Resilient St. Vrain Project

Letter of Map Revision: St. Vrain Creek from Upstream of Pratt Parkway to Upstream of Boulder Creek, Boulder County and Weld County, Colorado

Prepared for

City of Longmont

July 13, 2020

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Contents

Appendices

Abbreviations and Acronyms

CAD	Computer-Aided Design
BNSF	Burlington Northern Santa Fe
BFE	Base Flood Elevation
CDOT	Colorado Department of Transportation
CFR	Code of Federal Regulations
cfs	cubic feet per second
City	City of Longmont
CHAMP	Colorado Hazard Mapping Program
CWCB	Colorado Water Conservation Board
FEMA	Federal Emergency Management Agency
FIPS	Federal Information Processing Standard
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GIS	Geographic Information System
HARN	High Accuracy Reference Network
HEC-RAS	Hydrologic Engineering Centers River Analysis System
Jacobs	Jacobs Engineering Group Inc.
LIDAR	Light Detection and Ranging
NAD	North American Datum
NFIP	National Flood Insurance Program
RSVP	Resilient St. Vrain Project
SAM	Surveying and Mapping, LLC
TIN	Triangulated Irregular Network

I hereby affirm that this LOMR application entitled *St. Vrain Creek Letter of Map Revision: St. Vrain Creek from Upstream of Pratt Parkway to Upstream of Boulder Creek, Boulder County and Weld County, Colorado* was prepared in accordance with applicable, viable, and pertinent technical data and criteria for the Colorado Water Conservation Board, the Federal Emergency Management Agency, the City of Longmont, Boulder County, and Weld County, CO. The document, report, and all attachments submitted herewith were prepared in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the necessary information and accurately prepared the document.

Additionally, I hereby certify that no insurable structures are impacted due to the documents in the LOMR application.

Signature:

Jacobs Engineering Group Inc.
David A. Bergh, P.E.
Colorado Registered Professional Engineer, No. 52016

1.0 Introduction

1.1 Purpose

The City of Longmont, Colorado (City) experienced significant damage due to the flooding of St. Vrain Creek during the floods of September 2013. Catastrophic flooding caused extensive damage in the Longmont area, damaging both public infrastructure and private property. Damage to public infrastructure included roads and bridges, water and sewer utilities, parks and trails, and public buildings. Flows passed through both commercial areas and residential neighborhoods, damaging businesses and homes. As a result, the City has undertaken the Resilient St. Vrain Project (RSVP), a multi-year, multi-phase project to improve the channel, reduce flooding throughout the City, and make St. Vrain Creek more resilient to future flood events. The overall RSVP extends from upstream of Airport Road to the St. Vrain Creek confluence with Boulder Creek near State Highway 119 (Highway 119). This Letter of Map Revision (LOMR) includes four reaches and three new roadway bridges within a portion of the overall RSVP, including the following (listed in order from upstream to downstream):

- City Reach 2A – Extends from near Colorado Way located upstream of Pratt Parkway to Main Street.
- Pratt Parkway Bridge (within City Reach 2A).
- Main Street Bridge (downstream limit of City Reach 2A).
- City Reach 1 – Extends from Main Street to near the confluence with Left Hand Creek. City Reach 1 includes as-constructed Boston Avenue topography that is just north of St. Vrain Creek between Main Street and Martin Street.
- Gap Reach – Connects City Reach 1 with the Sandstone Ranch Reach.
- County Line Road Bridge (downstream limit of the Gap Reach).
- Sandstone Ranch Reach – Extends from County Line Road to the St. Vrain Creek confluence with Boulder Creek upstream of Highway 119.

This LOMR accounts for constructed improvements within the reaches and at the bridges noted above. The Gap Reach connects City Reach 1 and the Sandstone Ranch Reach. No improvements were constructed in the Gap Reach, but it is included in the hydraulic model with updated topographic information to form one continuous hydraulic model for this LOMR. Figure 1 in Appendix A contains a Reach Overview exhibit identifying the reaches used in this analysis.

Prior to construction, a Conditional Letter of Map Revision (CLOMR) 16-08-0342R was issued for City Reach 1 and Sandstone Ranch Reach with an issue date of October 28, 2016, refer to Appendix O for the determination letter from the Federal Emergency Management Agency (FEMA). No CLOMRs were submitted for City Reach 2A, Pratt Parkway Bridge, Main Street Bridge, or County Line Road Bridge, as each was determined to be a no-rise or no increase in flood height condition and were approved by the City, or appropriate jurisdiction (e.g. the City was not the local floodplain permitting agency for the County Line Road Bridge).

1.2 Community Information

The City is the requestor for this LOMR. Although a majority of the project construction has occurred in the City, portions of the project and impacted floodplain boundaries are located within unincorporated Boulder and Weld Counties. Maps showing the jurisdictional boundaries are included in Appendix A.

1.3 Effective Information

The current effective Flood Insurance Study (FIS) for the City and Unincorporated Boulder County is dated December 18, 2012. The effective FIS for unincorporated Weld County is dated January 20, 2016. The FIS and

Flood Insurance Rate Maps (FIRMs) are currently being revised as a result of the 2013 flood events, and Preliminary FIRM documents have been issued for Boulder County, which includes the City of Longmont. For the purposes of this LOMR, the Preliminary FIRM is considered the effective information, per Boulder County's agreement with the Colorado Water Conservation Board (CWCB) and FEMA (see memoranda from Boulder County Transportation Department and FEMA in Appendix N). Therefore, this LOMR and supporting documentation should be incorporated into the Preliminary FIRM.

The Preliminary FIRMs within Boulder County include detailed Zone AE floodplain boundaries for the project area. The effective floodplain in Weld County is approximate Zone A. The floodway is not mapped for St. Vrain Creek within the City, but the floodway is mapped for parcels within Unincorporated Boulder and Weld Counties. The affected published effective FIRM panels in the City and Unincorporated Boulder County include the following: 08013C0286J, 0287J, 0288J, 0289J, and 0293J. One Weld County FIRM panel is impacted, 08123C1870E, dated January 20, 2016. The Boulder County Preliminary FIRM panels include 08013C0286K, 0287K, 0288K, 0289K, 0292K, 0293K, and 0294K.

The purpose of this LOMR is to revise the floodplain delineation in the Preliminary FIRM for inclusion into the final effective models and FIRM for the above-mentioned reaches. The annotated FIRMs showing the Colorado Hazard Mapping Program's (CHAMP) preliminary FIRM (which for this LOMR application is considered the effective FIRM), and as-constructed floodplain boundaries are attached in Appendix B. Additionally, annotated profiles and floodway tables are also included in Appendix B. The annotated floodway tables do not include floodway elevations for some cross sections, consistent with the Preliminary FIRM.

The City has submitted a Preliminary FIRM Appeal Application to FEMA titled *St. Vrain Creek Preliminary FIRM Appeal Application, West of Highway 119 to County Line Road, Boulder County, Colorado, May 2020* to more accurately define the floodplain mapping through the Gap Reach, as further detailed below. The Appeal Application is currently in for FEMA review. Due to uncertainty with the timing of the appeal process and incorporation into the Preliminary FIRM, the appeal information is included with this LOMR submittal. The complete Appeal Application is included in Appendix K. See Section 2.7 Gap Reach Appeal Application for additional information.

2.0 Constructed Projects

One of the goals of the RSVP is to reduce the risk of damage from a 100-year flood event to City facilities and infrastructure and surrounding private properties. Additionally, the project will restore riparian and wetland habitat along the creek, improve water quality, and repair and restore damage caused by the 2013 flood. The constructed projects addressed in this LOMR are described in the following sections. A photographic summary has been included in Appendix M, showing the constructed bridges (Pratt Parkway, Main Street, County Line Road, and the pedestrian bridges) and photographs from each representative channel reach.

2.1 City Reach 2A

2.1.1 Channel Design and Bank Protection

In order to convey the 100-year flow rate, the existing channel through City Reach 2A was widened and lowered. The low flow channel within City Reach 2A was realigned adding sinuosity and natural channel elements, and a floodplain overbank was constructed between the low flow channel and the channel banks. Two channel bank treatments were used, including buried soil riprap bank protection and modular block walls. Rootwads were also installed where feasible at the edge of the low flow channel. Downstream of Pratt Parkway, graded slopes with buried soil riprap bank protection were installed. Upstream of Pratt Parkway, large block gravity retaining walls were installed to maximize channel conveyance capacity within the narrow urban corridor. Both bank treatments were evaluated for the 100-year flood event protection. The City Reach 2A improvements integrate with the new Pratt Parkway Bridge, which is within City Reach 2A.

2.1.2 Stormwater Outfalls

Twelve stormwater outfalls were constructed within City Reach 2A. The pipes outfall onto the St. Vrain Creek floodplain overbank and into vegetated swales before entering St. Vrain Creek.

2.1.3 Pratt Parkway Bridge

Within City Reach 2A, a new roadway bridge was constructed at Pratt Parkway to convey the 100-year flood event and tie into upstream and downstream channel improvements. The new bridge has an approximate span of 240 feet and width of 88 feet. The Pratt Parkway Bridge was designed by others and constructed separately from City Reach 2A.

2.2 Main Street Bridge

A new roadway bridge was constructed at Main Street to convey the 100-year flood event and tie into upstream and downstream channel improvements. The new bridge has an approximate span of 245 feet and width of 99 feet. The Main Street Bridge was designed by others and constructed separately from City Reach 2A and City Reach 1.

2.3 City Reach 1

City Reach 1 extends from Main Street to near the confluence of St. Vrain Creek with Left Hand Creek. The primary goals of the RSVP within City Reach 1 were to stabilize the channel and banks of St. Vrain Creek, allow safe conveyance of 100-year flows, and enhance the aquatic, riparian, and recreational functions of the creek. It is noted that the Martin Street Bridge located within City Reach 1 was not changed, as it already had 100-year flow capacity. The City Reach 1 constructed project elements are described in the following sections.

2.3.1 Channel Design

In order to accommodate the 100-year flows, St. Vrain Creek was lowered between 1 and 5 feet and approximately 3,900 linear feet of the low flow channel was realigned. The constructed low-flow channel is between 30 and 50 feet wide with overbank benches.

A backwater channel was constructed approximately 700 feet downstream of Main Street through an area of existing degraded riparian habitat. The channel will provide a backwater area for riparian and wetland habitat during low flows. During large flood flows, water will be conveyed in both the main channel and the backwater channel. The backwater channel is a section of the pre-flood channel with a bottom width varying between 15 and 25 feet and has a longitudinal channel slope of approximately 1 percent. Riprap was placed at the upstream end of the backwater channel where it splits from the main channel of St. Vrain Creek and a grade control structure was constructed on the main channel of St. Vrain Creek below the downstream end of the backwater channel.

2.3.2 Grade Control Structures

Nine grade control structures were constructed within the low-flow channel in City Reach 1. Six structures were placed between Main Street and Martin Street, and three structures were placed downstream of Martin Street near the newly constructed Bonus Ditch diversion structure. The locations of the grade control structures were selected to accommodate flood conveyance, irrigation ditch diversions, and create wetlands. Each grade control structure incorporates a series of pools for fish and boat passage. The structures are approximately 70 feet wide and vary between 25 and 50 feet in length. All of the grade control structures are 4 to 5 feet tall and consist of grouted boulders. The height of the hydraulic drop within the structures is between 12 and 18 inches. The channel benches adjacent to the structures were planted with native seed and riparian vegetation.

Fish passage channels were incorporated into each grade control structure. Fish passage channels consist of 10-to- 15-feet wide channels along either the northern or southern edge of each grade control structure. The fish passage channels are lined with boulders and the substrate consists of void-filled riprap. The longitudinal slope of each fish passage is approximately 1 percent.

2.3.3 Bank Stabilization

Two types of bioengineered bank protection were used within City Reach 1. The first type of bank protection consists of laying back the banks to a slope of 3 Horizontal to 1 Vertical (3:1) or flatter, installing buried soil riprap on the bank, and reinforcing the toe by installing wetland vegetation and keying the riprap into bedrock. A minimum of 6 inches of topsoil was placed over the soil riprap and blanketed with coir mat. The second type of bank protection consists of laying back the banks, constructing nearly flat benches of varying widths, and reinforcing the toe near the low flow channel with wetland vegetation. Native riparian vegetation was planted on the overbank benches, which are between 18 and 36 inches above the low flow channel. A mix of both types of bank protection was installed along both banks of the new channel.

2.3.4 Pedestrian Bridges

Two pedestrian bridges that were damaged or destroyed in the 2013 flood were removed and three new pedestrian bridges were constructed. The first two new pedestrian bridges were constructed approximately 750 feet downstream of Main Street with one bridge spanning St. Vrain Creek and one bridge spanning the backwater channel. A third new pedestrian bridge was constructed approximately 870 feet upstream of Martin Street. The bridge constructed over St. Vrain Creek has a span of approximately 135 feet with a width of 12 feet. The second bridge, constructed over the backwater channel, spans approximately 111 feet with a width of 12 feet. The first two bridges are connected by a short section of pedestrian trail. The third bridge has an approximate span of 183 feet with a width of 12 feet.

2.4 The Gap Reach

The Gap Reach connects City Reach 1 and the Sandstone Ranch Reach. There were no improvements made within this reach, thus it is termed the “Gap” Reach. This reach is included in the LOMR model to form a single model from City Reach 2A through the Sandstone Ranch Reach and to include model and mapping changes submitted in the Preliminary FIRM Appeal Application to FEMA.

Multiple topographic data sources were used for the St. Vrain Creek modeling and mapping that were incorporated into the Preliminary FIRM, including the State of Colorado’s Light Detection and Ranging (LIDAR) and project-specific LIDAR for the City’s RSVP. The Gap Reach used only the State LIDAR, which was used for the Preliminary FIRM. As part of a recent and more detailed analysis along Highway 119 in the Gap Reach for the Appeal Application, it was determined that the Gap Reach LIDAR needed to be adjusted vertically to more accurately represent actual ground elevations. The Gap Reach LIDAR shift adjusts the LIDAR to match the State Plane coordinate system being used in the rest of the Preliminary FIRM model and floodplain mapping, which is North American Datum (NAD) 1983 High Accuracy Reference Network (HARN) State Plane Colorado North Federal Information Processing Standard (FIPS) 0501 (US Feet). The shift in general lowers the ground elevation by 1.0 to 1.5 feet. The shifted topography was field verified by a Professional Land Surveyor. The modeling and mapping in this LOMR use the shifted Gap Reach LIDAR. Since the LOMR model now reflects lowered topography in the Gap Reach, the water surface elevations are also lowered, and the resulting floodplain has no negative impact on structures in the area and no longer overtops Highway 119 to the south during the 100-year flow event.

2.5 County Line Road Bridge

A new roadway bridge was constructed at County Line Road to convey the 100-year flow. The new bridge has an approximate span of 270 feet and width of 46 feet. The County Line Road Bridge was designed by others and constructed as a separate project through Boulder County.

2.6 Sandstone Ranch Reach

The Sandstone Ranch Reach is east of the urban portion of Longmont in Weld County. The Sandstone Ranch Reach is bordered by Highway 119 to the north, County Line Road to the west, Boulder Creek to the east, and private lands to the south. During the September 2013 flood event, St. Vrain Creek breached its channel and began flowing to the south of its original channel. The post-flood flows have continued to flow south of the pre-flood channel and have formed a series of braided channels that are supporting new wetland and riparian growth.

2.6.1 Channel Design

The primary goal of the project in the Sandstone Ranch Reach was to stabilize portions of the channel banks of St. Vrain Creek to protect public and private property, restore open space lands, and repair a regional recreational trail. The constructed project keeps the channel in its post-flood alignment, and eroded areas or areas likely to erode along St. Vrain Creek were stabilized. The Sandstone Ranch Reach constructed project elements are described in the following sections.

2.6.2 Pedestrian Bridge and Trail Improvements

During the 2013 flood, a regional recreational trail that crossed St. Vrain Creek was destroyed in multiple areas. A small pedestrian bridge over St. Vrain Creek near the confluence with Spring Gulch No. 2 was also damaged. The Sandstone Ranch Reach project included repairing the existing pedestrian bridge, installation of a new pedestrian bridge over the post-flood channel, and reconnection of the greenway trail. The new bridge is approximately 281 feet long and 12 feet wide. The bridge includes concrete abutments at the ends of the bridge and pier support in the center of the bridge. The new trail follows an embankment to the south of the new bridge and connects to the pre-flood trail to the south.

2.6.3 Grade Control Structure

A riffle grade control structure was installed at the new pedestrian bridge over the post-flood St. Vrain Creek channel. The riffle grade control structure is approximately 90 feet long and 100 feet wide and consists of void-filled riprap and natural channel material. The longitudinal slope of the structure is approximately 2 percent to allow for fish passage. The vertical height of the structure is approximately 4 feet. The channel benches adjacent to the riffle structure were planted with native seed and riparian vegetation.

2.6.4 Bank Stabilization

Several types of bioengineered bank protection were constructed within the Sandstone Ranch Reach. The first type of bank protection consists of grading the banks to a slope of 4 Horizontal to 1 Vertical (4:1) or flatter. Buried soil riprap and void-filled riprap were placed along the bank and keyed-in for erosion protection. Additionally, reinforced soil lifts and rootwads were installed where feasible. Disturbed areas were revegetated with native seed, wetland plugs, and willow stakes.

The second type of bank stabilization consists of regrading portions of the banks to a less steep slope (4:1 or flatter) and planting native plant species. Disturbed areas were revegetated with native seed, wetland plugs, and shrubs.

2.6.5 Diversion Structure

As previously discussed, during the 2013 flood the St. Vrain Creek channel moved from its pre-flood location to a new alignment to the south. In the current post-flood conditions, the pre-flood channel will not receive water from St. Vrain Creek during low flows. However, during flooding conditions, a small portion of the flood flows will flow into the pre-flood channel and continue eastward. Additionally, the pre-flood channel receives base flows from Spring Gulch No. 2 during both low flow and flooding conditions.

Constructed with this project was a flow-splitting diversion structure located approximately 1,200 feet downstream of the confluence of Spring Gulch No. 2 and the pre-flood channel. The purpose of this structure is for the City to manage flows in the pre-flood channel for water rights purposes, as needed. The structure allows flow to be directed to the pre-flood channel, the post-flood channel, or both as needed.

2.7 Gap Reach Appeal Application

On March 23, 2020, Boulder County began its appeal process for the Preliminary FIRM for Boulder County. The Preliminary FIRM includes St. Vrain Creek, which is located within portions of the City and Unincorporated Boulder County. Appeals, comments, and supporting documentation had to be submitted to FEMA before June 23, 2020.

The Gap Reach Appeal Application has been submitted to FEMA by the City to more accurately define the St. Vrain Creek hydraulic modeling and floodplain mapping from upstream of the Highway 119 crossing of St. Vrain Creek to the County Line Road crossing of St. Vrain Creek. The Appeal Application complies with the allowable reasons for appeal as described below:

1. Appeals to Floodplain Boundaries Due to More Accurate Data: The Appeal Package corrects the LIDAR topography in the Gap Reach to match the vertical datum used elsewhere in the Preliminary FIRM. Additional topographic data was also collected along Highway 119. This results in changes to the Preliminary FIRM Base Flood Elevations (BFEs).
2. Hydraulic Modeling Methodology to Produce More Accurate Results: The Appeal Application presents a more detailed technical hydraulic analysis using a 2-Dimensional (2D) Hydrologic Engineering Centers River Analysis System (HEC-RAS) model, which is then used to calibrate the 1-Dimensional (1D) Appeal HEC-RAS model. These models use the updated topography described above. The City analyzed the Gap Reach in more detail because the Preliminary FIRM shows overtopping of Highway 119. Overtopping of Highway 119 is a critical issue for the City because the highway is a major arterial roadway leading to and from the City. The appeal analysis results show no overtopping of Highway 119.

The Preliminary FIRM hydraulic model shows overtopping of Highway 119 at Cross Section 119863.6. During the flood events of September 2013, Highway 119 was not overtopped, and flooding remained north of the highway. For these reasons, and since the highway is a major thoroughfare for the public, emergency responders, City staff, and others, a more in-depth analysis of the Preliminary FIRM model at the overtopping location was conducted.

The following steps were taken as part of the more detailed hydraulic analysis:

1. The Preliminary FIRM (CHAMP) model was updated to include the adjusted topography, including updated cross section geometry and associated parameters.
2. An additional cross section was added to the model at the low point in Highway 119 where the Preliminary FIRM shows overtopping of the highway during the 100-year flood event.
3. The model shows that the floodplain limits are influenced by the three berms. Due to the modeling complexities of these berms, a 2D HEC-RAS analysis was conducted.
4. Two topographic scenarios were analyzed in the 2D model (“with berms” and “without berms”) and show that no overtopping of Highway 119 occurs. The City coordinated with the CHAMP team regarding the 2D analysis and their recommended path forward for appealing the Preliminary FIRM. The CHAMP team advised that the 2D model results be used to calibrate the 1D model.
5. The 1D model was then calibrated to match the results of the 2D model. Calibration was successfully achieved by modifying the Manning’s n-values. The resulting model is herein referred to as the 1D Calibrated Appeal model. The 1D Calibrated Appeal model was then truncated upstream of Cross Section 121616 and downstream of Cross Section 111103.1 to tie-in to the Preliminary FIRM.
6. Floodway conditions were modeled for St. Vrain Creek using the 1D Calibrated Appeal model. The Floodway is only mapped within Unincorporated Boulder County in the Gap Reach, consistent with the approach used in the Preliminary FIRM.

The Appeal floodplain mapping, which is based on the 1D Calibrated Appeal model, closely matches the 2D modeling results. In order to represent all storm events accurately, two separate geometries were created for the 1D Calibrated Appeal model, as follows:

- Geometry for 10, 25, 50, and 100-year flood events: Cross sections located upstream of the Highway 119 bridge that intersect Highway 119 to the south are truncated at the crown of Highway 119 in order to not show inaccurate flooding south of Highway 119.
- Geometry for the 100-year plus and 500-year flood events: Cross sections located upstream of the Highway 119 bridge that intersect Highway 119 to the south are not truncated, since Highway 119 is overtopped during the 100-year plus and 500-year events. The lengths of the cross sections used to model the 100-year plus and 500-year flood events match those in the Preliminary FIRM model.

Due to the timing of the Appeal Application and this LOMR submittal, the Gap Reach appeal information is also included in this LOMR submittal. The entire Appeal Application is included in Appendix K.

3.0 Hydrology

3.1 Hydrologic Study

Following the September 2013 flood, the Colorado Department of Transportation (CDOT) requested a study of several of the flooded tributaries, including St. Vrain Creek. The study, entitled "*Lower St. Vrain Watershed Phase 2 Hydrologic Evaluation Post September 2013 Flood Event"* was finalized in July 2015 (Jacobs, 2015). This study was officially adopted by the CWCB in July 2015 as the new effective flow rates for St. Vrain Creek. The flows have also been adopted by FEMA as the best available data for St. Vrain Creek and were used in the production of the Preliminary FIRM. As a result of the study, the flows for St. Vrain Creek increased by approximately 50 percent at several locations. Flow rates at key locations are presented below in Table 1. A copy of the final report is attached in Appendix E. The new flow rates are used in the modeling for this LOMR.

TABLE 1
100-Year Flow Rates at Select Locations

Description / Location	100-Year Flow Rate (cfs)
St. Vrain Creek at Airport Road	13,200
St. Vrain Creek below Hwy 287 (Main Street) at Dry Creek #1 Old Channel	15,200
St. Vrain Creek at Martin Street	16,300
St. Vrain Creek at Confluence with Left Hand Creek	17,400

cfs – cubic feet per second

4.0 Hydraulics

4.1 Effective and Duplicate Effective Models

The currently effective Boulder County FIS (December 18, 2012) states that the effective model for St. Vrain Creek was prepared by the CWCB in 1981 (Reference No. 4 in the FIS). However, under an agreement with FEMA, the CHAMP model is considered the effective model for this LOMR and all LOMRs that are revising the Preliminary FIRMs dated September 30, 2019. See the letter from FEMA and memorandum prepared by the Boulder County Transportation Department located in Appendix N. A duplicate effective model was then created from the Preliminary FIRM (CHAMP) model by upgrading to the current HEC-RAS version 5.0.7. Negligible changes were required for the model to run. These changes include removing extraneous upstream and downstream deck and

roadway points for Pratt Parkway Bridge crossing the BNSF railroad for the Izaak Walton Split (station 4814.86). The model was truncated to Preliminary FIRM sections 128361.7 (upstream) to 94261.94 (downstream).

4.2 Corrected Effective Model

A corrected effective model was created from the duplicate effective model using updated survey mapping, topography, and aerial imagery to revise the thalweg location of the St. Vrain Creek alignment. The revised channel thalweg required the main channel lengths to be revised within the model to match mapped conditions. No man-made changes need to be incorporated into the corrected effective model. Therefore, an existing conditions model is not needed, and the corrected effective model represents the pre-project conditions.

Two geometry files were created for the corrected effective and as-constructed models. The first geometry includes the 10, 25, 50, and 100-year storm events and truncates cross sections upstream of Highway 119 to follow the appeal process which proposes to remove the area south of Highway 119 from the 100-year floodplain. The second geometry includes the 100-year plus and 500-year event which does not have these cross sections truncated since overtopping occurs during these storm events.

The Gap Reach Appeal Application changes were then incorporated, including the topography shift and adding one cross section at the Highway 119 low point. The corrected effective model presents a new detailed study to replace the Preliminary FIRM detailed study.

HEC-RAS version 5.0.7 was used to model the corrected effective model of St. Vrain Creek. GeoRAS version 10.6 was used to develop the cross sections for the model. Manning's n-values were provided as input using previous models, aerial photography collected by SAM, and supplemented with on-the-ground field visits. Ineffective flow areas were applied at bridges, culverts, and any other location with significant expansions or contractions.

Special consideration was placed on split flows occurring during the 100-year flow conditions. The Izaak Walton and Sandstone Ranch flow splits, as identified in the Preliminary FIRM (CHAMP) model, were used for this LOMR. These flow splits use hard coded flow rates at each cross section due to the hydraulic model not being able to converge. The Preliminary FIRM uses this method and was replicated for this LOMR.

4.3 As-Constructed Conditions Model

The upstream limit of this LOMR is located just downstream of the Burlington North Santa Fe (BNSF) railroad bridge at Preliminary FIRM Section 128361.7. City Reach 2A connects with City Reach 1 at Main Street described as Section 125419.8. The Gap Reach then connects City Reach 1 to the Sandstone Ranch Reach at Cross Section 109210.5. The Sandstone Ranch Reach ties into the effective Cross Section 94261.9 upstream of Boulder Creek. Because the downstream end of the as-constructed model forms a tie-in to an effective FEMA Zone A boundary, the Preliminary FIRM water surface elevation was used for the downstream boundary condition. Per the corrected effective model, in addition to the main channel flow of St. Vrain Creek, there is also an existing split flow (the Izaak Walton split flow) that re-enters St. Vrain Creek just upstream of Martin Street within City Reach 1.

The as-constructed project components presented in Section 2 were modeled to determine the effects of the constructed project on the BFEs for St. Vrain Creek. The 100-year flows used in the corrected effective model and discussed in Section 3.1 were used in the as-constructed conditions model. The as-constructed project grading was input into Geo-RAS within Geographic Information System 10.6 (GIS) as a Triangulated Irregular Network (TIN) and the as-constructed cross sections were cut from the surface.

Cross sections were maintained at the same locations as the Preliminary FIRM for City Reach 2A, the Gap Reach, and Sandstone Ranch Reach. Cross section locations for City Reach 1 utilize the locations from the CLOMR due to the significant channel and overbank improvements made within that reach. Additional cross sections were placed in City Reach 1 at grade control structures, pedestrian bridges, areas of contraction and expansion, and around significant bends in the channel, as presented in the CLOMR, to accurately describe the as-constructed improvements. Several new cross sections were also added in the Sandstone Ranch Reach where bank improvements were made. Along with geometry, the cross-sectional properties and characteristics were

updated to reflect as-constructed conditions. Cross sections were updated to reflect updated topography and as-constructed ground survey data. Locations of cross sections are shown on the topographic workmaps in Appendix I.

Manning's n-values were established using the corrected effective values as a baseline. The values were then further refined to reflect design elements (buried riprap, grouted boulders, vegetation, etc.). Constructed structures were modeled using the design parameters (such as bridge openings, pier configuration and shape, and railing configuration) which can be found in the plan drawings attached in Appendix D and confirmed with as-built survey data located in Appendix J.

At the upstream end of the LOMR reach, the as-constructed conditions model ties in at Preliminary FIRM Cross Section 128631.7. The upstream BFE of 4957.87 in the as-constructed model compares to the Preliminary FIRM BFE of 4957.97, indicating a drop of 0.10 feet.

As previously stated for City Reach 1, the as-constructed cross sections are aligned differently than the Preliminary FIRM cross sections, and are located at different stream stations to match the location of the CLOMR cross sections. Because of the difference in cross section locations and alignments, the comparison of BFEs between the Preliminary FIRM and as-constructed conditions was done by interpolating BFEs between cross sections as needed. Appendix H provides a comparison of the BFEs between corrected effective and as-constructed conditions.

The as-constructed hydraulic modeling is summarized as follows:

- City Reach 2A: There are no BFE increases in City Reach 2A.
- City Reach 1: The hydraulic modeling shows that as a result of the as-constructed City Reach 1 project, there are both increases and decreases in BFEs as compared to the Preliminary FIRM. The highest increase in BFEs (~2.49 feet) is located upstream of Martin Street and is similar to the results from the CLOMR.
- Gap Reach: The hydraulic modeling shows that there are increases and decreases in BFEs throughout this reach. However, the increases show a max increase 0.04 feet. Most sections match the corrected effective conditions model with decreases in a couple of sections near County Line Road bridge due to the new bridge construction. The as-constructed hydraulic modeling through the Gap Reach indicates no overtopping of Highway 119 during the 100-year flood event, consistent with the Gap Reach Appeal.
- Sandstone Ranch Reach: The modeling shows that as a result of the as-constructed Sandstone Ranch Reach project, there are both increases and decreases in BFEs as compared to the Preliminary FIRM. The highest increase in BFEs (~2.65 feet) is located upstream of the new pedestrian bridge and is an increase from the CLOMR. This increase does not affect any insurable structures.

4.4 Floodway Model and Mapping

The floodway has been modeled in HEC-RAS in the Preliminary FIRM, and therefore, the floodway has been modeled in the LOMR as-constructed model. Encroachments were taken from the Preliminary FIRM and the Highway 119 Appeal as a base model and modified in the as-constructed model to establish increases of less than 0.5 foot. Minor changes to encroachments were needed to maintain the maximum allowable increase. Encroachments were also modified to remove disallowed values.

The Preliminary FIRM for St. Vrain Creek does not show the floodway within the City. Therefore, the floodway has not been mapped through the City with this LOMR. The floodway has been mapped for areas within unincorporated parcels of Boulder and Weld Counties, consistent with the approach used in the Preliminary FIRM. The floodway is shown on the topographic workmaps in Appendix I.

4.5 Summary of Hydraulics

A comparison table of BFEs is presented in Appendix H comparing the Duplicate Effective, Corrected Effective, and CLOMR to the LOMR. As compared to the effective conditions, the as-constructed model shows both increases and decreases in BFEs within the project limits. The decreases in BFEs are largely due to the constructed improvements and hydraulic modeling changes that occurred with updated channel lengths, roughness coefficients, ineffective areas, and geometries. Impacted properties within the floodplain are shown on the Property Owners Exhibit in Appendix C.

No insurable structures are negatively impacted due to the improvements made to St. Vrain Creek for the reaches included in this LOMR. Because of the increases in BFEs in City Reach 1 and the Sandstone Ranch Reach, the requirements of Code of Federal Regulations (CFR) 65.12 are presented in Section 6.1.

5.0 Floodplain Mapping

5.1 Survey Data

SAM performed the initial RSVP LIDAR and ground survey in 2014 to create a surface with 1-foot contours of the site. A survey was completed in 2019 by Jacobs to document the as-constructed improvements, including project topography and structures. This information was then used in the as-constructed modeling. Digital copies of the LIDAR and survey data are provided with this LOMR application. Additionally, a certified copy of the survey data is attached in Appendix J. An electronic copy of the combined as-constructed surface is provided in Appendix L.

The vertical datum for the project is North American Vertical Datum of 1988 and the horizontal datum is NAD 1983 HARN State Plane Colorado North FIPS 0501 (US Feet), scaled to ground at 0, 0, 0 with a scale factor of 1.000276887. The data meets the FEMA mapping standards.

5.2 Floodplain Mapping

Certified topographic workmaps showing the effective and as-constructed conditions 100-year and 500-year floodplain mapping are attached in Appendix I. Additionally, the GIS shapefiles and topographic surface used to develop the mapping are provided in Appendix L.

6.0 Regulatory Requirements

6.1 Increases in BFEs (CFR 65.12)

CFR Title 44, Chapter 1, Section 65.12 states that approval is required for encroachments into the SFHA or effective floodway. In addition, Section 65.12 includes three additional requirements that must be met in order to obtain approval. Those requirements and their compliance in relation to this project are described below.

1. An evaluation of alternatives that would not result in an increase in BFEs.

   The as-constructed project is designed to improve flood flow conditions, increase safety, repair damaged infrastructure, and provide resiliency to future floods. The project is also designed to minimally impact the existing stream geomorphology, stream banks, and property owners as best possible. Other alternatives were considered, but they did not align with project goals and constraints, were determined to not be feasible, or would cause changes in BFEs.

   An increase in BFEs occurs between effective and as-constructed conditions at several locations within City Reach 1 due to the constructed improvements made. The alternative of not constructing the associated improvements would not meet the project goals.

Additionally, there is an increase in BFEs because of the constructed pedestrian bridge in the Sandstone Ranch Reach, where flood flows scoured a new alignment south of the pre-flood creek alignment. The alternative of not constructing the associated improvements and reconnecting the regional greenway trail would not meet the project goals.

2. Documentation of individual legal notice to all impacted property owners.

   The notices to impacted property owners associated with this LOMR are included in Appendix C.

3. Certification that no insurable structures are impacted by increased BFEs.

   With this report, Jacobs Engineering Group hereby certifies that no insurable structures are negatively impacted due to the as-constructed conditions on St. Vrain Creek along the reaches included in this LOMR.

The determination letter from the CLOMR used for this project (Case Number 16-08-0342R) is included in Appendix O.

7.0 Supporting Documentation

As part of this application, the following supporting documentation is provided in the Appendices:

Appendix A – Jurisdictional Boundaries

- Reach Overview – Figure 1
- Jurisdictional Boundaries Exhibits – Figures 2 through 4

Appendix B – Annotated FIS Documents

- Annotated FIRM Maps
- Annotated Flood Profiles
- Annotated Floodway Table

Appendix C – Regulatory Requirements

- No Impact to Insurable Structures Certification Letters
- Template for Property Notification Letters
- Land Ownership Exhibit
- Parcel Notification List

Appendix D – Plan Drawings

- City Reach 1 Bid Documents
- City Reach 2A Bid Documents
- County Line Road Bridge Bid Documents
- Main Street Bridge Documents
- Pratt Parkway Bridge Documents
- Sandstone Ranch Reach Bid Documents

Appendix E – CDOT Hydrology Report

- Lower St. Vrain Watershed Phase 2 Hydrologic Evaluation

Appendix F – Preliminary FIRM Effective Information

- Preliminary FIRM Hydraulic Models
- Preliminary FIRM Panels

Appendix G – Hydraulic Model
List of plans:

- Duplicate Effective Model
- Corrected Effective Model – 10, 25, 50, 100 Year Geometry
- Corrected Effective Model – 100 Year Plus, 500 Year Geometry
- As-Constructed Condition Model – 10, 25, 50, 100 Year Geometry
- As-Constructed Condition Model – 100 Year Plus, 500 Year Geometry
- As-Constructed 100-Year Floodway

Appendix H – BFE Comparison and Agreement Tables

- BFE Comparison Tables
- Floodplain and Floodway Map Agreement Tables

Appendix I – Topographic Workmaps

- Topographic Workmaps – Figures 5 through 7

Appendix J – Certified Survey Data

- County Line Road Bridge As-Built Survey
- CR2A and CR1 Combined As-Built Survey (including Main Street Bridge and Pratt Parkway Bridge)
- Highway 119 Data Certification
- Sandstone Ranch Reach Survey

Appendix K – Gap Reach Appeal Submittal

- Application Form
- Report
- Figures
- Tables
- Models
- CAD_GIS

Appendix L – GIS Shapefiles

- GIS Layer Packages

Appendix M – Photographic Summary

Appendix N – Boulder County Department of Transportation Memoranda

- Procedure for LOMR's and CLOMR's on CHAMP Studied Streams in Boulder County
- Boulder County LOMR Memo Public Notification Response 2-6-19
- Procedure for CLOMR/LOMR Submittals on CHAMP Studied Streams in Boulder County and Updated Fees for Boulder County floodplain permit and CLOMR/LOMR reviews

Appendix O – CLOMR Determination Letter

8.0 References

FEMA. 2012. FIRM #s 08013C0266J, 08013C0267J, 08013C0266J, 08013C0269J, 08013C0286J, 08013C0288J, 08013C0293J, and 08123C1870E.

FEMA. 2019. Preliminary FIRM #s 0813C0286K, 0813C0287K, 0813C0288K, 0813C0289K, 0813C0292K, 0813C0293K, and 08013C0294K.

FEMA. 2019. Preliminary Flood Insurance Study *#08013CV001E*.

Jacobs Engineering Group (Jacobs). July 2015. *Lower St. Vrain Watershed Phase 2 Hydrologic Evaluation Post September 2013 Flood Event*.

CH2M Hill, Revised May 2016, *Resilient St. Vrain Project, Conditional Letter of Map Revision: City Reach 1 and Sandstone Ranch Reach.* CLOMR Case No. 16-08-0342R

Appendix A
Jurisdictional Boundaries

Appendix B
Annotated FIS Documents

Appendix C
Regulatory Requirements

Appendix D
Plan Drawings

Appendix E
CDOT Hydrology Report

Appendix F
Preliminary FIRM Effective Information

Appendix G
Hydraulic Model

Appendix H
BFE Comparison and Agreement Tables

Appendix I
Topographic Workmaps

Appendix J
Certified Survey Data

Appendix K
Gap Reach Appeal Application

Appendix L
GIS Shapefiles

Appendix M
Photographic Summary

Appendix N
Boulder County Transportation Department Memoranda

Appendix O
CLOMR Determination Letter