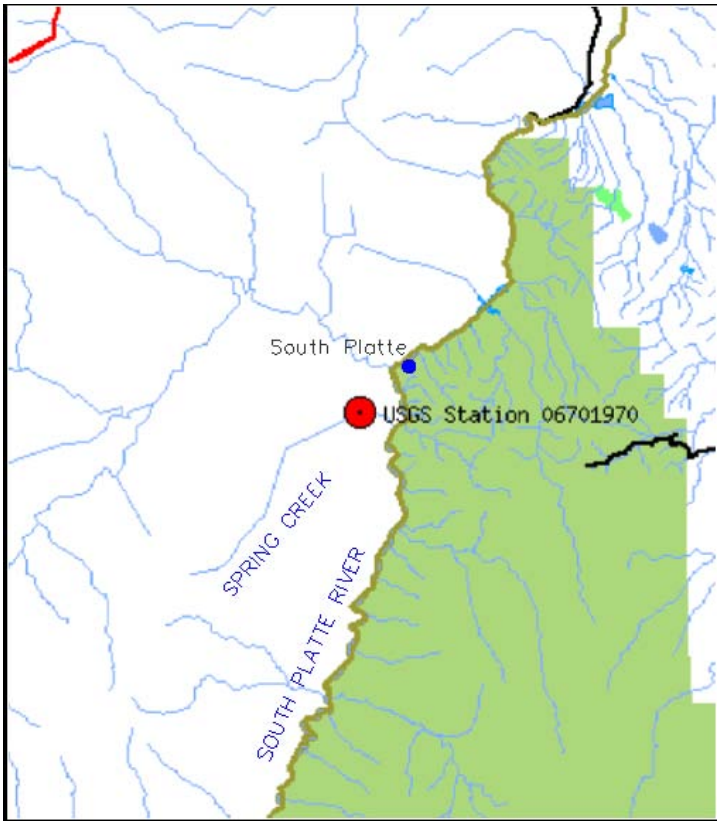


Figure 1.4 – Map of Spring Creek Rain Gage Location.

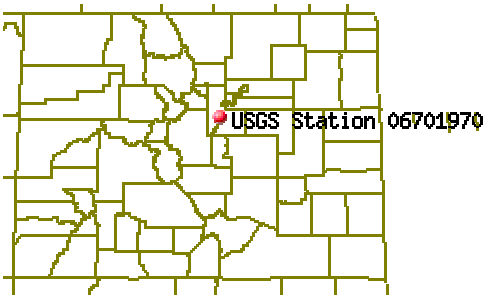


Figure 1.5 – Spring Creek Rain Gage Location in Relation to State of Colorado.

Rocky Mountain News reported that, "about 2 inches of rain fell in (an) hour and a half." Another article by the Denver Post quotes a spokesman for the Jefferson County Sheriff's office, saying "...she had heard that about 1/3-inch of rain fell in the area."

Official rain gage data was also available for this studied area. Since the Hayman Fire scorched the land, the potential for floods and mudslides increased dramatically due to the loss of erosion reducing weeds, trees, and natural grasses. Several new rain gages were installed near Deckers, and around the burn area, in order to help warn the surrounding communities of flash flood producing storms. According to the rain gage near Deckers, 0.14 inches of rain fell on July 10th, and 0.12 inches of precipitation was recorded on July 22nd. Figures 1.4 and 1.5 show the location

of this rain gage and a map of the gage's location in relation to the state of Colorado. Color radar images for the state of Colorado were found on the National Climatic Data Center's website. The NEXRAD radar images show a small pocket of storm activity that formed within the Hayman Burn Area at approximately 7:30PM. These images are shown below, and on the following page, in Figures 1.6 through 1.12. Next to Figures 1.6 and 1.8 is a legend indicating the higher the color number, the more intense the storm. In order to locate the Deckers area on the NEXRAD radar images, Figure 1.13 (next page) contains a map of the state of Colorado with the town of Deckers highlighted.

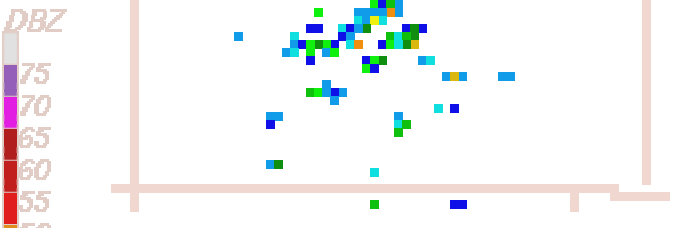


Figure 1.6 – State of Colorado NEXRAD Radar Image July 10th, 2002 at 1:00PM.

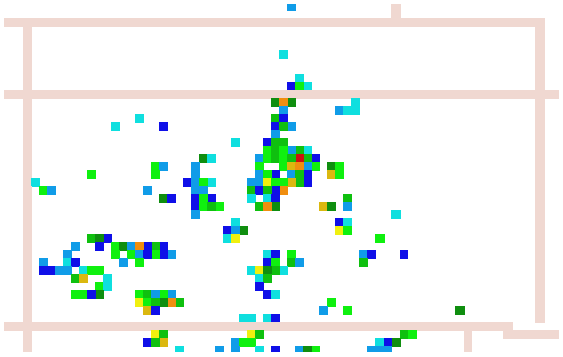


Figure 1.7 – State of Colorado NEXRAD Radar Image July 10th, 2002 at 2:00PM.

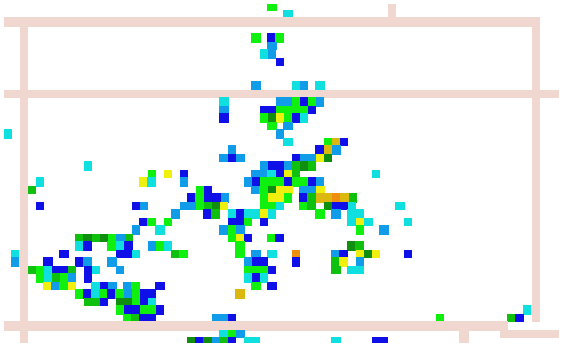


Figure 1.8 – State of Colorado NEXRAD Radar Image July 10th, 2002 at 3:00PM.

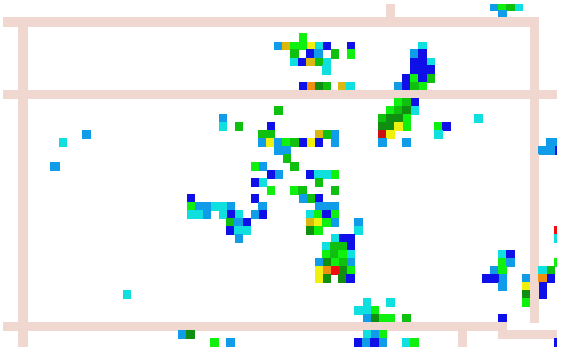


Figure 1.9 – State of Colorado NEXRAD Radar Image July 21st, 2002 at 7:00PM.

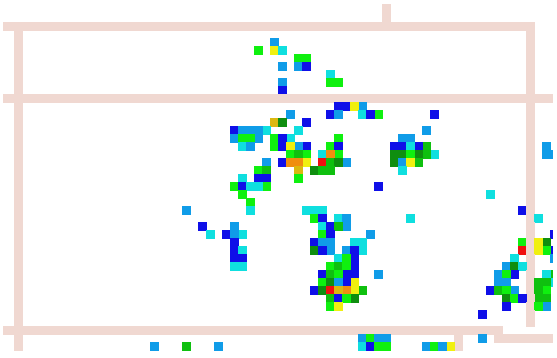


Figure 1.10 – State of Colorado NEXRAD Radar Image July 21st, 2002 at 8:00PM.

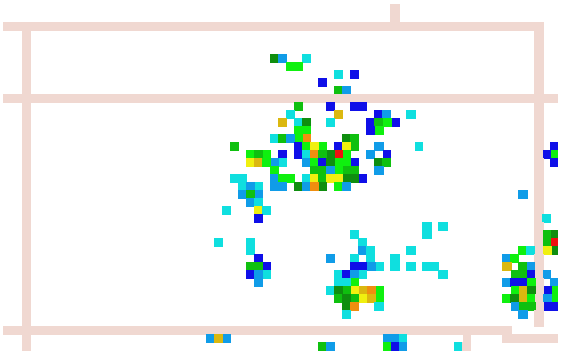


Figure 1.11 – State of Colorado NEXRAD Radar Image July 21st, 2002 at 9:00PM.

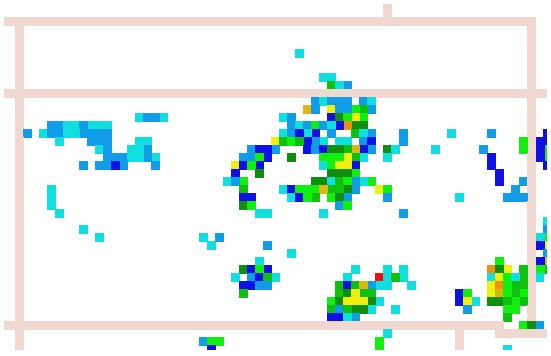


Figure 1.12 – State of Colorado NEXRAD Radar Image July 21st, 2002 at 10:00PM.

Figure 1.13 – Map of the Town of Deckers in Relation to the State of Colorado.
Map courtesy of Mapquest website.

Hydrologic and Hydraulic Conclusions

Damage resulting from the two storms studied was due to mudslides and overland flow from the effects of the Hayman fire.

According to information obtained from Mapquest, Deckers lies near the confluence of Horse Creek and the South Platte River at an elevation of approximately 6400 feet. Cheesman Reservoir is located just to the southwest of Deckers along the South Platte River. The South Platte flows to the north and is flow-controlled by the reservoir.

Hydrologic analyses were performed using available baseline data from NOAA Atlas 2 in order to generate Intensity Duration Frequency, or IDF, curves for rainfall events within the Deckers area. Using the varying amounts of rainfall mentioned in the Storm Characteristics section of this chapter, and the duration of the storm, one could estimate the frequency of the specific events. The results of this analysis are shown in Table 1.1 below.

Table 1.1 – Hydrologic Analysis Summary

	July 10, 2002 Storm	**July 21, 2002 Storm**
Event Duration (hours)	3.0	1.5
2-YR Total Precipitation (in.)	0.89	0.79
50-YR Total Precipitation (in.)		1.93
100-YR Total Precipitation (in.)		2.20
Total Event Precipitations As Reported (in.)	0.60	2.00*
	0.14	0.33
	0.06	0.12
Est. Event Frequency (yr)	**Less Than 2**	**Less Than 2**

* = Outlying data point not included in frequency estimation.

According to an article published by the Rocky Mountain News, during the July 21st storm, 2.0 inches of rain fell in approximately 1.5 hours. This value is unusually high and

does not concur with the other precipitation amounts that were documented, or the obtained radar images. The data source for this information was not documented, nor was it determined where this precipitation was recorded. It is possible that this amount of rainfall did occur in a localized area however, for the benefits of this analysis, this value is thought to be an outlying data point and is therefore not considered in the storm frequency analysis.

No flow gages were analyzed or considered in this analysis because there were no reports of flooding due to nearby streams.

Flooded Area Description

Since no rivers or streams flooded during the two studied events, few areas sustained major damage or were underwater.

During the July 10th event, the Lost Valley Dude Ranch sustained minor flood damage from a "river of frothy black water" that covered the area (Emery, 1). The ranch is located within a natural drainage-way where runoff from the storm began to concentrate before flowing down its drainage path. The dude ranch is located just off Jefferson County road 126, which is also known locally as South Deckers Road.

South Deckers Road had to be closed during the July 21st event due to a four foot deep river of water flowing across the road near "...Six Mile Hill, which is south of Forest Road 550 and north of Deckers" (Denver Post, 1).

Estimated Flood Damages & Any Special Factors Affecting the Flood

Since the studied events were minor in origin (both less than 2-year events) with no rivers or streams flooding, damage to infrastructure and personal property was minimal.

The only reported damage from the July 10th event was to the Lost Valley Dude Ranch. A small amount of water found it's way into the lodge soaking a $10,000 area rug (Emery, 1). It is assumed the ranch also sustained some clean-up costs associated with the "river of frothy black water" but these costs were unknown at the time of this report.

No damage or associated cost estimates were reported for the storm on July 21st. Most likely, there was erosion damage and clean-up costs for South Deckers Road but, these costs were unknown.

No injuries or casualties were reported from these events.

The Hayman Fire was a unique factor that affected the storm events analyzed in this chapter. In fact, it is reasonable to conclude the damage from this fire caused, or at least increased, the effects from the storms. The hydraulic conclusions suggest these storms were less than 2-year events meaning they were common storms experienced by Deckers and the surrounding area. It is also reasonable to conclude that under pre-fire circumstances, no flooding or damage would have occurred at all.

The wildfires within, and adjacent, to the subject study area created a significant adverse effect on the hydrologic response of the burned watersheds. There is a great concern for increased storm and runoff-related natural hazards due to the destruction of vegetation in conjunction with the possible development of hydrophobic (water repellent) soils in the burned forested areas. Downstream property owners, citizens, motorists, and other parties will be exposed to a greatly increased risk of floods, mudslides, and debris flows compared with pre-fire conditions. Concerned parties should contact their local floodplain administrator within their effected community, or county, for additional information. Local emergency response and emergency management agencies are responsible for initially handling emergencies if and when they occur. The Colorado Water Conservation Board can be contacted for technical information related to post-wildfire hydrology and related data.

The Tuesday before the first storm event (July 9, 2002), the U.S. Forest Service announced a $24.8 million dollar project to try to rehabilitate the forest. The BAER Team (Burned Area Emergency Rehabilitation) proposed to use a combination of methods including: the application of mulch, seeding, and scarifying the hardened soil in order to increase it's ability to hold water and provide small channels for the water to flow (Ensslin, 1-2).

Additional Support Information

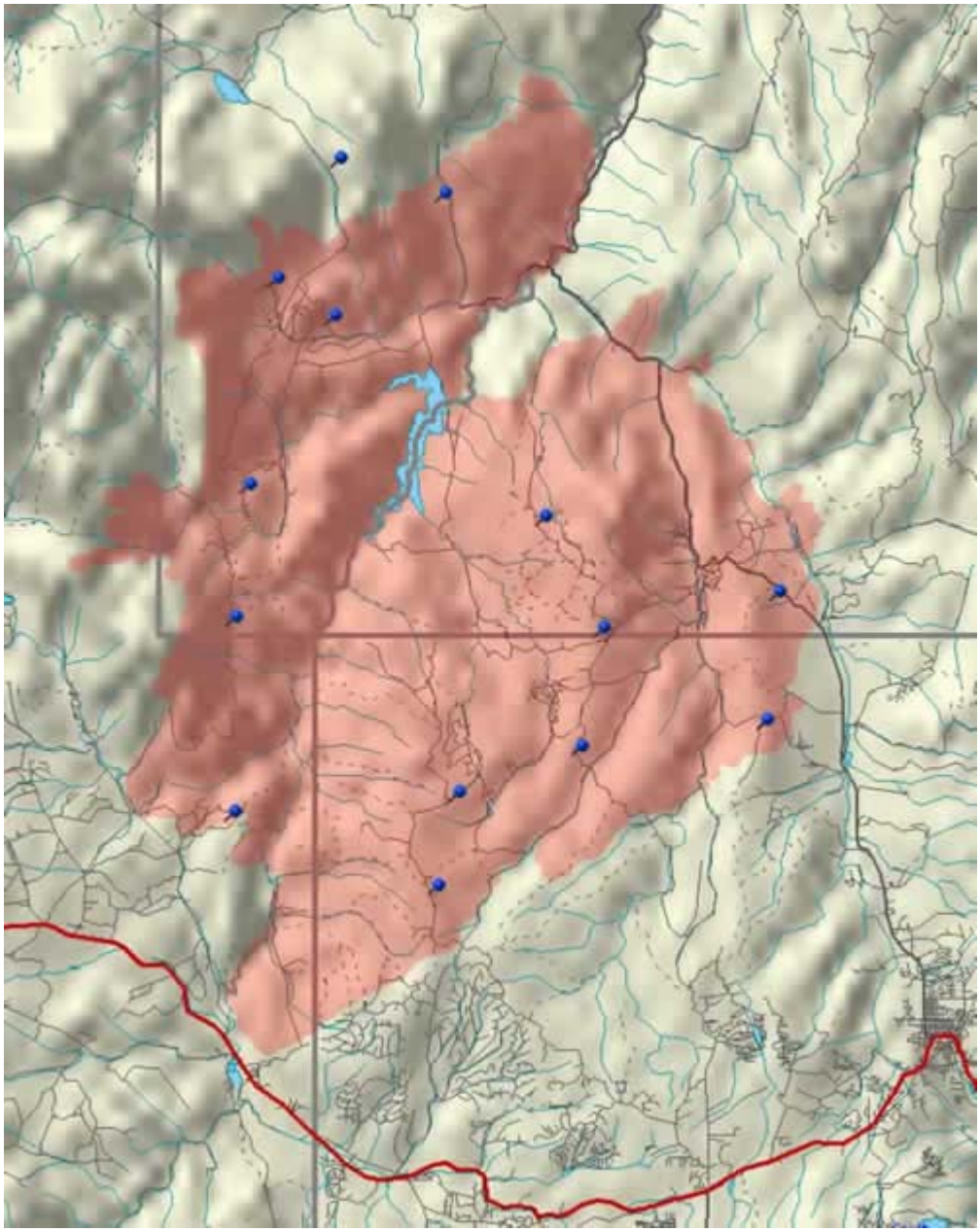


Figure 1.14 – Highlighted Hayman Burn Area and New Rain Gage Location.
Picture obtained from DIAD Incorporated's Hayman Fire website at http://haymanfire.diad.com/gage2.htm .

CHAPTER 2

Rifle, Colorado Floods of July 18th and 19th, 2002
Government and Rifle Creeks
(Garfield County)

Introduction

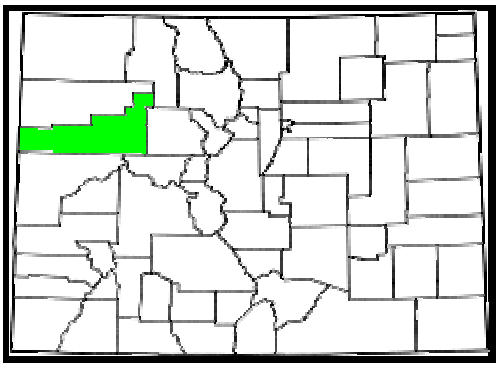


Figure 2.1 – Garfield County Location in the State of Colorado.
Map courtesy of the Colorado Herpetological Society.

On Thursday, July 18th and Friday July 19th, 2002, two separate storms produced heavy amounts of rainfall on the town of Rifle and it's surrounding area. According to the local police chief, Daryl Meisner, the Thursday storm released approximately 1.5 inches of rain in a 30-minute period sending mud, water and large amounts of debris down Government and Rifle creeks. The precipitation amount for the Friday storm was not documented however, according to a local newspaper, it had similar characteristics to the previous day's event. Despite the significant amount of rainfall produced by these storms, most of the reported flood damage was minor. According to Mr. Meisner, the last serious flood event for Rifle occurred on May 15th, 1993 which led to the construction of a flood control dam.

Location and Description

Rifle, Colorado is located just west of Glenwood Springs along Interstate 70 in Garfield County (see Figure 2.3 on the next page). According to the 2000 Census, Rifle's population is 6,784 out of a total county population of 43,791 (U.S. Census Bureau,

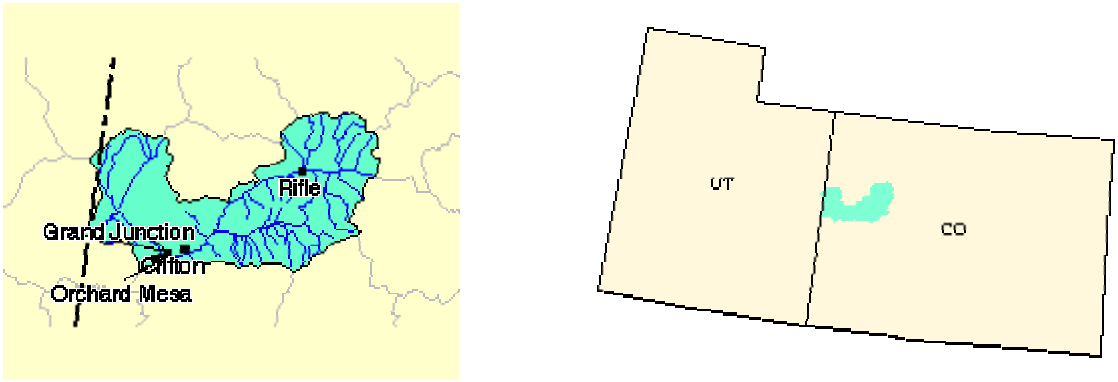


Figure 2.2 – Colorado Headwaters-Plateau Watershed and Location
Obtained from the Environmental Protection Agency's "Surf Your Watershed" website.

"Factfinder" website). The County Seat is located in Glenwood Springs, which is approximately 27 miles to the east along I-70.

The town of Rifle lies within the Colorado Headwaters-Plateau watershed along with several other towns and cities including Grand Junction (see Figure 2.2 on previous page).

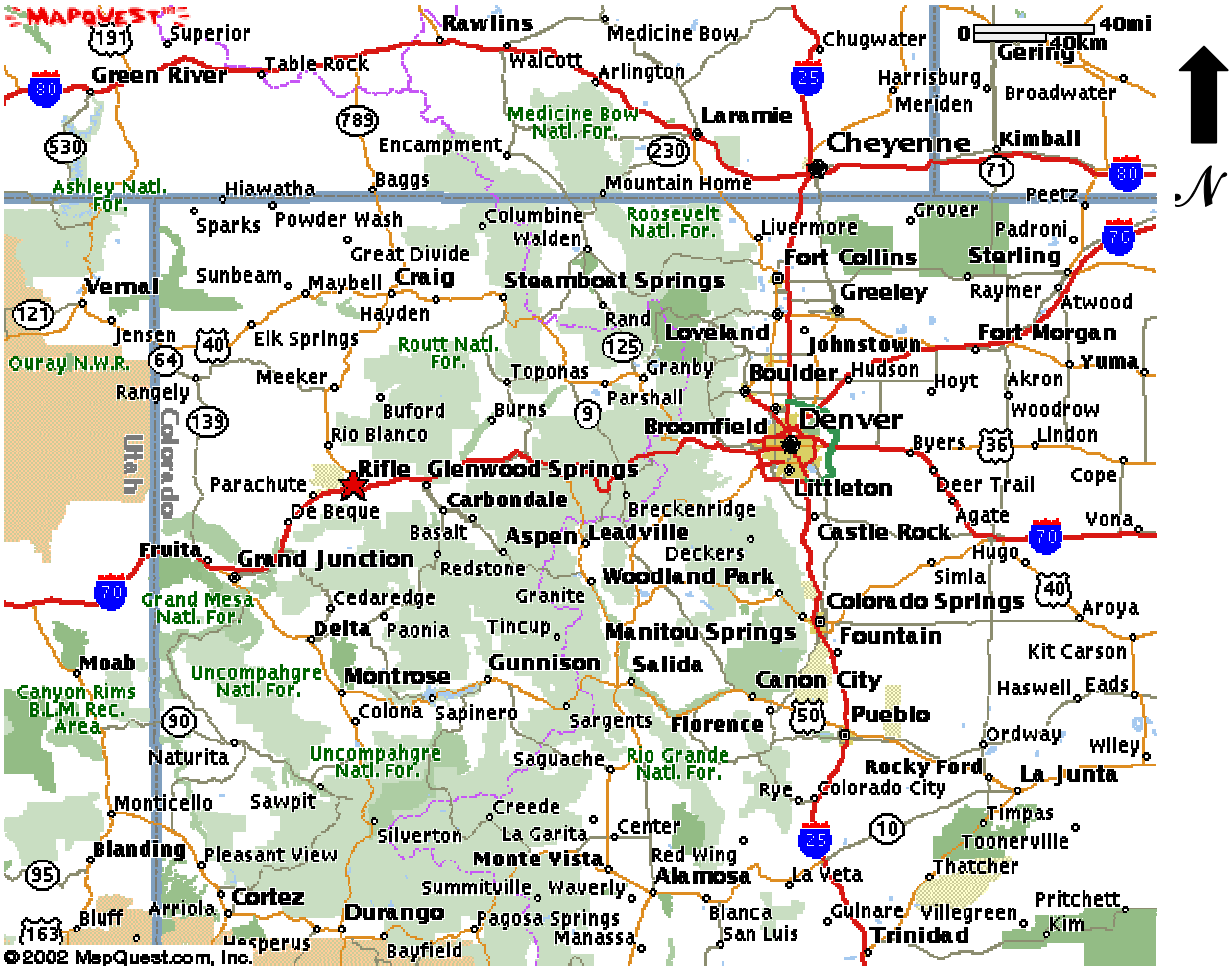


Figure 2.3 – Map of Rifle, Colorado in Relation to the Front Range Area.

Storm Characteristics and Information

Obtaining rainfall information and storm characteristics for the two storms in Rifle was difficult. Since the two storms occurred on consecutive days, most contacts could not separate defining traits of each storm. In most cases, information could be obtained about one storm but not the other. In addition, since the storms did not cause significant damage to the town of Rifle or any injuries, no federal flood mitigation was necessary.

The only known precipitation amount, within the area of the storm, was obtained by The Daily Sentinel newspaper in Grand Junction Colorado. According to Rifle Police Chief Daryl Meisner, approximately 1.5 inches of rain fell in half an hour, northwest of the

town, in an area known as the Roan Plateau. It is not known how the police chief obtained this information, although it is likely he received the information from the National Weather Service's regional office in Grand Junction.

According to the National Climatic Data Center's NEXRAD radar images, a small pocket of severe storm activity formed just northwest of Rifle at approximately 7:30PM. These images are shown below, and on the following page, in Figures 2.4 through 2.8. Next to Figures 2.4 and 2.6 is a legend indicating the higher the color number, the more intense the storm. In order to locate the town of Rifle on the NEXRAD radar images, Figure 2.9 (next page) contains a map of the state of Colorado with the town of Rifle highlighted.

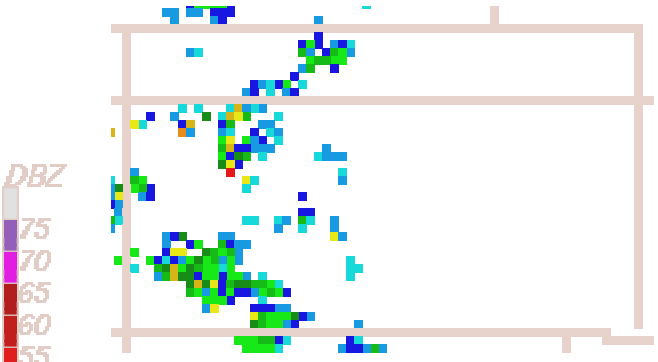


Figure 2.4 – State of Colorado NEXRAD Radar Image July 18th, 2002 at 7:00PM.

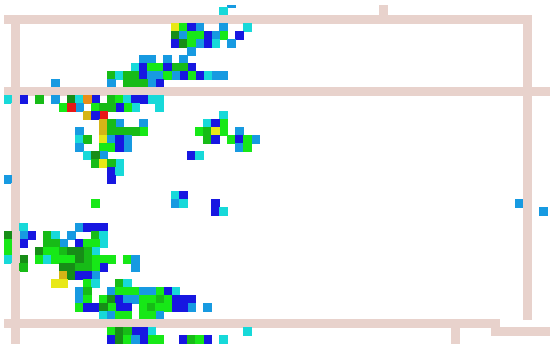


Figure 2.5 – State of Colorado NEXRAD Radar Image July 18th, 2002 at 8:00PM.

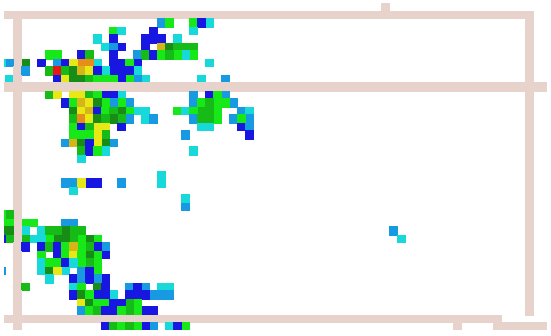


Figure 2.6 – State of Colorado NEXRAD Radar Image July 18th, 2002 at 9:00PM.

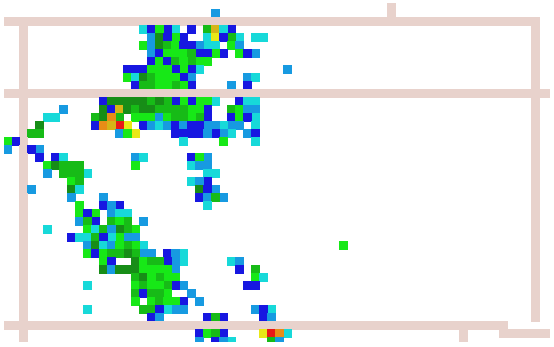


Figure 2.7 – State of Colorado NEXRAD Radar Image July 19th, 2002 at 7:00PM.

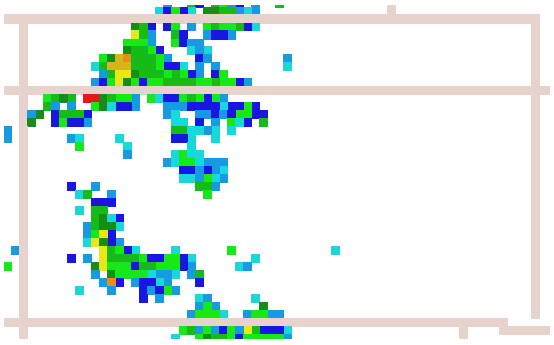


Figure 2.8 – State of Colorado NEXRAD Radar Image July 19th, 2002 at 8:00PM.

Figure 2.9 – Map of the Town of Rifle in Relation to the State of Colorado.
Map courtesy of the Mapquest website.

Hydrologic and Hydraulic Conclusions

Only a small amount of information could be found about the hydrologic characteristics of Rifle and Government Creeks. According to information obtained from the city's chamber of commerce website and Mapquest, both Rifle and Government creeks flow north to south into the town of Rifle. After entering the town, Government creek joins Rifle creek and Rifle creek continues south through the city where, after receiving more flows from various sources, it flows directly into the Colorado River.

Hydrologic analyses were performed using available baseline data from NOAA Atlas 2 in order to generate Intensity Duration Frequency, or IDF, curves for rainfall events within the town of Rifle. Using the amount of rainfall reported for the July 18th storm event (1.5 inches of rain in 30 minutes), and the derived total precipitation amounts for the city, one could estimate the frequency of the specific event. However, since this storm event occurred northwest of the city, one must take into account the total area impacted by the storm upstream of the studied city (see Figure 2.10 on the next page).

Figure 2.10 shows the estimated area boundary for the studies events. The storms were centered over the Roan Plateau area and the resulting precipitation flowed off the plateau spilling into Rifle Creek, Government Creek, and it's western tributaries.

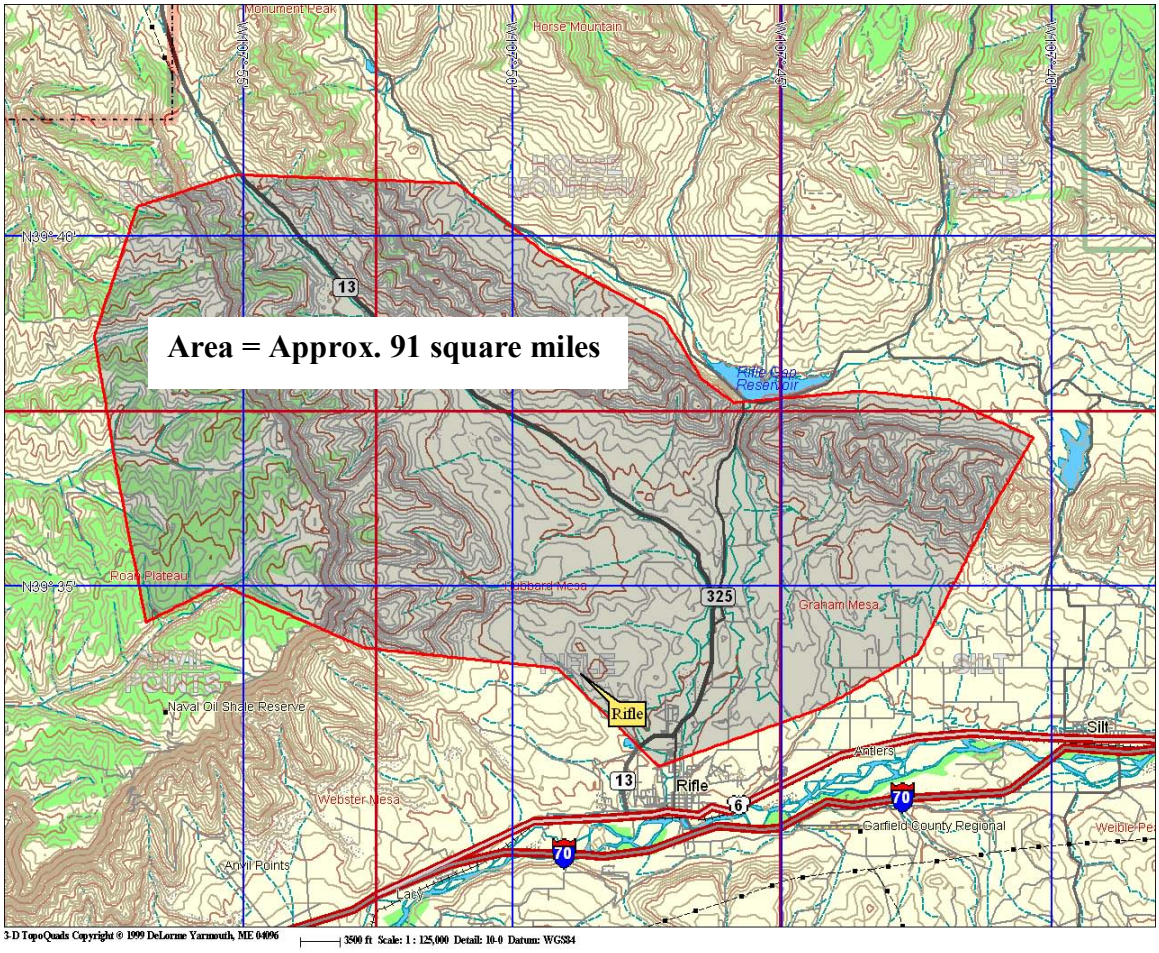


Figure 2.10 – Topographic Map Area in Rifle, Colorado Impacted by Storm.

Using NOAA Atlas 2 as a guide, the area was accounted for in the form of a percent reduction factored into the reported total point precipitation. The results are summarized below in Table 2.1.

Table 2.1 – Hydrologic Analysis Summary

Flood Event Date	July 18, 2002
Event Duration (mins.)	30
10-YR Total Precipitation (in.)	0.83
25-YR Total Precipitation (in.)	1.00
100-YR Total Precipitation (in.)	1.31
Total Event Precipitation As Reported (in.)	1.50
Est. Drainage Area (sq. miles)	91
Est. Correction Factor (percent)	63%
Event Precipitation Corrected (in.)	**0.95**
Est. Event Frequency (yr)	**Less Than 20**

There are no gages available for either of the stream areas investigated by this study. Two gages were found on Rifle Creek, however both gages were upstream of the affected areas near Rifle Gap Reservoir. According to officials with the Department of Water Resources, these gages have been giving unreliable and inaccurate data all summer due to the current drought conditions in the state.

Flooded Area Description

Areas of the city that were inundated with flood water, mud, and debris include:

> "...White River Avenue, the Lamplighter and Bookcliff Apartments and RV Park on Railroad Avenue, the county fairgrounds, Howard and Park avenues and along Rifle Creek from the northern city limits to U.S. Highway(s) 6& 24 (The Daily Sentinel, 2)."

Estimated Flood Damages & Any Special Factors Affecting the Flood

Both flood events eroded roads and various areas surrounding both creeks. Damage included a culvert, a walking bridge, approximately 120 feet of chain link fence, and involved a lot of mud and debris cleanup around the city and fairgrounds. See Figures 2.11 through 2.17 for fairground damage pictures obtained through Steve Denney with the office of Emergency Management (next several pages). In addition, "three homes sustained major damage and four others were slightly damaged (Daily Sentinel, 1)." Water damage was also reported at the Colorado State Veterans Nursing Home and the Alpine Bank.

No injuries or casualties were reported from these events.

Damage estimates were obtained through Mr. Denney with the Office of Emergency Management. The fairgrounds estimated damage at $28,000, which included the replacement of a culvert and a walking bridge. Pictures of the fairgrounds damage are included in the Additional Support Information section of this chapter, courtesy of Mr. Denney.

Cleanup damage throughout the city was estimated at $5,500, but at the time of this study, it was unknown if these were the final damage figures.

The Daily Sentinel reported that after the flood in May 1993, the city constructed a flood control dam to help control and alleviate damage to the areas surrounding the creeks. No further information could be obtained at this time concerning this structure, however the police chief believes it helped to minimize the damage.

Additional Support Information

Figure 2.11 – Rifle Fairgrounds Damage Picture 1.

Figure 2.12 – Rifle Fairgrounds Damage Picture 2.

Figure 2.13 – Rifle Fairgrounds Damage Picture 3.

Figure 2.14 – Rifle Fairgrounds Damage Picture 4.

Figure 2.15 – Rifle Fairgrounds Damage Picture 5.

Figure 2.16 – Rifle Fairgrounds Damage Picture 6.

Figure 2.17 – Rifle Fairgrounds Damage Picture 7.

CHAPTER 3

Buena Vista, Colorado Flood of July 22nd, 2002
Cottonwood Pass
(Chaffee County)

Introduction

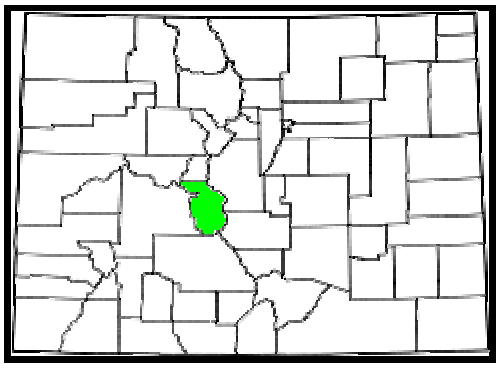


Figure 3.1 – Chaffee County Location in the State of Colorado.
Map courtesy of the Colorado Herpetological Society.

On Monday, July 22nd, a thunderstorm produced a significant amount of rainfall that fell on the town of Buena Vista and the Cottonwood Pass area. The storm triggered three different mudslides in the area that damaged roads and stranded motorists. According to a newspaper article published by the Denver Post, an inch of rain fell in the area between the hours of 6:00 and 7:00pm. The mudslides closed at least two of the affected roads while maintenance and rescue workers searched for stranded people and began to clean up the mess left behind. Several motorists were rescued from their vehicles and treated at local hospitals for minor injuries and hypothermia.

Location and Description

Buena Vista, Colorado is located approximately 86 miles southwest of Denver, at the intersection of U.S. Highway 24 and CR 306 in Chaffee County (see Figure 3.3 on the next page). According to the 2000 Census, Buena Vista's population is 2,195 out of a total county population of 16,242 (U.S. Census Bureau, "Factfinder" website). The County Seat is located in Salida, which is approximately 22 miles to the south.

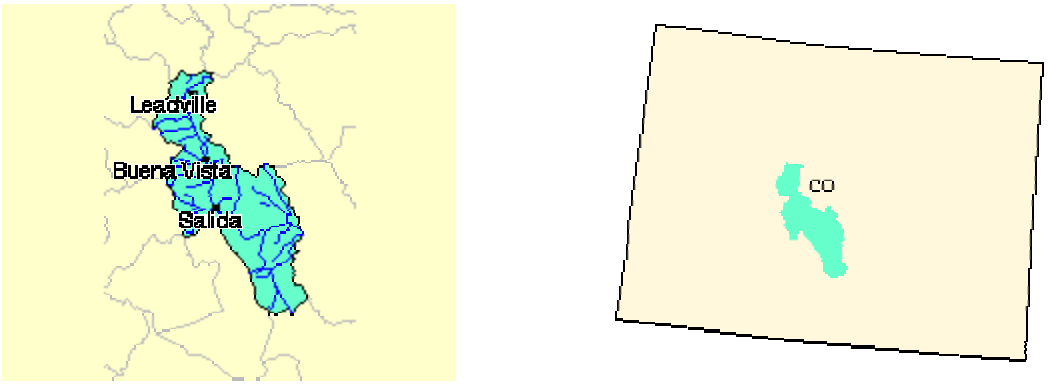


Figure 3.2 – Arkansas Headwaters Watershed and Location
Obtained from Environmental Protection Agency's "Surf Your Watershed" website.

Buena Vista lies within the Arkansas Headwaters watershed along with several other towns and cities. This watershed spans nine counties including Lake, Eagle, and Gunnison.

Figure 3.3 – Map of Buena Vista, Colorado in Relation to Nearby Front Range Area.

Storm Characteristics and Information

Three different newspaper and online articles were found that discussed the events of July 22nd. However, the majority of the articles focused on the mudslides, the damage caused, and people's reactions to the threat they posed. Only one article gave any information on the storm itself. One official from Chaffee County was contacted about the storm and resulting mudslides. Information obtained from the official included what was damaged and the costs associated with that damage. He did not have any information on the storm itself.

Since this storm did not cause major damage to the area, or any injuries/deaths, there was no federal flood mitigation.

An article published in the Denver Post by Barbara Hernandez and Becca Blond, states "...an inch of rain fell between 6 and 7 p.m." (20A). Another web article published by TheDenverChannel.com, stated rain and hail came down in sheets around the area (2).

There was no official rain gage data found for this area.

Color radar images for the state of Colorado were found on the National Climatic Data Center's website. The NEXRAD radar images show a small pocket of storm activity that formed near Buena Vista at approximately 6:00PM. These images are shown below, and on the following page, in Figures 3.4 through 3.7. Next to Figures 3.4 and 3.6, is a legend indicating the higher the color number, the more intense the storm. In order to locate the Buena Vista area on the NEXRAD radar images, Figure 3.7 (next page) contains a map of the state of Colorado with the town of Buena Vista highlighted.

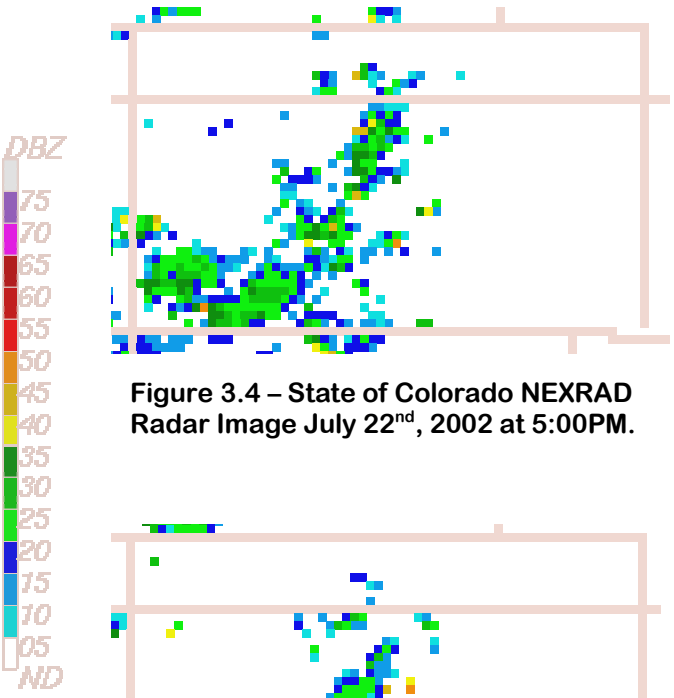


Figure 3.4 – State of Colorado NEXRAD Radar Image July 22nd, 2002 at 5:00PM.

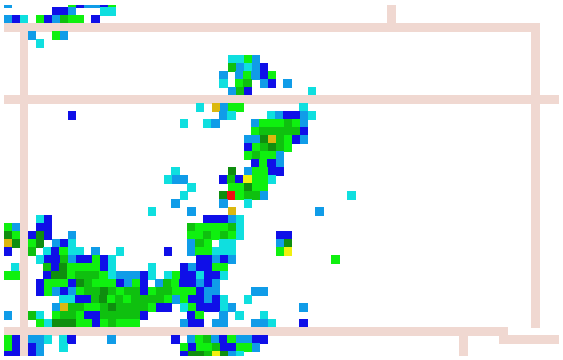


Figure 3.5 – State of Colorado NEXRAD Radar Image July 22nd, 2002 at 6:00PM.

Figure 3.6 – State of Colorado NEXRAD Radar Image July 22nd, 2002 at 7:00PM.

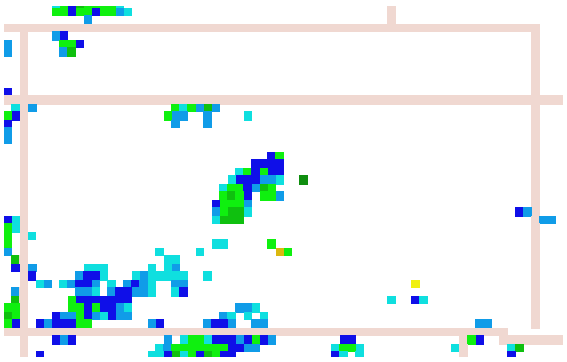


Figure 3.7 – State of Colorado NEXRAD Radar Image July 22nd, 2002 at 8:00PM.

Figure 3.8 – Map of the Town of Buena Vista in Relation to the State of Colorado.
Map courtesy of Mapquest website.

Hydrologic and Hydraulic Conclusions

There was no reported flooding associated with any streams or rivers in the studied area. Any damage was due to the mudslides and overland flow that resulted from the storm.

According to information obtained from Mapquest, and Buena Vista's Chamber of Commerce website, Buena Vista lies near several major watersheds including the Arkansas River. The area surrounding the town has several rivers, creeks, and drainage ditches. Whitewater rafting in the area is extremely popular and Buena Vista is even considered by many to be the U.S. capitol of whitewater rafting. The town lies near at elevation of 7945 feet above sea level with Cottonwood Pass, just to the west of the town, topping out at an elevation of 12,126.

Hydrologic analyses were performed using available baseline data from NOAA Atlas 2 in order to generate Intensity Duration Frequency, or IDF, curves for rainfall events near the Buena Vista and Cottonwood Pass area. Using the rainfall amount mentioned in the Storm Characteristics section of this chapter, and the estimated duration of the storm, one could determine the frequency of the specific event. The results of this analysis are shown in Table 3.1 below.

Table 3.1 – Hydrologic Analysis Summary

Flood Event Date	July 22, 2002
Event Duration (hrs)	1.0
5-YR Total Precipitation (in.)	0.90
10-YR Total Precipitation (in.)	1.10
Total Event Precipitation As Reported (in.)	1.00
Est. Event Frequency (yr)	**Less Than 10**

No flow gages were analyzed in this analysis because there were no reports of flooding due to nearby streams. However, a USGS flow gage was found on the Arkansas River

that shows a small peak in the river discharge on July 22nd. Figures showing the discharge, as well as the gage's location, are included below and on the following page.

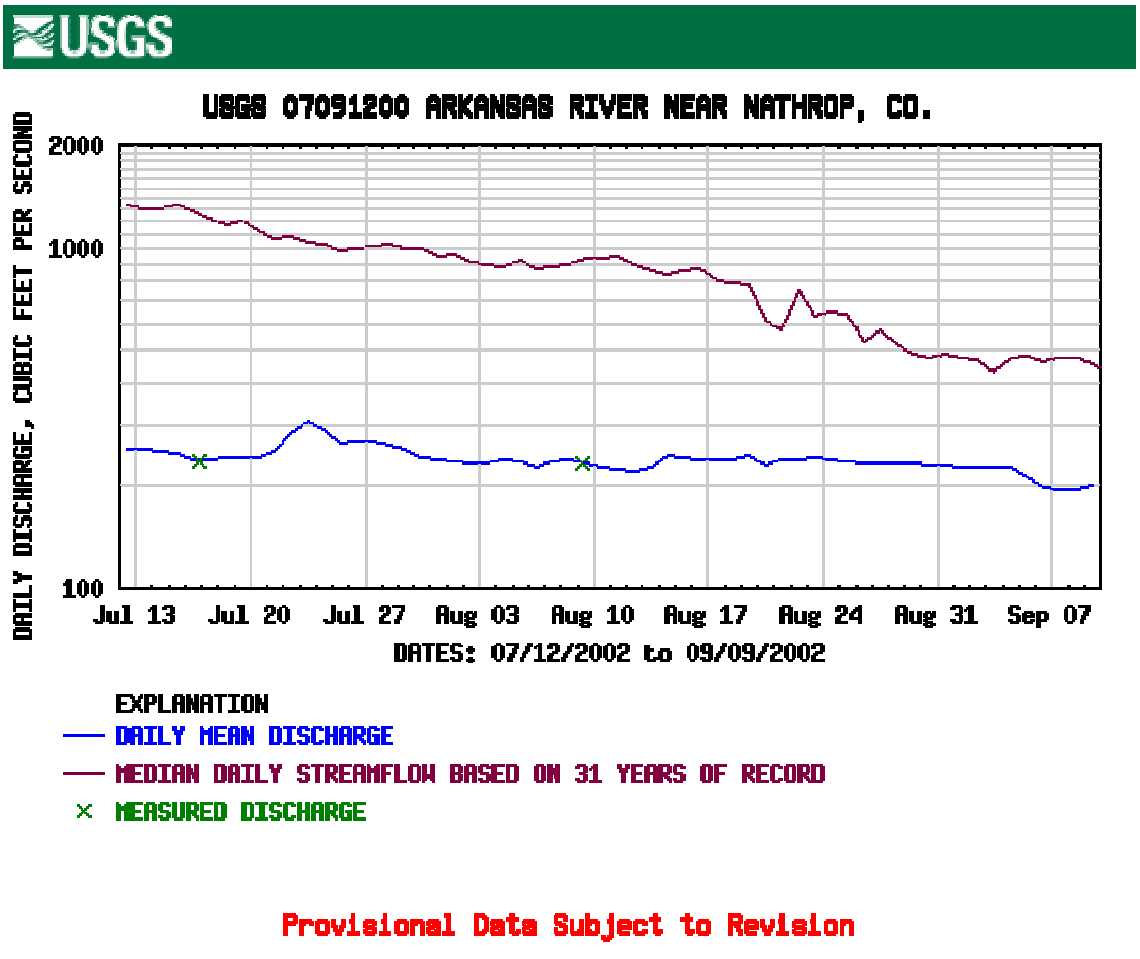


Figure 3.9 – Graph of Daily Discharge for USGS Arkansas River Gage near Buena Vista, Colorado.

Flooded Area Description

Since no rivers or streams flooded during the studied event, there were few areas underwater.

During the July 22nd event, three different county roads were affected by mudslides. County Roads 162, 36, and 306 were covered with debris ranging from two to twenty feet deep in spots. Cottonwood Hot Springs Resort was inundated with mud from a secondary slide near CR 306. The parking lot, and part of the main building, was covered with mud, water and debris (Hernandez, 20A).

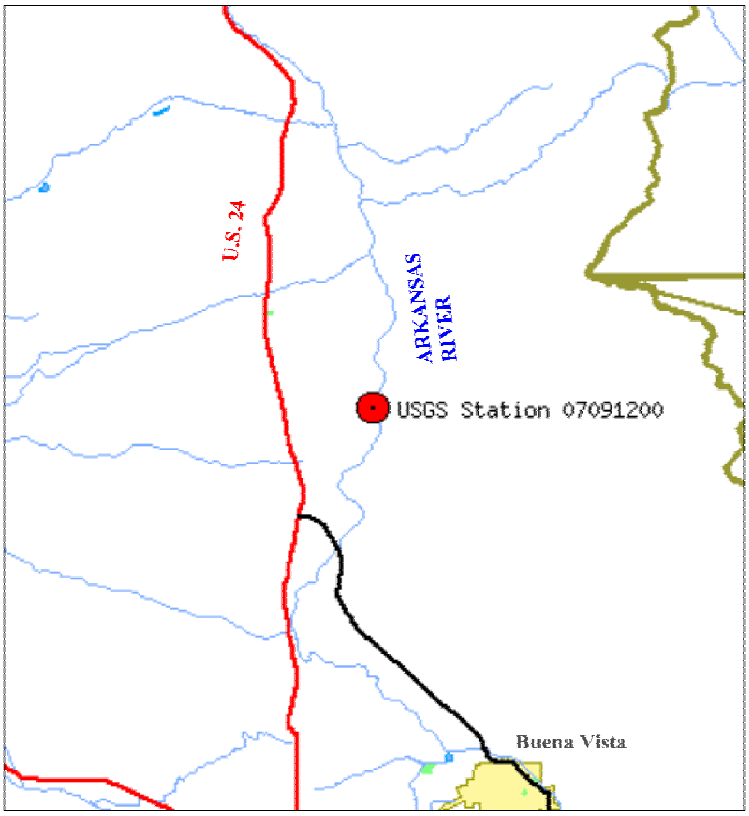


Figure 3.10 – USGS Arkansas River Gage Location near Buena Vista, Colorado.

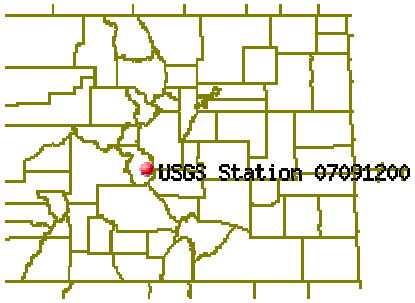


Figure 3.11 – USGS Arkansas River Gage Location in Relation to the State of Colorado.

Estimated Flood Damages & Any Special Factors Affecting the Flood

Since the studied event was minor in origin (less than 10-year event) with no rivers or streams flooding, damage to infrastructure and personal property was limited to erosion and significant clean-up of mud and debris.

All three mud-covered county roads sustained erosion and nuisance damage. County Road 306 had the most severe damage from the storm. Pictures of the CR 306 mudslide damage, and trapped cars, are shown in the Additional Support Information section of this chapter. According to Mr. Carl Hasselbrink with Chaffee County, this route was closed for approximately ten days for repairs. The guardrail was replaced in places and patchwork was done to the road, as well as the nearby hillside, due to erosion. The total cost associated with these damages, was $76,835.

Minor injuries, most involving mild hypothermia, were reported for the event. No casualties were reported.

Additional Support Information

Figure 3.12 – County Road 306 Location in Relation to Buena Vista.
Picture obtained from Denver's News 7 website at http://www.thedenverchannel.com/ .

Figure 3.12 – Minivan trapped in CR 306 Mudslide.
Picture obtained from Denver's News 7 website at http://www.thedenverchannel.com/ .

Figure 3.13 – Close-Up of Minivan trapped in CR 306 Mudslide.
Picture obtained from Denver's News 7 website at http://www.thedenverchannel.com/ .

Figure 3.14 – Interior Picture of Minivan trapped in CR 306 Mudslide.
Picture obtained from Denver's News 7 website at http://www.thedenverchannel.com/ .

Figure 3.15 – Unknown Individual Walking Site of CR 306 Mudslide.
Picture obtained from Denver's News 7 website at http://www.thedenverchannel.com/ .

CHAPTER 4

Durango, Colorado Floods of July 23rd and August 3rd, 2002
Missionary Ridge Burn Area
(La Plata County)

Introduction

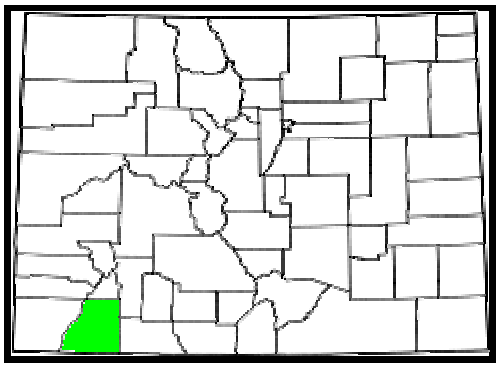


Figure 4.1 – La Plata County Location in the State of Colorado.
Map courtesy of the Colorado Herpetological Society.

On Tuesday, July 23rd and Saturday, August 3rd, two separate storms produced moderate amounts of rainfall that fell on the Missionary Ridge Burn area. The town of Durango Colorado, and it's surrounding area, experienced mild flooding and several mudslides as a result of the storms. According to various sources, as much as 1.48 inches of rain fell on July 23rd, and as much as 0.8 inches of precipitation was recorded for the August 3rd event. Most of the reported storm damage was minor to moderate. Several county roads had to be closed during and after the events due to mudslides and flooding in low-lying areas where the rainwater collected.

Location and Description

Durango is located in southwestern Colorado approximately 169 miles south of Grand Junction, at the intersection of U.S. Highway 160 and U.S. Highway 550 in La Plata County (see Figure 4.3 on the next page). According to the 2000 Census, the city of Durango's population is 13,922 out of a total county population of 43,941 (U.S. Census Bureau, "Factfinder" website). Durango is the La Plata County Seat.

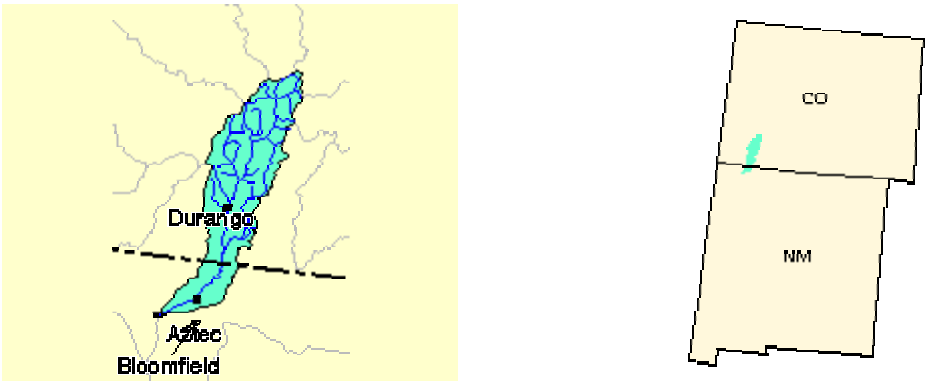


Figure 4.2 – Animas Watershed and Location
Obtained from Environmental Protection Agency's "Surf Your Watershed" website.

Durango lies within the Animas River watershed along with several other towns and cities. Most of this watershed lies within the state of Colorado with the southern end crossing into New Mexico. The watershed spans eight counties including La Plata, San Juan County in Colorado, and San Juan County in New Mexico.

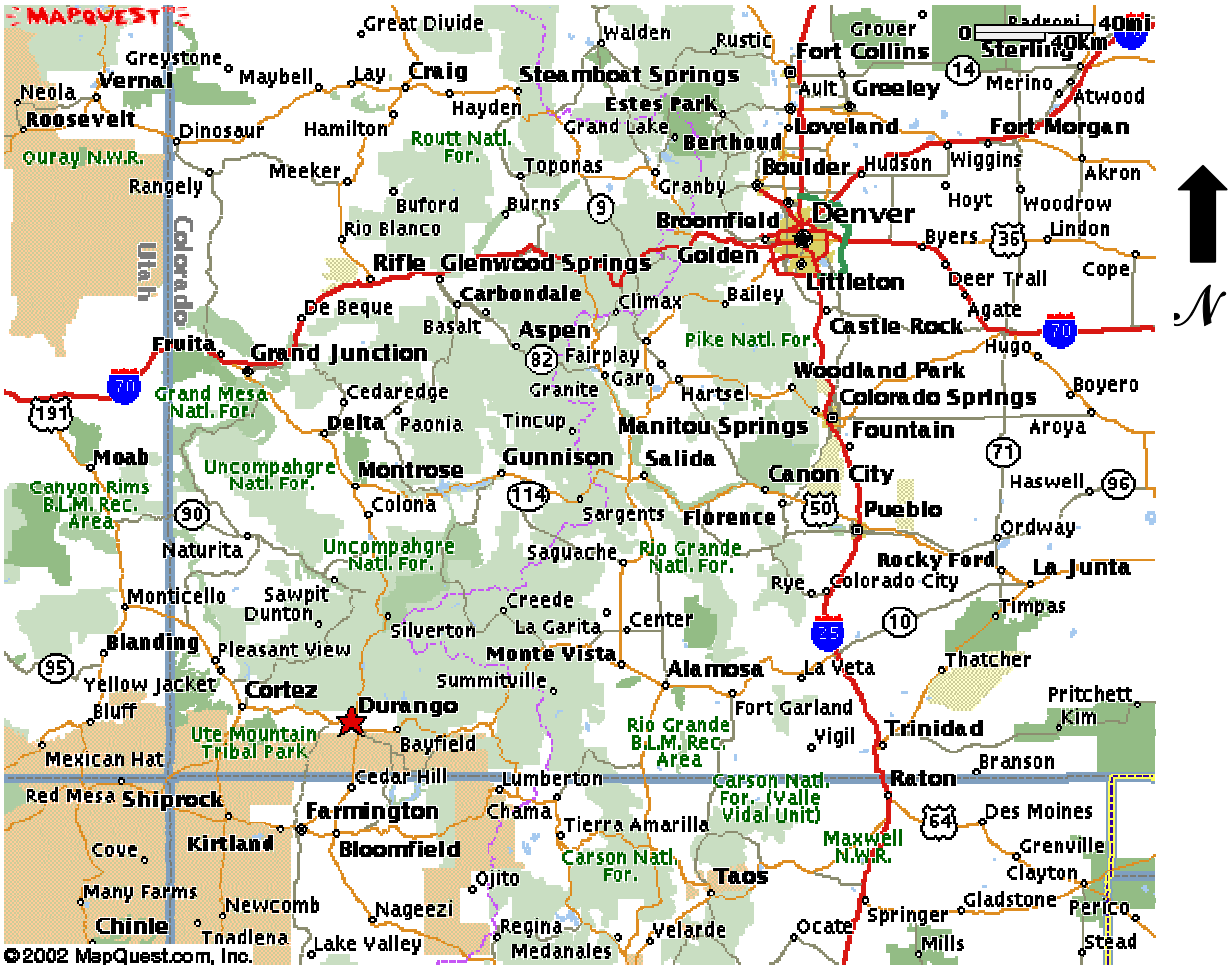


Figure 4.3 – Map of Durango, Colorado in Relation to the Front Range Area.

Storm Characteristics and Information

Finding rainfall information and storm characteristics for the two events in the Durango area was easy in comparison to other studied flood events. Because the two storms occurred in an area that has been highly publicized, due to the recent Missionary Ridge Fire, newspapers and other sources made it a priority to collect information on the two storms and their effects.

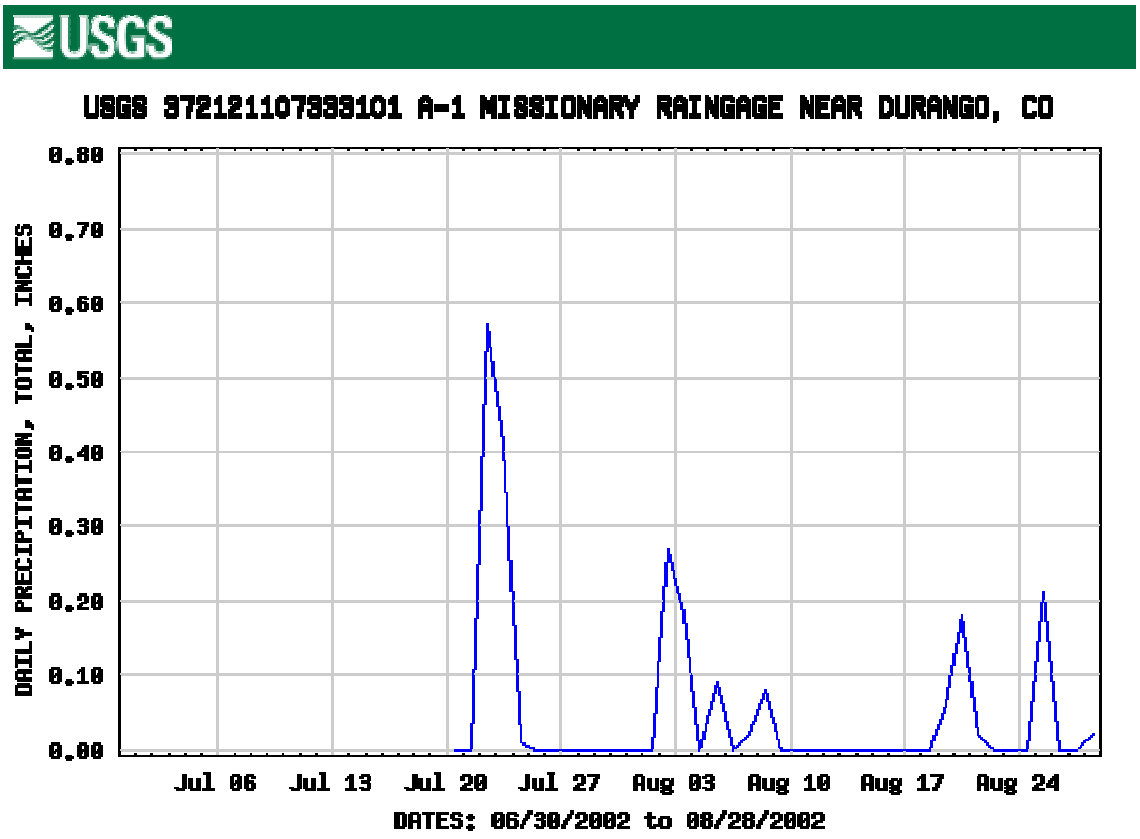


Figure 4.4 – Precipitation Graph of Missionary Ridge Burn Area Rain Gage A-1 Near Durango.

Since the storms did not cause severe damage to the community and surrounding area, or any casualties, no federal flood mitigation assistance was necessary.

Total precipitation amounts varied according to different sources and different locations throughout the burn area. This variation is expected and normal for storm fronts in the state. The Rocky Mountain News reported that 1.4 inches of rain fell in less than an hour during the July 23rd event (Ensslin, 1). Four official rain gages reported varying amounts of total precipitation as well (0.57, 0.52, 1.48, 0.30 inches). These amounts are discussed in detail below.

The difference in precipitation amounts continued for the August 3rd storm. The Rocky Mountain News reported that according to Butch Knowlton with the office of Emergency Management, "...three-quarters of an inch of rain...fell over an 8- to 12-hour period" (Rebchook, 1). Another article by the Denver Post quotes a technician for the National Weather Service in Grand Junction, saying "...as much as 0.8 inches of rain fell in the burn area" (Turner, 1). The previously mentioned rain gages, also gave varying amounts of rain for this event (0.27, 0.42, 0.30, 0.20 inches).

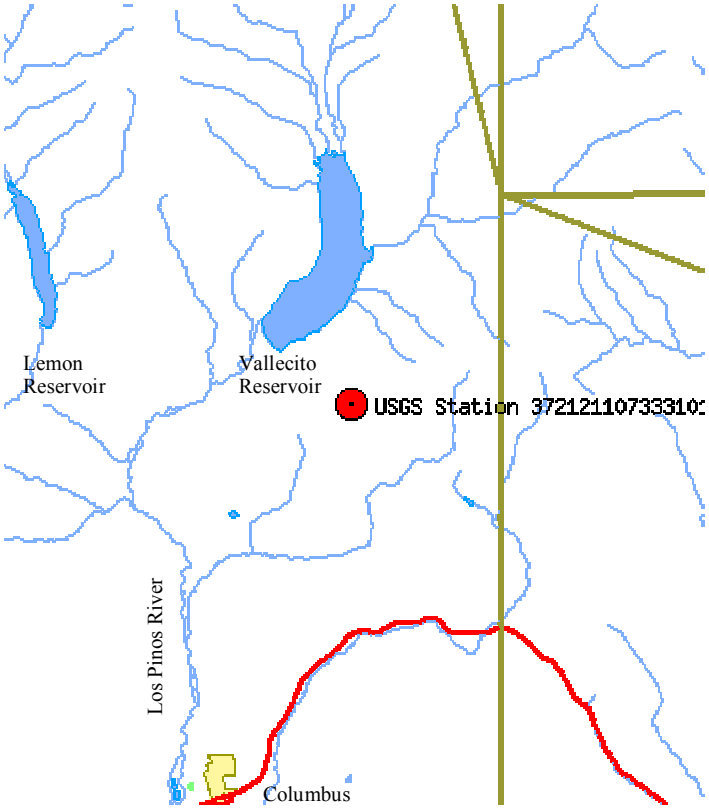


Figure 4.5 – Map of Missionary Ridge Rain Gage A-1 Location.

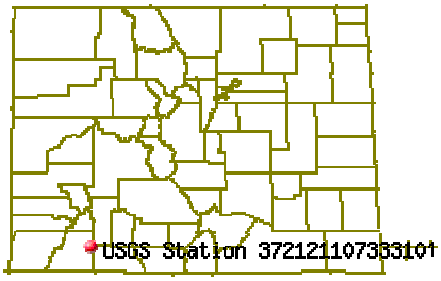


Figure 4.6 – Missionary Ridge Rain Gage A-1 Location in Relation to the State of Colorado.

As discussed previously, official rain gage data was available for this studied area. Since the Missionary Ridge Fire scorched the land, the potential for floods and mudslides increased dramatically due to the loss of erosion reducing grasses, shrubs, and trees. Several new rain gages were installed around the burn area, northeast of Durango, in order to help warn the surrounding communities of flash flood producing storms. According to the rain gage A-1, approximately 0.57 inches of rain fell on July 23rd, and 0.27 inches of precipitation was recorded for the August 3rd storm. Figure 4.4 on the previous page shows daily precipitation totals for each day between the end of June and the end of August. Figures 4.5 and 4.6 show the location of this rain gage and a map of the gage's location in relation to the state of Colorado.

Additional rain gages were found in the burn area along with one at Vallecito Reservoir, which is about 25 miles northeast of Durango. Daily precipitation graphs, as well as the figures showing the location of each gage, are included in the Additional Support Information section of this chapter. Supplementary rain gages were installed in the burn area by the federal Burned Area Emergency Rehabilitation (BAER) Team. Their locations are shown in a map also located in the Additional Support Information section of this chapter.

Color radar images for the state of Colorado were found on the National Climatic Data Center's website. The NEXRAD radar images show a small pocket of storm activity that formed within the Missionary Ridge Burn Area at approximately 7:30PM. These images are shown below, and on the following page, in Figures 4.7 through 4.15. Next to the figures is a legend indicating the higher the color number, the more intense the storm. In order to locate the Durango area on the NEXRAD radar images, Figure 4.16 (next page) contains a map of the state of Colorado with the town of Deckers highlighted.

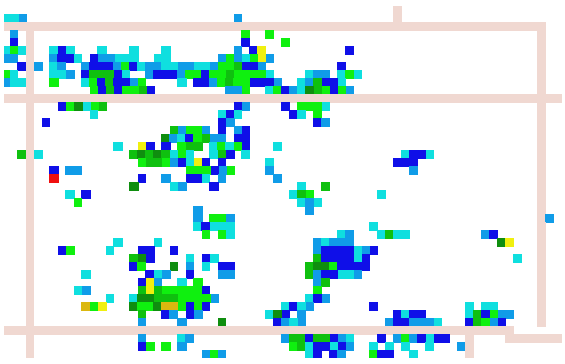


Figure 4.7 – State of Colorado NEXRAD Radar Image July 23rd, 2002 at 2:00PM.

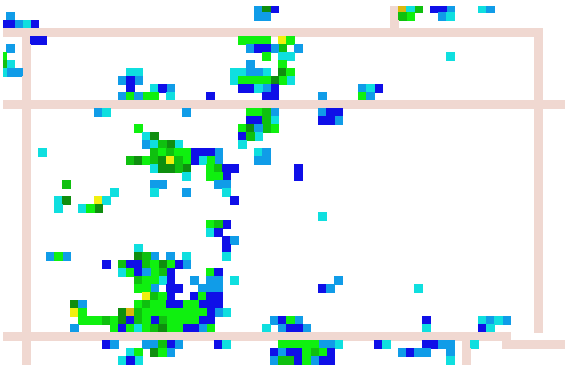


Figure 4.8 – State of Colorado NEXRAD Radar Image July 23rd, 2002 at 3:00PM.

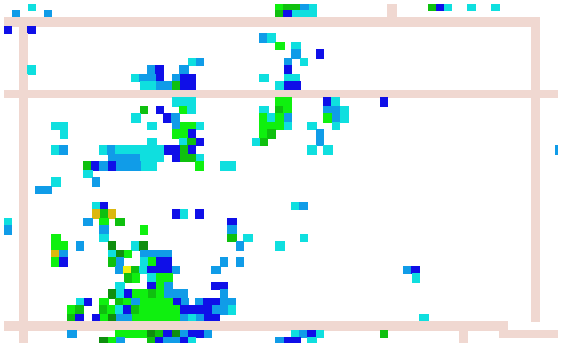


Figure 4.9 – State of Colorado NEXRAD Radar Image July 23rd, 2002 at 4:00PM.

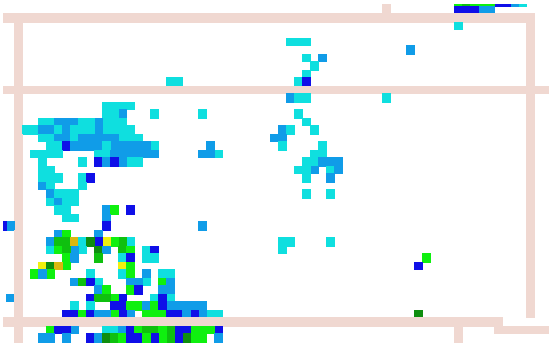


Figure 4.10 – State of Colorado NEXRAD Radar Image July 23rd, 2002 at 5:00PM.

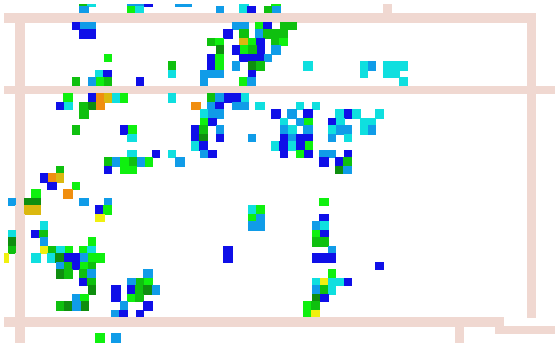


Figure 4.11 – State of Colorado NEXRAD Radar Image August 3rd, 2002 at 1:00PM.

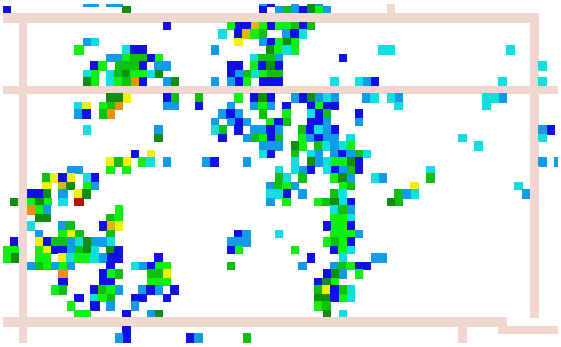


Figure 4.12 – State of Colorado NEXRAD Radar Image August 3rd, 2002 at 2:00PM.

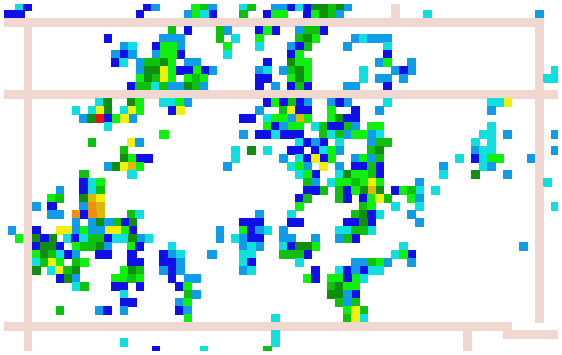


Figure 4.13 – State of Colorado NEXRAD Radar Image August 3rd, 2002 at 3:00PM.

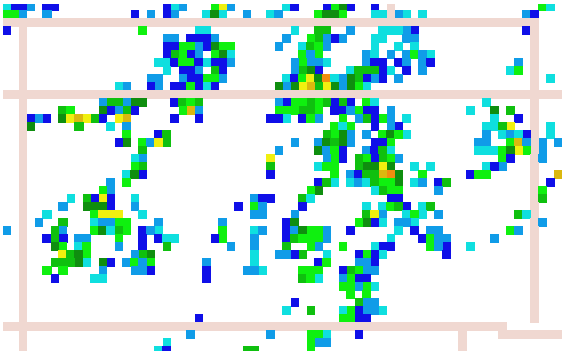


Figure 4.14 – State of Colorado NEXRAD Radar Image August 3rd, 2002 at 4:00PM.

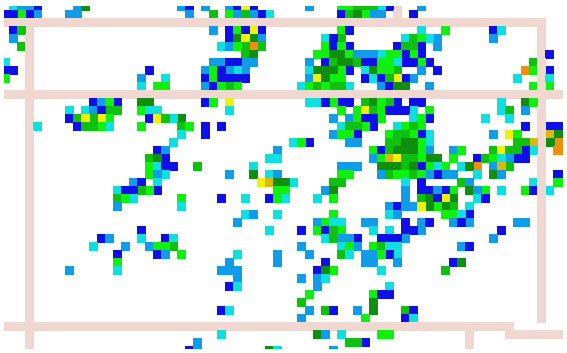


Figure 4.15 – State of Colorado NEXRAD Radar Image August 3rd, 2002 at 5:00PM.

Figure 4.16 – Map of the Town of Durango in Relation to the State of Colorado.
Map courtesy of Mapquest website.

Hydrologic and Hydraulic Conclusions

There was no flooding associated with any streams or rivers in the studied area. Any damage was due to the increased intensity of mudslides and overland flow from the effects of the Missionary Ridge fire.

According to information obtained from Mapquest, the Animas River runs through the city of Durango at an elevation of approximately 6550 feet. Vallecito and Lemon Reservoirs are located to the northeast of Durango at elevations of 7671 and 8143 respectively. The Vallecito Reservoir is an on-stream reservoir of the Los Piños River and the Lemon Reservoir is an on-stream reservoir of the Florida River.

Hydrologic analyses were performed using available baseline data from NOAA Atlas 2 in order to generate Intensity Duration Frequency, or IDF, curves for rainfall events within the Durango area. Using the varying amounts of rainfall mentioned in the Storm Characteristics section of this chapter, and the estimated duration of the storm, one could estimate the frequency of the specific events. The results of this analysis are shown in Table 4.1 below.

Table 4.1 – Hydrologic Analysis Summary

	July 23, 2002 Storm	**August 3, 2002 Storm**
Event Duration (hours)	3.0	3.0
2-YR Total Precipitation (in.)	0.81	0.81
2-YR Total Precipitation (in.) - 8-HOUR DURATION		1.10
25-YR Total Precipitation (in.)	1.71	
25-YR Total Precipitation (in.) - 1-HOUR DURATION	1.42	
Total Event Precipitation As Reported (in.)	1.4 (1-HOUR DURATION)	0.75 (8-HOUR DURATION)
	0.57	0.80
	0.52	0.27
	1.48	0.42
	0.30	0.30
		0.20
Est. Event Frequency (yr)	**Less Than 2 to Less Than 25**	**Less Than 2**

According to two separate articles published by the Rocky Mountain News, 1.4 inches of rain fell in less than an hour during the July 23rd storm, and 0.75 inches of rain was recorded in an 8-hour period for the August 3rd storm. Since these values do not share the estimated storm duration of three hours, their durations are called-out specifically in the table.

No flow gages were analyzed or considered in this analysis because there were no reports of flooding due to nearby streams.

Flooded Area Description

Since no rivers or streams flooded during the two studied events, few areas sustained major damage or were underwater for an extended length of time.

During the July 23rd event, "...a bridge providing the only access to Lemon Reservoir was covered in a 4-foot thick wall of boulders, tree limbs, and mud" (Kostka, 2). Several other roads and bridges were covered with mudflows including: CR (County Road) 240, CR 250, CR 243, CR 245, CR 501, and some residential driveways.

County Roads 240 and 501 were closed once again after the August 3rd event. According to an article published by the Denver Post, three to four homes were damaged by water and silt. Several businesses also had water and debris in their property and in their parking lots (Turner, 1).

Estimated Flood Damages & Any Special Factors Affecting the Flood

Both storms caused damage to areas south of Vallecito and Lemon Reservoirs. Roads, bridges, culverts, and other public facilities were covered with mud and debris and were closed until the clean-up process was complete. Some houses and businesses suffered water and mud damage in low-lying areas. However, most of the damage was limited to the outdoor areas surrounding the home, or building, rather than the structures themselves. A common occurrence during both storms was area propane tanks being lifted away from their supports and transported hundreds of feet away. Vehicles, farm machinery, sheds, and clothing were among the other kinds of personal property that were also relocated by the flood flows.

At the time of this study, no damage cost estimates could be obtained from city or county contacts.

No injuries or casualties were reported from these events.

The Missionary Ridge Fire was a unique factor that affected the storm events analyzed in this chapter. In fact, it is reasonable to conclude that the damage from this fire caused, or at least increased, the effects from the two storms. The hydraulic conclusions suggest these storms were likely less than 2-year events meaning they were common storms experienced

by Durango and the surrounding area on at least a semiannual basis. It is also reasonable to conclude that under pre-fire circumstances, only minor flooding or no damage would have occurred as a result of these two storms.

The wildfires within, and adjacent, to the subject study area created a significant adverse effect on the hydrologic response of the burned watersheds. There is a great concern for increased storm and runoff-related natural hazards due to the destruction of vegetation in conjunction with the possible development of hydrophobic (water repellent) soils in the burned forested areas. Downstream property owners, citizens, motorists, and other parties will be exposed to a greatly increased risk of floods, mudslides, and debris flows compared with pre-fire conditions. Concerned parties should contact their local floodplain administrator within their effected community, or county, for additional information. Local emergency response and emergency management agencies are responsible for initially handling emergencies if and when they occur. The Colorado Water Conservation Board can be contacted for technical information related to post-wildfire hydrology and related data.

As discussed in the Storm Characteristics and Information section of this chapter, additional rain gages were installed in the burn area in an attempt to help alert residents, and government officials, to the impending threat of mudslides and flooding in the burn area. In an article published by the Rocky Mountain News, the failure of one gage resulted in a lack of warning for the nearby Aspen Trails subdivision on July 23rd.

Additional Support Information

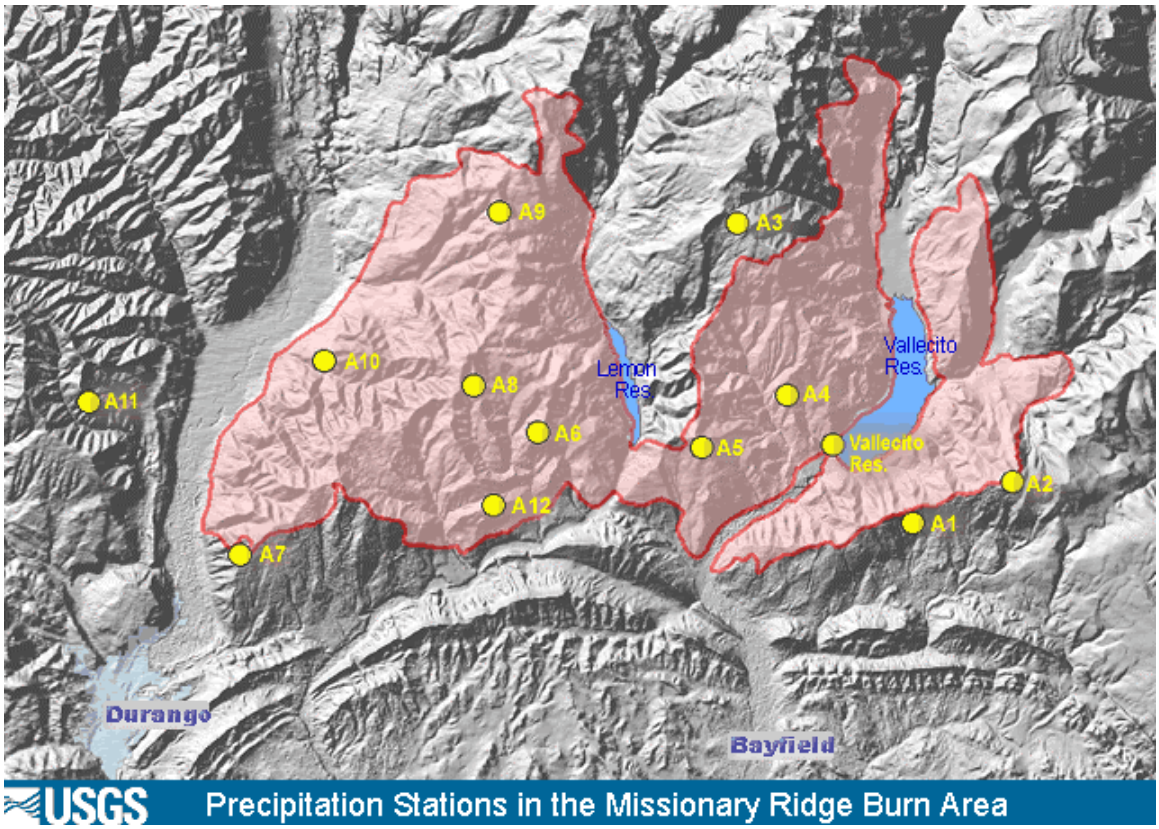


Figure 4.14 – Highlighted Missionary Ridge Burn Area and New Rain Gage Locations.
Picture obtained from the USGS's Colorado Water Resources website at http://co.water.usgs.gov/Data/index.html

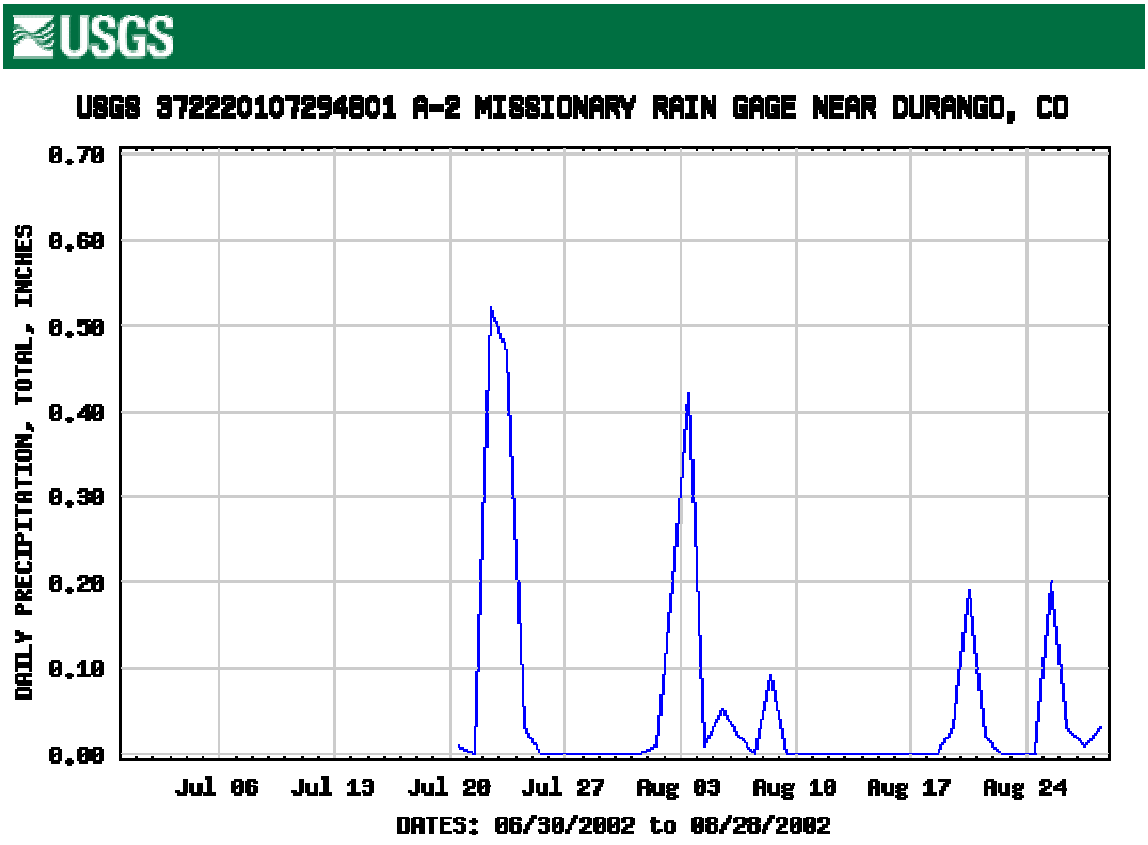


Figure 4.15 – Precipitation Graph of Missionary Ridge Burn Area Rain Gage A-2 Near Durango.

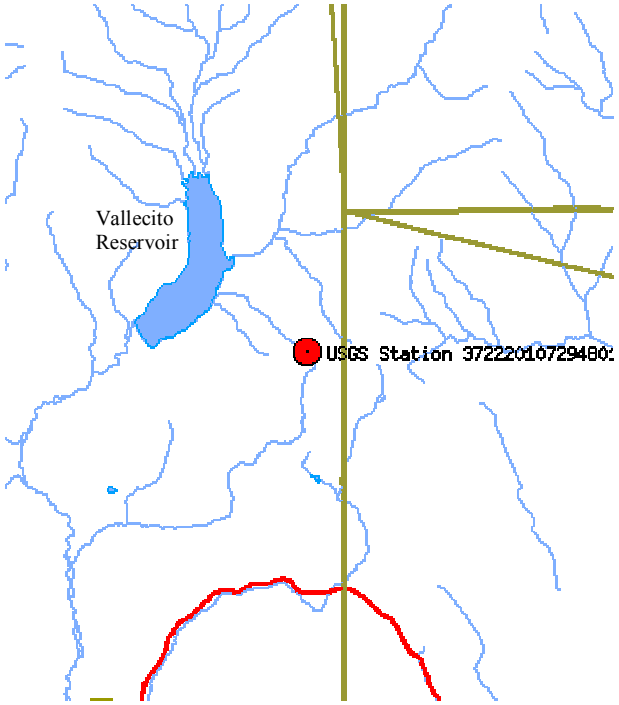


Figure 4.16 – Map of Missionary Ridge Rain Gage A-2 Location.

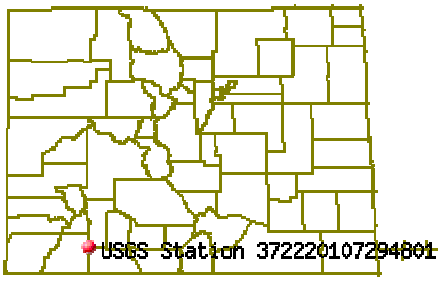


Figure 4.17 – Missionary Ridge Rain Gage A-2 Location in Relation to the State of Colorado.

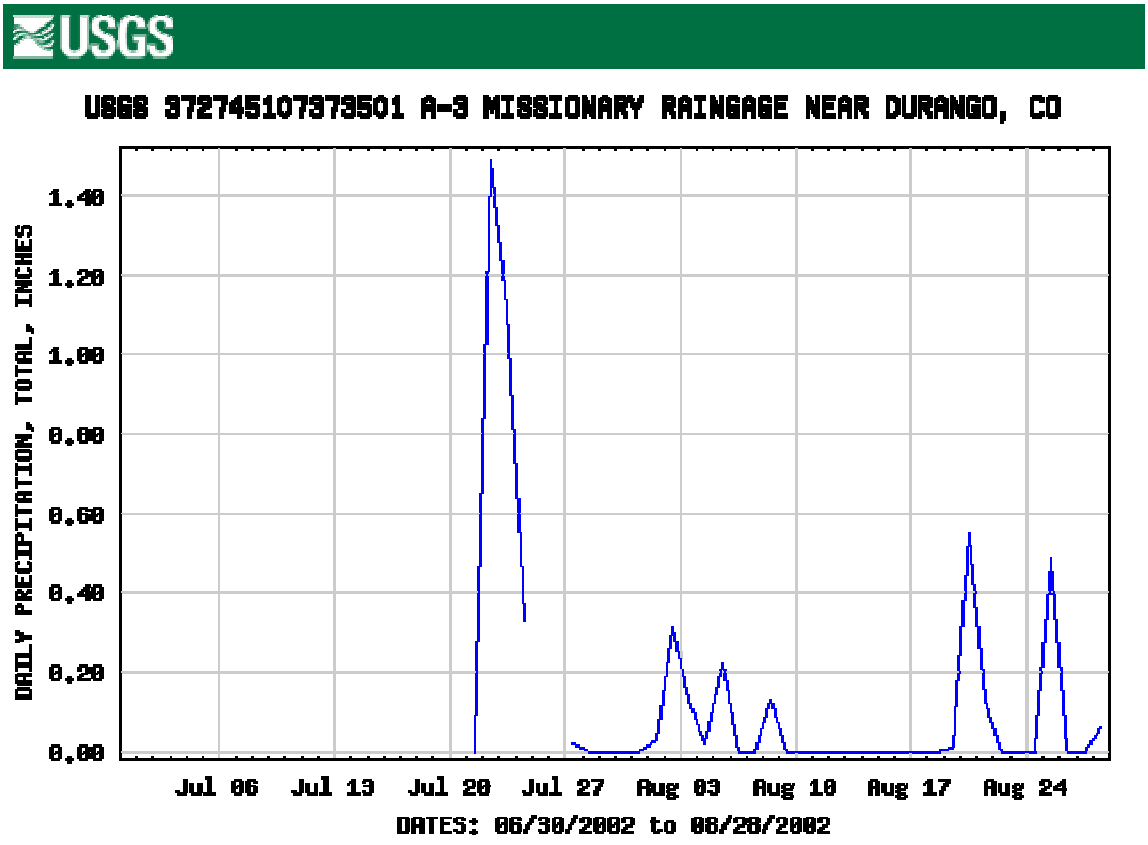


Figure 4.17 – Precipitation Graph of Missionary Ridge Burn Area Rain Gage A-3 Near Durango.

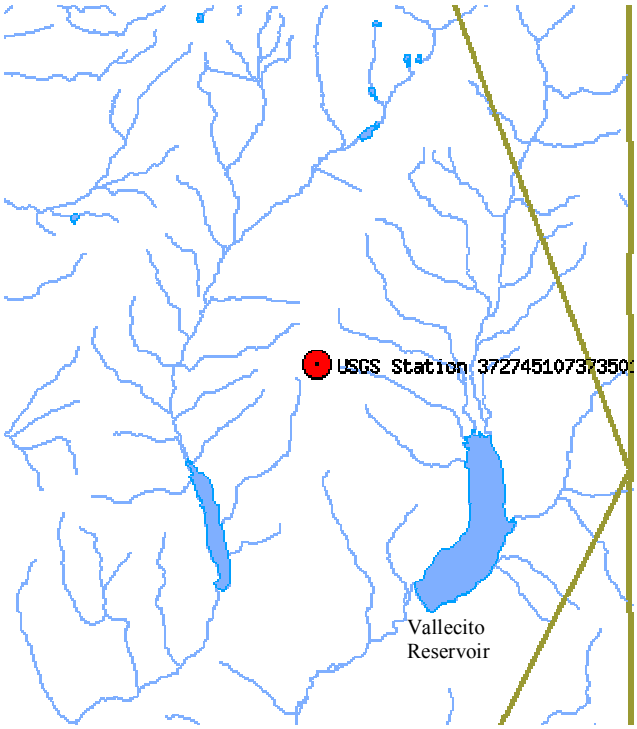


Figure 4.18 –Map of Missionary Ridge Rain Gage A-3 Location.

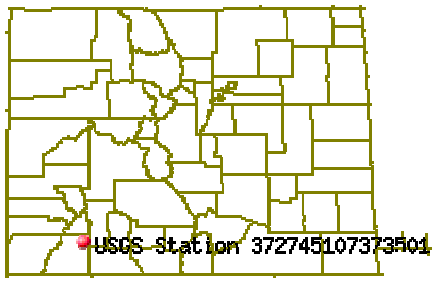


Figure 4.19 – Missionary Ridge Rain Gage A-3 Location in Relation to the State of Colorado.

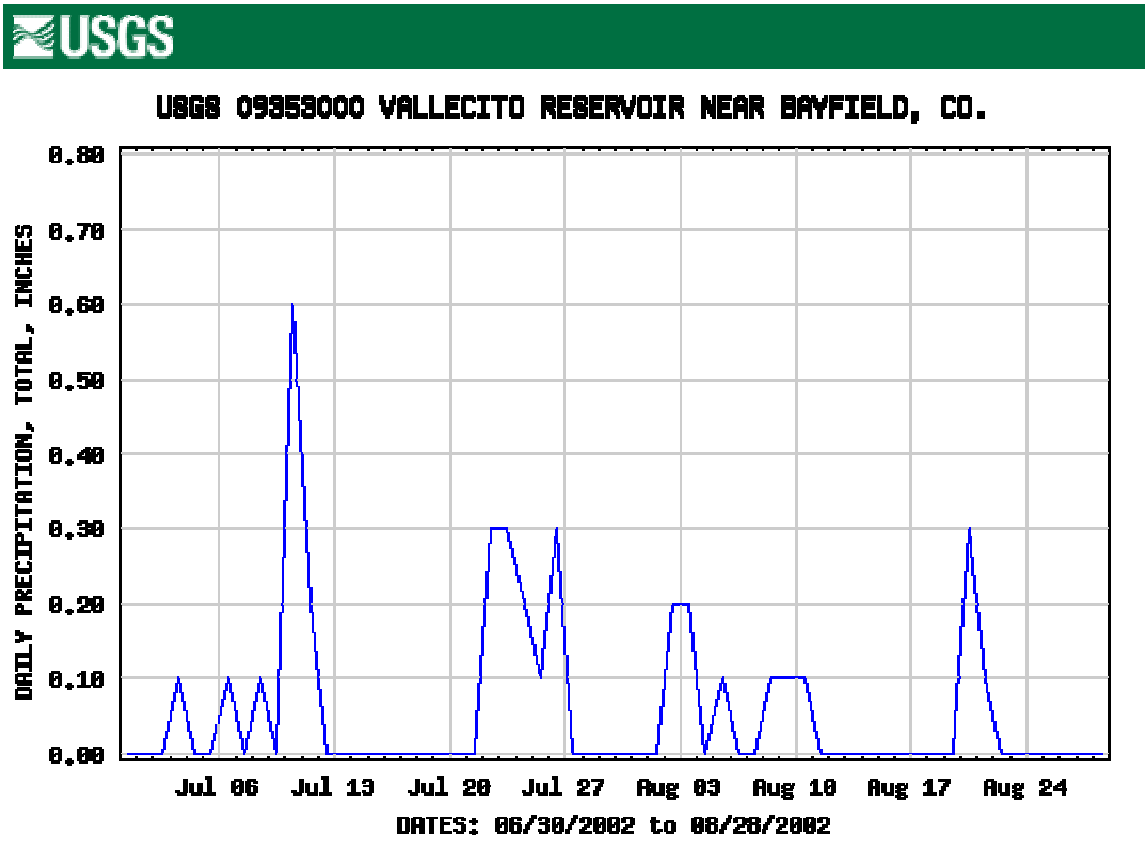
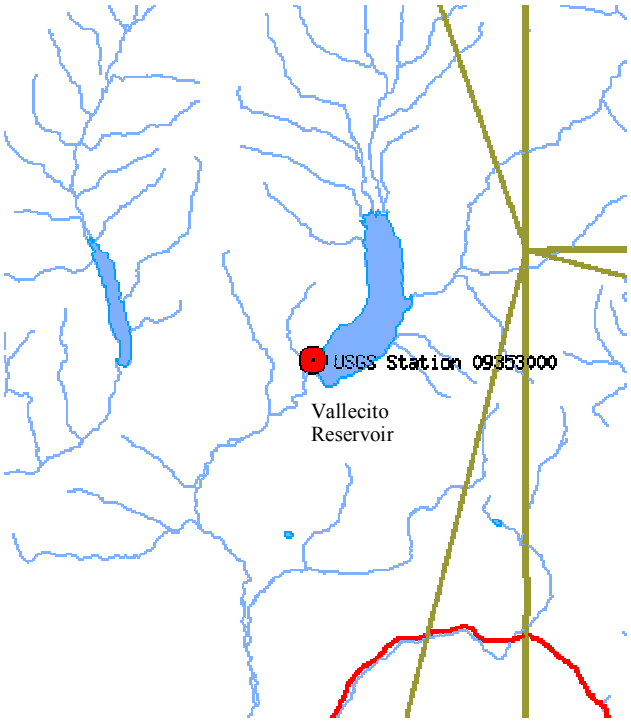


Figure 4.20 – Daily Precipitation Graph of Vallecito Reservoir.



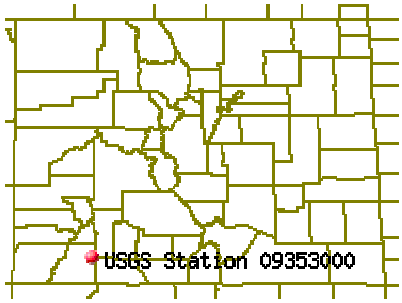


Figure 4.22 –Vallecito Reservoir Gage Location in Relation to the State of Colorado.

Figure 4.21 –Map of Vallecito Reservoir Gage Location.

CHAPTER 5

Glenwood Springs, Colorado Flood of August 5th, 2002
Mitchell Creek
(Garfield County)

Introduction

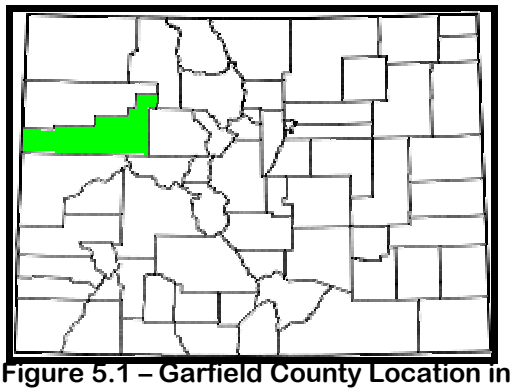


Figure 5.1 – Garfield County Location in the State of Colorado.
Map courtesy of the Colorado Herpetological Society.

On Monday, August 5th, 2002, three tenths of an inch of rain fell on the Glenwood Springs, Colorado area in a period of 20 minutes (Wallace, 2). Normally this moisture would be a welcome and common occurrence in this small town along Interstate 70. However, after a nearby forest fire destroyed most of the trees and vegetation in the area, the rain brought mudslides and minor flooding to the residents of this mountain community. Several mudslides were reported in the area and roughly, 150 families were evacuated due to flood warnings issued for the Mitchell Creek watershed. No injuries were reported from this event and families were allowed to return to their homes and businesses the next morning. According to the Central Colorado OEM (Office of Emergency Management) Field Representative, Steve Denney, a Mitchell Creek flood mitigation project was recently completed in the area to help minimize the damages from this and future events. In addition, work was done to stabilize parts of a steep hillside in West Glenwood Springs by Dan Sokal with the U.S. Bureau of Land Management (McGregor, 2). Both of these projects were thought to have helped minimize the impacts to the community from this storm.

Location and Description

Glenwood Springs, Colorado is located 157 miles west of the Denver area along Interstate 70 in Garfield County (see Figure 5.3 on the next page). According to the 2000 Census,

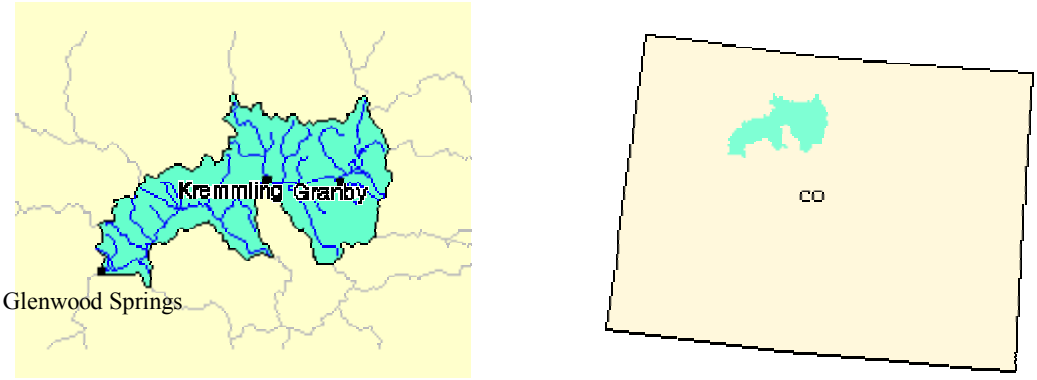


Figure 5.2 – Colorado Headwaters Watershed and Location
Obtained from the Environmental Protection Agency's "Surf Your Watershed" website.

Glenwood's population is 7,736 out of a total county population of 43,791 (U.S. Census Bureau, "Factfinder" website). Glenwood Springs is the County Seat.

The city of Glenwood Springs lies at the junction point of three different watersheds. Mitchell Creek lies within the Colorado Headwaters watershed, which is shown in Figure 5.2. Figures 5.4 (below) and 5.5 (next page) show the Colorado Headwaters-Plateau and Roaring Fork watersheds respectively. The Colorado Headwaters watershed crosses into

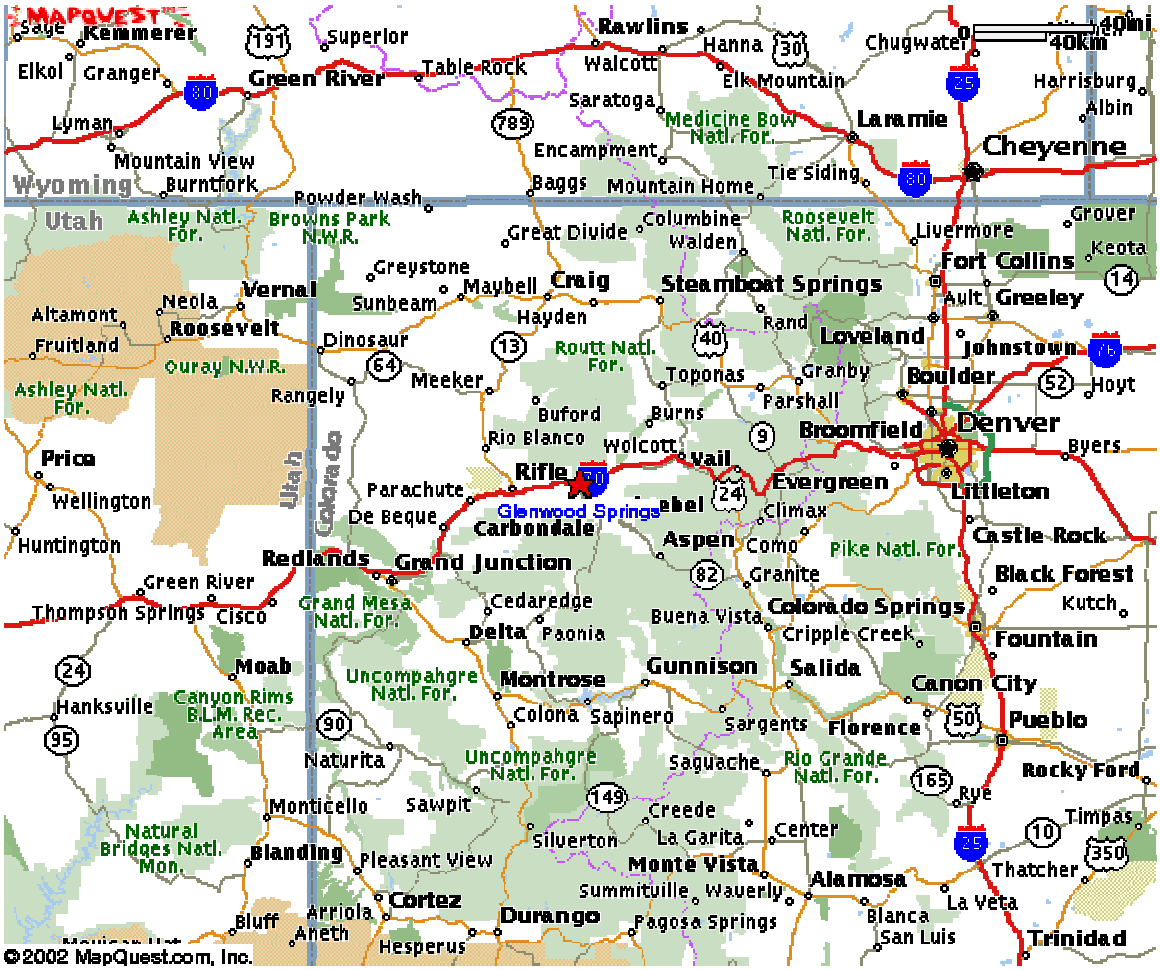


Figure 5.3 – Map of Rifle, Colorado in Relation to the Front Range Area.

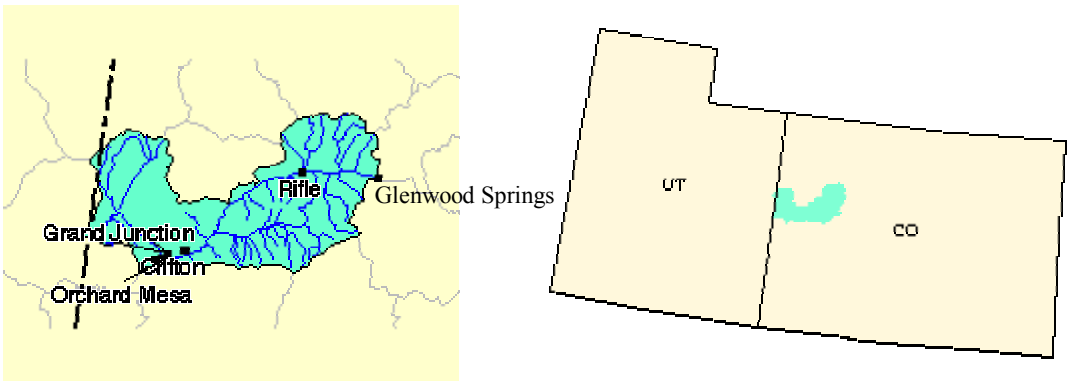


Figure 5.4 – Colorado Headwaters-Plateau Watershed and Location
Obtained from the Environmental Protection Agency's "Surf Your Watershed" website.

ten different counties within the state of Colorado.

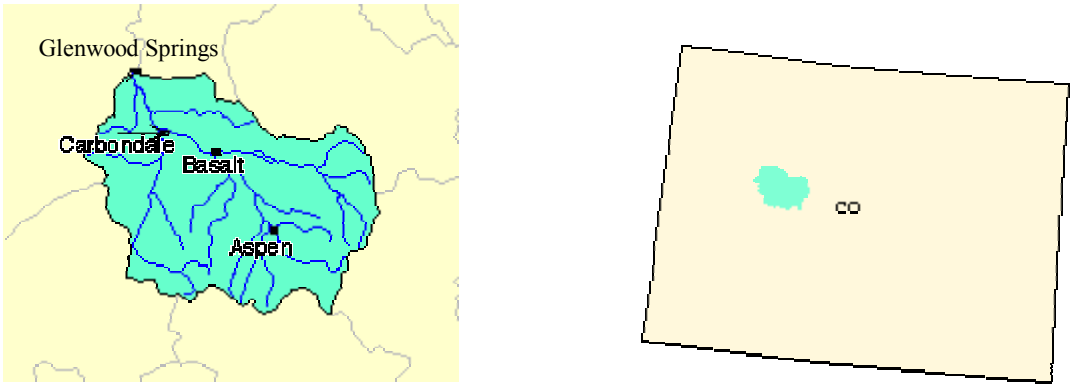


Figure 5.5 – Roaring Fork Watershed and Location
Obtained from the Environmental Protection Agency's "Surf Your Watershed" website.

Storm Characteristics and Information

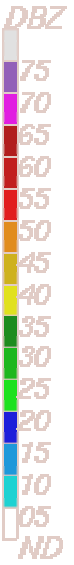
Obtaining rainfall information and storm characteristics for the event in Glenwood Springs was difficult. Since the storm occurred right between various seasonal storms, most contacts could not separate defining traits of this specific storm. In addition, since this storm was minor and did not cause significant damage to the town or any injuries, no federal flood mitigation was necessary.

The Glenwood Springs Post Independent, a local newspaper, published an article after the storm in which the various rainfall amounts were summarized. According to the author, Heather McGregor, several rain gages in the area reported varying amounts of rainfall for this storm. The recorded rainfall amounts were: "...0.3 inch(es) at the mouth of Mitchell Creek and at the Bowles Ranch on lower Mitchell Creek, 0.48 inch(es) at the Glenwood Springs Fish Hatchery, 0.28 inch(es) on the rim of Mitchell Creek basin at 9,000 feet," and "...across the Colorado River and to the west the storm dropped 0.67 inch(es) near the head of SOB basin near South Canyon" (McGregor, 1). It is unknown how the author obtained this information, but it is believed she used various sources including local rain gages installed by the federal government's BAER (Burned Area Emergency Rehabilitation) Team and monitored by the local city and county governments.

One other source was able to provide a rainfall amount that was similar to the amounts reported in the Post Independent. The Rocky Mountain News reported approximately 0.3 inches of rain fell in 20 minutes (Wallace, 1). Again, it is not known how the author obtained this information, although it is likely she received the information from the National Weather Service's regional office in Grand Junction.

According to the National Climatic Data Center's NEXRAD radar images, a small pocket of storm activity moved over the Glenwood Springs area sometime after 8:00PM. The images are shown below, in Figures 5.6 through 5.9. Next to Figures 5.6 and 5.8 is a legend

indicating the higher the color number, the more intense the storm. In order to locate the city of Glenwood Springs on the NEXRAD radar images, Figure 5.10, below the radar images, contains a map of the state of Colorado with Glenwood Springs highlighted.



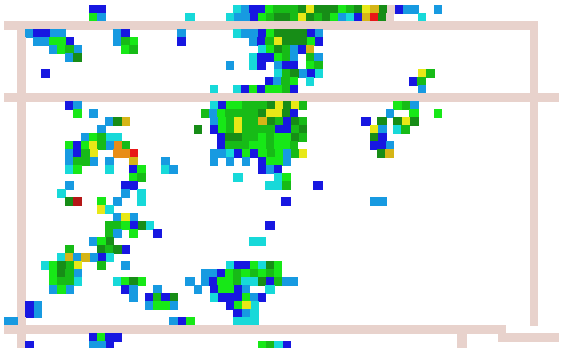


Figure 5.6 – State of Colorado NEXRAD Radar Image August 5th, 2002 at 8:00PM.

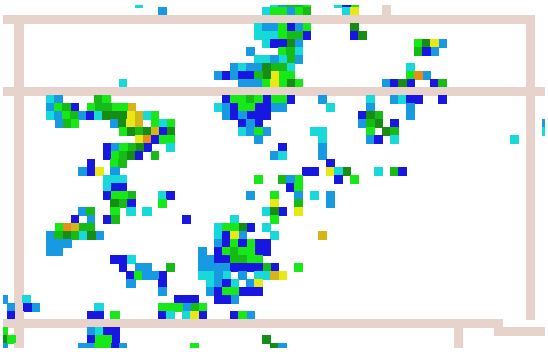


Figure 5.7 – State of Colorado NEXRAD Radar Image August 5th, 2002 at 9:00PM.

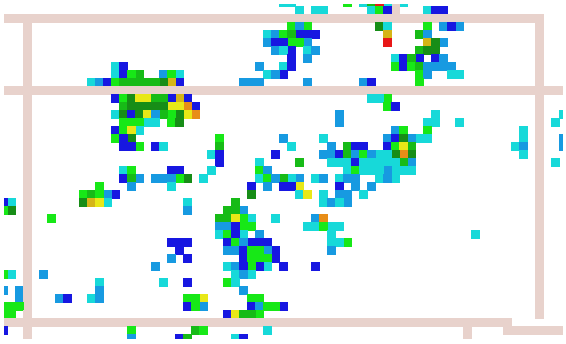


Figure 5.8 – State of Colorado NEXRAD Radar Image August 5th, 2002 at 10:00PM.

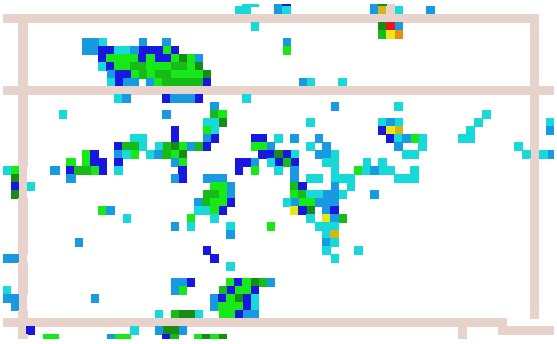


Figure 5.9 – State of Colorado NEXRAD Radar Image August 5th, 2002 at 11:00PM.

Figure 5.10 – Map of the Town of Glenwood Springs in Relation to the State of Colorado.
Map courtesy of Mapquest website.

Hydrologic and Hydraulic Conclusions

The Colorado River is the major river in the Glenwood Springs area. This river flows to the west through the city where it receives inflow from several creeks in the area. Mitchell Creek is on the western end of town and flows to the south until it's eventual confluence with the Colorado River. Oasis, Cascade, No Name, and Grizzly Creeks all have similar characteristics to Mitchell Creek flowing from the north to the south until they empty into the Colorado River.

Hydrologic analyses were performed using available baseline data from NOAA Atlas 2 in order to generate Intensity Duration Frequency, or IDF, curves for rainfall events within the Glenwood Springs area. Using the rainfall amounts mentioned in the Storm Characteristics and Information section of this chapter and the estimated storm duration from the NEXRAD radar images (roughly two hours), one could estimate the frequency of this specific event. The results of this analysis are summarized below in Table 5.1.

Table 5.1 – Hydrologic Analysis Summary

	August 5, 2002 Storm
Event Duration (minutes)	30
2-YR Total Precipitation (in.)	0.49
2-YR Total Precipitation (in.) - 20-MINUTE DURATION	0.41
5-YR Total Precipitation (in.)	0.71
Total Event Precipitations As Reported (in.)	0.3 (20-MINUTE DURATION)
	0.30
	0.48
	0.28
	0.67*
Est. Event Frequency (yr)	**Less Than 2***

* = Outlying data point not included in frequency estimation.

According to the Glenwood Springs Post Independent, "...across the Colorado River and to the west the storm dropped 0.67 inch(es) near the head of SOB basin near South Canyon" (McGregor, 1). This area is about 8 miles west of the city of Glenwood Springs. Since this point rainfall amount occurred outside the Glenwood Springs area, and since it is much greater than the other rainfall amounts, this precipitation amount was considered an outlying data point and not used to estimate the event frequency.

There are no flow gages available for Mitchell Creek. Two gages were found for rivers near Glenwood Springs but, since these rivers did not flood, they were not considered in the hydrologic analysis. However, the information found is included in the Additional Support Information section of this chapter.

Flooded Area Description

Since Mitchell Creek did not overtop it's banks and flood during this event, few areas sustained damage due to floodwater. Any damage sustained was due to several mudslides that occurred throughout the region.

Areas of the city, and nearby area, that were inundated with mud, water, and debris include: Mitchell Creek Road, West Midland Avenue, parts of Ami's Acres campground, part of the railroad tracks in South Canyon, "a channel that was set up between Two Rivers Chevrolet and Glenwood Springs Ford..." (Daniels, 2), and several residential driveways and yards.

Estimated Flood Damages & Any Special Factors Affecting the Flood

Since the studied event was minor in origin (less than a 2-year event) with no rivers or streams flooding, damage to infrastructure and personal property was limited to erosion and a lot of mud clean-up work.

Mudslide damage included several roads around the Glenwood Springs area. Mitchell Creek Road, and West Midland Avenue, were all closed for varying amounts of time as cleanup work was done. Mitchell Creek Road got the worst of the mud and was closed to nonresidents for days as the mud and debris were removed with construction equipment. Mitchell Creek sustained mud damage as well, and work had to be done to clear out the debris and mud from the creek bottom in preparation for future storm events. Various residents had mud covering their driveways and yards and some minor erosion damage was reported.

Luckily, no injuries or casualties were reported from this event. During the evacuation, several people became trapped in their cars by the powerful mudflows but were freed by rescue workers and other residents.

Damage estimates were obtained through Mr. Denney with the Office of Emergency Management. It cost $10,370 to clean-up Mitchell Creek and remove the mud from nearby Mitchell Creek Road. Pictures of the damage to the road and the creek are included in the Additional Support Information section of this chapter, courtesy of Mr. Denney.

Cleanup damage for the rest of the city was estimated at $8,795, but at the time of this study, it was unknown if these were the final damage figures.

According to Mr. Denney, and an article in the Glenwood Springs Post Independent by Heather McGregor, several mitigation efforts had been underway before the storm hit on the 5th of August. An effort to clean out the creek and contain overflowing water and mudflows along the creek's drainage path was completed costing an estimated $130,000. The project used "Jersey Barriers" and sand bags to contain any large debris during a

flood event. This project was a small piece of a large federal project by the BAER Team designed to mitigate the damage done by the Coal Seam Fire. Mr. Denney provided some pictures of the mitigation effort, which are also included in the Additional Support Information section of this chapter.

Another part of the BAER Team's effort was to stabilize the steep hillsides on the east side of Mitchell Creek by using mats of pressed straw, straw wattles, and rolls of straw to help contain mud and debris. According to the article by Ms. McGregor, the effort apparently paid dividends as evidence of retained mud was visible on the hillsides.

The Coal Seam Fire was a unique factor that affected the storm event analyzed in this chapter. In fact, it is reasonable to conclude that the damage from this fire caused, or at least increased, the effects from the storm. The hydrologic conclusions suggest this storm was a common storm experienced by Glenwood Springs occurring on a semiannual basis. It is also reasonable to conclude that under pre-fire circumstances, minimal flooding or mud damage would have occurred because of this event.

The wildfires within, and adjacent, to the subject study area created a significant adverse effect on the hydrologic response of the burned watersheds. There is a great concern for increased storm and runoff-related natural hazards due to the destruction of vegetation in conjunction with the possible development of hydrophobic (water repellent) soils in the burned forested areas. Downstream property owners, citizens, motorists, and other parties will be exposed to a greatly increased risk of floods, mudslides, and debris flows compared with pre-fire conditions. Concerned parties should contact their local floodplain administrator within their effected community, or county, for additional information. Local emergency response and emergency management agencies are responsible for initially handling emergencies if and when they occur. The Colorado Water Conservation Board can be contacted for technical information related to post-wildfire hydrology and related data.

Additional Support Information

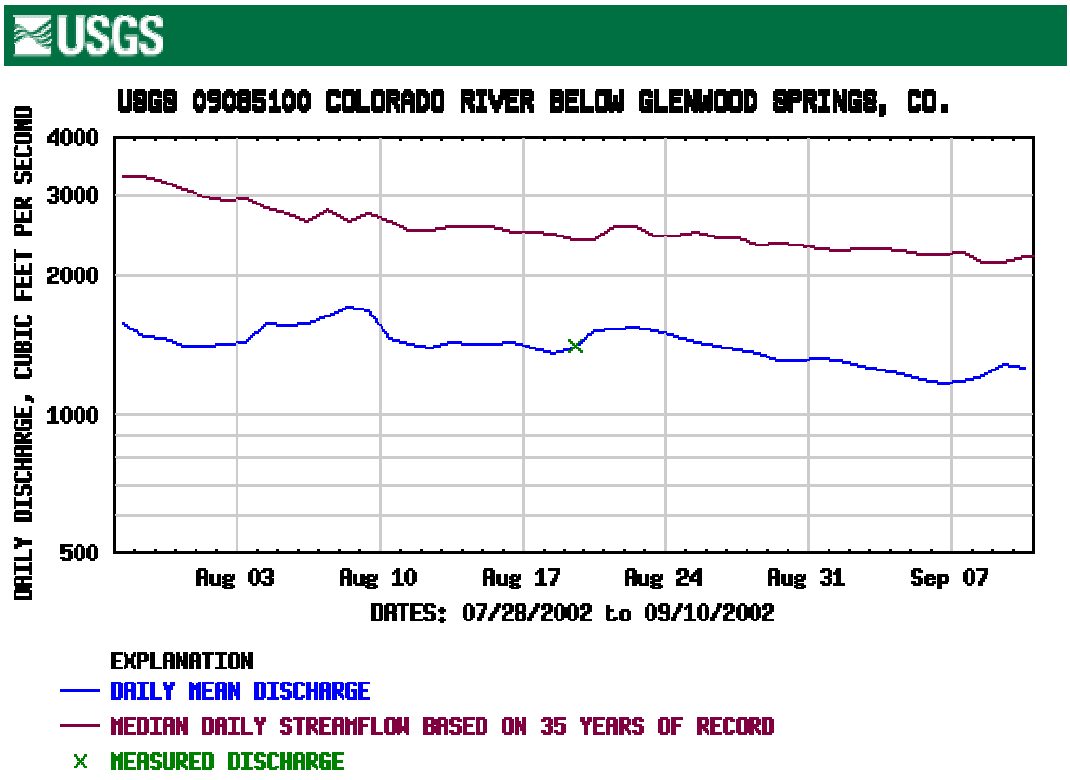


Figure 5.11 – Graph of Daily Discharge for USGS Flow Gage on Colorado River.

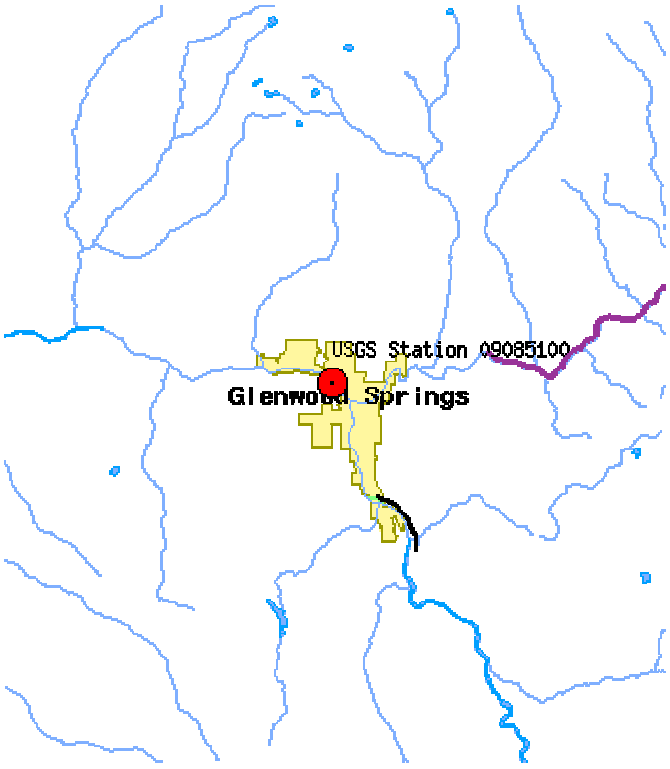


Figure 5.12 –Map of Colorado River Gage Location.

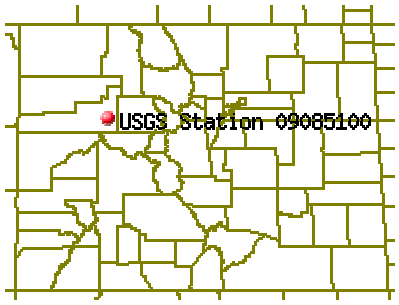


Figure 5.13 – Colorado River Below Glenwood Springs Gage Location in Relation to the State of Colorado.

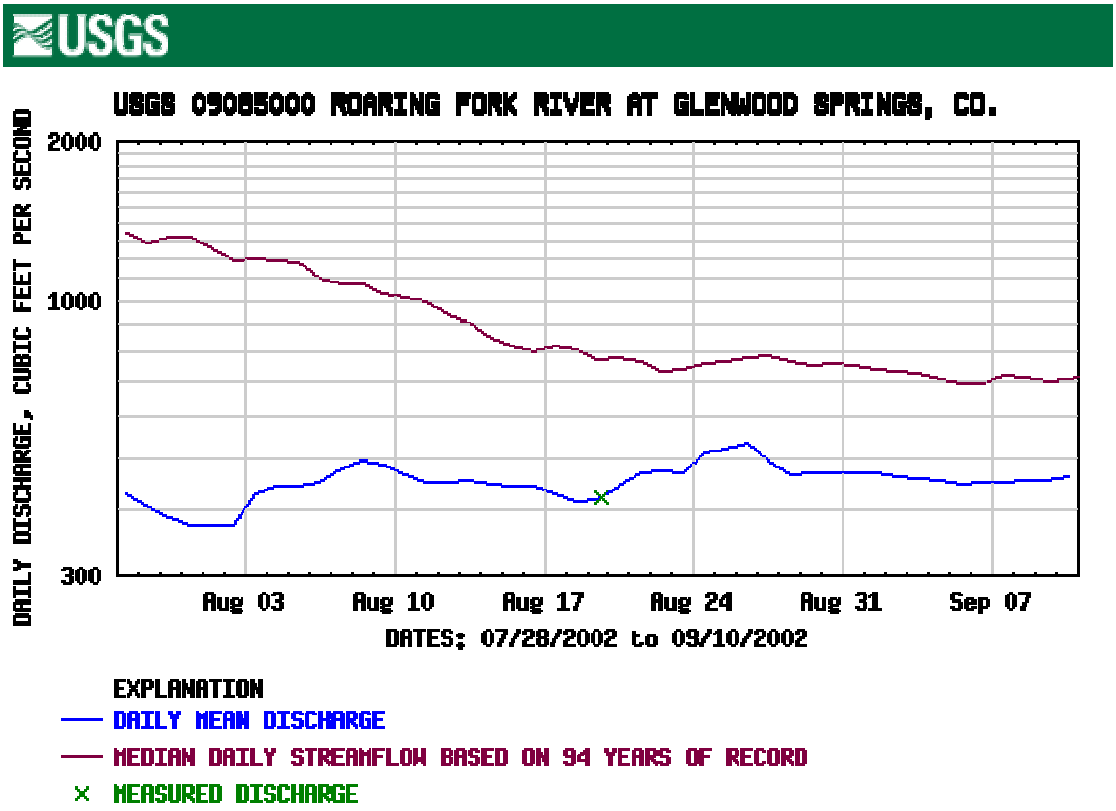


Figure 5.14 – Graph of Daily Discharge for USGS Flow Gage on Roaring Fork River.

Figure 5.15 –Map of Roaring Fork River Gage Location.

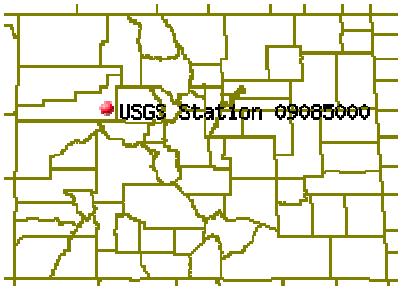


Figure 5.16 – Roaring Fork River At Glenwood Springs Gage Location in Relation to the State of Colorado.

Figure 5.17 – Picture of Center Street Bridge Over Mitchell Creek During Mitigation Effort.

Figure 5.18 – Picture #2 of Center Street Bridge Over Mitchell Creek During Mitigation Effort.

Figure 5.19 – Picture of Mitchell Creek Road Looking West During Mitigation Effort.

Figure 5.20 – Picture of Dump Truck with Typical Debris Being Removed During Mitigation Effort.

Figure 5.21 – Picture of Donagan Road with Jersey Barriers Installed During Mitigation Effort.

Figure 5.22 – Picture of Mitchell Creek Road During Cleanup Efforts After the Event.

Figure 5.23 – Picture #2 of Mitchell Creek Road During Cleanup Efforts After the Event.

Figure 5.24 – Picture #3 of Mitchell Creek Road During Cleanup Efforts After the Event.

Figure 5.25 – Picture #4 of Mitchell Creek Road During Cleanup Efforts After the Event.

Figure 5.26 – Picture of Mud's Flow Path Down to Mitchell Creek Road During Cleanup Effort.

CHAPTER 6

Wiley and Lamar, Colorado Floods of August 28th, 2002
Wiley Drainage Ditch and Willow Creek
(Prowers County)

Introduction

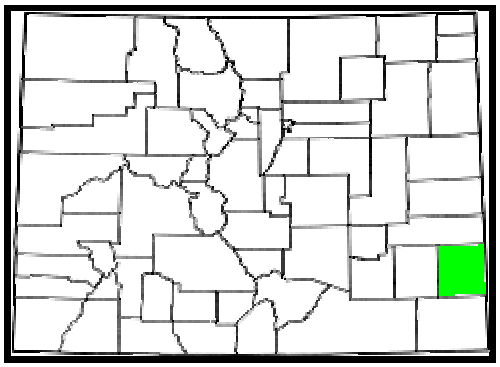
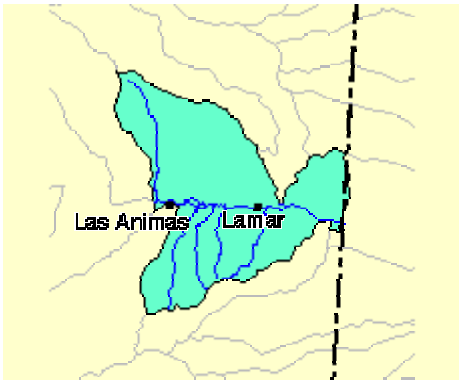


Figure 6.1 – Prowers County Location in the State of Colorado.
Map courtesy of the Colorado Herpetological Society.

On Wednesday, August 28th, 2002, a large storm front, moving east across the state, produced a significant amount of rainfall that impacted the towns of Lamar and Wiley Colorado. According to an area newspaper article by the Pueblo Chieftain, as much as 7 inches of total precipitation fell on the surrounding area. The onslaught of rain produced by this storm, sent water, mud, and debris down Wiley Drainage Ditch, Willow Creek in Lamar, and other surrounding tributaries, flooding homes and businesses in the region. Despite the heavy amount of rainfall produced by this storm, most of the reported flood damage was minor with no injuries or deaths reported. According to local officials, and confirmed by the Hydrology Report for Wiley Drainage Ditch, the last serious flood event for this area occurred on May 26th, 1995 when 3 to 6 inches of total precipitation was reported.

Location and Description

Lamar, Colorado is located 31 miles west of the Colorado-Kansas state border at the intersection of U.S. Highways 50 and 287 in Prowers County (see Figure 6.3 on the next page). Wiley is situated approximately 8 miles to the northwest of Lamar along U.S.



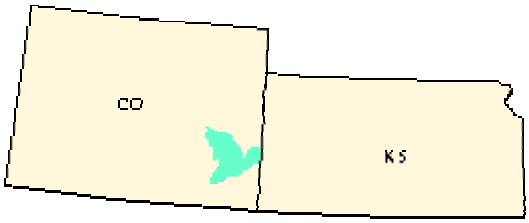


Figure 6.2 – Upper Arkansas–John Martin Watershed and Location
Obtained from the Environmental Protection Agency's "Surf Your Watershed" website.

Highway 287. According to the 2000 Census, Lamar's population is 8,869 and Wiley's population is 483. The total county population is 14,483 (U.S. Census Bureau, "Factfinder" website) with Lamar being the County Seat.

Both communities lie within the Upper Arkansas-John Martin watershed along with several other towns and cities including nearby Las Animas (see Figure 6.2 on previous page). The watershed spans 10 different counties including Prowers, Baca, Lincoln, Greeley, and others.

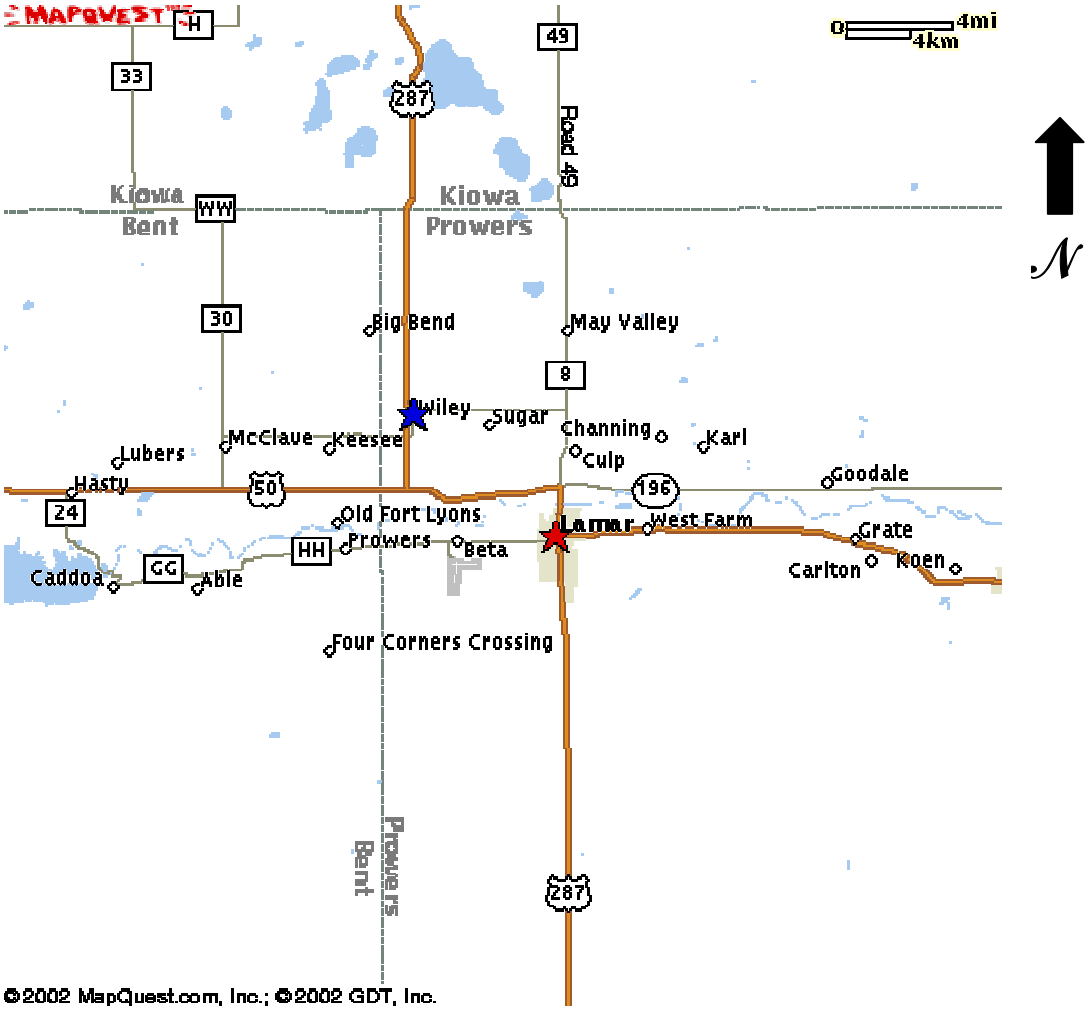


Figure 6.3 – Map of Lamar and Wiley, Colorado.

Storm Characteristics and Information

Storm characteristics and rainfall information for this storm was plentiful. A field visit was done for this event, which included talking directly to private citizens, as well as city and county officials, on the characteristics of this storm. Some field surveying was also performed in order to obtain high-water marks and drainage-way cross-sections. No

federal flood mitigation was necessary since the storm did not cause severe damage to either community.

Total precipitation amounts were obtained from two different sources. Anthony Mestas, of the Pueblo Chieftain, reported amounts as high as 7 inches. It is not known how Mr. Mestas obtained this information, but it is believed he obtained it from local officials or the National Weather Service's regional office in Pueblo. The other source is two different rainfall maps that were found on the Intellicast website for the storm date. These maps are shown below, and on the following page, in Figures 6.4 and 6.5. According to Figure 6.4, the area surrounding the city of Lamar received approximately 3 to 6 inches of total precipitation. The weekly total for the same area is in the range of 4 to 8 inches according to Figure 6.5.

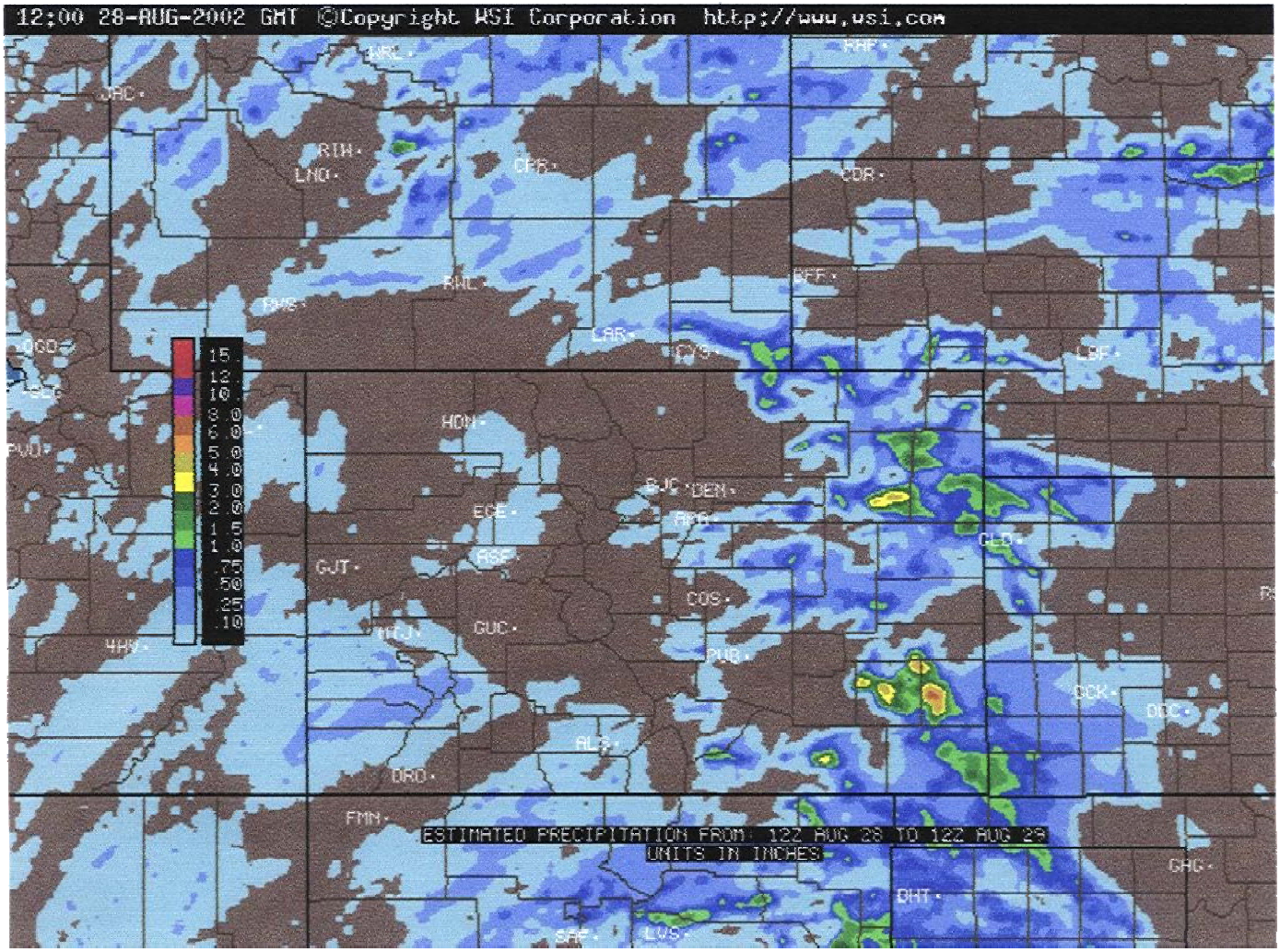


Figure 6.4 – Estimated total daily precipitation for the state of Colorado and surrounding area on August 28th, 2002.
Map Courtesy www.intellicast.com

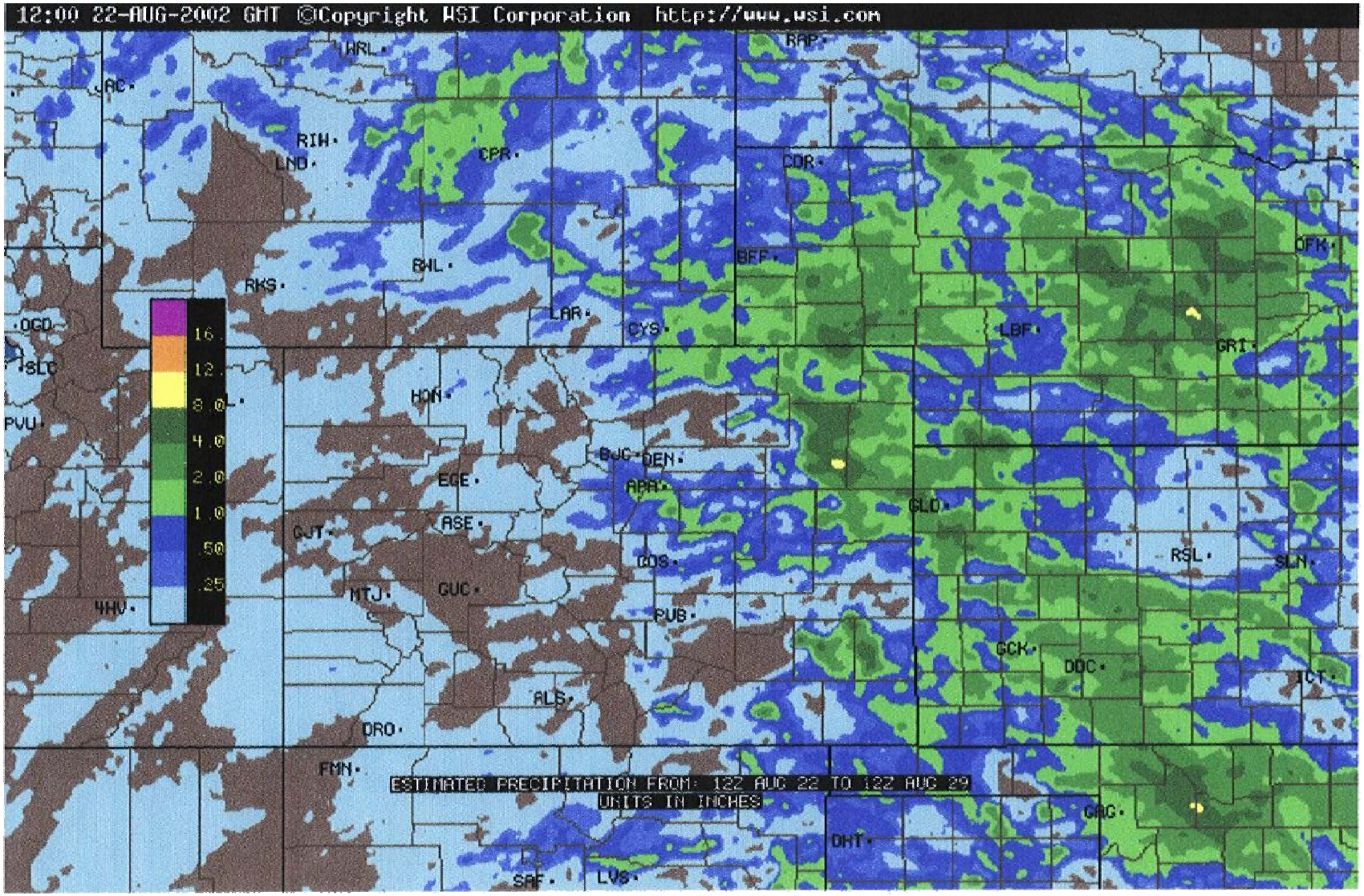


Figure 6.5 – Estimated total weekly precipitation for the state of Colorado and surrounding area for the week including August 28th, 2002.
Map Courtesy www.intellicast.com

According to the National Climatic Data Center's NEXRAD radar images, a large front of severe storm activity formed near Lamar and Wiley at approximately 3:00PM and ended at approximately 8:00PM. These images are shown below, and on the following page, in Figures 6.6 through 6.11. Next to Figures 6.6 and 6.8 is a legend indicating the higher the color number, the more intense the storm. In order to locate the towns of Lamar and Wiley on the NEXRAD radar images, Figure 6.12 (next page) contains a map of the state of Colorado with the town of Lamar highlighted.

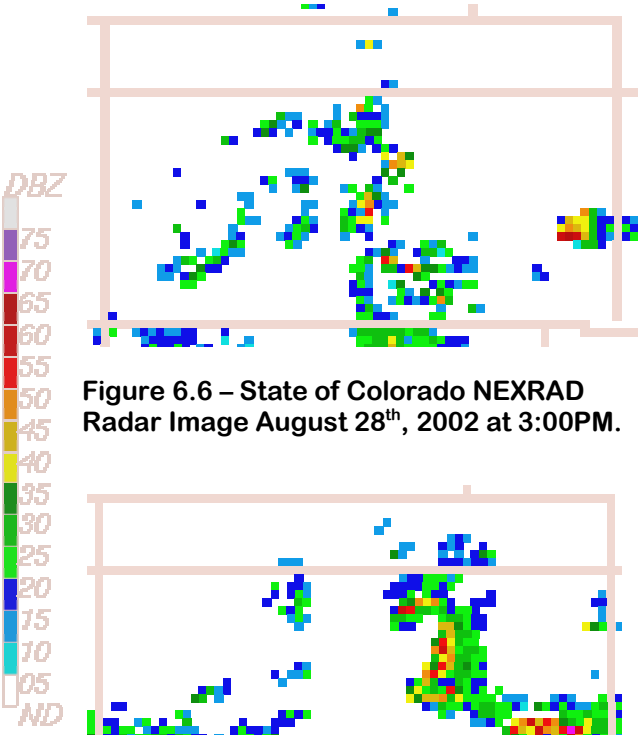


Figure 6.6 – State of Colorado NEXRAD Radar Image August 28th, 2002 at 3:00PM.

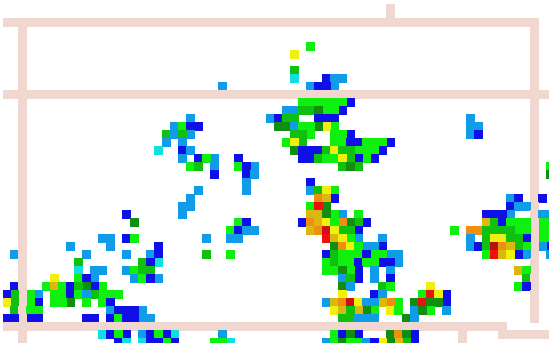


Figure 6.7 – State of Colorado NEXRAD Radar Image August 28th, 2002 at 4:00PM.

Figure 6.8 – State of Colorado NEXRAD Radar Image August 28th, 2002 at 5:00PM.

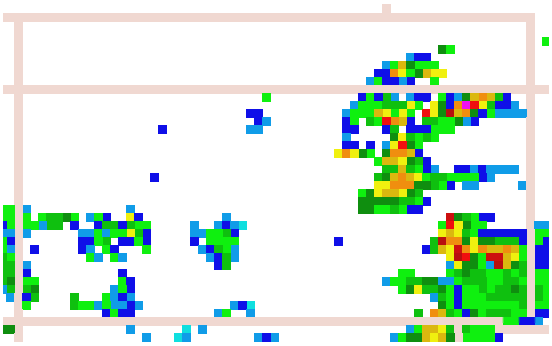


Figure 6.9 – State of Colorado NEXRAD Radar Image August 28th, 2002 at 6:00PM.

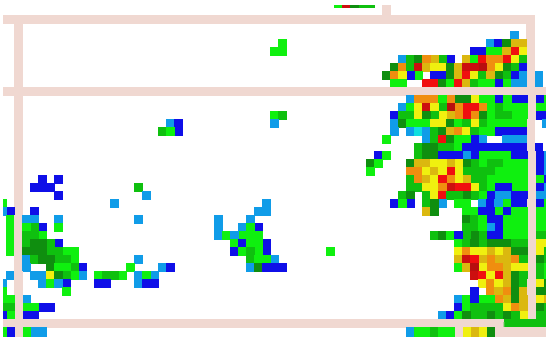


Figure 6.10 – State of Colorado NEXRAD Radar Image August 28th, 2002 at 7:00PM.

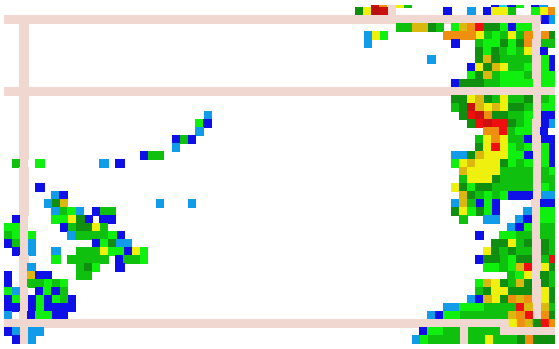


Figure 6.11 – State of Colorado NEXRAD Radar Image August 28th, 2002 at 8:00PM.

Figure 6.12 – Map of the Town of Lamar in Relation to the State of Colorado.
Map courtesy of the Mapquest website.

Hydrologic and Hydraulic Conclusions

Hydrologic information for these two towns was obtained from site visits and several other sources. Willow Creek flows south to north into Lamar where it turns east and continues along the south side of Highway 50. East of Lamar, Willow Creek then combines with Clay Creek and Clay Creek continues to flow north where it finally empties into the Arkansas River. Willow Creek drains an estimated 62 square mile area including a large rural area southwest of Lamar.

Based on information obtained from the site visit, the Hydrology Report for Wiley Drainage Ditch, and available mapping, Wiley Drainage Ditch forms north of Wiley and flows north to south into town where it continues south until spilling into the Arkansas River. The estimated drainage basin area for Wiley Drainage Ditch is 71.5 square miles (see Figure 6.14).

A Flood Insurance Study (FIS) was available for the city of Lamar. This document did include flood profiles for Willow Creek, as well as some hydrologic and hydraulic information for the studied area. During the visit to the community on September 3rd and 4th, high water marks were identified and surveyed in order to obtain approximate flood elevations. These high water elevations were then compared to the flood profiles included in the FIS study. The results are summarized on the next page in Table 6.1.

A Flood Insurance Study was not available for the city of Wiley. However, a Flood Information Report (FIR) from the Colorado Water Conservation Board was on hand. The report included data for a hydraulic model of Wiley Drainage Ditch analyzed using the U.S. Army Corps of Engineer's computer backwater hydraulics program known as HEC-2. Once the data was obtained, it was then imported into a more recent hydraulic program called HEC-RAS. This data could then be analyzed in order to obtain flood profiles for use in estimating the frequency of the event that occurred in Wiley. The results are included in Table 6.1.

Table 6.1 – Hydrologic and Hydraulic Analysis Summary

	Wiley Drainage Ditch		Willow Creek	
	HWM #1	HWM #2	HWM #1	HWM #2
High-water Mark - Approximate Location	250 ft. North of Highway 196, 285 ft. East of Ditch	395 ft. North of Highway 196, 300 ft. East of Ditch	50 ft. South of Memorial Drive Bridge, Along Eastern Bank of Creek	120 ft. Southwest of Energy Dissipater, Along Eastern Side of 1st Street
High-water Mark - Elevation	3728.91	3729.48	3640.72	3628.47
10-Year Event - Water Surface Elevation	3728.20	3728.30		
25-Year Event - Water Surface Elevation	3732.50	3732.50		
50-Year Event - Water Surface Elevation			3640.20	3627.30
100-Year Event - Water Surface Elevation			3641.90	3630.40

* = All elevations use the NAVD '29 Datum.

Analysis using the flood profiles indicated the event in Wiley to be somewhat greater than a 10-year event, and the event in Lamar to be in the range of a 50 to a 100-year event. These results concur with what was estimated during the site visit given the damage to the infrastructure of the town, businesses, and surrounding homes.

Further hydrologic analyses were performed using available baseline data from NOAA Atlas 2 in order to generate Intensity Duration Frequency, or IDF, curves for rainfall events within the two communities. Using the amount of rainfall that was reported for the storm event (7.0 inches of rain in 5 hours), one could estimate the frequency of the specific event. According to the images presented in Figures 6.4 and 6.5, the 7-inch value reported by the Pueblo Chieftain seems to be accurate as a total precipitation amount. However, when viewing figures 6.4 through 6.11, one notices that the area of most precipitation appears just to the south of Lamar, and just to the north of Wiley. This finding was confirmed after talking to local officials during the site visit. Since the areas with the most precipitation occurred just outside of each community, one must take into account the total drainage area of each basin upstream of the studied area.

Figures 6.13 and 6.14, on the following pages, show the estimated drainage boundary for each area studied. In Lamar, the resulting precipitation flowed overland to the north until collecting in Willow Creek. In Wiley, the water flowed overland to the southeast where it spilled into Wiley Drainage Ditch and Kicking Bird Canal. Following the information set forth in the Hydrology Report for Wiley Drainage Ditch, Kicking Bird Canal is assumed to fill and spill. Therefore the canal contributes to the peak flow and thus is considered part of the drainage area for Wiley Drainage Ditch.

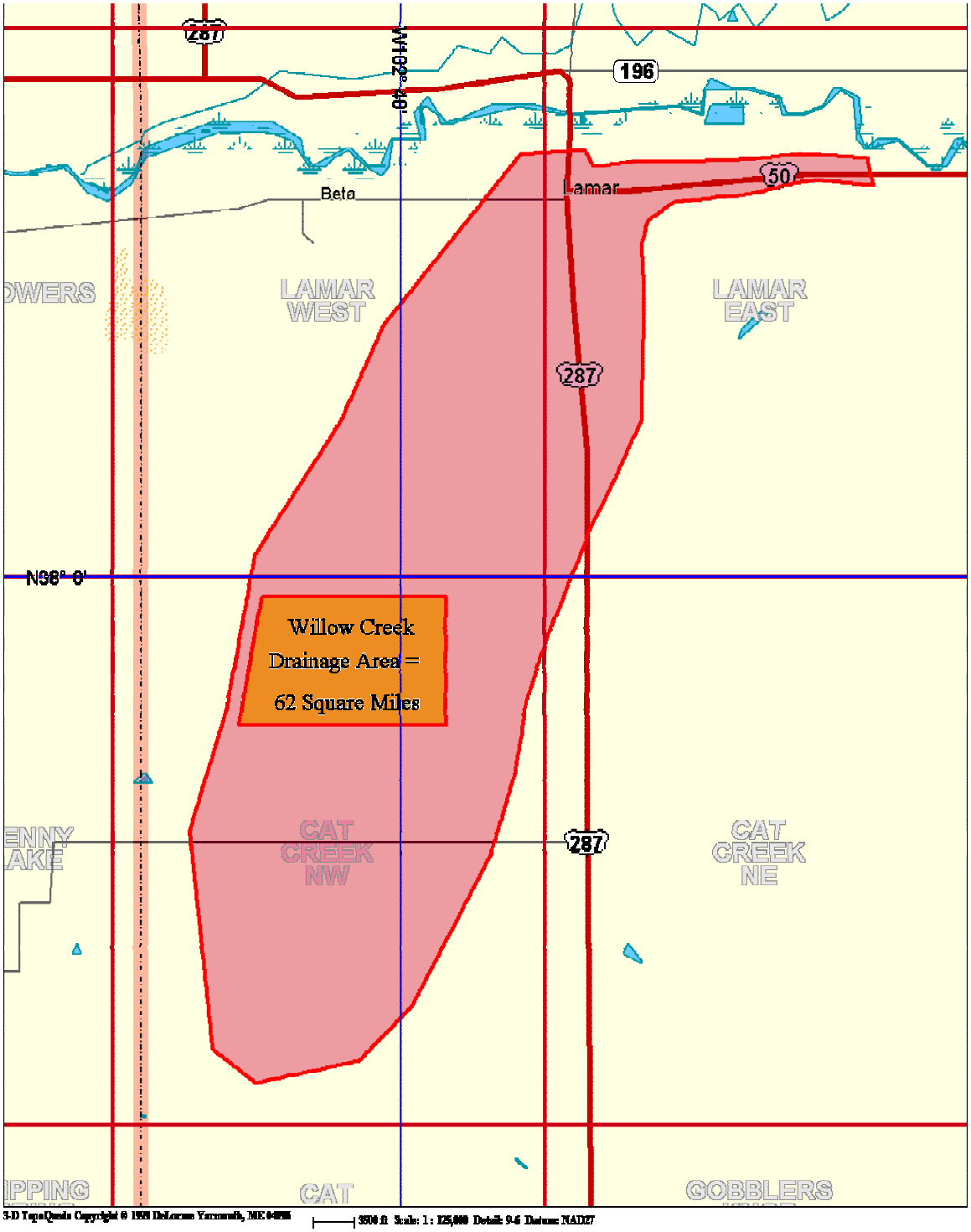


Figure 6.13 – Lamar, Colorado Drainage Basin Boundary Topographic Map.

Using NOAA Atlas 2 as a guide, the drainage basin's area was accounted for in the form of a reduction factor for the reported total precipitation. Even with the correction factor, the results indicate an event greater than a 100-year flood occurred in both communities. It is believed that the results obtained from this part of the analysis procedure do not give an accurate representation of the flood events that occurred.

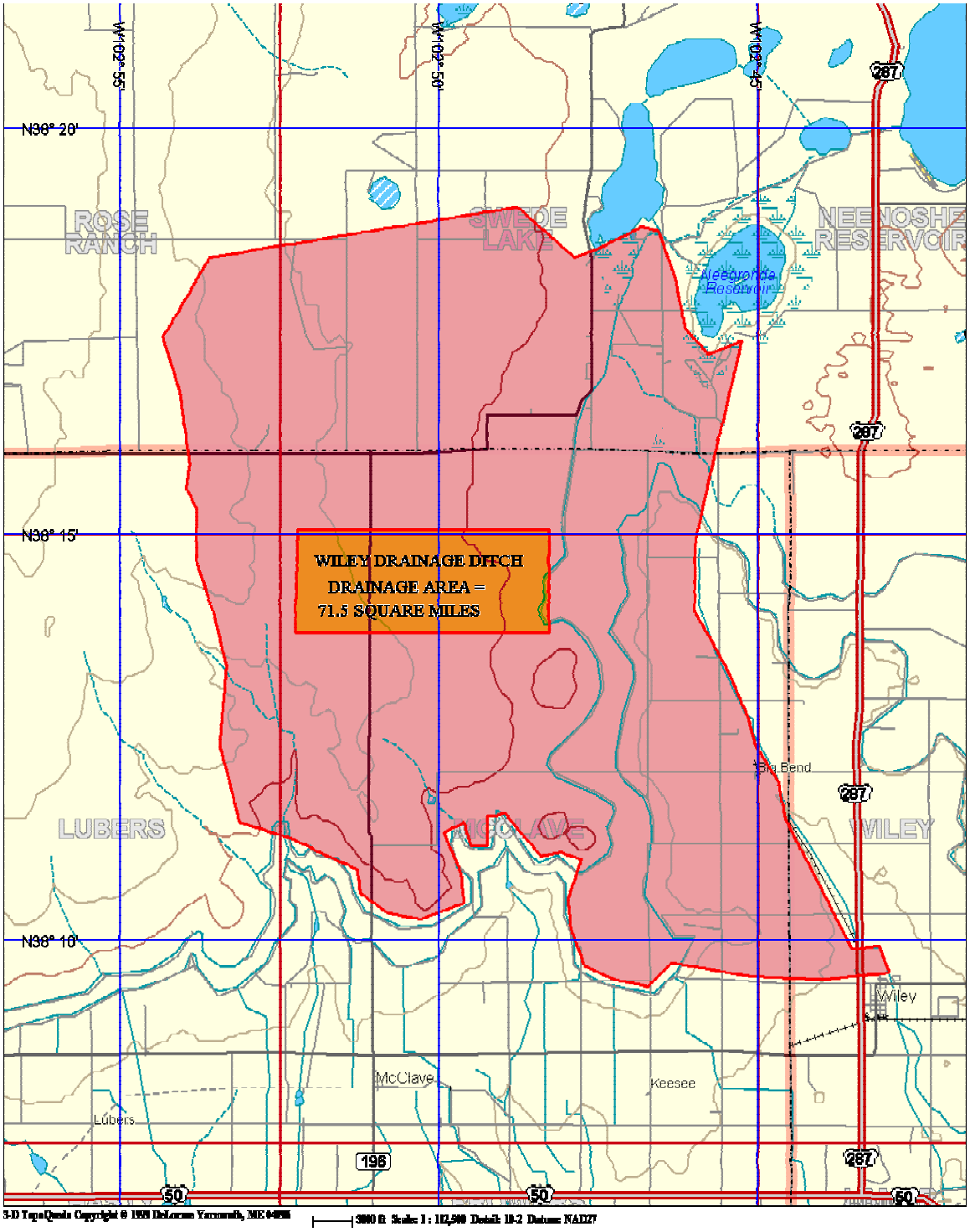


Figure 6.14 – Wiley, Colorado Drainage Basin Boundary Topographic Map.

The precipitation frequency analysis does not have a high correlation to the flood frequency as determined using the preceding comparison of measured high-water marks to routed, calculated flood profiles. Due to the lack of rainfall measurements over the entire basin, it is believed that the high-water mark frequency method results in a more reliable frequency estimate. The NOAA Atlas 2 frequency analysis is included in the Technical Addendum for reference purposes only.

Gage data was available for the Arkansas River near Lamar, and the Lamar Canal. Both gages show a large increase in flow on or around August 28th. Figures showing the gage data and each gage's location are shown in Figures 6.15 through 6.17.

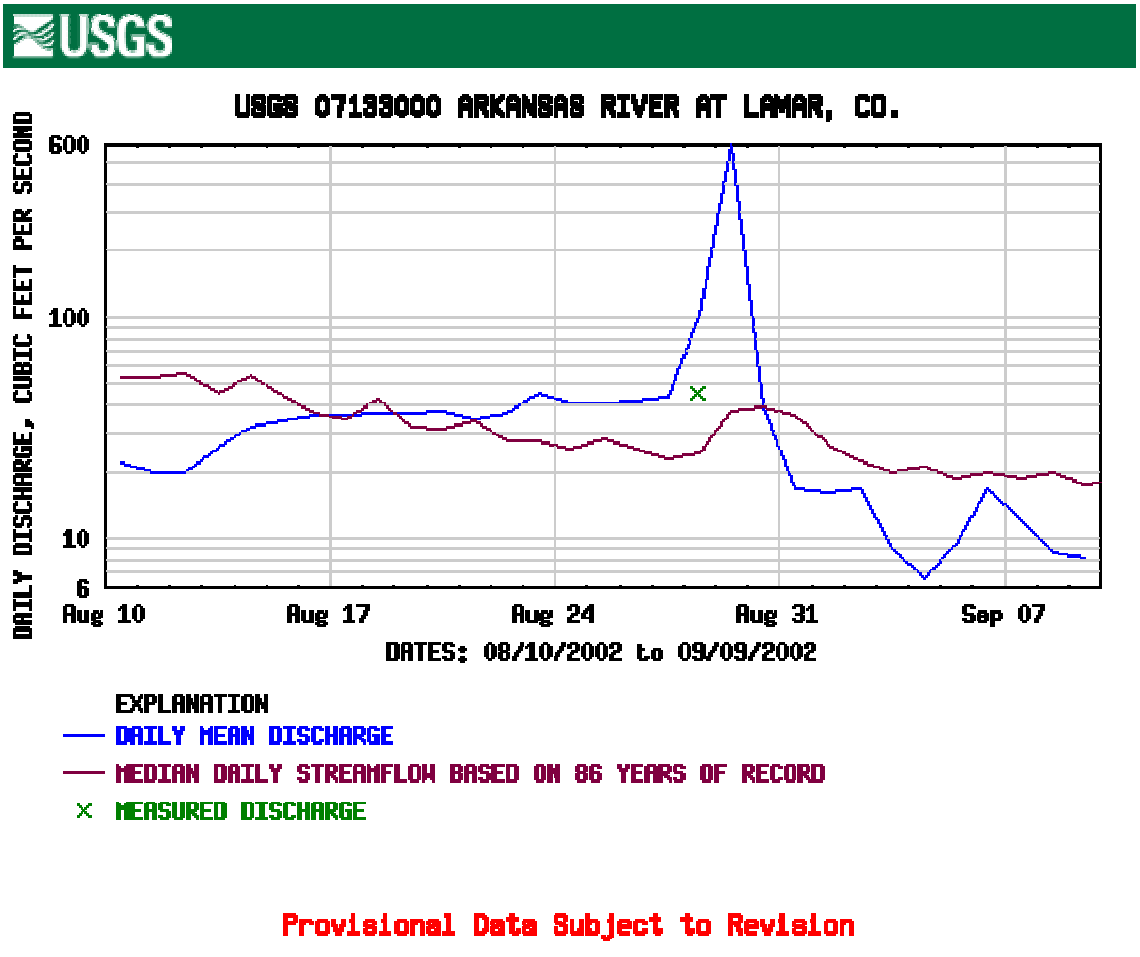


Figure 6.15 – Flow Gage Data for the Arkansas River near Lamar, Colorado.
Graph courtesy of the U.S.G.S. website

Flooding on the Arkansas River near Lamar was not a major issue however, in looking at Figure 6.15, one can see a large discharge peak on the storm event date in the range of 600 cubic feet per second. After looking at Figure 6.16, it is apparent that this gage is located upstream of Clay Creek's confluence. In addition, the Arkansas River accepts flows from not only Willow Creek and Wiley Drainage Ditch, but Clay Creek, as well as many other drainage elements and thus no accurate event frequency can be determined with this data.

Figure 6.17 shows a peak discharge around August 28th although, the data presented in this figure cannot be used to develop an event frequency for Lamar, or Wiley, because of the same reasons mentioned above.

There is no gage information available for Wiley Drainage Ditch or Willow Creek.

Flooded Area Description

Areas of Lamar that were inundated with floodwater, mud, and debris include: College Road, Willow Valley Road, 1st Street, areas of Spreading Antlers Golf Course near Willow Creek, a park just north of Memorial Drive Bridge, several houses and businesses along U.S. Highway 50, and finally several low-lying local roads that cross Willow Creek and it's floodplain.

Flooded areas in Wiley include: most houses in the Gold Addition subdivision, the local roads surrounding the subdivision, a park just west and north of Highway 196, and other low-lying areas near the ditch.

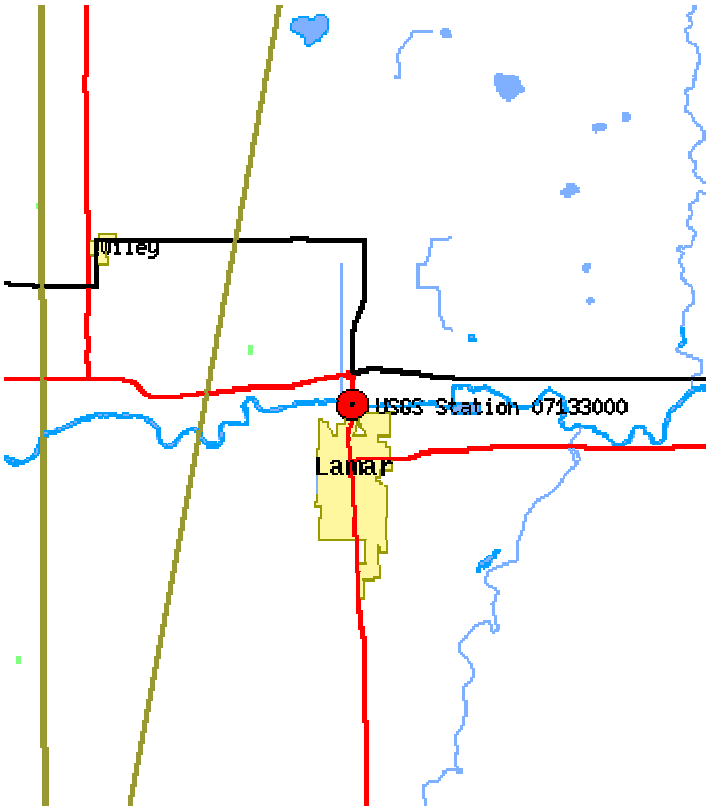


Figure 6.16 – Arkansas River Flow Gage Location near Lamar, Colorado.
Map courtesy of the U.S.G.S. website

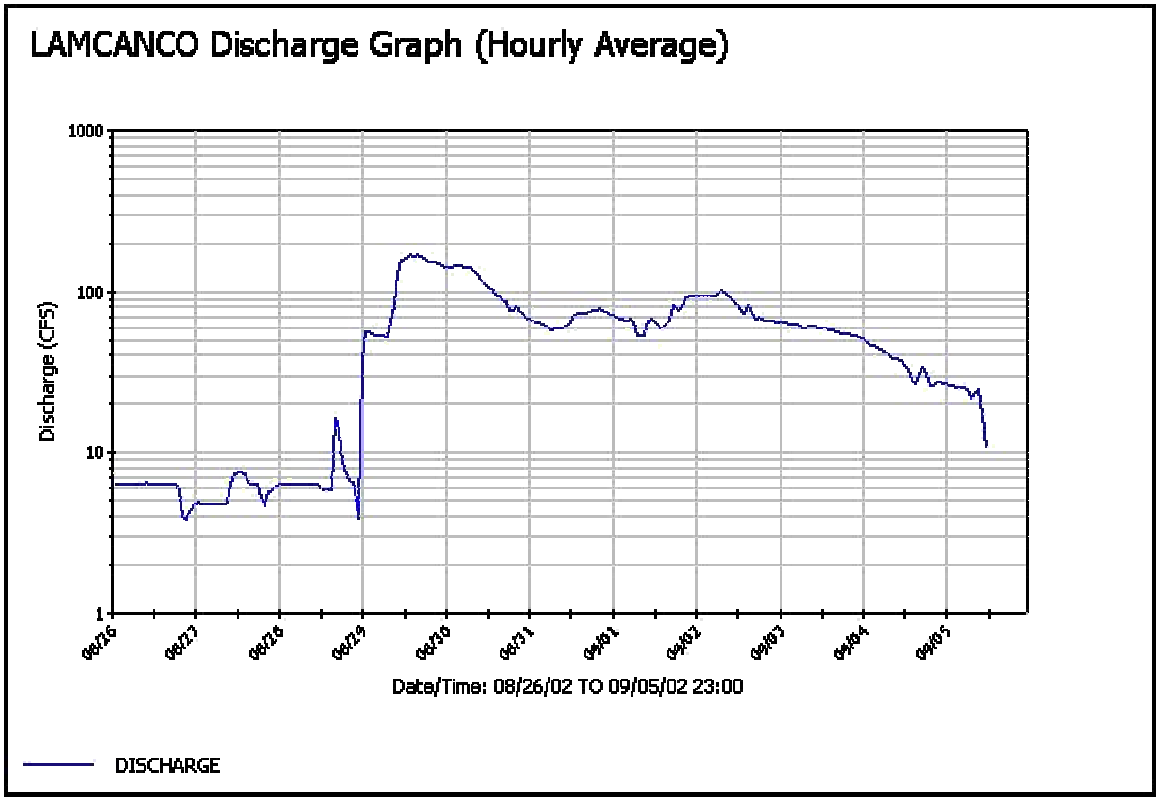


Figure 6.17 – Flow Gage Data for the Lamar Canal.
Graph courtesy of the Colorado Division of Water Resources website.

Estimated Flood Damages & Any Special Factors Affecting the Flood

Both towns had minor damage from the storm with the most damage occurring in Lamar. Damage in Lamar included: the loss of a walking bridge and erosion damage to some greens on the golf course, water and erosion damage to several houses and businesses along Highway 50 and, erosion damage to approximately 14 different city and county roads. Wiley damage included water damage to most houses in the Gold Addition subdivision and erosion damage to some fields and land surrounding the Wiley Drainage Ditch. Both towns had a lot of mud and debris to cleanup around the floodplain areas. Figures 6.18 through 6.30 include flood photographs taken by city and county officials on August 28th, and "day-after" pictures taken by ICON Engineering during the site visit on September 3rd and 4th, 2002.

According to the Pueblo Chieftain, no injuries or casualties were reported (2).

Damage estimates were obtained through the City of Lamar and Southeastern Land and Environment. The flood cleanup costs (excluding road damage) for the flood was estimated at $127,400, which included cleanup on the golf course in Lamar. Road damage throughout the area was estimated at $137,127. These damage estimates do not include damage to residential or business properties.

Several factors typically increase the damage that occurs from a flood. Often road crossings such as bridges and culverts are undersized causing the water to overtop the

roadway thereby increasing flood levels upstream of the crossing. Large bends, or meanders, in the drainage-way alignment often cause inefficient flow in the channel and can lead to eventual overtopping of the banks. These factors are evident in Lamar and Wiley.

The Highway 196 Bridge, crossing Wiley Drainage Ditch, is an example of an undersized bridge crossing. The Highway 196 Bridge has been discussed in previous reports published by the Colorado Water Conservation Board. During flood events, this bridge affects the Gold Addition subdivision directly.

In Lamar, where Willow Creek crosses 1st Street, there is a 42" Corrugated Metal Pipe that appears to be undersized, causing water to overtop the street and enter a nearby field before returning to the Willow Creek channel. Downstream of this area there are several 90-degree bends in the creek-alignment where water backed up and eventually left the confines of the channel.

Additional Support Information

Figure 6.18 – Gold Addition Subdivision in Wiley, Colorado on August 28, 2002.

Figure 6.19 – View of Wiley Drainage Ditch from Highway 196 Bridge on August 28, 2002.

Figure 6.20 – Wiley Drainage Ditch Looking North During the Flood.

Figure 6.21 – Wiley Drainage Ditch Looking East at Highway 196 Bridge.

Figure 6.22 – Highway 196 Bridge in Wiley, Colorado Looking South After the Flood.

Figure 6.23 – Walking Bridge Over Wiley Drainage Ditch on September 3, 2002.

Figure 6.24 – Looking West at Park Across Wiley Drainage Ditch on September 3, 2002.

Figure 6.25 – Willow Creek in Lamar Just North of Memorial Bridge on August 28, 2002.

Figure 6.26 – Looking North at Willow Creek on Memorial Bridge in Lamar During Flood Event.

Figure 6.27 – Willow Creek Looking Downstream on August 28, 2002.

Figure 6.28 – Looking South along Highway 50, in Lamar, at High-Water Line on Structure.

Figure 6.29 – High-Water Debris Line in Chain-Link Fence along Highway 50 in Lamar.

Figure 6.30 – Looking North at Debris Pile along Highway 50 in Lamar, Colorado.

CHAPTER 7

Ogallala, Nebraska Flood of July 6th, 2002
Interstate 80 Drainage Ditch
(Keith County, Nebraska)

Introduction

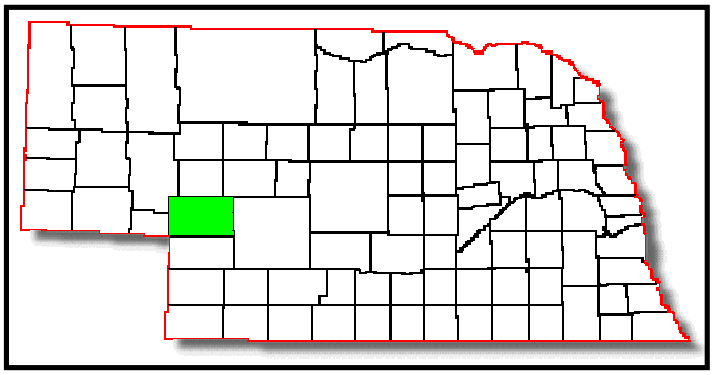


Figure 7.1 – Keith County Location in the State of Nebraska.
Map courtesy of Texas A&M University's "Do It Yourself Color-Coded State Maps" website.

On Saturday, July 6th, 2002, a large storm front, moving east through the state of Colorado and into Nebraska, dumped a large amount of rainfall in the vicinity of Ogallala, Nebraska. The storm front resulted in as much as 11 inches of rain in 10 hours. The city and surrounding area's infrastructure was overwhelmed with the amount of runoff produced and significant flooding occurred as a result. There was one fatality related to this storm. A semi-truck driver was killed in an accident near an I-80 ravine where two bridges (eastbound and westbound lanes of the highway) that cross a drainage ditch on the interstate had been washed away by the torrential rain. Interstate 80, a major North American east-west thoroughfare, had to be closed for a week as road and bridge crews rushed to repair the damaged bridges. After talking to state, county, and local officials, it is unknown when the last major flood event of this size occurred in this area.

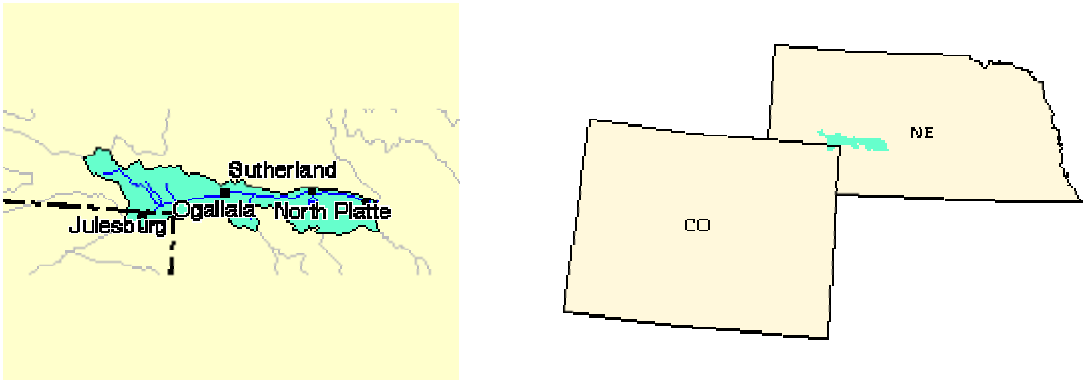


Figure 7.2 – Upper Arkansas–John Martin Watershed and Location
Obtained from the Environmental Protection Agency's "Surf Your Watershed" website.

Location and Description

Ogallala, Nebraska is located just east of the northeast corner of the Colorado state border at the intersection of U.S. Highways 26 and 30 in Keith County (see Figure 7.3 below). The city of Ogallala is located right off Interstate 80 east of the intersection of I-76 and I-80. According to the 2000 Census, Ogallala's population is 4,930 out of a total county population of 8,875 (U.S. Census Bureau, "Factfinder" website). Ogallala is the Keith County Seat.

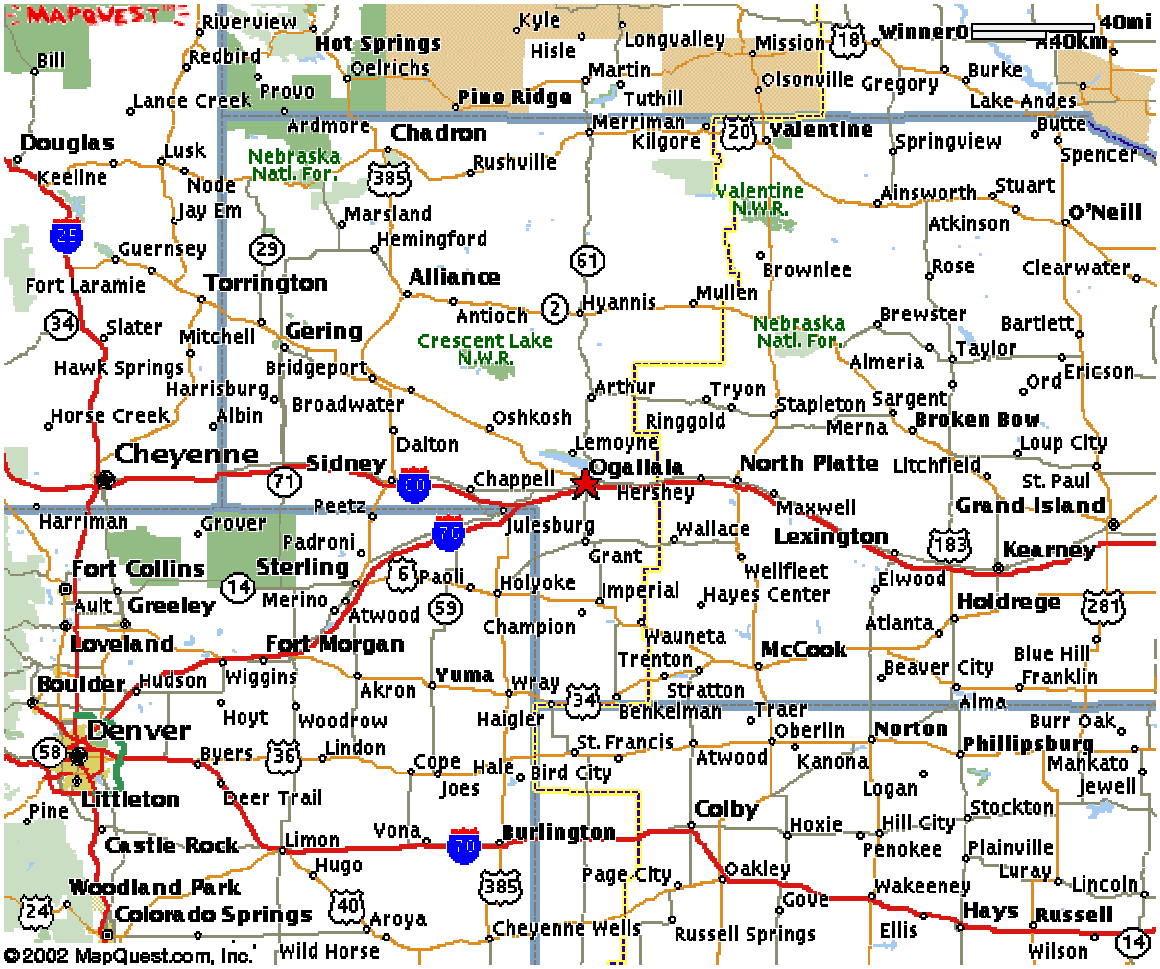


Figure 7.3 – Map of Ogallala, Nebraska in Relation to Denver and the State of Colorado.

The town of Ogallala lies within the Lower South Platte watershed along with several other towns and cities including: Sutherland and North Platte, Nebraska as well as Julesburg, Colorado (see Figure 7.2 on previous page). The watershed spans six different counties in Nebraska including Lincoln, Keith, Perkins, and others. It also crosses into Sedgwick County in Colorado.

Just to the north of the Lower South Platte watershed is the Lower North Platte watershed. Since this watershed also experienced flooding from the same storm, the

figure showing this watershed, and its location, has been included in the Additional Support Information section of this chapter.

Storm Characteristics and Information

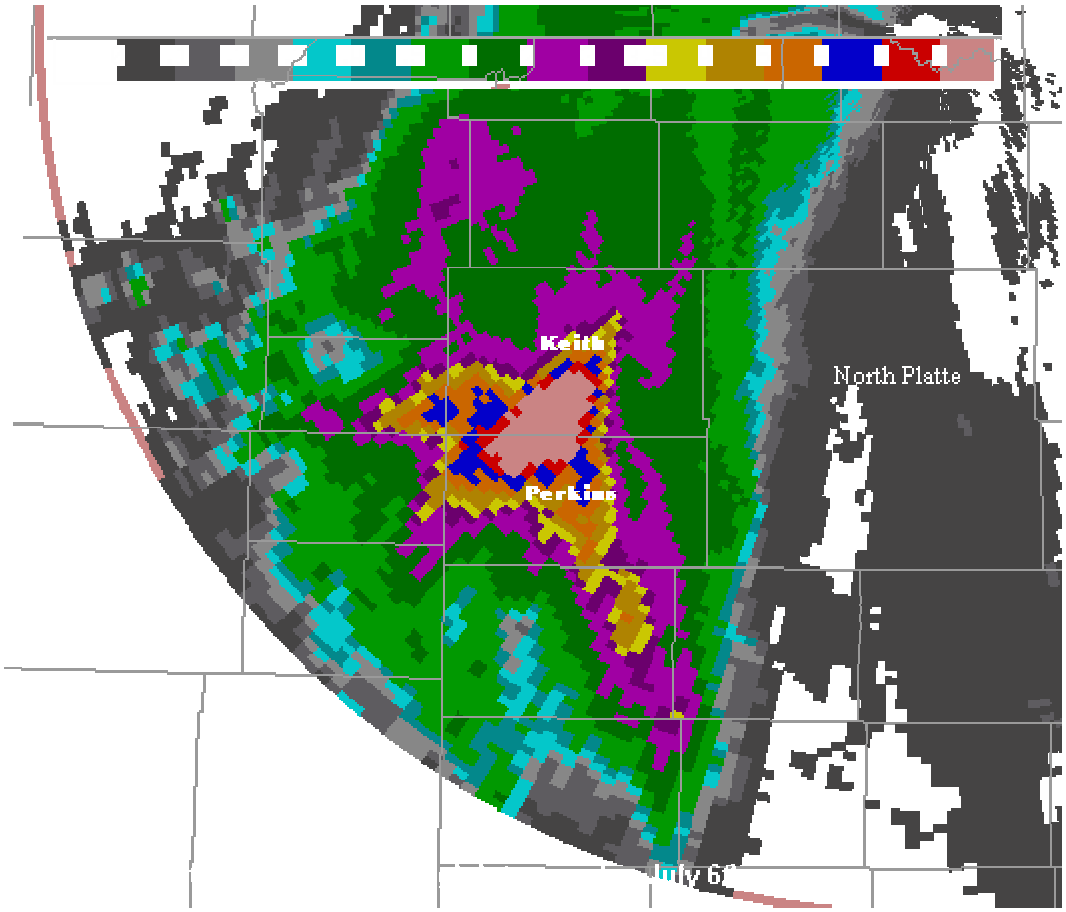


Figure 7.4 – Total Precipitation Map of Keith and Perkins County, Nebraska for July 6, 2002 Storm.
Obtained from the National Weather Service's North Platte Regional Office website.

Storm characteristics and rainfall information for this storm was plentiful. Since it was a serious event that made the national news, a lot of information was collected about the storm and it's characteristics.

Total precipitation amounts varied according to different sources. According to Deb Blondin with the National Weather Service, "11 to 12 inches of rain fell in a 10 to 12-hour period." Figure 7.4 (above) was obtained through the National Weather Service's website. It shows a large area with rain amounts in the 8-inch range however, this is the highest amount of rainfall on the included scale and thus it is believed there were areas with precipitation amounts in excess of 8 inches. Steve McMaster with the Nebraska Department of Natural Resources, provided information indicating 11 inches of rain fell

in a 10-hour period. Next, an article by Brian Crecente, published by the Rocky Mountain News, stated "10 inches of rain fell over an 8-hour period..." Finally, several similar articles published by different sources stated 10 inches of rain fell during this storm. These articles did not include information about the duration of the storm, so it was assumed these measurements were precipitation totals for a 10-hour period.

According to the National Climatic Data Center's NEXRAD radar images, a large front of severe storm activity formed near the northeast corner of Colorado and moved east into Nebraska around midnight on July 6th. The storm finally moved northeast of the area approximately 10-hours later. These images are shown below, and on the following page, in Figures 7.5 through 7.15. Next to Figures 7.5 and 7.6, is a legend indicating the higher the color number, the more intense the storm. In order to locate the town of Ogallala on the NEXRAD radar images, Figure 7.16 contains a map of the state of Nebraska with the town of Ogallala highlighted.

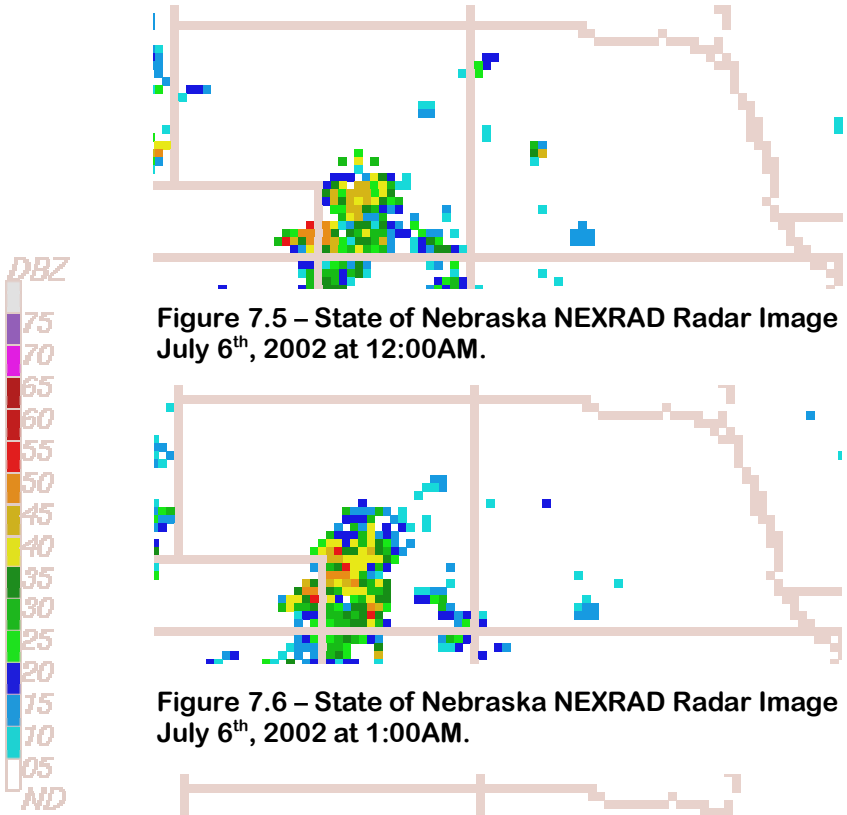


Figure 7.5 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 12:00AM.

Figure 7.6 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 1:00AM.

Figure 7.7 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 2:00AM.

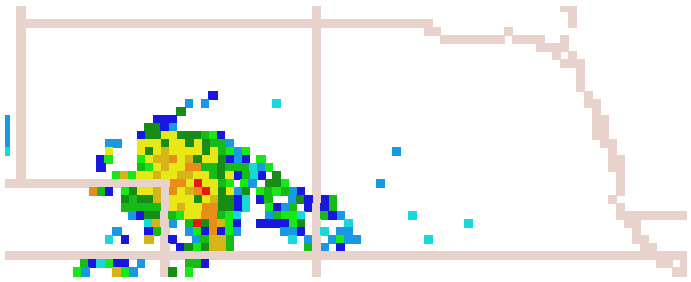


Figure 7.8 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 3:00AM.

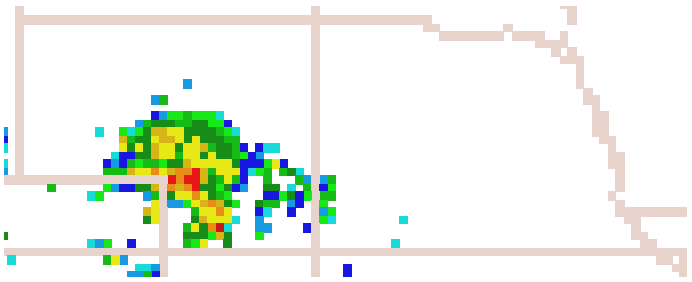


Figure 7.9 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 4:00AM.

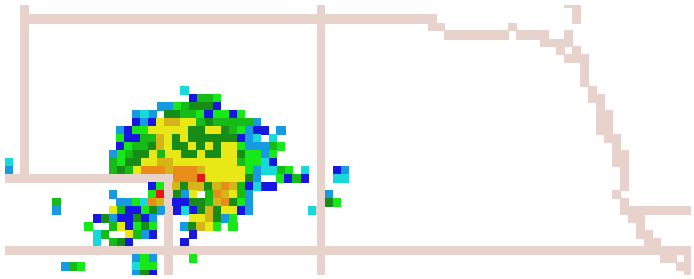


Figure 7.10 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 5:00AM.

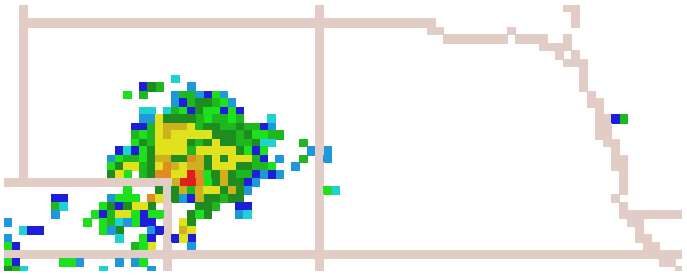


Figure 7.11 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 6:00AM.

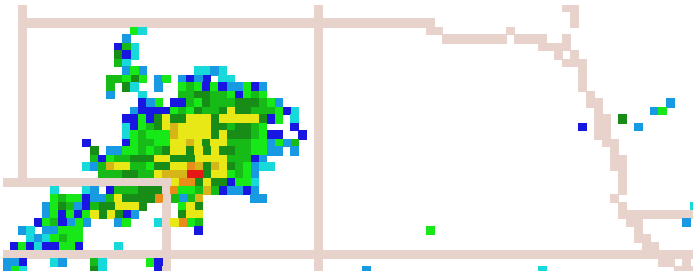


Figure 7.12 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 7:00AM.

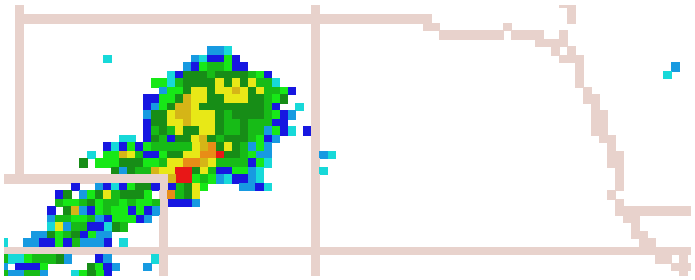


Figure 7.13 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 8:00AM.

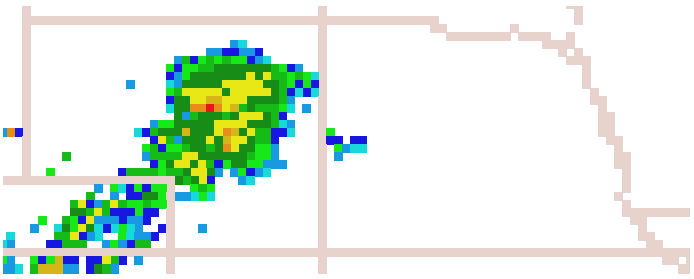


Figure 7.14 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 9:00AM.

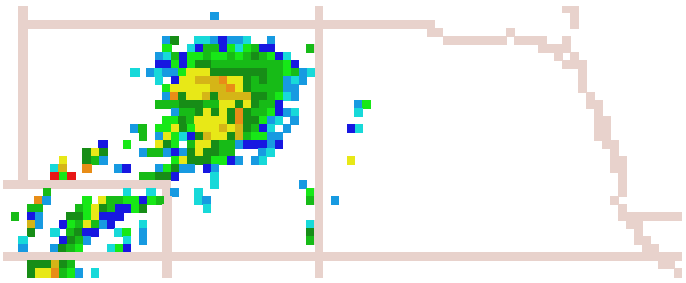


Figure 7.15 – State of Nebraska NEXRAD Radar Image July 6th, 2002 at 10:00AM.

Figure 7.16 – Map of the Town of Ogallala in Relation to the State of Nebraska.
Map courtesy of the Mapquest website.

Hydrologic and Hydraulic Conclusions

Hydrologic information for the Ogallala area was found using available mapping and in the various articles and interviews used in this chapter. The South Platte River is the major river in the area. The South Platte flows west to east through the southern end of the city paralleling I-80. Ogallala has a diverse network of drainage ditches and channels that feed off or drain into the South Platte River. This network helps irrigate the area for farming, ranching, and other commercial and residential uses. The drainage ditch that washed out two bridges on I-80 is west of the city between Ogallala and Brule. Lake McConaughy lies approximately 8 miles to the north of the city and is a major recreational areas and tourist attraction for this region.

Hydrologic analyses were performed using available baseline data from NOAA Technical Papers 35 and 40 (TP-35, TP-40) in order to generate Intensity Duration Frequency, or IDF, curves for rainfall events within the town. Using the rainfall amounts, and durations, mentioned in the Storm Characteristics and Information section of this chapter, one could estimate the frequency of this specific event. The results of this analysis are summarized below in Table 7.1.

Table 7.1 – IDF Curve Hydrologic Summary

July 6, 2002 Storm			
Event Duration (hours)	**8.0**	**10.0**	**12.0**
100-YR Total Precipitation (in.)	4.40	4.53	4.65
Total Event Precipitations As Reported (in.)	10.00	10.00	11.00
		11.00	12.00
		12.00	
Exceeds 100-YR Total Precipitation by As Much As...	**2.3 Times**	**2.7 Times**	**2.6 Times**

According to Table 7.1, the event in the Ogallala area exceeded the 100-year event's total precipitation by more than two times indicating this was a very rare and serious event for this area.

Since the storm exceeded the 100-year frequency, it would be beneficial to compare the event's precipitation to the Probable Maximum Precipitation (PMP) for the area. This analysis is summarized in Table 7.2.

Table 7.2 – PMP Comparison Summary

Probable Maximum Precipitation (PMP) 12-HR Duration	28.4 inches
Maximum Total Event Precipitation (AS REPORTED) 12-HR Duration	12.0 inches

The American Meteorological Society defines Probable Maximum Precipitation as: "the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year." This value can be found by using one of several Hydrometeorological Reports put out by the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and U.S. Army's Corp of Engineers. In this case, report #51 was used to find an isopluvial map for a 12-hour storm in an estimated 10 square mile drainage area. The analysis indicates the event in Ogallala was roughly 40% of the PMP.

Gage data was available for the South Platte River near Roscoe Nebraska, but not for the drainage ditch that destroyed the two bridges over I-80. According to Dan Hitch with the U.S. Geological Survey (USGS), "peak discharge at the Roscoe gage was 11,400 cfs (cubic feet per second) at approximately 2:40PM." Figures that contain the gage data for the South Platte River are included in the Additional Support Information section of this chapter.

Flooded Area Description

Many regions in the Ogallala area were underwater for varying amounts of time. Most of these regions were located in the southeastern part of the city. They included: at least 65 mobile homes in three different mobile home parks, several restaurants, hotels, a truck stop, various county roads and highways, and parts of Interstate 80. Several dams in the area overtopped during the peak flooding stages as well. Pictures of these areas were made available through the Nebraska Department of Transportation's website. They have been included under the Additional Support Information heading at the end of this chapter.

Estimated Flood Damages & Any Special Factors Affecting the Flood

The damage to the town of Ogallala, and surrounding areas in Keith and Perkins counties, was severe.

The flood inundated at least 65 homes destroying 24 of them. Infrastructure throughout the area was damaged and or destroyed by the rain. In addition to the two bridges being washed away on I-80, culverts, pipes, inlets, dams, and county roads all over the area had erosion damage and were surrounded by mud and debris left by the receding water. As mentioned above, several businesses were flooded and had severe water damage to the lower lying areas. Pete Peterson, the local representative with the Office of Emergency Management, indicated at least $450,000 total damage to county roads, with over $1,000,000 being spent to reconstruct the bridges along I-80. At the time of his interview, it was unknown what the damage estimate was for businesses and residential neighborhoods, but it is believed to number in the hundreds of thousands of dollars. Pictures of the damage to I-80, and several other areas, are included at the end of this chapter courtesy of the National Weather Service and the Nebraska Department of Transportation.

As mentioned in the Introduction section of this chapter, there was one fatality attributed to this storm. A truck driver was killed in a traffic accident on I-80. However, no other serious injuries were reported, most likely due to the evacuations ordered by local government officials.

Several special factors affected the flood and the resulting damage. Since this was an extremely rare and intense storm that exceeded the 100-year frequency, the damage was significant to the region. The resulting flows exceeded the hydraulic capacity of the I-80 Interstate crossing structure resulting in the bridge failure. However, since the area impacted was composed of small towns and rural areas, the total cost of the damage was relatively minor. Had this same event occurred over a dense urban area, the damage likely would have been significantly greater.

Additional Support Information

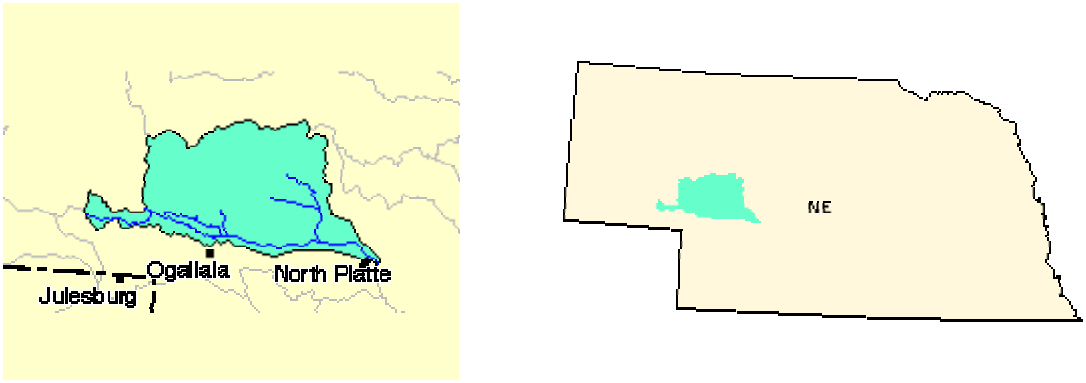


Figure 7.17 – Lower North Platte Watershed and Location
Obtained from the Environmental Protection Agency's "Surf Your Watershed" website.

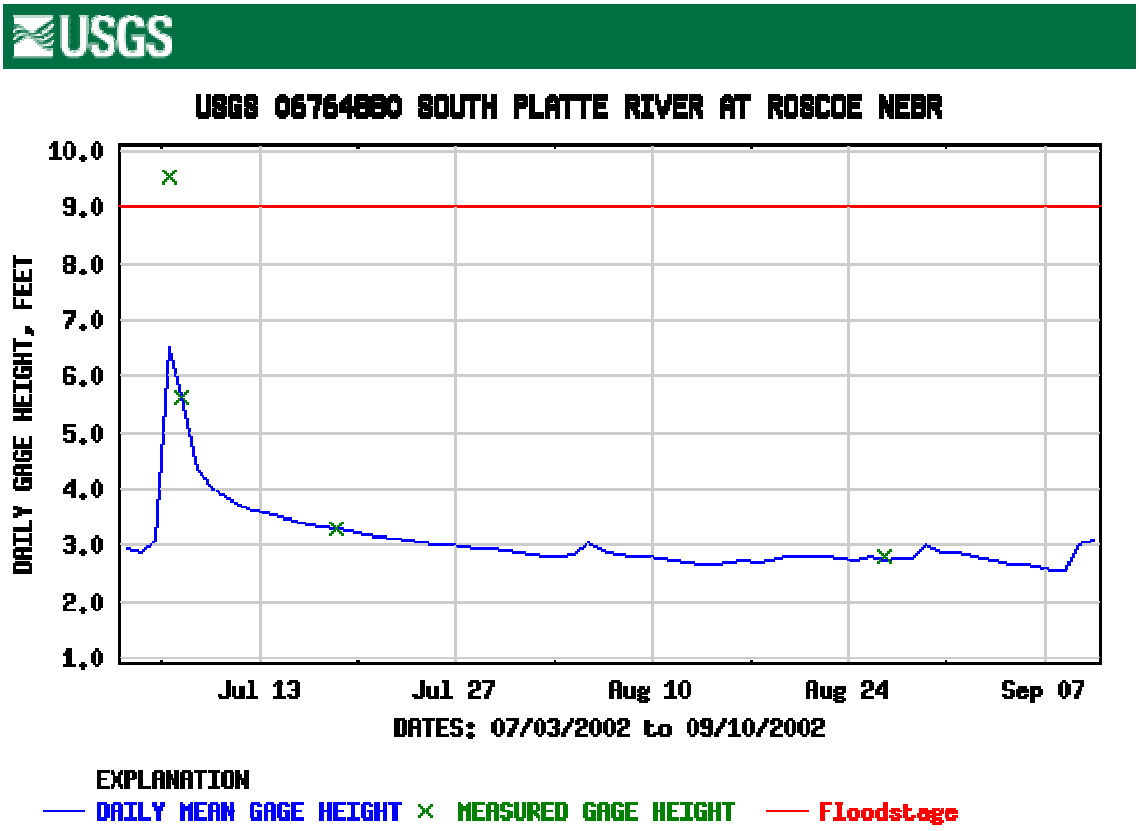


Figure 7.18 – Flow Gage Height Graph for the South Platte River at Roscoe, Nebraska.
Graph courtesy of the U.S.G.S. website

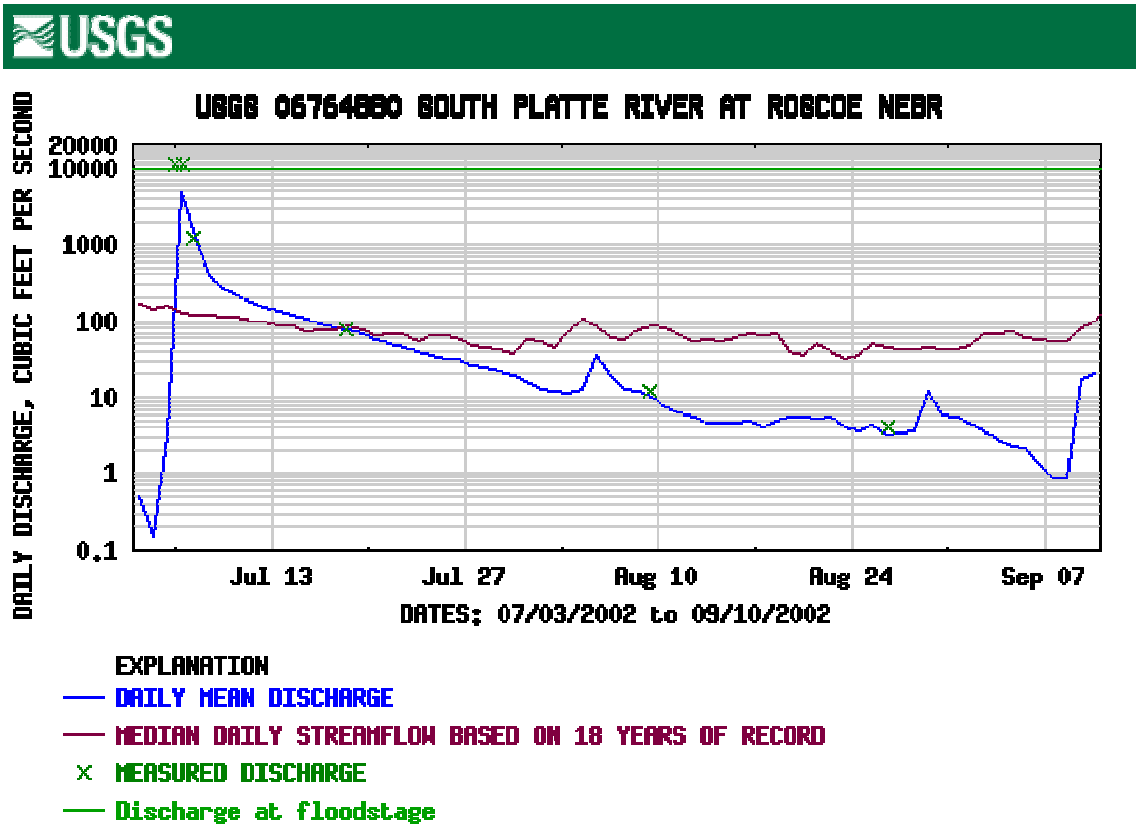


Figure 7.19 – Daily Discharge Graph for the South Platte River at Roscoe, Nebraska.
Graph courtesy of the U.S.G.S. website

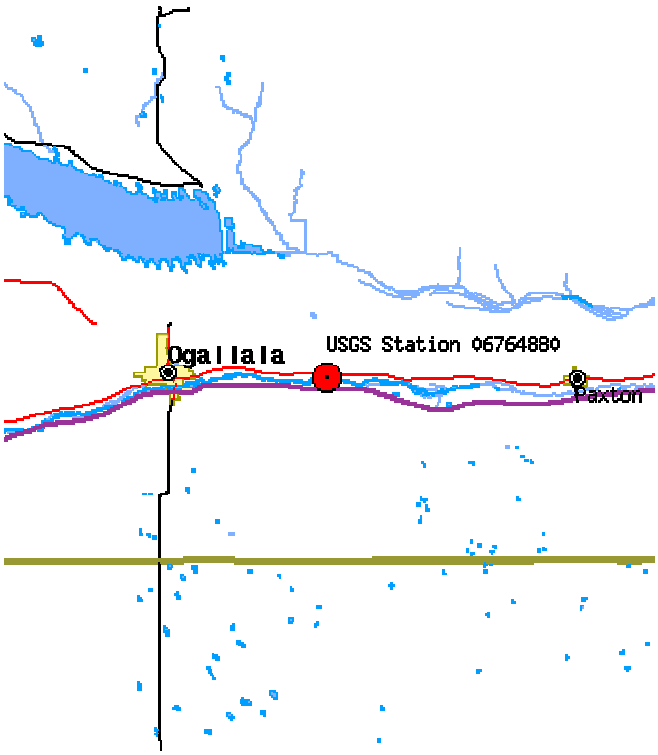


Figure 7.20 – Map of South Platte River Gage Location.
Map courtesy of the U.S.G.S. website

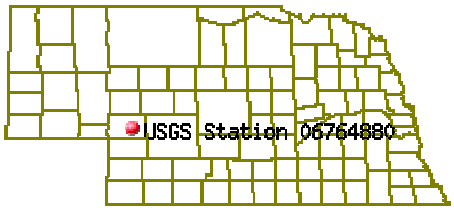


Figure 7.21 – South Platte River At Roscoe Gage Location in Relation to the State of Nebraska.
Map courtesy of the U.S.G.S. website.

Figure 7.22 – Aerial Picture of Rural Flooding Near I-80 in Nebraska.
Picture courtesy of the Nebraska DOT.

Figure 7.23 – Aerial Picture of Rural Flood Damage to Two Bridges on I-80.
Picture courtesy of the Nebraska DOT.

Figure 7.24 – Close-Up Picture of Flood Damage to Bridge on I-80.
Picture courtesy of the Nebraska DOT.

Figure 7.25 – Traffic Back-Up Due to I-80 Closure.
Picture courtesy of the Nebraska DOT.

Figure 7.26 – Local Business Flooding Due to July 6th Event.
Picture courtesy of the Nebraska DOT.

Figure 7.27 – Flooded Road Interchange in Ogallala.
Picture courtesy of the Nebraska DOT.

Figure 7.28 – Flooded Rural Road.
Picture courtesy of the Nebraska DOT.

Figure 7.29 – Erosion Damaged Spillway Along Interstate 80.
Picture courtesy of the Nebraska DOT.

Figure 7.30 – Flooded Area Near Ogallala.
Picture courtesy of the Nebraska DOT.

Figure 7.31 – Wendy's Parking Lot During Flood.
Picture courtesy of the Nebraska DOT.

Figure 7.32 – National Weather Service Picture #1.

Figure 7.33 – National Weather Service Picture #2.

Figure 7.34 – National Weather Service Picture #3.

Figure 7.35 – National Weather Service Picture #4.

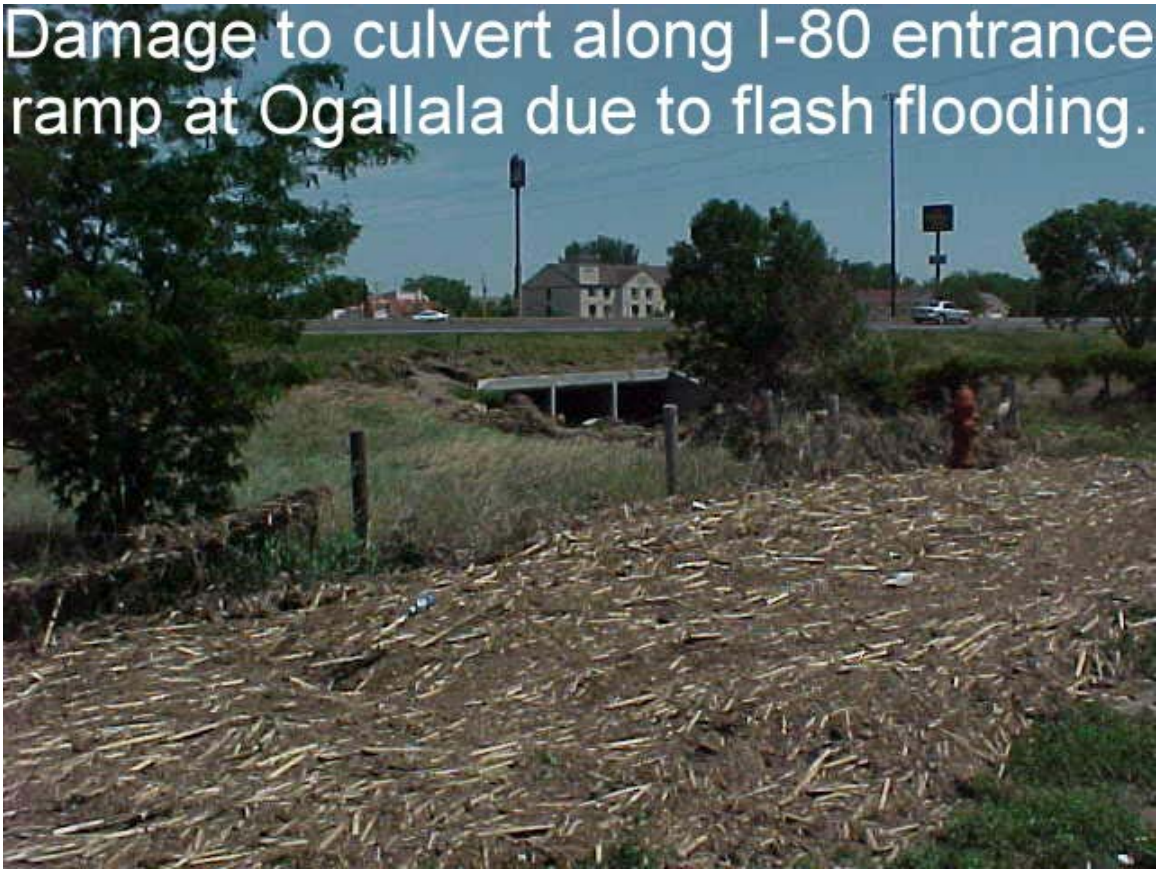


Figure 7.36 – National Weather Service Picture #5.

Figure 7.37 – National Weather Service Picture #6.

Figure 7.38 – National Weather Service Picture #7.

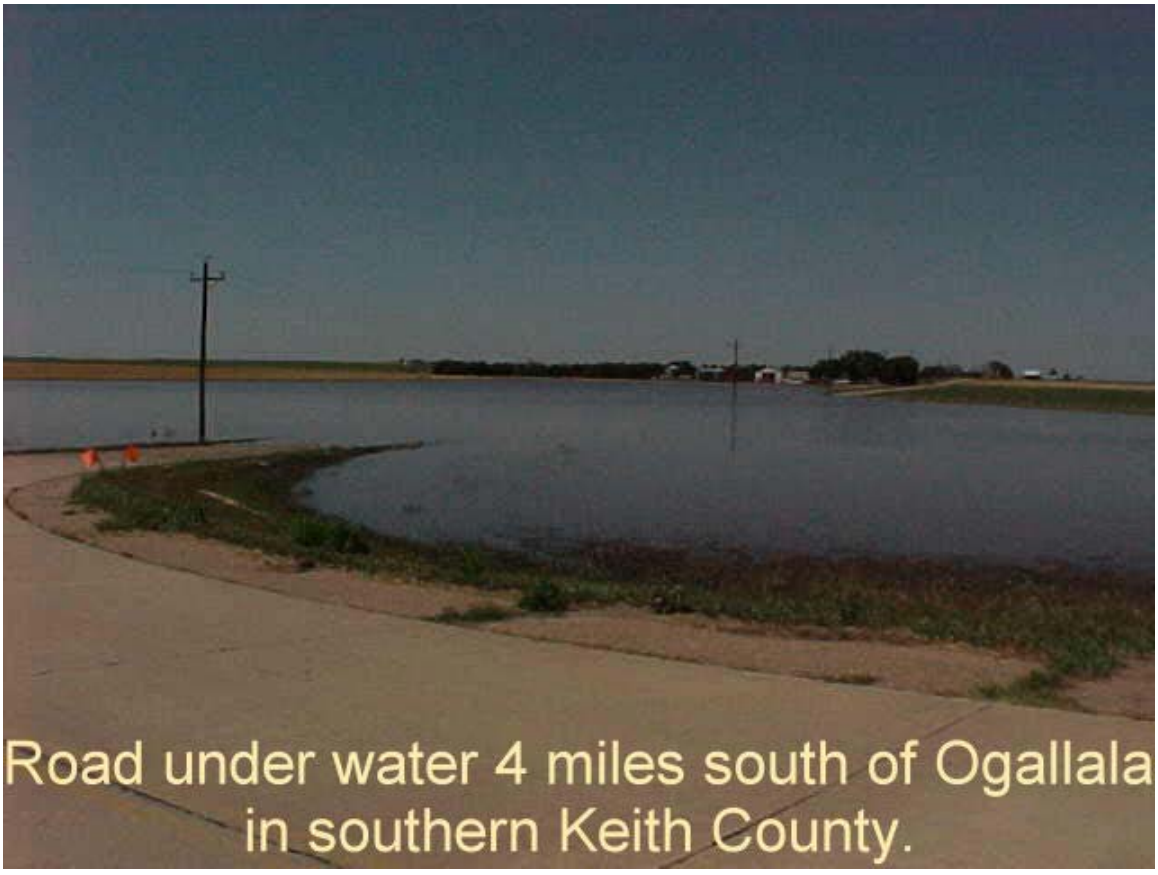


Figure 7.39 – National Weather Service Picture #8.

Figure 7.40 – National Weather Service Picture #9.

Figure 7.41 – National Weather Service Picture #10.

Figure 7.42 – National Weather Service Picture #11.

Figure 7.43 – National Weather Service Picture #12.

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