

site**works**

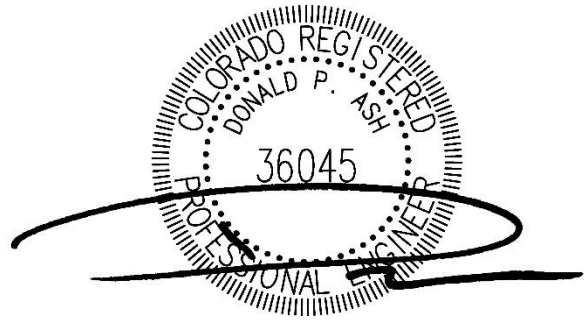
Phase I Drainage Report

Louisville Mill Site Redevelopment
540 County Road
Louisville, CO

09/12/2025

ENGINEER'S STATEMENT

I hereby certify that this Phase I Drainage Report for 540 County Road was prepared by me, or under my direct supervision, in accordance with sound engineering practice and all applicable state, federal and local regulations.



Donald P. Ash
Registered Professional Engineer
State of Colorado No. 36045

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I. GENERAL LOCATION AND DESCRIPTION

A. Location

1. This report is submitted as the Phase I Drainage Report of the existing and proposed conditions for the property located at 540 County Road in Louisville, Colorado.
2. The site is located in the southeast quarter of Section 8, Township 1 South, Range 69 West of the 6th Principal Meridian in the City of Louisville, Boulder County, State of Colorado.
3. The site is bounded by Burlington Northern Railway to the east, commercial lots to the south and north, County Road to the West, and residential lots on the west side of County Road. A Vicinity Map is included in Appendix A.

B. Description of Property

1. The existing .58-acre site is currently developed with an existing mill building.
2. Existing ground cover consists of grass, a gravel driveway and existing mill building.
The site generally flows to the north and surface drains into an existing asphalt parking lot and into a 2'x2' inlet located in Lot 3. Existing drainage patterns are shown on the Drainage Plan that is included with this report.
3. The United States Department of Agriculture (USGS) Natural Resources Conservation Service (NRCS) Soil Survey for the site identifies the majority of the existing site soils as Ascalon Sandy Loam (AcA) with a hydrologic soil group of B.
4. There are no major or minor drainageways located on or near the property.
5. There are no irrigation facilities located on or near the site.
6. The proposed land use will be commercial. A Planned Unit Development (PUD) Zoning overlay will control the specific zoning on the subject property.
7. There are no wetland areas located on the property.
8. There are no drainage easements that are affected by the proposed improvements.

II. HISTORIC DRAINAGE

A. Major Basin Description

1. This site is not located within any drainageways.
2. FEMA LOMR effective: March 8, 2018 reduced the mapped flooding potential on the site from Zone AH to Zone X (shaded) and the site is now mostly outside of any mapped flood zone.
3. Based on the FEMA Flood Insurance Rate Map (FIRM) - Map Number 08013C0582K dated August 15, 2019. The north of Outlot A is located in Zone X (shaded), areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage area less than 1 square mile. The entirety of Lot 2 is outside of any mapped floodplain.
4. The majority of the site generally slopes from the south to north to the northeast at an approximate slope of 1%-3%. Existing ground cover consists of grass, a gravel driveway and an existing mill building. The site drainage discharges via surface drainage to the asphalt drive on the south side of Lot 3, where it drains through the parking lot to the east and north into an existing 2'x2' graded inlet.
5. There are no irrigation ditches or facilities which will be affected by the proposed development.
6. There are no lakes or ponds which influence or may be influenced by the local drainage. There are no dams on or adjacent to the subject property.

B. Sub-Basin Description

1. For the purposes of this report, the existing site has been broken into one (1) sub-basin, Basin H. Basin H consists of the entire site. Runoff from within this basin flows to the north where the site drainage discharges via surface drainage to the asphalt drive on the south side of Lot 3, where it drains through the parking lot to the east and north into an existing 2'x2' graded inlet.
2. There is no offsite drainage that affects the site
3. The runoff from the existing site is summarized in Table 1. Existing runoff calculations have been included in Appendix B.

III. DRAINAGE DESIGN CRITERIA

A. Development Criteria Reference and Constraints

1. A Preliminary Drainage Report was submitted by JVA Consulting Engineers, dated April 3, 2014. This report has been included in appendix E.
2. The site drainage was generally constrained by the existing conditions. Grading was constrained by the existing grades along the existing asphalt drives on lots 1 and 3, and the existing grain elevator. The site was also constrained by the existing curb and gutter elevations along County Road to the west.
3. There are no wetland areas located on the property.
4. The following reports, files and drawings form the basis of this report: 1) City of Louisville Municipal Code; 2) City of Louisville Manual of Design Criteria & Standard. 3) Urban Drainage and Flood Control District (UDFCD) Urban Storm Drainage Criteria Manual, Volumes 1-3 (USDCM). Relevant sections, as required, can be found in the Appendix located at the back of this report.
5. This drainage plan is in general conformance with the City of Louisville Manual of Design Criteria & Standard Specifications, the UD&FCD Storm Drainage Criteria Manual and the Stormwater Masterplan.
6. This report details the Phase 1 plan of the Mill site development and designs Lot 2 and Outlot A. A Phase 2 drawing has been included in this report in Appendix B, outlining the drainage plan for future development. Future development will connect the storm sewer on Outlot A to a stormceptor unit located on Lot 3, the stormceptor will provide water quality treatment for the entirety of the Mill Site Development.

B. Hydrological Criteria

1. The design rainfall data used in this study was taken from the CRITERIA, Volume 2 – Chapter 5 – Rainfall, Section 2.O – Rainfall Depth-Duration Frequency and Section 4.O – Intensity-Duration Curves for Rational Method. One-hour rainfall depth was taken from Table 1 and used in conjunction with the intensity equation listed under Section 4.O. This was correlated to the Intensity-Duration Frequency Curve from Figure 1.

As required in the CRITERIA, for all land uses, hydrologic information was developed for an initial storm return period of 2-years and major storm return period of 100-years. The criteria and methodology used in determining the storm runoff peaks and volumes were those outlined in the USDCM as directed by the CRITERIA.

2. Runoff calculations were obtained using the Rational Method as outlined in the Manual for basins having less than 130 acres.

Rational Formula is:

$$Q = CIA$$

Where: Q = Peak Discharge (cfs)
 C = Runoff Coefficient (USDCM)
 I = Rainfall Intensity (in/hr) (USDCM)
 A = Drainage Basin Tributary Area (acres)

C. Hydraulic Criteria

1. The proposed site ultimately drains to the north. The mill building and the road to the east of the mill building drain flow into rain gardens located on the north and south side of the mill building. The west portion of the side flows into a concrete drainage pan and swale and flows to the existing type R inlet located in Lot 3, north of the site.
2. Water quality volumes, discharges and storage calculations are based on the USDCM Volume 2, Storage. Detention and water quality facilities have been designed in accordance with the USDCM Volume 3, Best Management Practices. The UDFCD detention worksheets were used for calculations of the detention and water quality facilities.

D. Adaptions from Criteria

1. There are no adaptions or variances requested from the Criteria.

IV. DRAINAGE FACILITY DESIGN

A. General Concepts

1. Developed runoff from the site drains either to the north to an existing storm sewer or to the west on to County Road. Runoff from the roof will be drained in to two raingardens and treated for water quality.
2. Offsite basins will be unaffected by the redevelopment.
3. Proposed drainage patterns are shown on the Drainage Plan. Proposed runoff from the site is shown in Table 1.

B. Specific Details

1. The Drainage Plan shows the proposed site plan, on-site grading and overland flow directions. Under the proposed conditions, the site will be broken into three (3) sub-basins, Basins A1 through A3 as well as two (2) off-site basins, Basins OS1 and OS2.

Drainage from Basin A1 comprises of the western portion of the site. It includes lawn, the southern and northern parking spaces. Runoff from within this basin flows to the northwest corner of the southern parking lot via overland flow, into a swale running along the west edge of the site which eventually flows into the existing Type R inlet located in Lot 3. All runoff in this basin will drain into the gravel swale or concrete drain pan.

Water quality for Basin A1 will be provided during the phase 2 improvements. Currently, the basin contains large amounts of landscaping and some existing asphalt parking areas. The imperviousness of the basin will increase slightly but the overall impact to the drainageway will be negligible. Therefore, water quality for this basin will be delayed until phase 2 to accommodate future improvements and increased impervious areas.

Drainage from Basin A2 comprises of the east portion of the site and the north half of the Mill Building roof. Runoff from within this basin flows north into proposed Rain Garden 1 (RG-1) This rain garden has been designed to treat the Water Quality Capture Volume and pass the 100-year storm.

Drainage from Basin A3 comprises the south half of the roof. Runoff from this site will be piped into Rain Garden 2 (RG-2). This rain garden has been designed to treat the Water Quality Capture Volume and pass the 100-year storm.

Drainage from Basin OS1 comprises the west portion of the parking area of Lot 1. Runoff from this basin follows existing drainage patterns and flows into Basin A1 where is runoff follows the proposed routing for that basin.

Drainage from Basin OS2 comprises the east portion of the parking area of Lot 1. Runoff from this basin flows into Basin A2.

The existing and proposed conditions for the entire site were analyzed for the 5 and 100-year storm events. The results are shown in the following Table 1 and the relevant calculation sheets are provided in Appendix B.

TABLE 1
RUNOFF CALCULATIONS SUMMARY

Drainage Basin	Area (acres)	C ₂	C ₁₀₀	2-Year Peak Runoff (cfs)	100-Year Peak Runoff (cfs)
Basin H	0.58	0.22	0.59	0.25	2.22
Basin A	0.58	0.39	0.60	0.44	2.15
Basin A1	0.34	0.53	0.73	0.26	1.28
Basin A2	0.16	0.43	0.70	0.15	0.82
Basin A3	0.03	0.80	0.90	0.06	0.23
Basin OS1	0.21	0.63	0.81	0.33	1.36
Basin OS2	0.05	0.73	0.84	0.10	0.35

2. The rain gardens have been designed for the Water Quality Capture Volume per the recommended approach in the USDCM and will accommodate the Water Quality Capture Volume (WQCV).

TABLE 1
DETENTION POND SUMMARY

Pond	Basin Area (ac)	WQCV (CF) Needed	WQCV (CF) Provided
RG-1	0.16	170	180
RG-2	0.03	44	50

3. Maintenance of the water quality rain garden will be provided by the property owner.

V. SUMMARY

A. Compliance with Standards

1. This drainage report and plan are in general conformance with the City of Louisville Municipal Code.
2. This drainage report and plan are in general conformance with the Town of Lyons Storm Drainage Criteria Addendum to Urban Drainage Storm Drainage Criteria Manuals, Volumes 1, 2 and 3 (CRITERIA)
3. This drainage report and plan are in general conformance with the Urban Drainage and Flood Control District Urban Storm Drainage Criteria Manual.

B. Drainage Concept

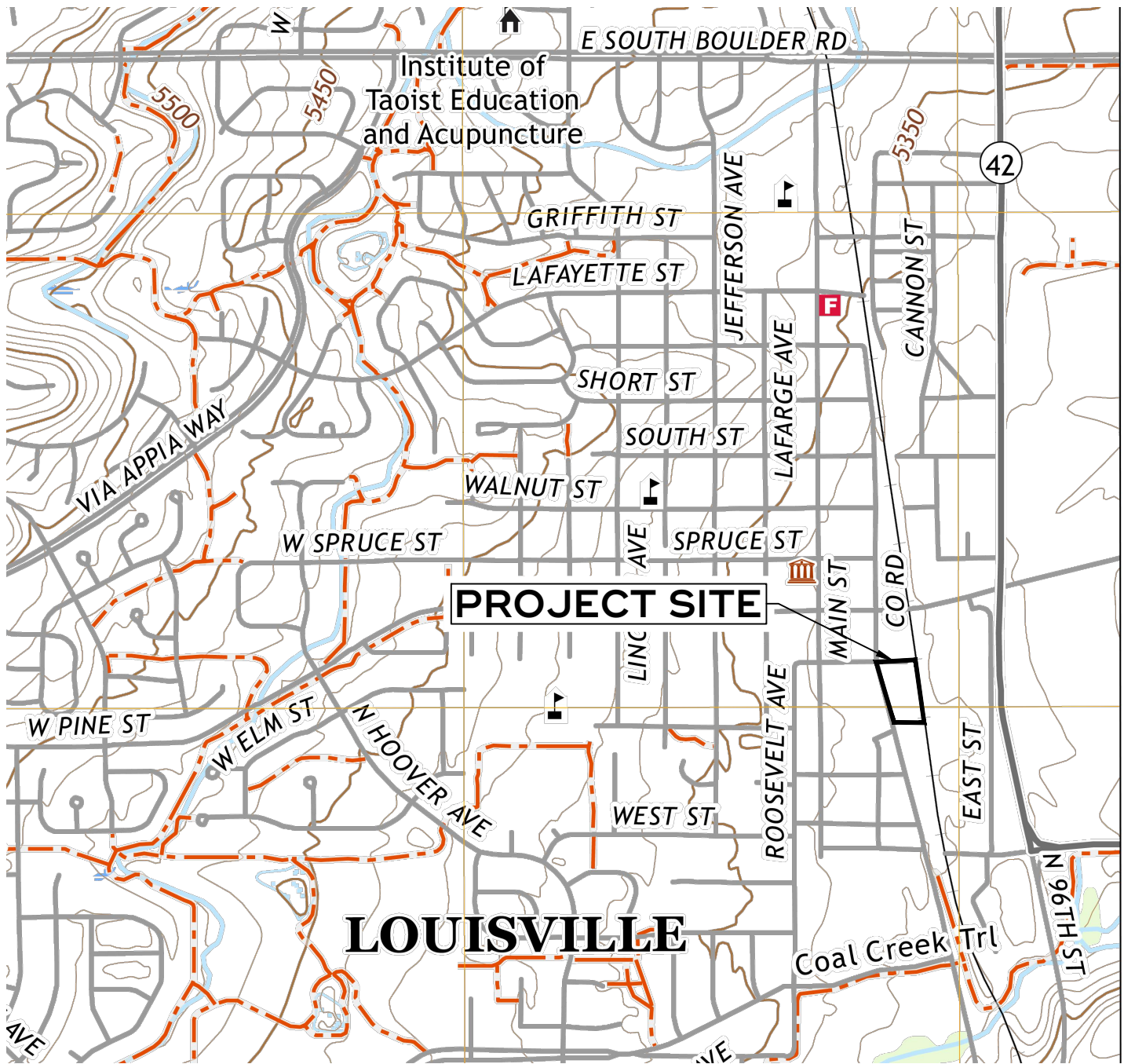
1. The primary consideration for this project was to design a drainage plan to offset the impact of the proposed construction. The drainage plan accommodates on-site runoff and off-site flows. The drainage will not negatively affect any upstream or downstream properties.
2. While this report is focused on the current redevelopment of Lot 2 and Outlot A, the drainage plan for the entire Mill Site development has also been included in a Phase 2 drawing, included in Appendix B. The Phase 2 drainage plan will include additional storm sewer lines to tie the parking lot cut off storm sewer to the existing type R inlet in the northeast corner of lot 3. Water quality will be provided in the form of a stormceptor that will treat runoff from Basins A1 and OS1

VI. REFERENCES

1. Urban Drainage and Flood Control District Urban Storm Drainage Criteria Manual, Volumes 1-3, dated August 2018.
2. FEMA LOMR 17-08-0625P, City of Louisville, dated March 8, 2018.
3. Preliminary Drainage Report for Louisville Mill Site, by JVA Consulting Engineers, dated April 3, 2015.

APPENDIX A

LOCATION MAP



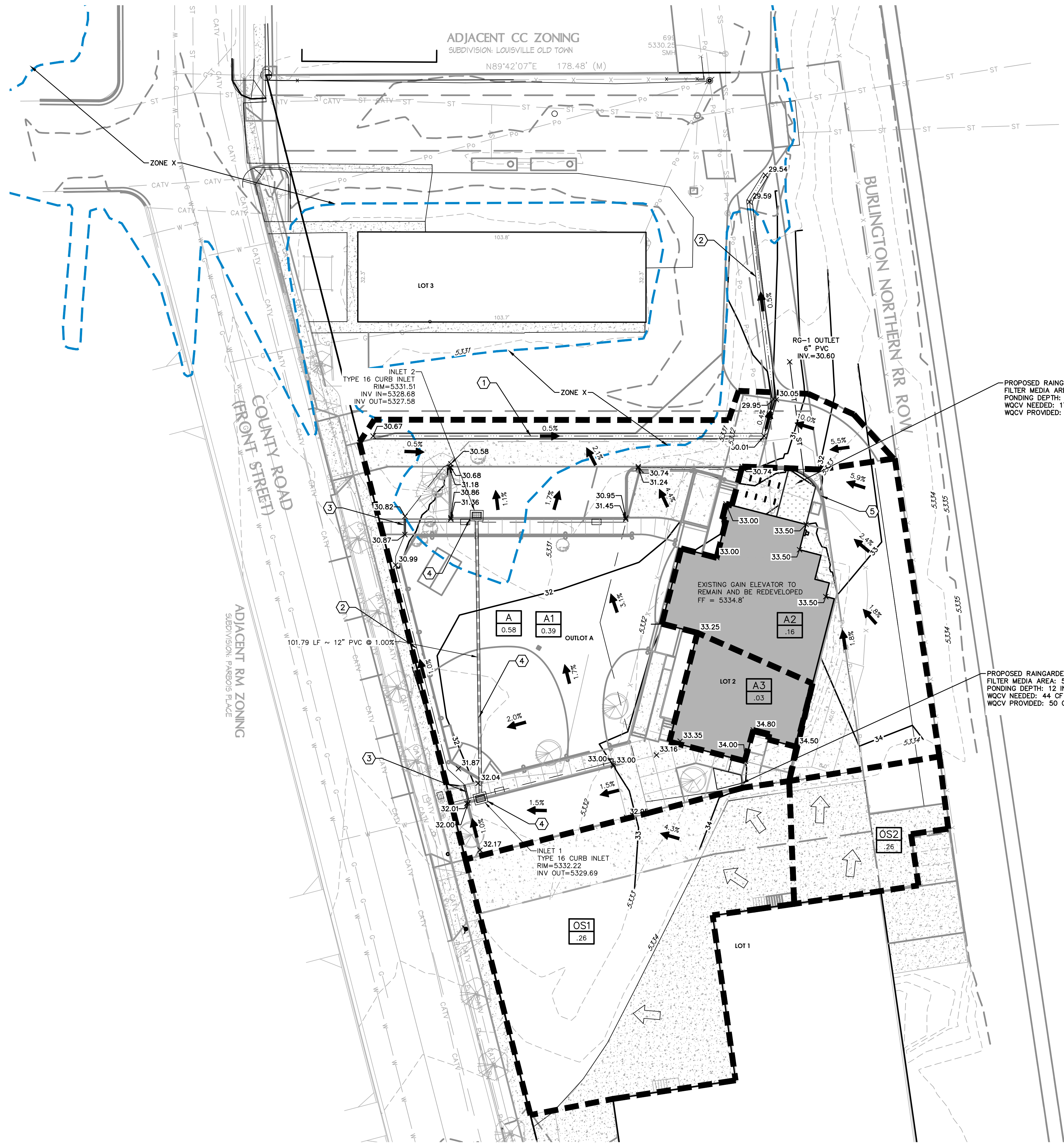
1 LOCATION MAP

SCALE: 1" = 1000'

N

APPENDIX B

DRAINAGE PLAN



LEGEND

- 5 PROPOSED CONTOUR
ADD 5300 TO ALL CONTOURS
- X 25.8 PROPOSED SPOT ELEVATION
ADD 5300 TO ALL SPOT ELEVATIONS
- X 25.8 EXISTING SPOT ELEVATION
- PROPOSED FLOW DIRECTION
- HISTORIC SHEET FLOW
- A
1 PROPOSED SUB-BASIN DESIGNATION
- AREA IN ACRES
- PROPOSED BASIN BOUNDARY

GRADING NOTES

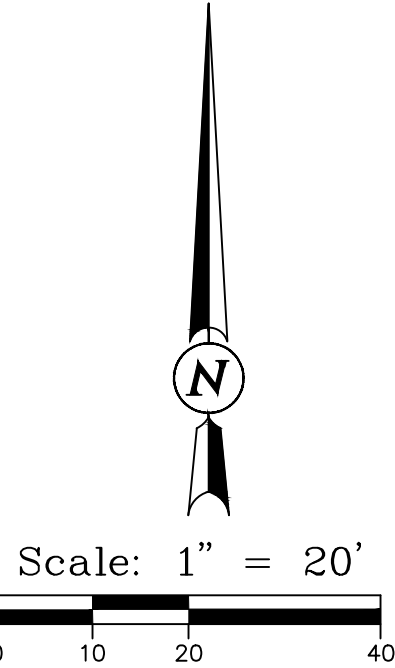
- FLOOD INFORMATION: ACCORDING TO FEMA FLOOD INSURANCE MAP NO. 08013C0582K DATED 08/15/2019. THE NORTH OF OUTLOT A IS LOCATED IN ZONE X (SHADED). AREAS OF 0.2% ANNUAL CHANCE FLOOD; AREAS OF 1% ANNUAL CHANCE FLOOD WITH AVERAGE DEPTHS OF LESS THAN 1 FOOT OR WITH DRAINAGE AREA LESS THAN 1 SQUARE MILE. THE ENTIRETY OF LOT 2 IS OUTSIDE OF ANY MAPPED FLOODPLAIN.
- BENCHMARK INFORMATION: CITY OF LOUISVILLE LPS, FOUND 2.5" ALUMINUM CAP IN A RANGE BOX IN SOUTH ST. BEING THE CENTER E 1/4 CORNER OF SECTION 8 ELEVATION=5349.49' (NAVD88). SITE BENCHMARKS AS SHOWN. CONTOURS SHOWN ARE FROM A GROUND SURVEY.
- THE LOCATION OF THE ABOVE GROUND UTILITIES SHOWN HEREON ARE BASED ON THE FIELD SURVEY BY SITESURVEYS LLC DATED 08/26/2015. THE LOCATIONS OF THE UNDERGROUND UTILITIES SHOWN HEREON ARE BASED ON SAID SURVEY AND INFORMATION PROVIDED BY OTHERS (WHICH MAY INCLUDE THE UTILITY OWNER OR UTILITY LOCATING SERVICES). SITEWORKS, LLC. IS NOT RESPONSIBLE FOR UTILITY INFORMATION PROVIDED BY OTHERS. SITEWORKS, LLC. RECOMMENDS THAT THE LOCATION OF THE UTILITIES BE FIELD VERIFIED PRIOR TO ANY DIGGING ON, OR ADJACENT TO THE SUBJECT PROPERTY.

KEYED NOTES

- PROPOSED 2' CONCRETE SWALE.
- PROPOSED GRAVEL SWALE.
- PROPOSED SIDEWALK CHASE.
- PROPOSED UNDERGROUND STORM SEWER FOR FUTURE PHASE 2 DEVELOPMENT. STEEL COVER TO GO OVER STORM SEWER INLETS TO PREVENT ANY DRAINAGE UNTIL FUTURE DEVELOPMENT.
- PROPOSED 12" CURB CUT TO ALLOW RUNOFF TO DRAIN INTO RAINGARDEN THROUGH SLOTTED CURB.

PROPOSED RAINGARDEN: RG-1
FILTER MEDIA AREA: 180 SF
PONDING DEPTH: 12 IN
WQCV NEEDED: 170 CF
WQCV PROVIDED: 180 CF

PROPOSED RAINGARDEN: RG-2
FILTER MEDIA AREA: 50 SF
PONDING DEPTH: 12 IN
WQCV NEEDED: 44 CF
WQCV PROVIDED: 50 CF



siteworks
creativity for
the built environment

LOUISVILLE MILL SITE REDEVELOPMENT
& HISTORIC GRAIN ELEVATOR
520 & 540 COUNTY ROAD, LOUISVILLE, CO
Louisville Mill Site LLC - Louisville's Living Room LLC

PHASE 1
FINAL PUP
AMENDMENT

PROJECT # 25138A
DATE 04/12/2025
DRAWN BY: DRS
CHECKED BY: DPA
REVISIONS:

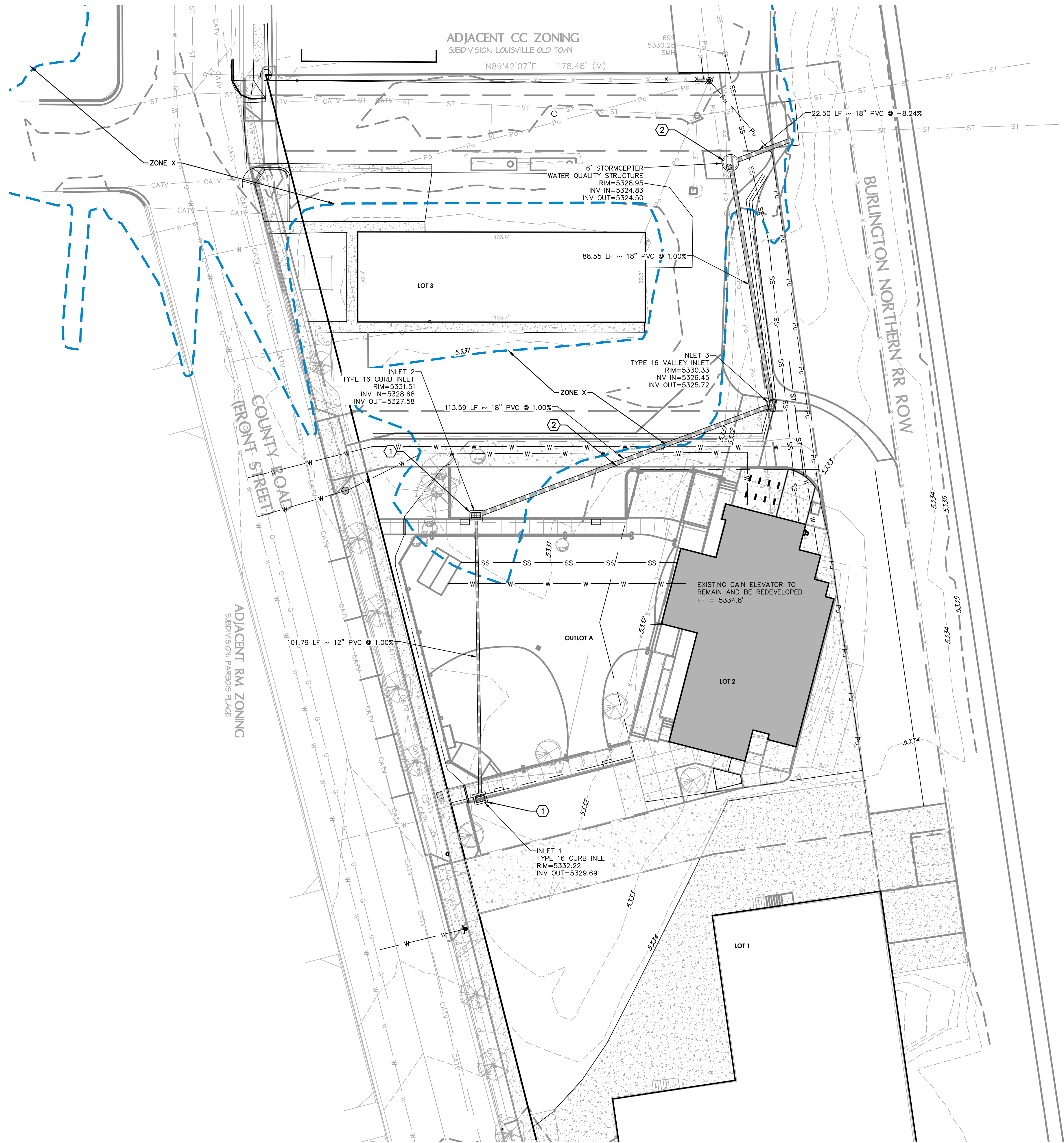
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GRADING
&
DRAINAGE
PLAN

Sheet

C-101

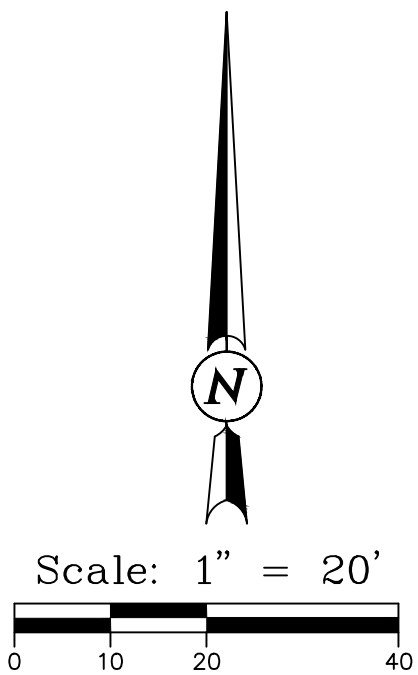
1 of 4 Sheets



LEGEND	
	EXISTING CONTOUR
	EXISTING SEWER CLEANOUT
	EXISTING WATER METER
	EXISTING STORM MANHOLE
	EXISTING WATER VALVE
	EXISTING POWER POLE
	EXISTING LIGHT POLE
	EXISTING SIGN
	EXISTING FIRE HYDRANT
	EXISTING FENCE
	EXISTING OVERHEAD POWER LINE
	EXISTING SANITARY SEWER W/MANHOLE
	EXISTING WATER W/FIRE HYDRANT
	EXISTING STORM SEWER W/MANHOLE
	PROPOSED WATER W/FIRE HYDRANT
	PROPOSED SANITARY SEWER SERVICE
	PROPOSED GAS SERVICE
	PROPOSED WATER METER

KEYED NOTES ①

1. PROPOSED UNDERGROUND STORM SEWER FOR FUTURE TIE IN. STEEL COVER TO BE REMOVED AND INLETS ALLOWED TO DRAIN.
2. PROPOSED PHASE 2 STORM SEWER IMPROVEMENT. PARKING LOT INLETS TO DRAIN INTO STORMCEPTER AND TIE INTO EXISTING TYPE R INLET.



siteworks

LOUISVILLE MILL SITE REDEVELOPMENT
& HISTORIC GRAIN ELEVATOR
520 & 540 COUNTY ROAD, LOUISVILLE, CO
Louisville Mill Site LLC - Louisville's Living Room LLC

PHASE 1
FINAL PUD
AMENDMENT

PROJECT # 25138A
DATE 05/16/2025
DRAWN BY:
CHECKED BY:
REVISIONS:

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Hartmont Associates, p.c.

UTILITY
PLAN
PHASE
2

Sheet

C-201

4 of 4 Sheets

APPENDIX C

HYDROLOGIC CALCULATIONS



Loisville Mill
540 County Road
Loisville, CO

Project #: 25138
Date: 3/18/2025
By: DRS

	Runoff Coefficients						Initial Overland Time (t _i) t _i =1.8(1.1-C ₅)L ^{1/2} S ^{-1/3}			Travel Time (t _t) t _t =Length/(Velocity*60)					t _c Computed	t _c Urbanized Check		t _c Final	Rainfall Intensities (in/hr)				Flow Rates (cfs)			
Municipality: Boulder	Parcel Size (sf)														Time of Conc t _i + t _t = t _c			Minimum t _c =5 min								
Parcel Name		C ₂	C ₅	C ₁₀	C ₁₀₀	% Impervious	Overland Flow (L _o) (ft)	Slope (ft/ft)	t _i (min)	Length (ft)	Slope (ft/ft)	C _v	Velocity (ft/s)	t _t (min)		Total Length (ft)	t _c =(L/180)+10 (min)		I ₂	I ₅	I ₁₀	I ₁₀₀	Q ₂	Q ₅	Q ₁₀	Q ₁₀₀
Basin H	25,429	0.22	0.29	0.37	0.59	53.65	175.0	0.015	17.1	40	0.0200	7	0.99	0.7	17.8	215	11.2	11.2	2.01	2.69	3.36	6.41	0.25	0.46	0.73	2.22
Basin A	25,265	0.39	0.42	0.47	0.60	55.59	320.0	0.020	17.6	40	0.0200	7	0.99	0.7	18.3	360	12.0	12.0	1.95	2.61	3.26	6.23	0.44	0.64	0.89	2.15
Basin A1	16,988	0.34	0.36	0.40	0.53	47.18	320.0	0.020	19.2	40	0.0150	7	0.86	0.8	20.0	360	12.0	12.0	1.95	2.61	3.26	6.23	0.26	0.37	0.51	1.28
Basin A2	6,970	0.43	0.49	0.55	0.70	68.72	100.0	0.030	7.8	20	0.0150	7	0.86	0.4	8.2	120	10.7	8.2	2.26	3.03	3.79	7.24	0.15	0.24	0.34	0.82
Basin A3	1,307	0.80	0.85	0.90	0.90	95.00	50.0	0.010	3.2	20	0.0150	7	0.86	0.4	3.6	70	10.4	5.0	2.63	3.53	4.41	8.41	0.06	0.09	0.12	0.23
Basin OS1	9,148	0.63	0.66	0.70	0.81	83.33	100.0	0.030	5.5	20	0.0150	7	0.86	0.4	5.9	120	10.7	5.9	2.51	3.36	4.21	8.02	0.33	0.47	0.62	1.36
Basin OS2	2,178	0.73	0.75	0.77	0.84	88.00	100.0	0.030	4.5	20	0.0150	7	0.86	0.4	4.9	120	10.7	5.0	2.63	3.53	4.41	8.41	0.10	0.13	0.17	0.35

APPENDIX D

WATER QUALITY CALCULATIONS

Site Layout

SCM Design, Version 4.00 (April 2024)

Designer: DRS

Company: Siteworks, LLC

Date: September 12, 2025

Project: Louisville Mill Site Redevelopment

Location: 540 County Road

SITE LAYOUT INFO (User Input in Blue Cells)

Water Quality Event (WQE)0.60 inches

Outfall ID	1	2										
Total Tributary Area (ft²)	1,469	7,048										
Imperviousness (%)	95.0%	85.0%										
MS4 Design Standard	WQCV	WQCV										
SCM Type	BR	BR										

Notes:

OUTFALL RESULTS

SCM Worksheet Name	BR_1	BR_2										
Untreated Area (ft³)	0	0										
Default WQCV (ft³)	44	170										
WQCV Reduction (ft³)	0	0										
Remaining WQCV (ft³)	44	170										
WQCV Reduction (%)	0%	0%										
Design WQCV of SCM (ft³)	50	180										
Pollutant Removal (ft³)	0	0										
Untreated WQCV (ft³)	0	0										

TOTAL SITE RESULTS (Sums results from all Outfalls)

Total Site Area	8,517	ft²	0.20	acres
Treated Area	8,517	ft²	0.20	acres
Untreated Area	0	ft²	0.00	acres
Total Site Imperviousness	86.7%	%		
Default WQCV	214	ft³	0.005	acre-feet
Remaining WQCV	214	ft³	0.005	acre-feet
WQCV Reduction	0%	%		
Design WQCV	230	ft³	0.005	acre-feet
Untreated WQCV	0	ft³	0.000	acre-feet

Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

Designer:

DRS

Company:

Siteworks, LLC

Date:

September 12, 2025

Project:

Louisville Mill Site Redevelopment

Location:

540 County Road

Outfall ID:

2

1. Subsurface Exploration and Infiltration System Selection

- A) Identify Site Constraints

i) Is subgrade depth to bedrock < 3 feet?

ii) Is subgrade depth to seasonal high groundwater table < 3 feet?
- B) Identify Site Risks

i) Are expansive/collapsible soils present?

ii) Are highly concentrated pollutant sources present (hotspot)?

iii) Is site located above contaminated soils or groundwater?

iv) Is SCM located at top of steep slope? (> 3H:1V)

v) Is SCM located adjacent to building, hardscape, or pavement?

vi) Is SCM located above building foundation wall backfill?

vii) Are there other concerns that indicate high risk for infiltration?
- C) Preliminary Infiltration/Percolation Tests of underlying soils

i) Were preliminary infiltration/percolation tests conducted?

ii) Preliminary estimate of infiltration rate
- D) Final Design Infiltrometer Test

i) Were infiltrometer tests conducted?

ii) Select type of infiltrometer test performed:

iii) How many locations were tested?

iv) Describe test locations relative to borings/pits

v) What was the maximum infiltration rate tested?

vi) What was the minimum infiltration rate tested?

vii) Design Infiltration Rate
- E) Recommended Infiltration System

F) Select Infiltration System to use for Design
-
-
- F_{prelim} =

in/hr
-
- N_{Tests} =
-
- F_{Max} =

in/hr

F_{Min} =

in/hr

F_{Design} =

in/hr
-
-
-
- SCM-Design-v4.00, BR_2
- Sheet 1 of 6
- 9/12/2025, 1:53 PM

Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

Designer:

DRS

Company:

Siteworks, LLC

Date:

September 12, 2025

Project:

Louisville Mill Site Redevelopment

Location:

540 County Road

Outfall ID:

2

2. Inlet Design and Pretreatment

A) Is RPA (GB/GS) used for Runoff Reduction upstream of SCM?

NO

Define inflow points for all areas tributary to the SCM below.

B) Inflow Points contributing to SCM (max 8)

Inflow Design Point ID	1	2						
Tributary Area to Inflow Point (ft ²)	2,415	4,632						
Imperviousness above Inflow Point (%)	85.0%	85.0%						
Default WQCV for Inflow Point (ft ³)	58	112						
WQCV Reduction above Inflow Point (ft ³)	0	0						
Remaining WQCV at Inflow Point (ft ³)	58	112						
Will pretreatment be provided with a Sedimentation MTD (HDS)	NO	NO						
Paired Pretreatment HDS Worksheet Name	--	--						
Sheet or Concentrated Flow	Conc	Sheet						

C) Sheet Flow

Select sheet flow inflow feature	--	Slotted						
Is Concrete Edger used?	--	--						
Spacing between slots, recommend ≤ 2 ft on center (ft)	--	0.50						
Slot Opening Length, recommend 1.5 (in)	--	1.50						
Select type of blind swale used to distribute flow	--	--						
Select energy dissipation method for level spreader	--	--						
Height of drop, recommend 2 to 3 (in)	--	2.00						
Is concrete mowing strip provided to facilitate maintenance?	--	NO						

D) Concentrated Flow

Select concentrated flow inflow feature	Downspout	--						
Is downspout extension needed to bridge backfill zone?		--						
Depth of gutter flow line depression for curb opening, recommend 3 (in)	--	--						
Curb opening inlet width (ft)	--	--						
Height of drop to sediment pad/forebay, recommend ≥ 1 (in)	--	--						
Select energy dissipation method for downspouts and/or curb openings.		--						
Select energy dissipation method for swales, channels, and piped outfalls	--	--						

v) Forebay

Impervious area tributary to concentrated inflow location (ft ²)	--	--						
Forebay Type (Concrete Sediment Pad sufficient for Imp Area ≤ 2 acre)	--	--						
Minimum Forebay Volume (ft ³)	--	--						
Design Forebay Volume (ft ³)	--	--						
Maximum Forebay Depth (in)	--	--						
Design Forebay Depth (in)	--	--						
Rectangular Weir Notch Width to Empty Forebay in 5-minutes (in)	--	--						
Design Notch Width (in)	--	--						
Forebay Drain Time (minutes)	--	--						

Provide pretreatment to remove coarse sediment, trash and debris. This is especially critical for roadway runoff to bioretention systems.

Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

Designer:	DRS
Company:	Siteworks, LLC
Date:	September 12, 2025
Project:	Louisville Mill Site Redevelopment
Location:	540 County Road
Outfall ID:	2

3. Design Storage Volume A) Contributing Watershed Area (including bioretention area) B) Imperviousness of Tributary Area C) Default WQCV D) WQCV Reduction resulting from Upstream RPA (GB/GS) E) Remaining WQCV	Inflow Points above should be fully defined before proceeding below Area = 7,048 ft² i = 85.0% % V_{WQCV Default} = 170 ft³ WQCV Reduction = 0 ft³ V_{WQCV Remaining} = 170 ft³
4. Bioretention System Basin Geometry A) Mimimum Filter Media Surface Area B) Design Filter Media Surface Area C) WQCV Ponding Depth (recommend max. 12-inch) D) Media Surface Slope (typically flat or mild slope < 0.01 ft/ft) E) Max. Side Slope (Z = 4:1 or flatter, horiz. dist per unit vertical) (Use "0" if bioretention has vertical walls) F) Media Surface Length-to-Width Ratio G) Calculated WQCV (based on A_{F Design}, D_{WQCV}, and Z) H) Design WQCV (based on actual design geometry) I) If basin geometry is irregular, design volume differs, or media pore space is being utilized, please provide description.	A_{F Min} = 120 ft² A_{F Design} = 180 ft² D_{WQCV} = 12.00 in S_{Surface} = 0.000 ft / ft Z = 0.00 ft / ft R_{L/W} = 1.8 V_{WQCV Calculated} = 180 ft³ V_{WQCV Design} = 180 ft³

Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

DRS

Siteworks, LLC

September 12, 2025

Louisville Mill Site Redevelopment

540 County Road

2

5. Underdrain System, Impermeable Liner, and Geotextile	
A) Are underdrains provided?	
B) Is a Drain Trench provided consistent with Figure 4-2? - Trench Bottom Width $\geq$ 12 inches, Trench Depth $\geq$ 15 inches - Drain gravel satisfies gradation specifications for AASHTO M 43 No. 8 coarse aggregate - Filter sand above drain gravel satisfies gradation specifications for AASHTO M 43 fine aggregate - Filter sand depth above drain trench $\geq$ 6 inches - Filter sand extends $\geq$ 12 inches beyond trench top width	
C) Select Factory-Slotted Pipe Size and Material	
D) Does the specified pipe material meet the specifications for slot configurations shown in Table 4-6 and Figure 4-3.	
E) Are cleanouts provided for inspection and maintenance?	
F) Is an impermeable geomembrane liner provided?	
G) Are details provided regarding sealing at underdrain penetrations similar to Figure 4-6?	
H) Are geomembrane connections to vertical concrete surfaces consistent with Figure 4-7?	
I) Do the plans specify <u>thermal</u> welding and air lance testing of joints?	

-
-
-
-
-
-

Page 10 of 10

Page 10 of 10

Page 10 of 10

Page 10 of 10

6. Bioretention Media A) Depth of Media (18-inch minimum, 36-inch when trees planted) B) Do construction documents specify media testing requirements?	D_{Media} = in _____ _____ _____ _____
--	--

[illegible]

Page 10 of 10

Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

Designer:	DRS
Company:	Siteworks, LLC
Date:	September 12, 2025
Project:	Louisville Mill Site Redevelopment
Location:	540 County Road
Outfall ID:	2

--	--

Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

Designer:

DRS

Company:

Siteworks, LLC

Date:

September 12, 2025

Project:

Louisville Mill Site Redevelopment

Location:

540 County Road

Outfall ID:

2

7. Vegetation A) Select the method of vegetation planting (pulldown list). Consult with vegetation specialist to consider shade, heat island effects, application of deicers in the watershed, and other site-specific factors. B) Has a landscape/vegetation management plan been developed? C) Describe vegetation/landscaping considerations: - Stability issues (steep slopes, high erosion potential)? - Topsoil management (assessment, stockpiling, and placement)? - Community benefits with place-making approach? - Biodiversity of the site including pollinator species? - Environmental stewardship through conservation? - Inundation frequency and depth impacts on vegetation? - Required maintenance activities and intervals?	
8. Irrigation A) How will irrigation be provided for vegetation establishment?	
9. Outlet A) Underdrain Orifice Diameter for 12-hour drain time i) Underdrain Orifice Invert Depth (distance from filter media surface to orifice invert) ii) Calculated Underdrain Orifice Diameter Simplified Equation (when not using MHFD-Detention) MHFD-Detention Calculation (if used) iii) Underdrain Orifice Diameter specified on construction plans B) Describe Underdrain Orifice Outlet Configuration. C) Describe Outlet Structure(s) for events larger than WQCV. (full-spectrum detention, overflow spillway, etc.)	y = in Dia. Simplified = in Dia. MHFD-Detention = in Orifice Dia. Design = in
Notes:	

Designer:

DRS

Company:

Siteworks, LLC

Date:

September 12, 2025

Project:

Louisville Mill Site Redevelopment

Location:

540 County Road

Outfall ID:

1

1. Subsurface Exploration and Infiltration System Selection

- A) Identify Site Constraints
- i) Is subgrade depth to bedrock < 3 feet?

ii) Is subgrade depth to seasonal high groundwater table < 3 feet?

- B) Identify Site Risks
- i) Are expansive/collapsible soils present?

ii) Are highly concentrated pollutant sources present (hotspot)?

iii) Is site located above contaminated soils or groundwater?

iv) Is SCM located at top of steep slope? (> 3H:1V)

v) Is SCM located adjacent to building, hardscape, or pavement?

vi) Is SCM located above building foundation wall backfill?

vii) Are there other concerns that indicate high risk for infiltration?

- C) Preliminary Infiltration/Percolation Tests of underlying soils
- i) Were preliminary infiltration/percolation tests conducted?

ii) Preliminary estimate of infiltration rate

- D) Final Design Infiltrometer Test
- i) Were infiltrometer tests conducted?

ii) Select type of infiltrometer test performed:

iii) How many locations were tested?

iv) Describe test locations relative to borings/pits

- v) What was the maximum infiltration rate tested?

vi) What was the minimum infiltration rate tested?

vii) Design Infiltration Rate

E) Recommended Infiltration System

F) Select Infiltration System to use for Design

NO

F_{prelim} =

in/hr

N_{Tests} =

F_{Max} =

in/hr

F_{Min} =

in/hr

F_{Design} =

in/hr

Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

Designer:

DRS

Company:

Siteworks, LLC

Date:

September 12, 2025

Project:

Louisville Mill Site Redevelopment

Location:

540 County Road

Outfall ID:

1

2. Inlet Design and Pretreatment

A) Is RPA (GB/GS) used for Runoff Reduction upstream of SCM?

NO

Define inflow points for all areas tributary to the SCM below.

B) Inflow Points contributing to SCM (max 8)

Inflow Design Point ID	1							
Tributary Area to Inflow Point (ft ²)	1,469							
Imperviousness above Inflow Point (%)	95.0%							
Default WQCV for Inflow Point (ft ³)	44							
WQCV Reduction above Inflow Point (ft ³)	0							
Remaining WQCV at Inflow Point (ft ³)	44							
Will pretreatment be provided with a Sedimentation MTD (HDS)								
Paired Pretreatment HDS Worksheet Name								
Sheet or Concentrated Flow	Conc							

C) Sheet Flow

Select sheet flow inflow feature	--							
Is Concrete Edger used?	--							
Spacing between slots, recommend ≤ 2 ft on center (ft)	--							
Slot Opening Length, recommend 1.5 (in)	--							
Select type of blind swale used to distribute flow	--							
Select energy dissipation method for level spreader	--							
Height of drop, recommend 2 to 3 (in)	--							
Is concrete mowing strip provided to facilitate maintenance?	--							

D) Concentrated Flow

Select concentrated flow inflow feature	Downspout							
Is downspout extension needed to bridge backfill zone?	NO							
Depth of gutter flow line depression for curb opening, recommend 3 (in)	--							
Curb opening inlet width (ft)	--							
Height of drop to sediment pad/forebay, recommend ≥ 1 (in)	--							
Select energy dissipation method for downspouts and/or curb openings.	Concrete							
Select energy dissipation method for swales, channels, and piped outfalls	--							

v) Forebay

Impervious area tributary to concentrated inflow location (ft ²)	--							
Forebay Type (Concrete Sediment Pad sufficient for Imp Area ≤ 2 acre)	--							
Minimum Forebay Volume (ft ³)	--							
Design Forebay Volume (ft ³)	--							
Maximum Forebay Depth (in)	--							
Design Forebay Depth (in)	--							
Rectangular Weir Notch Width to Empty Forebay in 5-minutes (in)	--							
Design Notch Width (in)	--							
Forebay Drain Time (minutes)	--							

Provide pretreatment to remove coarse sediment, trash and debris. This is especially critical for roadway runoff to bioretention systems.

Bioretention System (BR)

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Designer:	DRS
Company:	Siteworks, LLC
Date:	September 12, 2025
Project:	Louisville Mill Site Redevelopment
Location:	540 County Road
Outfall ID:	1

3. Design Storage Volume A) Contributing Watershed Area (including bioretention area) B) Imperviousness of Tributary Area C) Default WQCV D) WQCV Reduction resulting from Upstream RPA (GB/GS) E) Remaining WQCV	Inflow Points above should be fully defined before proceeding below Area = 1,469 ft² i = 95.0% % V_{WQCV Default} = 44 ft³ WQCV Reduction = 0 ft³ V_{WQCV Remaining} = 44 ft³
4. Bioretention System Basin Geometry A) Mimimum Filter Media Surface Area B) Design Filter Media Surface Area C) WQCV Ponding Depth (recommend max. 12-inch) D) Media Surface Slope (typically flat or mild slope < 0.01 ft/ft) E) Max. Side Slope (Z = 4:1 or flatter, horiz. dist per unit vertical) (Use "0" if bioretention has vertical walls) F) Media Surface Length-to-Width Ratio G) Calculated WQCV (based on A_{F Design}, D_{WQCV}, and Z) H) Design WQCV (based on actual design geometry) I) If basin geometry is irregular, design volume differs, or media pore space is being utilized, please provide description.	A_{F Min} = 28 ft² A_{F Design} = 50 ft² D_{WQCV} = 12.00 in S_{Surface} = 0.000 ft / ft Z = 0.00 ft / ft R_{L/W} = 2 V_{WQCV Calculated} = 50 ft³ V_{WQCV Design} = 50 ft³

Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

Bioretention System (BR)	
SCM Design, Version 4.00 (April 2024)	
Designer:	DRS
Company:	Siteworks, LLC
Date:	September 12, 2025
Project:	Louisville Mill Site Redevelopment
Location:	540 County Road
Outfall ID:	1

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Bioretention System (BR)

SCM Design, Version 4.00 (April 2024)

Designer:

DRS

Company:

Siteworks, LLC

Date:

September 12, 2025

Project:

Louisville Mill Site Redevelopment

Location:

540 County Road

Outfall ID:

1

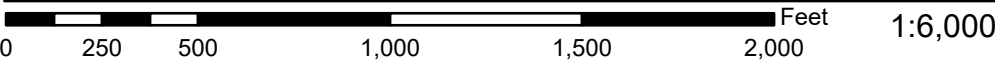
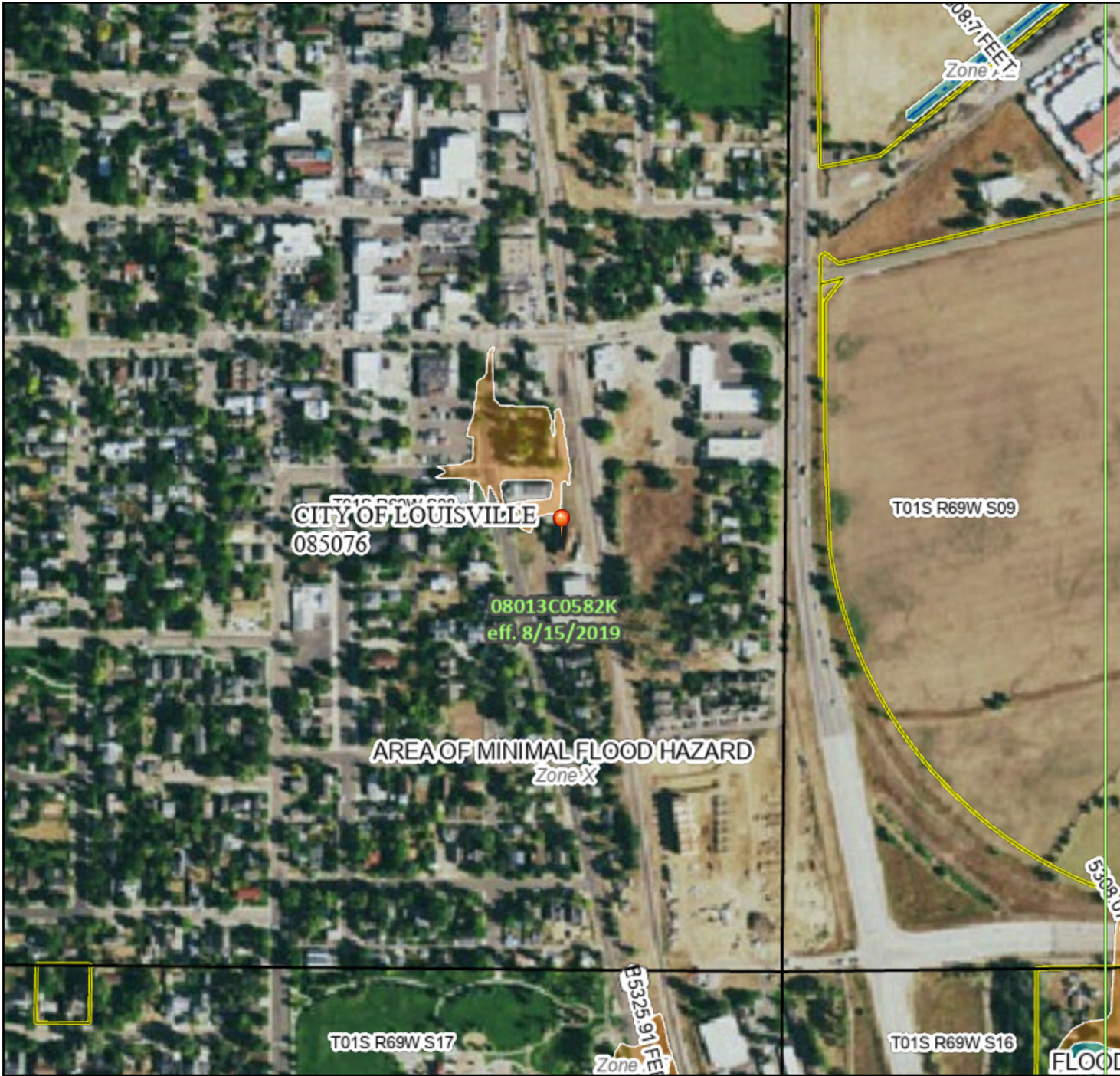
7. Vegetation A) Select the method of vegetation planting (pulldown list). Consult with vegetation specialist to consider shade, heat island effects, application of deicers in the watershed, and other site-specific factors. B) Has a landscape/vegetation management plan been developed? C) Describe vegetation/landscaping considerations: - Stability issues (steep slopes, high erosion potential)? - Topsoil management (assessment, stockpiling, and placement)? - Community benefits with place-making approach? - Biodiversity of the site including pollinator species? - Environmental stewardship through conservation? - Inundation frequency and depth impacts on vegetation? - Required maintenance activities and intervals?	
8. Irrigation A) How will irrigation be provided for vegetation establishment?	
9. Outlet A) Underdrain Orifice Diameter for 12-hour drain time i) Underdrain Orifice Invert Depth (distance from filter media surface to orifice invert) ii) Calculated Underdrain Orifice Diameter Simplified Equation (when not using MHFD-Detention) MHFD-Detention Calculation (if used) iii) Underdrain Orifice Diameter specified on construction plans B) Describe Underdrain Orifice Outlet Configuration. C) Describe Outlet Structure(s) for events larger than WQCV. (full-spectrum detention, overflow spillway, etc.)	y = 3.0 in Dia. Simplified = 0.25 in Dia. MHFD-Detention = in Orifice Dia. Design = in
Notes:	

APPENDIX E

RELEVANT DOCUMENTS

National Flood Hazard Layer FIRMMette

105°8'7"W 39°58'45"N



Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee. See Notes. Zone X
		Area with Flood Risk due to Levee Zone D
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard Zone X
		Effective LOMRs
		Area of Undetermined Flood Hazard Zone D
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 5/16/2025 at 4:56 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.



Federal Emergency Management Agency

Washington, D.C. 20472

October 25, 2017

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

The Honorable Bob Muckle
Mayor, City of Louisville
749 Main Street
Louisville, CO 80027

IN REPLY REFER TO:

Case No.: 17-08-0625P
Community Name: City of Louisville, CO
Community No.: 085076
Effective Date of
This Revision: March 8, 2018

Dear Mayor Muckle:

The Flood Insurance Study report and Flood Insurance Rate Map for your community have been revised by this Letter of Map Revision (LOMR). Please use the enclosed annotated map panel(s) revised by this LOMR for floodplain management purposes and for all flood insurance policies and renewals issued in your community.

Additional documents are enclosed that provide information regarding this LOMR. Please see the List of Enclosures below to determine which documents are included. Other attachments specific to this request may be included as referenced in the Determination Document. If you have any questions regarding floodplain management regulations for your community or the National Flood Insurance Program (NFIP) in general, please contact the Consultation Coordination Officer for your community. If you have any technical questions regarding this LOMR, please contact the Director, Mitigation Division of the Department of Homeland Security's Federal Emergency Management Agency (FEMA) in Denver, Colorado, at (303) 235-4830, or the FEMA Map Information eXchange (FMIX) toll free at 1-877-336-2627 (1-877-FEMA MAP). Additional information about the NFIP is available on our website at <http://www.fema.gov/national-flood-insurance-program>.

Sincerely,

Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration

List of Enclosures:

Letter of Map Revision Determination Document
Annotated Flood Insurance Rate Map
Annotated Flood Insurance Study Report

cc: The Honorable Deb Gardner
Chair, Boulder County
Board of Commissioners

Mr. Aaron Asquith P.E.
City Engineer
City of Lafayette

The Honorable Christine Berg
Mayor, City of Lafayette

Ms. Deb Ohlinger, P.E. CFM
Project Engineer
Olsson Associates

Mr. Robert Zuccaro, AICP
Planning & Building Safety Director
City of Louisville

Ms. Varda Blum, CFM
Floodplain Program Manager
Boulder County



Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION DETERMINATION DOCUMENT

COMMUNITY AND REVISION INFORMATION		PROJECT DESCRIPTION	BASIS OF REQUEST
COMMUNITY	City of Louisville Boulder County Colorado	CHANNELIZATION	HYDRAULIC ANALYSIS HYDROLOGIC ANALYSIS UPDATED TOPOGRAPHIC DATA
	COMMUNITY NO.: 085076		
IDENTIFIER	Lafayette-Louisville Boundary Area Drainage Improvements Project	APPROXIMATE LATITUDE AND LONGITUDE: 39.982, -105.120 SOURCE: USGS QUADRANGLE DATUM: NAD 83	
ANNOTATED MAPPING ENCLOSURES		ANNOTATED STUDY ENCLOSURES	
TYPE: FIRM* NO.: 08013C0601J DATE: December 18, 2012 TYPE: FIRM* NO.: 08013C0582J DATE: December 18, 2012		DATE OF EFFECTIVE FLOOD INSURANCE STUDY: December 18, 2012 PROFILES: 381P-383P SUMMARY OF DISCHARGES TABLE: 4	

Enclosures reflect changes to flooding sources affected by this revision.

* FIRM - Flood Insurance Rate Map

FLOODING SOURCES AND REVISED REACHES

See Page 2 for Additional Flooding Sources

Drainageway A-2 - From the confluence with Drainageway A to approximately 1,170 feet upstream of the confluence with Drainageway A

SUMMARY OF REVISIONS

Flooding Source	Effective Flooding	Revised Flooding	Increases	Decreases
Drainageway A-2	Zone X (unshaded)	Zone AE	YES	NONE
	No BFEs*	BFEs	YES	NONE
	Zone AE	Zone X (unshaded)	NONE	YES
	Zone AH	Zone X (shaded)	NONE	YES

* BFEs - Base Flood Elevations

DETERMINATION

This document provides the determination from the Department of Homeland Security's Federal Emergency Management Agency (FEMA) regarding a request for a Letter of Map Revision (LOMR) for the area described above. Using the information submitted, we have determined that a revision to the flood hazards depicted in the Flood Insurance Study (FIS) report and/or National Flood Insurance Program (NFIP) map is warranted. This document revises the effective NFIP map, as indicated in the attached documentation. Please use the enclosed annotated map panels revised by this LOMR for floodplain management purposes and for all flood insurance policies and renewals in your community.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional Information about the NFIP is available on our website at <http://www.fema.gov/national-flood-insurance-program>.

Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration

17-08-0625P

102-I-A-C



Federal Emergency Management Agency
Washington, D.C. 20472

**LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)**

OTHER FLOODING SOURCES AFFECTED BY THIS REVISION

FLOODING SOURCE AND REVISED REACH

Drainageway A-2 - From the confluence with Drainageway A to approximately 1,170 feet upstream of the confluence with Drainageway A
Drainageway A - From the confluence with Drainageway 7 to approximately 800 feet upstream of the confluence with Drainageway A-2

SUMMARY OF REVISIONS

Flooding Source	Effective Flooding	Revised Flooding	Increases	Decreases
Drainageway A-2	BFEs*	No BFEs	NONE	YES
	Zone A	Zone AE	NONE	YES
	Zone X (shaded)	Zone X (unshaded)	NONE	YES
Drainageway A	Zone X (shaded)	Zone X (unshaded)	NONE	YES
	Zone AH	Zone X (unshaded)	NONE	YES
	Zone AE	Zone X (unshaded)	NONE	YES
	Zone X (shaded)	Zone AE	YES	YES
	No BFEs	BFEs	YES	NONE
	BFEs	No BFEs	NONE	YES

* BFEs - Base Flood Elevations

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional Information about the NFIP is available on our website at <http://www.fema.gov/national-flood-insurance-program>.

Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration

17-08-0625P

102-I-A-C



Federal Emergency Management Agency
Washington, D.C. 20472

**LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)**

OTHER COMMUNITIES AFFECTED BY THIS REVISION

CID Number: 080023 **Name:** Boulder County, Colorado

AFFECTED MAP PANELS			AFFECTED PORTIONS OF THE FLOOD INSURANCE STUDY REPORT
TYPE: FIRM*	NO.: 08013C0601J	DATE: December 18, 2012	DATE OF EFFECTIVE FLOOD INSURANCE STUDY: December 18, 2012 PROFILES: 381P-386P SUMMARY OF DISCHARGES TABLE: 4
TYPE: FIRM*	NO.: 08013C0582J	DATE: December 18, 2012	

CID Number: 080026 **Name:** City of Lafayette, Colorado

AFFECTED MAP PANELS			AFFECTED PORTIONS OF THE FLOOD INSURANCE STUDY REPORT
TYPE: FIRM*	NO.: 08013C0601J	DATE: December 18, 2012	DATE OF EFFECTIVE FLOOD INSURANCE STUDY: December 18, 2012 PROFILES: 384P SUMMARY OF DISCHARGES TABLE: 4

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional Information about the NFIP is available on our website at <http://www.fema.gov/national-flood-insurance-program>.

Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration



Federal Emergency Management Agency
Washington, D.C. 20472

**LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)**

COMMUNITY INFORMATION

APPLICABLE NFIP REGULATIONS/COMMUNITY OBLIGATION

We have made this determination pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (P.L. 93-234) and in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, P.L. 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65. Pursuant to Section 1361 of the National Flood Insurance Act of 1968, as amended, communities participating in the NFIP are required to adopt and enforce floodplain management regulations that meet or exceed NFIP criteria. These criteria, including adoption of the FIS report and FIRM, and the modifications made by this LOMR, are the minimum requirements for continued NFIP participation and do not supersede more stringent State/Commonwealth or local requirements to which the regulations apply.

NFIP regulations Subparagraph 60.3(b)(7) requires communities to ensure that the flood-carrying capacity within the altered or relocated portion of any watercourse is maintained. This provision is incorporated into your community's existing floodplain management ordinances; therefore, responsibility for maintenance of the altered or relocated watercourse, including any related appurtenances such as bridges, culverts, and other drainage structures, rests with your community. We may request that your community submit a description and schedule of maintenance activities necessary to ensure this requirement.

COMMUNITY REMINDERS

We based this determination on the 1-percent-annual-chance discharges computed in the submitted hydrologic model. Future development of projects upstream could cause increased discharges, which could cause increased flood hazards. A comprehensive restudy of your community's flood hazards would consider the cumulative effects of development on discharges and could, therefore, indicate that greater flood hazards exist in this area.

Your community must regulate all proposed floodplain development and ensure that permits required by Federal and/or State/Commonwealth law have been obtained. State/Commonwealth or community officials, based on knowledge of local conditions and in the interest of safety, may set higher standards for construction or may limit development in floodplain areas. If your State/Commonwealth or community has adopted more restrictive or comprehensive floodplain management criteria, those criteria take precedence over the minimum NFIP requirements.

We will not print and distribute this LOMR to primary users, such as local insurance agents or mortgage lenders; instead, the community will serve as a repository for the new data. We encourage you to disseminate the information in this LOMR by preparing a news release for publication in your community's newspaper that describes the revision and explains how your community will provide the data and help interpret the NFIP maps. In that way, interested persons, such as property owners, insurance agents, and mortgage lenders, can benefit from the information.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional information about the NFIP is available on our website at <http://www.fema.gov/national-flood-insurance-program>.

Patrick "Rick" F. Sacbitt, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration



Federal Emergency Management Agency
Washington, D.C. 20472

**LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)**

We have designated a Consultation Coordination Officer (CCO) to assist your community. The CCO will be the primary liaison between your community and FEMA. For information regarding your CCO, please contact:

Ms. Jeanine D. Petterson
Director, Mitigation Division
Federal Emergency Management Agency, Region VIII
Denver Federal Center, Building 710
P.O. Box 25267
Denver, CO 80225-0267
(303) 235-4830

STATUS OF THE COMMUNITY NFIP MAPS

We are processing a revised FIRM and FIS report for Boulder County in our countywide format; therefore, we will not physically revise and republish the FIRM and FIS report for your community to incorporate the modifications made by this LOMR at this time. Preliminary copies of the countywide FIRM and FIS report, which present information from the effective FIRMs and FIS reports for your community and incorporated communities in Boulder County, were submitted to your community for review on February 16, 2017. We will incorporate the modifications made by this LOMR into the countywide FIRM and FIS report before they become effective.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional information about the NFIP is available on our website at <http://www.fema.gov/national-flood-insurance-program>.

A handwritten signature in black ink, appearing to read "Rick F. Sacbibit".

Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration



Federal Emergency Management Agency
Washington, D.C. 20472

**LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)**

PUBLIC NOTIFICATION OF REVISION

A notice of changes will be published in the *Federal Register*. This information also will be published in your local newspaper on or about the dates listed below, and through FEMA's Flood Hazard Mapping website at https://www.floodmaps.fema.gov/fhm/bfe_status/bfe_main.asp

LOCAL NEWSPAPER

Name: *The Daily Camera*

Dates: November 1, 2017 and November 8, 2017

Within 90 days of the second publication in the local newspaper, any interested party may request that we reconsider this determination. Any request for reconsideration must be based on scientific or technical data. Therefore, this letter will be effective only after the 90-day appeal period has elapsed and we have resolved any appeals that we receive during this appeal period. Until this LOMR is effective, the revised flood hazard determination presented in this LOMR may be changed.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Information eXchange toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMC Clearinghouse, 3601 Eisenhower Avenue, Suite 500, Alexandria, VA 22304-6426. Additional Information about the NFIP is available on our website at <http://www.fema.gov/national-flood-insurance-program>.

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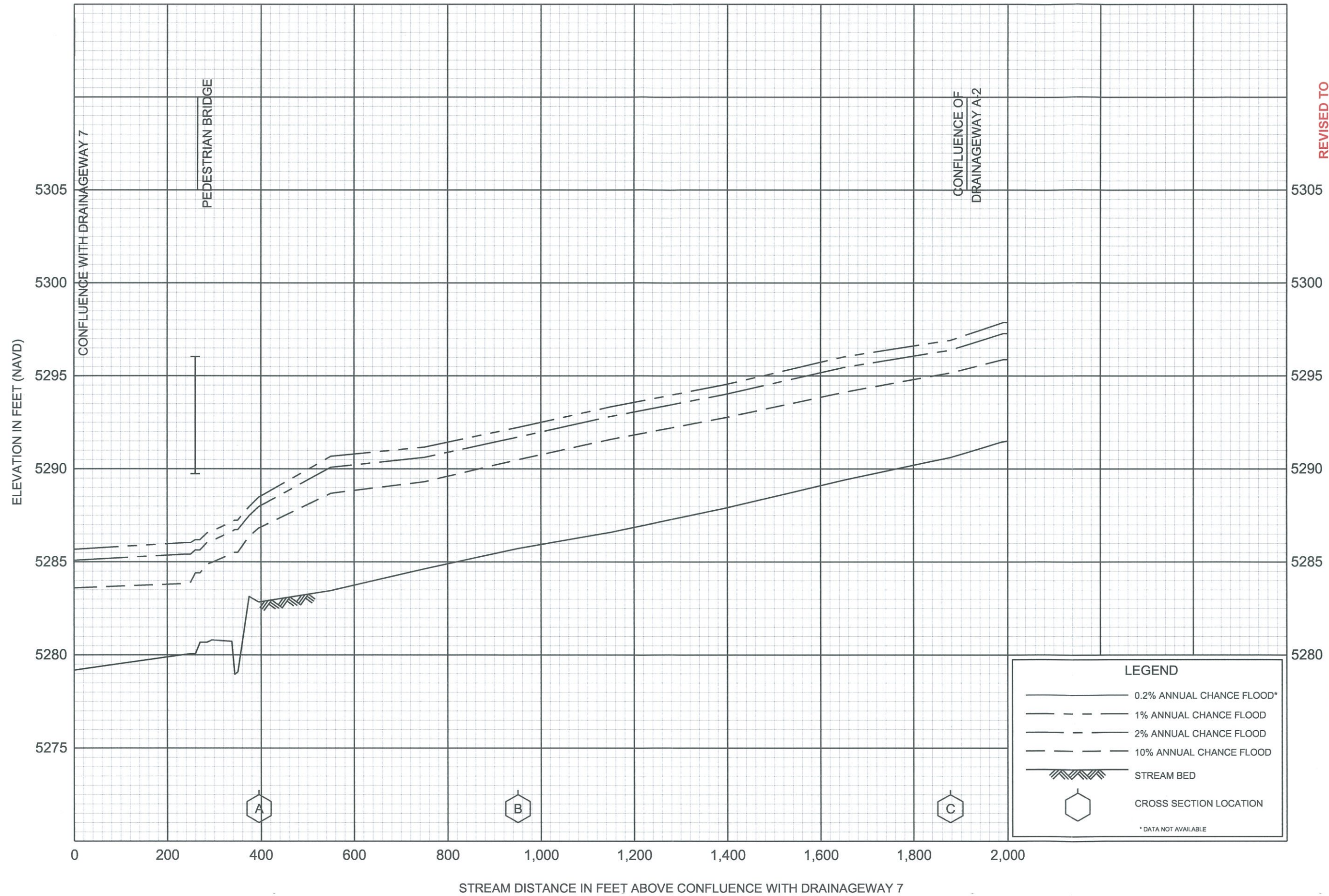
Patrick "Rick" F. Sacbibit, P.E., Branch Chief
Engineering Services Branch
Federal Insurance and Mitigation Administration

Table 4 - Summary of Discharges (Continued)

<u>Flooding Source and Location</u>	<u>Drainage Area (Square Miles)</u>	<u>10-Percent Annual Chance</u>	<u>Peak Discharges (cfs)</u>		
			<u>2-Percent Annual Chance</u>	<u>1-Percent Annual Chance</u>	<u>0.2-Percent Annual Chance</u>
Drainageway A Upstream of Confluence with Drainageway 7	1.39	400	724	894	— ¹
Upstream of Confluence with Drainageway A-2	1.13	157	281	367	— ¹
Drainageway A-2 Upstream of Confluence with Drainageway A	0.21	266	457	566	— ¹
Drainageway 7-2 Upstream of Confluence with Drainageway 7	0.39	181	315	383	— ¹
Drainageway 7 Upstream of Confluence with Coal Creek	1.92	647	1,238	1,544	— ¹

¹ Data Not Available

**REVISED TO
REFLECT LOMR
EFFECTIVE: March 8, 2018**

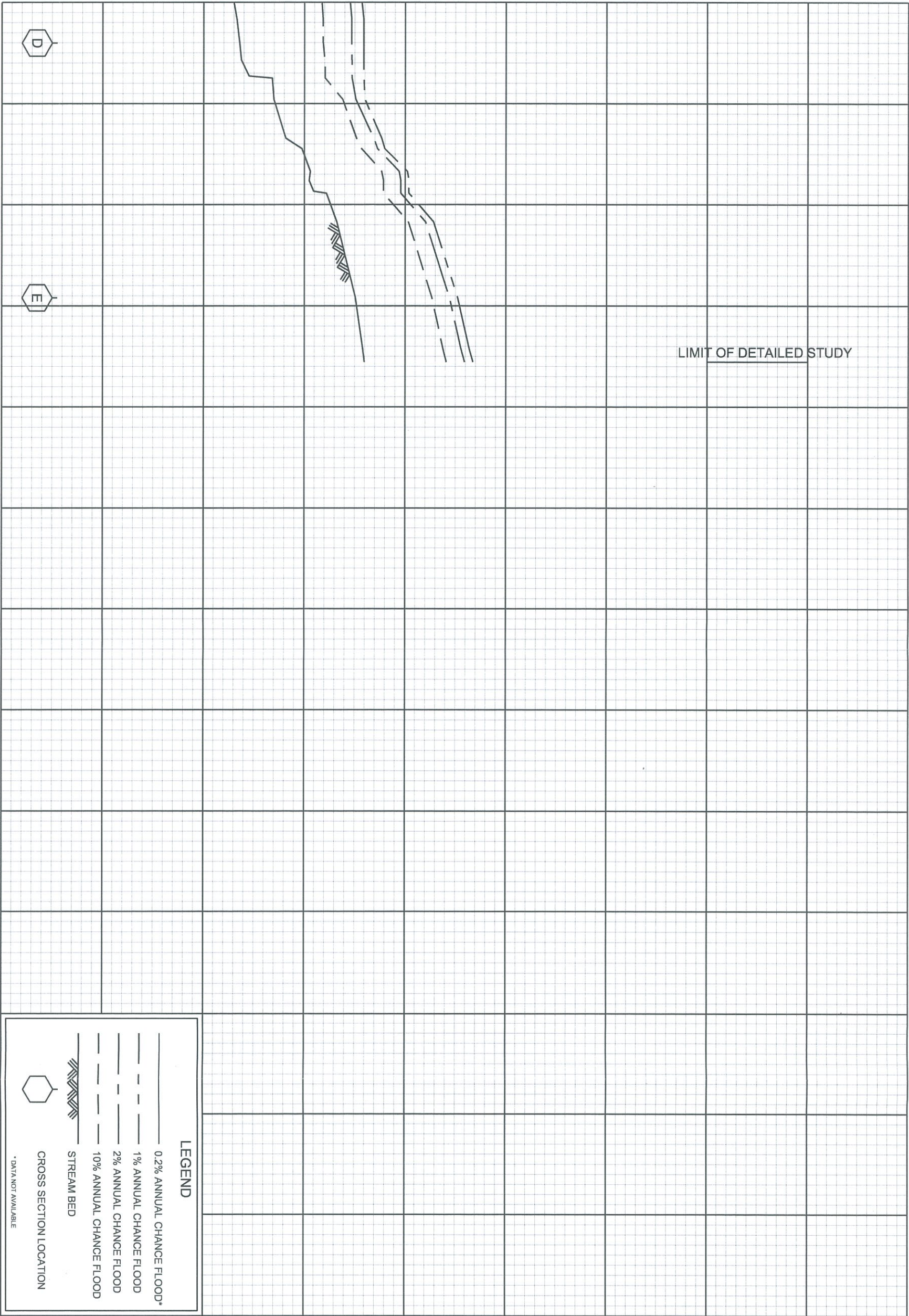


REVISED TO
REFLECT LOMR
FLOOD PROFILES
EFFECTIVE: March 8, 2018

DRAINAGEWAY A

FEDERAL EMERGENCY MANAGEMENT AGENCY

BOULDER COUNTY, CO
AND INCORPORATED AREAS



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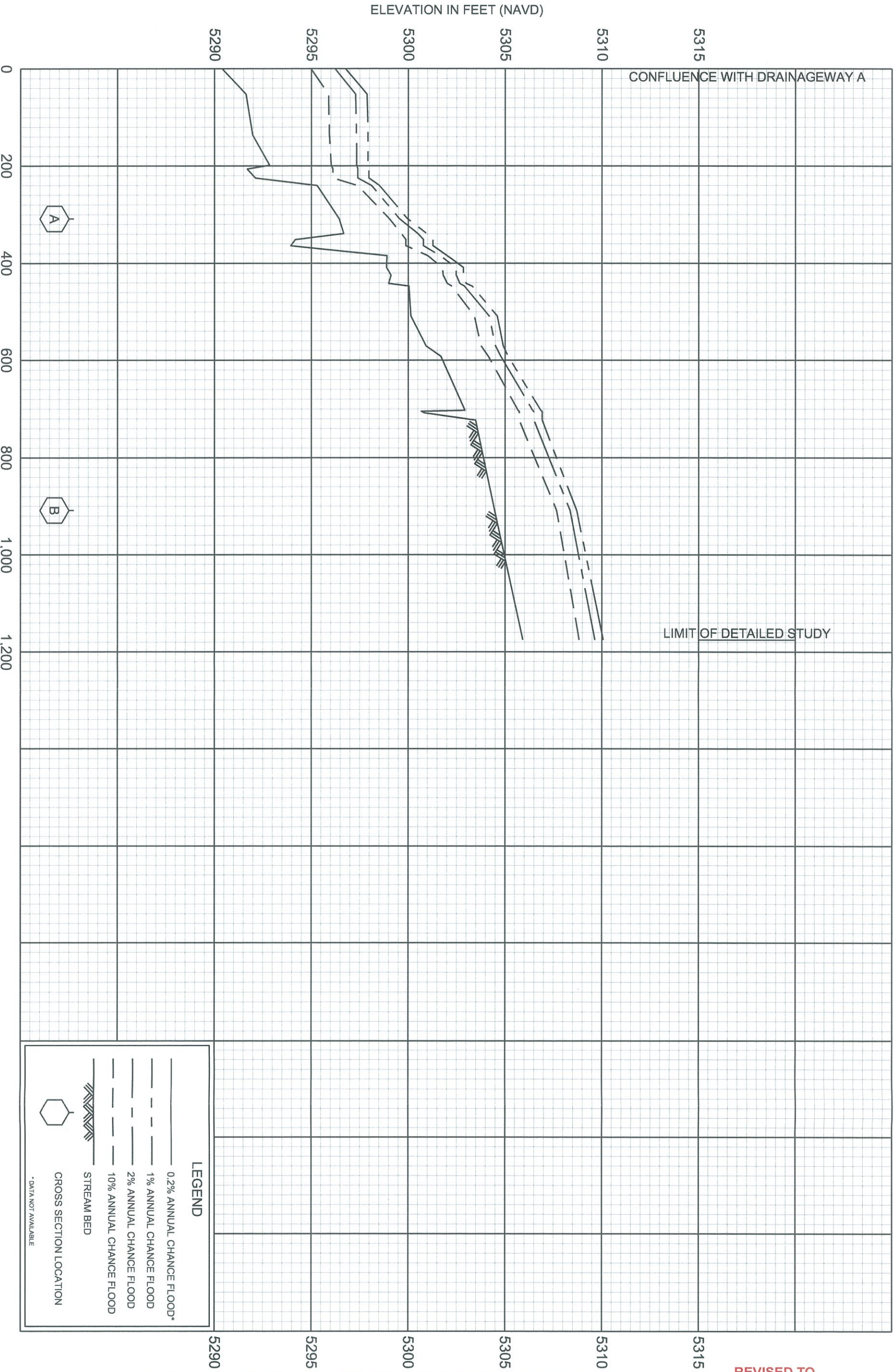
FLOOD PROFILES

DRAINAGEWAY A

FEDERAL EMERGENCY MANAGEMENT AGENCY

BOULDER COUNTY, CO

AND INCORPORATED AREAS



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REFLECT LOMR
EFFECTIVE: March 8, 2018

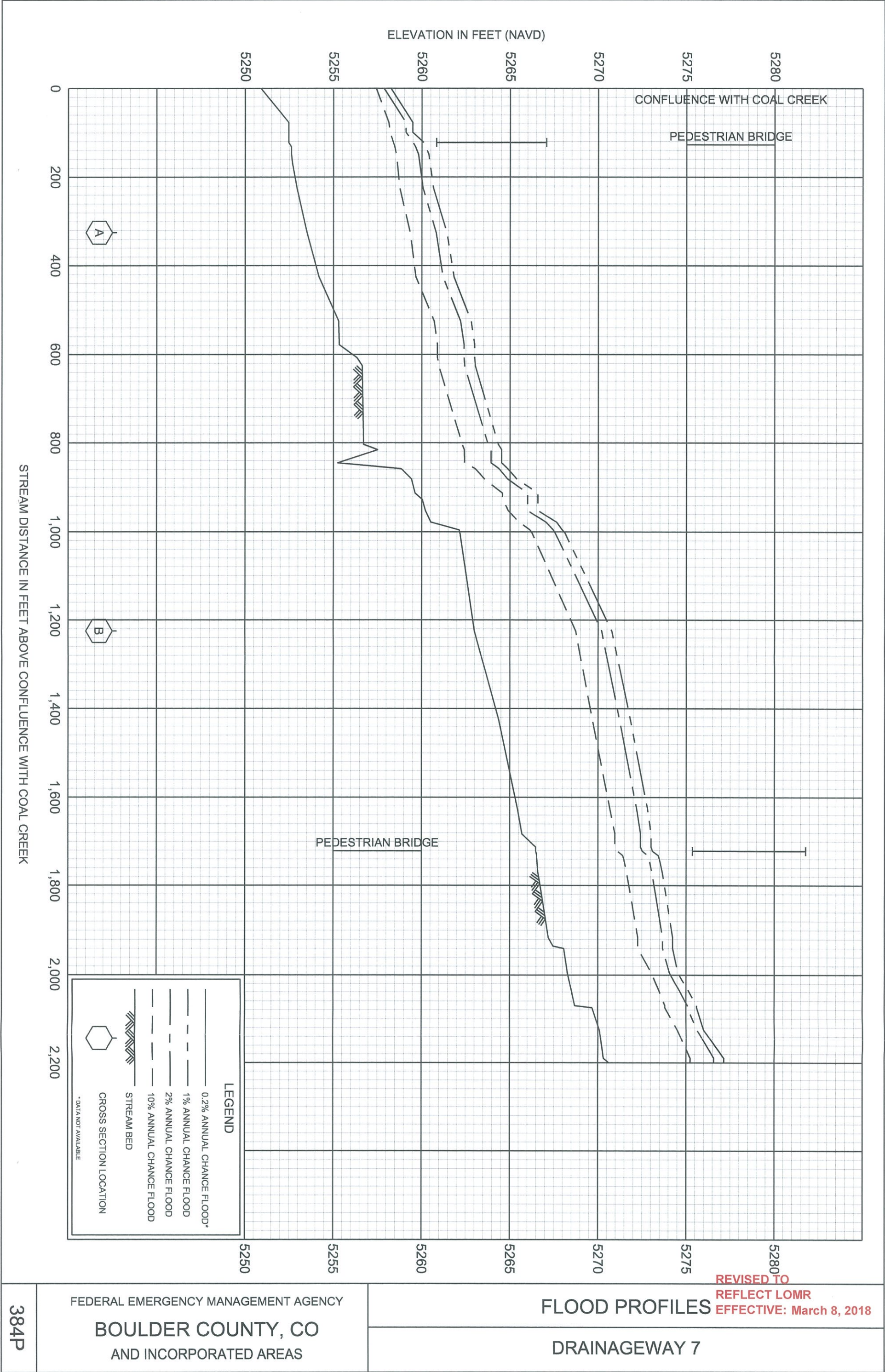
FLOOD PROFILES

DRAINAGEWAY A-2

FEDERAL EMERGENCY MANAGEMENT AGENCY

BOULDER COUNTY, CO

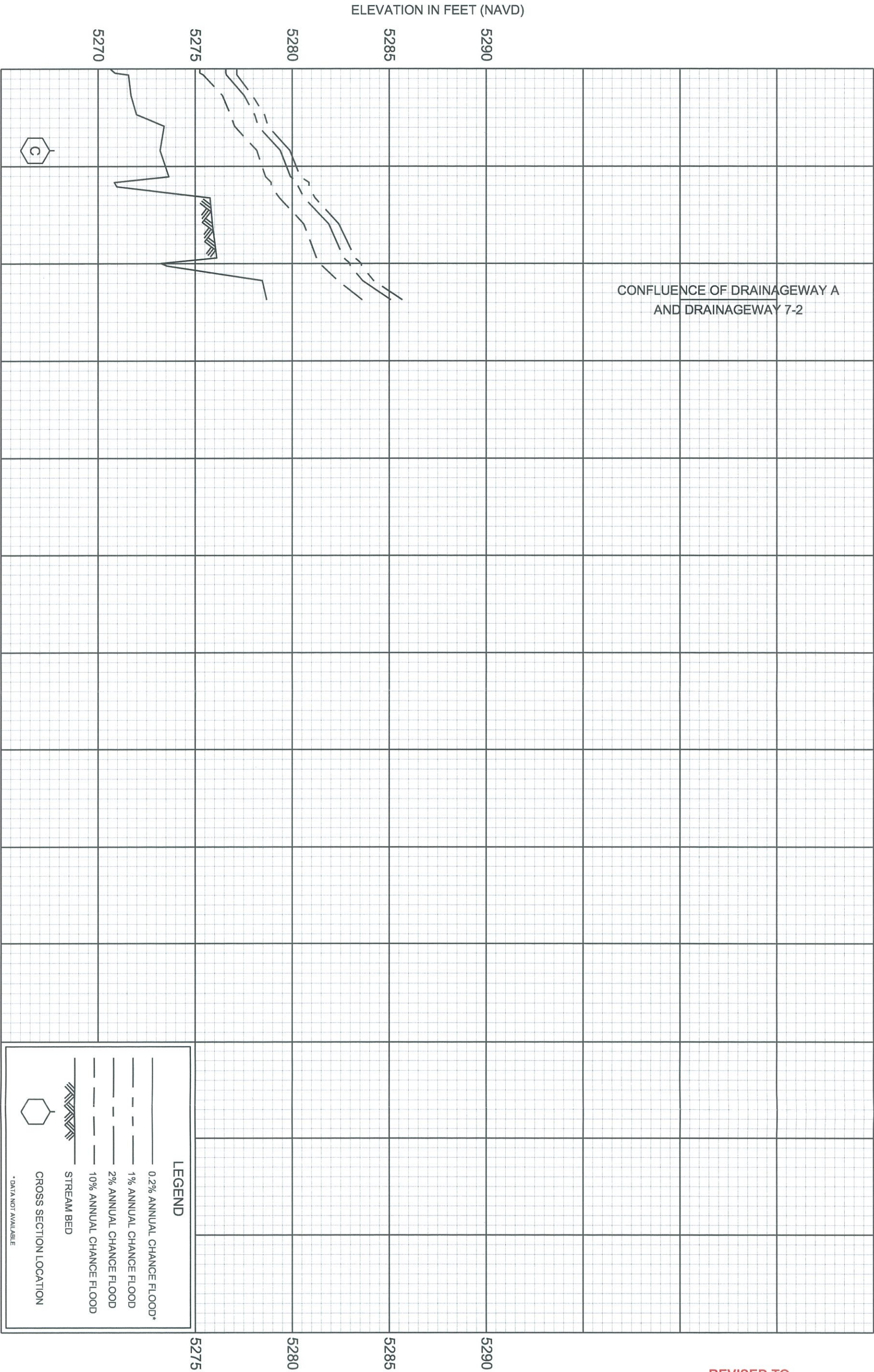
AND INCORPORATED AREAS



REVISED TO
REFLECT LOMR
EFFECTIVE: March 8, 2018

FLOOD PROFILES
DRAINAGEWAY 7

FEDERAL EMERGENCY MANAGEMENT AGENCY
BOULDER COUNTY, CO
AND INCORPORATED AREAS



REVISED TO
REFLECT LOMR
EFFECTIVE: March 8, 2018

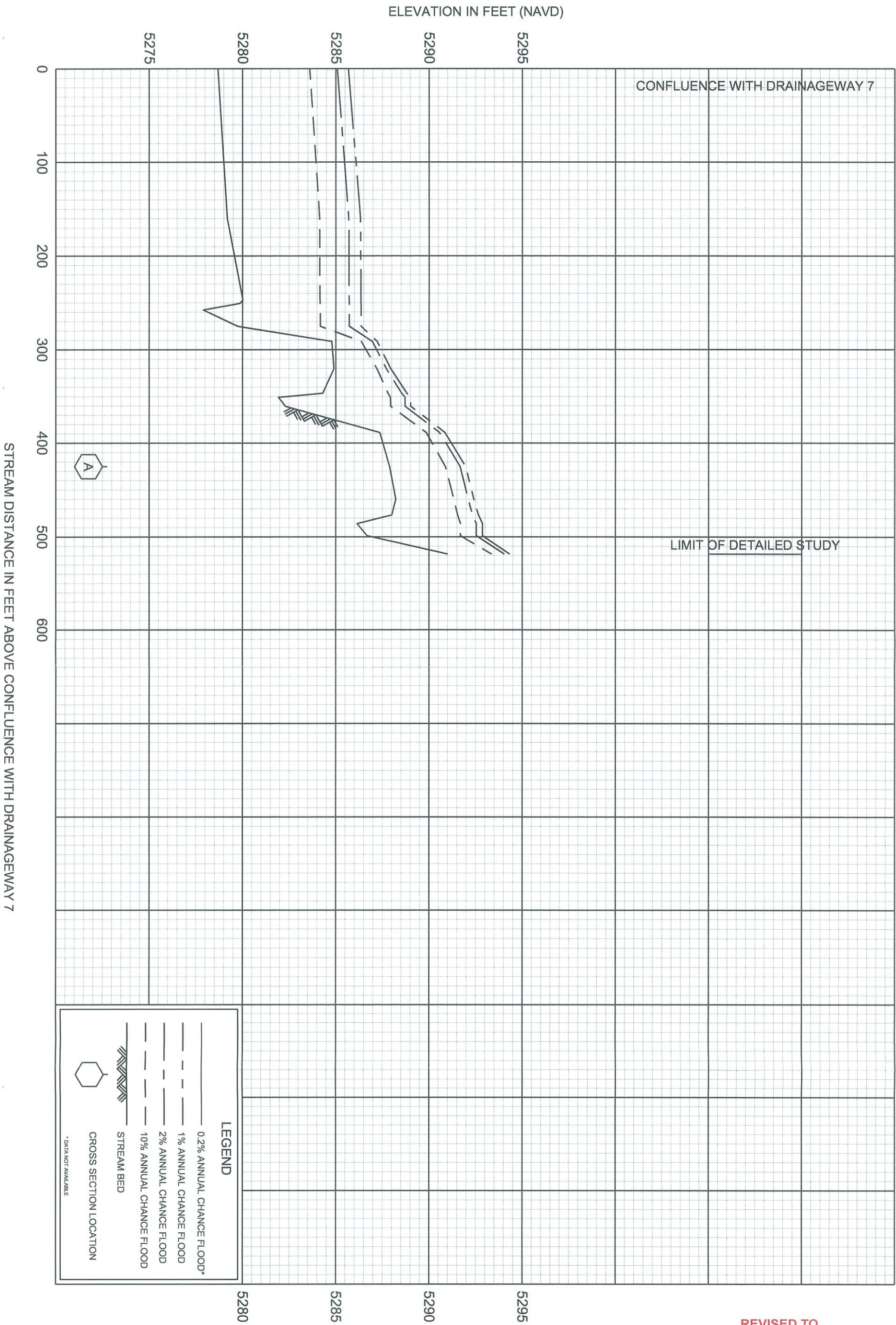
FLOOD PROFILES

DRAINAGEWAY 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

BOULDER COUNTY, CO

AND INCORPORATED AREAS



REVISED TO
REFLECT LOMR
EFFECTIVE: March 8, 2018

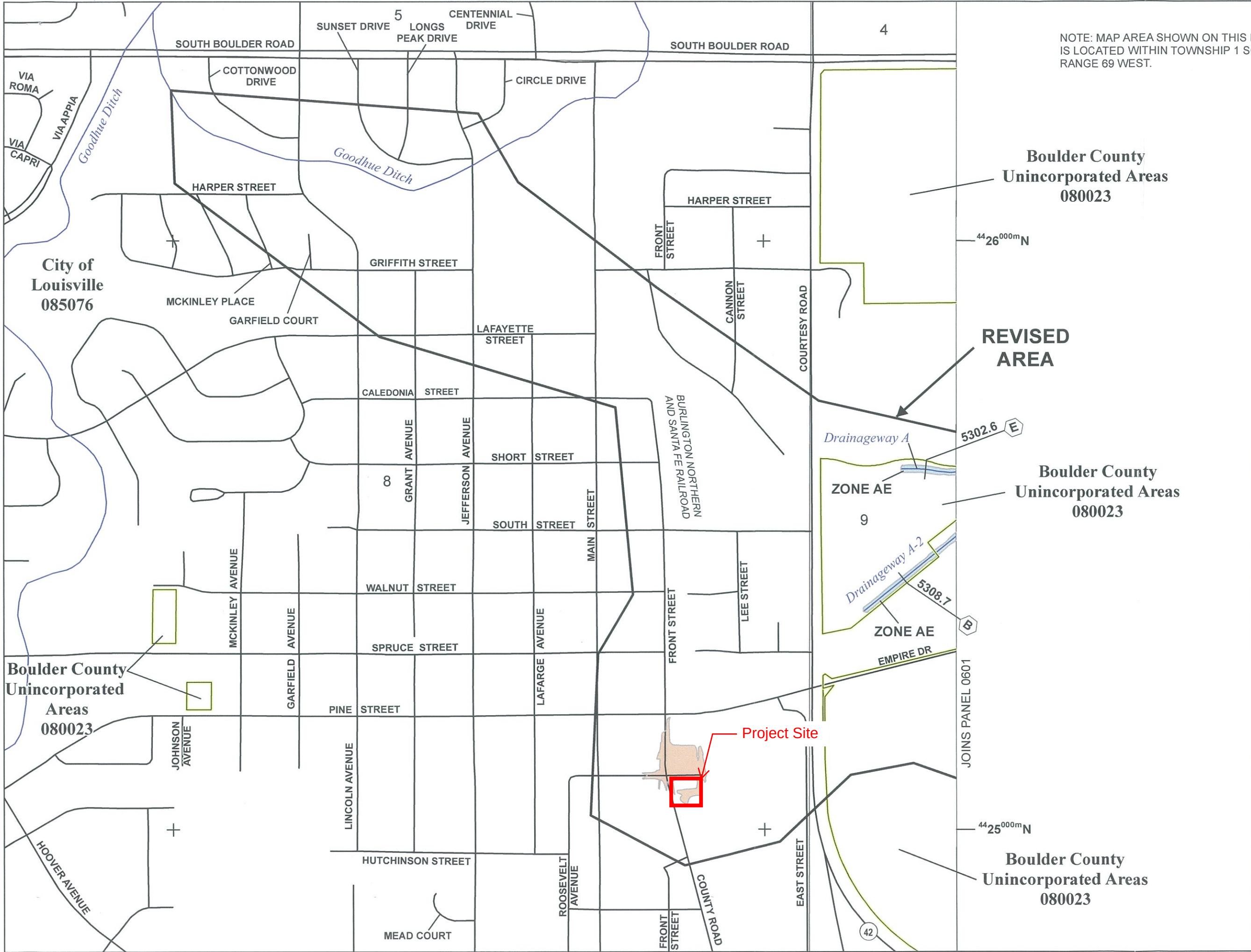
FLOOD PROFILES

DRAINAGEWAY 7-2

FEDERAL EMERGENCY MANAGEMENT AGENCY

BOULDER COUNTY, CO

AND INCORPORATED AREAS



NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 1 SOUTH, RANGE 69 WEST.

**Boulder County
Unincorporated Areas
080023**

**REVISED
AREA**

**Boulder County
Unincorporated Areas
080023**

**Boulder County
Unincorporated
Areas
080023**

**Boulder County
Unincorporated Areas
080023**

SPECIAL FLOOD HAZARD AREAS

- Without Base Flood Elevation (BFE)
Zone A, V, A99
- With BFE or Depth
Zone AE, AO, AH, VE, AR
- Regulatory Floodway
- 0.2 % Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile
Zone X
- Future Conditions 1% Annual Chance Flood Hazard
Zone X
- Area with Reduced Flood Risk due to Levee
See Notes, Zone X

OTHER AREAS OF FLOOD HAZARD

SCALE

Map Projection:
Universal Transverse Mercator NAD 1983 UTM Zone 13N
Western Hemisphere; Vertical Datum: NAVD 88

1 inch = 500 feet 1:6,000

0 250 500 1,000 Feet

0 62.5 125 250 Meters

FEMA

National Flood Insurance Program

**NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP**

BOULDER COUNTY, COLORADO
and Incorporated Areas

PANEL 582 OF 615

Panel Contains:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOULDER COUNTY	080023	0582	J
LAFAYETTE, CITY OF	080026	0582	J
LOUISVILLE, CITY OF	085076	0582	J

**REVISED TO
REFLECT LOMR
EFFECTIVE: March 8, 2018**

VERSION NUMBER
1.1.1.0

MAP NUMBER
08013C0582J

MAP REVISED
DECEMBER 18, 2012

T-3 BIORETENTION SYSTEMS

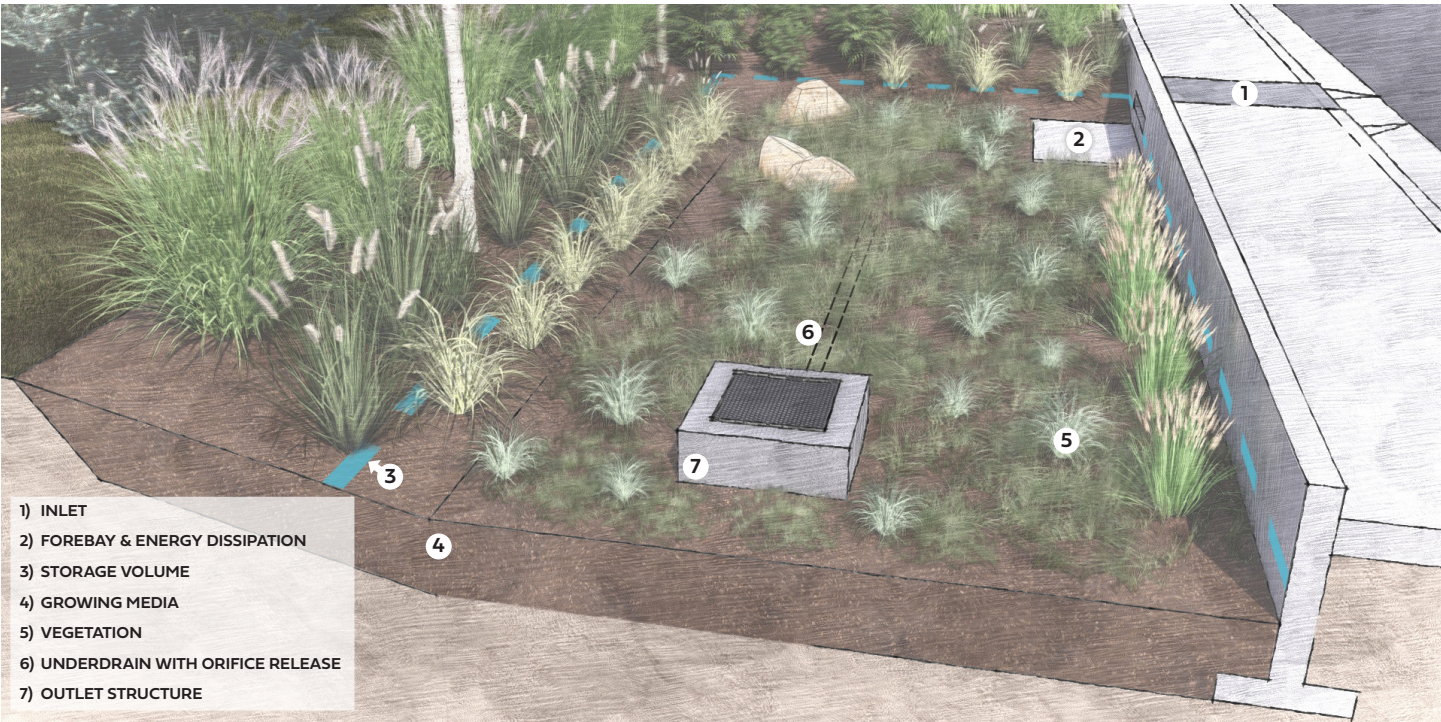


Figure BR-1. Bioretention System Components

DESCRIPTION

Bioretention systems are vegetated, engineered, depressed landscape areas designed to capture and filter and/or infiltrate the water quality capture volume (WQCV). Engineered media and vegetation facilitate filtration, adsorption, absorption, and biological processes that retain stormwater pollutants and enhance infiltration capabilities. The terms porous landscape detention (PLD), rain garden, and bioretention are often used interchangeably in the MHFD region. The term rain garden is sometimes used to describe smaller engineered bioretention systems or non-engineered installations and when describing this SCM to the public. Bioretention can be configured in several ways in urban areas and may be described as streetside planters, curbside bioretention, bump-out stormwater planters. Ultra-urban adaptations of bioretention can also include tree trenches and tree pits (although not described in this fact sheet). Local jurisdictions may have additional or different requirements for various types of bioretention systems.

MHFD strongly encourages use of bioretention as a stormwater control measure (SCM) because properly designed, constructed and maintained bioretention systems provide effective stormwater treatment, reduce runoff volume and erosive flow rates, and provide community connection benefits and green space in the urban environment.

Bioretention systems can be designed to provide detention for events exceeding the WQCV by incorporating storage of the Excess Urban Runoff Volume (EURV) and 100-year detention storage volumes above the WQCV, with drain times and release rates in accordance with the *Storage* chapter.

TABLE BR-1. BR OVERVIEW

BIORETENTION SYSTEMS	
MS4 Permit Applicability (Dependent on design and level of treatment)	
Meets Runoff Reduction Standard	Potential ¹
Meets WQCV Capture Standard	Yes
Meets Pollutant Removal Standard	Yes
Typical Effectiveness for Targeted Pollutants	
Sediment/Solids	High
Total Phosphorus	Low-Medium ¹
Total Nitrogen	Low-Medium ¹
Total Metals	High
Bacteria	Medium
Common Applications	
Runoff Reduction (General)	Potential ¹
Used for Pretreatment	No
Integrated with Flood Control	Yes

¹ Depends on design including full-infiltration, partial infiltration or no-infiltration section.

SCM COMPONENTS

The primary components of bioretention include inlet(s), energy dissipation and forebay(s), a surcharge volume, engineered media, vegetation, an underdrain (for no- or partial-infiltration designs), and an outlet structure (Figure BR-1). The primary outflow for the WQCV is typically an underdrain or infiltration into the underlying soil. When bioretention is designed to provide full spectrum detention, design the outlet to release the EURV and 100-year volumes in accordance with the EURV drain time and 100-year release rates. Even if the bioretention system is only designed to treat the WQCV, an emergency overflow (outlet or spillway) is necessary to safely convey flows from larger events.

See Section 3.0 *Site Assessment* and Section 4.0 *Filtration and Infiltration Systems* of this chapter for guidance and criteria on determining the appropriate type of bioretention system and designing underdrain and liner systems as needed based on site-specific conditions. Section 5.0 *SCM Inflow Features* and Section 6.0 *SCM Outflow Features* of this chapter provide guidance on creative ways to drain runoff into the SCM and release the treated runoff.

Check bioretention media sourcing and composition is important. MHFD recommends confirming the gradation and nutrient content in the field. The engineered media and vegetation are the core water quality treatment

TABLE BR-2. BR COMPONENTS

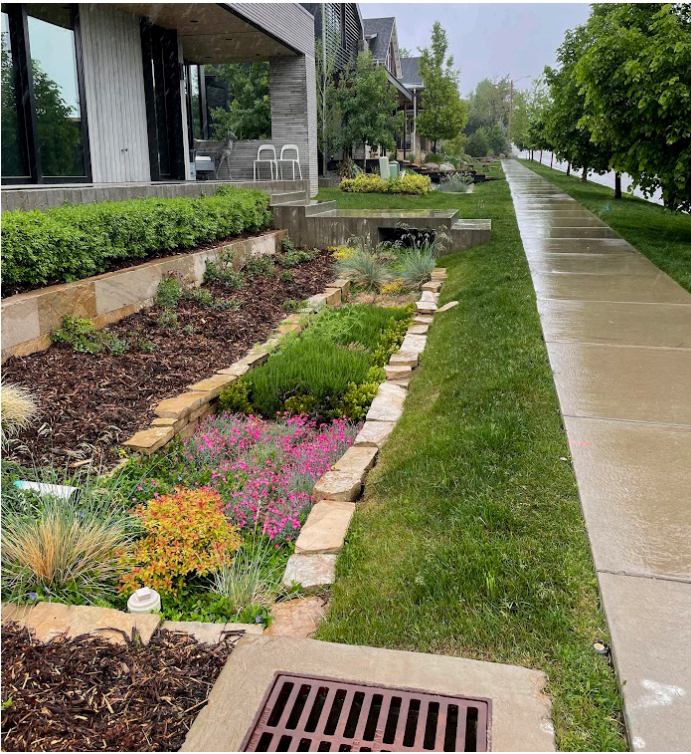
COMPONENT	INTENT
Inlet	Allows stormwater to enter the SCM.
Forebay	Facilitates removal of trash and coarse sediments, providing pretreatment for the SCM.
Energy Dissipation	Minimizes potential for erosion of media surface.
Storage Volume	Provides temporary storage needed to attenuate design flows.
Engineered Media	Supports plant growth and reduces pollutants by filtering and through other biological treatment processes.
Vegetation	Helps maintain infiltration over time through root penetration of media, increases evapotranspiration and biological uptake of pollutants, aerates media, catalyzes soil ecology, and creates an attractive SCM.
Underdrain with Orifice Release	For partial and no infiltration systems, collects and slowly releases the WQCV over 12 hours to reduce erosion in the receiving stream and enhance treatment by increasing contact time with the media.
Outlet Structure	Safely conveys stormwater flows that exceed the design volume. For bioretention systems that detain the EURV and/or 100-year flow, surface outlet structures will have additional orifice controls for surface discharge rather than infiltration through the media.

BENEFITS OF BIORETENTION

- When designed and constructed correctly, routine maintenance is straightforward consisting of sediment/debris removal from the forebay and vegetation management.
- Incorporates multiple treatment processes including sedimentation, filtering, adsorption, evapotranspiration, and biological uptake of constituents.
- Stormwater features are integrated with landscaping.
- Decreases urban heat island effects.
- Can be integrated into space-constrained urban areas in a variety of shapes and sizes.
- Avoids problems with clogging of small orifices common with some EDBs.

LIMITATIONS OF BIORETENTION

- Vegetation requires management.
- Requires additional steps when near a building foundation or when expansive soils exist.
- In a developing or otherwise erosive watershed, sediment loads can clog the system.
- Trash and sediment can block inlets and cause bypass of flows, if not maintained.



Photograph BR-1. This bioretention area treats runoff from the roof and lot, while serving as an aesthetically pleasing landscape feature. Photo: Wright Water Engineers.



Photograph BR-2. Bioretention system treating urban stormwater during runoff event. Photo: Wright Water Engineers.

elements of bioretention. The media must balance good infiltration capabilities with properties needed to support vegetation. MHFD has conducted significant testing of different mixes for bioretention media to develop the recommended specifications in this fact sheet. Additionally, national research has included media amendments targeting specific pollutants (Tirpak et al. 2021, Pitt and Clark 2010, Clark and Pitt 2012, Erickson et al. 2012 & 2021, Hunt et al. 2012, Chandrasena 2014, Mohanty and Boehm 2015, O'Neil and Davis 2012a&b, Mohanty et al. 2018, Herrera 2020, among many others). This fact sheet focuses on a basic engineered media design suitable for broad use in the MHFD jurisdiction, but does not preclude consideration of media amendments designed to target specific pollutants, provided that they maintain the intended functions of MHFD's media.

Other bioretention design variations in the underdrain configuration, such as use of an upturned underdrain elbow to create an internal water storage zone (Brown et al. 2009) to reduce nitrogen, are discussed further in Section 4.3.3 of this chapter.

SITE CONSIDERATIONS

Bioretention is an excellent choice for small sites because it treats the WQCV and serves as a landscape feature. It is typically a much better choice for small sites than an extended detention basin (EDB) because EDBs treating small drainage areas have outlet structures with small orifices that are prone to clogging. Bioretention can also be incorporated into larger sites and can be designed to provide full spectrum detention.

Bioretention systems typically are installed in locations such as:

- Plazas
- Parks
- Parking lot islands
- Street medians



Photograph BR-3. Terraced bioretention SCM in recreation center parking lot. Photo: MHFD

- Landscape areas between the road and a detached walk
- Planter boxes that collect roof drain flows

To avoid clogging of media, bioretention requires a stable watershed. When the watershed includes phased construction, sparsely vegetated areas, or steep slopes, consider another SCM that is less susceptible to clogging or provide pretreatment to facilitate sedimentation before runoff from these areas reaches the bioretention media surface. Additionally, bioretention is intended to dry out between runoff events; therefore, it should not be used when a baseflow is anticipated.

The surface of the bioretention media should be flat or at a mild slope. For this reason, bioretention can be more difficult to incorporate into steeply sloping terrain; however, terracing can be used to create flat areas suitable for bioretention even with sloped topography.

When bioretention areas are located adjacent to structures or infrastructure that could be adversely affected by infiltrating runoff or in areas with expansive soils, consult with a geotechnical engineer. A geotechnical engineer can evaluate the suitability of soils, identify potential impacts, and establish minimum distances or other physical barriers to implement between the bioretention system and structures. See Section 3.0 *Site Assessment* and Section 4.0 *Filtration and Infiltration Systems* for guidance and criteria on geotechnical considerations and testing requirements, underdrain and filter layers, perimeter barriers, and other aspects common to infiltration-based SCMs including bioretention.

COMMUNITY VALUES

Bioretention provides opportunities to provide a high level of treatment for stormwater while also creating landscape features that add value to a site by enhancing the landscape aesthetics and experience. Bioretention areas that are an integral part of the site's landscape provide far more benefits than areas dedicated solely to stormwater treatment, such as small EDBs, because bioretention areas are multifunctional and can serve other purposes including meeting landscape area requirements, providing attractive pockets of interesting plants, aesthetic screening of parking lots, and others.

It is important to establish pre-design planning objectives to facilitate a successful design. At an early stage, determine the aesthetic design approach that best meets the overall project objectives. There are many opportunities for creativity in grading, plant selection, and design of inflow and outflow features for bioretention. Design approaches typically endeavor either to integrate the SCM into its surroundings with a “contextual design,” or consciously contrast with the surroundings to highlight the SCM as a “stand-alone element,” providing a counterpoint to the context of the site.

In a contextual design, the design responds to and builds on the character of the surroundings. Forms and shapes are related to and harmonious with surrounding structures and site improvements and fit into their environment through use of similar or complementary materials, scale, and design detailing. Materials used in this approach may directly reflect materials used in the surrounding architectural and engineering improvements. Coordinate design details for the bioretention area, such as concrete or stone edgers and retaining walls, with the surrounding site improvements to provide a unifying effect with the surroundings. Plant materials should also relate to surrounding landscape in overall character, massing, and degree of formal or naturalistic arrangement, while selecting drought-tolerant plants that will also thrive in the periodically wet environment.

A “stand-alone” or counterpoint design aims to create a feature that contrasts with its surroundings through uses of form, scale, materials, color, and other features. A counterpoint design can create a strong dramatic effect, but to be successful, it must be done in a way that creates an overall balanced site design.

Of these two approaches, contextual design is more common and is generally easier to accomplish. With either approach, the emphasis should be on creating a feature that adds value to the site while effectively treating the WQCV. Maintenance is critical for ensuring long-term function of bioretention and community acceptance, so planning for maintenance and selecting plants that are suitable for the hydrologic conditions in the SCM are important design aspects to avoid burdensome maintenance.

Appropriate plant selection enhances the community value of bioretention systems. Considerations for plant selection from a community-values perspective include:

- Select plants that thrive and perform over the long-term without excessive maintenance. For bioretention to be accepted by the community, it should be attractive (Davis, Traver and Hunt 2022), which requires healthy plants and routine maintenance.
- Select plants appropriate for the site’s unique micro-climatic conditions and bioretention design features, construction techniques, and expected maintenance levels of service. Microclimate, including solar aspect, exposure to wind, and shading or sun reflections from adjacent buildings, can have a significant effect on the conditions that plants must tolerate. Visiting the site during different times of the day in summer months prior to design is very informative for understanding sun and shading as well as urban heat island effects.
- Small trees can provide significant added value to bioretention areas, including runoff reduction and mitigation of urban heat island effects. When considering trees for bioretention systems, assess the compatibility of different species with the hydrologic, soil, and solar aspect of the SCM. Healthy trees also require adequate above and belowground space (Davis et al. 2022). (See additional considerations for trees in the Design section of this fact sheet.)
- Use natives plant species when feasible. Native species tend to tolerate the region’s hot summers and cold winters better than most non-natives. Native grasses have deep roots that can reach residual moisture in the bioretention media during times of drought.
- Select plants that are drought tolerant but that can also tolerate prolonged periods of inundation or media saturation, particularly during sequential storms.
- Consider planting vegetation in groupings or masses of single or similar species. Generally, large masses of plants grouped relatively close together create dense stands of vegetation that grow together to out-compete weed growth, while enhancing infiltration through root penetration that creates macropores as roots die and decay.

MAINTENANCE

Routine maintenance of bioretention is similar to landscape maintenance, consisting of trash and sediment removal from the forebay and care for vegetation. Chapter 6 of this manual provides recommended maintenance practices for all SCMs. During design, consider the following during design to ensure ease of maintenance over the long-term:

- Consider how the SCM will be accessed for routine and restorative maintenance, what equipment will be required, and how routine maintenance activities can be performed in a way that minimizes impacts to vegetation.
- Understand the level of maintenance that will be needed over the long term. Bioretention features designed as aesthetic amenities in public areas may require more frequent maintenance than those with more naturalized designs in suburban settings. Do not select plantings that require frequent maintenance if the owner does not have the resources to perform such maintenance. Poorly maintained bioretention areas can become weedy eye sores that contribute to poor public acceptance.
- Make the bioretention surface area (bowl) as shallow as needed. Increasing the depth unnecessarily can create erosive side slopes and complicate maintenance. Shallow bioretention areas are also more attractive.
- The best surface cover for bioretention is full vegetation, in part because it reduces weeding and various mulch-related maintenance issues. Use rock mulch sparingly because it limits infiltration, is more difficult to maintain and can also increase urban heat island effects. Wood mulch handles sediment build-up better than rock mulch; however, wood mulch floats and can settle unevenly or clog the overflow depending on the configuration of the outlet. Some municipalities may not allow wood mulch for this reason. When specifying mulch, look for shredded varieties. Also, increase density of grasses at the interface of the forebay and vegetation to slow flows entering the basin.
- Provide pretreatment when it will reduce the extent and frequency of maintenance necessary to maintain function over the life of the SCM. Provide a forebay for any concentrated inflows. For small inflows, the forebay may consist of a pad for sediment accumulation and removal surrounded by grasses to help keep sediment from migrating onto the filter area.
- Note that research shows that deicers can cause reduced infiltration rates in media and soils with clay content (Sileshi, Pitt and Clark 2017). Understand the composition of the media and the underlying soils in this respect and develop the planting plan accordingly. Deicers in runoff can stress vegetation, which may result in increased maintenance and vegetation replacement requirements. Conifers are particularly sensitive to salt.
- Establishing healthy vegetation is critical for this SCM to properly function. Design and adjust the irrigation system (temporary or permanent) to provide appropriate water for the establishment and maintenance of selected vegetation.
- Consider maintenance access and requirements for tree pruning and frequency of raking, if trees are included in bioretention systems. Do not operate heavy equipment on the media surface (e.g., cherry picker lifts) for tree pruning.
- Do not put a filter sock on the underdrain. This is not necessary and can cause the underdrain to clog.
- Never use bioretention systems for snow storage. Designate a location for snow storage elsewhere.

DESIGN PROCEDURES & CRITERIA

Criteria and guidance for bioretention components including inlets, forebays, underdrains, liners, and outlets are provided in the front section of this chapter. Reference this section for design of these specific features.

The SCM Design workbook, available at www.mhfd.org, is an Excel-based workbook that steps through the criteria listed below and performs design calculations for bioretention. Use this workbook to ensure designs meet criteria for treating the WQCV. Use a separate tool, MHFD-Detention, to develop and route storm hydrographs for a range of events through bioretention systems.

The following steps outline the design procedures and criteria for designing bioretention for water quality:

1. **Subsurface Exploration and Determination of a Full Infiltration, Partial Infiltration or No-Infiltration Section:** See Section 3.0 *Site Assessment* and Section 4.0 *Filtration and Infiltration Systems* of this chapter to determine the most appropriate type of filtration and/or infiltration system for the bioretention area based on site conditions.
2. **Inlet Design and Pretreatment:** See Section 5.0 *SCM Inflow Features* of this chapter for guidance and criteria for inlets, energy dissipation, and forebays. Provide pretreatment with a properly designed forebay or other device designed to remove coarse sediment, trash, and debris. Pretreatment of roadway runoff to remove sediment is especially critical for bioretention systems receiving roadway runoff.

Where feasible, inlets set above the WQCV elevation will reduce maintenance requirements related to sediment deposition in the inflow pipe due to backwater conditions.
3. **Design Storage Volume:** Provide a storage volume equal to the WQCV¹ based on a 12-hour drain time, after accounting for runoff-reduction SCMs in the contributing watershed. Determine the required WQCV (watershed inches of runoff) using Equation 3-2 of Chapter 3 of this manual (for WQCV). Always size SCMs based on their tributary area. When sizing the basin for EURV or larger detention volumes, see the *Storage* chapter of Volume 2. Where needed to meet the required volume, also consider the available void storage capacity of the media at 15 percent.
4. **Bioretention System Basin Geometry:** Basin geometry considerations include surface area, filter surface slopes and ponding depth.
 - **Media Surface Area:** Equation BR-1 provides a minimum media surface area for the WQCV allowing for some of the volume to be stored beyond the flat area of the media (i.e., above the side slopes of the bioretention basin). Additional surface area beyond this minimum may be necessary to meet the maximum recommended ponding depth.

$$A_F = 0.02 \cdot A \cdot I$$

Equation BR-1

Where:

A_F = minimum filter area (ft²)

A = area tributary to the SCM (ft²)

I = imperviousness of tributary area draining to the SCM (percent expressed as a decimal)

Use vertical walls or slope the sides of the basin to achieve the required volume. Side slopes should be no steeper than 4:1.

- **Ponding Depths:** Maximum ponding depths vary depending on the bioretention design, with a maximum recommended WQCV ponding depth of 12 inches stored above the surface to minimize stress to vegetation for frequent inundation and to manage the hydraulic loading. When the bioretention basin is designed for the WQCV only, locate the overflow spillway crest at or above the elevation associated with the maximum ponding depth for the WQCV measured vertically from the flat filter media surface.
- **Media Surface Slopes:** The media surface of the bioretention area typically should be flat. The exception to this is when a mild slope (e.g., < 1%) from the inlet to the outlet will help distribute runoff to the vegetation and reduce sediment deposited at the inlet. Linear systems, such as streetside stormwater planters, may benefit from a mild slope from inlet to outlet. When the flow path is long, consider level grade beams to maintain sheet flow. The intent is to fully use the filter area to avoid higher sediment deposition in lower areas of the basin.

¹MHFD's standard design procedure is based on treatment of the WQCV, which corresponds to the Colorado's MS4 WQCV design standard. In some cases, bioretention systems may be designed to meet a volume reduction target, particularly where underlying soils allow for infiltration. In this case, conduct site-specific analysis to determine whether the volume reduction target can be met for site conditions.

TABLE BR-3. BIORETENTION MEDIA PROPERTIES

SOIL PARAMETERS	TEST NAME	BIORETENTION MEDIA PROPERTIES
Texture/Gradation	ASTM D7928 Sedimentation (Hydrometer) Method	<u>Particle Size Distribution:</u> 70-80% Sand (0.05-2.0 mm diameter) 5-25% Silt (0.002-0.05 mm diameter) 5-15% Clay (<0.002 mm diameter) <u>Notes:</u> Sand, silt and clay percentages are by dry weight. Particle sizes are based on the USDA soil classification system. Distribution is measured after gravel > 2 mm is removed from sample. Media should have no more than 25% material > 2 mm. Equivalent sieve sizes for the upper and lower limit of sand are #10 and #240, respectively.
Organic Matter	ASTM D2974	1-5% by dry weight
pH	ASA/AASHTO	6.0 - 8.5
Salinity/Salts (EC) dS/m or mmhos/cm	Saturated Paste	<3
Nitrate Nitrogen (ppm)	ASA2 33-3	<30
Phosphorus (ppm)	Use Olsen when pH>6.2, otherwise use Mehlich-3	Olsen: <20 or Mehlich-3: <30

5. **Underdrain System, Impermeable Liner, and Geotextile Separator Fabric:** See Section 4.0 *Filtration and Infiltration Systems* of this chapter for guidance and criteria based on the type of filtration and infiltration system selected. Underdrain systems in bioretention basins consist of a slotted PVC pipe placed within a layer of drain gravel beneath the bioretention media. A 6-inch layer of sand is also specified above the drain gravel in Section 4.0. Research (Herrera 2020) indicates that a sand layer below the media can serve as a polishing layer for the effluent.

6. **Bioretention Media:** Provide a minimum of 18 inches of bioretention media to enable establishment of the roots of the vegetation. If trees are planted, increase the media depth to 36 inches.

MHFD's bioretention media is intended to balance high infiltration capacity with properties needed to support healthy vegetation. Table BR-1 outlines recommended parameters for bioretention media. MHFD's media recommendation begins with topsoil that can be amended as needed, typically with sand, until it meets the specifications in Table BR-1. See *Availability of Bioretention Media in the MHFD Region* (MHFD 2023) for more information. It is important that the media contain organic material with living soil organisms such as earthworms, bacteria, and fungi to enhance agronomic and infiltration properties and create a healthy, living media. Do not add compost to the bioretention media; instead, other forms of organic matter such as mulch, peat or woodchips should be used if needed because they have lower nitrogen and phosphorus content and are more resistant to microbial degradation (Davis, Hunt and Traver 2022).

The media texture in Table BR-1 has a slightly higher proportion of silts and clays and a lower sand percentage compared to prior MHFD media specifications. The purpose of this change is to increase moisture and nutrient holding capacity to aid in the establishment of a dense vegetation cover, which ultimately helps to sustain infiltration capacity.

A high level of quality control for the media is critical. Quality control measures include reviewing media particle size distribution data, media chemistry data, and results of nutrient analysis to ensure that the media meets specifications. The media can either be sampled after delivery and prior to placement, or sampled by the supplier just prior to site delivery. In any case, the samples should be collected within several days of placement of the media so that the results are representative of the media placed.

7. **Vegetation:** The media must be vegetated. MHFD recommends drought-tolerant species that thrive in sandy soils. Approaches to vegetating bioretention areas can include planting sod-forming native grasses from seed, installing sand-grown sod, and/or planting container-grown plants or small trees. Consult with a vegetation specialist to understand which types of vegetation will be successful in a given location, considering shade, heat island effects, application of deicers in the watershed, and other site-specific factors. Recommendations for vegetation established from seed, planted in containers or plugs, and trees follow. While establishment from seed typically costs less than container-grown plants, container-grown plants establish more quickly and are less susceptible to being washed away during establishment. A mixture of container-grown plants and seed may help with initial vegetation cover and media stabilization.

Table BR-4 provides a suggested seed mix for sites that typically will not need to be irrigated after the grass has been established, except for periods of extended drought. Guidelines for establishing vegetation from seed include:

- Mix seed well and broadcast, followed by hand raking to cover seed .
- Immediately after seeding, install a biodegradable 100-percent coconut erosion control blanket over the media to keep seed and media in place during runoff and irrigation events during establishment.
- Consider seasonality when planting to ensure establishment. Both frequent storms and extended hot, dry periods can affect seed establishment.
- Do not place seed when standing water or snow is present or if the ground is frozen.
- Weed control is critical in the first two to three years, especially when starting with seed.

When using sod, specify sand-grown sod which is available in Colorado, although not as common as conventional sod. Do not use conventional sod. Conventional sod is grown in clay soil that can seal the filter area, greatly reducing overall function of the SCM. Be aware that local jurisdictions may restrict use of turf varieties with high irrigation requirements (e.g., Kentucky bluegrass) and may require native grasses for water conservation reasons.

TABLE BR-4. NATIVE SEED MIX FOR BIORETENTION

COMMON NAME	SCIENTIFIC NAME	VARIETY	PURE LIVE SEED (PLS)	
			POUNDS/ACRE	OUNCES/ACRE
Sand bluestem	<i>Andropogon hallii</i>	Garden	3.5	
Sideoats grama	<i>Bouteloua curtipendula</i>	Butte	3	
Prairie sandreed	<i>Calamovilfa longifolia</i>	Goshen	3	
Indian ricegrass	<i>Oryzopsis hymenoides</i>	Paloma	3	
Switchgrass	<i>Panicum virgatum</i>	Blackwell	4	
Western wheatgrass	<i>Pascopyrum smithii</i>	Ariba	3	
Little bluestem	<i>Schizachyrium scoparium</i>	Patura	3	
Alkali sacaton	<i>Sporobolus airoides</i>		3	
Sand dropseed	<i>Sporobolus cryptandrus</i>		3	
Pasture sage ¹	<i>Artemisia frigida</i>			2
Blue aster ¹	<i>Aster laevis</i>			4
Blanket flower ¹	<i>Gaillardia aristata</i>			8
Prairie coneflower ¹	<i>Ratibida columnifera</i>			4
Purple Prairie Clover ¹	<i>Dalea (Petalostemum) purpurea</i>			4
Sub-Totals:			27.5	22
Total pounds/acre			28.9	

¹ Wildflower seed (optional) for a more diverse and natural look.

TABLE BR-5. CONTAINER-GROWN PLANTS AND PLUGS FOR BIORETENTION (SOURCE: CITY & COUNTY OF DENVER 2016)

COMMON NAME	SCIENTIFIC NAME
Grasses	
Dancing Wind Big Bluestem	<i>Andropogon gerardii</i> 'Dancing Wind'
Windwalker Big Bluestem	Winter <i>Andropogon gerardii</i> 'P003S'
Feather Reed Grass	Winter <i>Calamagrostis x acutiflora</i> 'Karl Forester'
Tufted Hair Grass	<i>Deschampsia caespitosa</i>
Blonde Ambition Grama Grass	<i>Bouteloua gracilis</i> 'Blonde Ambition'
Hot Rod Switchgrass	<i>Panicum virgatum</i> 'Hot Rod'
Northwind Switchgrass	<i>Panicum virgatum</i> 'Northwind'
Prairie Sky	<i>Panicum virgatum</i> 'Prairie Sky'
Prairie Blues Little Bluestem	<i>Schizachirium scoparium</i> 'Prairie Blues'
Undaunted Ruby Muhly	<i>Muhlenbergia reverchoni</i> 'Undaunted'
Prairie dropseed	<i>Sporobolus heterolepis</i>
Herbaceous Perennials	
Pearly Everlasting	<i>Anaphalis margaritacea</i>
Prairie Bluebell	<i>Mertensia lanceolata</i>
Dakota Sunshine Sunflower	<i>Helianthus maximiliani</i> 'Dakota Sunshine'
Western Blue Flag Iris	<i>Iris missouriensis</i>
Rocky Mountain Gayfeather	<i>Liatris ligulistylis</i>
Wild Bergamont	<i>Monarda fistulosa</i>
Eastern Bergamont	<i>Monarda bradburiana</i>
Evening Primrose	<i>Oenothera fruticosa</i> 'Fireworks' / Fyrveckeri
Husker Red Penstemon	<i>Penstemon digitalis</i> 'Husker Red'
Garden Phlox	<i>Phlox paniculate</i> 'Blue Paradise'
Border Phlox	<i>Phlox paniculate</i> 'David'
Prairie coneflower	<i>Ratibida pinnata</i>
Bluebird smooth aster	<i>Symphiotrichum laeve</i> 'Bluebird' smooth aster
Bulbs	
Blue Danube Wild Hyacinth	<i>Camassia leichtlinii</i> 'Blue Danube'
Shrubs	
Leadplant	<i>Amorpha canescens</i>
Prairie Snow White Cinquefoil	<i>Dasiphora</i> (Potentilla) <i>fruticosa</i> var. <i>dahurica</i> 'Prairie Snow'
Apache Plume	<i>Fallugia paradoxa</i>
Pawnee Buttes Sand Cherry	<i>Prunus besseyi</i> 'Pawnee Buttes'
Autumn Amber Skunkbush Sumac	<i>Rhus trilobata</i> 'Autumn Amber'
Glow Girl Spirea	<i>Spirea betulifolia</i> 'Tor Gold'

When selecting a container-grown plant palette, consider water needs, exposure (sun/shade), plant height and spread, recommended container sizes, plant spacing and future maintenance requirements. Common container-grown plants or plugs suitable for bioretention systems in urban areas are listed in Table BR-3 (City and County of Denver 2016). Other drought-tolerant plants may also be considered.

When using an impermeable liner, select plants with diffuse (or fibrous) root systems, not taproots. Taproots can damage the liner and/or underdrain pipe.

Small trees may be considered in bioretention areas, provided that adequate media, irrigation, and space are available. Trees are generally better suited for larger bioretention areas. Recommendations for planting trees in bioretention areas include:

- Do not install trees in bioretention systems with an impermeable liner.
- Provide irrigation for trees.
- Consider planting trees on side slopes, above the more frequently inundated areas.
- Select trees that can withstand periods of inundation.
- Avoid conifers in areas exposed to deicing chemicals.
- Provide access for tree maintenance, which may include pruning, removal of bioretention media removal and replacement, tree removal and replacement, and incidental removal of other vegetation.
- Install trees at least 5 feet away from inlets, outlets, and underdrains because tree roots may obstruct inlets and outlets or damage the underdrain. Consider limiting the length of the underdrain to allow for placement of trees where desired.
- For deciduous trees, plan for additional seasonal maintenance to remove leaf litter and avoid media clogging.
- Avoid trees with fruit litter.
- Select shade-tolerant species for tree understory plants.
- When considering trees for bioretention systems located in easements, check local requirements regarding allowed vegetation types and replacement requirements.
- Be aware that some jurisdictions may not allow trees in bioretention.
- See Denver's Ultra-Urban Guidelines (Denver 2016) for tree pit/trench bioretention variations.

8. **Irrigation:** Irrigation is required for vegetation establishment, for supplemental water during extended dry periods, and may be needed on a routine basis depending on plant selection. During establishment, all plants should receive approximately 1 inch of moisture (combined rain and irrigation) per week for the first growing season to promote establishment. Some plants may require more than one growing season to become fully established. Providing a permanent irrigation system at the time of SCM installation provides greater flexibility in plant selection and aesthetics, even if regular irrigation is not routinely required after plant establishment.

Install spray irrigation at or above the WQCV elevation when permanent irrigation is provided or place temporary irrigation on top of the bioretention media surface. Do not place sprinkler heads on the flat media surface as they can become buried over time. Remove temporary irrigation pipes that are laid on the surface once vegetation is established.

VEGETATION ESTABLISHMENT AND INFILTRATION RATES

During vegetation establishment, water applied to bare media can mobilize and rearrange fine silt and clay particles on the surface to create a lower permeability layer. For this reason, vegetation is a critical component in maintaining infiltration in the bioretention system over time. When establishing vegetation from seed, install seed and blanket immediately after media is placed to reduce the mobilization of fines and facilitate germination of the seed.

If left in place, temporary irrigation will become buried over time and will be damaged during maintenance operations.

Adjust irrigation schedules during the growing season to provide the minimum amount of water necessary to maintain plant health, while maintaining free pore space for infiltration.

9. **Outlet:** For partial and no-infiltration configurations, drain the underdrain to the outlet structure and use an orifice plate to drain the WQCV over approximately 12 hours. Section 6.0 *SCM Outflow Features* of this chapter includes conceptual details for the underdrain and orifice outlet both for attenuating the WQCV and larger volumes. When designing for EURV and/or 100-year attenuation, flows greater than the WQCV are controlled and released at the outlet structure, rather than forced through the filter area of the bioretention basin. Provide a spillway for larger events that will convey overflows to the receiving drainage system without adversely affecting adjacent structures or infrastructure. Use the simplified equation in Section 6.1 of this chapter or the MHFD-Detention workbook to size the orifice. MHFD-Detention also aids with design of outlet controls for larger runoff events.

CONSTRUCTION CONSIDERATIONS

Proper construction of bioretention areas involves careful attention to material specifications, final grades, and construction details. For a successful project, implement the following practices:

- Protect the bioretention area from excessive sediment loading during construction. This is the most common cause of clogging of bioretention systems. The portion of the site draining to the SCM must be stabilized before allowing flow into the bioretention area. This includes completion of paving operations.
- Avoid over-compaction of the bioretention area to preserve infiltration rates (for partial and full infiltration sections).
- Provide construction observation to ensure compliance with design specifications. It is important to avoid improper installation, particularly related to elevations of the inlet, underdrain and outlet. Observation/oversight is recommended for the following:
 - » Conformance of subgrade with design assumptions.
 - » Installation of impermeable liner (for no infiltration sections).
 - » Construction of underdrain and installation of media layer.
 - » Review of bioretention media test data to verify conformance with specifications prior to installation.
- Provide adequate construction staking to ensure that the site properly drains into the SCM, particularly with respect to surface drainage away from adjacent buildings.

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participants

Custom Soil Resource Report for Boulder County Area, Colorado



Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

Custom Soil Resource Report

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report Soil Map



Custom Soil Resource Report

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

Special Point Features

 Blowout

 Borrow Pit

 Clay Spot

 Closed Depression

 Gravel Pit

 Gravelly Spot

 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry

 Miscellaneous Water

 Perennial Water

 Rock Outcrop

 Saline Spot

 Sandy Spot

 Severely Eroded Spot

 Sinkhole

 Slide or Slip

 Sodic Spot

 Spoil Area

 Stony Spot

 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

Water Features

 Streams and Canals

Transportation

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Boulder County Area, Colorado
Survey Area Data: Version 21, Sep 6, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 1, 2020—Jul 2, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AcA	Ascalon sandy loam, 0 to 3 percent slopes	1.7	100.0%
Totals for Area of Interest		1.7	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Custom Soil Resource Report

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Boulder County Area, Colorado

AcA—Ascalon sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2swl3
Elevation: 3,870 to 5,960 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 135 to 160 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Ascalon and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ascalon

Setting

Landform: Interfluves
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Wind-reworked alluvium and/or calcareous sandy eolian deposits

Typical profile

Ap - 0 to 6 inches: sandy loam
Bt1 - 6 to 12 inches: sandy clay loam
Bt2 - 12 to 19 inches: sandy clay loam
Bk - 19 to 35 inches: sandy clay loam
C - 35 to 80 inches: sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to very slightly saline (0.1 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water supply, 0 to 60 inches: Moderate (about 7.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: B
Ecological site: R067BY024CO - Sandy Plains
Hydric soil rating: No

Minor Components

Olnest

Percent of map unit: 10 percent

Landform: Interfluves

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Tread

Down-slope shape: Linear

Across-slope shape: Linear

Ecological site: R067BY024CO - Sandy Plains

Hydric soil rating: No

Vona

Percent of map unit: 5 percent

Landform: Interfluves

Landform position (two-dimensional): Summit

Down-slope shape: Linear

Across-slope shape: Linear

Ecological site: R067BY024CO - Sandy Plains

Hydric soil rating: No

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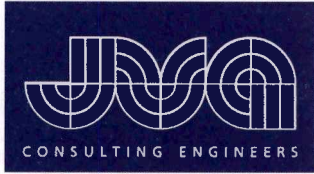
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- United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. <http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084>

Custom Soil Resource Report

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PRELIMINARY DRAINAGE REPORT

FOR THE

LOUISVILLE MILL SITE

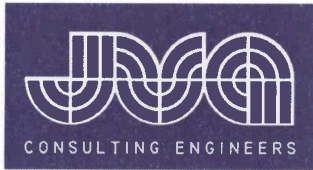
AT

**500, 540, AND 544 COUNTY ROAD
LOUISVILLE, COLORADO 80027**

FOR

LOUISVILLE MILL SITE, LLC

April 3, 2014
Revised September 30, 2014
Revised March 12, 2015



JVA, Incorporated
1319 Spruce Street
Boulder, CO 80302
Ph: 303.444.1951
Fax: 303.444.1957
Toll Free: 877.444.1951

Web site:
www.jvajva.com

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info@jvajva.com

March 12, 2015

Mr. Craig Duffin, Assistant City Engineer
City of Louisville – Engineering Development Review
749 Main Street
Louisville, CO 80027

RE: Preliminary Drainage Report
Louisville Mill Site
Louisville, CO 80027
JVA No. 2221c

Dear Craig:

The following *Preliminary Drainage Report* and enclosed drainage figures for this project have been prepared for the above referenced project. The stormwater report and figures have been produced in accordance with the “City of Louisville, Storm Drainage Design and Technical Criteria, 2013 Edition” and comply with provisions thereof. Revisions have been made to this report based on comments received from the Final PUD submittal on December 31, 2014.

It is our understanding that the information provided herein meets all requirements of the City of Louisville.

Please contact us if you have any questions regarding this submission.

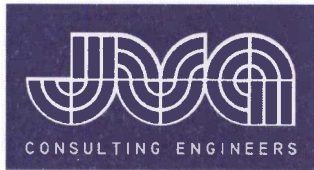
Sincerely,
JVA, Inc.

A handwritten signature in blue ink, appearing to read 'Darren Stewart', is written over a horizontal line.

Darren Stewart
Project Manager

A handwritten signature in black ink, appearing to read 'Charlie R. Hager, IV', is written over a horizontal line.

Charlie R. Hager, IV, P.E.
Vice President



ENGINEER'S STATEMENT:

"I hereby certify that this report (plan) for the final drainage design of Louisville Mill Site was prepared by me (or under my direct supervision) in accordance with the provisions of City of Louisville Storm Drainage Design and Technical Criteria for the owners thereof."

Charlie R. Hager
Registered Professional Engineer
State of Colorado No. 37146

PRELIMINARY DRAINAGE REPORT
LOUISVILLE MILL SITE
AT
500, 540, AND 544 COUNTY ROAD
LOUISVILLE, COLORADO 80027
FOR
LOUISVILLE MILL SITE, LLC

JVA, Inc.
1319 Spruce Street
Boulder, CO 80302
phone (303) 444-1951
fax (303) 444-1957

JVA Project No. 2221c

April 3, 2014
Revised September 30, 2014
Revised March 12, 2015

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FIGURE 1 – HISTORIC DRAINAGE MAP
FIGURE 2 – DEVELOPED DRAINAGE MAP

PRELIMINARY DRAINAGE REPORT

INTRODUCTION

GENERAL LOCATION AND DESCRIPTION

Louisville Mill Site, LLC, is proposing the redevelopment of the existing historic Louisville Mill Site located at the southeast corner of the intersection of County Road and Elm Street in Louisville, Colorado. The subject property is approximately 1.54 acres of previously developed land located in the Southeast Quarter of the Southeast Quarter of Section 8, Township 1 South, Range 69 West of the 6th Principal Meridian in Boulder County, City of Louisville, State of Colorado. More specifically, the site is bound by County Road 124 to the west, a railroad right-of-way for BNSF Railway Company to the east, and residential properties to the north and south. A vicinity map is included in Appendix A of this report.

PROPOSED PROJECT

The proposed development will include the preservation and restoration of the existing historic mill building, an addition to an existing warehouse building on the south side of the site, and a new commercial and office building on the north side of the site. The areas surrounding these buildings within the site will be redeveloped with parking, access drives, utility infrastructure and landscaping. The right-of-way along County Road will be redeveloped out to the edge-of-roadway and includes curb and gutter replacement, sidewalk replacement, site drive ramps, street lighting upgrades, and landscape improvements.

HISTORIC DRAINAGE

MAJOR DRAINAGE BASIN DESCRIPTION

The site's ultimate outfall is Coal Creek southeast of the property.

According to the FEMA Flood Insurance Rate Map Number 08013C0582J, dated December 18, 2012, the north end of the site is located within Flood Zone AH, with an elevation of NAVD88 5333. A portion of the referenced flood map is included in Appendix A.

EXISTING SITE DRAINAGE AND FACILITIES

Stormwater detention and water quality enhancements are not provided in the existing condition. The existing site consists of a one story commercial building, the historic mill building and the existing warehouse building. The site generally lies between 5335 feet and 5330 feet on the NAVD88 datum with existing grades generally sloping south to north. The existing site is approximately 60% impervious, with pervious areas consisting of irrigated turf and landscape and gravel parking areas. An additional 0.48 acres of offsite flows enter the site from the railroad ROW to the east. Refer to the Historic Drainage Map (see enclosed Figure 1).

The soils found onsite are Ascalon sandy loam with a NRCS hydrologic soils group rating of B. Soils with a rating of B have a moderate infiltration rate when thoroughly wet and therefore have moderate runoff potential. A copy of the NRCS soils classification map is included in the Appendix.

Runoff from the site currently flows overland to the northeast corner of the site where an existing Type R curb inlet is located in the BNSF Railroad ROW and a small catch basin is located within the property limits. The catch basin is connected to a 54" diameter City storm drain that comes from County Road and has an outfall on the east side of Highway 42. The Type R inlet outlets into a ditch on the other side of the railroad. The Type R sits slightly above grade, therefore most likely only works in a ponding condition. Drainage flows from the existing Type R inlet are conveyed by open channel and culverts to State Highway 42, then is conveyed south by sheet flow through CDOT ROW to Coal Creek.

During smaller storm events, runoff is conveyed through the catch basin. Per discussions with City staff, this storm sewer system is planned to be improved to convey flood flows out of this area and under the railroad with work possibly starting in 2015.

PROPOSED (REDEVELOPED) DRAINAGE

DRAINAGE DESIGN CRITERIA

The proposed private storm drainage facilities for the project are designed to comply with the "City of Louisville, Storm Drainage Design and Technical Criteria," 2013 Edition, and the Urban Drainage and Flood Control District's Urban Storm Drainage Criteria Manual (USDCM), June 2001 Edition.

HYDROLOGIC METHOD AND DESIGN STORM FREQUENCIES

Design storm recurrence intervals for this project are consistent with the City of Louisville requirements for residential and commercial areas: the minor or initial storm will be the 2-year event (for onsite private storm systems), and the major storm will be the 100-year event (for overland and street conveyance).

The Rational Method ($Q=CIA$) was used to determine the storm runoff (Q) from the site, with composite runoff coefficients (C) and contributing areas (A) given for design points in sub-basins. Intensities (I) were determined using the Time-Intensity-Frequency Curves for Louisville, Colorado (Table 2) and a calculated Time of Concentration (t_c). Post-development Time of Concentration calculations for each sub-basin, corresponding rainfall intensities, and composite runoff coefficients for each sub-basin are provided in the Appendix.

PROPOSED SITE BASINS

The development is divided into four overall onsite basins that contribute to the primary storm drain system which provides water quality treatment. Two smaller basins flow offsite without water quality treatment. Three offsite basins east of the site currently flow across the existing site, and these will be routed to the proposed storm drainage system. As requested by the City as part of their flood improvement project, two 15-ft Type R curb inlets are proposed along the northern access drive. These inlets will be in a sump condition and connect directly to the existing 54" storm drain. As proposed, all basins free release runoff, undetained.

Basin Descriptions:

- Basin A: 0.06 acres – Basin A is located in the northern portion of the site and is comprised of an asphalt parking lot and landscaping. Runoff from this basin will flow overland to be captured by inlets and conveyed into the proposed storm drain system and water quality device.
- Basin B: 0.20 acres – Basin B consists of the roof drainage from the commercial building on Lot 3. This drainage will be connected directly to the proposed storm drainage system and water quality device.
- Basin C: 0.14 acres – Basin C consists of asphalt parking, sidewalks, roof drainage from the existing mill building and landscape areas. Runoff will be conveyed via curb inlet to the proposed storm sewer and water quality device.
- Basin D: 0.28 acres – Basin D is located on the western perimeter of the site adjacent to the public right-of-way. Runoff from the basin will flow overland into the right-of-way and into gutters on County Road. Flows will be intercepted by an existing Type R inlet at the corner of the existing north access to the property and County Road on the northern edge of the project.
- Basin E: 0.38 acres – Basin E is located in the southern end of the property and consists of asphalt parking, sidewalks, and roof drainage from the existing warehouse building and landscape areas. Runoff will be conveyed via curb and gutter to the Type 16 curb inlet and conveyed to the water quality device.
- Basin F: 0.18 acres – Basin F lies on the southern perimeter of the site and will maintain the historic drainage pattern that conveys flows south into an existing irrigation ditch. No changes are proposed in this basin as part of this development. Currently, the owner of 500 County Road is in contact with the irrigation ditch owner for approval.
- Basin G: 0.11 acres – Basin G lies north of the proposed building on Lot 3 and consists primarily of paved roadway. This basin will convey flow to the 2- 15-ft Type R inlets and directly into the existing 54” storm drain.
- Basin H: 0.20 acres – Basin H lies west of the mill building and consists of primarily landscaped areas. This basin will drain to an area drain that connects to the proposed storm sewer.
- Basin OS1: 0.24 acres – Basin OS1 is located on the southeast corner of the site in the railroad ROW. This area has historically drained through the property and consists of gravel parking and dirt and grass areas. This basin will be conveyed via curb and gutter curb inlet located in Basin E.
- Basin OS2: 0.07 acres – Basin OS2 is located on the eastern edge of the site in the railroad ROW. This area has historically drained through the property and consists of gravel parking and dirt and grass areas. This basin will be conveyed via curb and gutter to the Type 13 inlet at Design Point 8.

- Basin OS3: 0.15 acres – Basin OS3 is located on the northeast edge of the site in the railroad ROW. This area has historically drained through the property and consists of gravel parking and dirt and grass areas. This basin will be conveyed via a concrete pan to the Type 13 inlet at Design Point 9. The existing Type R inlet located in this basin is approximately 12-inches above grade and will only function in a flooding event. If this basin is developed for parking, improvements will incorporate this inlet and not negatively impact its flood overflow functionality.

RUNOFF AND STORMWATER QUALITY ENHANCEMENT/DETENTION FACILITIES

Due to the developed nature of the site, constraints of working around the historic grain elevator, limited amount of landscaped area, and location within the shallow flooding Zone, a water quality capture volume BMP and detention are not provided for the redevelopment project, as discussed with the City. An underground water quality unit (hydronic separator type) will be provided prior to connecting the proposed storm sewer to the existing City storm sewer to provide water quality for the developed site. This unit is located adjacent to an access road for maintenance access. The proposed project will increase imperviousness from 57% to 67%, therefore post developed flows will show a small increase from historic levels. The overall 10-year design flow rate from the site will increase from 4.4 cfs to 6.0 cfs. The overall 100-year design flow rate from the site will increase from 8.8 cfs to 11.2 cfs.

Water quality will be provided for the majority of the site as well as some off-site basins including Basins A, B, C, H, E, OS-1, OS-2 and OS-3 by an underground water quality unit (Contech CDS Unit). This unit will be sized to provide treatment for the 2-year developed storm event and bypass the 100-yr event.

As requested, detention and water quality capture volume calculations are provided for the developed site in the appendix for reference.

STREETS

No street improvements are proposed with this development, however walks will be installed along the east side of County Road.

OPEN CHANNEL FLOW

No open channel flow is proposed with this development.

STORM SEWERS

All onsite inlets and storm pipes are designed to capture and carry the minor (2-year) and major (100-year) storm events to the existing storm sewer system.

STORMWATER MANAGEMENT PLAN

The Stormwater Management Plan (SWMP) will be included in the final engineering plans, with all structural and non-structural Best Management Practices (BMP's) shown as required.

STRUCTURAL BMP'S

Temporary structural erosion control features will be established during overlot grading and prior to the building construction. All erosion control measures will be maintained until vegetation becomes established. Vehicle tracking control and inlet protection BMP's will be included on the construction plans. Silt fencing will be installed at critical locations on the site with respect to current and proposed drainage.

NON-STRUCTURAL BMP'S

Non-structural erosion controls, including project schedule, surface roughening and other pollution prevention measures, will be detailed in the construction activities of the SWMP. Permanent, perennial, native seeding will be established onsite in locations specified by the SWMP and Landscape Architect. The seed mix will be provided in the SWMP reference.

WETLAND IMPACTS

No wetland impacts are proposed with this development.

CONCLUSION

20 The drainage facilities for the development of the Louisville Mill Site have been designed in accordance with the City of Louisville, Storm Drainage Design and Technical Criteria, 2013 Edition. Stormwater detention and water quality enhancements are not provided in the existing condition. An underground treatment unit is proposed to provide water quality for the majority of the developed area. The proposed redevelopment will result in a small increase in flow rate as a result of increased imperviousness over the entirety of the site.

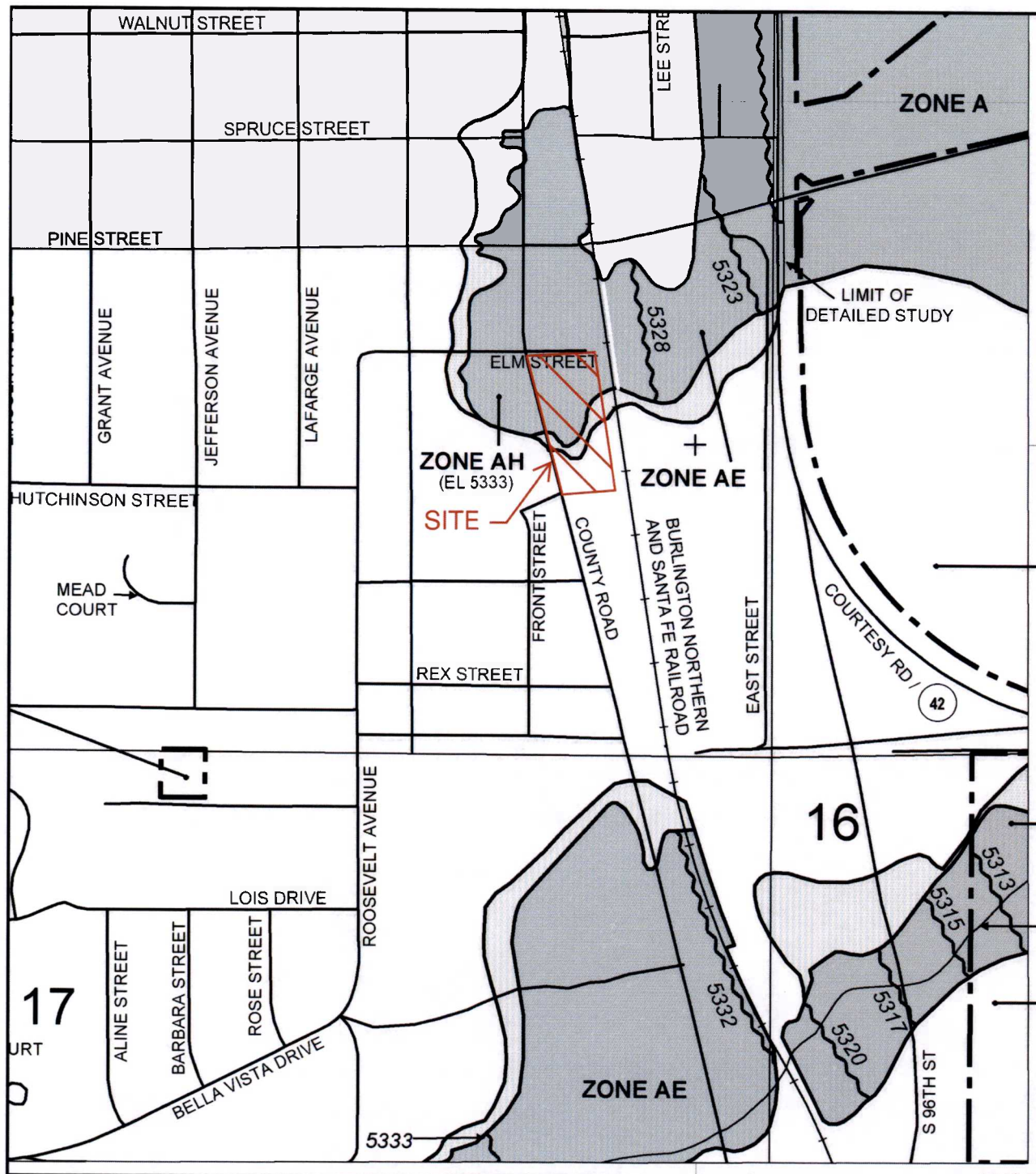
The drainage report for the redevelopment project is non-conforming to the City of Louisville Storm Drainage Design and Technical Criteria Manual. A variance from the City of Louisville Storm Drainage Design and Technical Criteria Manual is being requested for no onsite detention due to lack of landscaped areas, as well as the interest to preserve the historic mill site grounds. In addition, a variance is being requested for the release of runoff into the irrigation ditch from a portion of the existing warehouse building on Lot 1, preserving historic conditions. Currently, the owner of 500 County Road is requesting approval from the irrigation ditch owner to continue historic drainage conditions.

REFERENCES

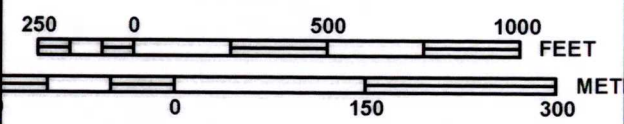
1. "City of Louisville, Storm Drainage Design and Technical Criteria," 2013 Edition.
2. "Urban Storm Drainage Criteria Manual," Urban Drainage and Flood Control District, Revised June 2001.

APPENDIX A – SITE MAPS

AT
500, 540, AND 544 COUNTY ROAD
LOUISVILLE, COLORADO 80027



MAP SCALE 1" = 500'



NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0582J

FIRM

FLOOD INSURANCE RATE MAP
BOULDER COUNTY,
COLORADO
AND INCORPORATED AREAS

PANEL 582 OF 615

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOULDER COUNTY	080023	0582	J
LAFAYETTE, CITY OF	080026	0582	J
LOUISVILLE, CITY OF	085076	0582	J

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.



MAP NUMBER
08013C0582J

MAP REVISED
DECEMBER 18, 2012

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

APPENDIX B— SOIL INFORMATION



United States
Department of
Agriculture

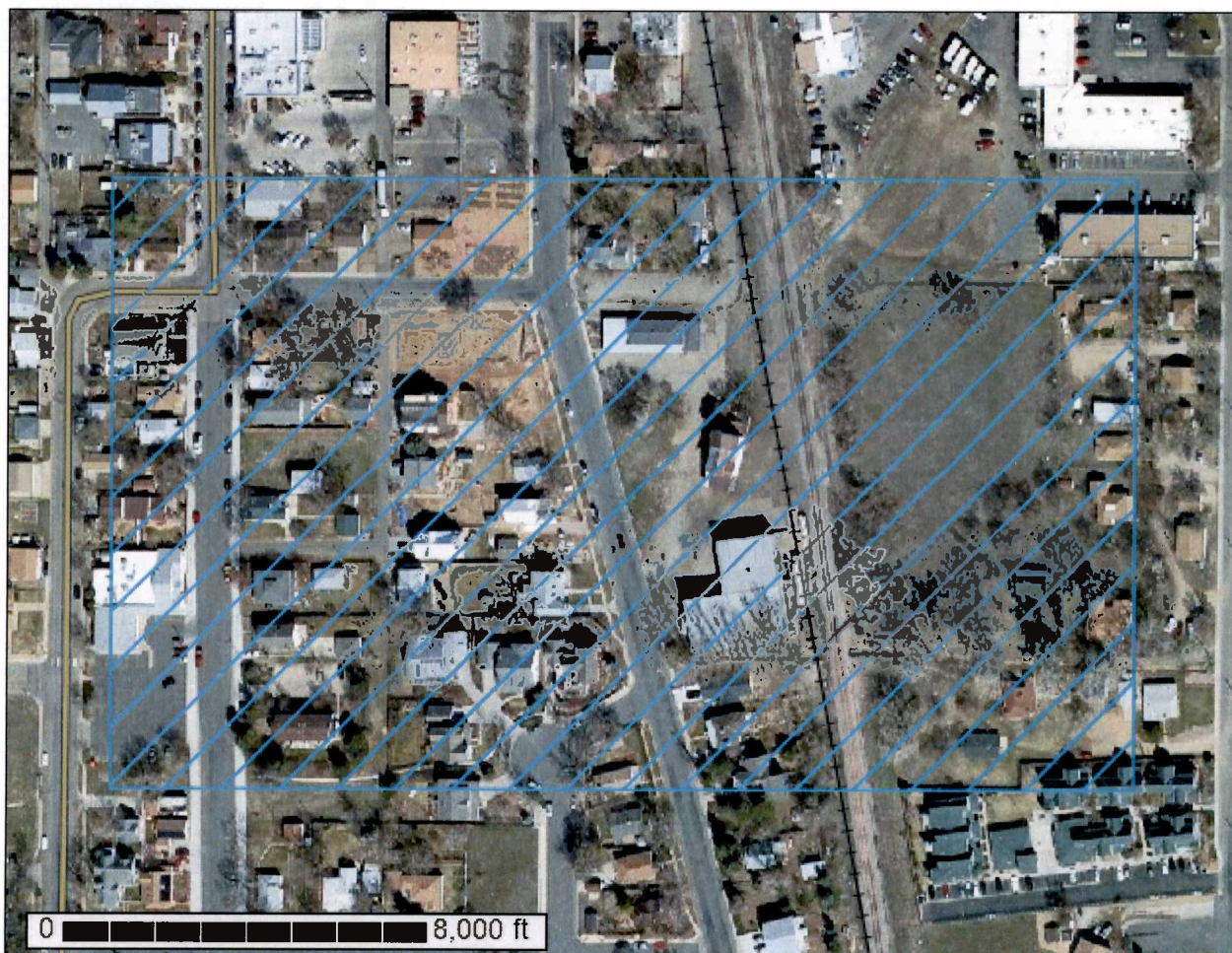


NRCS

Natural
Resources
Conservation
Service

A product of the National
Cooperative Soil Survey,
a joint effort of the United
States Department of
Agriculture and other
Federal agencies, State
agencies including the
Agricultural Experiment
Stations, and local
participants

Custom Soil Resource Report for Boulder County Area, Colorado



April 1, 2014

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<http://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

Custom Soil Resource Report

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

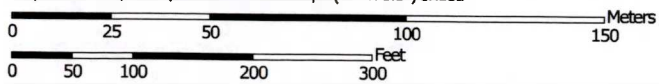
Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report Soil Map



Map Scale: 1:1,910 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

Special Point Features

 Blowout

 Borrow Pit

 Clay Spot

 Closed Depression

 Gravel Pit

 Gravelly Spot

 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry

 Miscellaneous Water

 Perennial Water

 Rock Outcrop

 Saline Spot

 Sandy Spot

 Severely Eroded Spot

 Sinkhole

 Slide or Slip

 Sodic Spot

 Spoil Area

 Stony Spot

 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

Water Features

 Streams and Canals

Transportation

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Boulder County Area, Colorado
Survey Area Data: Version 10, Dec 30, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 28, 2011—Aug 29, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Boulder County Area, Colorado (CO643)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AcA	MLRA 67B - Ascalon sandy loam, 0 to 3 percent slopes	15.6	87.2%
AcC	Ascalon sandy loam, 3 to 5 percent slopes	2.3	12.8%
Totals for Area of Interest		17.9	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If

Custom Soil Resource Report

intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Boulder County Area, Colorado

AcA—MLRA 67B - Ascalon sandy loam, 0 to 3 percent slopes

Map Unit Setting

Elevation: 3,870 to 5,960 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 135 to 160 days

Map Unit Composition

Ascalon and similar soils: 85 percent

Description of Ascalon

Setting

Landform: Paleoterraces, plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Wind-reworked alluvium and/or calcareous sandy eolian deposits

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.1 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Moderate (about 7.7 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 4c
Hydrologic Soil Group: B
Ecological site: Sandy Plains (R067BY024CO)

Typical profile

0 to 6 inches: Sandy loam
6 to 12 inches: Sandy clay loam
12 to 19 inches: Sandy clay loam
19 to 35 inches: Sandy clay loam
35 to 80 inches: Sandy loam

AcC—Ascalon sandy loam, 3 to 5 percent slopes

Map Unit Setting

Elevation: 4,900 to 5,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 140 to 155 days

Map Unit Composition

Ascalon and similar soils: 90 percent

Description of Ascalon

Setting

Landform: Terraces
Landform position (three-dimensional): Side slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed loamy alluvium and/or eolian deposits

Properties and qualities

Slope: 3 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very high (about 16.5 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Sandy (R067XB026CO)

Typical profile

0 to 8 inches: Sandy loam
8 to 19 inches: Sandy clay loam, sandy loam
19 to 60 inches: Fine sandy loam, loamy fine sand, sandy loam

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APPENDIX C – HYDROLOGY

TIME - INTENSITY - FREQUENCY TABULATION

TIME OF CONCENT. (min)	INTENSITY - IN/HR			
	FREQUENCY - YEARS			
	2	5	10	100
5	3.35	4.90	5.85	9.40
10	2.58	3.88	4.65	7.30
15	2.20	3.25	3.88	6.20
20	1.90	2.83	3.35	5.40
25	1.68	2.43	2.95	4.78
30	1.53	2.23	2.63	4.25
35	1.38	2.02	2.38	3.85
40	1.28	1.84	2.18	3.53
45	1.18	1.68	2.02	3.25
50	1.10	1.58	1.87	3.03
55	1.02	1.46	1.76	2.85
60	0.96	1.38	1.68	2.70

NOTE: 1. The minimum time-of-concentration for use with the Rational Method is 5 minutes.

2. Refer to Figure-1 for a plot of the data

3. Refer to Text Section 4.3 "Rational Method"

WRC, Inc.

Reference:

Date: Dec, 1981

NOAA Atlas 2, Precipitation - Frequency Atlas of the Western United States, Volume III - Colorado

CITY OF LOUISVILLE
STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA

TABLE 3

RUNOFF COEFFICIENTS FOR RATIONAL METHOD

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	2	5	10	100
<u>Business:</u>					
Commercial Areas	95	.87	.88	.90	.93
Neighborhood Areas	65	.60	.65	.70	.80
<u>Residential:</u>					
Single-Family	40	.40	.45	.50	.70
Multi-Unit (detached)	50	.50	.55	.60	.75
Multi-Unit (attached)	70	.65	.70	.70	.80
1/2 Acre Lot or Larger	30	.30	.40	.45	.65
Apartments	70	.65	.70	.70	.80
<u>Industrial:</u>					
Light Areas	80	.75	.80	.80	.85
Heavy Areas	90	.80	.80	.85	.90
<u>Parks, Cemeteries</u>	7	.15	.25	.35	.60
<u>Playgrounds</u>	13	.20	.30	.40	.70
<u>Schools</u>	50	.50	.55	.60	.75
<u>Railroad Yard Areas</u>	40	.40	.45	.50	.70
<u>Undeveloped Areas:</u>					
Historic Flow Analysis	2	.10	.20	.30	.60
Greenbelts, Agricultural					
Offsite Flow Analysis (when land use not defined)	45	.45	.50	.55	.72
<u>Streets:</u>					
Paved	100	.87	.88	.90	.93
Gravel	7	.15	.25	.35	.65
<u>Drives and Walks</u>	96	.85	.87	.90	.92
<u>Roofs</u>	90	.80	.85	.90	.90
<u>Lawns, Sandy Soil</u>	0	.00	.10	.20	.50
<u>Lawns, Clayey Soil</u>	0	.10	.20	.30	.60

NOTE: These Rational Formula coefficients do not apply for larger basins where the time-of-concentration exceeds 60 minutes.

WRC, Inc.

Reference: Urban Drainage & Flood Control District Rational Formula Procedure, Hydrology Research Program, August 1979.

Date: Dec, 1981

APPENDIX D – CALCULATIONS



JVA Incorporated
1319 Spruce Street
Boulder, CO 80302
Ph: 303.444.1951
Fax: 303.444.1957

Job Name: Louisville Mill Site
Job Number: 2221c
Date: 9/3/14
By: MDE

Louisville Mill Site

Historic Runoff Coefficient & Time of Concentration Calculations

Location: Louisville
Minor Design Storm: 10
Major Design Storm: 100
Soil Type: C/D

$$CA = KA + (1.31i3 - 1.44i2 + 1.135i + 0.12)$$

$$CCD = KCD + (0.858i3 - 0.786i2 + 0.774i + 0.04)$$

$$CB = (CA + CCD)/2$$

Basin Design Data

	I (%) =	100%	90%	90%	40%	10%	25%	0%	0%		I (%)	Runoff Coeff's				Initial Overland Time (t _i) t _i =0.395(1.1-C _s)L ^{1/2} S ^{-1/3}			Travel Time (t _t) x 60)				t _t =Length/(Velocity			t _c Comp	tc Urbanized Check ON		t _c Final
Basin Name	Design Point	A _{paved streets} (sf)	A _{drives/co nc} (sf)	A _{roof} (sf)	A _{gravel} (sf)	A _{plygnd} (sf)	A _{art. turf} (sf)	A _{escape (R soil)} (sf)	A _{escape (C/D soil)} (sf)	A _{Total} (sf)	A _{Total} (ac)	Imp (%)	C2	C5	C10	C100	Upper most Length (ft)	Slope (%)	t _i (min)	Length (ft)	Slope (%)	Type of Land Surface	C _v	Velocity (fps)	t _t (min)	Time of Conc t _t + t _c = t _c	Total Length (ft)	t _c =(L/180)+10 (min.)	Min t _c
H1	1		2,840					325		3,165	0.07	80.8%	0.60	0.63	0.67	0.75	62	1.5%	5.9			Paved areas & shallow paved swales	20	0.0	0.0	5.9	62	10.3	5.9
H2	2		3,570		4,555			800		8,925	0.20	56.4%	0.38	0.43	0.49	0.62	125	2.2%	10.5			Paved areas & shallow paved swales	20	0.0	0.0	10.5	125	10.7	10.5
H3	3			6,525				1,295		7,820	0.18	75.1%	0.54	0.58	0.62	0.71	119	2.0%	8.3			Paved areas & shallow paved swales	20	0.0	0.0	8.3	119	10.7	8.3
H4 OFF	4				19,812					19,812	0.45	40.0%	0.28	0.35	0.42	0.58	420	2.0%	22.4			Paved areas & shallow paved swales	20	0.0	0.0	22.4	420	12.3	12.3
H4 ON	5		17065	10173	8,353			11,785		47,376	1.09	58.8%	0.40	0.45	0.50	0.63	313	1.8%	17.4			Paved areas & shallow paved swales	20	0.0	0.0	17.4	313	11.7	11.7
TOTAL SITE		0	23,475	16,698	32,720	0	0	14,205	0	87,098	2.00	56.5%	0.38	0.43	0.49	0.62													

$$I = (28.5 P1) / ((10 + TC) 0.786)$$

Basin Name	Design Point	Time of Conc (tc)	Runoff Coeff's				Rainfall Intensities (in/hr)				Area		Flow Rates (cfs)			
			C2	C5	C10	C100	2	5	10	100	A _{Total} (sf)	A _{Total} (ac)	Q2	Q5	Q10	Q100
H1	1	5.9	0.60	0.63	0.67	0.75	3.11	4.47	5.44	8.75	3,165	0.07	0.14	0.21	0.26	0.48
H2	2	10.5	0.38	0.43	0.49	0.62	2.55	3.66	4.46	7.16	8,925	0.20	0.20	0.33	0.45	0.91
H3	3	8.3	0.54	0.58	0.62	0.71	2.79	4.00	4.87	7.83	7,820	0.18	0.27	0.41	0.54	1.00
H4 OFF	4	12.3	0.28	0.35	0.42	0.58	2.38	3.43	4.17	6.71	19,812	0.45	0.30	0.54	0.79	1.78
H4 ON	5	11.7	0.40	0.45	0.50	0.63	2.44	3.50	4.26	6.85	47,376	1.09	1.05	1.71	2.33	4.68
TOTAL SITE											87,098	2.00	1.96	3.20	4.37	8.84



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Job Name: Louisville Mill Site
 Job Number: 2221c
 Date: 3/12/15
 By: MDE

Louisville Mill Site

Composite Runoff Coefficient Calculations

Location: Louisville
 Minor Design Storm: 2
 Major Design Storm: 100
 Soil Type: C/D

$$CA = KA + (1.31i^3 - 1.44i^2 + 1.135i + 0.12)$$

$$CCD = KCD + (0.858i^3 - 0.786i^2 + 0.774i + 0.04)$$

$$CB = (CA + CCD)/2$$

Basin Design Data												CB = (CA + CCB)/2				
	I (%) =	100%	90%	90%	40%	10%	25%	0%	0%			I (%)	Runoff Coeff's			
Basin Name	Design Point	A _{paved streets} (sf)	A _{drives/c} (sf)	A _{roof} (sf)	A _{gravel} (sf)	A _{piygnd} (sf)	A _{art. turf} (sf)	A _{iscape (B soil)} (sf)	A _{iscape (C/D soil)} (sf)	A _{Total} (sf)	A _{Total} (ac)	Imp (%)	C2	C5	C10	C100
A	1		2,550					195		2,745	0.06	83.6%	0.64	0.67	0.70	0.77
B	2			8,625						8,625	0.20	90.0%	0.73	0.75	0.77	0.83
C	3		4,985					1,000		5,985	0.14	75.0%	0.54	0.57	0.62	0.71
D	4		5,532					5,850		11,382	0.26	43.7%	0.30	0.37	0.43	0.59
E	5		8,125	7,610				945		16,680	0.38	84.9%	0.66	0.68	0.71	0.78
F	6			6,525				1,345		7,870	0.18	74.6%	0.54	0.57	0.61	0.71
G	10		4,395					275		4,670	0.11	84.7%	0.65	0.68	0.71	0.78
H	11		2,370	3,435				3,164		8,969	0.21	58.3%	0.39	0.45	0.50	0.63
OS1	7		2,965		7,310					10,275	0.24	54.4%	0.37	0.42	0.48	0.61
OS2	8		1,670		1,355					3,025	0.07	67.6%	0.47	0.51	0.56	0.67
OS3	9		225		6,475					6,700	0.15	41.7%	0.29	0.36	0.42	0.59



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 By: MDE

Louisville Mill Site

Time of Concentration Calculations

Location: **Louisville**
 Minor Design Storm: **2**
 Major Design Storm: **100**
 Soil Type: **C/D**

Sub-Basin Data				Initial Overland Time (t_i)			Travel Time (t_t) $t_t = \text{Length} / (\text{Velocity} \times 60)$							t_c Comp	tc Urbanized Check ON	t_c Final
Basin Name	Design Point	A_{Total} (ac)	C5	Upper most Length (ft)	Slope (%)	t_i (min)	Length (ft)	Slope (%)	Type of Land Surface	C_v	Velocity (fps)	t_t (min)	Time of Conc $t_i + t_t = t_c$	Total Length (ft)	$t_c = (L/180) + 10$ (min)	Min t_c
A	1	0.06	0.67	123	1.5%	7.7			Paved areas & shallow paved swales	20	0.0	0.0	7.7	123	10.7	7.7
B	2	0.20	0.75	120	2.0%	5.7			Paved areas & shallow paved swales	20	0.0	0.0	5.7	120	10.7	5.7
C	3	0.14	0.57	80	4.0%	5.4	35	5.0%	Grassed waterway	15	3.4	0.2	5.6	115	10.6	5.6
D	4	0.26	0.37	67	1.5%	9.6			Paved areas & shallow paved swales	20	0.0	0.0	9.6	67	10.4	9.6
E	5	0.38	0.68	143	2.5%	6.8	45	5.0%	Grassed waterway	15	3.4	0.2	7.0	188	11.0	7.0
F	6	0.18	0.57	119	2.0%	8.4			Paved areas & shallow paved swales	20	0.0	0.0	8.4	119	10.7	8.4
G	10	0.11	0.68	0	2.0%	0.0	75	2.0%	Paved areas & shallow paved swales	20	2.8	0.4	0.4	75	10.4	5.0
H	11	0.21	0.45	40	2.0%	6.0	45	2.0%	Grassed waterway	15	2.1	0.4	6.4	85	10.5	6.4
OS1	7	0.24	0.42	114	0.5%	16.7	117	1.0%	Paved areas & shallow paved swales	20	2.0	1.0	17.7	231	11.3	11.3
OS2	8	0.07	0.51	30	0.5%	7.4	56	1.5%	Paved areas & shallow paved swales	20	2.4	0.4	7.8	86	10.5	7.8
OS3	9	0.15	0.36	130	2.0%	12.3			Paved areas & shallow paved swales	20	0.0	0.0	12.3	130	10.7	10.7



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Louisville Mill Site

Developed Storm Runoff Calculations

Design Storm :

2 Year

Point Hour Rainfall (P₁) : **0.96**

$$I = (23.5 P_1) / ((10 + TC)^{0.786})$$

Basin Name	Direct Runoff							Total Runoff				Inlets			Pipe					Pipe/Swale Travel Time			Total Time (min)
	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	
A	1	0.06	0.64	7.70	0.04	2.86	0.12	7.70	0.04	2.86	0.12							0.1					
B	2	0.20	0.73	5.70	0.14	3.14	0.45	5.70	0.14	3.14	0.45							0.5					
C	3	0.14	0.54	5.60	0.07	3.16	0.23	5.60	0.07	3.16	0.23							0.2					
D	4	0.26	0.30	9.60	0.08	2.64	0.21	9.60	0.08	2.64	0.21							0.2					
E	5	0.38	0.66	7.00	0.25	2.95	0.74	7.00	0.25	2.95	0.74							0.7					
F	6	0.18	0.54	8.40	0.10	2.77	0.27	8.40	0.10	2.77	0.27							0.3					
G	10	0.11	0.65	5.00	0.07	3.26	0.23	5.00	0.07	3.26	0.23												
H	11	0.21	0.39	6.40	0.08	3.04	0.25	6.40	0.08	3.04	0.25												
OS1	7	0.24	0.37	11.30	0.09	2.47	0.21	11.30	0.09	2.47	0.21							0.2					
OS2	8	0.07	0.47	7.80	0.03	2.85	0.09	7.80	0.03	2.85	0.09							0.1					
OS3	9	0.15	0.29	10.70	0.04	2.53	0.11	10.70	0.04	2.53	0.11							0.1					
TOTAL SITE		2.00							TOTAL SITE		2.91					TOTAL SITE		2.9					



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Louisville Mill Site

Developed Storm Runoff Calculations

Design Storm :

10 Year

Point Hour Rainfall (P₁) : **1.68**

$$I = (28.5 P_1) / ((10 + TC)^{0.786})$$

Basin Name	Design Point	Area (ac)	Runoff Coeff	Direct Runoff				Total Runoff				Inlets			Pipe					Pipe/Swale Travel Time			
				tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)
A	1	0.06	0.70	7.70	0.04	5.00	0.22	7.70	0.04	5.00	0.22							0.2					
B	2	0.20	0.77	5.70	0.15	5.50	0.84	5.70	0.15	5.50	0.84							0.8					
C	3	0.14	0.62	5.60	0.08	5.53	0.47	5.60	0.08	5.53	0.47							0.5					
D	4	0.26	0.43	9.60	0.11	4.62	0.52	9.60	0.11	4.62	0.52							0.5					
E	5	0.38	0.71	7.00	0.27	5.16	1.41	7.00	0.27	5.16	1.41							1.4					
F	6	0.18	0.61	8.40	0.11	4.85	0.54	8.40	0.11	4.85	0.54							0.5					
G	10	0.11	0.71	5.00	0.08	5.70	0.43	5.00	0.08	5.70	0.43							0.4					
H	11	0.21	0.50	6.40	0.10	5.31	0.55	6.40	0.10	5.31	0.55							0.5					
OS1	7	0.24	0.48	11.30	0.11	4.33	0.49	11.30	0.11	4.33	0.49							0.5					
OS2	8	0.07	0.56	7.80	0.04	4.98	0.19	7.80	0.04	4.98	0.19							0.2					
OS3	9	0.15	0.42	10.70	0.07	4.42	0.29	10.70	0.07	4.42	0.29							0.3					
TOTAL SITE		2.00							TOTAL SITE		5.94					TOTAL SITE		5.9					



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Developed Storm Runoff Calculations

Design Storm :

100 Year

Point Hour Rainfall (P_1) : **2.70**

$$I = (28.5 P_1) / ((10 + TC)^{0.786})$$

Basin Name	Design Point	Area (ac)	Runoff Coeff	Direct Runoff				Total Runoff				Inlets			Pipe					Pipe/Swale Travel Time			
				tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)
A	1	0.06	0.77	7.70	0.05	8.04	0.39	7.70	0.05	8.04	0.39							0.4					
B	2	0.20	0.83	5.70	0.17	8.84	1.46	5.70	0.17	8.84	1.46							1.5					
C	3	0.14	0.71	5.60	0.10	8.88	0.86	5.60	0.10	8.88	0.86							0.9					
D	4	0.26	0.59	9.60	0.15	7.42	1.14	9.60	0.15	7.42	1.14							1.1					
E	5	0.38	0.78	7.00	0.30	8.30	2.49	7.00	0.30	8.30	2.49							2.5					
F	6	0.18	0.71	8.40	0.13	7.80	0.99	8.40	0.13	7.80	0.99							1.0					
G	10	0.11	0.78	5.00	0.08	9.16	0.77	5.00	0.08	9.16	0.77							0.8					
H	11	0.21	0.63	6.40	0.13	8.54	1.10	6.40	0.13	8.54	1.10							1.1					
OS1	7	0.24	0.61	11.30	0.14	6.95	1.01	11.30	0.14	6.95	1.01							1.0					
OS2	8	0.07	0.67	7.80	0.05	8.01	0.37	7.80	0.05	8.01	0.37							0.4					
OS3	9	0.15	0.59	10.70	0.09	7.11	0.64	10.70	0.09	7.11	0.64							0.6					
TOTAL SITE		2.00							TOTAL SITE		11.23					TOTAL SITE		11.2					



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Detention Pond Volume Calculations: $V = K \cdot A$ Method

ALLOWABLE RELEASE RATE

Table SO-1 - Maximum Unif Flow Release Rates (cfs/ac)

Design Frequency	NRCS Hydrologic Soil Group		
	A	B	C & D
5-year	0.07	0.13	0.17
10-year	0.13	0.23	0.30
100-year	0.50	0.85	1.00

Q release = Area * Max Unit Flow Release Rate

Soil Type: C/D

Release Rates:

Q10 = 0.46 CFS

Q100 = 1.54 CFS

DETENTION POND SIZING

$$V = K \cdot A$$

(UDFCD, Vol 2, Chapter 10, Equation SO-1)

10 Year Pond Volume

$$K = (0.95 \cdot I - 1.9) / 1000$$

(UDFCD, Vol 2, Chapter 10, Equation SO-3)

100 year Pond Volume:

$$K = (1.78 \cdot I - 0.002 \cdot I^2 - 3.56) / 900$$

(UDFCD, Vol 2, Chapter 10, Equation SO-2)

I = **68.1%**
 A = **1.5** acres

I = Percent Impervious
 A = Tributary Area
 V = Required Volume

K10 = 0.0628

K100 = 0.1204

V10 =	4,210	CF
V100 =	8,075	CF

TOTAL DETENTION POND VOLUME

Water Quality Capture Volume (WQCV) =		1,266 CF
Volume Minor =	V10 + 0% WQCV =	4,210 CF
Volume Major =	V100 + 0% WQCV =	8,075 CF

Design Procedure Form: Rain Garden (RG)

Sheet 1 of 2

Designer: REP
 Company: JVA, Inc.
 Date: March 12, 2015
 Project: Louisville Mill (Developed Site-Basins A-H)- For reference only, no WQCV provided for site
 Location: Louisville, Colorado

1. Basin Storage Volume

- A) Effective Imperviousness of Tributary Area, I_a
(100% if all paved and roofed areas upstream of rain garden)
- B) Tributary Area's Imperviousness Ratio ($i = I_a/100$)
- C) Water Quality Capture Volume (WQCV) for a 12-hour Drain Time
($WQCV = 0.8 \cdot (0.91 \cdot i^3 - 1.19 \cdot i^2 + 0.78 \cdot i)$)
- D) Contributing Watershed Area (including rain garden area)
- E) Water Quality Capture Volume (WQCV) Design Volume
 $Vol = (WQCV / 12) \cdot Area$
- F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm
- G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume
- H) User Input of Water Quality Capture Volume (WQCV) Design Volume
(Only if a different WQCV Design Volume is desired)

$I_a =$ 71.5 %

$i =$ 0.715

WQCV = 0.23 watershed inches

Area = 67,285 sq ft

$V_{WQCV} =$ 1,266 cu ft

$d_s =$ _____ in

$V_{WQCV \text{ OTHER}} =$ _____ cu ft

$V_{WQCV \text{ USER}} =$ _____ cu ft

2. Basin Geometry

- A) WQCV Depth (12-inch maximum)
- B) Rain Garden Side Slopes ($Z = 4$ min., horiz. dist per unit vertical)
(Use "0" if rain garden has vertical walls)
- C) Minimum Flat Surface Area
- D) Actual Flat Surface Area
- E) Area at Design Depth (Top Surface Area)
- F) Rain Garden Total Volume
($V_T = ((A_{Top} + A_{Actual}) / 2) \cdot \text{Depth}$)

$D_{WQCV} =$ 12 in

$Z =$ 4.00 ft / ft

$A_{Min} =$ 844 sq ft

$A_{Actual} =$ 844 sq ft

$A_{Top} =$ 1700 sq ft

$V_T =$ 1,272 cu ft

3. Growing Media

Choose One

- ☒ 18" Rain Garden Growing Media
☐ Other (Explain): _____

4. Underdrain System

- A) Are underdrains provided?
- B) Underdrain system orifice diameter for 12 hour drain time
- i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice
- ii) Volume to Drain in 12 Hours
- iii) Orifice Diameter, 3/8" Minimum

Choose One

- ☐ YES
☒ NO

$y =$ N/A ft

$Vol_{12} =$ N/A cu ft

$D_o =$ N/A in

