FLOOD INSURANCE STUDY

VOLUME 1 OF 4

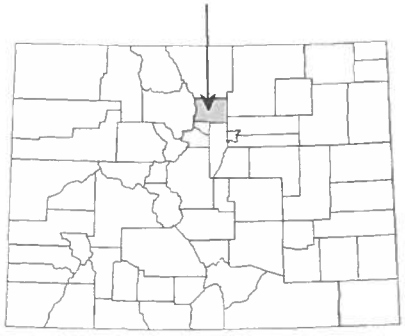
BOULDER COUNTY, COLORADO

AND INCORPORATED AREAS

Community Name	*Community Number*
BOULDER, CITY OF	080024
BOULDER COUNTY (UNINCORPORATED AREAS)	080023
ERIE, TOWN OF	080181
JAMESTOWN, TOWN OF	080216
LAFAYETTE, CITY OF	080026
LONGMONT, CITY OF	080027
LOUSIVILLE, CITY OF	085076
LYONS, TOWN OF	080029
NEDERLAND, TOWN OF	080255
SUPERIOR, TOWN OF	080203
*WARD, TOWN OF	080292

* No Special Flood Hazard Areas Identified

Boulder County



Revised: December 18, 2012

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
08013CV001B

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) report may not contain all data available within the Community Map Repository. Please contact the Community Map Repository for any additional data.

The Federal Emergency Management Agency (FEMA) may revise and republish part or all of this FIS report at any time. In addition, FEMA may revise part of this FIS report by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS report. Therefore, users should consult with community officials and check the Community Map Repository to obtain the most current FIS report components.

Initial Countywide FIS Effective Date: June 2, 1995

Revised FIS Dates: May 6, 1996
October 4, 2002
December 18, 2012

NOTE: The South Boulder Creek floodplain, flood profiles and base flood elevations are based on two-dimensional modeling which provides highly detailed results that reveal multiple flow paths and significant variations in base flood elevations across the floodplain. The multiple profiles and the highlighted base flood elevations (BFEs) provide some detail that can be used to establish flood hazard at various locations across the floodplain. However, use of BFEs from the MIKE FLOOD BFE contour mapping or inundation raster GIS data is recommended to ensure accurate determination of BFEs for any given location.

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FLOOD INSURANCE STUDY
BOULDER COUNTY, COLORADO AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and supersedes the FIS reports and/or Flood Insurance Rate Maps (FIRMs) in the geographic area of Boulder County, Colorado, including the Cities of Boulder, Lafayette, Longmont, and Louisville, and the Towns of Erie, Jamestown, Lyons, Nederland, Superior, and Ward, and unincorporated areas of Boulder County (hereinafter referred to collectively as Boulder County) and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates. This information will also be used by Boulder County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

Please note that the City of Longmont and the Town of Erie are geographically located in Boulder and Weld Counties. The Town of Superior is geographically located in Boulder and Jefferson County. The City of Longmont and Towns of Erie and Superior are included in their entirety in the Boulder County FIS report. Also note that there are no special flood hazard areas shown in the Town of Ward.

The City and County of Broomfield has a separately published FIS report and FIRM panels with an effective date of August 18, 2004. Broomfield has been removed from this FIS report and any references made on the Boulder County FIRM panels are for informational purposes only.

The Town of Erie has a separately published FIS report and FIRM panels with an effective date of December 2, 2004. This data has been incorporated in its entirety into this FIS.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The countywide FIS was prepared by combining data from the Cities of Boulder, Lafayette, Longmont, and Louisville, and the Towns of Erie, Jamestown, Lyons, Nederland, and Superior, and unincorporated areas of Boulder County. Information on the authority and acknowledgements as compiled from their previously printed individual FIS reports is shown below.

Boulder County (Unincorporated Areas)

The hydrologic and hydraulic analyses for the original study for the unincorporated areas of Boulder County were performed by the U.S. Soil Conservation Service (SCS), for the Federal Emergency Management Agency (FEMA), under Interagency Agreement No. IAAA-H-16-72, Project Order No. 5. This study was completed in August 1974.

City of Boulder

The hydrologic and hydraulic analyses for the original study for the City of Boulder were performed by the U.S. Army Corps of Engineers (USACE), for FEMA, under Interagency Agreement No. IAA-H-15-72, Project Order Nos. 2 and 3, Amendment No. 1. This work was completed in October 1975.

The original hydrologic and hydraulic analyses completed for South Boulder Creek was developed by Greenhorne and O'Mara, Inc. in 1986 using a traditional floodplain mapping approach. The hydrologic and hydraulic analyses for South Boulder Creek were updated by HDR Engineering, Inc (HDR). This work was completed in 2009.

Revised hydrologic and hydraulic analyses for the City of Boulder for Boulder Creek were completed in January 1983 by Muller Engineering Co, Inc.

Revised hydrologic and hydraulic analyses for the City of Boulder for Wonderland, Fourmile Canyon, Skunk Canyon, Bear Canyon, Twomile, and Goose Creeks were performed by MSM/SP Group, for FEMA, under Contract No. EMW-C-0709. This work was completed in April 1985.

Revised hydrologic and hydraulic analyses for the City of Boulder for Sunshine Canyon, Gregory Creek, Bluebell Canyon, and Fourmile Canyon Creeks and Kings Gulch were done by Greenhorne and O'Mara, Inc. This work was completed in August 1983.

Town of Erie

The hydrologic and hydraulic analyses for the area north of Perry Street, dated April 1978, were performed by Gingery Associates, Inc. (GAI), for FEMA, under Contract No. H-4017. Subsequent refinements of this hydrologic and hydraulic data were developed by Water Resources Consultants, Inc (WRC), in August 1980, and Michael Baker, Jr., Inc., in March 1981.

The hydrologic and hydraulic analyses for the reach of Coal Creek, south of the Union Pacific Railroad (UPRR), were performed by the U.S. Department of the Interior, Bureau of Reclamation, for FEMA, under Contract No. EMW-87-E-2551. This study was completed in August 1988.

Town of Jamestown

The hydrologic and hydraulic analyses for the original study for the Town of Jamestown were performed by Howard, Needles, Tammen & Bergendorff, for FEMA, under Contract No. H-4016. This work, which was completed in February 1978, covered all significant flooding sources.

City of Lafayette

The hydrologic and hydraulic analyses for the original study for the City of Lafayette were performed by Howard, Needles, Tammen & Bergendorff, for FEMA, under Contract No. H-4016. This work was completed September 1977.

City of Longmont

The hydrologic and hydraulic analyses for the original study for the City of Longmont were performed by Gingery Associates, Inc., for FEMA, under Contract No. H-3716. This work was completed in March 1976.

The additional hydrologic and hydraulic analyses for the City of Longmont for the revised study were performed by Gingery Associates, Inc., Simons, Lee and Associates, and Water Resources Consultants, Inc., for the Colorado Water Conservation Board (CWCB), as reported in floodplain information reports for Lefthand Creek, and for Dry Creek No. 1 and St. Vrain Creek.

City of Louisville

The hydrologic and hydraulic analyses for the original study for the City of Louisville were performed by the Soil Conservation Service (SCS), for FEMA, under Interagency Agreement No. IAA-H-16-72, Project Order No. 16. This work was completed in January 1973.

Town of Lyons	The hydrologic and hydraulic analyses for the initial study for the Town of Lyons were performed by Howard, Needles, Tammen & Bergendorff, for FEMA, under Contract No. H-4016. This work, which was completed in October 1977, covered all significant flooding sources affecting the Town of Lyons.
Town of Nederland	The hydrologic and hydraulic analyses for the original study for the Town of Nederland were performed by Howard, Needles, Tammen & Bergendorff, for FEMA, under Contract No. H-4016. This work was completed in November 1978.
Town of Superior	The hydrologic and hydraulic analyses for the original study for the Town of Superior were performed by Howard, Needles, Tammen & Bergendorff, for FEMA, under Contract No. H-4016. This work was completed October 1977.

There was no previously printed Flood Insurance Study for the Town of Ward.

The revised hydrologic and hydraulic analyses for these studies were performed by various engineering firms for the purposes of floodplain evaluation and are discussed in Section 7.0.

The digital base mapping information was provided by the FEMA Map Service Center, P.O. Box 1038, Jessup, Maryland 20794-1038, and the Boulder Area Spatial Information Cooperative (BASIC), P.O. Box 471, Boulder, CO 80306. Additional input was provided by the Town of Erie, P.O. Box 750, Erie, CO 80516, and the City of Longmont, 350 Kimbark Street, Longmont, CO 80501. The road and railroad data for Boulder County were provided by the Boulder County GIS Department. Further information about these road and railroad files can be obtained by contacting the GIS Department. Road data was also obtained from the Town of Erie, and was created at a scale of 1:20,000 or better. Further information about the Erie road information can be obtained by contacting the Town of Erie. The Boulder County and Erie road data were then merged into 1 database that met FEMA specifications. The coordinate system used for the projection of the FIRMs is Colorado State Plane North FIPS 0501 Feet, North American Datum of 1983, GRS80 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of information shown on the FIRMs.

1.3 Coordination

For this revision of the countywide FIS, the initial CCO meeting was held on October 2, 2003, and was attended by representatives of FEMA, CWCB, UDFCD, Boulder County, City of Boulder, Town of Erie, Town of Jamestown, City of Lafayette, City of Longmont, City of Louisville, Town of Lyons, Town of Superior, and the study contractor.

An intermediate CCO meeting was held on December 9, 2004, and was attended by representatives of FEMA, CWCB, Boulder County, City of Boulder, Town of Erie, City of Jamestown, City of Longmont, Town of Lyons, and the study contractor. The purpose of this meeting was to present preliminary results of the study to the communities.

The results of the study were reviewed at a CCO meeting held on August 16, 2005, and attended by representatives of FEMA, CWCB, Boulder County, City of Boulder, Town of Erie, Town of Longmont, Town of Lafayette, and the study contractor. All problems raised at the meeting were addressed.

The results of the revised study were reviewed at the final CCO meeting held on July 7, 2010, and attended by representatives of FEMA, CWCB, Boulder County, City of Boulder, Town of Erie, Town of Longmont, Town of Lafayette, and the study contractor. All problems raised at the meeting have been addressed.

For the October 4, 2002 revision of the countywide FIS, the initial Consultation Coordination Officer (CCO) meeting was held on August 4, 1993. This meeting was attended by representatives of Boulder County, the Cities of Broomfield and Lafayette, the Towns of Erie and Superior, CWCB, the Urban Drainage and Flood Control District (UDFCD), and the study contractor.

The countywide FIS was prepared by combining data from the Cities of Boulder, Lafayette, and Longmont, and the Towns of Erie, Jamestown, Lyons, Nederland, and Superior, and unincorporated areas of Boulder County. Information on the coordination of the original studies as compiled from their previously printed individual FIS reports is shown below.

Boulder County (Unincorporated Areas)

During the preparation of the original study for the unincorporated areas of Boulder County, the following were contacted: the USACE, Omaha District; the U.S. Geological Survey (USGS), Water Resources Division, Colorado District Office; the U.S. Weather Bureau; Denver Regional Council of Governments; UDFCD; CWCB; Boulder County; and the City of Longmont.

The final coordination meeting for the original study for the unincorporated areas of Boulder County was held on July 13, 1976, and attended by representatives of FEMA, the study contractor, and the county. Comments from county officials and citizens were taken into account.

City of Boulder

An initial coordination meeting for the revision of the original study for the City of Boulder was held in Boulder on July 30, 1981. This meeting, attended by representatives of the City of Boulder, FEMA, MSM/SP Group, UDFCD, CWCB, and Boulder County, was held to discuss the nature and purpose of the study and the scope and limits of work.

The following agencies and individuals were contacted and supplied information used in the preparation of this revised study: USGS; USACE, Omaha District; CWCB; the City of Boulder Engineering Department; the Boulder County Engineering Department; UDFCD; and the Colorado Department of Highways.

Town of Erie

Initial meetings to identify streams requiring detailed study within the Town of Erie were held on March 31 and April 16, 1976. These meetings were attended by representatives of the CWCB, FEMA, the Weld County Planning Department, and GAI. Another meeting was held on January 28, 1977, and was attended by representatives of FEMA, the Major and Town Clerk of Erie, and GAI. The purpose of this meeting was to gather flooding information and to outline study procedures for the reach of Coal Creek, north of the UPRR, near Perry Street. The U.S. Soil Conservation Service (SCS) (now the Natural Resources Conservation Service) was also contacted for information concerning flood hazards.

A final coordination meeting for this reach of the study was held on November 7, 1977. The meeting was attended by FEMA, officials from the Town of Erie, interested local groups, and GAI.

On October 6, 1987, a meeting was held between representatives of FEMA, the Town of Erie, and the U.S. Department of the Interior, Bureau of Reclamation. The purpose of this meeting was to discuss the detailed analysis of flood hazards along Coal Creek, south of the UPRR. The Town of Erie provided maps, which were used in the analysis.

In addition, the SCS, USGS, USACE, and the CWCB were contacted for pertinent technical information regarding flood hazards within the Town of Erie. The SCS provided a copy of its flood hazard analysis, "Coal Creek and Rock Creek, Boulder and Weld Counties, Colorado," dated October 1976. The SCS also provided hydraulic backwater computer model input for Coal Creek near Erie. The USGS provided copies

of flood prone area maps for the study area. The USACE indicated that it had no pertinent technical information that could be included in the Coal Creek Study.

The CWCB provided a copy of the Technical Addendum, "Floodplain Information, Flood Control and Floodplain Management Plan for Coal Creek at Erie, Colorado," prepared by WRC, dated August 1980. The addendum contained copies of the HEC-2 computer modeling for a portion of the study area. Robinson Engineering, Inc. (REI) was contacted in response to a recommendation from the Town of Erie. REI provided detailed topographic mapping for a portion of the study area.

Town of Jamestown

An initial coordination meeting for the original study for the Town of Jamestown was held on February 25, 1977, and attended by representatives of FEMA, the Mayor, several town council members, and the study contractor to discuss the areas to be studied and methods to be used.

A number of Federal agencies, including the SCS, the U.S. Forest Service, the USACE, and the CWCB were contacted for available data.

A general information search was made at the State Historical Society, the Denver Public Library, the Boulder County Courthouse, and the *Boulder Daily Camera* for historical background information, available publications, and photographs of past floods.

The final coordination meeting was held on August 7, 1978, and was attended by representatives of FEMA, the study contractor, and the town. All problems raised at the meeting were resolved.

City of Lafayette

An initial coordination meeting for the original study for the City of Lafayette was held on February 18, 1977, with representatives of FEMA, the City Manager, and Howard, Needles, Tammen & Bergendorff to discuss areas to be studied, and methods to be used. The SCS, CWCB, the Boulder County Courthouse, the USGS, and the State Historical Society were contacted for available data.

The results of the original study were reviewed at a final community coordination meeting held on July 18, 1978. Attending the meeting were representatives of FEMA, the study contractor, and the city. All problems raised at the meeting were resolved.

City of Longmont

The Longmont Engineering Department supplied zoning and corporate boundary maps for use in the initial study for the City of Longmont, as well as various detailed drawings for channel improvements, such as final construction plans for the Spring Gulch Linear Park and storm drainage facilities, dated January 1973, and the structural plans for the Pratt Street bridge, over St. Vrain Creek. The Longmont Planning Department supplied a copy of the St. Vrain Comprehensive Plan (Reference 5), which describes the comprehensive plan for what is called the Prime Urbanized Area (PMA) of Longmont. The Planning Department also provided a copy of the floodplain and floodway zoning ordinance, and various historical aspects of flooding and community development. Meetings were held with the City Planning and Engineering Department's staff on July 23, 1974; May 14, 1975; and December 30, 1975; to discuss detailed aspects regarding the streams studied.

The USACE, Omaha District, provided mapping of St. Vrain Creek and parts of Lefthand Creek, Dry Creek No. 1, and Spring Gulch (Reference 6). Computer input regarding the hydrology and hydraulic analyses for St. Vrain Creek and Lefthand Creek were also provided by the USACE. The floodplain information reports completed by the USACE in January 1969 for Lefthand Creek (Reference 7) and in June 1972 for Lower St. Vrain Creek (Reference 8) served as an important basis for comparison in the study. On October 16, 1974, a conference was held with the USACE to gather additional information on Longmont and to review potential problems.

The USGS was contacted to obtain historic flood flow data (References 9, 10, and 11). Maps of flood prone areas, prepared by the USGS, showing approximate floodplain delineations at a scale of 1:2,400 were also reviewed (Reference 12).

At a meeting on August 27, 1974, attended by representatives of the UDFCD, FEMA, and Gingery Associates, Inc., study reaches and methods for the initial study were decided. An additional meeting was held on January 24, 1975, in Washington, D.C., to further clarify the purpose of the study and the methods used for floodplain delineations.

Other agencies and individuals contacted for background information included the CWCB, the Colorado Highway

Department, and the Longmont *Daily Times-Call* newspaper. Private citizens of Longmont were also interviewed regarding past floods, high-water marks, and flood damage.

A final community coordination meeting for the initial study was held on January 7, 1976, by the Longmont Planning Department.

In April 1985, FEMA authorized the revision of the FIS for Longmont to incorporate the aforementioned floodplain information reports (References 1 through 4).

On August 5, 1986, the results of the revised study were discussed at the final community coordination meeting, which was attended by representatives of FEMA, the study contractor, and the community. All significant problems raised at that meeting were addressed in the revised study.

Town of Lyons

An initial coordination meeting for Lyons was held on February 25, 1977, and was attended by representatives of FEMA, the study contractor, and the Mayor of Lyons, to discuss areas to be studied and methods to be used. The USACE and CWCB were contacted for available data.

A general information search was made at the Denver Public Library and at the Boulder County Courthouse for historical background information, available publications, and photographs of past floods. The USGS and the State Historical Society were also contacted.

A final community coordination meeting, held on June 19, 1978, was attended by representatives of FEMA, the CWCB, the study contractor, city officials, and interested citizens. The study incorporated all appropriate comments, and all problems were resolved.

Town of Nederland

An initial coordination meeting for Nederland was held on February 18, 1977, attended by the study contractor, Nederland officials, and a representative of FEMA to discuss areas to be studied and methods to be used.

A number of Federal agencies, including the SCS, the U.S. Forest Service, and the USACE were contacted for available data. The CWCB was also contacted.

A general information search was made at the State Historical Society, the Denver Public Library, the Boulder

County Courthouse, and the *Boulder Daily Camera* for historical background information, available publications, and photographs of past floods.

Peak discharge-drainage area relationships used in the study were reviewed by the CWCB and were found to be acceptable.

The results of the study were reviewed at a final community coordination meeting held on July 11, 1978. Attending the meeting were representatives of FEMA, the study contractor, and the town. No problems were raised at the meeting.

Town of Superior

An initial coordination meeting for Superior was held on April 21, 1976, and attended by a representative of FEMA, the Mayor of Superior, and representatives of the Boulder County Planning and Public Works Department, the CWCB, and Howard, Needles, Tammen & Bergendorff. The purpose was to discuss areas to be studied and methods to be used. On February 18, 1977, representatives of FEMA, and Howard, Needles, Tammen & Bergendorff met in Superior to review the study limits.

The SCS, the CWCB, the Boulder County Courthouse, the USGS, and the State Historical Society were contacted for available data.

The results of the study were reviewed at a final community coordination meeting held on July 18, 1978. Attending the meeting were representatives of FEMA, the study contractor, the Boulder County Planning and Public Works Department, the CWCB, and the town. The study incorporated all appropriate comments, and all problems were resolved.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Boulder County, Colorado including the Cities of Boulder, Lafayette, Longmont, and Louisville, and the Towns of Erie, Jamestown, Lyons, Nederland, Superior, and Ward, and unincorporated areas of Boulder County.

The streams studied by detailed methods are presented in Table 1.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through 2004.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and Boulder County.

The following are streams for which only approximate flood hazards are presented: Anderson Ditch, Bluebell Canyon Creek, David's Draw, Gregory Creek, Kings Gulch, Little Dry Creek, Sunshine Gulch, and the upper and lower reaches of St. Vrain Creek.

Table 1 – Streams Studied by Detailed Methods

55th Street Split Flow
Arapahoe Avenue Overflow
Arapahoe Avenue Spill Flow
Balarat Creek
Bear Canyon Creek
Boulder Creek
Boulder Creek High School Overflow
Boulder Creek (Right Bank Overflow)
Bullhead Gulch
Canyon Boulevard Overflow
Clover Basin Tributary
Coal Creek
Dry Creek
Dry Creek Ditch No. 2
Dry Creek No. 1
Dry Creek No. 1 (Old Channel)
Dry Creek No. 2
Dry Creek No. 2 Ditch Split Flow
Dry Creek No. 3
Elmers Twomile Creek
Fourmile Canyon Creek
Fourmile Canyon Left Bank Overflow
Fourmile Creek
Goose Creek
Gregory Canyon Creek
Highway 93 Split Flow
James Creek
Lefthand Creek
Lefthand Creek (North Overflow Channel)
Lefthand Creek (South Overflow Channel)
Little James Creek
Little Thompson River
Middle Boulder Creek
Middle St. Vrain Creek
North Beaver Creek
North Goose Creek
North St. Vrain Creek
Prince Tributary, East Branch
Prince Tributary, West Branch
Rock Creek
St. Vrain Creek
St. Vrain Creek Secondary Channel
St. Vrain Creek (Vicinity of Lyons)
Skunk Creek
South Boulder Creek
South St. Vrain Creek
Spring Gulch
Steele Lakes Tributary
Twomile Canyon Creek
West Valley Split Flow
Wonderland Creek

2.2 Community Description

Boulder County (Unincorporated Areas)
Boulder County is located in north-central Colorado, approximately 50 miles south of the Colorado-Wyoming state line. In 2000, the population of Boulder County was 291,288 (Reference 13), an increase of 29.3 percent from a population of 225,339 in 1990 (Reference 14).

Boulder Creek is a steep mountain stream draining a portion of the eastern slope of the Rocky Mountains in Boulder County. The creek extends 22 miles eastward from the Continental Divide to emerge from the mountains and pass through the City of Boulder. Boulder Creek then flows 18 more miles to enter St. Vrain Creek five miles east of the City of Longmont. Boulder Creek drains an area of 440 square miles. Slightly more than one-half of the drainage area is in the mountains.

South Boulder Creek is a major tributary to Boulder Creek. This stream runs a parallel course to Boulder Creek through the mountains and emerges at El Dorado Springs. South Boulder Creek then turns north and joins Boulder Creek approximately two miles east of the City of Boulder.

The Bear Canyon Creek, Fourmile Canyon Creek, Skunk Creek, and Twomile Canyon Creek Basins originate in the foothills west of the City of Boulder. The terrain of these upstream subbasins is steep and rocky, and consists of topsoil in the C and D hydrologic soils groups, as classified by the SCS (Reference 15).

The entire reaches of Bear Canyon, Elmers Twomile, Fourmile Canyon, and Skunk Creeks consist of well-defined channels. Wonderland Creek has a well-defined channel, except for the reach southeast of Valmont Road. Both Goose and Twomile Canyon Creeks have extensive reaches without well-defined channels.

The Lefthand Creek watershed extends approximately 30 miles eastward from its headwaters in the Roosevelt National Forest to its confluence with St. Vrain Creek at the City of Longmont. Most of the watershed lies in the mountains and varies in elevations from 5,600 to 11,000 feet. The remainder of the watershed lies in the high plains. Until recently, the floodplain was devoted entirely to agriculture. Now, because of expanding population and industrialization, urban development has begun at both ends and in the middle of the study reach.

St. Vrain Creek is a continuously flowing stream that drains the east slope of the Continental Divide by way of North and South St. Vrain Creeks. From the confluence of these creeks at the Town of Lyons, St. Vrain Creek flows southeasterly through the City of Longmont, then northeasterly to the South Platte River. Dry Creek No. 1, Lefthand Creek, Spring Gulch, and Loomiller Basin join St. Vrain Creek within the City of Longmont.

The climate of the study area is classified as semiarid. The average annual precipitation is 18.3 inches, which includes an average annual snowfall of 83 inches (Reference 33). Location with respect to the foothills west of the City of Boulder has a slight influence on the total precipitation depths in the study-area subbasins. Those areas east of the foothills receive more precipitation (a few tenths of an inch per event) than the areas adjacent to the foothills. The occurrence of precipitation varies; however, most of the rainfall is concentrated in May. Thunderstorms also occur irregularly throughout the summer months. The temperature extremes in Boulder County are evidenced by mean maximums ranging from 46.3 degrees Fahrenheit (°F) in January to 88.3°F in July, and by mean minimums ranging from 21.6°F in January to 61.0°F in July.

City of Boulder

The City of Boulder is located in central Boulder County, along the foothills of the Front Range. In 2000, the City of Boulder had a population of 94,673 (Reference 13), an increase of 13.6 percent from a population of 83,312 in 1990 (Reference 14). This population growth is expected to continue with further expansion into identified floodplain areas.

The study area includes the drainage basins of seven streams located throughout the City of Boulder area. All study streams are tributaries to Boulder Creek, with a total drainage area of approximately 23.2 square miles. The elevation of the City of Boulder ranges from 8,520 feet at the headwaters of Fourmile Canyon Creek to 5,155 feet at the confluence of Fourmile Canyon Creek with Boulder Creek.

All stream reaches east of the foothills are located within urbanized areas with occasional open-space and park areas. The terrain of these subbasins consists of mild slopes with topsoil in the B and C hydrologic soils group with some D soils. Vegetation for most of the stream reaches is characteristic of urban areas. Vegetation along the downstream reaches of Bear, Goose, Skunk, and Wonderland Creeks consists of natural grasses and weeds.

Town of Erie

The town of Erie is approximately 40 miles north of Denver, in the southwest corner of Weld County and the northeast corner of Boulder County, in north-central Colorado.

In the late 1800's, coal mining led to the development of the Town of Erie along the banks of Coal Creek. Today, Erie is mostly a commercial and residential community with some agricultural development in the surrounding area. The estimated population of Erie was 1,258 in 1990 (Reference 14) and rose to 6,291 in 2000 (Reference 13).

The average annual precipitation in Erie is 12.7 inches, and the normal mean temperature is 48.6°F. Vegetation in the area consists primarily of native grass. The soils in the area are shallow, very gravelly and stony, and in the rock outcrop Juget-Baller Association. The topography in the developed part of Erie is relatively flat and gradually slopes toward Coal Creek. Both residential and commercial developments exist in the floodplain area.

Coal Creek flows northerly along Erie's eastern corporate limits and empties into Boulder Creek. Recently, the Town of Erie has annexed areas that include floodplains along Coal Creek, Prince Tributary East Branch, Prince Tributary West Branch and Bullhead Gulch from Boulder and Weld Counties.

Town of Jamestown

Jamestown is a small mountain community located in the central northwest section of Boulder County, approximately 10 miles northwest of the City of Boulder. The 1990 population was 251 (Reference 14) and was estimated at 205 (Reference 13) in 2000. Communities near Jamestown are Lyons, approximately 11 miles to the northeast, and Longmont, approximately 16 miles to the east.

Historically a mining town, Jamestown is now a residential community. Most of its residents are commuters to the Cities of Boulder, Denver, and Longmont.

Little James Creek, draining an area of approximately three square miles, joins James Creek in Jamestown. James Creek, with a drainage area of 14.5 square miles at the downstream study limit, is a tributary to Lefthand Creek, which flows eastward to join St. Vrain Creek near Longmont. Rainfall in the basin averages nearly 24 inches annually.

The terrain is mountainous with steep slopes. The soils of the Allen Park Series, which formed on the mountain slopes between elevations of 6,300 and 8,200 feet, are loamy colluviums and weathered granite residuum. The surface layer, approximately two inches thick, is dark-gray, gravelly sandy loam. The subsurface layer is light brownish-gray, gravelly sandy loam. The Fern Cliff Series is loamy mixed alluvium on short fans and valley side slopes in the mountain area in the same elevations range. The top layer of this series is light gray, stony sandy loam. The barren areas are predominantly exposed bedrock that consist of mixed materials, including granite, sandstone, shale, and limestone. The dominant land cover species is Ponderosa pine; above an elevation of 8,000 feet, there are some Douglas fir and lodge pole pines.

Little James Creek flows into town from the north, through mostly vacant land. Existing development in Jamestown is located on both sides of James Creek, from the confluence with Little James Creek at Ward Street to 13th Street. Land use is primarily residential, single-family homes, with some business and commercial uses.

City of Lafayette

Lafayette is located in southeastern Boulder County, approximately 20 miles north of Denver. The population of Lafayette was 14,548 (Reference 14) in 1990, and was 23,197 in 2000 (Reference 13). Nearby communities include the following: Louisville, two miles west; the City of Boulder, 11 miles west; Superior, approximately six miles southwest; and Broomfield, seven miles south. Lafayette is surrounded by unincorporated Boulder County.

The Coal Creek and Rock Creek watersheds drain approximately 79 square miles, most of which are located in southeastern Boulder County. Coal Creek flows northeasterly, joining Boulder Creek in east-central Boulder County. Boulder Creek flows into St. Vrain Creek, a major tributary to the South Platte River. These drainages are in the South Platte subregion of the Missouri River Water Resources Region, as designated by the U.S. Water Resources Council. Rock Creek is a tributary to Coal Creek, joining it just east of Lafayette.

Coal Creek and Rock Creek flow through primarily agricultural land. The southwestern part of the city, the land occupied by Coal Creek, is zoned open agricultural, with primarily residential land uses and zoning adjacent to it. Where it crosses the southeastern part of the city, zoning is open agricultural and industrial. Rock Creek enters the southeastern part of the city just east of the Burlington Northern and Santa Fe Railway and flows through open agricultural-zoned land.

The upstream drainage area originates in the foothills east of the Rocky Mountains, and the geology is characterized by a series of folded and faulted sedimentary strata. For the most part, the strata are classified as Fox Hills Sandstone and Laramie formation. Soils are shallow, very gravelly, and stony, and in the rock outcrop Juget-Baller association. Ground cover consists of native grasses and woodland. Except for a narrow fringe of Rocky Mountain juniper, Ponderosa pine makes up the bulk of the woodland cover. The woodlands are very picturesque, and most of the area is used for grazing and home sites, with both year-round and summer homes. Average annual precipitation is approximately 18.5 inches and the normal mean temperature is 51.8°F. Extremes of annual precipitation have varied from a maximum of 29.09 inches in 1938 to a minimum of 10.91 inches in 1954. The mean maximum and minimum temperatures in July are 85.3°F and 59.0°F, respectively.

City of Longmont

Longmont is located in northeastern Boulder County, approximately 38 miles north of Denver. Agriculture is the economic base of Longmont, although nearby Denver and Boulder have influenced the growth of new commercial and industrial development. This is reflected in the population trends of Longmont. The population figures for Longmont are 8,099 (1950), 11,489 (1960), 23,209 (1970), 42,942 (1980), 68,154 (1990), and 71,093 (2000) (Reference 14).

The climate is temperate. Daily average temperatures are 65°F for May to September and 37°F for October to April. The average annual precipitation is 12 inches for Longmont with an average monthly rate of 1.5 inches from April to September.

The city lies within the St. Vrain Creek Basin; headwaters extend by way of North and South St. Vrain Creeks into the Rocky Mountains up to the Continental Divide. Elevations range from 4,900 feet in Longmont to more than 14,000 feet at Longs Peak. The water of St. Vrain Creek has been appropriated for municipal and irrigation usage.

The topography of Dry Creek No. 1, Lefthand Creek, and St. Vrain Creek Basins ranges from rugged and heavily forested Rocky Mountain canyons in the west, to slightly rolling prairie land near Longmont, where pasture land and cropland border stream banks lined with brush, willow, and cottonwood trees. Spring Gulch has a basin that extends to Terry Lake, but it has a channel only from 15th Avenue to St. Vrain Creek in Longmont. Loomiller Basin lies entirely within Longmont.

Dry Creek No. 1, Lefthand Creek, and Spring Gulch originate outside the PMA of Longmont in the Rocky Mountain foothills and follow generally easterly courses through the city. Spring Gulch consists of an improved channel that starts south of East 15th Avenue and continues as a concrete-lined channel through Spring Gulch Linear Park to Third Avenue, then down to St. Vrain Creek. Loomiller Basin is a depression oriented in a northwest-southeast direction through central Longmont. Floodwater accumulates in the depression and subsequently drains into Spring Gulch Basin near Third Avenue and Atwood Street. A large portion of the area within the PMA of Longmont limits and adjoining the streams is fully developed.

Commercial and residential developments exist in the floodplains of all the streams studied. On St. Vrain Creek, from Airport Road to the confluence with Dry Creek No. 1, industrial and commercial buildings, farms, and mobile home parks share the floodplain with gravel-mining sites. The Dry Creek No. 1 floodplain is occupied by both commercial buildings and single-family dwellings from Sunset Street to the confluence with St. Vrain Creek. Development along Spring Gulch is also represented by pastureland and a linear park bounded by single-family dwellings from 15th Avenue to Third Avenue. Commercial and industrial buildings occupy the Spring Gulch floodplain from Third Avenue to the confluence with St. Vrain Creek. Loomiller Basin is totally developed with residential and commercial buildings.

Town of Lyons

Lyons is located in north-central Boulder County, approximately 40 miles north of Denver. In 1990, the population of Lyons was 1,227 (Reference 14), and was estimated at 1,585 in 2000 (Reference 13). Nearby communities include Longmont, 11 miles southeast; the City of Boulder, 16 miles south; and Estes Park, 20 miles northwest. Lyons is bordered on all sides by unincorporated Boulder County.

Rainfall in the mountains west of Lyons averages approximately 17 inches annually. The average annual temperature in the basin is approximately 40°F. The basin topography changes from forested mountain terrain on the west, to rolling plains on the east, which are primarily pasture and cultivated fields. The drainage area at Lyons is 219 square miles, with 125 square miles on North St. Vrain Creek and 94 square miles on South St. Vrain Creek.

North St. Vrain Creek enters the town on vacant land near the northwestern corner of the community. In the areas south and west of U.S. Highway 36, the existing zoning, and land use is primarily residential, consisting of mobile and single-family permanent homes. West of Fifth Avenue, the land is vacant. Between Fifth Avenue and Second Avenue, the creek flows through a single-family residential area, north of the business community.

South St. Vrain Creek parallels State Highway 7, enters the town near Fifth Avenue, and flows through residential land that is partially developed with single-family residences and mobile homes.

St. Vrain Creek roughly parallels the Burlington Northern and Santa Fe Railway east of Second Avenue and flows through open land zoned medium-density residential.

Town of Nederland

Nederland is a small mountain community located approximately 13 miles west of the City of Boulder. The population, based on the 1990 census, was 1,099 (Reference 14), and was estimated to be 1,394 in 2000 (Reference 13). Communities adjacent to Nederland are Ward, approximately seven miles north, and Central City, approximately 12 miles south.

North Beaver Creek, draining approximately 5.2 square miles, joins Middle Boulder Creek at Nederland. Middle Boulder Creek, with a drainage area of 36.2 square miles at the downstream study limit, is a tributary to Barker Reservoir. This reservoir, located approximately 12 miles upstream from the City of Boulder and completed in 1910, has a

storage capacity of 11,500 acre-feet and reduces the peak flows of floods originating from Middle Boulder Creek and North Beaver Creek. Rainfall in the basins averages 24 inches annually. Land use adjacent to the streams is primarily residential, with some commercial buildings.

The terrain is mountainous with steep slopes. Soil types within the study area vary. The soils of the Allen Park Series, which formed on the mountain slopes between 6,300- and 8,200-foot elevations, are loamy colluviums and weathered granite residuum. The surface layer, approximately 2 inches thick, is dark-gray, gravelly, sandy loam. The subsurface layer is light brownish-gray, gravelly, sandy loam. The Fern Cliff Series is loamy mixed alluvium on short fans and valley side slopes in the mountain area in the same elevation range. The top layer of this series is dark grayish-brown, stony, sandy loam and the subsurface layer is light-gray, stony, sandy loam. The barren areas are predominantly exposed bedrock that consist of mixed materials, including granite, sandstone, shale, and limestone. The dominant land-cover species is Ponderosa pine, and, above 8,000 feet elevation, there are some Douglas fir and lodge pole pines.

Town of Superior
Superior is located in southeastern Boulder County, approximately 20 miles northwest of Denver. In 1990, the population of Superior was 255 (Reference 14). In 2000, the population rose to 9,011 (Reference 13). Nearby communities are Louisville, five miles northeast; the City of Boulder, six miles northwest; Lafayette, approximately seven miles northeast; and Broomfield, seven miles southeast. The unincorporated areas of Boulder County surround Superior.

Coal Creek flows through primarily agricultural land. Land use, which is not zoned within Superior, is primarily residential.

Average annual precipitation is approximately 18.5 inches and the normal mean temperature is 51.8°F. Extremes of annual precipitation have varied from a maximum of 29.09 inches in 1938 to a minimum of 10.91 inches in 1954. The mean maximum and minimum temperatures in July are 85.3°F and 59.0°F, respectively.

2.3 Principal Flood Problems

Boulder County (Unincorporated Areas)
Flooding in Boulder County is due mainly to snowmelt combined with heavy rainfall, although heavy rainfall, especially in the form of cloudbursts, is alone capable of causing flooding. Floods caused by rainstorms can peak within a few hours of the rainfall, leaving little time for evacuation. Much of the floodplain is used for agriculture, thus the flood damage is mainly to crops, irrigation equipment, roads, and bridges. Damage to residential and industrial areas occurs in and around several communities that are excluded from the study area. However, many of these communities are experiencing rapid growth, and thus are increasing encroachment on the adjacent floodplains. There are also undefined, very localized zones of velocity hazard throughout the studied reaches of Lefthand Creek. Generally, these zones are in the channel and near bridges.

Significant floods occurred in the South Boulder and Boulder Creek watersheds in 1894, 1914, and 1938; a somewhat smaller flood occurred in 1938. Flooding occurred in the Lefthand Creek watershed in 1864, 1876, 1894, 1921, 1938, 1949, and 1951.

City of Boulder

The principal cause of flooding problems on the study streams in the City of Boulder is intense localized thunderstorms.

Numerous floods have occurred in the City of Boulder area, with the most extensive flood occurring in 1894. This flood generally has been designated as the 1-percent-annual chance flood; however, there is little documentation of the flooding on streams other than Boulder Creek. Flooding was widespread during the 1894 flood, and nearly all bridges in the city were washed out.

The most extensive flood since 1894 occurred on May 7 and 8, 1969. This flood was also the most expensive, with damages estimated to be $325,000. Bear Canyon, Skunk and Twomile Canyon Creeks all overflowed their banks according to newspaper accounts. On May 8, 1969, the *Boulder Daily Camera* reported "motorists were still being routed around the intersection of Table Mesa Drive and Broadway, where Bear Creek raged out of its banks, flooding the entire area Wednesday."

Past studies of the South Boulder Creek floodplain have identified a riverine floodplain that is generally confined to areas along the main channel. Historic records of flooding have indicated that the floodplain is more expansive than reported in the past mapping efforts and includes areas of the west valley along the Foothills Parkway corridor.

Twomile Canyon Creek has frequently overtopped its banks with silt-laden floodwater. The worst flood on Twomile Canyon Creek occurred in September 1933, while others occurred in 1909, 1941, 1942, 1949, and 1965. On August 19, 1965, the *Boulder Daily Camera* headline read: "Twomile Canyon Gully Washer Spews Mud Across Broadway and Into Yards." The article stated "Water cascading down normally-dry Twomile Canyon Creek spewed mud across sections of Broadway and silted yards and basements of 8 or 10 homes near Broadway and Iris Avenue Wednesday afternoon."

Fourmile Canyon Creek has flooded occasionally, with notable events occurring in 1916, 1941, and 1951. In 1916 and 1941, railroad bridges were washed out (Reference 16). Localized flooding along the lower reaches of Fourmile Canyon Creek occurs frequently, according to local residents. Damages and losses along Fourmile Canyon Creek in the past were generally been low, because the area was primarily undeveloped. Presently Fourmile Canyon Creek flows through urbanized areas.

Significant flooding along Goose Creek occurred in August 1951 and July 1954. The 1954 event damaged an addition to the Community Hospital, which was under construction.

These floods are just a few that have occurred in the area. Major, area-wide floods also occurred in 1904, 1909, 1914, 1921, and 1923. During May 1973, flooding caused an estimated $70,000 worth of damage. No estimates of the recurrence intervals of the

historic floods have been made. There has been little documentation of flooding on Elmers Twomile, Skunk, and Wonderland Creeks.

There is a history of debris blockage and flow diversions throughout the City of Boulder.

Town of Erie
The main sources of flooding in the Town of Erie are heavy thunderstorms in spring and summer. Flooding can become especially severe when these thunderstorms follow either rapid snowmelt or prolonged rainy weather (Reference 18).

The 1876 flood is the largest recorded at Erie and approximates the 1-percent-annual recurrence interval, as determined by the SCS (Reference 18), using synthetic methods for flood routing. The most recent floods in the watershed occurred on June 9, 1949; May 9, 1957; and May 1969.

Town of Jamestown
Floods in the Jamestown study area usually occur during the period of May through September. Mountain snowmelt in May and June contributes significant runoff, but serious flooding does not occur unless rainfall accompanies the snowmelt.

Peak flooding will usually occur within a few hours after a single rainfall event. Flooding is generally of short duration, but may be prolonged significantly by snowmelt runoff.

The steep stream slopes create swift currents during a flood, which produce added damages. Debris carried by the fast-moving water not only threatens bridges and culverts, but batters houses and other structures on the floodplain. The bridge and culvert crossings often result in channel restriction, raising the water surface elevation (WSEL). Erosion undercuts and destroys structures that would otherwise receive little damage from inundation. Large quantities of rock are often deposited in portions of the channel, leaving little capacity for future floods.

In June 1894, a flood roared down James Creek and washed away much of the low-lying area of the town. Heavy rains accompanied by heavy spring runoff caused the flood. Most of the houses on the north side of Main Street were ruined or washed away, as was much of the road. A similar flood occurred in August 1913, damaging or destroying almost every house along James Creek. All wagon bridges and footbridges were destroyed, and it took two weeks to open the road to traffic.

In August 1955, a brief cloudburst, lasting approximately 30 minutes, damaged four bridge and culvert crossings and deposited several inches of mud in local residences.

The town was also flooded in 1965, and again in May 1969, following three days of heavy snow and rain. The floodwaters left the normal channel, destroying a number of buildings and the town water supply.

Readings by members of the University Institute of Arctic and Alpine Research showed snow content or rainfalls of 6.56 inches at 10,000 feet, 9.10 inches at 8,500 feet, and 8.90

inches at 7,200 feet (Reference 17). Flood damage estimates in a 9-county area were $7,000,000, including $700,000 for roads and bridges in Boulder County alone.

City of Lafayette and Town of Superior
Historical documentation of flood damage is meager in the area of Lafayette and Superior. This is probably due to the small stream size and lack of extensive urbanization. Major flood damages in the watershed are to roads, bridges, irrigation structures, and agricultural land. Duration of flooding is brief, due to steep slopes and small drainage area. In general, peak flows last from 1 to 4 hours during a flooding period of 6 to 24 hours.

The following floods have been reported: The floods of 1876; 1891; June 3, 1921; and May 26, 1935; were caused by rapid snowmelt in the mountains and heavy rainfall in the area of Lafayette.

City of Louisville
A flood occurred in June 1896 that was reported as the maximum of record in the part of the valley near Louisville. The flood of September 2, 1938, was caused by cloudbursts in the mountains and foothills, resulting in a flood slightly higher than that of 1935. Using slope-area measurements, the USACE estimated the flood discharges on Coal Creek near Erie to be 13,200, 7,800, and 3,500 cubic feet per second (cfs) in 1876, 1921, and 1938, respectively (Reference 18).

The following are recorded accounts of flood damage on Coal Creek and Rock Creek:

> September 2, 1938. "Parts of the residential area in Louisville were under several inches of water, but the business district was not damaged. One person was killed in an automobile accident on the flooded highway east of Louisville. The bridge at Empire Drive and State Highway 42 was on the verge of failure, but was saved."
>
> June 9, 1949. "The bridge at the junction of Coal Creek and Rock Creek, 3 miles north and 1/4 mile west of Erie was threatened and closed to traffic. The bridge over Coal Creek, ¾ mile east of Superior, went out."
>
> May 1969. "Damage to land irrigation structures and agriculture totaled approximately $75,000."

City of Longmont
St. Vrain Creek flows through the City of Longmont in a broad channel bed of shifting sandbars bounded by banks 10 to 15 feet high. Dry Creek No. 1, Lefthand Creek, and Spring Gulch flow in relatively steep, narrow channels. The overbanks of all the streams studied are relatively flat, with the exception of the north overbanks of St. Vrain Creek and Lefthand Creek, which rise more steeply.

As is characteristic of the region, flooding on these streams generally occurs between May and September. Peak annual flows usually occur in May and June, however, resulting from a combination of snowmelt runoff and spring rains. Floods having the most damaging effect in the Longmont area, such as the flood of June 2-7, 1921, occur when a

long-duration rainstorm forms over the St. Vrain Creek Basin with the heaviest rainfall accumulation downstream of the Lyons gaging station. Extensive damage was done to bridges, with severe erosion nearby to roads and along the channel banks. Public and private property damage amounted to $50,000.

Lefthand Creek also produced a large flood on May 7-8, 1969, with the primary damage being done to the South Pratt Parkway Bridge, which was ultimately destroyed by the floodwater. There is little known regarding floods of record other than what was stated concerning the gaged discharges. There are no existing stage data for the floods on Lefthand Creek later than May 1957. The largest flood on record was the one that occurred in June 1949.

Flood problems in the area have been the result of not only rare storm events, but also improper floodplain development. Visual accounts of floods have noted the debris collected by the floodwater, including natural debris such as trees, rocks, and soil, but consisting chiefly of items foreign to the floodplain, such as houses, bridges, automobiles, heavy equipment, lumber, house trailers, and butane storage tanks. With these items obstructing bridges and culverts, flood levels rise and cause more extensive damage. Property that was not structurally damaged by flood depths and velocities experienced much damage and cleanup expense resulting from mud, silt deposition, and erosion.

Town of Lyons

Lyons lies in a natural bowl, on gently sloping land surrounded by sandstone hills on all sides. The steep stream slopes create swift currents during a flood, which produce additional damage. Debris carried by the fast-moving water not only threatens bridges, but also may batter houses or other structures on the floodplain. The bridge crossings are often the points of channel restriction, thus raising the water-surface profile. Erosion undercuts and destroys structures that would otherwise receive little damage from inundation. Large quantities of rocks have been deposited in portions of the channel, leaving little capacity for future floods.

Early records of floods in the study reach are fragmented and lacking in detail. Flooding occurred on St. Vrain Creek in 1864, 1876, 1894, 1919, 1941, 1949, 1951, 1957, and 1969. The floods of June 1864 and May 1876 were severe and much valley farmland was flooded. The flood of May 31, 1894, inundated the entire lower part of town. Although 20 homes at Lyons were washed away, no lives were lost. This flood had an estimated peak discharge of 9,800 cfs at Lyons, with most of the flow coming from South St. Vrain Creek.

In late July 1919, a series of severe thunderstorms caused flash flooding along St. Vrain Creek. The following is from the *Lyons Recorder*, dated August 2, 1919:

> "The heaviest and most destructive cloudburst . . . in the memory of the oldest inhabitant visited Lyons on Wednesday, July 30, between 2:30 and 3:45 P.M. It took out all the bridges on the North St Vrain for about 5 miles up and 5 miles downstream. The Longmont and Lyons water mains up the canyon were torn out along the narrow canyon."

> "The people living . . . along the banks of the river were flooded out, and many abandoned their homes for higher ground and safety . . . homes (in the lower part of town) . . . were in a roaring sea of water 2 and 3 feet deep."

Another crest on the following day flooded houses again in the lower areas of town and washed out 300 yards of railroad track east of Lyons. The peak discharge on July 30 was later computed to be 9,400 cfs. The right bank of North St. Vrain Creek was flooded to a width of 300 feet (Reference 19).

The largest peak discharge of record on St. Vrain Creek at Lyons was 10,500 cfs on June 22, 1941. This flood originated mostly on South St. Vrain Creek, and the creek peaked very rapidly with floodwaters receding quickly. It is assumed that an extremely localized cloudburst occurred over South St. Vrain Creek a short distance upstream from Lyons.

The effects of the June 4, 1949, flood were felt largely downstream of Lyons. Prolonged rainfall and heavy snowmelt kept St. Vrain Creek out of its banks in rural areas during most of the month of June. Bridges, roads, and irrigation headworks were damaged.

Lyons received 6.3 inches of rain from a cloudburst storm that began at approximately 6 p.m. on August 3, 1951. This combined with generally heavy rains over the basin to cause flooding from Lyons to the mouth of St. Vrain Creek. The flood lasted for less than 12 hours. Severe damage resulted to State Highway 7 along South St. Vrain Creek. In the rural areas downstream from Lyons, many grain shocks were washed from the fields.

On May 8 and 9, 1957, approximately 3 to 5 inches of rain fell over the entire basin of St. Vrain Creek. The rain began at approximately 10 p.m. and stopped at approximately 6 a.m. On May 9, at approximately 1 a.m., St. Vrain Creek peaked at Lyons at 3,060 cfs. The flood damaged and destroyed irrigation diversion works and bridges downstream from Lyons.

In 1969, heavy rainfall combined with snowmelt caused prolonged high flows on St. Vrain Creek. The worst flooding occurred on May 7 and 8 and from June 15 to June 21. Roads and bridges along the stream were extensively damaged, stream banks were eroded, and farmlands were flooded. On May 7, the peak discharge at Lyons was 2,900 cfs.

The steep stream slopes create swift currents during a flood, which produces added damages. Debris carried by the fast-moving water not only threatens bridges and culverts, but batters houses or other structures on the floodplain. The bridge and culvert crossings often result in channel restriction, raising the water-surface profile. Erosion undercuts and destroys structures that would otherwise receive little damage from inundation. Large quantities of rocks are often deposited in portions of the channel, leaving little capacity for future floods. Vegetative growth in the channel also reduces the channel capacity and causes increased overbank flow during high floods. Major flood damages in the study area are to roads, culverts, and residential buildings.

Town of Nederland

Early records of floods in Nederland study area are fragmented and lacking in detail. A description of the more-recent floods follows:

June 22, 1951 - *Boulder Daily Camera*:

> Nederland reservoir at the head of Boulder Canyon is full for the first time in two years.
>
> With water pouring over the 132-foot-high spillway at the dam and heavy rains falling in the mountains, a flood threat developed in Boulder Creek Thursday night but there was little damage. Contrary to broadcast reports, the water did not reach the canyon highway or cause any interference with road bridges . . . It is not unusual for the reservoir to fill; it has happened more than half of the years since the dam was completed in 1910. But with the dam unable to hold any more water, it means a possible flooding of Boulder Creek if there are heavy rains and fast thaws of snow at the headwaters.

May 16, 1957 - *Boulder Daily Camera*:

> Nederland reservoir of the Public Service Company is now half full, The Camera was informed today. Rumor had it that water was spilling over the dam for the first time in many years. Prospects are good for the reservoir filling but not until later in the summer.
>
> Meantime reservoirs in Boulder Valley are rapidly filling with floodwater, and irrigation ditches (not those running through Boulder) are carrying a full load to the reservoirs they service.

2.4 Flood Protection Measures

There were no structural flood protection measures at the time of the original study in Boulder County. Presently, Barker Reservoir on Boulder Creek and Gross Reservoir on South Boulder Creek are far enough upstream from the areas studied by detailed methods that their flood protection effects are negligible. Since 1971, Boulder County has undertaken an active program of floodplain management.

Past urbanization in the City of Boulder has encroached drainage ways and reduced stream storage, thereby increasing runoff peaks and volumes. Undersized culverts and channels exist throughout the city. A few measures have been taken to alleviate these problems on some of the study streams and are discussed below. This discussion excludes drainage improvements constructed to provide protection from erosion. The degree to which the flood-control measures discussed protect from return interval floods is unknown at this time.

The improved Bear Canyon Creek channel along Table Mesa Drive from Broadway to Gillespie Street (upstream limit of detailed study) will efficiently convey moderate flood flow downstream; however, major storms will continue to cause flooding problems. The

channel improvements in Martin Park completed under a UDFCD maintenance project were not designed to contain the 1-percent annual chance flood flow in the channel (Reference 23).

For flood protection from Boulder Creek, a levee was constructed around the 75th Street Wastewater Treatment Plant. The levee was found to provide protection from the 1-percent annual chance flood, and it meets all of the requirements set forth in Section 65.10 of the NFIP regulations (Reference 64).

The University of Colorado South Campus Levee provides protection from the 1-percent-annual-chance flood event.

Flood protection measures along Dry Creek include channelization and construction of a new bridge at Flatirons Parkway (Reference 24).

Three adjacent detention ponds on Elmers Twomile Creek were constructed by the City of Boulder to control runoff. These ponds are located just south of Iris Avenue behind the K-Mart store. These ponds will attenuate the 1-percent annual chance peak flood discharge from 615 to 510 cfs.

Flood protection measures along Fourmile Canyon Creek include channelization through the Palo Park Subdivision (Reference 25), and construction of a culvert at Sumac Avenue.

Flood protection measures along Goose Creek include channelization of North and South Goose Creeks.

Flood protection measures along Skunk Creek include the channelization of the stream between Morehead Avenue and U.S. Highway 36.

A small detention/siltration pond on Twomile Canyon Creek just upstream of Linden Avenue will control moderate flows; however, it does not attenuate the 1-percent annual chance peak flood flow.

Flood-protection measures along Wonderland Creek consist of Wonderland Lake (Reference 20); the ponding area between Wonderland Lake and Broadway; the channelization projects along the Winding Trail Village and Aspen Grove developments, located between the Longmont Diagonal and 26th Street (Reference 21); the constructed 26th Avenue Crossing culvert and drop inlet (Reference 21); the detention pond east of 47th Street (Reference 22), and channelization from approximately 130 feet downstream of Valmont Drive to approximately 1,070 feet upstream of Valmont Drive. Wonderland Lake, while not designed to provide flood protection, will attenuate the 1-percent annual chance peak flood flow from 400 to 100 cfs. For the routing analysis, Wonderland Lake will be considered filled to the spillway crest at the time of storm runoff routing. The area between Wonderland Lake and Broadway creates an unplanned flood-control structure, because the culvert at Broadway will convey very little flow and a considerable ponding volume is available. This unplanned flood reservoir was not included in the hydrologic analysis. Spill flow from Fourmile Canyon Creek to the north will also reach Wonderland Creek at this location.

The 26th Avenue Crossing culvert and drop structure have been constructed and are designed to contain the 1-percent annual chance flood flow (Reference 16). The pond east of 47th Street will have little effect on the 1-percent annual chance peak flow.

Flood protection measures along Coal Creek in the Town of Erie include channelization and the construction of levees from approximately 5,700 feet downstream to approximately 600 feet upstream of the UPRR (Reference 95). As a result of this project, the base flood and floodway are contained within the channel from approximately 2,750 feet downstream to the UPRR. The flooding associated with the Coal Creek West Line Overflow through the town has been eliminated.

There are no flood protection measures along the segments of Bullhead Gulch and the Prince Tributaries in the Town of Erie.

No flood protection structures or measures exist or are planned for the flooding sources of Jamestown.

No flood protection structures exist or are planned within and adjacent to Lafayette. Lafayette has building ordinances along the floodplains that prohibit certain types of construction.

There is little evidence of flood protection measures along the study segment of St. Vrain Creek in Lyons, except the channelization between Sunset Street and the Burlington Northern and Santa Fe Railway Bridge. There is a line of low levees along the trailer park on the south side of this segment. There are three dams in the upper mountain segments of St. Vrain Creek. Button Rock Dam was completed on North St. Vrain Creek in 1969, six miles west of Lyons, to store the municipal water supply. It was not designed to store floodwater; but, during the May 1969 flood, it reduced the magnitude of the discharge that could have inundated Longmont. Both the Longmont Dam, located one mile downstream of the Button Rock Dam, and Beaver Reservoir, near the South St. Vrain Creek headwaters, have no effect on the flood discharge in Longmont.

Lefthand Creek has been channelized along the segment from Pike Road (State Highway 22) to the mouth. The channel from Pike Road to South Pratt Parkway is grass-lined and is designed to contain a flow of approximately 3,650 cfs. From South Pratt Parkway to its mouth, Lefthand Creek has been channelized; however, the overbanks remain unimproved. Other flood protection measures include construction of a side channel north of the existing channel, construction of a cutoff channel parallel to South Main Street from Lefthand Creek to approximately 2,000 feet south, and channelization along Lefthand Creek from just downstream to approximately 1,200 feet downstream of South Main Street.

Various structural improvements such as grass- or concrete-lined channels, detention ponds, and outfall culverts have been implemented on Spring Gulch in the segment from Ninth Avenue to Third Avenue. These improvements are inadequate to contain even the 10-percent annual chance flood discharge.

No flood protection measures have been taken in Loomiller Basin, except for using Loomiller Pond as a flood-storage facility. Various properties along the streets in Loomiller Basin have low retaining walls along the street frontage to prevent yard flooding.

Flood protection measures along Dry Creek No. 1 include channel improvements from downstream of a private road to approximately 1,450 feet downstream of Airport Road, the construction of four 12-foot by 8-foot box culverts at Airport Road, channelization from approximately 400 feet downstream of South Fordham Street to South Fordham Street, the construction of box culverts under South Fordham Street, realignment and channelization from approximately 1,450 feet downstream to just downstream of Grandview Meadows Drive, replacement of an existing culvert under Grandview Meadows Drive, and construction of a flood-detention basin along Dry Creek No. 1 approximately 600 feet upstream of Grandview Basin Tributary. Clover Basin Tributary has been channelized from just upstream to approximately 400 feet upstream of its confluence with Dry Creek No. 1.

In addition to the physical flood prevention measures mentioned, Longmont initiated an ordinance in May 1973 for floodplain regulation, and has followed with floodplain management policies outlined in the St. Vrain Comprehensive Plan (Reference 5).

Lyons practices non-structural floodplain management through a restrictive building code for structures located within the floodplain.

No flood protection structures or measures exist or are planned along Middle Boulder Creek and North Beaver Creek within Nederland.

No floodplain structures either exist or are planned within and adjacent to Superior.

Boulder County is provided some protection from floods through flood warning and forecasting by the National Oceanic and Atmospheric Administration (NOAA), National Weather Service.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, and 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent annual chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 1-percent annual chance flood in any 50-year period is

approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

Hydrologic data from the various engineering reports discussed in Section 7.0 have been used extensively for the revised study of Boulder County, including peak discharges and starting WSELs.

Boulder County (Unincorporated Areas)
Frequency-discharge data for Boulder Creek, Arapahoe Avenue Overflow, and Boulder Creek (Right Bank Overflow) were based on information published in the Flood Hazard Area Delineation for Boulder Creek report (Reference 60). The hydrology of the Boulder Creek basin was studied in conjunction with a report by the USACE on Boulder Creek for the Metropolitan Denver and South Platte River Study using the EPA's SWMM program (Reference 94). Historical Stream gage records were used to check the results from the SWMM model. Rainfall data used in the SWMM model was obtained from the NOAA Atlas 2, Volume III, Colorado, 1973 (Reference 33).

The hydrologic analysis completed by the USACE was used to establish peak discharges for the 10-, 2-, 1-, and 0.2-percent annual chance flood events for Boulder Creek, Arapahoe Avenue Overflow and Boulder Creek (Right Bank Overflow). The 0.2-percent annual chance values were estimated by extrapolating on arithmetic-probability paper. A diffusion routing technique developed by the USACE, Missouri River Division, was used for the flood routing calculations.

A hydrologic analysis for Dry Creek No. 2 Ditch Split Flow and Highway 93 Split Flow was completed by the USACE to determine the peak discharges of the 10-, 4-, 2-, 1-, and 0.2-percent annual chance flood events. Discharge-probability relationships were computed using the EPA's SWMM program (Reference 94). Rainfall data used in the SWMM model was obtained from the NOAA Atlas 2, Volume III, Colorado, 1973 (Reference 33). Rainfall hyetographs having six-hour storm durations were input into the model for each respective frequency storm. Soil infiltration rates of 0.5 inch per hour in the plains and 1.0 inch per hour in the mountains were used for the pervious areas in the hydrologic model. The impact of Gross Reservoir was evaluated by routing storm runoff through the reservoir pool. Significant reductions in peak discharges resulted with the various frequency routed storms. The 0.2-percent annual chance event was extrapolated from a frequency curve drawn through the plotted 10-, 4-, 2-, and 1-percent annual chance discharges for the different locations.

For South St. Vrain Creek and Middle St. Vrain Creek, the frequency-discharge relationships were based on a log-Pearson Type III distribution using the streamflow