BOULDER CIVIC AREA
FLOODPLAIN AND ENGINEERING
OPPORTUNITIES AND CONSTRAINTS
BOULDER, COLORADO

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for
BOULDER CIVIC AREA FLOODPLAIN AND ENGINEERING
OPPORTUNITIES AND CONSTRAINTS EVALUATION

Purpose of Study and Methodology

The purpose of this study was to conduct floodplain and engineering evaluations related to opportunities and constraints associated with site development options at the West and East Bookends of the Boulder Civic Area. The West Bookend is defined as the area between Canyon Boulevard and Arapahoe Avenue, extending from 9th Street to the Boulder Public Library. The East Bookend is the block bounded by 13th and 14th Streets, between Canyon Boulevard and Arapahoe Avenue.

The portion of the West Bookend located north of Boulder Creek is impacted by flooding along Boulder Creek, the portion of the West Bookend located south of Boulder Creek is primarily impacted by flooding from Gregory Canyon Creek. The East Bookend is subject to flooding along both 13th and 14th Streets by a flow split from Boulder Creek onto Canyon Boulevard at Broadway. A portion of this split flow is carried from Canyon Boulevard back toward the creek along 13th and 14th Streets. In addition, Boulder Slough flows from west to east through the middle of the East Bookend, carrying irrigation flows, local storm runoff, and flood overflows from Boulder Creek.

This study evaluated at a conceptual level the areas potentially available for development within the West Bookend, both north and south of Boulder Creek, as well as the East Bookend. This study represents only a first step in evaluating the potential for redevelopment and/or expanding use of this area; hence, a specific plan of improvements does not currently exist and hydraulic modeling of actual proposed improvements was not possible. Consequently, this assessment consisted of identifying potentially developable areas located outside of both the High Hazard Zone (HHZ) and Conveyance Zone (CZ), except for the northern portion of the West Bookend, which is entirely located within the CZ. In that case, the areas identified as potentially available for development include those areas located outside of the HHZ while also falling within areas that are either ineffective or obstructed with respect to conveying flood flows.

The concept behind this assessment is that physical changes (such as construction of buildings or other facilities) could be made in these potentially developable areas while meeting floodplain regulations, particularly without causing a rise in 100-year flood levels. The potentially developable areas identified herein should be considered conceptual only; specific development plans prepared in the future would need to be subjected to detailed hydraulic modeling in order to confirm compliance with all floodplain regulations.

Definition of Options

Several options for the West Bookend were considered by this study, while only one option was evaluated for the East Bookend; these options are described below.

West Bookend, North of Boulder Creek

1. Making improvements to the Library North Wing, including a building addition to the west.
2. Removing the Bridge Wing of the Library while also making improvements to the Library North Wing, including a building addition to the west.

3. Removing both the Bridge Wing and Library North Wing, and constructing a new building and parking facilities.

West Bookend, South of Boulder Creek

Removing the Senior Center and constructing a new building and parking facilities.

East Bookend

Redeveloping the entire block, with the exception of historically designated buildings, by constructing new buildings and parking facilities.

Summary of Results

This evaluation determined that it may be possible to develop portions of each of these three areas while still meeting floodplain regulations, although there would likely be significant effort and cost associated with elevating ground levels in these areas and/or installing floodproofing measures (for non-residential buildings only). In order to redevelop these sites, there would also be considerable effort and cost required with respect to engineering and permitting.

The potentially developable areas for the West Bookend, north of Boulder Creek, do not vary substantially between the three options (as shown on Sheets 6 through 8, provided in the appendix to this report), although removal of the Bridge Wing of the Library would lower 100-year flood levels by nearly 1.5 feet and modestly increase the developable footprint. In addition, City Staff would need to determine whether or not a single project that would include removal of the North Library and construction of a new building would actually require working within the reduced developable footprint shown on Sheet 8. Typically, floodplain regulations would allow comparison of proposed conditions to existing conditions, not to an interim condition within the same project, provided the entire project is completed within a reasonable timeframe.

For the West Bookend, south of Boulder Creek, a relatively large area is identified as potentially developable due to limited encroachment on this area by both the HHZ and CZ associated with Gregory Canyon Creek, and the presence of 100-year flood fringe only from Boulder Creek. The primary exception is a relatively wide corridor along the east side of 9th Street, which falls within the Gregory Canyon Creek HHZ. An additional corridor outside of the HHZ and CZ was reserved along the east side of 9th Street to accommodate potential future flood conveyance facilities for Gregory Creek. It is likely that the construction of such a conveyance element would likely reduce floodplain impacts on this portion of the West Bookend.

For the East Bookend, the majority of the block bounded by Canyon Boulevard, Arapahoe Avenue, 13th Street and 14th Streets would be available redevelopment, as shown on Sheet 13. The exceptions would be a relatively narrow strip of frontage along both Canyon and 14th Street, as well as the Boulder Slough corridor through the center of the block. However, Boulder Slough could be encased in a large concrete box culvert if this was needed to facilitate redevelopment options.

While Sheets 6, 7, 8 and 13 illustrate the potentially developable areas within the West and East Bookends, these regions would be inundated to varying levels during the 100-year flood on either Boulder Creek or Gregory Canyon Creek. In order to meet floodplain regulations, these areas would need to be protected to a height of 2 feet above the 100-year flood elevation. This could be accomplished by placing earthen fill and/or constructing retaining walls, possibly in conjunction with installing floodproofing measures (for non-residential buildings only), and including erosion/scour countermeasures.

The method which would produce the conservatively smallest buildable footprint would be placing earthen fill to a level which meets the flood protection elevation. For the current study, simple grading plans were prepared for all three West Bookend (north side) options, and one option each for the East Bookend and West Bookend (south side) such that: (a) no fill would be placed outside of the potential development areas; (b) all side slopes would be finished at 3H:1V; and (c) the top of fill would be set at 2 feet above the associated 100-year flood elevation. Based on this approach, potential flood protection elevation footprints/zones were defined for the West Bookend options as shown on Sheets 9 through 11, and for the East Bookend (exclusive of current historically designated buildings) on Sheet 14. It is noted the portion of the West Bookend south of Boulder Creek was considered in two separate pieces, given the large variation in flood elevations across that area. Development of structures could occur outside the zones shown on the mapping sheets by utilizing retaining walls and/or flood-protected structures. Moving forward with specific development plans for these sites would require detailed hydraulic modeling and engineering to ensure that proposed facilities would meet all floodplain regulations

If a plan to redevelop either the West or East Bookend was pursued, the proposed site and building(s) would be subject to a Land Use Review/PUD amendment, Technical Document Review, Building Permitting, Floodplain Permit, a possible Wetland Permit process, and a probable FEMA review. The East Bookend also includes historically significant and landmarked buildings and districts. It is likely that development on this Bookend will fall within the landmarked zone and, therefore, need the review of the Landmarks Design Review Committee. Due to the complexities of this area, this process would likely take longer than a more typical development site.

Other Development Considerations

This study focused on the potential for future building improvements and/or redevelopment within the West and East Bookends to meet engineering requirements and floodplain regulations. Another aspect of this discussion is whether or not it would prudent to improve or add facilities in these flood prone areas where the ability for people to exit, as well as providing emergency access, would be problematic during flooding conditions due to excessive water depths and flow velocities. This policy decision will likely be discussed at length by City staff and various City Boards. In order to assist with informing this discussion, 100-year flow depths and velocities adjacent to each of the potential redevelopment areas were identified and provided near the end of this report. Another item to be considered would be the ability for people to exit the facilities utilizing elevated walkways or bridges, or via non-HHZ/non-CZ areas, which could improve safety considerations for redevelopment.

To summarize this evaluation, the combination of 100-year flow depths and velocities adjacent to the three potential redevelopment sites are indicative of hazardous conditions at all locations (although somewhat less so along Arapahoe Avenue, due to the spill from Gregory Creek), with extremely hazardous conditions along Boulder Creek. It would be possible to facilitate access to the southern portion of the West Bookend during flooding events on Gregory Creek with the implementation of a 100-year flood control system along 9th Street, from south of Arapahoe Avenue to Boulder Creek. This facility would substantially reduce flooding potential along Arapahoe Avenue, thereby providing for relatively safe ingress and egress along Arapahoe for the southern portion of the West Bookend.

I. INTRODUCTION

The purpose of this study was to conduct floodplain and engineering evaluations related to opportunities and constraints associated with site development options at the West and East Bookends of the Boulder Civic Area. The West Bookend is defined as the area between Canyon Boulevard and Arapahoe Avenue, extending from 9th Street to the Boulder Public Library. The East Bookend is the block bounded by 13th and 14th Streets, also located between Canyon Boulevard and Arapahoe Avenue.

The portion of the West Bookend located north of Boulder Creek is impacted by flooding along Boulder Creek, the portion of the West Bookend located south of Boulder Creek is primarily impacted by flooding from Gregory Canyon Creek. The East Bookend is subject to flooding along both 13th and 14th Streets by a flow split from Boulder Creek onto Canyon Boulevard at Broadway. A portion of this split flow is carried from Canyon Boulevard back toward the creek along 13th and 14th Streets. In addition, Boulder Slough flows from west to east through the middle of the East Bookend, carrying irrigation flows, local storm runoff, and flood overflows from Boulder Creek.

The current study utilized hydraulic modeling and flood hazard mapping for Boulder Creek, taken from the report, "Boulder Creek Floodplain Mapping Study," [ACE, September 2013], as well as flood hazard mapping provided with the report, "Gregory Canyon Creek, Draft Flood Mitigation Plan," [CH2MHill, April 2015].

II. WEST BOOKEND EVALUATION

2.1 Corrected Effective Flood Hazard Mapping

Existing condition hydraulic modeling and mapping were reviewed to initiate the evaluation of the West Bookend. During this process, it was discovered that the loading dock area west of the North Library is located four or more feet below the 100-year water surface elevation; consequently, the depth criterion associated with the High Hazard Zone (HHZ) designation would be exceeded and a small area of HHZ was delineated on the west side of the North Library Wing. In addition, it was found that a backwater area along the west side of the South Library Wing should have been included in the 100-year floodplain; the floodplain boundary was adjusted accordingly. A corrected effective flood hazard map showing the adjusted 100-year floodplain and HHZ in the vicinity of the West Bookend is provided on Sheet 1; sheets for the West Bookend are included in Appendix A.1 of this report.

2.2 Definition of West Bookend Options

An alternative evaluation was conducted in an effort to define the opportunities and constraints associated with site development options for the West Bookend. The goals of the three options that were evaluated are defined below.

West Option 1

North Side: Determine whether the existing North Library Wing could be taken out of the HHZ for the purpose of building an addition on the west side of the existing building.

South Side: If the existing Senior Center were removed, determine how the site between 9th Street and the South Library Wing could be re-graded to maximize the developable area outside of the HHZ, including a below grade parking structure, while also maintaining a corridor along the east side of 9th Street for possible future flood conveyance facilities.

West Option 2

North Side: If the Bridge Wing of the library were removed, determine whether the existing North Library Wing could be taken out of the HHZ for the purpose of building an addition to the west side of the existing building.

South Side: Identical to Option 1.

West Option 3

North Side: If both the Bridge Wing of the library and North Library Wing were removed, determine whether the North Library site could be re-graded to maximize the developable area outside of the HHZ, including a below grade parking structure.

South Side: Identical to Option 1.

2.3 Boulder Creek Hydraulic Modeling and Flood Hazard Mapping for the West Bookend

In order to provide a basis for evaluating alternatives, hydraulic modeling and flood hazard mapping for the West Bookend were reviewed and modified in order to refine the definition of flood hazards in the study area. Beginning with West Option 1 (and continuing through all three options) two cross sections near the west end of the North Library were added to the hydraulic model.

For the West Option 1 analysis, 100-year water surface elevations are similar to existing conditions with increases in 100-year water surface elevations of less than 0.1 feet between the west side of the North Library and 9th Street. Correspondingly, the HHZ island which extends from the North Library to 9th Street is slightly smaller than the existing HHZ island, as shown on Sheet 2.

For West Option 2, wherein the Bridge Wing of the library and its supporting piers are assumed to be removed, the hydraulic modeling indicates that 100-year water surface elevations would be lowered by as much as 1.4 feet in the vicinity of the library, relative to West Option 1. This results in an expansion of the HHZ island which extends from the North Library to 9th Street, as illustrated on Sheet 3.

Hydraulic modeling results for West Option 3, which includes removal of both the Bridge Wing of the library and North Library Wing, show that 100-year water surface elevations would be lower than those for West Option 1 by as much as 1.3 feet, but generally higher than water surface elevations for Option 2 by approximately 0.1 to 0.2 feet. If the North Library Wing were to be removed, areas that were previously ineffective for, or obstructed from, conveying flood flows would be activated and the HHZ island in the vicinity of the North Library Wing would be reduced in size and separated from the HHZ island at 9th Street, as shown on Sheet 4.

Tabular results that summarize key parameters associated with the hydraulic modeling conducted in support of analyzing the West Bookend options are provided in Appendix B.

2.4 Initial Assessment of Potential Development Areas for the West Bookend

An initial assessment was conducted in order to define areas that would potentially be available for development for both the north and south sides of the West Bookend. Since this study represents only a first step in evaluating the potential for redevelopment and/or expanding use of this area, a specific plan of improvements does not currently exist; as a result, hydraulic modeling of proposed improvements was not possible. Instead, this assessment consisted of identifying the areas north of the creek that are located outside of the HHZ and are also located within areas that are shown in the hydraulic models to be either ineffective or obstructed with respect to conveying flood flows. The concept behind this assessment is that fill and/or flood-protected structures (non-residential only) could likely be placed within these ineffective/obstructed flow areas that are outside of the HHZ without causing a rise in 100-year water surface elevations, while also avoiding HHZ regulations, thereby making these areas potentially available for redevelopment. South of the creek, this assessment consisted of identifying areas located outside of both the HHZ and Conveyance Zone (CZ).

Without a current redevelopment plan to analyze, the potential development areas identified herein should be considered preliminary only and would need to be confirmed with detailed hydraulic

modeling. Specific development plans prepared in the future would need to be subjected to detailed hydraulic modeling in order to confirm compliance with all floodplain regulations.

For all four conditions analyzed (corrected effective and Options 1, 2 and 3), flow obstructions and ineffective flow areas contained in the associated hydraulic model were identified and the corresponding boundaries added to the flood hazard maps. These boundaries were compared to the HHZ delineations, composite boundaries were created that represent the regions that are in areas of ineffective/obstructed flow that are also outside of the HHZ (north side), or areas located outside of both the HHZ and CZ (south side). The mapping of these preliminary potential development areas for the corrected effective condition and Options 1, 2 and 3 are illustrated on Sheets 5 through 8, respectively.

2.5 Definition of Conceptual Flood Protection Elevation Zones for the West Bookend

While the potential development areas identified above, by definition, would be located outside of both the HHZ and CZ (or within ineffective/obstructed flow areas), these areas would still be located in the 100-year floodplain for either Boulder Creek or Gregory Canyon Creek. As such, future buildings or building additions would need to be protected to an elevation 2 feet above the 100-year flood elevation. The most conservative approach for accomplishing this elevation, in terms of the potentially available building footprint, is the placement of earthen fill to a level which meets the flood protection elevation. At the current concept level, simple grading plans were prepared for all three options such that: (a) no fill would be placed outside of the potential development areas; (b) all side slopes would be finished at 3H:1V; and (c) the top of fill would be set at 2 feet above the associated 100-year water surface elevation. Based on this approach, potential flood protection elevation footprints/zones were defined for Options 1, 2 and 3 as shown on Sheet 9, 10 and 11, respectively. The area south of the creek was considered in two separate pieces, given the variation in flood elevations across that region.

It is recognized that this approach would not likely be practical for an actual development plan since: (1) potential building shapes/footprints are not being considered; (2) it would be possible to enlarge the flood protection elevation zones by using retaining walls or other vertical elements, at least in select locations; and (3) floodproofing techniques could be used to lower the height of fill required to a relatively small degree.

At a coarse level, the flood protection zones shown on Sheets 9, 10 and 11 can be considered as potential building envelopes, with the following limitations: (a) various setbacks, such as those required for roadways and wetlands, are not currently being considered; (b) zoning restrictions; and (c) building height restrictions. There may be additional limitations to building in these areas that would need to be addressed when future plans are developed. This would include accommodating potential future flood conveyance facilities for Gregory Creek along the east side of 9th Street, which have been accounted for in these potential building envelopes, but at only a conceptual level.

2.6 Other Opportunities for the West Bookend

While the following discussion is not intended to provide an exhaustive list of development opportunities for the West Bookend, it does highlight a couple of opportunities for constructing improvements outside of the zones shown on the sheets. One such opportunity is the possible construction of a parking facility south of the creek that is accessed from Arapahoe Avenue near the southwest corner of the eastern zone, but which is constructed largely subgrade under both the western and eastern zones. Furthermore, it would be possible to facilitate access to the southern portion of the West Bookend during flooding events on Gregory Creek with the implementation of a 100-year flood control system along 9th Street, from south of Arapahoe Avenue to Boulder Creek. This facility could substantially reduce flooding potential along Arapahoe Avenue, eliminating the HHZ and CZ, thereby providing for relatively safe ingress and egress along Arapahoe for the southern portion of the West Bookend.

In addition, it appears that it would be possible construct a pedestrian bridge across Canyon Boulevard from the northeast corner of the North Library Wing to a future civic building to be constructed on the pad located directly east of the St. Julien Hotel. A pedestrian bridge such as this could improve safety conditions for redevelopment of the northern portion of the West Bookend by providing the ability for people to exit the facilities; however, a pedestrian bridge would not improve access for emergency vehicles during a severe flood event. In order to span both the existing HHZ and CZ along Canyon Boulevard, this pedestrian bridge would need to be on the order of 190 feet in length. It may be possible to place a pier in the median along Canyon to reduce individual span lengths. However, a pier in the roadway median would be located within both the CZ and HHZ, making it subject to a no-rise requirement and possible HHZ limitations.

Specific requirements and limitations of these and any other opportunities in the West Bookend would need to be fully vetted as plans are developed in the future.

2.7 Identification of Future Engineering and Permitting Requirements for the West Bookend

North of Boulder Creek – Option 1

Based on current and corrected effective flood hazard modeling and mapping, with no physical modifications in the West Bookend area, the HHZ touches the southwest corner of the existing North Library. Consequently, modifications to the North Library would be subject to the substantial modification limit (i.e., 50 percent of the structure's value).

North of Boulder Creek – Option 2

If the Bridge Wing of the library were removed, the North Library would no longer be located in the HHZ and the substantial modification limit would not apply, assuming the existing building was adequately floodproofed and a new addition elevated or floodproofed to the flood protection elevation.

North of Boulder Creek – Option 3

If the Bridge Wing of the library and North Library were removed, the areas shown on Sheet 8 could potentially be modified to allow construction of new buildings that were elevated or floodproofed to the flood protection elevation.

South of Boulder Creek

Without implementation of a 100-year flood conveyance facility between Arapahoe Avenue and Boulder Creek for flood flows along Gregory Canyon Creek, it would still be possible to remove the existing Senior Center and construct new buildings and parking facilities within the area shown on Sheet 8, provided the new facilities are elevated and/or floodproofed to the flood protection elevation.

Simply regrading these sites by adding earthen fill to achieve the required flood protection elevation would typically be the least costly approach to achieve flood protection elevations. For Options 1, 2 and 3 associated with the north side of the West Bookend, the cost to place fill as shown on Sheets 9 through 11, would range up to approximately $100,000 (based on a unit price of $30 per cubic yard for imported fill). For the South Side of the West Bookend, the cost to place fill as shown on these same sheets would be approximately $220,000. However, it should be noted that these simple grading plans do not consider site accessibility, buffer requirements and numerous other considerations. In order to address site functionality and possibly increase the potential developable area, it would likely be necessary to utilize retaining walls, column-supported structures, and/or floodproofing. Using these types of structural elements may reduce the amount of imported fill, but would increase the cost of improvements, perhaps by a significant amount depending on the selected strategy.

Given the considerable elevation requirements in the West Bookend (in order to meet flood protection elevations), potential limitations with respect to building heights, the probable need for extensive structural elements, and a range of possible floodplain permitting requirements, the planning, engineering and permitting costs associated with redeveloping the West Bookend areas would likely be significantly higher than with a less constrained property.

From a floodplain permitting standpoint, by either staying outside of the conveyance zone or demonstrating no-rise, this process may be limited to review and approval by the City. However, if it would be necessary to show that proposed improvements are out of the 100-year floodplain, either by elevation or floodproofing, a FEMA review process would be required. In addition, if proposed improvements would cause more than a 0.3-foot drop in 100-year water surface elevation at any location, State regulations would require a FEMA review and remapping process to reflect the lower flood elevations and potentially reduced floodplain and conveyance zone footprint.

If a plan to redevelop the West Bookend was pursued, the proposed site and building(s) would be subject to a Land Use Review/PUD amendment, Technical Document Review, Building Permitting, Floodplain Permit, a possible Wetland Permit process, and perhaps the FEMA review process discussed above. Due to the complexities of this area, this process would likely take longer than a more typical redevelopment site.

III. EAST BOOKEND EVAULATION

3.1 Corrected Effective Flood Hazard Mapping

Existing condition hydraulic modeling and mapping were reviewed to initiate the evaluation of the East Bookend. During this process, it was discovered that a small area of the HHZ at the northeast corner of 13th Street and Arapahoe Avenue was not correctly mapped in the effective study. The HHZ was adjusted and a small area was removed from the HHZ, a corrected effective flood hazard map showing the adjusted HHZ in the vicinity of the East Bookend is provided on Sheet 12; sheets for the East Bookend are included in Appendix A.2 of this report.

3.2 Boulder Creek Hydraulic Modeling and Flood Hazard Mapping for the East Bookend

Prior to conducting an evaluation of the opportunities and constraints associated with site development options for the East Bookend, the existing hydraulic modeling and flood hazard mapping for the East Bookend were reviewed and modified in an effort to determine if additional fringe areas of the East Bookend could be removed from the HHZ and/or CZ. Cross sections were added to the model at Station 303 on the 14th Street Split Flow Path and at Station 5219 on the Canyon Boulevard Split Flow Path. The HHZ, CZ and 100-year floodplain were analyzed with the new cross sections in the model and it was found that the widths of both the HHZ and CZ increased along the 14th Street Split Flow Path, while the changes to the CZ and HHZ along both the Canyon Boulevard and 13th Street Split Flow Paths were negligible. It should also be noted that the discharge along 14th Street increased due to the added cross sections, thereby affecting discharges along multiple flow paths from 14th Street to 28th Street. The identified change in split flow path discharge would make it necessary to conduct extensive flood hazard analyses in order to revise flood hazard mapping along numerous flow paths from 14th Street to 28th Street. Due to the potential effort and expense associated with adding cross sections the existing hydraulic model, it was recommended by ACE and decided by City staff to not pursue modifications to the existing condition hydraulic model.

3.3 Initial Assessment of Potential Development Areas for the East Bookend

An initial assessment was conducted in order to define areas that would potentially be available for development for the East Bookend. Since this study represents only a first step in evaluating the potential for redevelopment and/or expanding use of this area, a specific plan of improvements does not currently exist; as a result, hydraulic modeling of proposed improvements was not possible. Instead, this assessment consisted of identifying the areas bounded by 13th Street and 14th Street on the west and east and Canyon Boulevard and Arapahoe Avenue on the north and south that are located outside of both the HHZ and CZ.

Without a current redevelopment plan to analyze, the potential development areas identified herein should be considered preliminary only and would need to be confirmed with detailed hydraulic modeling. Specific development plans prepared in the future would need to be subjected to detailed hydraulic modeling in order to confirm compliance with all floodplain regulations. The boundaries

associated with both the HHZ and CZ were compared; composite boundaries were created that represent the regions that are outside of both the HHZ and CZ. The mapping of the East Bookend preliminary potential development areas for the existing condition are illustrated on Sheet 13.

3.4 Definition of Conceptual Flood Protection Elevation Zones for the East Bookend

While the potential development areas identified above by definition would be located outside of both the HHZ and CZ, these areas would still be located in the 100-year floodplain for Boulder Creek. As such, future buildings or building additions would need to be protected to an elevation 2 feet above the 100-year flood elevation. The most conservative approach for accomplishing this elevation, in terms of the potentially available building footprint, is the placement of earthen fill to a level which meets the flood protection elevation. At the current concept level, simple grading plans were prepared for the corrected effective analysis such that: (a) no fill would be placed outside of the potential development areas; (b) all side slopes would be finished at 3H:1V; and (c) the top of fill would be set at 2 feet above the associated 100-year water surface elevation. Based on this approach, potential flood protection elevation footprints/zones were defined as shown on Sheet 14.

It is recognized that this approach would not likely be practical for an actual development plan since: (1) potential building shapes/footprints are not being considered; (2) it would be possible to enlarge the flood protection elevation zones by using retaining walls or other vertical elements, at least in select locations; and (3) floodproofing techniques could be used to lower the height of fill required to a relatively small degree.

At a coarse level, the flood protection zones shown on Sheet 14 can be considered as potential building envelopes, with the following limitations: (a) various setbacks, such as those required for roadways and wetlands, are not currently being considered; (b) zoning restrictions; and (c) building height restrictions. There may be additional limitations to building in these areas that would need to be addressed when future plans are developed.

3.5 Identification of Future Engineering and Permitting Requirements for the East Bookend

Potential redevelopment within the East Bookend would need to occur outside of both the HHZ and CZ, in the two areas identified on Sheet 13. Simply regrading these two areas by adding earthen fill to achieve the required flood protection elevation would typically be the least costly approach to achieve flood protection elevations. For the simple grading plan shown on Sheet 14, which excludes the currently designated historical structures in the East Bookend, the cost to place the indicated fill would be approximately $850,000 (based on a unit price of $30 per cubic yard for imported fill). However, it should be noted that this simple grading plan does not consider site accessibility and numerous other considerations. In order to address site functionality and possibly increase the potential developable area, it would likely be necessary to utilize retaining walls, column-supported structures, and/or floodproofing. Using these types of structural elements may reduce the amount of imported fill, but would increase the cost of improvements, perhaps by a significant amount depending on the selected strategy.

Given the need for elevating any redevelopment area within the East Bookend (in order to meet flood protection elevations), the probable need for extensive structural elements, and a limited range of possible floodplain permitting requirements, the planning, engineering and permitting costs associated with redeveloping the East Bookend would likely be somewhat higher than with a less constrained property, but potentially not as costly as for the West Bookend.

From a floodplain permitting standpoint, by staying outside of the conveyance zone this process may be limited to review and approval by the City. However, if it would be necessary to show that proposed improvements are out of the 100-year floodplain, either by elevation or floodproofing, a FEMA review process would be required.

If a plan to redevelop the East Bookend was pursued, the proposed site and building(s) would be subject to a Land Use Review/PUD amendment, Technical Document Review, Building Permitting, Floodplain Permit, a possible Wetland Permit process, and perhaps the FEMA review process discussed above. The East Bookend also includes historically significant and landmarked buildings and districts. It is likely that development on this Bookend will fall within the landmarked zone and, therefore, need the review of the Landmarks Design Review Committee. Due to the complexities of this area, these processes would likely take longer than a more typical redevelopment site.

IV. OTHER DEVELOPMENT CONSIDERATIONS

This study focused on the potential for future building improvements and/or redevelopment within the West and East Bookends to meet engineering requirements and floodplain regulations. Another aspect of this discussion is whether or not it would prudent to improve or add facilities in these flood prone areas where the ability for people to exit, as well as providing emergency access, would be problematic during flooding conditions due to excessive water depths and flow velocities. This policy decision will likely be discussed at length by City staff and various City Boards. In order to assist with informing this discussion, 100-year flow depths and velocities adjacent to each of the potential redevelopment areas were identified and provided in Table 4.1.

Table 4.1. Summary of Approximate 100-Year Flow Depths and Flow Velocities Adjacent to the West and East Bookends

Potential Redevelopment Site	Flooding Location and Source	100-Year Flow Depth (feet)	100-Year Flow Velocity (fps)
West Bookend, North Side			
	South (Boulder Creek)	10 – 14	5 – 12
	North (Canyon Blvd)	3 – 5	4 – 9
West Bookend, South Side			
	North (Boulder Creek)	10 – 14	5 – 8
	South (Arapahoe Ave)	1 – 3	3 – 6
East Bookend			
	West (13th Street)	2 – 5	3 – 7
	East (14th Street)	2 – 3	6 – 9

To summarize this information, the combination of 100-year flow depths and velocities adjacent to the three potential redevelopment sites are indicative of hazardous conditions at all locations (although somewhat less so along Arapahoe Avenue, due to the spill from Gregory Creek), with extremely hazardous conditions along Boulder Creek.

APPENDIX A

WEST BOOKEND AND EAST BOOKEND AREA MAPPING

APPENDIX A.1

WEST BOOKEND

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OPTION 1 – ADDED CROSS SECTIONS

OPTION 2 – ADDED CROSS SECTIONS AND REMOVED LIBRARY BRIDGE AND PIERS

OPTION 3 – ADDED CROSS SECTIONS, REMOVED LIBRARY BRIDGE AND PIERS, AND REMOVED NORTH LIBRARY BUILDING

LEGEND

- CONVEYANCE ZONE – CORRECTED–EFFECTIVE
- HIGH HAZARD ZONE – CORRECTED–EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – CORRECTED–EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 — CROSS SECTION

CANYON BLVD

9TH STREET

310+00

315+00

SHALLOW FLOODING/
500-YEAR FLOODING

31689 31632 31468 31400 31357 31302 31269 31206 31132 31102 31025

0 40' 80'
SCALE: 1" = 40'

P:\COBLDR18_BOULDERCIVICPLANNING\ACAD\BOULDER CIVIC AREA WORKMAP.DWG

REVISIONS:####

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CORRECTED EFFECTIVE - FLOOD HAZARD MAPPING

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET:	1
INDEX:	

12/1/2015 9:46 AM

OPTION 1 – ADDED CROSS SECTIONS

OPTION 2 – ADDED CROSS SECTIONS AND REMOVED LIBRARY BRIDGE AND PIERS

OPTION 3 – ADDED CROSS SECTIONS, REMOVED LIBRARY BRIDGE AND PIERS, AND REMOVED NORTH LIBRARY BUILDING

LEGEND

- CONVEYANCE ZONE – WEST OPTION 1
- HIGH HAZARD ZONE – WEST OPTION 1
- 1% ANNUAL CHANCE FLOODPLAIN – WEST OPTION 1
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 CROSS SECTION

CANYON BLVD

9TH STREET

310+00

315+00

SHALLOW FLOODING/
500-YEAR FLOODING

31689 31632 31468 31400 31587 31302 31269 31206 31102 31032 31025

0 40' 80'
SCALE: 1" = 40'

P:\COBLDR18_BOULDERCIVICPLANNING\CAD\BOULDER CIVIC AREA WORKMAP.DWG

REVISIONS:####

ANDERSON CONSULTING ENGINEERS, INC
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Phone (970) 226-0120 | Fax (970) 226-0121
www.acewater.com

WEST OPTION 1 - FLOOD HAZARD MAPPING

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET:	2
INDEX:	

OPTION 1 – ADDED CROSS SECTIONS

OPTION 2 – ADDED CROSS SECTIONS AND REMOVED LIBRARY BRIDGE AND PIERS

OPTION 3 – ADDED CROSS SECTIONS, REMOVED LIBRARY BRIDGE AND PIERS, AND REMOVED NORTH LIBRARY BUILDING

LEGEND

- CONVEYANCE ZONE – WEST OPTION 2
- HIGH HAZARD ZONE – WEST OPTION 2
- 1% ANNUAL CHANCE FLOODPLAIN – WEST OPTION 2
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 CROSS SECTION

CANYON BLVD

9TH STREET

310+00

315+00

SHALLOW FLOODING/
500-YEAR FLOODING

31689 31632 31468 31400 31357 31302 31269 31206 31192 31102 31025

0 40' 80'
SCALE: 1" = 40'

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WEST OPTION 2 - FLOOD HAZARD MAPPING

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET:	3
INDEX:	

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12/1/2015 9:46 AM

OPTION 1 – ADDED CROSS SECTIONS

OPTION 2 – ADDED CROSS SECTIONS AND REMOVED LIBRARY BRIDGE AND PIERS

OPTION 3 – ADDED CROSS SECTIONS, REMOVED LIBRARY BRIDGE AND PIERS, AND REMOVED NORTH LIBRARY BUILDING

LEGEND

- CONVEYANCE ZONE – WEST OPTION 3
- HIGH HAZARD ZONE – WEST OPTION 3
- 1% ANNUAL CHANCE FLOODPLAIN – WEST OPTION 3
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 — CROSS SECTION

CANYON BLVD

9TH STREET

310+00

315+00

SHALLOW FLOODING/
500-YEAR FLOODING

31689 31632 31468 31400 31357 31302 31269 31206 31132 31102 31025

0 40' 80'
SCALE: 1" = 40'

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WEST OPTION 3 - FLOOD HAZARD MAPPING

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET:	4
INDEX:	

OPTION 1 – ADDED CROSS SECTIONS

OPTION 2 – ADDED CROSS SECTIONS AND REMOVED LIBRARY BRIDGE AND PIERS

OPTION 3 – ADDED CROSS SECTIONS, REMOVED LIBRARY BRIDGE AND PIERS, AND REMOVED NORTH LIBRARY BUILDING

LEGEND

- CONVEYANCE ZONE – CORRECTED–EFFECTIVE
- HIGH HAZARD ZONE – CORRECTED–EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – CORRECTED–EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 — CROSS SECTION

CANYON BLVD

9TH STREET

310+00

315+00

SHALLOW FLOODING/
500-YEAR FLOODING

31689 31632 31468 31400 31351 31302 31269 31206 31132 31102 31025

0 40' 80'
SCALE: 1" = 40'

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www.acewater.com

CORRECTED EFFECTIVE - INEFFECTIVE/OBSTRUCTED FLOW AREA OUTSIDE HHZ

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET:	5
INDEX:	

12/1/2015 9:47 AM

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REVISIONS:####

OPTION 1 – ADDED CROSS SECTIONS

OPTION 2 – ADDED CROSS SECTIONS AND REMOVED LIBRARY BRIDGE AND PIERS

OPTION 3 – ADDED CROSS SECTIONS, REMOVED LIBRARY BRIDGE AND PIERS, AND REMOVED NORTH LIBRARY BUILDING

LEGEND

- CONVEYANCE ZONE – WEST OPTION 1
- HIGH HAZARD ZONE – WEST OPTION 1
- 1% ANNUAL CHANCE FLOODPLAIN – WEST OPTION 1
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 CROSS SECTION

CANYON BLVD

9TH STREET

310+00

315+00

SHALLOW FLOODING/ 500-YEAR FLOODING

31689 31632 31468 31400 31351 31302 31269 31206 31132 31102 31025

0 40' 80'

SCALE: 1" = 40'

P:\COBLDR18_BOULDERCIVICPLANNING\ACAD\BOULDER CIVIC AREA WORKMAP.DWG

REVISIONS:####

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Phone (970) 226-0120 | Fax (970) 226-0121
www.acewater.com

WEST OPTION 1 - INEFFECTIVE/OBSTRUCTED FLOW AREA OUTSIDE HHZ

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET:	6
INDEX:	

12/1/2015 9:47 AM

OPTION 1 – ADDED CROSS SECTIONS

OPTION 2 – ADDED CROSS SECTIONS AND REMOVED LIBRARY BRIDGE AND PIERS

OPTION 3 – ADDED CROSS SECTIONS, REMOVED LIBRARY BRIDGE AND PIERS, AND REMOVED NORTH LIBRARY BUILDING

LEGEND

- CONVEYANCE ZONE – WEST OPTION 2
- HIGH HAZARD ZONE – WEST OPTION 2
- 1% ANNUAL CHANCE FLOODPLAIN – WEST OPTION 2
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 CROSS SECTION

CANYON BLVD

9TH STREET

310+00

315+00

SHALLOW FLOODING/ 500-YEAR FLOODING

31689 31632 31468 31400 31357 31302 31269 31206 31132 31102 31025

0 40' 80'

SCALE: 1" = 40'

P:\COBLDR18_BOULDERCIVICPLANNING\ACAD\BOULDER CIVIC AREA WORKMAP.DWG

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www.acewater.com

WEST OPTION 2 - INEFFECTIVE/OBSTRUCTED FLOW AREA OUTSIDE HHZ

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET: 7	INDEX:

OPTION 1 – ADDED CROSS SECTIONS

OPTION 2 – ADDED CROSS SECTIONS AND REMOVED LIBRARY BRIDGE AND PIERS

OPTION 3 – ADDED CROSS SECTIONS, REMOVED LIBRARY BRIDGE AND PIERS, AND REMOVED NORTH LIBRARY BUILDING

LEGEND

- CONVEYANCE ZONE – WEST OPTION 3
- HIGH HAZARD ZONE – WEST OPTION 3
- 1% ANNUAL CHANCE FLOODPLAIN – WEST OPTION 3
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 CROSS SECTION

CANYON BLVD

9TH STREET

310+00

315+00

SHALLOW FLOODING/ 500-YEAR FLOODING

31689 31632 31488 31400 31357 31302 31269 31206 31192 31102 31025

0 40' 80'

SCALE: 1" = 40'

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WEST OPTION 3 - INEFFECTIVE/OBSTRUCTED FLOW AREA OUTSIDE HHZ

BOULDER CIVIC AREA INEFFECTIVE/OBSTRUCTED FLOW AREA OUTSIDE HHZ

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET:	8
INDEX:	

12/1/2015 9:47 AM

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REVISIONS:####

CANYON BOULEVARD

LIBRARY
EX FFE: 5357.3±

EXISTING GRADE (TYP)

FLOOD PROTECTION ELEVATION ZONE 5361.40*

57.1

53.9

53.9

55.7

63.1

9TH STREET

HIGH HAZARD ZONE

CONVEYANCE ZONE

52.2

55.1

LIBRARY
EX FFE: 5358.1±

100-YEAR FLOODPLAIN

58.5

FLOOD PROTECTION ELEVATION ZONE 5375.70*

FLOOD PROTECTION ELEVATION ZONE 5361.40*

71.4

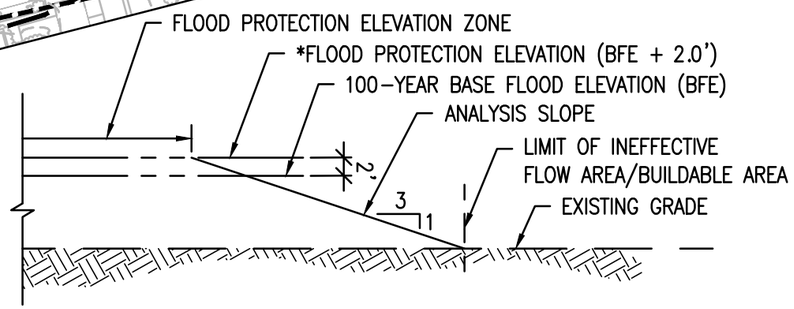
67.0

69.0

BOULDER SENIOR SERVICES
EX FFE: 5368.3±

BROADWAY

ARAPAHOE AVENUE



LEGEND

- INEFFECTIVE FLOW AREA/BUILDABLE AREA
- FLOOD PROTECTION ELEVATION ZONE BASED ON THE ELEVATION ANALYSIS
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE

100 0 100 200
SCALE IN FEET

FLOOD PROTECTION ELEVATION ANALYSIS DETAIL

NTS

JVA, Incorporated
1319 Spruce Street
Boulder, CO 80302
Phone: 303.444.1951
E-mail: info@jvajva.com

JVA CONSULTING ENGINEERS

NO.	DATE	DES'D	DWN

REVISION DESCRIPTION

JOB #: 2300C	DESIGNED BY: CFG		
DATE: 11/18/2015	DRAWN BY: REP		
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BOULDER CIVIC AREA
BOULDER, CO

FLOOD PROTECTION ELEVATION ZONE ANALYSIS
OPTION W1 - ADDITIONAL
CROSS SECTIONS

SHEET NO.
9

CANYON BOULEVARD

LIBRARY
EX FFE: 5357.3±

EXISTING GRADE (TYP)

57.1

53.9

FLOOD PROTECTION ELEVATION ZONE 5361.40*

53.9

55.7

63.1

9TH STREET

HIGH HAZARD ZONE

52.2

55.1

CONVEYANCE ZONE

LIBRARY
EX FFE: 5358.1±

100-YEAR FLOODPLAIN

58.5

FLOOD PROTECTION ELEVATION ZONE 5375.70*

FLOOD PROTECTION ELEVATION ZONE 5361.40*

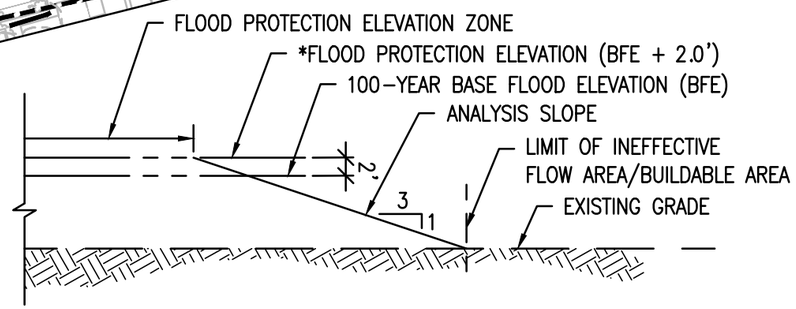
71.4

BOULDER SENIOR SERVICES
EX FFE: 5368.3±

67.0
69.0

BROADWAY

ARAPAHOE AVENUE



LEGEND

- INEFFECTIVE FLOW AREA/BUILDABLE AREA
- FLOOD PROTECTION ELEVATION ZONE BASED ON THE ELEVATION ANALYSIS
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE

100 0 100 200
SCALE IN FEET

FLOOD PROTECTION ELEVATION ANALYSIS DETAIL

NTS

JVA, Incorporated
1319 Spruce Street
Boulder, CO 80302
Phone: 303.444.1951
E-mail: info@jvajva.com

JVA CONSULTING ENGINEERS

NO.	DATE	DES'D	DWN

REVISION DESCRIPTION

JOB #: 2300C	DESIGNED BY: CFG		
DATE: 11/18/2015	DRAWN BY: REP		
© JVA INC	CHECKED BY: CRH		

BOULDER CIVIC AREA
BOULDER, CO

FLOOD PROTECTION ELEVATION ZONE ANALYSIS
OPTION W2 - ADDITIONAL CROSS SECTIONS
WITH LIBRARY BRIDGE REMOVED

SHEET NO.
10

CANYON BOULEVARD

BROADWAY

ARAPAHOE AVENUE

9TH STREET

LIBRARY
EX FFE: 5357.3±

EXISTING GRADE (TYP)

57.1

53.9

53.9

55.7

63.1

FLOOD PROTECTION ELEVATION ZONE 5361.29*

FLOOD PROTECTION ELEVATION ZONE 5361.40*

HIGH HAZARD ZONE

CONVEYANCE ZONE

52.2

55.1

LIBRARY
EX FFE: 5358.1±

100-YEAR FLOODPLAIN

58.5

FLOOD PROTECTION ELEVATION ZONE 5375.70*

FLOOD PROTECTION ELEVATION ZONE 5361.40*

71.4

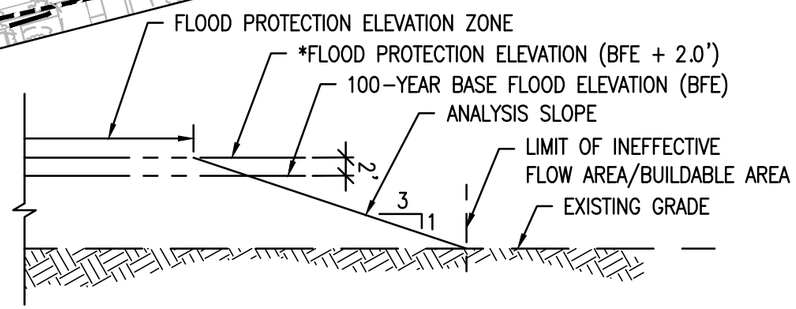
67.0

69.0

BOULDER SENIOR SERVICES
EX FFE: 5368.3±

LEGEND

- INEFFECTIVE FLOW AREA/BUILDABLE AREA
- FLOOD PROTECTION ELEVATION ZONE BASED ON THE ELEVATION ANALYSIS
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE



FLOOD PROTECTION ELEVATION ANALYSIS DETAIL

NTS

100 0 100 200

SCALE IN FEET

JVA, Incorporated
1319 Spruce Street
Boulder, CO 80302
Phone: 303.444.1951
E-mail: info@jvajva.com

JVA CONSULTING ENGINEERS

NO.	DATE	DESD	DWN	REVISION DESCRIPTION

DESIGNED BY:	CFG
DRAWN BY:	REP
CHECKED BY:	CRH
JOB #:	2300C
DATE:	11/06/2015

BOULDER CIVIC AREA
BOULDER, CO

FLOOD PROTECTION ELEVATION ZONE ANALYSIS
OPTION W3 - ADDITIONAL CROSS SECTIONS W/
LIBRARY BRIDGE AND NORTH BUILDING REMOVED

SHEET NO.
11

APPENDIX A.2

EAST BOOKEND

ANDERSON CONSULTING ENGINEERS, INC
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375 East Horsetooth Road, Building 5, Fort Collins, CO 80525
Phone (970) 226-0120 / Fax (970) 226-0121
www.acewater.com

CORRECTED EFFECTIVE - FLOOD HAZARD MAPPING

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER: COBLDR18	
DATE: 11/2/2015	
SHEET: 12	INDEX:

12/1/2015 9:55 AM

LEGEND

- CONVEYANCE ZONE – CORRECTED–EFFECTIVE
- HIGH HAZARD ZONE – CORRECTED–EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – CORRECTED–EFFECTIVE
- 1% ANNUAL CHANCE FLOODPLAIN – EFFECTIVE
- HIGH HAZARD ZONE – EFFECTIVE
- CONVEYANCE ZONE – EFFECTIVE
- POTENTIAL DEVELOPMENT AREA
- 2550 — CROSS SECTION

5470
5324
5142
50+00
CANYON BLVD
55+00
585
ZONE AO2
5+00
14TH STREET
544
ZONE AO3
51+00
13TH STREET
20+00
ZONE AO2
305+00
51
ZONE AO2
300+00
29922

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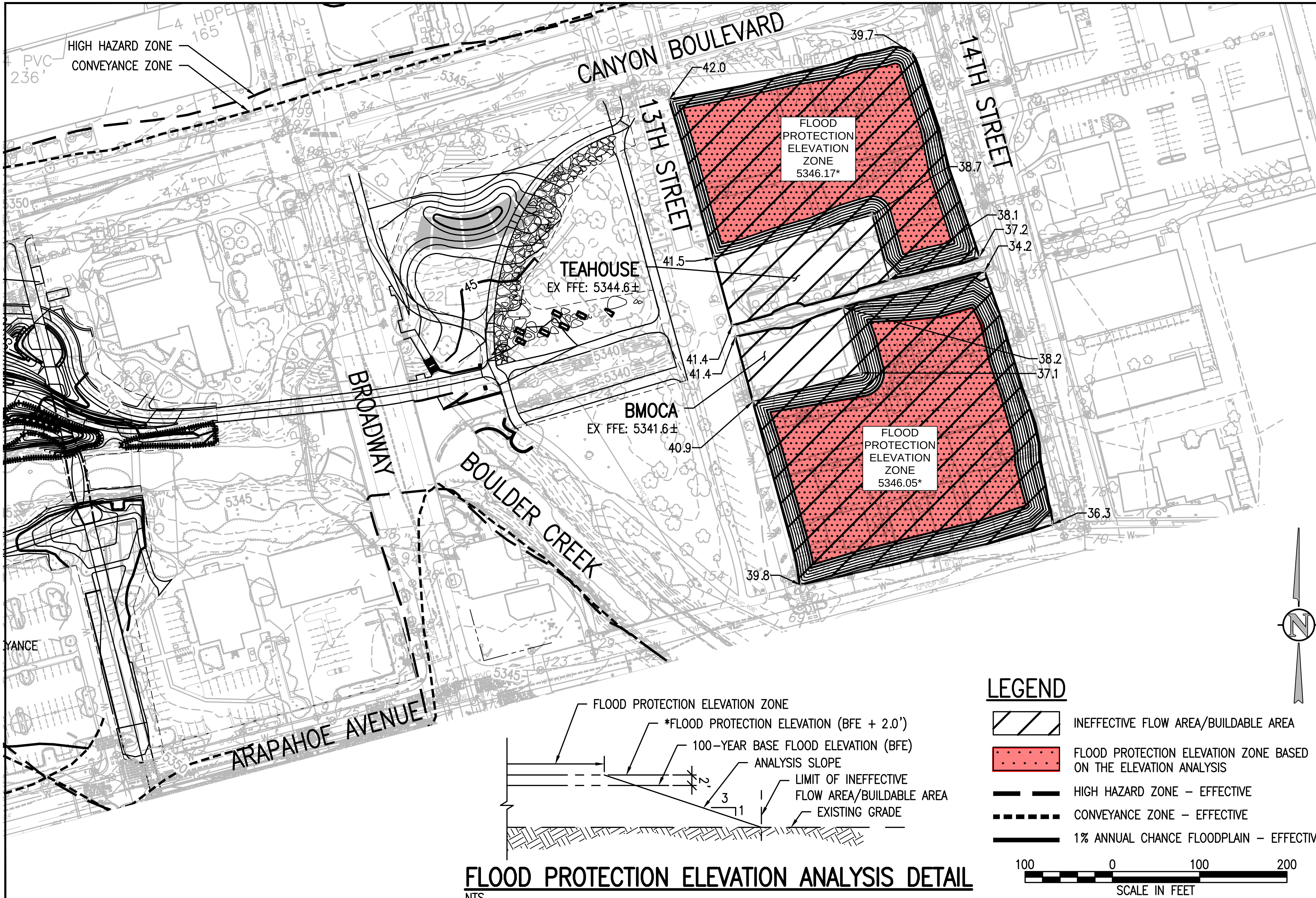
Civil • Water Resources • Environmental
375 East Elmer Street, Suite 100, Vail, CO 81657
Phone (970) 476-0120 | Fax (970) 476-0123
www.acevail.com

CORRECTED EFFECTIVE - INEFFECTIVE/OBSTRUCTED FLOW AREA OUTSIDE HHZ

BOULDER CIVIC AREA EVALUATION

DRAWN BY:	JMA
DESIGNED BY:	JMA
CHECKED BY:	GJK
PROJECT NUMBER:	COBLDR18
DATE:	11/2/2015
SHEET: 13	INDEX:



JVA, Incorporated
1319 Spruce Street
Boulder, CO 80302
Phone: 303.444.1951
E-mail: info@jvajva.com

CONSULTING ENGINEERS

NO.	DATE	DES'D	DWN	REVISION DESCRIPTION

JOB #: 2300C | DESIGNED BY: CFG
DATE: 11/18/2015 | DRAWN BY: REP
©JVA INC | CHECKED BY: CRH

BOULDER CIVIC AREA
BOULDER, CO

FLOOD PROTECTION ELEVATION ZONE ANALYSIS
OPTION E1 - EAST BOOKEND

SHEET NO.
14

APPENDIX B

SUMMARY OF KEY FLOOD HAZARD PARAMETERS FOR THE WEST BOOKEND

Comparison of Flood Hazard Limits and 100-Year Water Surface Elevations for the West Bookend

100-yr Floodplain Limit Comparison

Cross Section	Effective		West Option 1		West Option 2		West Option 3	
	Left Station	Right Station	Left Station	Right Station	Left Station	Right Station	Left Station	Right Station
31269	630.8	1083.8	630.8	1083.8	630.8	1083.8	630.8	1083.8
31302	140.2	1367.4	140.2	1367.4	288.2	1085.3	287.3	1085.3
31357	---	---	161	1410.1	318	1184.7	318	1189.3
31400	145	1164.6	145	1165.7	312	1156.5	312	1157.6
31468	---	---	26.5	1185.5	153	1163.7	153	1166.6
31632	282	1071.2	282	1071.2	563.2	1071.2	563.2	1071.2
31689	286.6	1111.3	286.6	1111.3	286.6	1111.3	286.6	1111.3

100-yr Water Surface Elevation Comparison

Cross Section	Effective	West Option 1	West Option 2	West Option 3
31269	5356.11	5356.11	5356.11	5356.07
31302	5358.82	5358.82	5357.43	5357.51
31357	---	5359.25	5358.24	5358.38
31400	5359.18	5359.24	5358.26	5358.41
31468	---	5359.29	5358.29	5358.41
31632	5359.4	5359.47	5358.76	5358.74
31689	5360.72	5360.74	5360.64	5360.64

Conveyance Zone Comparison

Cross Section	Effective		West Option 1		West Option 2		West Option 3	
	Left Encroach	Right Encroach	Left Encroach	Right Encroach	Left Encroach	Right Encroach	Left Encroach	Right Encroach
31269	660.75	1083.75	660.75	1083.75	655.55	1083.75	655.50	1083.75
31302	660.30	1085.31	660.30	1085.31	641.20	1085.31	641.20	1085.31
31357	---	---	713.40	1184.34	672.00	1184.34	672.00	1184.34
31400	696.00	1163.00	696.00	1163.00	662.70	1156.50	662.70	1157.58
31468	---	---	712.00	1164.28	685.00	1163.74	685.00	1164.28
31632	618.20	1071.18	618.20	1071.18	618.20	1071.18	618.20	1071.18
31689	656.84	1102.25	656.84	1102.25	656.84	1102.25	656.84	1102.25

High Hazard Zone Comparison

Cross Section	Effective				West Option 1				West Option 2				West Option 3			
	Left Station	Internal Station	Internal Station	Right Station	Left Station	Internal Station	Internal Station	Right Station	Left Station	Internal Station	Internal Station	Right Station	Left Station	Internal Station	Internal Station	Right Station
31269	630.8	---	---	1083.8	630.8	---	---	1083.8	630.8	---	---	1083.8	630.8	748.4	924.9	1083.8
31302	621.2	774.3	936.3	1085.3	621.2	774.3	936.3	1085.3	619.9	774.3	954.3	1085.3	620.0	786.8	954.3	1085.3
31357	---	---	---	---	653.0	820.5	932.2	1184.0	653.0	820.5	988.0	1184.0	653.0	820.5	988.0	1184.0
31400	636.0	809.0	924.4	1161.6	636.0	809.0	924.4	1161.6	636.0	809.0	924.4	1156.5	636.0	809.0	866.7	1157.6
31468	---	---	---	---	615.0	842.0	943.0	1164.3	615.0	785.3	1011.1	1163.7	615.0	914.0	1011.1	1164.3
31632	563.2	761.2	909.6	1069.2	563.2	761.2	909.6	1067.2	563.2	711.7	909.6	1069.2	563.2	711.7	909.6	1069.2
31689	628.3	---	---	1102.3	628.3	---	---	1102.3	628.3	---	---	1102.3	628.3			1102.3