Floodplain Development Permit Report

Coal Creek Drainageway A-1

GARFIELD AVENUE CULVERT REPLACEMENT

Prepared by:

Enginuity Engineering Solutions, LLC

10106 West San Juan Way, Suite 215

Littleton, CO 80127

Prepared for:

City of Louisville

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Enginuity

Table of Contents

LIST OF TABLES

APPENDICES

Project Description

The City of Louisville is in the process of replacing an undersized culvert crossing at Garfield Avenue along Drainageway A-1 which is a tributary to Coal Creek. Enginuity Engineering Solutions (Enginuity) was contracted to provide recommended improvements and final design for the culvert replacement and associated structures and channel grading.

This Floodplain Development Permit report has been prepared as part of the Drainageway A-1 Culvert Replacement Project in the City of Louisville and Boulder County, Colorado. Information and analysis contained in this document pertain to replacement of the existing culvert at Garfield Avenue and associated channel grading including a drop structure at the upstream end of the proposed culvert located on Flood Insurance Rate Map (FIRM) Panel 08013C0582K. **Figure 1** provides an overview of the project site. In 2020, Enginuity conducted an alternatives evaluation to determine the most appropriate culvert size and configuration for use at the crossing. The Alternatives Analysis Report is presented in **Appendix F**.

The culvert replacement and associated channel improvements extend for approximately 800 feet along Coal Creek Drainageway A-1, also known as the Goodhue Ditch. The CLOMR extents are from Jefferson Avenue on the downstream end to West South Boulder Road on the upstream end. This encompasses the existing mapped floodplain for Drainageway A-1. The Special Flood Hazard Zone (SFHA) in this reach is designated as a Zone AE, without floodway with the lower portion at Jefferson Avenue designated an AH as it is a stormwater detention and flood control facility. Zone X is delineated through the reach as well.

Purpose

The purpose of this report is to provide supporting analyses and documentation regarding any changes to the effective flood hazard area delineation along Drainageway A-1 due to the construction of the culvert replacement and associated improvements. Final results from the hydraulic modeling have been compiled and summarized and are included in this submittal.

Site Description

The project site for the Drainageway A-1 Culvert Replacement Project falls within FIRM Panel 08013C0582K with an effective date of August 15, 2019. The project area lies entirely within the City of Louisville. The project area is bounded on the north by South Boulder Road, Cottonwood Park to the west, Griffith Street to the south, and Jefferson Street to the east. The downstream limit of the project is the detention pond at Lawrence Enreitto Park. The project reach is approximately 2,200 feet long. The Boulder County Flood Insurance Study (FIS) has an effective date of June 2, 1995. The Special Flood Hazard Area (SFHA) along this reach of Drainageway is Zone AE, within the channel, and Zone AH, within the detention basin at the downstream end of the reach, without a designated floodway. The FIRM designation of Zone AE is defined as an area subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. In this area, a floodway is not mapped. The FIS volumes and FIRMs that were used for reference are located in **Appendix A.1**. An Approved Jurisdictional Determination was received from the US Army Corps of Engineers on March 30, 2021 which determined that the Drainageway A-1 channel within the CLOMR reach is not considered waters of the United States (WOTUS). This determination is provided in **Appendix G**.

Drainageway A-1 currently flows southeast from West South Boulder Road to its confluence with Drainageway A at the detention basin in Lawrence Enreitto Park. The Goodhue Ditch turn-out structure is located approximately 350 feet downstream of Garfield Avenue. The ditch continues east while the main Drainageway A-1 flow path turns to the south towards Lawrence Enreitto Park. Flow in pre-project conditions exceeds the existing culvert capacity at Garfield Avenue,

and a portion of flow overtops the roadway and flows south on Garfield Avenue and flows back into the detention basin at Lawrence Enreitto Park.

The culvert replacement project directly affects the Drainageway A-1 SFHA by increasing the culvert capacity, adding a drop structure, and channel grading. The intent of the proposed project at Garfield Avenue is as follows:

1. Increasing the hydraulic capacity of the existing culvert,
2. Improving maintenance access and addressing in-stream debris, and
3. Removing structures within the existing floodplain that reside within the backwater caused by the undersized culvert at Garfield Avenue.

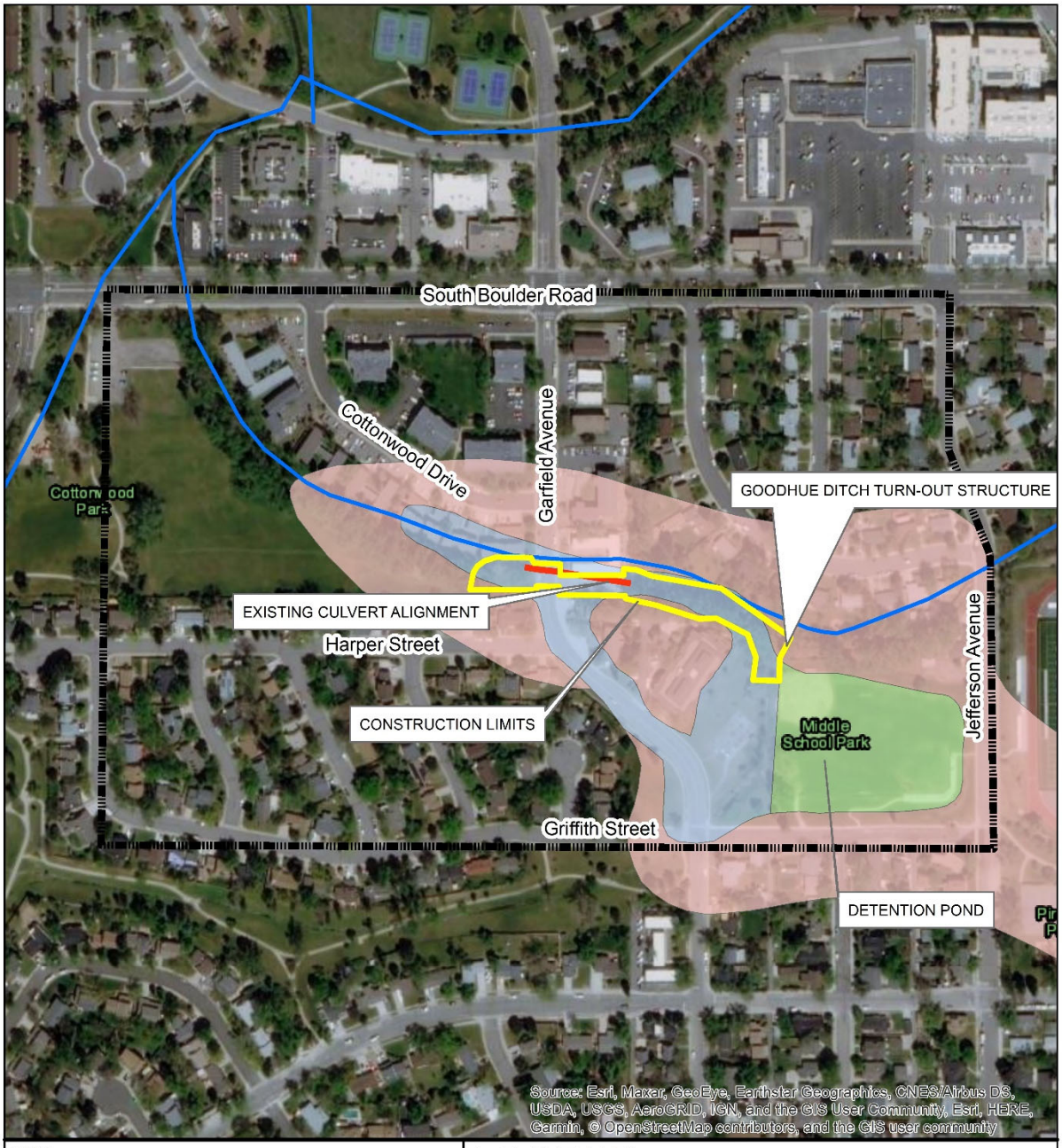

Figure 1 – Project Site Overview

Background

Previous Studies

FEMA published an effective Flood Insurance Study (FIS) (**Appendix A.1**) for Boulder County, Colorado and Incorporated Areas on June 2, 1995. Drainageway A-1 was not evaluated as part of the FIS.

On March 23, 1999, the "As-Built" Report for the Drainageway A Improvements – Louisville, Colorado, FEMA Case No. 97-08-274R **(Appendix A.2)** was submitted by Drexel Barrell & Co. This report presented the hydraulic analysis completed in constructing the detention basin at the Lawrence Enreitto Park. The analysis of the floodplain in the project reach was completed using UDSWM to determine Base Flood Elevations (BFEs) between the detention basin on the downstream end and a location just upstream of Garfield Avenue on the upstream end. Overflows that travelled down Garfield Avenue were determined via normal depth calculations based on the assumed split flow at the existing culvert.

Survey and Topographic data

Survey & Topographic Data Sources

A full topographic survey of the project area and adjacent overbanks was completed in July 2020 by True North Surveying & Mapping, LLC. In limited locations, 2014 LiDAR was used to define topography outside of the coverage of the design survey.

Datums

Flood elevation data contained in the 1999 "As-Built" Report for the Drainageway A Improvements – Louisville, Colorado are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Any data from those studies that is presented in this report has been converted to the North American Vertical Datum of 1988 (NAVD88). The National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS) Conversion & Transformation (NCAT) tool was used to determine that there is a 3.2-foot vertical datum shift between NGVD29 and NAVD88 for the project site. All elevation data and new work presented in this report are referenced to the following projection and datum:

- Projection: Colorado State Plane North
- Datum:
    - Horizontal – Colorado North FIPS 0501 State Plane NAD83 (2011), Foot_US
    - Vertical – North American Vertical Datum 1988, Geoid 12A

Hydraulic modeling

Discharges and Modeled Recurrence Intervals

The Drexel Barrell & Co. "As-Built" Report analyzed the 1%-annual-chance-flood event recurrence interval for Drainageway A using UDSWM. The UDSWM output lists a flow for Drainageway A-1 of 229 cfs in the channel. The Goodhue Ditch decreed flow is 90 cfs which was added to the peak flow reported from UDSWM for a total of 319 cfs. It was conservatively assumed that the peak storm flow and decreed ditch flow would occur simultaneously. A similar UDSWM model was developed for the 0.2%-annual-chance-flood event recurrence interval which gives a peak flow of 248 cfs for Drainageway A-1. Again, the decreed ditch flow was assumed to occur simultaneously with the peak storm flow which results in a peak flow of 338 cfs. **Table 1** lists the peak discharges used in this CLOMR analysis.

Table 1 – Peak Discharge for Drainageway A-1

Recurrence Interval	Peak Discharge (cfs)
1%-Annual-Chance-Event	319
0.2%-Annual-Chance-Event	338

Hydraulic Model Description

Effective

The effective floodplain mapping for Drainageway A-1 was developed using UDSWM output from the "As-Built" Report for the Drainageway A Improvements. No effective HEC-RAS model exists for the channel. Water surface elevation comparisons to the effective model were made by estimating BFE locations from the effective FIRM panel.

Corrected Effective/Existing

For purposes of this CLOMR, the US Army Corps of Engineers' (USACE) Hydrologic Engineering Center River Analysis System HEC-RAS Version 5.0.7 was used to analyze the channel hydraulics. All hydraulic computations in HEC-RAS were performed under steady-state flow conditions, assuming a subcritical flow regime.

A corrected effective/existing HEC-RAS model was developed for this CLOMR to model the current flood limits in the project reach and to be able to compare post-project conditions at the same locations.

Proposed Conditions

The proposed project conditions model builds on the pre-project model by including the new culvert at Garfield Avenue, drop structure at the culvert inlet, associated structures and channel grading to the HEC-RAS model to reflect the proposed conditions. The proposed project design plans are in **Appendix B** and more detailed information regarding the pre-project and proposed project modeling is provided in the next section of the report.

The HEC-RAS hydraulic model reports are included in **Appendix C**, and the CHECK-RAS reports are located in **Appendix D**. The hydraulic workmap is included in **Appendix E** along with the annotated FIRM panels, flood profiles, and map-model agreement tables.

Modeling Software

HEC-RAS version 5.0.7 was used to complete the floodplain analysis.

Cross Sections

Tables 2 through 4 provide a summary of stationing for cross-sections contained in the Corrected Effective/Existing and Proposed Conditions CLOMR models. As previously stated, UDSWM was used to determine BFEs and floodplain limits for the effective model. The Corrected Effective/Existing model includes reaches for the flow which overtops Garfield Avenue at the culvert crossing. These reaches are removed in the proposed model due to the increased capacity of the replaced culvert being able to convey the entire flow. Table 2 provides the cross-sections through the main flow path of Drainageway A-1. Table 3 shows the split flow on Garfield Avenue and Table 4 presents the cross-sections at, and downstream of, the Goodhue Ditch turn-out structure.

Table 2 – Main Flow Path Cross Section Summary

Corrected Effective/Existing Model			Proposed Conditions Model		
Reach	Description	Station	**Reach**	Description	Station
Upstream	Upstream Limit of Study	2375	Upstream	Upstream Limit of Study	2375
		2207			2207
		2060			2060
		1891			1890
		1728			1727
		1625			1625
		1552			1552
		1508			1508
		1467			1467
		1439			1439
		1435			1435
Downstream		1420			1420
	Culvert Crossing	1400		Culvert Crossing	1400
		1157			1157
		1142			1142
		1137			1137
		1089			1089
		1023			1023
		971			971
		905			905
		792	DS Weir Flow		792
		756			756
		731			731
		585			585
MS Det Pond		455	DS Weir Flow		455
		285			285
		195			195
	Downstream Limit of Study	112		Downstream Limit of Study	112

Table 3 - Garfield Split Flow Cross Section Summary

Corrected Effective/Existing Model			Proposed Conditions Model		
Reach	Description	Station	**Reach**	Description	Station
Garfield Split		800	N/A		-
		761			-
		706			-
		597			-
		537			-
		416			-
		269			-
		115			-
		73			-

Table 4 - Goodhue Ditch Turn-Out Structure Cross Section Summary

Corrected Effective/Existing Model			Proposed Conditions Model		
Reach	Description	Station	**Reach**	Description	Station
DSDivStruc		76	DSDivStruc		76
	Goodhue Ditch Turnout	70		Goodhue Ditch Turnout	70
		65			65
		15			15

Tie-Ins

No lettered cross-sections are located within the effective study for this reach of Drainageway A-1. The effective ponded water elevation within the detention pond at Lawrence Enreitto Park was used for the downstream tie-in. The effective tie-in water surface elevation data is summarized in **Table 5**. This elevation is reported in NAVD 88 datum in the effective FIRM. The "As-Built" Report lists the pond water surface elevation, for the 1%-Annual-Chance-Event, of 5,373.7 in NAVD 29 datum. The peak outflow from the detention pond for the 0.2%-Annual-Chance-Event was used to determine the peak water surface elevation using the stage-storage curve provided in the "As-Built" report.

Roughness Coefficients

Manning's n values for this CLOMR were based on a detailed site evaluation and were selected from Volume 1 of the Urban Storm Drainage Criteria Manual (USDCM). Manning's n-values are 0.04 and 0.06 for the channel and

overbank areas, respectively. A value of 0.05 was used for grouted boulder sections based on the Manning's Roughness Coefficient Calculation in the USDCM.

Ineffective Flow Areas

Due to the steep and narrow Drainageway A-1 corridor, there are few ineffective flow areas in the HEC-RAS model. Permanent ineffective flow areas were established at the upstream and downstream ends of the pre-project and proposed conditions culverts. A normal ineffective flow area was added where the Garfield split flow enters the downstream detention pond in the Corrected Effective/Existing model.

Expansion and Contraction Coefficients

The typical expansion and contraction loss coefficients of 0.3 and 0.1, respectively, were applied to most cross sections except in locations where the culvert is located. Cross sections immediately upstream and downstream of the pre-project and proposed conditions culverts used expansion and contraction coefficients of 0.5 and 0.3, respectively.

Structures

The only structure present within the model domain is the culvert crossing at Garfield Avenue. The pre-project culvert is a 48" corrugated metal pipe and the proposed condition is a 72" reinforced concrete pipe.

Boundary Conditions

The starting water surface elevation in the detention pond at Lawrence Enreitto Park is summarized in Error! Reference source not found.. The upstream extent of the CLOMR analysis is upstream of the limits of the effective analysis.

Table 5 - Starting Water Surface Elevation

Flood Event (cfs)	Water Surface Elevation (ft)
1%-Annual-Chance-Event	5,376.9
0.2%-Annual-Chance-Event	5,377.5

Summary of Hydraulic Models

Effective Model

The effective hydraulic model used for this study is the 1999 UDSWM model developed by Drexel Barrell & Co. for the Drainageway A Improvements. This data was used as a starting point in developing the Corrected Effective/Existing and Proposed hydraulic models. The tie-in elevations at the downstream end of the CLOMR reach as well as the general flow path of the split flow down Garfield Avenue was taken from the 1999 study. BFE locations were estimated from the effective FIRM for comparison. The effective FIRM BFEs are in NAVD88 and converted from NGVD29 as in the 1999 study.

Corrected Effective Model/Existing

The Corrected Effective/Existing model was developed in HEC-RAS version 5.0.7 to encompass the project area from the detention pond in Lawrence Enreitto Park upstream to South Boulder Road. Cross-sections were developed within the main channel of Drainageway A-1 from South Boulder Road downstream to the detention pond. Additionally, a reach was created for the flow breakout at Garfield Avenue from the intersection of Drainageway A-1 and Garfield Avenue, downstream to Lawrence Enreitto Park, where it rejoins the main Drainageway A-1 flow path. The Goodhue Ditch turn-out structure was included at the point where the main flow path turns south towards the detention pond. Cross-sections were added within the ditch, downstream of

the turnout structure, however, for the purposes of this study, the turnout structure was modeled as closed to send all flow to the detention pond. The existing 48" CMP culvert crossing at Garfield Avenue was input to the model using field survey data as shown in **Appendix B**. The Corrected Effective/Existing model used a known water surface at the detention pond at the downstream end of the model to match the Effective Model water surface elevation.

Proposed Project Conditions Model

The Proposed Conditions model was completed by incorporating the new, larger 72" RCP culvert along with associated wingwalls and channel grading improvements, drop structure at the inlet, and energy dissipation at the culvert outlet into the Corrected Effective/Existing hydraulic model.

To develop the Proposed Conditions model, data in the design plans in **Appendix B** were used to model the replaced culvert and channel improvements. Additionally, because of the increased culvert capacity, the split flow which takes overtopping flow from the existing culvert is removed in the Proposed Conditions model and all flow is conveyed in the main Drainageway A-1 channel. Because HEC-RAS is not well suited to model a culvert which has horizontal and vertical alignment changes, a separate storm sewer analysis was completed to verify the water surface elevations in the HEC-RAS output. The analysis showed headwater elevations slightly below those reported by HEC-RAS. This analysis is presented in **Appendix H**.

SUMMARY OF WATER SURFACE ELEVATIONS

A detailed comparison of the water surface elevation at cross-sections contained in the pre-project conditions, and proposed conditions models is provided in Tables 6 through 8 below.

Table 6 – Main Flow Path Comparison of Hydraulic Model Water Surface Elevations

Corrected Effective/Existing and Proposed Cross-Section (ID)	Effective BFE*	Corrected Effective BFE	Proposed BFE	Corrected Effective vs. Effective ΔBFE	Proposed vs. Effective ΔBFE	Proposed vs. Corrected Effective ΔBFE
2375	-	5409.30	5409.30	-	-	0
2207	-	5404.47	5404.47	-	-	0
2060	-	5402.61	5402.61	-	-	0
1891	-	5398.07	5398.09	-	-	0.02
1728	-	5396.32	5393.72	-	-	-2.6
1625	-	5396.23	5392.07	-	-	-4.16
1552	5398	5396.23	5390.67	-1.77	-7.33	-5.56
1508	5397.67	5396.24	5390.28	-1.43	-7.39	-5.96
1467	5397.13	5396.25	5390.32	-0.88	-6.81	-5.93
1439	5396.76	5396.25	5390.38	-0.51	-6.38	-5.87
1435	5396.68	5396.24	5390.40	-0.44	-6.28	-5.84
1420	5396.48	5396.24	5390.45	-0.24	-6.03	-5.79

Corrected Effective/Existing and Proposed Cross-Section (ID)	Effective BFE*	Corrected Effective BFE	Proposed BFE	Corrected Effective vs. Effective ΔBFE	Proposed vs. Effective ΔBFE	Proposed vs. Corrected Effective ΔBFE
1400	Culvert Crossing					
1157	5393.19	5381.65	5381.83	-11.54	-11.36	0.18
1142	5392.96	5380.71	5381.91	-12.25	-11.05	1.20
1137	5392.20	5380.9	5381.77	-11.30	-10.43	0.87
1089	5385.98	5380.21	5380.88	-5.77	-5.10	0.67
1023	5380.24	5380.08	5380.83	-0.16	0.59	0.75
971	5378.86	5379.96	5380.68	1.10	1.82	0.72
905	5377.90	5379.7	5380.29	1.80	2.39	0.59
792	5377.00	5379.16	5379.73	2.16	2.73	0.57
756	5377.00	5377.55	5378.04	0.55	1.04	0.49
731	5377.00	5376.81	5376.96	-0.19	-0.04	0.15
585	5377.00	5376.91	5376.91	-0.09	-0.09	0
455	5376.00	5376.90	5376.90	0.90	0.90	0
285	5376.00	5376.90	5376.90	0.90	0.90	0
195	5376.00	5376.90	5376.90	0.90	0.90	0
112	5376.00	5376.90	5376.90	0.90	0.90	0

* Effective BFEs Estimated from interpolating Effective FIRM BFEs

Table 7 - Garfield Split Flow Comparison of Hydraulic Model Water Surface Elevations

Corrected Effective/Existing and Proposed Cross-Section (ID)	Effective BFE*	Corrected Effective BFE	Proposed BFE	Corrected Effective vs. Effective ΔBFE	Proposed vs. Effective ΔBFE	Proposed vs. Corrected Effective ΔBFE
800	5396	5396.07	-	0.07	-	-
761	5394.27	5395.42	-	1.15	-	-
706	5393.86	5395.14	-	1.28	-	-
597	5392.17	5393.87	-	1.70	-	-
537	5389.85	5391.49	-	1.64	-	-
416	5385.33	5385.72	-	0.39	-	-
269	5381	5380.85	-	-0.15	-	-
115	5377	5376.85	-	-0.15	-	-

Corrected Effective/Existing and Proposed Cross-Section (ID)	Effective BFE*	Corrected Effective BFE	Proposed BFE	Corrected Effective vs. Effective ΔBFE	Proposed vs. Effective ΔBFE	Proposed vs. Corrected Effective ΔBFE
73	5377	5376.86	-	-0.14	-	-

* Effective BFEs Estimated from interpolating Effective FIRM BFEs

Table 8 - Goodhue Ditch Turn-Out Structure Comparison of Modeled Water Surface Elevations

Corrected Effective/Existing and Proposed Cross-Section (ID)	Effective BFE	Corrected Effective BFE	Proposed BFE	Corrected Effective vs. Effective ΔBFE	Proposed vs. Effective ΔBFE	Proposed vs. Corrected Effective ΔBFE
76	-	5380.15	5380.15	-	-	0.00
70	Goodhue Ditch Turnout					
65	-	5375.11	5375.07	-	-	-0.04
15	-	5375.03	5375.06	-	-	0.03

Discussion of Results

Hydraulics

Final comparison of modeled water-surface elevations along the project reach of Drainageway A-1 show that the proposed culvert replacement dramatically reduces water surface elevations upstream of the culvert location at Garfield Avenue. An increase in water surface elevations occurs downstream of the culvert due to the increased culvert capacity which presently does not allow a portion of flow to overtop Garfield Avenue and flow to the south. There are no impacts to adjacent structures in this area due to the increase in water surface elevation. Some properties upstream of the effective mapped floodplain have been added to the floodplain through the CLOMR modeling. The majority of the properties within the previously mapped floodplain have either had the floodplain reduced or removed from the property. Cross-sections upstream of the influence of the culvert crossing and within the detention pond show no change in water surface elevation.

Floodplain Mapping

Floodplain mapping for the 1%-annual-chance event and 0.2%-annual-chance-event was completed within the project reach. The floodplain ties into the effective pond elevation in the detention pond at Lawrence Enrietto Park on the downstream end. The upstream end of the CLOMR modeled reach is upstream of the upstream end of the effective floodplain.

Project Impacts

There are no impacts to insurable structures resulting from the proposed improvements. The proposed conditions floodplain is narrower than the pre-project floodplain upstream of the culvert as a result in the decreases in water surface elevation. The proposed conditions floodplain is slightly larger than the pre-project floodplain downstream of the culvert crossing due to an increase in water surface elevations resulting from increased flood discharges. However, the floodplain

is still contained within the main channel and no insurable structures are located in areas impacted by the increase in BFEs.

Alternatives Analysis

Enginuity completed the Coal Creek Drainageway A-1 at Garfield Avenue Alternatives Evaluation Report (**Appendix F**) in February 2021. The goals of the project are to:

- Increase the hydraulic capacity of the culvert crossing, and
- Remove structures from the floodplain upstream of the culvert crossing at Garfield Avenue

A "do nothing" alternative would not change the water surface elevations throughout the reach and would result in structures upstream of the culvert remaining in the floodplain in addition to some resultant flooding of structures in the split flow which presently travels down Garfield Avenue. The "do nothing" alternative is the only alternative which would not result in an increase of BFEs. As the goal of the project is to remove those structures from the floodplain by increasing the capacity of the culvert, a "do nothing" alternative is not a viable option.

References

- Federal Emergency Management Agency, Flood Insurance Study, Boulder County, Colorado and Incorporated Areas, June 2, 1995.
- Federal Emergency Management Agency, Flood Insurance Rate Map 08013C0582K, Boulder County, Colorado and Incorporated Areas, August 15, 2019.
- "As-Built" Report for the Drainageway A Improvements – Louisville, Colorado, FEMA Case No. 97-08-274R, Prepared by Drexel, Barrell, & Co., Boulder, Colorado, March 23, 1999.
- Federal Emergency Management Agency, MT-2 Procedures Manual, May 2009.
- Federal Emergency Management Agency, Procedure Memorandum 64 – Compliance with the Endangered Species Act (ESA) for Letters of Map Change, August 18, 2010.
- U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-RAS Version 5.0.7, River Analysis System, Davis, California, March 2019.
- Topographic Data, Bare Earth LIDAR Digital Elevation Model (DEM), USGS, 2014.

Appendices

Appendix A – FEMA Effective References

Appendix B – Proposed Project Plans

Appendix C – HEC-RAS Model Results

Appendix D – cHECk-RAS

Appendix E – Floodplain Data

Appendix F – Coal Creek Drainageway A-1 at Garfield Avenue Alternatives Evaluation Report

Appendix G – Approved Jurisdictional Determination

Appendix H – Storm Sewer Analysis