CITY OF BOULDER

COMPREHENSIVE FLOOD AND STORMWATER MASTER PLAN

DRAFT

TECHNICAL MEMORANDUM #8

Flood Mitigation, Property Acquisition, and Watershed Management

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Technical Memorandum Summary

The following policy recommendations are included in this Technical Memorandum:

Flood Mitigation

- Identify flood mitigation measures using standardized methodology and a robust public engagement process in a way that incorporates best practices identified by the Mile High Flood District and the Community Rating System.
- Emphasize the use of nature-based solutions for flood mitigation to protect people and property in a way that preserves or restores the ecological functions of creek and riparian corridors.
- It is the policy of the Boulder Valley Comprehensive Plan that the major drainageway system will be designed to transport the 100-year flood event or a modified standard in an approved plan. All mitigation plans are required to model and evaluate the 100-year flood event. However, physical characteristics vary greatly by major drainageway such that 100-year flood protection may not be feasible. In these situations, proposed mitigation alternatives shall strive to mitigate to the highest degree feasible based on drainageway characteristics and community preference.

Property Acquisition

- Promote open space uses of floodplains by removing existing structures through pre-flood and post-flood property acquisition. Purchases should be prioritized in locations that threaten the health, safety, and welfare of the community.

Watershed Management

- Flooding occurs when the volume and rate of stormwater runoff exceeds the capacity of the infrastructure intended to convey runoff. The Utility is committed to a comprehensive and interconnected approach to watershed management in all 16 of its major drainage basins that identifies and mitigates both sources of excess runoff and damaging effects of flooding, regardless of where they occur.
- Remain aware of major changes that occur in watersheds, such as fires and impacts due to climate change. Coordinate with active agencies within the watersheds to proactively address these changes.

1 Introduction

Floods are one of the costliest natural disasters in terms of economic losses and human hardship. One of the principal functions of the Stormwater and Flood Management Utility is to reduce or eliminate risk and losses caused by floods. A variety of tools are employed by the Utility to achieve this. The construction of major drainageway flood mitigation projects is one of the primary ways in which this is accomplished. The Utility has been working for many years to reduce the threat of floods through the implementation of flood mitigation projects by first planning, evaluating, and then constructing these projects through the city's Capital Improvement Program. Additionally, it is understood that floodplains provide several natural and beneficial functions for both humans and surrounding ecosystems. As Boulder's population expanded rapidly, development was pushed further into the floodplains. Because the majority of this development happened prior to the existence of floodplain regulations, it became increasingly difficult to provide floodplain protections while adequately addressing societal needs and challenges. Therefore, Boulder uses a combined approach involving a variety of programs to identify and address the tradeoffs associated with comprehensive floodplain management.

In addition to flood mitigation projects, the Utility also seeks to reduce exposure and prevent flood risks from increasing through property acquisition and watershed management. Property acquisition seeks to reduce the exposure of flooding to high-risk structures by removing them from the flood path. This further reduces or eliminates flood risk to life and property in dangerous flood prone areas. Watershed management, on the other hand, manages increases in stormwater runoff caused by development such that flood risks do not increase. When unmanaged, stormwater runoff from new development and redevelopment in a watershed can result in more frequent flooding, greater flood depths, and longer-lasting floods. Watershed master planning is a progressive way to address these issues, providing a plan of action to address current and expected problems and a tool to make decisions based on the data and science of a watershed's behavior.

Flood Impacts

- Injury or loss of life
- Property damage
- Infrastructure damage and road closures
- Economic losses
- Housing displacement
- Erosion and landslides

Include map of watersheds for Boulder's major drainageways

2 Policy Analysis

The City of Boulder's policies are aimed at supporting proactive flood management projects and programs that can adapt to changing conditions. Many of the improvement actions identified in the Policy and Program Evaluation point to a need to formulate specific policies that support and formalize work currently performed by the Utility. The following section discusses issues and approaches to address the identified improvement actions from a policy perspective.

Identified Improvement Actions

- Proactively preserve and restore floodplains
- Define and prioritize use of non-structural drainageway improvements
- Develop standardized guidance for flood mitigation plans and address flood protection levels based on drainageway
- Address future floodway maintenance needs
- Define terms like "unwise uses in the floodplain" and "non-structural practices"

Policy and Program Goals

Technical Memorandum #2 identified a set of goals and objectives that could be used to evaluate the existing policies and programs related to watershed management, flood mitigation, and property acquisition within the Utility. As part of the analysis, these goals and objectives were reviewed and refined to meet the current and future needs. The following policy analysis and recommendations support the goals and objectives listed below.

GOAL: Identify, evaluate, design, and construct improvements within the floodplain to mitigate damages to property and protect the public.

Objective:	Develop flood mitigation plans for major drainageways in the city
Objective:	Provide standardized guidance for the creation of mitigation plans
Objective:	Select, design and construct flood mitigation projects that incorporate nature-based solutions to remove people and property from the floodplain

GOAL: Remove structures and acquire privately owned properties in areas prone to flooding, especially within the city's high hazard zone, for the purposes of flood mitigation

Objective:	Develop a prioritized list of high-risk properties to inform property acquisitions
Objective:	Prevent reconstruction of structures that have sustained significant flood damage
Objective:	Retain undeveloped high hazard flood areas in their natural state whenever possible

GOAL: Ensure that major drainageways are maintained to accommodate the passage of floodwaters

- **Objective:** Routinely clear nuisance vegetation and sediment from channels and debris buildup from culverts and bridges
- **Objective:** Provide satisfactory maintenance access and public access easements or rights-of-way for the purposes of maintenance activities

GOAL: Preserve and protect the natural resources and beneficial functions of floodplains

- **Objective:** Preserve undeveloped floodplains through public land acquisition, private land dedications and multiple program coordination

GOAL: Reclaim and restore floodplains and their functions

- **Objective:** Incorporate floodplain restoration measures into flood mitigation projects
- **Objective:** Restore habitat for native species

GOAL: Protect cultural and recreational resources associated with stream corridors and floodplains

- **Objective:** Identify and protect historic resources within the floodplain
- **Objective:** Limit open space development to trails, trail linkages, and open recreational facilities that do not impede flood flows

Flood Management

As part of the flood management planning process, floodplains are first mapped prior to implementing any mitigation strategies. It is the Utility's policy to first implement nonstructural measures whenever feasible to mitigate risks associated with flooding. A particular advantage of nonstructural measures is their ability to be sustainable over the long term with minimal costs for operation, maintenance, repair, rehabilitation, and replacement. Once viable nonstructural solutions have been implemented, the Utility then identifies reaches of mapped creeks where structural modifications are most feasible for the mitigation of flood risk. When implementing structural measures, the Utility only considers the use of concrete lined channels, dams, levees, or floodwalls when there is a clear threat to life safety and other mitigation alternatives have been determined infeasible. In close coordination with community members and partner organizations like the Mile High Flood District, flood mitigation plans are developed to identify and evaluate the benefits and costs of potential major drainageway mitigation projects for design and construction. Due to the city's high risk for flash flooding and many tradeoffs associated with flood risk mitigation, it is not feasible to eliminate all risk within the City of Boulder. The Utility implements nonstructural systems and programs to further reduce risk where more targeted approaches are not warranted. However, flood risk reduction is most effective when community members also understand their responsibility and take action to continue to proactively address individual risk and implement nonstructural measures as needed to further protect themselves from harm and their property from damage.

Nonstructural Measures for Flood Risk Management

A set of techniques that do not change the physical shape of natural drainage channels and have little to no impact on the characteristics or extent of the flood itself. Methods are designed to alter the impact or consequences of flooding by eliminating exposure (i.e., removing structures) or reducing vulnerability of people and the built environment within the floodplain as it currently stands. Examples include:

- Advanced flood warning systems
- Flood preparedness education
- Floodplain regulations
- Obtaining flood insurance
- Floodproofing structures
- Removing structures from the floodplain

Structural Measures for Flood Risk Management

A set of techniques that modify the natural channel and associated riparian (overbank) area to reduce flooding extents and allow adequate room for the passage of floodwaters for the purposes of protecting people and property Examples include:

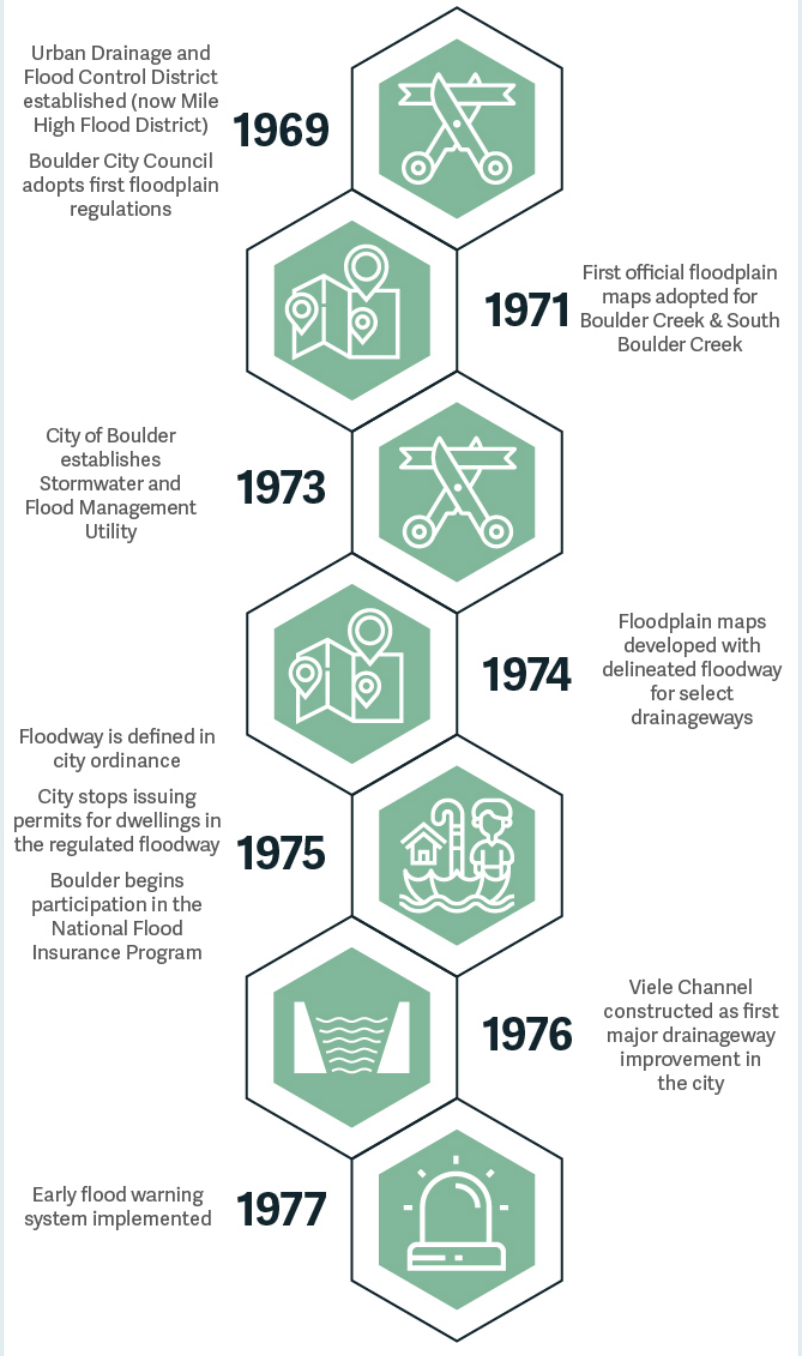
- Channel and overbank modifications: widening, deepening, or straightening
- Dams
- Floodwalls
- Levees
- Concrete lined channels

Boulder's History of Floodplain Management

The City of Boulder has a history of destructive flooding, and Boulder Creek is considered to have the highest flood risk in the State of Colorado based on population and property values (Pettem 2016, Truby and Boulas 1983). Throughout this history, the city has been both praised for a progressive and proactive stance on flood management and criticized for not doing more to heed early recommendations and warnings to limit development in the floodplains. During the first three quarters of the 20th century, more than twenty flood studies were conducted in which recommendations to either cease all building in the floodplains or to construct structural modifications to the creeks themselves were made to prevent future losses (Pettem 2016). However, without floodplain regulations in place, development in the floodplains continued. Following a series of floods in 1965 and 1969, many communities along the Front Range, including the City of Boulder, began to shift their approach to floodplain management (see timeline). The establishment of a Flood and Stormwater Utility and the development of floodplain regulations enhanced protection of life safety and Boulder's valuable environmental resources while still meeting the needs of a growing population. The Utility continues to strive for balance when planning for flood mitigation while recognizing that achieving all values may not be possible under any particular circumstance. Therefore, careful consideration of tradeoffs is necessary.

Many of the early flood mitigation plans proposed in Boulder included structural measures such as channel straightening and widening, concrete floodwalls, and levees. These plans were all rejected due to a lack of local support for structural modifications to Boulder Creek (U.S. Army

Boulder Floodplain Management: 1969-1977



Nonstructural and Non-Containment Policies

1977: Resolution No 141 Nonstructural Flood Control Policies for Boulder Creek

City Council adopts a policy that recommends guidelines for preservation and restoration over structural changes to Boulder Creek's channel or floodplain. Includes flood proofing, early warning systems, flood insurance, land use management, and floodplain filling restrictions.

1978: Boulder Valley Comprehensive Plan

City Council adopts "non-containment" policy for Boulder Creek to restrict development within the floodplain of Boulder Creek and its tributaries.

Corps of Engineers 1977). As a response, the city adopted several policies to recommend nonstructural mitigation strategies that would preserve the existing character of creeks and associated flooding patterns.

Property Acquisition

The removal or relocation of structures from the floodplain is an example of a nonstructural measure implemented by the Utility. The Utility's property acquisition program has been successful in acquiring multiple high-risk properties comprising over 200 dwelling units. However, as property values continue to increase within the city, the effectiveness of this program will decrease without significant increases in funding sources. At most, current funding allocation under this program only allows the pursuit of potentially one or two opportunities per year. This limited funding does not provide the latitude to pursue multiple property acquisition opportunities when opportunities arise, and opportunities are assessed only after targeted properties come on the market for sale. With the availability of additional funding, the program could expand significantly and allow a shift to a more proactive approach by actively engaging target property owners ahead of time for more large-scale or impactful acquisitions. One way to do this would be to leverage the Utility's available funding for this program by continuing to evaluate whether grants such as FEMA's suite of Hazard Mitigation Assistance grant programs, or the United States Department of Housing and Urban Development's Community Development Block Grant Disaster Recovery (CDBG-DR) and Mitigation (CGBG-MIT) programs could be used to significantly increase the overall funding for this program.

An example of a city that has shown great success with this approach is Portland, Oregon. In 1997, the city's department of Environmental Services developed the Johnson Creek Willing Seller Program to help move people and property out of areas that frequently flood. Restoration projects on land acquired through the program are used to increase flood storage, improve fish and wildlife habitat, restore wetlands, and create passive recreational activities for city residents. Portland staff contacts targeted property owners and offers willing sellers fair market value for their property. Owners are under no obligation to sell to the city. Following property purchases, the city uses deed restrictions to designate properties as open space in perpetuity, ensuring no future expenditure of federal disaster assistance funds in those locations. The Johnson Creek Willing Seller Land Acquisition Program is an implementation strategy for the 2001 Johnson Creek Restoration Plan, which addresses nuisance flooding, water quality problems, and fish and wildlife declines as related issues. The plan identifies common solutions to restore natural floodplain functions. Environmental Services land-banks acquired properties while designing floodplain management projects and securing funding. Through the Johnson Creek willing seller program, Portland has acquired over 100 acres land at a cost of $8.48 million since 1997 by leveraging local, state, and federal funding.

Flood Mitigation

Due to development patterns that started prior to the enactment of floodplain regulations and continued within the confines of existing regulations, flood mitigation solutions must now balance a wide range of community interests with public safety needs. To allow adequate room for the passage of floodwaters for the purposes of protecting people and property, natural channels are enlarged to reduce flooding extents. By reducing flooding extents, the floodplains are then reduced in size. Flood mitigation alternatives that preserve existing floodplains without altering the shape of the creek channel often require extensive removal of existing structures to increase the space needed for floods to spread out as they naturally do within the city. Existing structures that remain within the floodplain can be floodproofed to a certain degree, but this approach frequently does not address protection of the public infrastructure required to serve these areas during and after flood events.

Therefore, flood mitigation plans are completed for the major drainageways to analyze existing drainage conditions within the floodplain, develop mitigation alternatives, and select preferred conceptual designs that oftentimes include structural improvements. Structural flood mitigation is often thought to only include measures like concrete lined channels, dams, levees, or floodwalls. However, structural practices also include methods that refine the shape of the channel or adjacent riparian areas to convey floodwaters more efficiently within the confines of the open space that is available. Many organizations including the International Union for Conservation of Nature (IUNC) and FEMA have adopted what are called nature-based solutions for the mitigation and management of floods (FEMA 2021, Miles, et al. 2021). Nature-based solutions incorporate engineering practices to design modified channels and associated floodplains that protect people and property while also restoring or creating adaptive ecosystems. MHFD has similarly adopted high-functioning and low maintenance stream design to mimic natural processes through the design of engineered channels and floodplains. These approaches generally align with Boulder's community values, as space is limited, and ecological improvements can be incorporated into the new channel and riparian design. In the future, a realistic and practical option may be to continue to incorporate nonstructural approaches and emphasize nature-based solutions that change the channel and floodplain but continue to mimic natural processes and incorporate natural systems.

Regardless of the specific mitigation alternative, the city would benefit from establishing more standardized approach to flood mitigation planning to support easy comparison of proposed flood mitigation projects citywide. The 16 major drainageways that run through the city can have significant variations in their physical, hydraulic, and hydrologic characteristics, as well as physical constraints like proximity of structures or important site features to the stream channel. These characteristic differences have led to differences in flood mitigation analysis approaches. Additionally, urban service criteria and standards within the Boulder Valley Comprehensive Plan state that the major drainageway system should be designed to transport the 100-year flood event *unless a modified standard is approved* (City of Boulder and Boulder County 2015). Given the physical and design constraints that are often present in many of the major drainageways, transporting the 100-year event is not always feasible. Therefore, the Utility works with community members to develop mitigation alternatives that best represent channel and floodplain characteristics, as well as community desires. Prioritizing the conceptual designs generated by these basin-specific mitigation plans can be challenging. Therefore, the Utility needs a consistent approach to support uniform evaluation of projects for prioritization that can also accommodate changes in process and methodology as data and technology improve. *Technical Memorandum #10: Capital Improvement Program Project Prioritization* provides a set of criteria to be used for city-wide project prioritization that should be incorporated into the mitigation planning process as metrics to provide a consistent basis for comparison. This type of standardization will better allow the Utility to compare future projects and evaluate the functionality of projects once they are constructed.

Infrastructure Resilience

Unlike sanitary sewer or water systems, major flood mitigation projects are designed to provide a reasonable level of conveyance, called level of service. This comes with the understanding that capacity of this infrastructure will eventually be exceeded. While major flood mitigation projects are typically designed to reduce risks associated with the 100-year flood event, it is also understood that larger events can happen. Additionally, there is significant uncertainty surrounding the effects of climate change on the frequency and severity of larger flood events along the Front Range. This uncertainty should be addressed based on the best available scientific data. However, it is also understood that impacts of sudden extreme climate events can occur before changing conditions are observed in the data. The impacts of these extreme events should be planned for in a way that does not require the manipulation of existing data based on scientifically unproven methods.

In an effort to address the uncertainty of climate change in systems that are already designed for exceedance, it is recommended that infrastructure resilience become an integral part of the flood mitigation planning process. To accomplish this, preferred flood mitigation design alternatives should be evaluated over a wider range of events to model performance. This should include performance of the system in a 100-year flood event and a 500-year flood event, regardless of design level of service. Whenever possible, exceedance flows should be intentionally routed in areas that are least harmful to people and property. Incorporating a risk management approach that considers the design life of infrastructure and the use or occupancy of buildings and structures served by major flood mitigation projects is also recommended. This approach places increased analysis and informed decision making in areas where the consequences of flooding are high and are commonly associated with critical infrastructure.

Maintenance of Major Drainageways

Routine maintenance is necessary to preserve the function and conveyance capacity of the major drainageways. The community consistently voiced a desire to increase and enhance flood and storm maintenance activities throughout the public engagement process associated with this master plan. City staff also recognize the need for increased maintenance and have been actively investigating ways to more proactively address and resource maintenance of the major drainageways, irrigation ditches[1] and the stormwater collection and conveyance system. In 2021, the Utilities Maintenance work group continued to make major changes to increase maintenance efficiency and frequency by splitting into two separate groups, one of which is solely responsible for maintenance of drainageways and irrigation ditches citywide. Shortly thereafter, City Council approved the addition of four new staff positions dedicated to this area to support enhanced maintenance. While not specifically governed by policies within the Utility, support for the resources required to perform these maintenance functions are essential to achieving maintenance goals. It is recommended that data collected by this newly formed maintenance group be used to track maintenance activities and evaluate further resourcing needs going forward.

The Mile High Flood District (MHFD) contributes to drainageway maintenance throughout Boulder County both through direct maintenance efforts such as mowing, dredging and vegetation removal, but also through monetary contributions to maintenance efforts. The contributions are in the range of approximately 8-10 % of the city's maintenance workload. The city should continue to look for opportunities to enhance this relationship and leverage MHFD's support wherever possible.

[1] City maintenance of private irrigation ditches occurs when there is a contractual obligation in place. Otherwise, the irrigation ditch maintenance obligation remains with the irrigation ditch company.

At times, flood and storm maintenance impacts conflict with community expectations. For example, maintenance can include tree, vegetation and sediment removal. Such activities can result in resident calls to stop or intervene in the maintenance, for example, requesting that trees remain. Engagement and outreach efforts should include information on what to expect during flood maintenance for both the community and decision makers to minimize conflict.

Of important note, the city does not have access easements to all reaches of Boulder's major drainageways. The city typically receives easements as part of annexations, development, redevelopment, or by voluntary participation by landowners, but easement acquisition is not possible in all cases. Maintenance crews may only access creeks with easements or with landowner permission, and lack of access can delay or prohibit maintenance activities. Additionally, to be effective, creek maintenance should occur in a continuous fashion, versus sporadically along the length of a creek. Therefore, it is recommended that a plan and approach be developed for how to address obtaining outstanding easements along Boulder's 47 miles of stream so easements can be secured.

Watershed Management

Watershed management encompasses the functions of many programs within the Utility and does not fit neatly under any specific topic area. While discussed in this Technical Memorandum for its contribution to flooding reduction, many stormwater conveyance and stormwater quality benefits are also incorporated into watershed management and planning. Managing increases in stormwater volume and peak flow caused by urbanization is one of the biggest problems in floodplain management. To address future flood risk, flood management and mitigation needs to take a holistic approach to excess stormwater runoff generated by the entire watershed. Floodplain management is typically understood as the programs and activities that address riverine flooding which happens when streamflow overtops adjacent banks. However, excess stormwater runoff that originates in urban areas floods stormwater management infrastructure, which ultimately increases the extent and duration of flooding associated with the city's major drainageways. For this reason, the National Flood Insurance Program's Community Rating System (CRS) includes a Class 4 prerequisite of a watershed master plan that accounts for the management of increased runoff from a developing watershed. Essentially, it is the management of all flooding sources within a major drainageway's contributing watershed, regardless of where they originate.

The CRS Program encourages watershed management planning and provides guidance on best management practices for watershed-based master planning. The objective is to provide guidance on how to reduce increased flooding from future conditions, including new development, redevelopment and the impact of climate change throughout a watershed or community. Best management practices include:

- Evaluation of future conditions and long-duration storms
- Evaluation of the impact of climate change
- Identification of wetlands and natural areas
- Protection of natural channels
- Provision of a dedicated funding source for implementing the plan

The CRS Program requires that a watershed master plan, at a minimum, address future development and redevelopment within the watershed and the impact of these activities on flows during a 100-year event. These plans go a step beyond stormwater regulations in locating and addressing existing problems and identifying potential future problems. Associated modeling may show that different standards are needed for different

watersheds, or for different parts of the watershed. Communities may also discover that existing stormwater management regulations are adequate or need to be more stringent to prevent development from increasing the frequency and severity of existing and future problems.

For the purposes of the CRS Program, stating that both the Comprehensive Flood and Stormwater Master Plan and the Stormwater Master Plan are linked as pieces of an inclusive watershed management plan is recommended for future CRS technical review and scoring under the Watershed Master Plan element. Pierce County, Washington, also has a similar basin planning approach that it has implemented for over 15 years. This program has many similarities with the City of Boulder's basin-wide flood mitigation planning and has received credit for the Watershed Master Plan prerequisite with CRS.

3 Recommendations

Many of the components necessary for a well-rounded flood mitigation, property acquisition and watershed management program are already in place within the Utility. Ensuring that these components are well-integrated, standardized, and consistently proactive will strengthen the work that is already being done. It is recommended that the following policies and supporting actions be incorporated into the Master Plan:

Flood Mitigation

- Identify flood mitigation measures using standardized methodology and a robust public engagement process in a way that incorporates best practices identified by MHFD and the CRS.
    - Standardize inputs, methods, and outputs from mitigation studies to reflect current available data and industry accepted standards. Provide requirements that allow for comparison of alternatives between drainage basins. Examples of standardized outputs include floodplain models, GIS files for selected design concepts, and metrics for city-wide prioritization.
    - Incorporate future conditions into hydraulic and hydrologic models, including recommendations related to climate change based on scientific evidence and relevant climate science data.
    - As part of flood mitigation planning, it is necessary to better understand the resilience of flood mitigation measures in extreme flood events. Evaluate impacts of selected alternatives, regardless of design level of service, over a range of flood events up to and including the 500-year flood event.
- Emphasize the use of nature-based solutions for flood mitigation to protect people and property in a way that preserves or restores the ecological functions of creek and riparian corridors.
- It is the policy of the Boulder Valley Comprehensive Plan that the major drainageway system will be designed to transport the 100-year flood event or a modified standard in an approved plan. All mitigation plans are required to model and evaluate the 100-year flood event. However, physical characteristics vary greatly by major drainageway such that 100-year flood protection may not be feasible. In these situations, proposed mitigation alternatives shall strive to mitigate to the highest degree feasible based on drainageway characteristics and community preference.

Property Acquisition

- Promote open space uses of floodplains by removing existing structures through pre-flood and post-flood property acquisition. Purchases should be prioritized in locations that threaten the health, safety, and welfare of the community.
    - Identify, target, and seek funding from outside sources (i.e., state or federal grant funding such as FEMA's suite of Hazard Mitigation Assistance grant programs) to leverage existing funding for larger scale property acquisition.

- Create a prioritized list of structures to make the best use of existing funds and resources. Prioritization criteria should include consideration for racial and economic equity as well as risk to life safety.
- Develop and deploy an outreach program to targeted properties that promotes "willing sellers". Maintain a list of properties willing to participate should funding become available.
- Include the identification of properties that would be useful for flood mitigation as part of mitigation planning efforts. Maintain an updated list of properties targeted for acquisition to include value of property and how much the city would be willing to pay for this property. Proactively track real estate market to identify when these properties will be available before they come on the market.

Watershed Management

- Flooding occurs when the volume and rate of stormwater runoff exceeds the capacity of the infrastructure intended to convey runoff. The Utility is committed to a comprehensive and interconnected approach to watershed management in all 16 of its major drainage basins that identifies and mitigates both sources of excess runoff and damaging effects of flooding, regardless of where they occur.
    - Continue to advance basin-wide flood mitigation studies. Include an intentional integration of the stormwater collection and conveyance system and natural drainageways in flood mitigation planning.
    - Evaluate the impact of future conditions on watersheds and the receiving major drainageways for multiple storm events, including the 100-year storm.
    - Establish an evaluation protocol every 5 years to evaluate whether the data used for watershed master planning are still appropriate and whether the plan effectively manages stormwater runoff.
- Remain aware of major changes that occur in watersheds, such as fires and impacts due to climate change. Coordinate with active agencies within the watersheds to proactively address these changes.

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