

# CITY OF BOULDER FLOOD MANAGEMENT PROGRAM



*Skunk Creek Underpass  
at 27<sup>th</sup> Way  
September 2013*

October 2017

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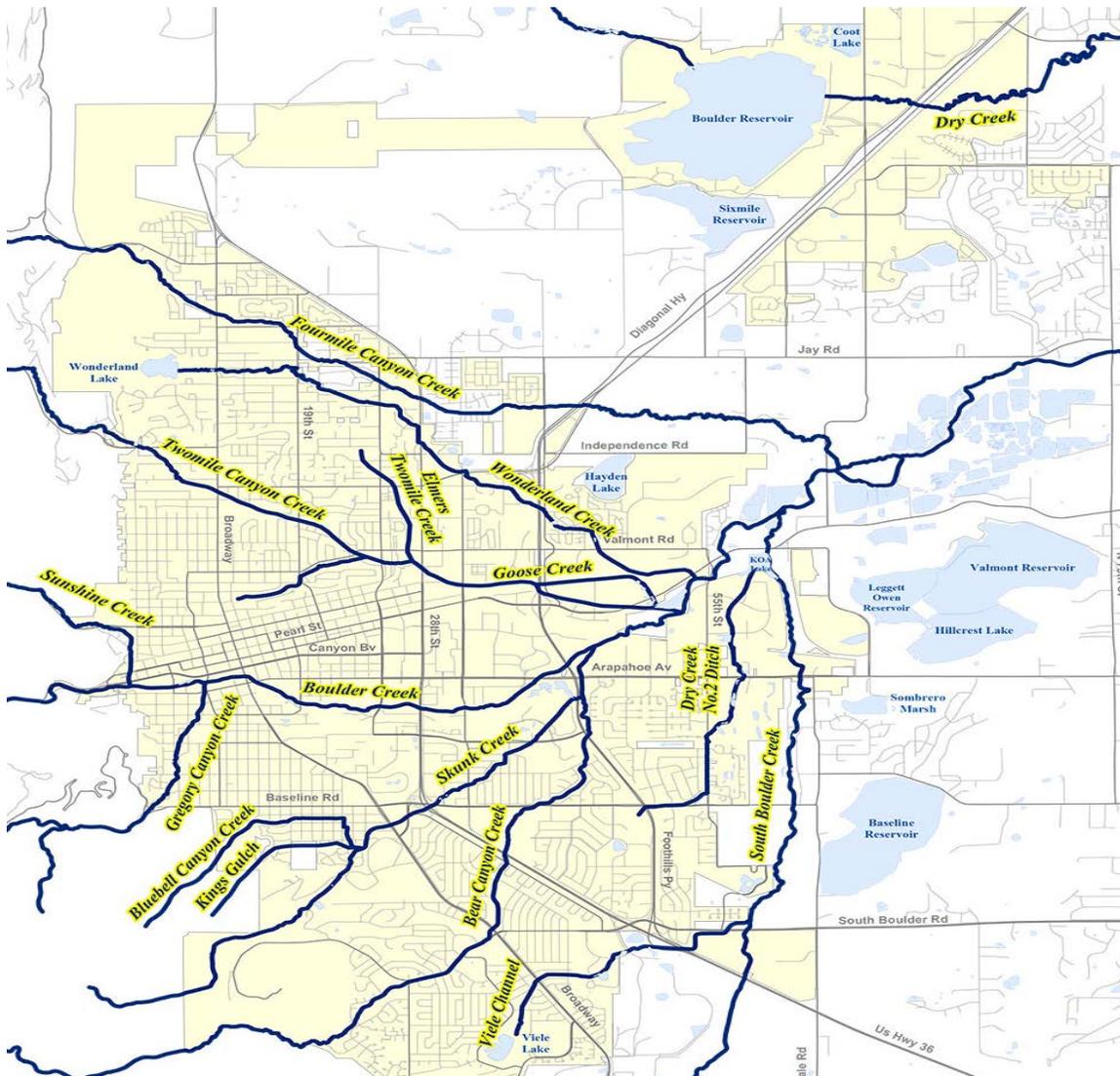
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## Introduction

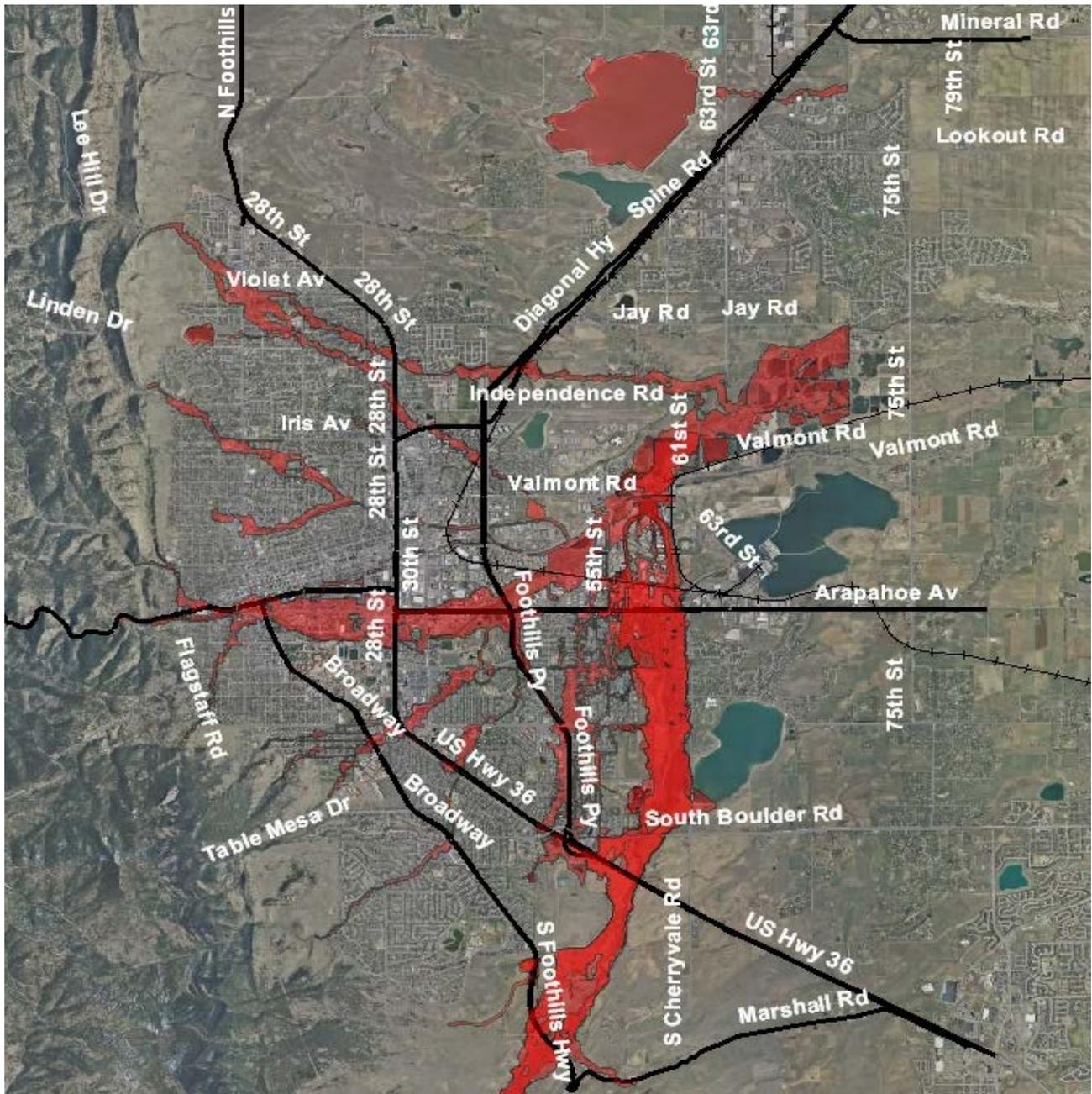
The City of Boulder has a significant flood risk, primarily due to its location at the mouth of Boulder Canyon and other canyon creeks. The city has a long history of flooding and has developed a comprehensive flood management program designed to identify and mitigate the risks of flooding, minimize loss of life and property damage, and support recovery following a major flood. Major components of the city's flood management program include mapping, mitigation master planning and construction, property acquisition, and flood protection through land use regulations and flood preparedness. This document provides a brief summary of each of the city's floodplain management program elements, along with a summary of the National Flood Insurance Program.

## Flood Risks

The City of Boulder has 15 major drainageways (**Figure 1**). Approximately 13 percent of the city is located within the regulatory 100-year floodplain (**Figure 2**), including approximately 2,000 individual structures.



**Figure 1: Major Drainageways**



**Figure 2: 100-Year Floodplain**

The greatest flash flood risk is generally considered to be between April 15 and Sept. 15, but flooding can occur at any time. Flooding can happen from both long-duration and short-duration storm events. Flash floods along the city’s creeks can occur very quickly, with little or no warning. The greatest threat is from thunderstorms that produce high-intensity rainfall in short periods of time.

The city has had several floods in the past. The largest flood on record hit Boulder Creek in 1894, greatly impacting the downtown area. Up to six inches of rain fell west of the city, resulting in 100-year flows in Boulder Creek, extensive flooding up to one mile wide and the loss of one life. Boulder Creek flooded again in both 1914 and 1929. South Boulder Creek flooded in 1938 and again in 1969, causing extensive damage in Eldorado Springs and within the city limits. In 1906, Sunshine Creek experienced flash flooding and in 1909, a flash flood on Twomile Canyon Creek resulted in two deaths. In 2007, a flash flood along Bear Canyon Creek resulted in floodwaters overtopping the roadway at Table Mesa

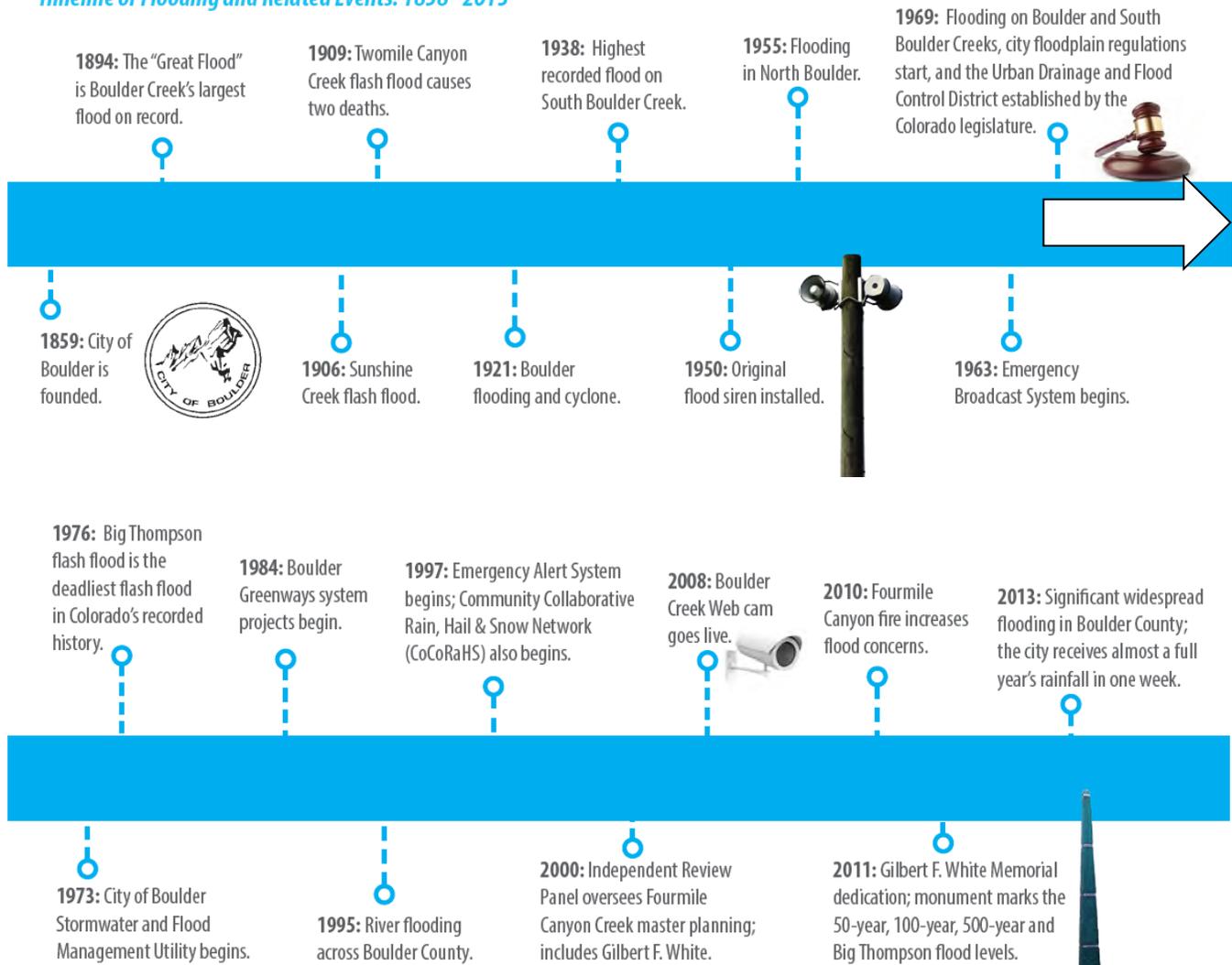
Drive. Fourmile Canyon Creek overtopped its banks in the summer of 2011, producing minor flooding within the city and greater flooding upstream in Boulder County.

In September 2013, the city experienced widespread flooding from a long-duration storm event that produced up to 19 inches of rain over an eight-day period. Private properties and public infrastructure were damaged by this storm event in a variety of ways, including impacts from localized drainage, groundwater and wastewater collection system backups. After the 2013 flood rainfall-runoff analysis was completed to estimate peak flows for each drainageway and determine estimated storm frequencies. The table below summarizes the findings of this analysis:

<b>Rainfall-Runoff Analysis                      September 2013 Flood Disaster                      (Drainageways listed South to North)</b>		
<b>Rainfall-Runoff Analysis</b>	<b>Location</b>	<b>Estimated Runoff Frequency (Year)</b>
South Boulder Creek	Eldorado Springs	10-25
South Boulder Creek	Highway 93	50-100
South Boulder Creek	South Boulder Road	25 -50
South Boulder Creek	West Valley Overflow	~100
Bear Canyon Creek	Broadway	~20
Bear Canyon Creek	Baseline Road	~20
Bluebell Creek	Chautauqua	~25
Kings Gulch	Chautauqua	~10
Skunk Creek	Baseline Road	~25
Gregory Canyon Creek	Baseline Road	~10-50
Boulder Creek	Broadway	~25
Boulder Creek	75 <sup>th</sup> St.	25-50
Two-mile Canyon Creek	Broadway	~100
Goose Creek	Folsom	50-100
Wonderland Creek	15 <sup>th</sup> St.	5 - 10
Fourmile Canyon Creek	Broadway	10-50
Fourmile Canyon Creek	Highway 119	50-100

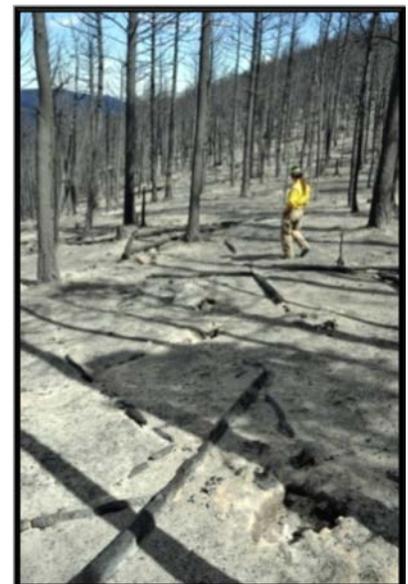
The flood management program focuses mitigation efforts on flooding of the major drainageways. The timeline below outlines major events that have impacted the city’s flood management program.

## Timeline of Flooding and Related Events: 1858 - 2013



## Wildfires

Wildfires can increase flood risks. The intense heat from a fire destroys vegetation and decreases the permeability of soils, resulting in increased runoff from burn areas. On Sept. 6, 2010, a wildfire started that eventually burned nearly 6,200 acres of the steep, forested Fourmile Canyon area just west of Boulder. Approximately 60 percent of the area was severely or moderately burned. Approximately 80 percent of the burn area is tributary to Fourmile Creek, which is a tributary to Boulder Creek (approximately two miles west of Boulder). Approximately 20 percent of the burn area is located in the Fourmile Canyon Creek watershed. Fourmile Canyon Creek flows through north Boulder and is also tributary to Boulder Creek, with a confluence downstream of the Boulder city limits. As a result of the burn, new hydrologic models were developed for the burn area. These models were calibrated and adjusted over time, based on changing vegetation levels and observed runoff from rainfall events.



## **Flood Emergency Preparedness**

Flood preparedness is a critical element in the city's floodplain management program. The more prepared the community can be with pre-flood readiness, ongoing monitoring, effective warning systems, trained response, and post-flood recovery, the better the chance that the impacts of flooding may be managed.

The [National Weather Service](#) (NWS) is the foremost forecaster of weather events. The NWS operates and maintains a network of weather radar stations, as well as other monitoring and broadcast systems, to provide forecasts and warnings for the protection of life and property.

To supplement the NWS information, the Urban Drainage and Flood Control District (UDFCD) contracts to have 24-hour meteorologist coverage for the Denver metro area during the peak flood season. The UDFCD meteorologists forward daily forecasts to the city and the Boulder Office of Emergency Management (OEM). The UDFCD also operates and maintains a network of stream and rainfall gauges in and around the city. This information provides [real-time data](#) that is monitored by the Boulder OEM during the flood season.

Due to the very short timeframe in which flooding can occur, there is often limited time available to provide adequate warning or to react. This is particularly true for some of the city's smaller creek systems, which lack stream gauges. In addition, thunderstorm cells can move and intensify very rapidly and often unpredictably. It is therefore critical that people who live and work within these floodplains be aware of the risk, monitor the weather and prepare an emergency plan in advance. Flood education, regulations and ordinances are therefore critical components of the city's flood emergency preparedness program.

## **Floodplain Mapping**

Floodplain mapping provides the basis for flood management by identifying the areas subject to the greatest risk of flooding. This information is essential for determining areas where life safety is threatened and property damage is likely, and forms the basis for floodplain regulations and the National Flood Insurance Program. The city's floodplain maps need to be periodically updated to reflect changes in the floodplain resulting from land development, flood mitigation improvements, new survey information and new study technologies.

The city delineates and regulates four flood zones:

***500-year floodplain:*** delineates the flood limits resulting from a design storm that has a 0.2 percent chance of occurring in any given year.

***100-year floodplain:*** defined as all land areas subject to inundation by floodwaters in a design storm having a one percent chance of being equaled or exceed in any given year.

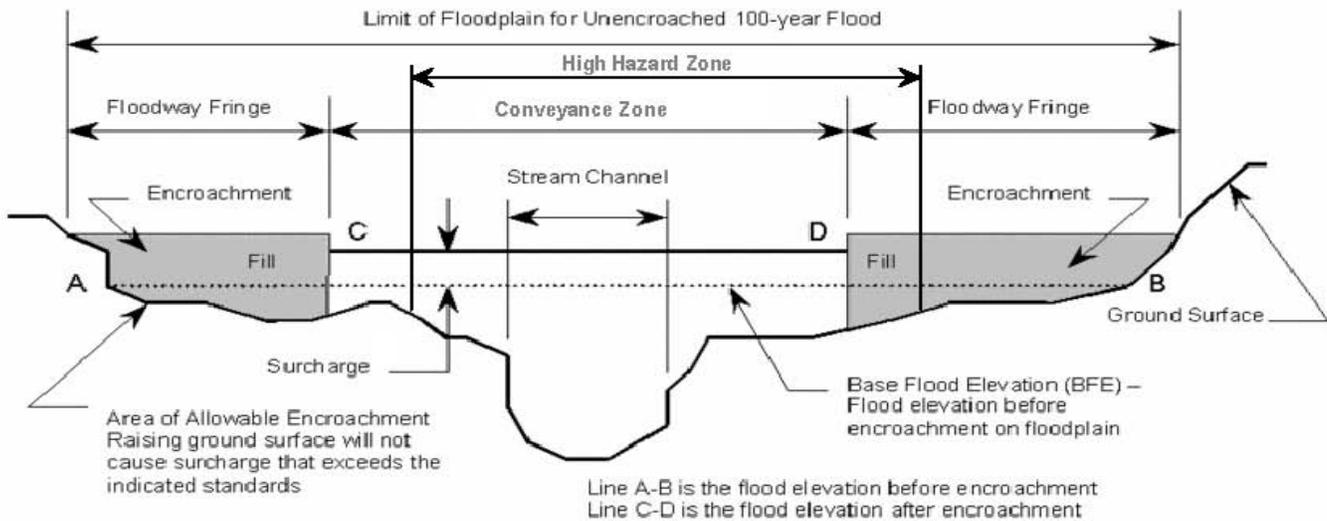
***Conveyance zone:*** represents a preservation zone for passing flood flows along the creek corridor without increasing flood depths, redirecting floodwaters or adversely impacting land areas. The establishment of a conveyance zone recognizes that development activities are expected to occur in the 100-year floodplain, but places a limit on these activities to prevent adverse impacts.

***High-hazard zone:*** This area of the floodplain has the greatest risk of loss of life. The area should not be occupied by people during a flood. The high-hazard zone represents areas in the 100-year floodplain

where an unacceptably high hazard to human safety exists and where there is the potential for floodwaters to sweep people off of their feet and wash them downstream.

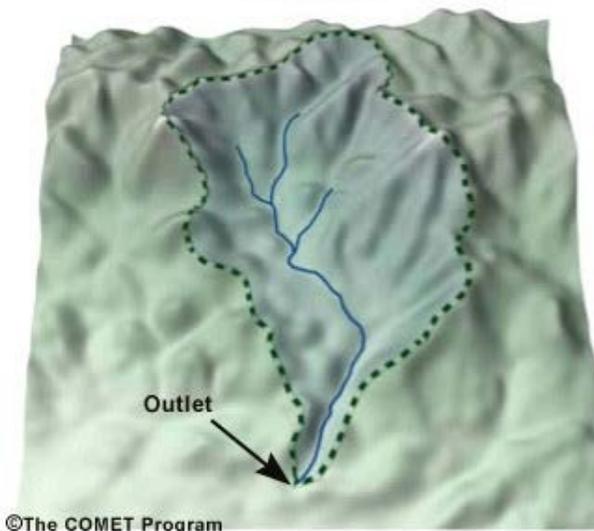
Research was conducted to determine the flood depths and velocities that were most likely to sweep people off of their feet. As a result of the research, the high-hazard zone is defined as all areas in the floodplain where the floodwater velocity (in cubic feet per second) multiplied by the floodwater depth (measured in feet) would equal or exceed four, or where the floodwater depth alone would equal or exceed four feet. An example would be a flood depth of three feet with the water moving 1.5 feet per second, which would result in a product number of 4.5, thus placing the area within the high-hazard zone.

The components of the 100-year floodplain are illustrated in **Figure 3**.



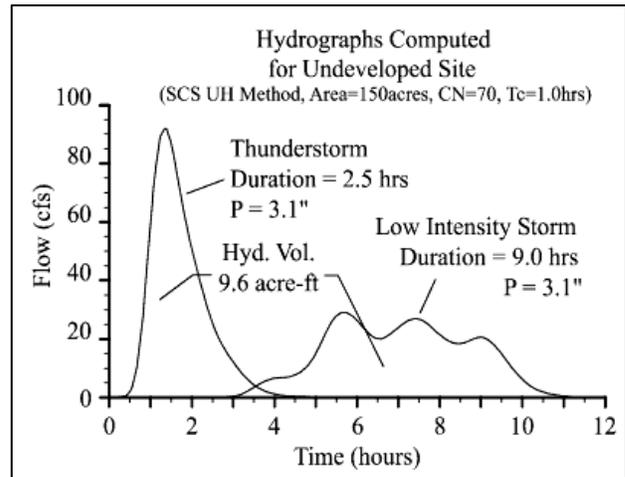
**Figure 3: Components of the 100-Year Floodplain**

**Watershed**



The flood flows used in floodplain mapping studies come from hydrologic analyses using Federal Emergency Management Agency (FEMA), Colorado Water Conservation Board, and Urban Drainage and Flood Control District (UDFCD) procedures and parameters. Peak flows are computed for each drainageway. Watershed characteristics such as size, shape, topography, vegetation, amount of pavement and impervious surfaces, and soils characteristics are used to compute the flood hydrographs for various design points in the basin.

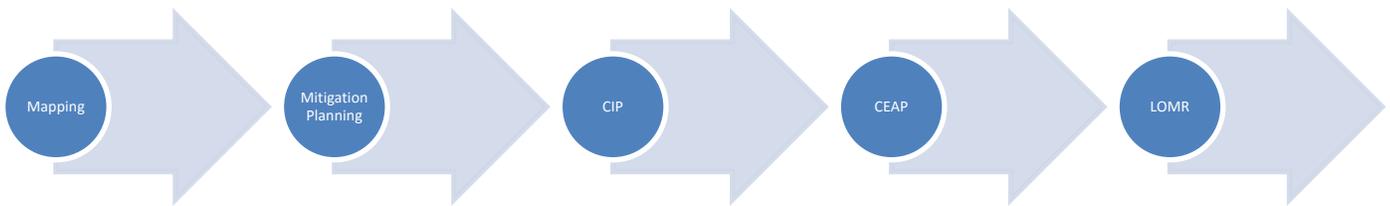
The design storm used in the hydrologic analysis (rainfall-runoff) is typically a short-duration (one- or two-hour) storm. Rainfall intensities, used to calculate the peak flows for floodplain mapping, come from the UDFCD Drainage Criteria Manual and range from 2.4 to 2.7 inches per hour for the 100-year flood. This design storm emulates a flash flood, which is quite different from the long-duration, less-intense storm that led to the flooding in September 2013. The hydrograph to the right shows the flow rate in a creek over time and provides a comparison of a flash flood with a longer-duration, lower-intensity storm. In both events, 3.1 inches of rain fell, but the shorter-duration and higher-intensity storm produced a much higher peak flow (90 cfs vs. 30 cfs).



### Flood Mitigation

The city has been working for many years to reduce the flood threat by implementing major drainageway flood mitigation projects. In 1973, the city established a separate Stormwater and Flood Management Utility to provide a consistent, long-term source of funding for these efforts. Flood mitigation master planning is typically scheduled to follow floodplain mapping updates. A flood mitigation plan identifies and evaluates the benefits and costs of potential improvement projects. Feasible projects from the plan are then programmed into the Capital Improvement Program (CIP) for design and construction. During the design phase, project alternatives are typically evaluated in a Community and Environmental Assessment Process (CEAP). Once a project is constructed, a Letter of Map Revision (LOMR) is completed and submitted to FEMA to update the floodplain mapping to reflect the improvements.

View the [Floodplain Mapping, Mitigation Planning and Capital Improvements Projects Schedule](#).



A CEAP is a formal internal city review process to consider the impacts of public development projects. The purpose of the CEAP is to assess potential impacts of conceptual project alternatives in order to inform the selection and refinement of preferred alternatives. The CEAP provides the opportunity to balance multiple community goals in the design of a capital project by assessing a project against the policies outlined in the Boulder Valley Comprehensive Plan (BVCP) and departmental master plans. Projects that will require the CEAP review are identified during the annual CIP and budget process. A Utilities-funded project, such as a floodplain mitigation project, that requires a CEAP review is ultimately set for a public hearing with the Water Resources Advisory Board (WRAB), which then makes a recommendation for City Council consideration.

In addition to flood mitigation, the Greenways Program integrates multiple objectives along the major drainageways including habitat protection, water quality enhancement, providing trails and recreation,

and preserving cultural resources. If a project meets more than one objective of the Greenways Program, the CEAP recommendation is made by the Greenways Advisory Committee (GAC), which is made up of representatives of six advisory boards. CEAP reviews are placed on the council's consent agenda for action, and may be called up for public hearing should council not agree with the WRAB or GAC decision, or should other issues arise.

The flood mapping, mitigation planning and construction process takes years to complete due to its often controversial nature and the extensive public process. As an example, the South Boulder Creek floodplain mapping study was initiated in 2002 and completed in 2007; the flood mitigation planning was initiated in 2009 and completed in 2015; the design was initiated in 2017 and is anticipated to take several years to complete. Design and construction of improvement projects also is a multi-year process. The Elmer's Twomile Creek Capital Improvement Project was initiated in 2001 and completed in 2010. Given the long implementation phase, it is important to complete floodplain mapping studies prior to moving forward with mitigation projects in order to document the risk of flooding and make property owners aware of the risk.

### **Property Acquisitions**

In addition to funding the construction of flood mitigation projects, the Stormwater and Flood Management Utility Capital Improvement Program allocates \$600,000 each year for property acquisition. This provides funds for the purchase of properties in areas prone to flooding, especially in the city's high-hazard regulatory area. High-risk properties have been identified and prioritized for purchase along each of the city's major drainageways. This program has been "opportunity-based," working with willing sellers and relying on properties that become available on the real estate market.

### **Overview of the Urban Drainage and Flood Control District**

The City of Boulder is part of the [Urban Drainage and Flood Control District](#) (UDFCD), which was established in 1969 by the Colorado Legislature to assist local governments in the Denver metropolitan area with drainage and flood control issues. The UDFCD receives funding for its programs through a mill levy on property taxes within participating communities. The mill levy for Boulder County is 0.608 mills. For example, a house with an assessed value of \$500,000 would pay \$304 per year based on the current mill. The UDFCD coordinates four programs: Master Planning; Design, Construction and Maintenance; Floodplain Management; and Information Services and Flood Warning. The Master Planning program assists local agencies with flood mitigation planning efforts. Projects identified through the master plans are then eligible for design, construction and maintenance funding through the UDFCD. The Floodplain Management program focuses on assisting local governments with delineating flood risks through floodplain mapping efforts. The Information Services and Flood Warning program is responsible for contracting with a private meteorological service to provide daily forecasts of flood potential and notify local agencies when threatening conditions develop. The UDFCD also installs and maintains a system of rainfall and stream flow gauges to help monitor the potential for flooding.

Each year, the City of Boulder requests funding assistance from the UDFCD for maintenance and capital improvement projects. The UDFCD also provides routine maintenance of designated drainageways, which includes debris removal and mowing. The UDFCD provides 100 percent of the funding for maintenance projects and up to 50 percent for capital improvements. Maintenance projects are managed and coordinated by the UDFCD, whereas the city is responsible for the management and oversight of capital projects. The UDFCD also provides up to 50 percent of the funding for flood mitigation planning efforts, which are coordinated by the city. Limited funding is also available for floodplain mapping updates, which are also the responsibility of the city. The UDFCD is currently providing financial assistance for the capital improvement projects along Wonderland and Fourmile Canyon

creeks; the mitigation planning studies on South Boulder Creek, Gregory Canyon Creek, Bear Canyon Creek and Boulder Creek; and the mapping study for Twomile Canyon Creek.

### **Floodplain Regulations**

Floodplain regulations are land use regulations intended to reduce risks to people and property in areas along drainageways that are prone to flooding. The City of Boulder adopted its first floodplain regulations in 1969, in response to flooding along the Front Range of Colorado.

The city's "Floodplain Regulations" are contained in Chapter 9-3, Boulder Revised Code (B.R.C.) 1981.

#### ***100-year floodplain***

A floodplain development permit is required for all development activities in the 100-year floodplain. Development within the 100-year floodplain is permitted, subject to the provision of flood protection measures designed to mitigate the risk of property loss or damage. For residential structures, this requires that the lowest floor of any new structure or addition be elevated above the flood protection elevation, which is two feet above the floodwater surface elevation. Basements are not permitted for residential structures in the 100-year floodplain.

For non-residential structures, the lowest floor of any new structure or addition must be elevated above the flood protection elevation or be floodproofed to ensure that the structure is watertight, with walls substantially impermeable to the passage of floodwaters below the flood protection elevation. Floodproofing of structures must be provided in an automatic manner and not require any human intervention to be effective. This is often accomplished through the use of floodgates that will automatically rise during a flooding event, such as the floodgates at the Municipal Building, the St. Julien Hotel or Alfalfa's Market.

New structures in the 100-year floodplain are required to install protection against sewer backups that may occur if the sanitary sewer system becomes surcharged during flood conditions. New parking lots are not permitted in the 100-year floodplain where flood depths would exceed 18 inches, since automobiles are buoyant and become flood debris at these depths. Hazardous materials may not be stored below the flood protection elevation (except for existing gasoline storage tanks that were in place prior to 1989). Mobile homes placed after July 1, 1989, must be elevated on a permanent foundation, and new structures must be oriented to minimize flood flow obstruction.

#### ***500-year floodplain***

In 2014, the city enacted new floodplain regulations to provide additional flood protection for critical facilities, such as hospitals, police and fire stations, day care facilities and utility treatment facilities in the 500-year floodplain.

#### ***Conveyance zone***

The conveyance zone represents a preservation zone for passing flood flows along the creek corridor without increasing flood depths, redirecting floodwaters or adversely impacting land areas or properties. The establishment of a conveyance zone recognizes that development activities are expected to occur in the 100-year floodplain, but places a limit on these activities to prevent adverse impacts. Development in the conveyance zone typically requires a private engineering analysis to ensure that flooding conditions are not worsened. Flood mitigation measures are sometimes required to offset the development and keep the floodplain from expanding or floodwaters from getting deeper. Regulations for the 100-year floodplain also apply to the conveyance zone. All regulations apply if an area is located in both the conveyance zone and the high-hazard zone.

### ***High-hazard zone***

Development in the high-hazard zone is most restricted, due to life safety concerns. No new structures or additions to existing structures intended for human occupancy are permitted in the high-hazard zone. It is anticipated that many structures within the high-hazard zone will require evacuation during a major flooding event due to structural failure or potential issues with fire, sanitation, electrical hazards, broken utilities, or debris. Additionally, no new parking lots and no changes of use of an existing non-residential structure to a residential use are permitted. Regulations for the 100-year floodplain also apply to the high-hazard zone.

### **Flood Insurance and the Community Rating System (CRS)**

The City of Boulder participates in the [National Flood Insurance Program](#) (NFIP) by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federal government-backed flood insurance available to homeowners, renters and business owners, whether or not their properties are in a floodplain. Flood insurance covers direct losses caused by surface flooding, including a river overflowing its banks, a lake storm and local drainage problems. The NFIP insures buildings with two types of coverage: structural and contents. Structural coverage is for the walls, floors, insulation, furnace, and other items permanently attached to the structure. Contents insurance is intended to cover personal possessions.

There is a mandatory requirement to purchase flood insurance that applies to all forms of federal or federally-related mortgages for buildings located in the 100-year floodplain. The maximum amount available for a single-family house is \$250,000. While not mandated by law, a lender may also require a flood insurance policy as a condition of a loan for a property in any zone on a Flood Insurance Rate Map.

The NFIP's Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements.

Flood insurance premium rates are discounted to reflect the reduced flood risk resulting from community actions that meet the three goals of the CRS:

1. Reduce flood losses;
2. Facilitate accurate insurance rating; and
3. Promote the awareness of flood insurance.

For CRS participating communities, flood insurance premium rates are discounted in increments of five percent: i.e., a Class 9 community would receive a 5 percent premium discount, while a Class 8 community would receive a 10 percent discount. The city joined the CRS in 1992 as a Class 8 community, improved to a Class 7 in 2008 and then to a Class 6 in 2012. The city was awarded a Class 5 rating in early 2013. As a result, standard policyholders now receive a 25 percent discount on flood insurance with anticipated citywide annual savings of more than half a million dollars. As of Jan. 31, 2014, there were 3,830 policies held by City of Boulder residents, with a total insured coverage of \$857,163,100 at a total premium cost of \$2,909,611.

Boulder has by far the largest number of flood insurance policies (required on all federally backed mortgages) and largest insured property value of any municipality in Colorado. City of Boulder residents and businesses pay nearly \$3 million in total annual flood insurance premiums. Community investment in flood mitigation serves to reduce the associated risks and related insurance costs.

<b>FLOOD INSURANCE COMPARISON</b>				
<b>Source - Insurance Service Office, April 2014</b>				
<b>Community</b>	<b>Estimated 2013 Population</b>	<b>Number of Policies</b>	<b>Annual Insurance Premiums</b>	<b>Total Insured Value (thousands \$)</b>
Boulder	103,000	3830	\$ 2,909,611	\$ 857,163
Colorado Springs	440,000	2727	\$ 1,715,597	\$ 615,724
Denver	650,000	1381	\$ 1,553,231	\$ 331,491
Arvada	112,000	506	\$ 634,467	\$ 111,951
Fort Collins	152,000	439	\$ 271,142	\$ 116,049
Lakewood	147,000	467	\$ 484,764	\$ 115,335
Longmont	90,000	376	\$ 348,693	\$ 89,795
Centennial	106,000	130	\$ 64,467	\$ 31,831
Loveland	71,000	127	\$ 103,533	\$ 33,286
Westminster	111,000	118	\$ 82,425	\$ 30,187
Pueblo	108,000	99	\$ 62,855	\$ 20,960
Thornton	127,000	97	\$ 52,153	\$ 21,983
Greeley	97,000	66	\$ 76,238	\$ 14,794

### **Flood Recovery**

Flood recovery efforts have become a significant component of the city's flood management program. The September 2013 flood resulted in sediment and debris in all 15 drainageways, bank erosion, and damages to creek infrastructure, including drop structures, trash racks, culverts and retaining walls. In addition to the restoration efforts, the flood recovery work also includes documenting damages and flood extent information; assisting property owners; analyzing rainfall information; and coordinating with the State of Colorado and the FEMA. Flood recovery work is expected to continue throughout 2014, with follow-up documentation and audits for an additional two years.

### **Flood Outreach**

The city reaches out to community members in a variety of ways to raise awareness of the flood risk and provides resources to help them prepare for a flood. Flood safety information is distributed to every school in the Boulder Valley School District to be sent home with every student. Flood safety classroom programs are offered to all elementary school teachers and information is provided to families of fifth grade students who participate in the annual Water Festival. Annual direct mailings to all properties located in the 100-year floodplain are coordinated through the Urban Drainage and Flood Control District. Flood awareness door hangers are distributed to University of Colorado off-campus housing neighborhoods and to high-hazard residential properties. Information is distributed via local media, both through press releases and paid advertisements. A utility bill insert is provided annually to 26,000 customers. Outdoor emergency sirens are tested monthly during the peak flood season. The city's flood website, [www.boulderfloodinfo.net](http://www.boulderfloodinfo.net), includes extensive flood information, including the [Community Guide to Flood Safety](#).