State of Colorado
2003 Flood Documentation Report

Vail, Colorado Flood of May 31st, 2003
I-70 Drainage Culvert – Bighorn Creek Confluence with Gore Creek
Photo Courtesy of Colorado Department of Transportation.

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COLORADO
DEPARTMENT OF
NATURAL
RESOURCES

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COLORADO WATER CONSERVATION BOARD
STATE OF COLORADO
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CHAPTER 1

Vail, Colorado Flood of May 31st, 2003
I-70 Drainage Culvert – Bighorn Creek's Confluence with Gore Creek
(Eagle County, Colorado)

Introduction

On Saturday, May 31st, 2003, a thunderstorm released a significant amount of rainfall on the Vail, Colorado area in Eagle County. Runoff was significantly increased on Bighorn Creek, which is a tributary of Gore Creek just upstream of Vail. The combination of rainfall on snowmelt compounded the event. Significant damage occurred in the town of Vail with the most severe impact being the formation of a large sinkhole along Interstate Highway 70 at the Bighorn Creek crossing. I-70 is a major east-west thoroughfare in the state, and the resulting damage forced the temporary closure of the Interstate in both directions.

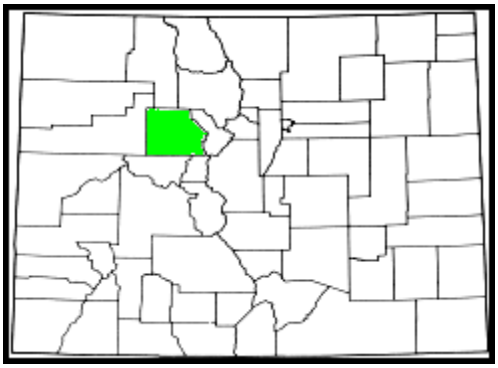

Figure 1.1 – Eagle County Location in the State of Colorado.
Map courtesy of the Colorado Herpetological Society.

Residents throughout East Vail were evacuated using the city's reverse 911 system and in some cases, by door to door visits by the local police and sheriff's department. According to an official news release by the town of Vail, 133 homes were "...in the path of the flooding with 28 of those residences receiving non-structural damage from debris and flooding."

Location and Description

Vail, Colorado is located about 97 miles west of Denver along Interstate 70 in Eagle County (see Figure 1.3 on the next page). According to the 2000 Census, Vail's population

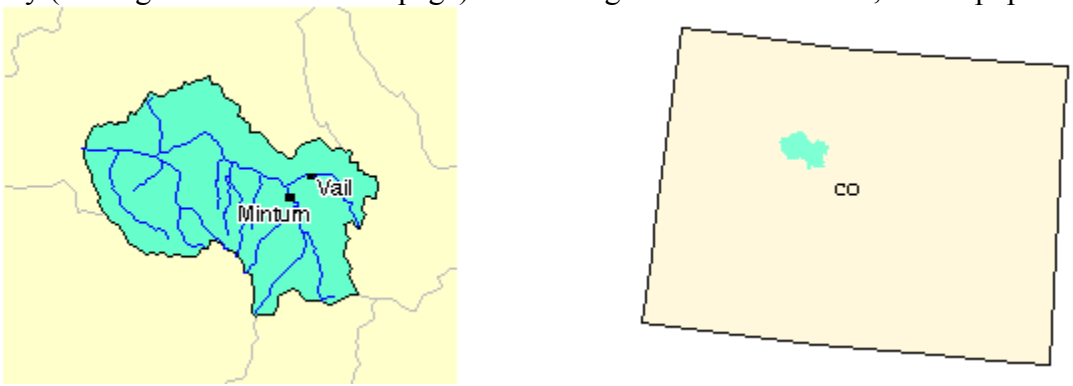

Figure 1.2 – Eagle Watershed and Location
Obtained from the Environmental Protection Agency's "Surf Your Watershed" website.

is 4,531 out of a total county population of 41,659 (U.S. Census Bureau, "Factfinder" website). The town of Eagle is the County Seat.

The City of Vail lies in the northeast quadrant of the Eagle watershed, which is shown above in Figure 1.2. The Eagle watershed crosses into four different counties including Eagle County.

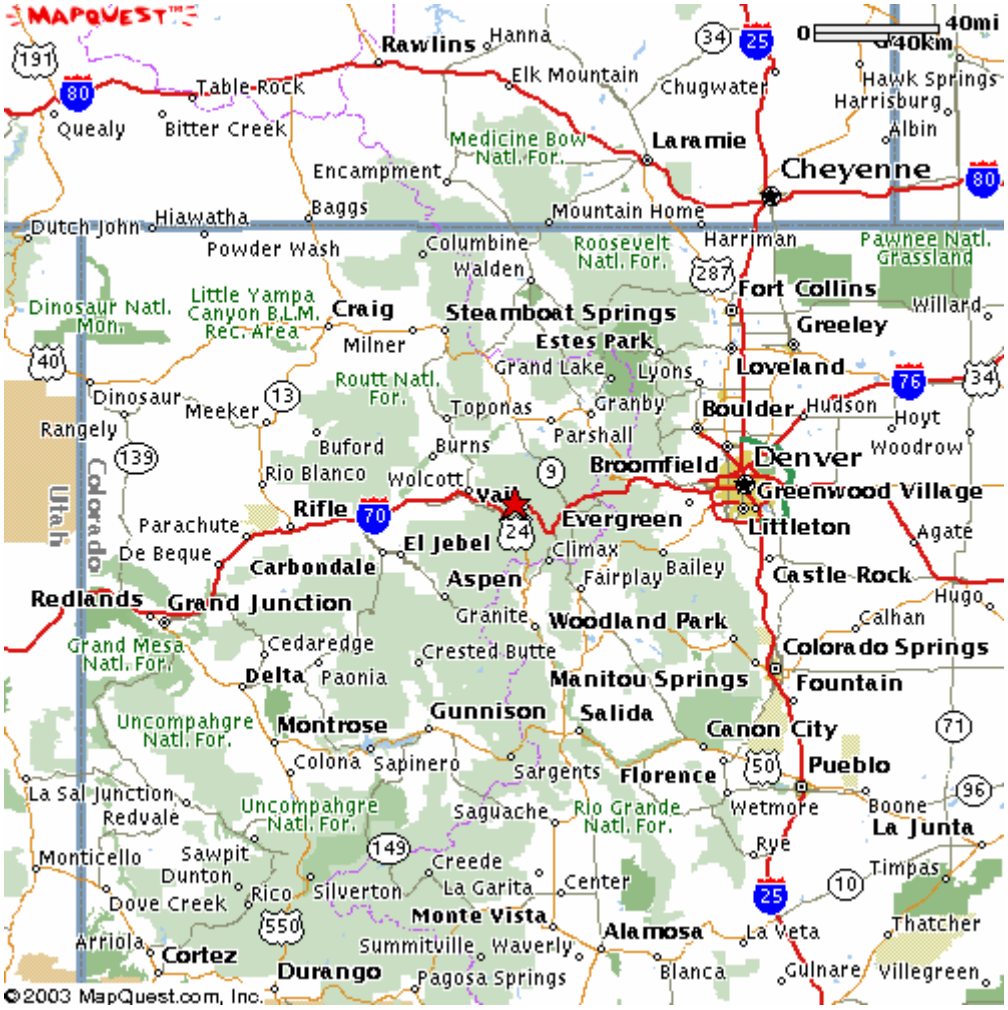

Figure 1.3 – Map of Vail, Colorado in Relation to the Front Range Area.

Storm Characteristics and Information

Obtaining rainfall information and storm characteristics for the event in Vail 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 the damage associated with this event was attributed to the combination of several factors, not just the thunderstorm, facts about the storm itself were not found.

According to the National Climatic Data Center's NEXRAD radar images, a small pocket of storm activity moved over the Vail area sometime after 5:00PM. The images are shown below, in Figures 1.4 through 1.12. Next to Figures 1.4 and 1.6 is a legend indicating the higher the color number, the more intense the storm. In order to locate the city of Vail on the NEXRAD radar images, Figure 1.13, on the next page, contains a map of the state of Colorado with Vail highlighted.

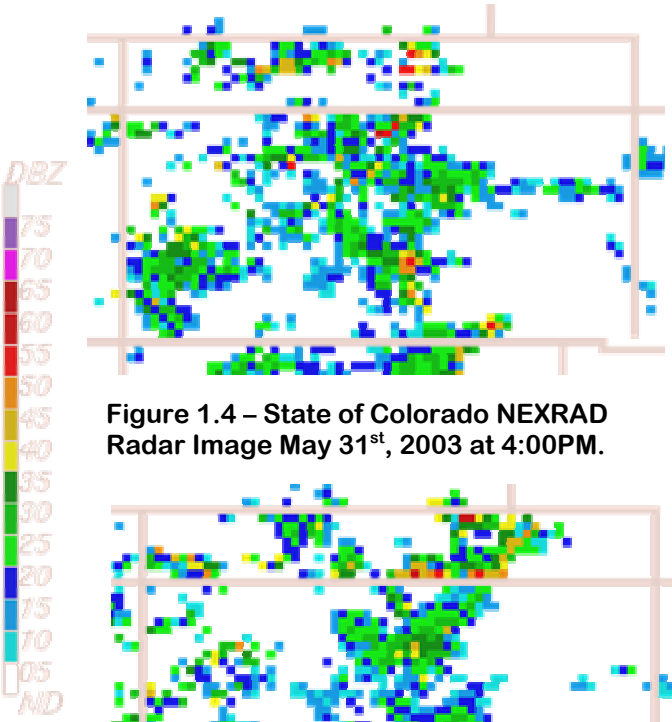

Figure 1.4 – State of Colorado NEXRAD Radar Image May 31st, 2003 at 4:00PM.

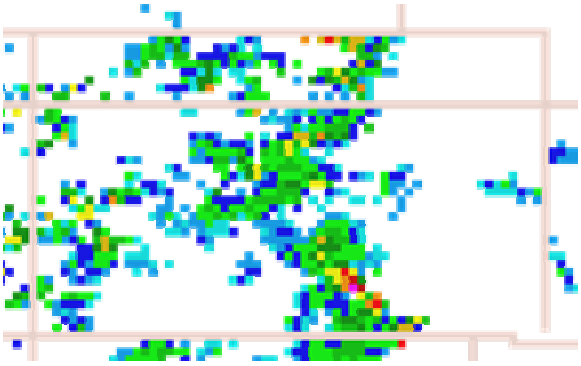

Figure 1.5 – State of Colorado NEXRAD Radar Image May 31st, 2003 at 5:00PM.

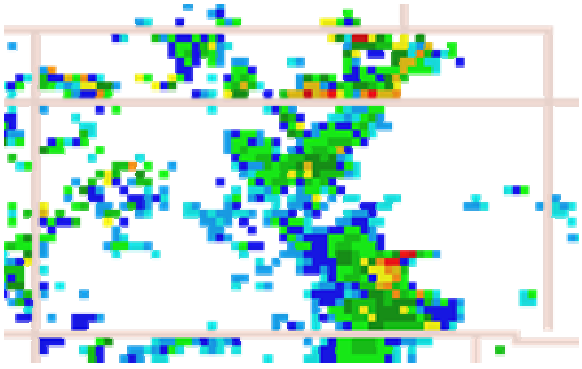

Figure 1.6 – State of Colorado NEXRAD Radar Image May 31st, 2003 at 6:00PM.

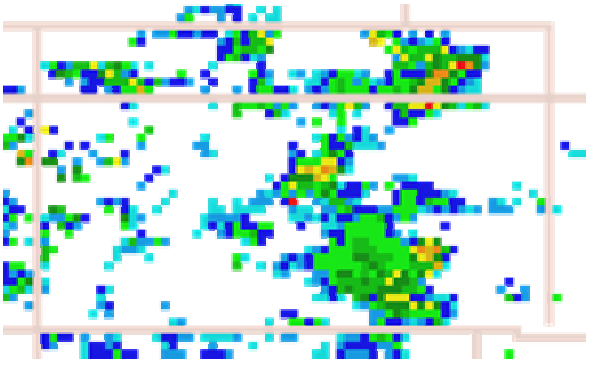

Figure 1.7 – State of Colorado NEXRAD Radar Image May 31st, 2003 at 7:00PM.

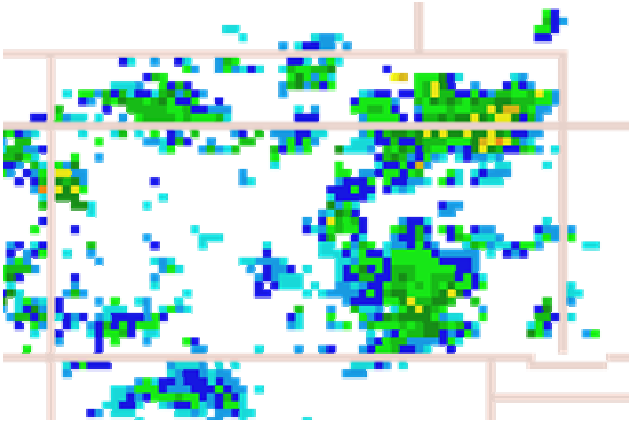

Figure 1.8 – State of Colorado NEXRAD Radar Image May 31st, 2003 at 8:00PM.

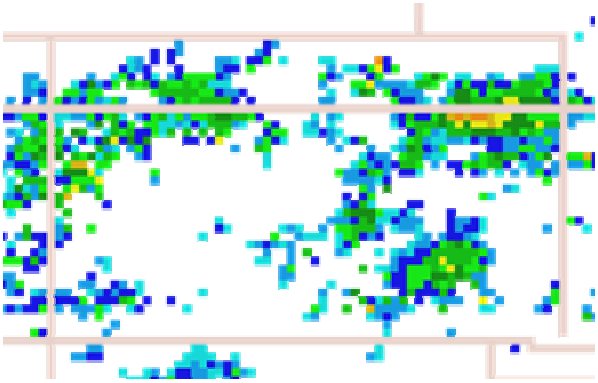

Figure 1.9 – State of Colorado NEXRAD Radar Image May 31st, 2003 at 9:00PM.

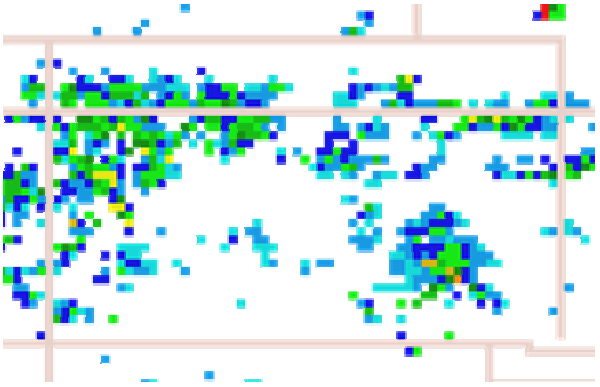

Figure 1.10 – State of Colorado NEXRAD Radar Image May 31st, 2003 at 10:00PM.

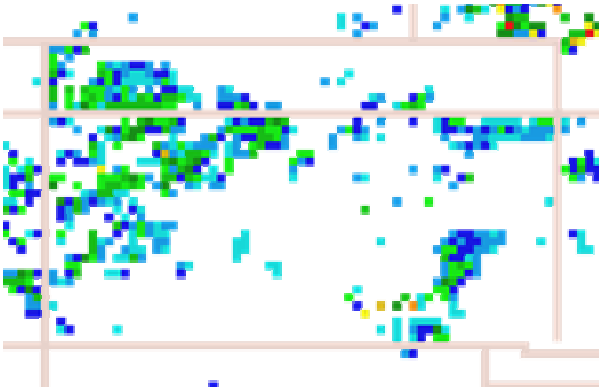

Figure 1.11 – State of Colorado NEXRAD Radar Image May 31st, 2003 at 11:00PM.

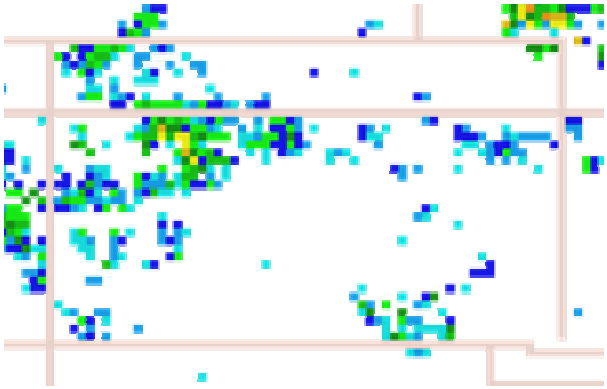

Figure 1.12 – State of Colorado NEXRAD Radar Image June 1st, 2003 at 12:00AM.

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

An accurate daily precipitation amount was not found for this event. Several town officials were contacted to find precipitation amounts for the storm but no values were obtained. Various weather-related web sites were also investigated to no avail. However, a weekly precipitation amount was obtained from a map located on the Intellicast website for the week including the storm date. This map is shown on the following page in Figure 1.14. The Eagle County area is highlighted using a red box. According to the map, the area around the city of Vail received approximately 1 to 2 inches of total precipitation for that week.

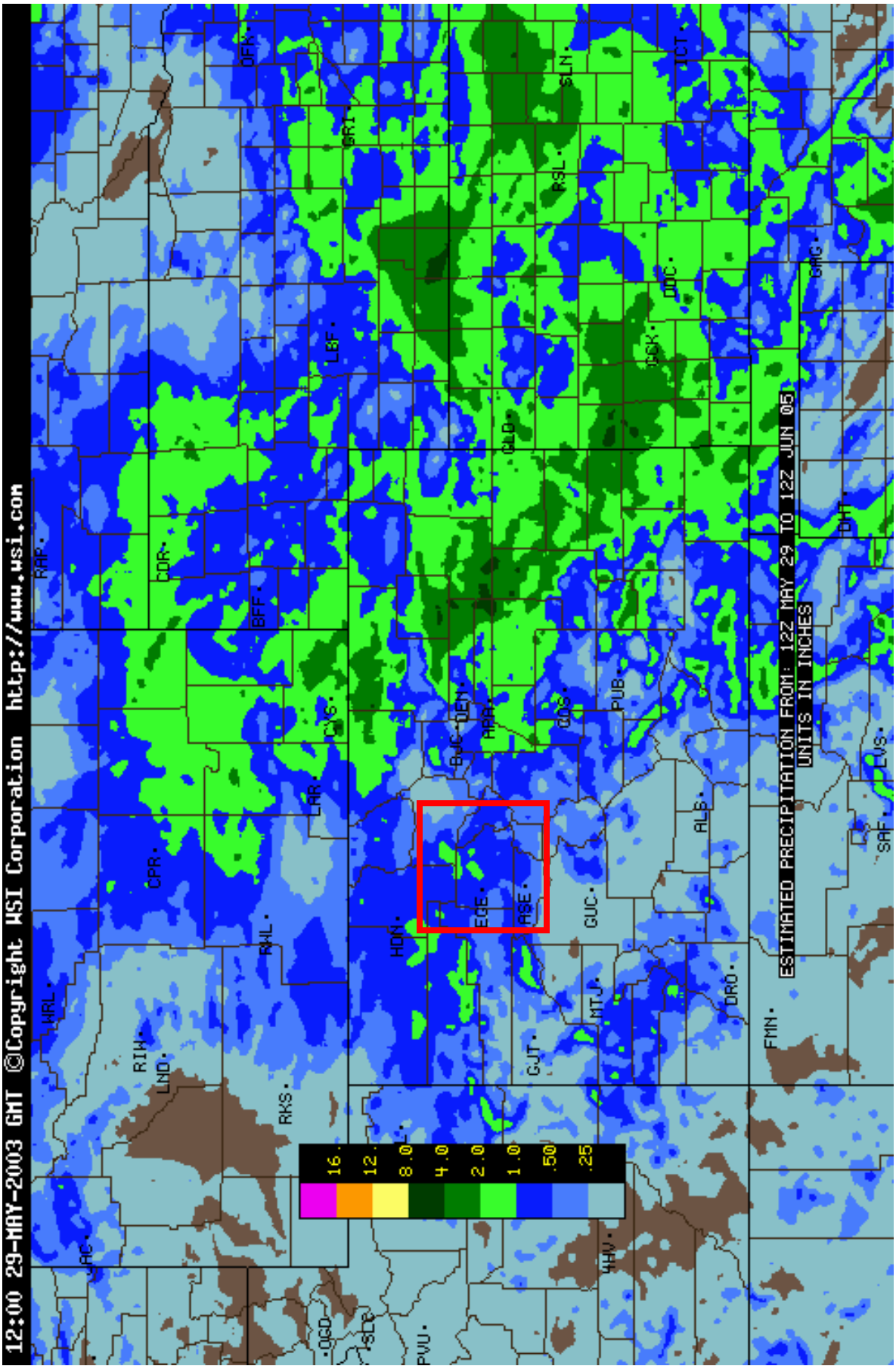

Figure 1.14 – Estimated total weekly precipitation for the state of Colorado, and surrounding area, for week of May 29th thru June 5th, 2003.
Map Courtesy www.intellicast.com

Hydrologic and Hydraulic Conclusions

The Eagle River is the major river in the Vail area. This river flows to the west through the area where it receives inflow from several creeks in the region. Bighorn Creek is on the eastern end of town and flows to the south until its confluence with Gore Creek. Gore Creek continues to the west until its confluence with the Eagle River.

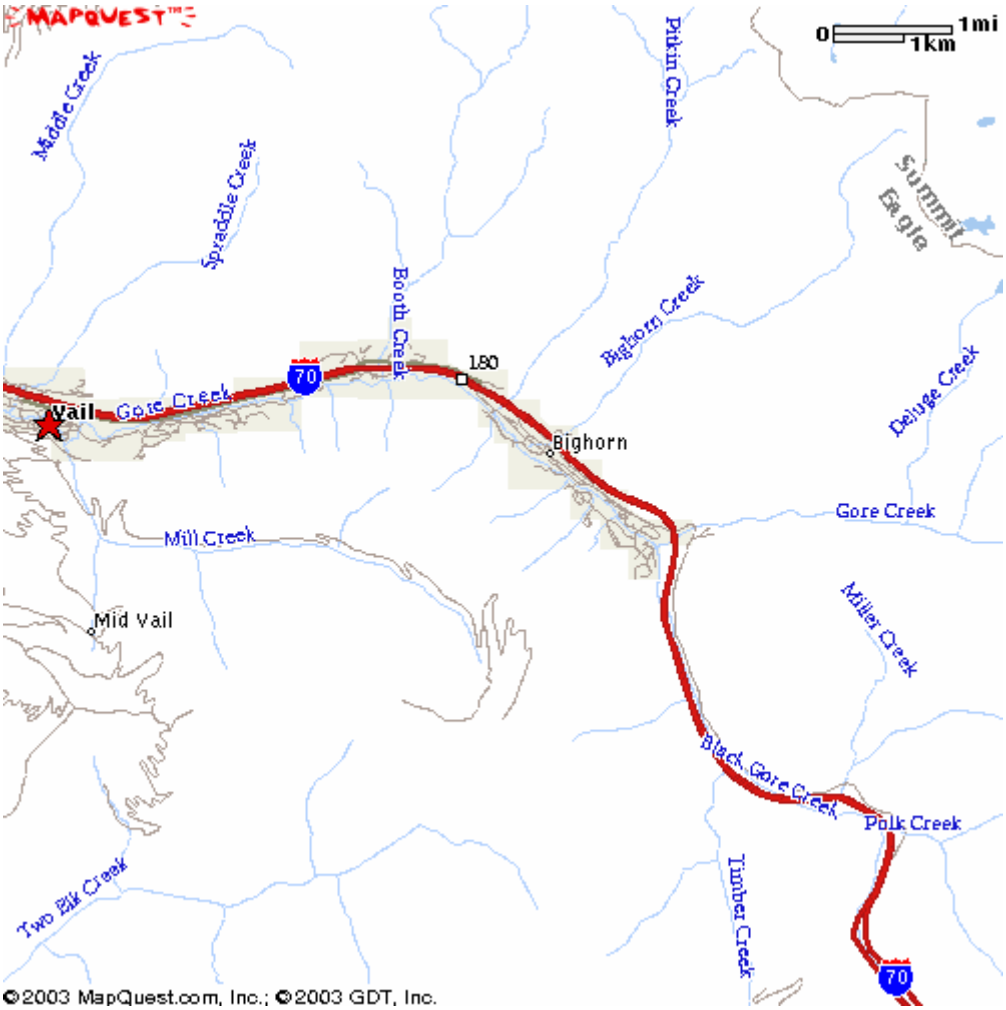

Figure 1.15 – Map of Vail Colorado Showing the Surrounding Creeks.

A Flood Insurance Study (FIS) was available for the City of Vail. This document included flood profiles for Bighorn Creek, as well as a summary of peak discharges at a United States Geological Survey (USGS) Gage (#661) along the creek, just upstream of the confluence with Gore Creek. Recent gage flow data, including data from the evening of the storm, was then obtained with the help of the USGS. The highest recorded peak flow during the storm was then compared to the peak discharge values from the Flood Insurance Study in order to approximate an event frequency. The results of this analysis are summarized below in Table 1.1.

Table 1.1 – Hydraulic Analysis Summary

	May 31, 2003 Storm
10-Year Peak Discharge (cfs)	160*
50-Year Peak Discharge (cfs)	220*
Peak Gage Discharge During Event (cfs)	165
Est. Event Frequency	**10-Year**

* Values obtained from Town of Vail Flood Insurance Study Dated November 1992

Based on the forgoing table, it is apparent that the peak flow was near the estimated 10-year event from the Flood Insurance Study. Additional flow gage data was available for creeks and rivers in the area. These gages did show a peak discharge occurring on the date of the storm and are included in the Additional Support Information section of this chapter for reference purposes only.

Base flow in the Bighorn Creek contributed to the flood's damage and intensity. Runoff from melting snow combined with the rain from the storm, intensifying the duration of water flowing through Bighorn Creek. The amount of melting snow was relatively large due to the above average annual snow pack, and due to a large blizzard that occurred in late March that dumped as much as 7-feet of wet heavy snow in the region. Before the May 31st storm, the Vail area experienced several days of warm weather with above average temperatures. It is believed that these temperatures increased the amount of runoff from snow melt that flowed into Bighorn Creek.

Flooded Area Description

Areas of East Vail, and the nearby area, that were inundated with water and debris include: 125 homes in the East Vail neighborhood, Bighorn Road, Columbine Drive, Spruce Way, several side streets, a small pond along the northern side of I-70 at mile marker 181, the area surrounding a 60" CMP culvert that failed at mile marker 181 of I-70, and a small box culvert (Columbine Drive underpass) used for limited vehicle access across (under) I-70. I-70 was closed from the initial pipe collapse (which was estimated to have occurred at 12:30 P.M. on Sunday, June 1), until two lanes were opened to traffic on Wednesday, June 4th. Four lanes were opened in a temporary configuration on Monday, June 16th.

Estimated Flood Damages & Any Special Factors Affecting the Flood

Damages sustained from the flood were extensive. In an official news release from the Town of Vail dated 6/10/2003, damage estimates were as follows:

- $150,000 in damage to the Town of Vail's Public Infrastructure (includes streets, culverts, and other drainage systems)
- More than $2,000,000 in damage and repair costs for the failed culvert causing the closure of I-70 at mile marker 181

- $100,000 in flood mitigation and emergency response costs for more than 9 different government agencies involved in the flood response

No estimates were found for lost business revenue or any increase in transportation costs to trucking companies due to the closure of Interstate 70.

No injuries or casualties were reported from this event. This is most likely due to evacuations of approximately 220 properties using the town's reverse 911 system as well as door-to-door evacuations.

Several special factors were thought to have contributed to the effects of the flood. The major factor being the failure of a Corrugated Metal Pipe (CMP) that crosses under the interstate. This failure caused a 20 by 20-foot sinkhole to form under I-70 closing the interstate to all traffic for several days. The culvert failure also caused Bighorn Creek to leave its flow path inundating the eastern part of Vail. Once the culvert failed and water began to pool along I-70, the flow traveled northwest until it encountered the box culvert at the Columbine Street Underpass. The water traveled through the culvert and emptied into the East Vail neighborhood flowing through local streets and residences before finally emptying into Gore Creek once again.

Based upon information provided by CDOT, and based upon the data provided by the USGS gage station on Bighorn Creek, it is apparent that the design capacity of the culvert under I-70 was not exceeded. Rather, it is believed that abrasion and corrosion occurred in the pipe invert, resulting from potentially years of high flow velocities coupled with high sediment bed load. It is further believed that a grade break in the pipe slope may have contributed to failure at a pipe joint. The original pipe was a 66-inch CMP laid at a slope varying from 8% to 15%. Bury depth of the pipe was approximately 40-feet deep. It is believed that the pipe invert buckled upwards, allowing flows along the outside of the pipe, which washed away soil supporting the pipe, creating the sinkhole.

A site visit was conducted on Tuesday June 19, 2003 by several ICON Engineering personnel. At that time, repair of the CMP was still actively underway. In fact, construction of the repairs continued on a 24-hour basis, seven days a week for a six week period. Enclosed with this report are several pictures of the area that was impacted by the flooding. The pictures are provided by the City of Vail, and by ICON Engineering as noted. Additional information was provided courtesy of CDOT.

Additional Support Information

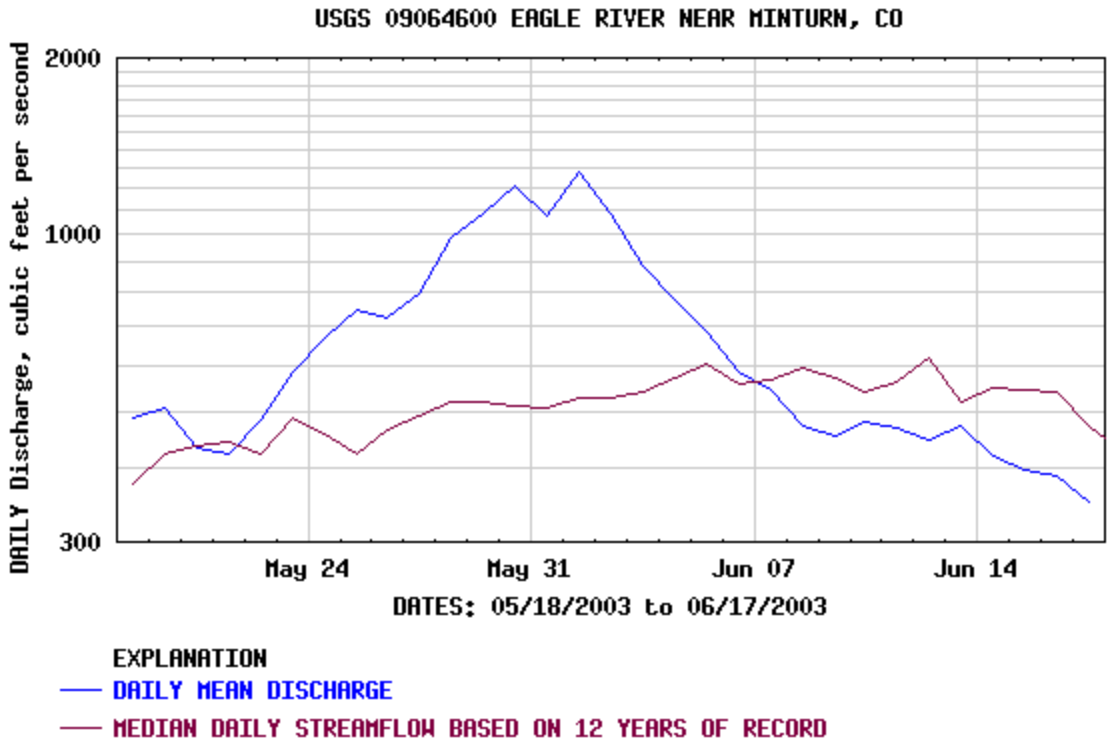

Figure 1.16 – Graph of Daily Discharge for USGS Flow Gage on Eagle River.

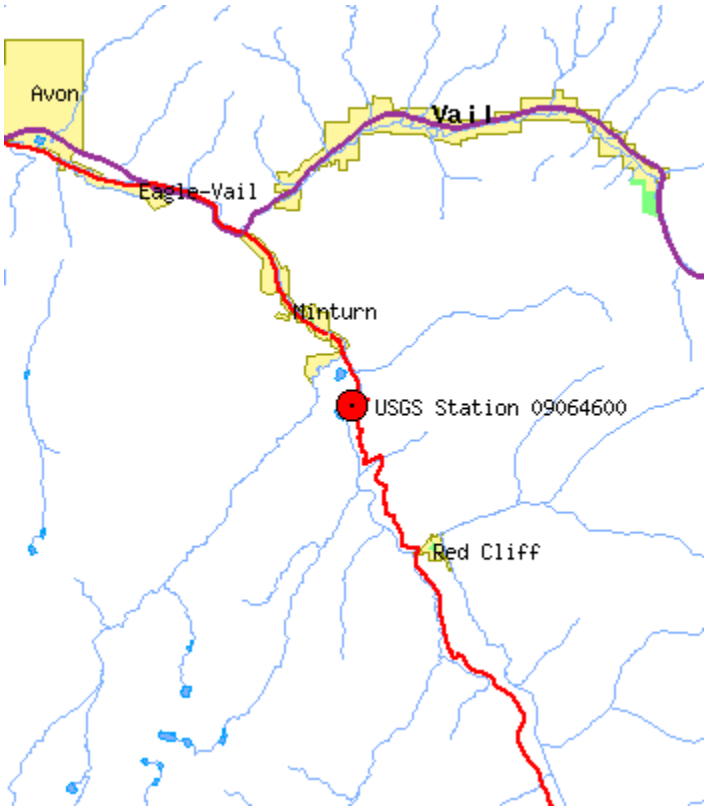

Figure 1.17 –Map of Eagle River Gage Location.

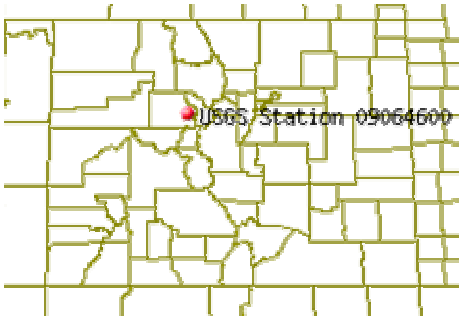

Figure 1.18 – Eagle River Gage Location in Relation to the State of Colorado.

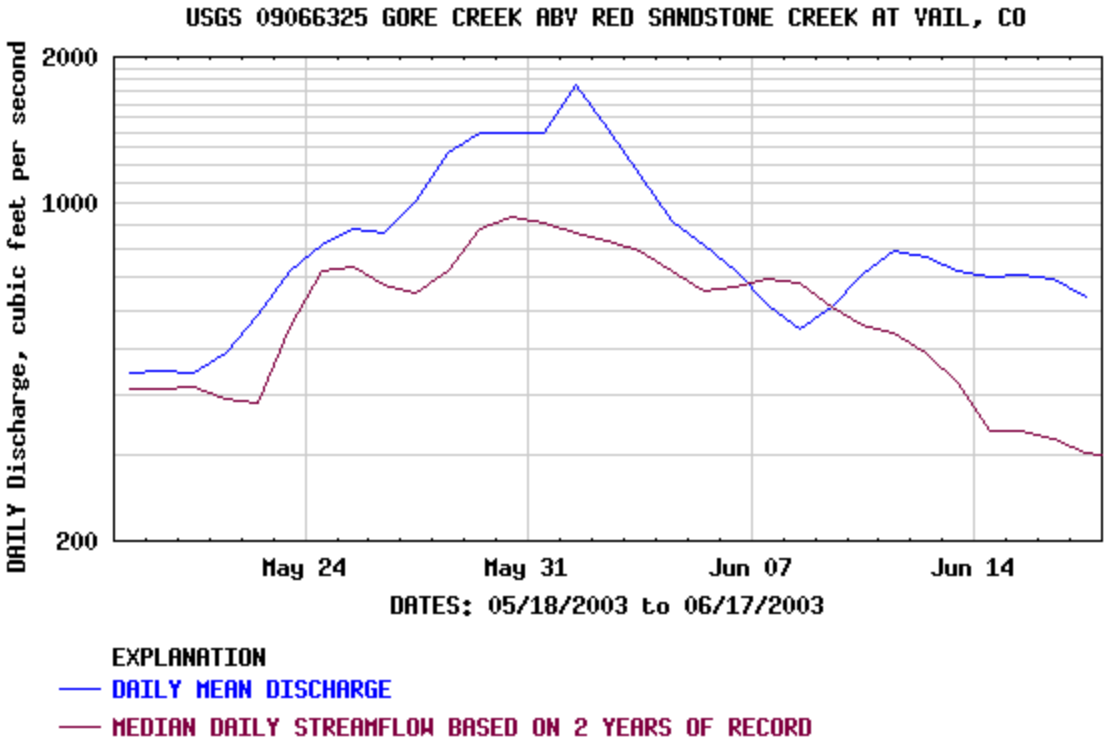

Figure 1.19 – Graph of Daily Discharge for USGS Flow Gage on Gore Creek Above Red Sandstone Creek.

Figure 1.20 –Map of Gore Creek Above Red Sandstone Creek Gage Location.

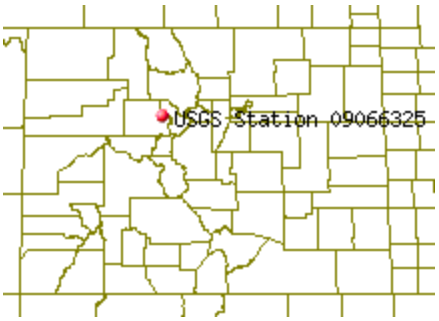

Figure 1.21 – Gore Creek Gage Location in Relation to the State of Colorado.

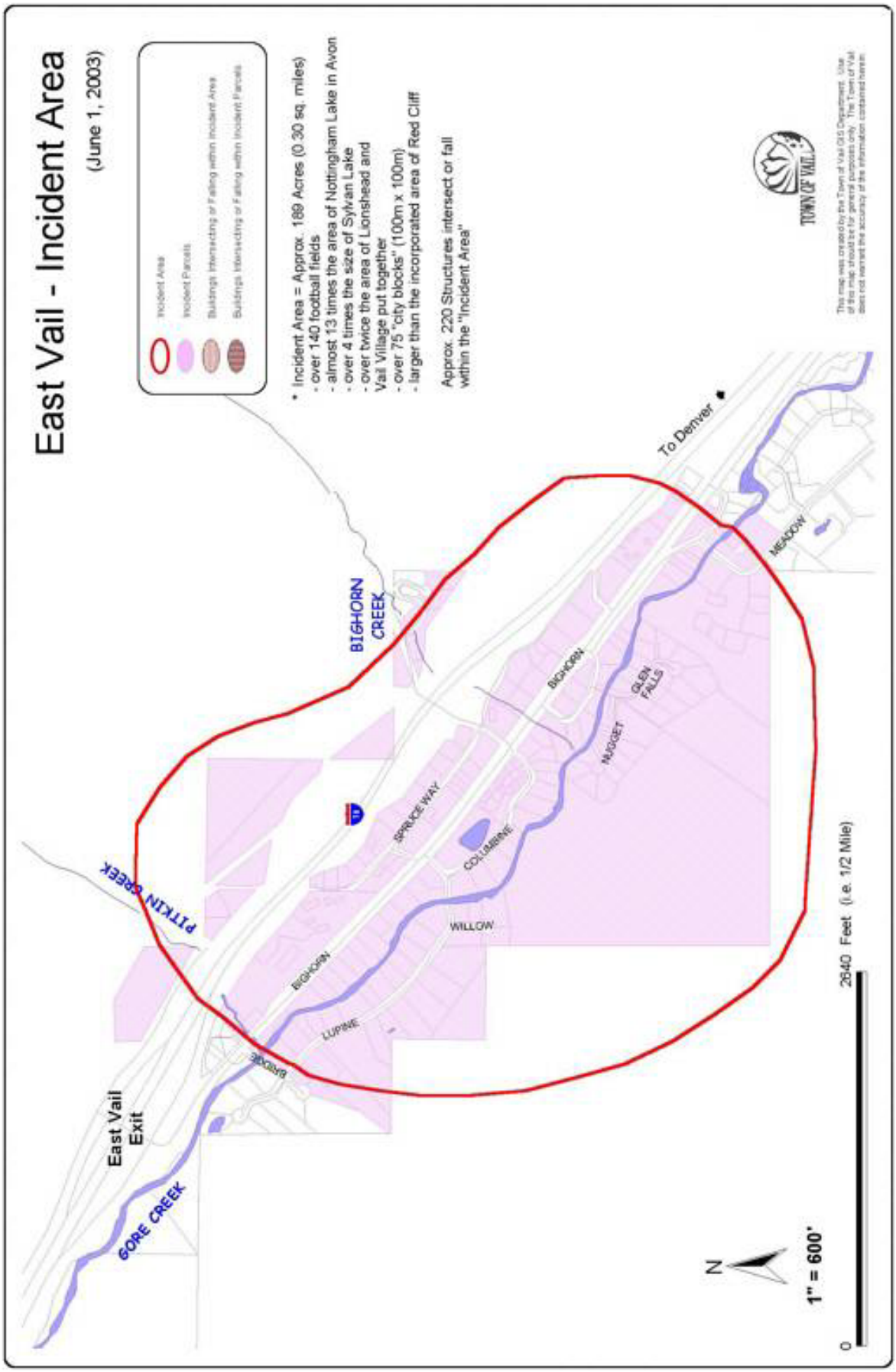

Figure 1.22 – Figure Showing East Vail Flood Impact Area Created by the Town of Vail.

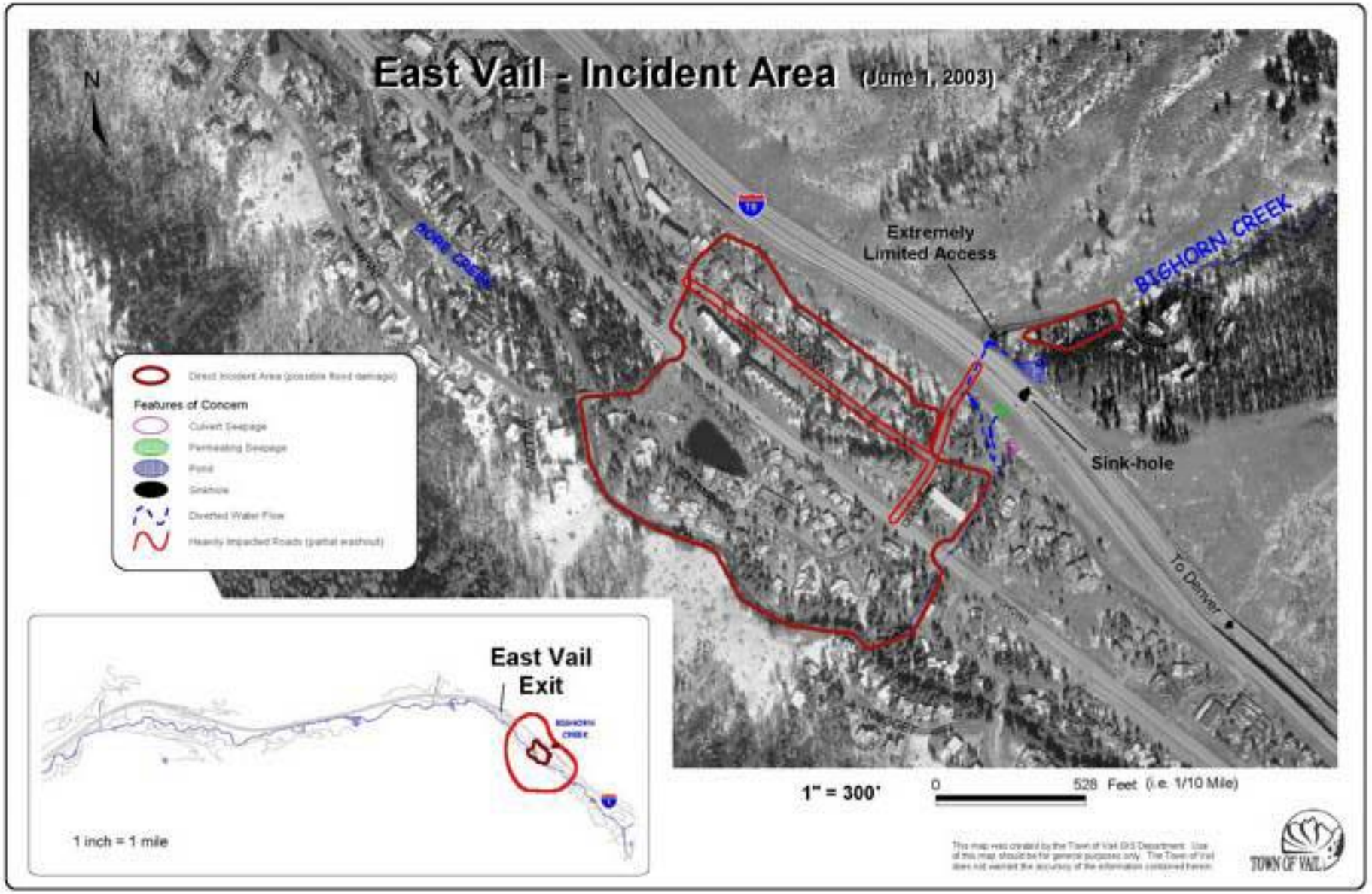

Figure 1.23 – Figure Showing Aerial View of East Vail Flood Impact Area Created by the Town of Vail.

Figure 1.24 –Picture of Interstate 70 Sinkhole
Courtesy of Colorado Department of Transportation

Figure 1.25 –Picture of Corrugated Metal Pipe Degradation at I-70 Culvert
Courtesy of Colorado Department of Transportation

Figure 1.26 –Picture of Culvert at Columbine Drive Underpass
Courtesy of Colorado Department of Transportation

Figure 1.27 –Picture of Hillside Erosion Along I-70 at Mile Marker 181
Courtesy of Colorado Department of Transportation

Figure 1.27 –Picture of Spruce Way Looking West after the Storm
Courtesy of Town of Vail

Figure 1.28 –Picture of Damage to Columbine Drive
Courtesy of Town of Vail

Figure 1.29 –Picture of Damage to Columbine Drive below Interstate 70
Courtesy of Town of Vail

Figure 1.30 –Picture of Debris Pile at Pond near Columbine Drive after the Storm
Courtesy of Site Visit by ICON Engineering, Inc.

Figure 1.31 –Close-up Picture of Debris Pile at Pond near Columbine Drive
Courtesy of Site Visit by ICON Engineering, Inc.

Figure 1.31 – Picture of Erosion Damage to Spruce Way
Courtesy of Site Visit by ICON Engineering, Inc.

Figure 1.31 – Picture of Debris Piles and High Water Mark on Residence along Spruce Way
Courtesy of Site Visit by ICON Engineering, Inc.