C I T Y O F B O U L D E R
FLOODPLAIN MANAGEMENT PROGRAM

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 floodplain 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 event. Major components of the city's floodplain 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**). Nearly 2,600 individual structures are located within this flood zone.

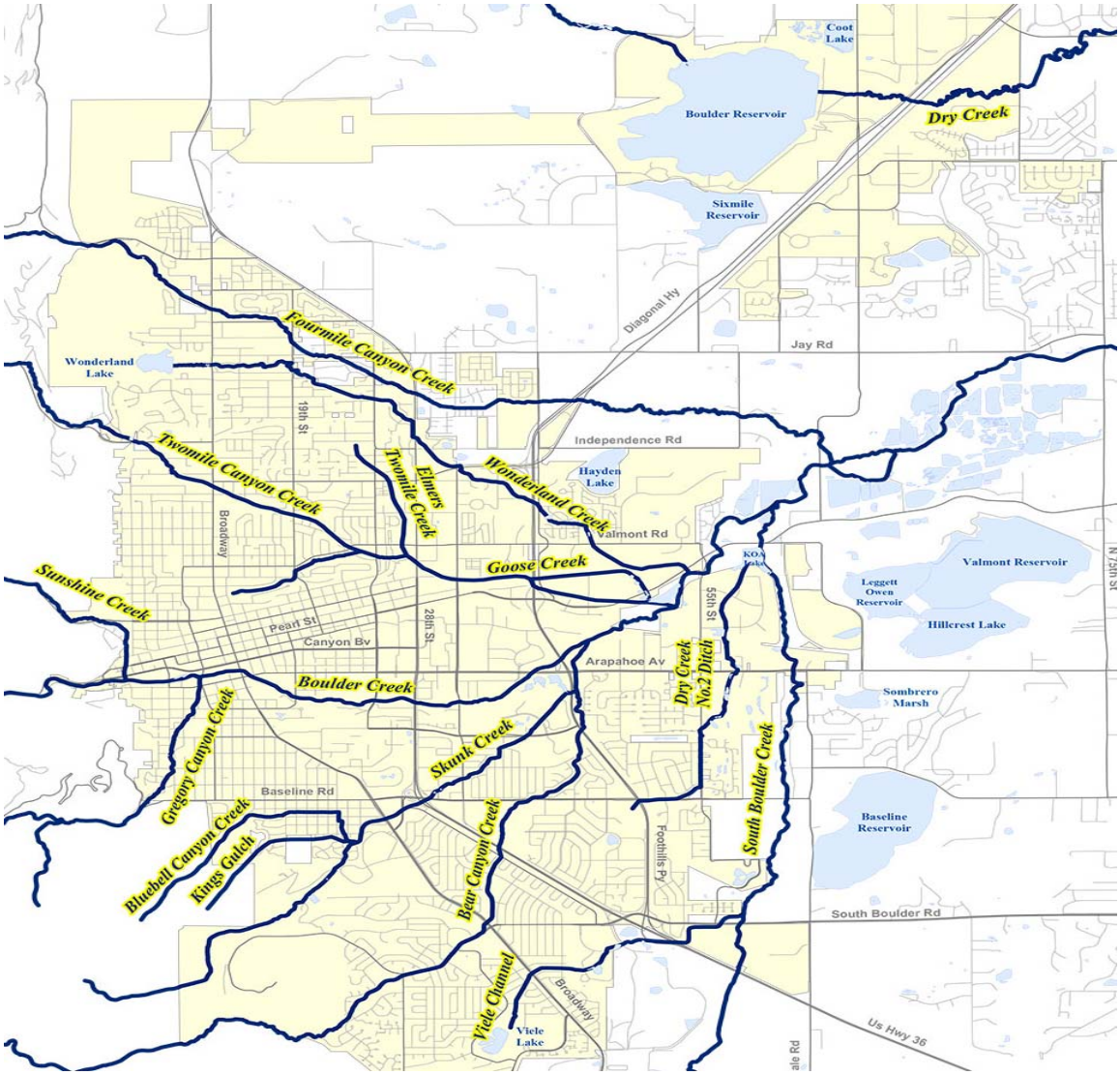


Figure 1: Major Drainageways

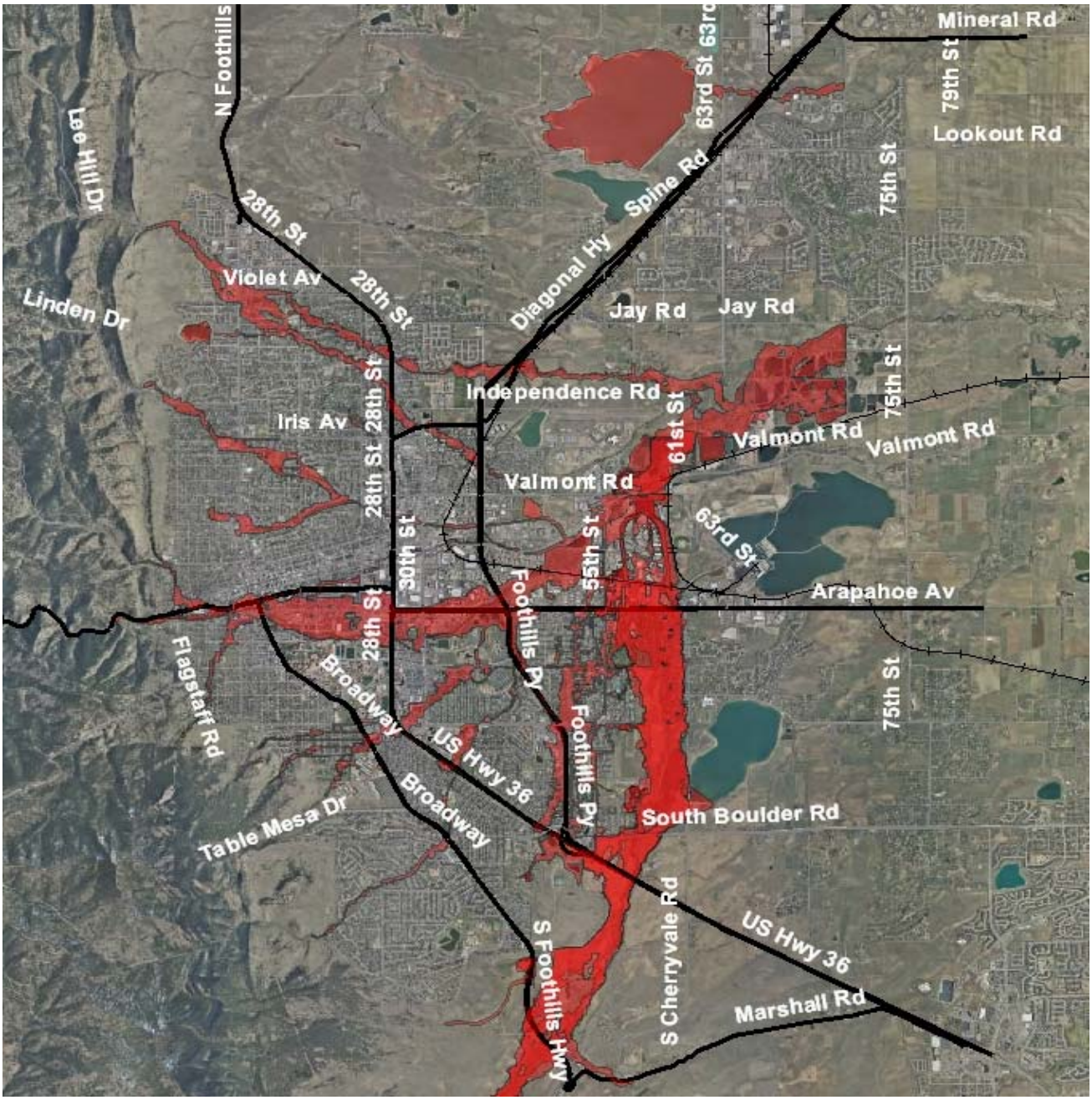
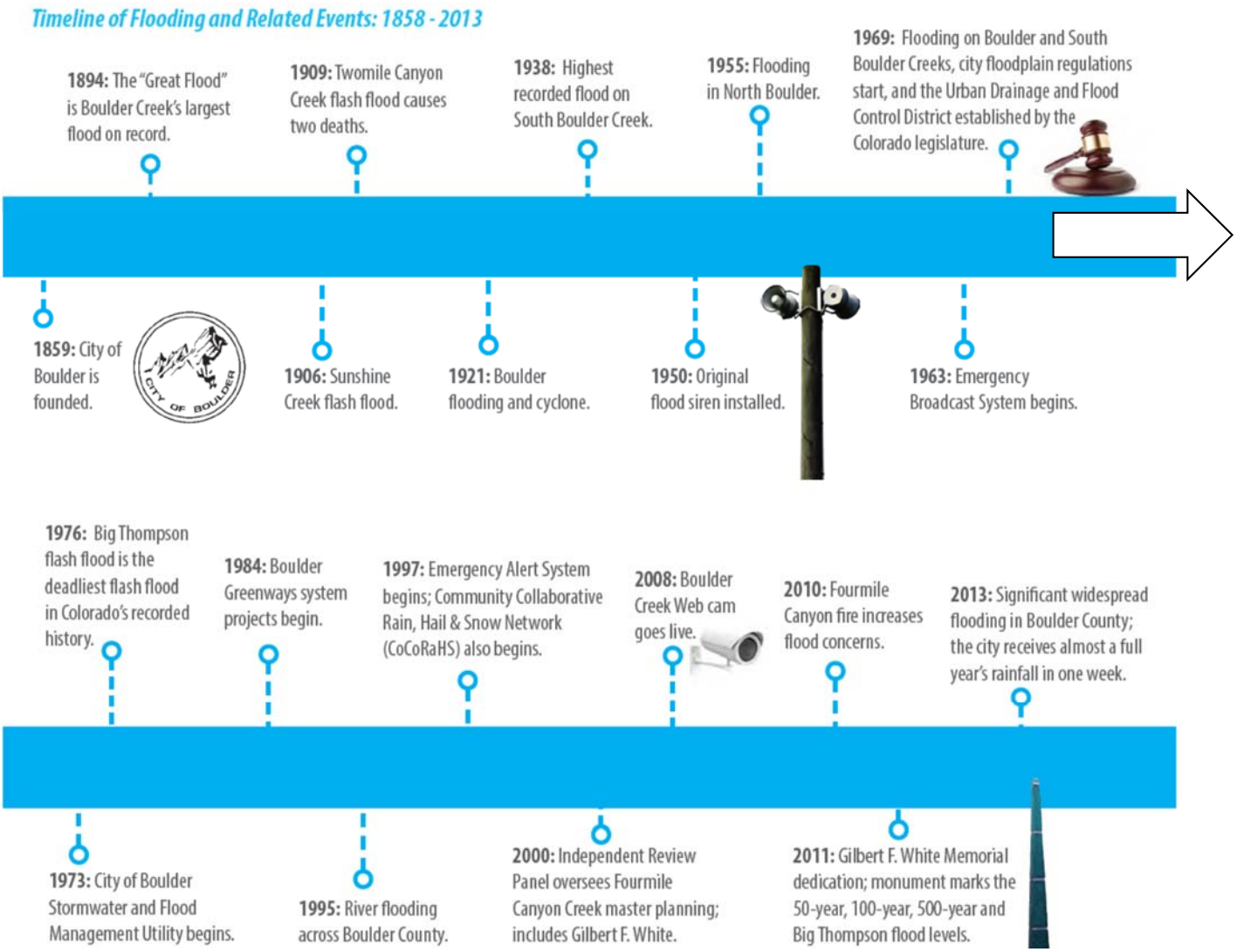


Figure 2: 100-Year Floodplain

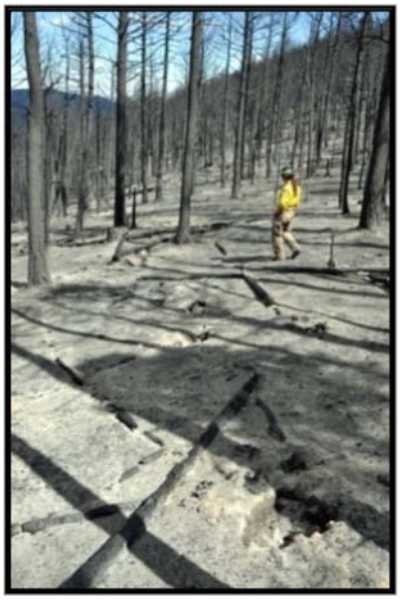
The greatest flash flood risk is generally considered to be between April 15 and Sept. 15, but flooding can occur at any time. Flooding can happen from both long duration and short duration storm events. Flash floods along the city's creeks can occur very quickly with little or no warning. The greatest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

The city has had several flood events 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 event 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. More recently, a flash flood event in 2007 along Bear Canyon Creek resulted in roadway overtopping 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 8 day period. Private properties and public infrastructure were damaged by this storm event in a variety of ways including impacts from localized drainage, ground water and wastewater collection system back-ups. The floodplain management program focuses mitigation efforts on flooding of the major drainageways. The timeline below outlines major events that have impacted the city's floodplain management program.



Wildfires



Wildfires can increase flooding 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 chance the impacts of flooding may be managed.

During the peak flood season, the Urban Drainage and Flood Control District (UDFCD) contracts to have 24-hour meteorologist coverage for the Denver metro area. The UDFCD meteorologists forward daily forecasts to the city and the Boulder Office of Emergency Management (Boulder 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 time frame 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 that 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 is 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 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 flood waters in a design storm event 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 flood waters 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 to the floodplain.

High hazard zone: This area of the floodplain is where there is the greatest risk of loss of life. The area should not be occupied by people during a flooding event. The high hazard zone represents those areas in the 100-year floodplain where an unacceptably high hazard to human safety exists and where there is the potential for flood waters 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 flood water velocity (feet per second) multiplied by the flood water depth (measured in feet) would equal or exceed four or where flood water depth alone would equal or exceed four feet. An example would be a flood depth of three feet with the water only moving 1½ feet per second, which would result in a product number of 4½, thus placing the area within the high hazard zone.

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

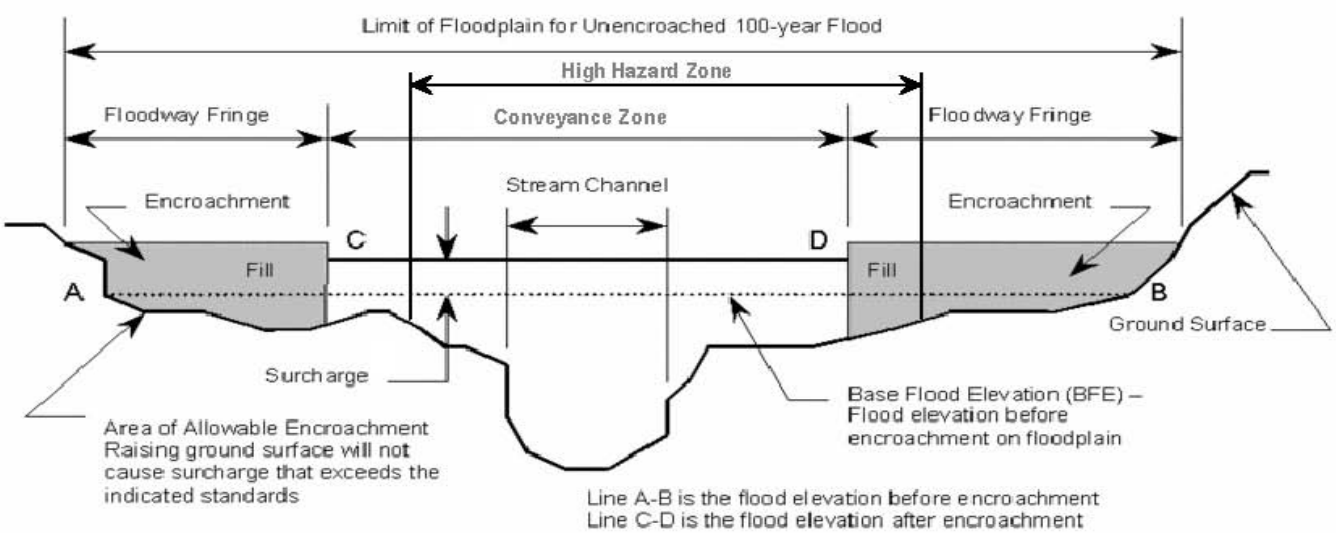
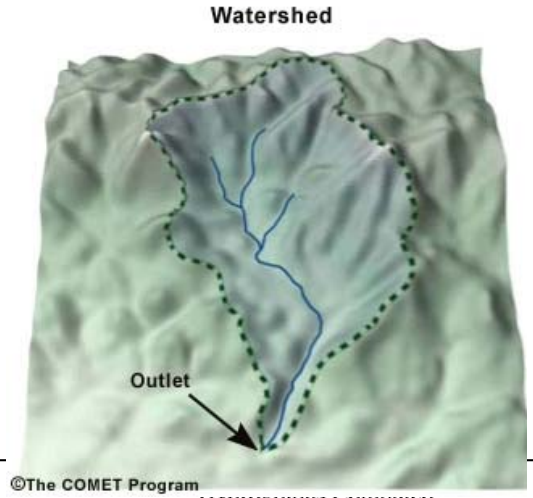
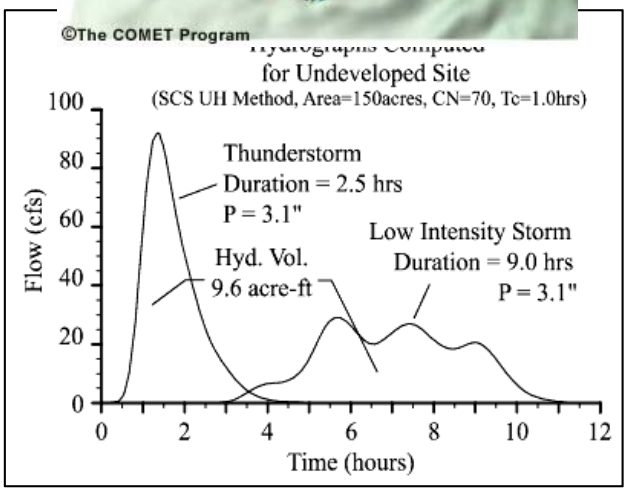


Figure 3: Components of the 100-Year Floodplain

The flood flows used in floodplain mapping studies come from hydrologic analyses using FEMA, Colorado Water Conservation Board and Urban Drainage and Flood Control District 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.

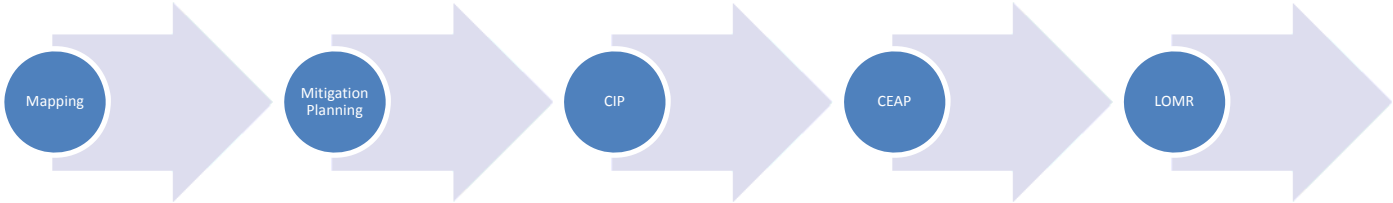


The design storm used in the hydrologic analysis is typically a short duration (1 or 2 hour) storm. Rainfall intensities, used to calculate the peak flows for flood mapping, come from the UDFCD Drainage Criteria Manual and range from 2.4 to 2.7 inches per hour for the 100-year event. This design storm emulates a flash flooding event which is quite different from the long duration, less intense storm that led to the flooding in September. This diagram shows a comparison of a flash flood event with a longer duration, lower intensity storm event. In both events, 3.1 inches of rain fell, but the shorter duration and higher intensity storm produced a much higher peak flow (90cfs vs. 30cfs).



Flood Mitigation and Property Acquisitions

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 flood 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 flood mapping to reflect the improvements.



A schedule for the current and recently completed floodplain mapping, mitigation planning and capital improvements can be found at:

Flood Mapping, Mitigation Planning and CIP Schedule

The flood mapping, mitigation planning and construction process takes years to complete due to its controversial nature and the extensive public process. As an example, the South Boulder Creek mapping study was initiated in 2002 and completed in 2007. The mitigation planning effort for this drainageway was initiated in 2009 and is still being evaluated. The design and construction of improvement projects also is a multi-year process. The Elmer's Twomile Capital Improvement Project was initiated in 2001and completed in 2010. Given the long implementation phase, it is important to complete 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.

In addition to funding the construction of flood mitigation projects, the Stormwater and Flood Management Utility Capital Improvement Program allocates $500,000 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.

Floodplain Regulations

Floodplain regulations are land use regulations intended to reduce risks to people and property in areas along rivers and streams 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. Regulated flood areas are :

- 500-year floodplain
- 100-year floodplain
- Conveyance zone
- High hazard zone

500-year floodplain

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

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 to mitigate the risk of property loss or damage. In residential applications, 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 flood elevation). Basements are not permitted for residential structures.

In non-residential applications, the lowest floor of any new structure or addition must be elevated above the flood protection elevation or be flood proofed to ensure that the structure is watertight with walls substantially impermeable to the passage of flood waters below the 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 flood gates that will automatically raise during

a flooding event, such as the flood gates 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 back-ups that are likely to 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 are to be oriented to minimize flood flow obstruction.

Conveyance zone

The Conveyance zone represents a preservation zone for passing flood flows along the creek corridor without increasing flood depths, redirecting flood waters 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 to the floodplain. Development in the conveyance zone typically requires an 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. If an area is located in both the conveyance zone and the high hazard zone, all regulations apply.

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, electric hazards, broken utilities, or debris. Additionally, no new parking lots and no change of use of an existing non-residential structure to a residential use is permitted. Regulations for the 100-year floodplain also apply to the high hazard zone and conveyance 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 or ocean 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.

There is a mandatory flood insurance purchase requirement 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.

As a result, 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 five 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 a Class 6 in 2012. The city was awarded a Class 5 in early 2013. As a result, standard policy holders now receive a 25 percent discount on flood insurance with anticipated city-wide annual savings of over half a million dollars. As of January 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.

Flood Recovery

Flood recovery efforts have become a significant component of the city's floodplain 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 Federal Emergency Management Agency. Flood recovery work is expected to continue through 2014 with follow-up documentation and audits for an additional 2 years.

Flood Outreach

The City reaches out to community members in a variety of ways to raise awareness of the risk of flooding 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 class room programs are offered to all elementary school teachers and information is provided to families of 5th 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 off-campus housing neighborhoods and 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. Since the September 2013 flood, the city conducted seven open houses to share information, help individuals recover and help us understand more about what happened during the event. Prior to the start of the 2014 flood season, two community preparedness open houses were held, which were attended by approximately 150 people. The City's website includes extensive flood information at https://bouldercolorado.gov/flood including a newly created Community Guide to Flood Safety.