City of Louisville
COLORADO • SINCE 1878

Community Development Department

749 Main Street • Louisville CO 80027 • 303.335.4592 • www.louisvilleco.gov

Development Review Application Form

Please complete this form and include it with the submittal documents for your development review application. Applications will not be processed until all required information is provided to the satisfaction of the City of Louisville Planning Department.

Property Information

Common Address(es): Redtail Ridge (Rockcress Drive, formerly known as Tape Drive)
Legal Description:
Lot 1 Block 3 Subdivision Redtail Ridge Filing No. 1
Lot Area: 1,009,540 Sq. Ft. or 23.18 Acres

LAND USE PROCESS (check all that apply)

- ☐ Annexation
- ☐ Concept Plan
- ☐ Easement Vacation
- ☐ Oil and Gas
- ☐ General Development Plan (GDP)
  - ☐ Amendment
  - ☐ New GDP
- ☐ Planned Unit Development (PUD)
  - ☐ Amendment
  - ☐ Preliminary
  - ☐ New PUD
- ☐ Rezoning
- ☐ Special Review Use (SRU)
  - ☐ Amendment
  - ☐ New SRU
- ☐ Subdivision
  - ☐ Final or Replat
  - ☐ Preliminary Plat
- ☐ Temporary Use Permit
- ☐ Variance
- ☐ Vested Property Right
- ☐ Wireless Facility
- ☐ Other: _____

PROJECT DESCRIPTION:

This PUD is proposed to include (1) two-story life science building at roughly 102,621 square feet and (1) amenity building at roughly 15,600 square feet with outdoor amenity areas. This PUD will also include walking trails, a dog park, and outdoor patios with canopies. We are also referencing this PUD as PUD-5 in our master plan.

Property Owner Information

Name: Marshall Wheel Entity (if applicable) Redtail Ridge Portfolio, LLC
Address: 100 Bayview, suite 355, Newport News, CA 92660
Phone: 858-833-1007 Email: mwheel@sterlingbay.com

Application Representative Information

Name: Eric Swartz Entity (if applicable) Harris Kocher Smith
Address: 1120 Lincoln St, Suite 1000 • Denver, Colorado 80203
Phone: 303-623-6300 Email: eswartz@hkseng.com

Certification/Signature

I certify that the information I have submitted is true and correct to the best of my knowledge and in filing the application and submittal documents, I am acting as and/or with the knowledge and consent of those persons who are owners of the subject property or are parties to this application.

DocuSigned by:
Signature: 0254F0564AD1E4C5...

Marshall Wheel
Print Name

12/17/2024
Date

***If acting as a representative/agent of the owner, include written authorization from the owner that certifies the agent's right to submit this application**

MEMORANDUM

To: City of Louisville, Public Works Department

From: Cassie Slade, P.E., PTOE

Date: September 29, 2023

Project: Redtail Ridge

Subject: PUD 5 Traffic Conformance Letter

The Fox Tuttle Transportation Group has prepared this traffic conformance letter for the proposed development of research and development buildings located in the Retail/Life Science District of the Redtail Ridge development in Louisville, Colorado. The site is located southeast of the intersection of Rockcress Drive and Sorrel Avenue, as shown on **Figure 1** at the end of this memorandum. PUD 5 of Redtail Ridge plans to one (1) research and development building with a total of 97,890 square feet (sf). It is understood that there will be one (1) full movement access to the south leg of the Rockcress Drive and Sorrel Avenue roundabout and one (1) right-in right-out access on Rockcress Drive.

The purpose of this "traffic conformance letter" is to determine if the proposed use of PUD 5 is significantly different than the trip generation assumptions for this site as analyzed in the "Master" study and to identify if additional traffic analysis is necessary.

Comparison to Master Traffic Study

A "Master" Transportation Study[1] (MTS) was previously prepared for the entire Redtail Ridge development that will include a mix of industrial, GMP, life science, office, research and development, retail, hospital and medical office uses. The buildings within PUD 5 were assumed to be a mix of retail and life science uses. Development staging in the MTS was done in phases by horizon year rather than specific PUD lots, and the life science use of PUD 5 was included within Phase 1 of the MTS. Phase 1 of the MTS assumed a total development of 509,260 sf of industrial, 300,000 sf of life science and 598,940 sf of GMP space by Year 2025. The proposed PUD 5 use is consistent with uses assumed

[1] *Redtail Ridge Traffic and Mobility Study*. Fox Tuttle Transportation Group, LLC. August 2023 (updated).

in Phase 1 of the MTS with additional development anticipated beyond PUD 5 in Phase 1. The PUD 5 area in the MTS also included retail use to be built in Phase 2 that has been removed in the plan for PUD 5 and will no longer be constructed on this lot. **The plan for PUD 5 is consistent with the land uses and roadway needs in the MTS.**

Trip Generation

To establish the volume of trips associated with the proposed project, the data contained in the *Institute of Transportation Engineers (ITE) Trip Generation Manual*[2] for the appropriate uses was applied. The proposed land use is estimated to mostly be new trips, known as 'primary trips', which is discussed below:

Primary Trips. These trips are made specifically to visit the site and are considered "new" trips. Primary trips would not have been made if the proposed project did not exist. Therefore, this is the only trip type that increases the number of trips made on a regional basis.

Non-Auto Trips. These trips are those that are completed by walking, biking, or transit. The existing transit service will provide employees the opportunity to travel to/from work by bus rather than a personal vehicle. The planned bicycle network throughout Redtail Ridge will provide high-comfort bicycle connections to bicycle facilities near the site. The development plans to use transportation demand management (TDM) to encourage carpooling and other modes to reduce the number of single-occupant vehicle (SOV) commute trips. A non-SOV reduction of 12% was applied for all uses within Redtail Ridge.

Multi-Use (Internal) Trips. These trips are internal from one land use or building to another within the site boundaries. For example, an office patron may also use a retail store or restaurant in one vehicle trip to the site. Multi-use or multi-purpose trips typically do not affect the exterior site access points, nor add any additional traffic volumes to the adjacent street network. For this project it is projected that the small retail uses on the site will be focused on serving the office and industrial employees of the project and most (75% estimated) of the trips accessing them will be on-site or internal trips. The other end of these internal trips were attributed to the office and industrial employees and resulted in a 3% reduction for those uses. Based on this approach, the multi-use factors applied for this project were assumed to be 3% for industrial and office uses and 75% for the retail uses.

[2] *Trip Generation Manual*. 11th Edition. Institute of Transportation Engineers. Washington, DC. 2021.

Table 1 summarizes and compares the trip generation estimated for these buildings of the MTS and the PUD 5 site plan for weekday daily, weekday AM and weekday PM peak periods.

Table 1. Trip Generation Summary and Comparison

	Land Use	Size	Unit	Non-SOV	Internal Capture	Net Reduction Factor	Average Weekday Trips		Weekday AM Peak Hour Trips				Weekday PM Peak Hour Trips			
							Rate	Total	Rate	Total	In	Out	Rate	Total	In	Out
MTS	#760 Research and Development Center (Life Science + Amenity)	99.0	KSF	**12%**	**3%**	85%	**	1,031	1.03	87	71	16	0.98	83	13	70
MTS	#820 Shopping Center	14.0	KSF	**12%**	**75%**	22%	37.75	116	0.94	3	2	1	3.81	12	6	6
MTS		**113.0**	**KSF**			**Subtotal**		**1,147**		**90**	**73**	**17**		**95**	**19**	**76**
PUD 5	#760 Research and Development Center (Life Science + Amenity)	97.98	KSF	**12%**	**3%**	85%	**	1,023	1.03	86	71	15	0.98	82	13	69
PUD 5		**97.98**	**KSF**			**Subtotal**		**1,023**		**86**	**71**	**15**		**82**	**13**	**69**
	Difference in Trips (PUD 4 vs. MTS)							**-124**		**-4**	**-2**	**-2**		**-13**	**-6**	**-7**

PUD 5 is estimated to generate nearly the same number of trips for that space as expected in the MTS. Land uses and trip generation of PUD 5 are aligned with the proposed uses in the MTS with a very slight reduction in life science square footage (1% difference) and removal of the retail use. The capacity analysis in the MTS indicated the study intersections would operate acceptably (LOS D or better) with the full Phase 1 predicted development and associated roadway improvements, so therefore it is expected that the study intersections will operate acceptably with PUD 5 trips.

Proposed Access

Concurrent with the construction of PUD 1, internal roadways will be constructed as planned for Phase 1 of the MTS. More detailed discussion of the roadways to be built with PUD 1 is available in the PUD 1 Conformance Memorandum.

Access from the PUD 5 buildings will be provided to Rockcress Drive. One (1) full movement access is planned at the Rockcress Drive and Sorrel Avenue roundabout intersection. One (1) right-in right-out side-street stop-controlled access to Rockcress Drive is also provided east of Sorrel Avenue. The proposed site plan including access locations is shown in **Figure 2** at the end of this memorandum.

An estimate of traffic entering and exiting the accesses was performed, based on the site plan, truck and vehicle trips were assigned to an access point based on the building use and square footage accessible from each access. Vehicle distribution through the street network used the same distribution assumption for external trip origins and destinations that were used in the MTS. The added trips generated by PUD 5 at public street intersections are shown in **Figure 3**. Comparing **Figure 3** and **Figure 4**, the trips generated by PUD 5 are slightly fewer than the trips generated by the total expected in Phase 1. Therefore PUD 5 trips are expected to be accommodated by the planned

roadway network found to function acceptably with the complete traffic volume anticipated for Phase 1.

Conclusions

The plan for PUD 5 of Redtail Ridge is consistent with the land use assumptions of the MTS for the parcel with a slight reduction in life science use and removal of retail use. PUD 5 is expected to generate slightly fewer trips as expected in that space in the MTS. Access points to PUD 5 are similar to the planned roadways and access in the MTS and are expected to distribute traffic to public streets consistent with the assumptions in the MTS. **It is anticipated that the planned roadway network and intersections can accommodate PUD 5 trips without the need for additional analysis or mitigation measures since it is consistent with the MTS.**

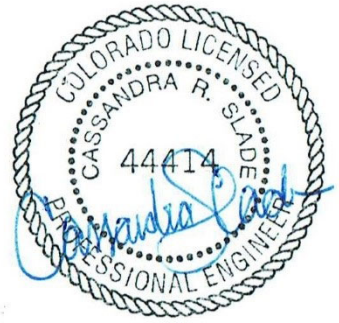
Hopefully the contents of this memorandum are helpful. If you have any questions, please give me a call.

Sincerely,

FOX TUTTLE TRANSPORTATION GROUP, LLC

Cassie Slade

Cassie Slade, P.E., PTOE
Principal



PUD 5 Area

LIFE SCIENCE DISTRICT WEST

Amenity Building Area (SF)	30,000
Tot. Life Sciences Building Area (SF)	270,000
Total District Building Area (SF)	300,000
Total Parking Stalls	1,208
Avg. Parking Ratio per 1K GSF	4

INDUSTRIAL DISTRICT

GMP Building Area (SF)	598,940
Industrial Building Area (SF)	509,260
R&D Building Area (SF)	118,800
Total District Building Area (SF)	1,227,000
Total Parking Stalls	2,513
Avg. Parking Ratio per 1K GSF	2.05

LIFE SCIENCE PARK EAST

Tot. Life Sciences Building Area (SF)	165,000
Total Parking Stalls	492
Avg. Parking Ratio per 1K GSF	3

OFFICE DISTRICT

Total Office Building Area (SF)	360,000
Total Parking Stalls	1,170
Avg. Parking Ratio per 1K GSF	3.25

RETAIL / LIFE SCIENCES

Retail (SF)	14,000
Life Science Building Area (SF)	99,000
Total District Building Area (SF)	113,000
Total Parking Stalls	506
Avg. Parking Ratio per 1K GSF	4.5

HOSPITAL

Total Building Area	435,000

TOTAL SITE DEVELOPMENT

Total Building Area (SF)	**2,600,000**

Life Science
Office
GMP
Retail
Industrial
Campus Amenity/ Conference
R&D
Hospital

Perkins&Will TRYBA ARCHITECTS Redtail Ridge

FOX TUTTLE TRANSPORTATION GROUP

REDTAIL RIDGE PUD 5 CONFORMANCE

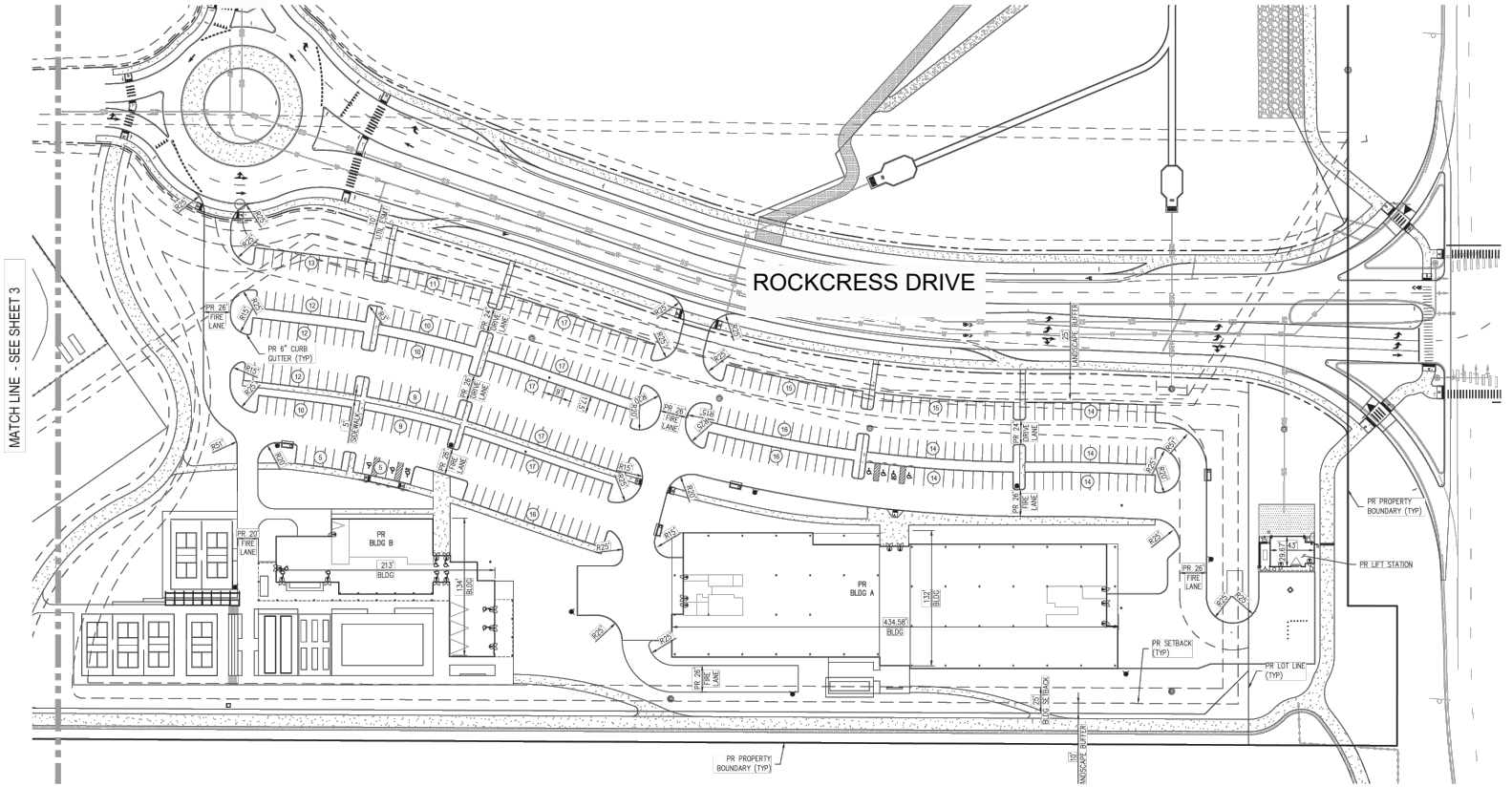
PUD 5 AREA

FT Project #	19055	Original Scale	NTS	Date	9/26/2023	Drawn by	SKK	Figure #	1

REDTAIL RIDGE PUD #5

SITUATED IN THE SOUTH HALF OF SECTION 20 AND THE NORTH HALF OF SECTION 29, TOWNSHIP 1 SOUTH, RANGE 68 WEST OF THE SIXTH PRINCIPAL MERIDIAN, CITY OF LOUISVILLE, COUNTY OF BOULDER, STATE OF COLORADO

PUD PLANS



REVISION DATE: #### ISSUE DATE: ####

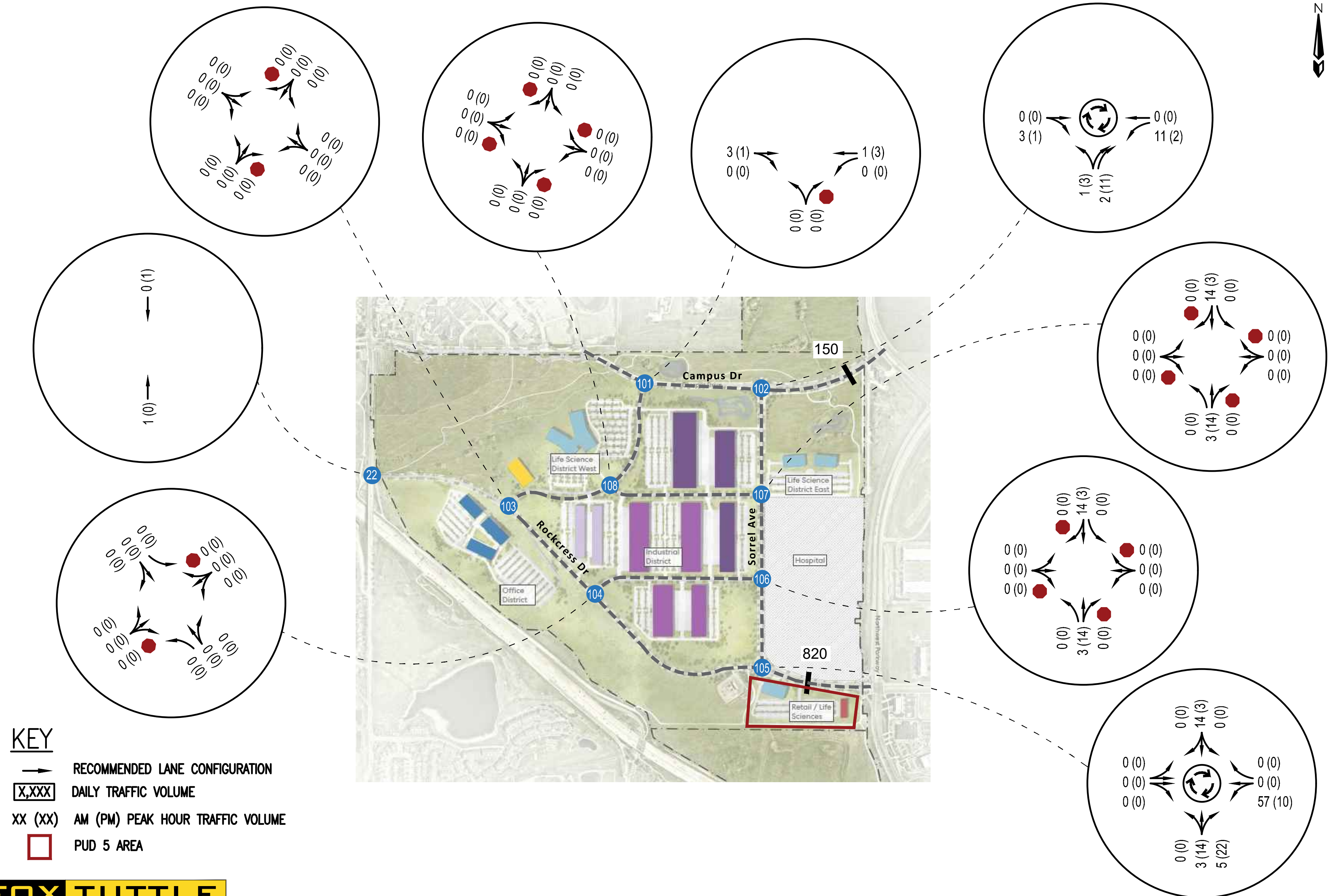
DEVELOPMENT PLAN
SHEET 2 OF 7
REDTAIL RIDGE PUD #5

FOX TUTTLE TRANSPORTATION GROUP

REDTAIL RIDGE PUD 5 CONFORMANCE

PUD 5 SITE PLAN

FT Project #	19055	Original Scale	NTS	Date	9/26/2023	Drawn by	SKK	Figure #	2

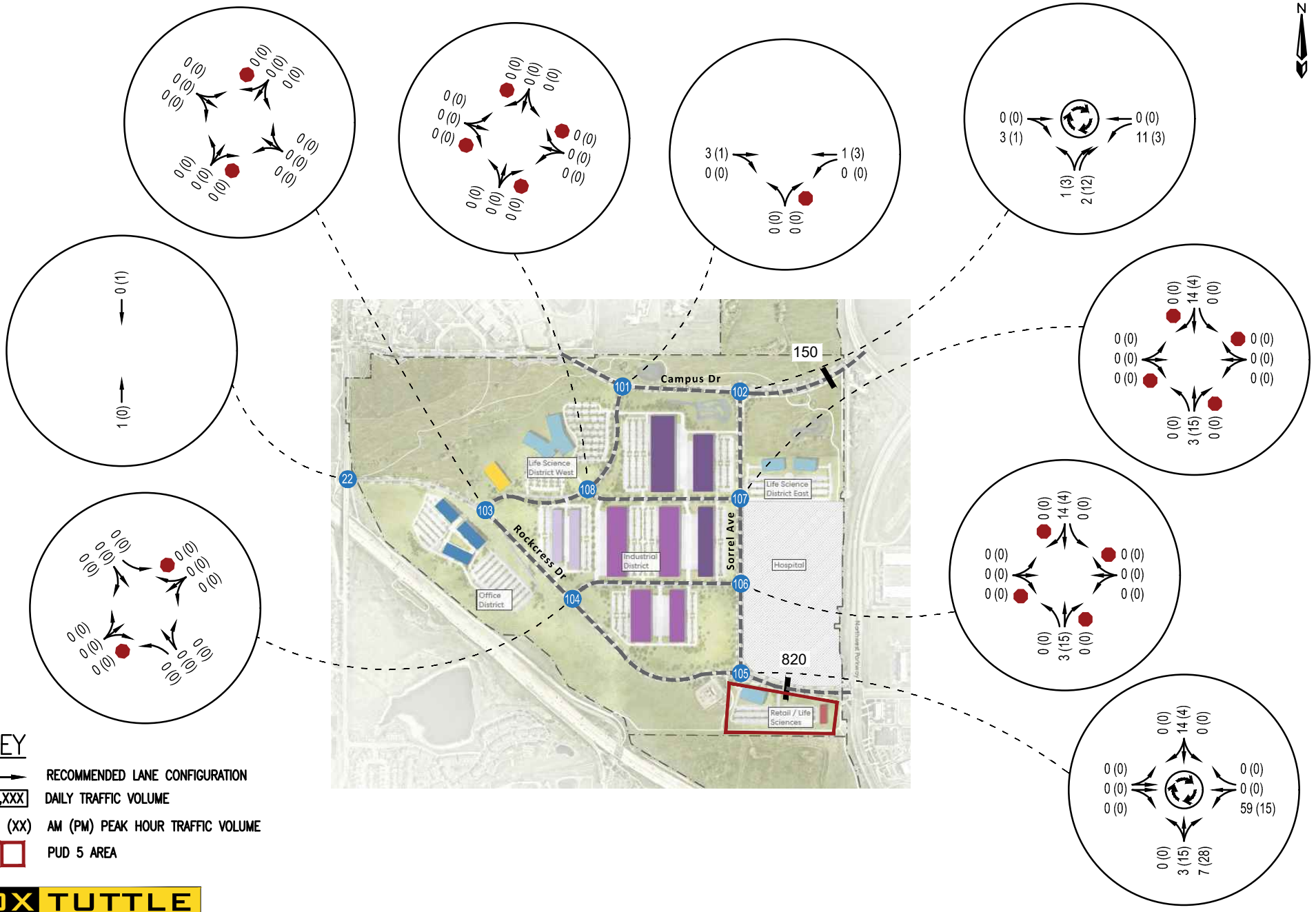


FOX TUTTLE TRANSPORTATION GROUP

REDTAIL RIDGE PUD 5 CONFORMANCE

PUD 5 GENERATED TRIPS

FT Project # 19055	Original Scale NTS	Date 9/26/2023	Drawn by SKK	Figure # 3



FOX TUTTLE
TRANSPORTATION GROUP

REDTAIL RIDGE PUD 5 CONFORMANCE

MTS - PUD 5 AREA GENERATED TRIPS

FT Project #	19055	Original Scale	NTS	Date	9/29/2023	Drawn by	SKK	Figure #	4

HARRIS KOCHER SMITH
DENVER • DALLAS/FORT WORTH

December 9th, 2024

Attention:
City of Louisville
Department of Public Works
Engineering Division
749 Main St.
Louisville, CO 80027

The purpose of this letter is to serve as a formal recognition of compliance with the Final Master Drainage Report for Redtail Ridge dated March 6th, 2024. This report outlined the overall project stormwater and drainage characteristics of the proposed Redtail Ridge development. Applicable excerpts of the Final Master Drainage Report are included in **Appendix A**. This letter analyzes sub-basins within PUD5 and the compliance of watershed imperviousness and proposed runoff of PUD5 to the Redtail Ridge Master Drainage Report.

PUD 5 is part of the Redtail Ridge Master Drainage Plan (see attached Master Drainage Report for Redtail Ridge). Redtail Ridge is divided into multiple drainage basins. PUD 5 is in Basins D-1, D-2, and D-3 of the Redtail Ridge Master Drainage Plan. Basin D-2 will remain undeveloped during this phase and will follow existing drainage patterns. Sub-basins D-1 and D-2 are being modified as part of PUD 5 and are routed to Pond C-2 for water quality and volume control. As part of the PUD 5 development, flows from Basin D-1 and D-3 will be conveyed east by on-site stormwater infrastructure to Pond C-2 (see Pond C-2 location on Master Drainage Plan in Appendix A).

SUB-BASIN DESCRIPTION

Sub-Basin D-1 (14.55 acres, 70% imperviousness) contains the southeast corner of the Site, an area bounded by Rockcress Drive to the north, by property boundary to the south and by an existing ridge to the west. Flows from Sub-Basin D-1 shall be routed to storm sewer east of the intersection of Rockcress Drive and Sorrel Avenue through curb, gutter, inlets, and storm sewer. Flows will then be routed to the Full Spectrum Detention Facility Pond C-2, where flows will be detained for both the WQCV event and the major storm event. In order for the parcel to drain to Pond C-2 fill is required to be placed on the Site. If alternate parcel development plans are desired, this area may be released south to Rock Creek with the proper Jurisdictional approvals.

Sub-Basin D-2 (19.40 acres, 2% imperviousness) is proposed as open space and will drain as it does historically. The historical flows for Basin D-2 generally flow from northeast to southwest into an empty field within the City and County of Broomfield. There appears to be an outfall crossing Northwest Parkway and Storage Tek Drive approximately 800’ south from the southeast corner of the Site where runoff from D-2 eventually ends and continues downstream.

Sub-Basin D-3 (11.26 acres, 70% imperviousness) contains the southeast corner of the Site, an area bounded by Rockcress Drive to the north, by property boundary to the south and Northwest Parkway to the west. Flows from Sub-Basin D-3 shall be routed to storm sewer east of the intersection of Rockcress Drive and Northwest Parkway via a stub out for future connection. Flows will then be routed to the Full

Spectrum Detention Facility Pond C-2, where flows will be detained for both the WQCV event and the major storm event. In order for the parcel to drain to Pond C-2 fill is required to be placed on the Site. If alternate parcel development plans are desired, this area may be released south to Rock Creek with the proper Jurisdictional approvals.

SUMMARY

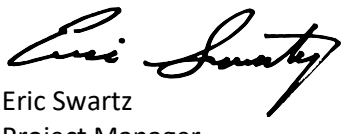
Redtail Ridge PUD 5 - Pond C-2 Summary Table		
	D-1 & D-3 (Master)	PUD 5
Tributary Area (AC)	25.82	23.94
Imperviousness (%)	70.0	46.09
Q_{100} (CFS)	143.87	72.15

Please see attached an exhibit which shows the basin delineation between the Master Drainage Plan and PUD 5. Runoff from PUD 5 will be collected by private storm infrastructure and conveyed to detention ponds where it then outfalls to existing storm infrastructure. PUD 5 development is compliant with the current submitted Master Drainage Report. PUD 5 will not contribute any additional runoff that has not been accounted for to the existing off-site water quality and detention facilities. The portion of basin D-1 & D-3 has an effective watershed imperviousness of 46.09% and basin D-2 has an effective watershed imperviousness of 2.0%. Both basins are in compliance with the Master Drainage Report. All stormwater runoff from PUD 5 will be conveyed by the storm sewer system proposed in the Redtail Ridge Master Drainage plan and is in conformance with the City of Louisville Wastewater standards and Mile High Flood District criteria. Sterling Bay - West will be responsible for maintaining the storm infrastructure apart of PUD 5.

Please contact me if you have any questions or require additional information at eswartz@hkseng.com or 303-623-6300.

Sincerely,

HARRIS KOCHER SMITH



Eric Swartz
Project Manager

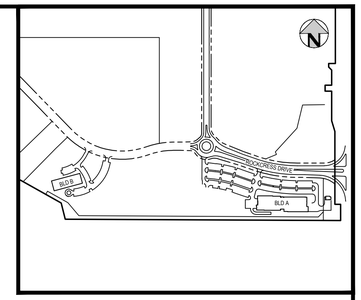
HARRIS KOCHER SMITH
DENVER • DALLAS/FORT WORTH

APPENDIX A – REDTAIL RIDGE PUD#5 DRAINAGE PLAN

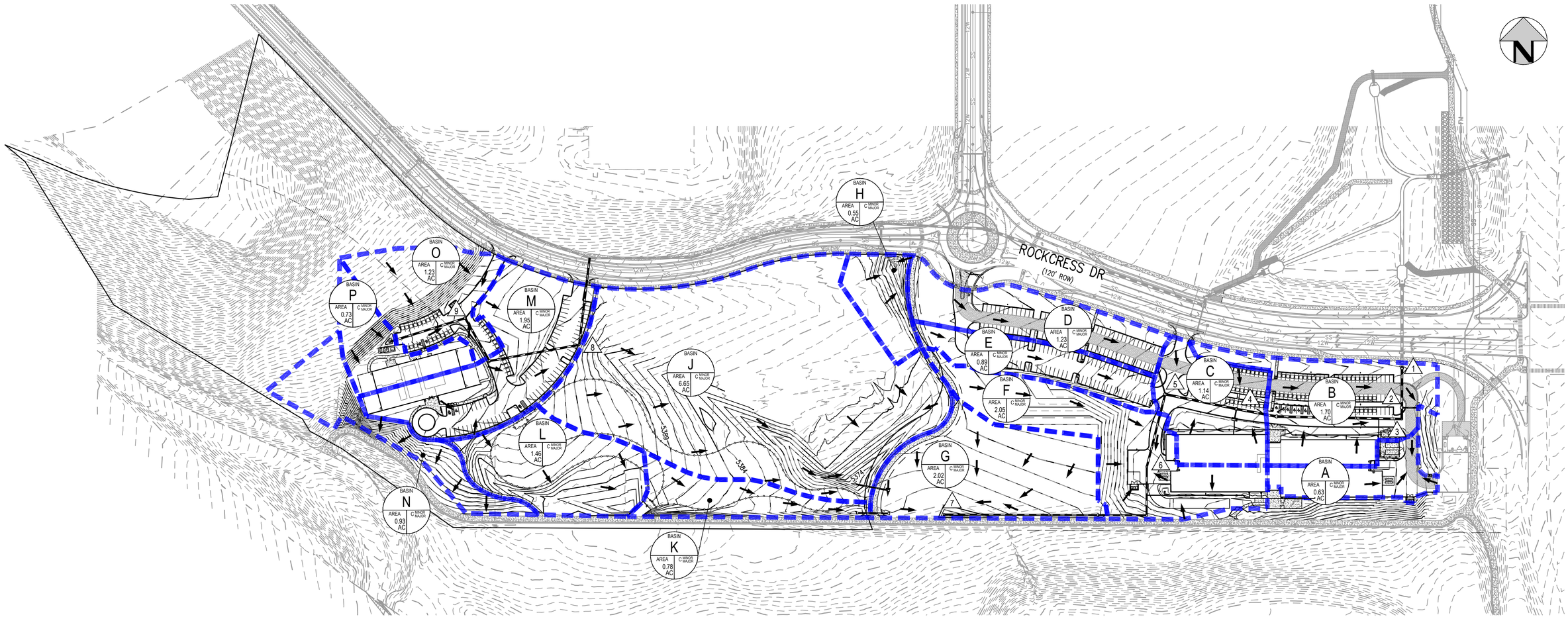
LEGEND

- RIGHT-OF-WAY
- PROPERTY BOUNDARY
- EX CONTOUR — 5410
- PR CONTOUR — 5410
- EX STORM SEWER
- PR LANDSCAPE DRAIN
- DRAINAGE BASIN BOUNDARY
- DESIGN POINT — 1
- FLOW ARROW

BASIN DESIGNATION — BASIN A — AREA 1.0 AC — C MINOR 0.53 — C MAJOR 0.65 — BASIN AREA IN ACRES — C-VALUE MINOR / C-VALUE MAJOR



KEY MAP
SCALE: 1" = 300'



811 Know what's below. Call before you dig.

100 0 100 200
SCALE: 1" = 100'

DESIGNED BY: MM
CHECKED BY: ECS
DRAWN BY: MM

ISSUE DATE: 06-14-2024

DATE	REVISION COMMENTS

HARRIS KOCHER SMITH
451 S Main Street, Suite 210
Fort Worth, Texas 76104
817.769.6279
HarrisKocherSmith.com
TBPE Firm No. F-15501

STERLING BAY

REDTAIL RIDGE PUD5
DRAINAGE PLAN

PRELIMINARY NOT FOR CONSTRUCTION

PROJECT #: 230508
SHEET NUMBER
ST8
14 OF 33

FILEPATH: P:\2023\230508\ENGINEERING\DRAINAGE\CD_DRAINAGE PLAN.DWG, LAYOUT: LAYOUT1
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PLOTTED: THU 12/19/24 3:36:02P BY: ERIC SWARTZ

APPENDIX B – FINAL MASTER DRAINAGE REPORT SUMMARY

FINAL DRAINAGE REPORT
FOR
REDTAIL RIDGE SUBDIVISION PHASE 1

CITY OF LOUISVILLE
BOULDER COUNTY
STATE OF COLORADO

March 6, 2024

Prepared For:

Sterling Bay

5910 Pacific Center Blvd, Suite 200
San Diego, CA 92121
(540)-798-8455

Prepared By:

1120 Lincoln Street, Suite 1000
Denver, CO 80203
Ph: 303-623-6300, Fax: 303-623-6311

Contact:
Mark A. West, PE, CFM, LEEDAP

Harris Kocher Smith Project No. 190108

HARRIS KOCHER SMITH
DENVER • DALLAS/FORT WORTH

Table of Contents

ENGINEER CERTIFICATION

“I hereby certify that this Phase 1 Final Drainage Report for the final drainage design of the Redtail Ridge project was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Louisville Storm Drainage Design and Technical Criteria for the owners thereof.”

_____

Mark A. West, PE, CFM, LEEDAP
Licensed Professional Engineer
State of Colorado
No. 38561
On behalf of Harris Kocher Smith

I. EXECUTIVE SUMMARY

A. PHASE 1 FINAL DRAINAGE REPORT FOR REDTAIL RIDGE

The purpose of this report is to outline the proposed stormwater and drainage characteristics for the sustainable redevelopment of the former Storage Tek and ConocoPhillips property. All proposed development within Phase 1 follows the guidelines set forth in the Final Master Drainage Report for Redtail Ridge or provides design alternatives or improvements that do not cause adverse impact to adjacent facilities, downstream entities, or property owners.

This report provides design information for the Phase 1 stormwater and drainage infrastructure to support the proposed major roadways of Campus Drive, Rockcress Drive (formerly Tape Dr.), and Sorrel Avenue as well as utility infrastructure to create developable parcels within the overall Site.

Phase 1 shall include the construction of all of Campus Drive and associated storm sewer, Sorrel Avenue, the east segment of Rockcress Drive (From the Northwest Parkway to Sorrel Avenue), Tributary I, the Goodhue Ditch crossing, and Full Spectrum Detention Ponds C-1, C-2 and B. With Phase 1, all runoff from developed infrastructure was routed to either Pond C-1 or C-2.

Phase 2 is currently proposed to include the construction of the west segment of Rockcress Drive (from Sorrell Avenue to S. 88th Street), and the associated storm network.

A Phasing line displaying the construction phases of the overall Site is included in the drainage plan for the project, located in Appendix D.

For the purposes of this report, the analysis, computations, and design procedure will focus solely on Phase 1 of the Redtail Ridge Project. For full details related to the Redtail Ridge project, refer to the Master Drainage Report or Phase 2 Drainage report.

II. GENERAL LOCATION AND DESCRIPTION

A. Location

The proposed Redtail Ridge Phase 1 development by Brue Baukol Capital Partners on the former Storage Tek / ConocoPhillips Site property (hereinafter referred to as "Site" or "Project") is situated in the City of Louisville (hereinafter referred to as "City"); specifically the Northeast ½ and South ½ of Section 20, the North ½ of Section 29, and the Northwest ¼ of Section 28, Township 1 South, Range 69 West of the 6th P.M. Counties of Boulder and Broomfield, State of Colorado.

The Project is located east of S. 88th Street, South of Campus Drive, West of S. 96th Street and Northwest Parkway, and Northeast of Highway 36. A Vicinity Map is included in Appendix A for reference.

There is an existing Outfall System Plan which was used as reference for the Site. The City of Louisville/Boulder County Outfall System Plan (hereinafter referred to as "Louisville OSP") dated November 1982 indicates that there are several existing ponds at low points throughout the Site. Excerpts from this report are included in Appendix B.

The adjoining parcels include the Monarch K-8 School campuses north of Campus Drive, the Health Park complex west of S. 88th Street and northwest of the Site, and the Parkway Circle development east of S. 96th Street.

B. Description of Property

The Site is approximately 389 acres and was formerly a developed office campus that has been demolished and removed from the Site. The Site is currently covered with grass vegetation, remnants of building slabs, and several private roadways. A ridge bisects the Site approximately along the alignment of the existing Tape Drive.

To the north, existing runoff flows from the ridge north and east towards S. 96th Street at slopes approximately ranging from 2-3%. To the South, existing runoff flows from the ridge south and east towards Highway 36 at slopes approximately ranging from 2-45%.

The Site is shown to be in a Zone X Flood Area according to FIRM map 08013C0584K, Boulder County, Colorado, and Incorporated Areas, August 15, 2019. Zone X is described on this map as areas outside the 0.2% annual chance of flood. Runoff from the northwest portion of the Site generally flows into the existing Tributary I at slopes ranging from 5-10%. Tributary I is not a FEMA regulated floodplain. Tributary I is, and will remain, a natural channel terminating on-site into a roadway culvert at S. 96th Street, that will be replaced with proposed construction on S. 96th Street. See Section IV for specific details about the Tributary I. A copy of the FIRM map is included in Appendix A for reference.

The Louisville OSP also describes several irrigation swales traversing the Site, specifically Goodhue Ditch (hereinafter referred to as “Ditch”) in the northeast corner of the Site and Tributary I along the Site’s northern property boundary. Specific details on the Ditch culvert crossing are provided in Section IV of this report.

According to the Request for Approved Jurisdictional Determination for Phillips 66 Site Boulder and Broomfield Counties, Colorado issued on January 24, 2019, by ERO Resources Corp., none of the existing drainage features within the Project area are jurisdictional except for the Ditch and Rock Creek. Development is not planned in the vicinity of Rock Creek, and no modifications to Rock Creek are proposed.

According to the Phillips 66 Site – Delineation of the Ditch and Rock Creek issued on September 23, 2019, by ERO Resources Corp., there are wetlands abutting the Ditch. ERO mapped approximately 0.428 acres of open water along the Ditch and approximately 0.121 acres of wetlands abutting the Ditch within the Project area during a 2019 Site visit. A copy of this report can be found in Appendix B for reference.

According to soils information provided by CTL|Thompson for the project, the soil borings for the Site consist of existing fill and/or natural sandy clay with fewer amounts of sand, gravel and cobble, which overlie claystone and interbedded claystone/sandstone bedrock of the Laramie Formation. A majority of the soils on the Site are Type C soils. A copy of the geologic, bedrock, and groundwater maps is included in Appendix B for reference.

According to the Boulder Valley School District (hereinafter referred to as “BVSD”) Louisville Campus PUD Drainage Report (hereinafter referred to as “School Report”), there is an existing pond at the northwest corner of the Site (hereinafter referred to as “School Pond”), that is a part of the Monarch K-8 school’s drainage system. According to the School Report, the pond collects runoff from an off-site basin tributary to the school’s site. This runoff is detained in the pond at the northwest corner of the Site and then released into a drainage swale that drains to a culvert under Campus Drive and outfalls into the Bus Loop Pond on the school’s site. The School Report specifies that this runoff was detained off-site because the engineer was concerned that peak flows from this basin would increase the size of the on-site systems and the size of Bus Loop Pond. A copy of the Master Drainage Plan for the BVSD Monarch School Campus is included in Appendix B for reference.

C. Historic Drainage

1. Major Basin Description

The Site is located within Basins 4-I, 5-I, 6-I, 2-J, and 10-H of the Louisville OSP. The north portion of the Site is tributary to Rock Creek Tributary I, and the balance of the Site is tributary to the Rock Creek main channel. Rock Creek eventually combines with Coal Creek and is tributary to Boulder Creek. The following is how the Louisville OSP describes the Rock Creek and Coal Creek basins:

> *"The Rock Creek basin has a northeast aspect with the high point of the basin (elevation 5560) just southwest of U.S. 36. The upper section of the basin has slopes that range from 5 to 10% and then level out to an average of 1.5% in the lower reaches of the basin."*

> *"The Coal Creek basin has a West to East aspect with the high point (elevation 5670) of the basin on the Davidson Mesa. The slopes on top of the mesa are very mild, but rapidly approach 6 to 7% upon decent from the mesa. The terrain then levels out to an average grade of 2% for the remaining portion of the basin."*

The Site contains several irrigation swales and ditches that were utilized with the previous land uses but are no longer in service. The only active and defined irrigation ditch is located in the far northeast corner of the Site and is owned by the Goodhue Ditch & Reservoir Company (hereinafter referred to as "Ditch Company"). All other irrigation swales and ditches are non–binding and will be routed on a Site level basis per development plans for individual parcels.

2. Sub-Basin Description

Basin delineation, areas, and flows for the Existing Drainage Plan were derived from the Louisville OSP as the existing condition. The Site design maintains the historical drainage patterns and the allowable flow at S. 96th Street (specified by the Louisville OSP) will not be exceeded with the proposed development.

Runoff flows from the northern portion of the Site (Louisville OSP Basins 4-I and 5-I) historically drains to the existing Rock Creek Tributary I channel, which contains two existing in line ponds. The central portion of the Site (Louisville OSP Basin 6-I) historically drains from southwest to northeast into a channel on the eastern side of the Site which conveys flows from South to North along the Northwest Parkway. The southern portion of the Site (Louisville OSP Basin 2-J) historically flows from west to east across the Site to the Northwest Parkway. As shown in the Louisville OSP, approximately half of basins 4-I and 5-I drain on-site from off-site. The flows from these basins, as well as portions of basin 10-H, are accounted for in the design of Rock Creek Tributary I. See Appendix D to reference the Existing Drainage Plan.

The historic basin 2-J of the Louisville OSP located in the southeast portion of the site drains to an existing 48" HDPE culvert located at the East side of the basin that conveys flows offsite underneath Northwest Parkway where it joins an existing "Northern" storm sewer that discharges flows to the Northeast. Historical records indicate that it conveys a flow of 39.17 CFS and 80.5 CFS for the 5- and 100-year storm respectively. Additional Information and flows can be found in Appendix B of the Via Varra & West Midway Improvements construction documents prepared by Drexel Barrel & CO (December 4, 2002), included in Appendix B.

Off the northeast corner of the Site, at the Tributary I crossing, the Northwest Parkway Toll Authority installed the existing dual (2) 10' x 6' Reinforced Concrete Box Culvert (hereinafter referred to as "RCBC") at the intersection of the Northwest Parkway and S. 96th Street. The existing culvert under the Northwest Parkway will be maintained as the outfall for the Site flows. Per Table 4 of this report, peak flows to this culvert are lower than historic in the developed condition.

III. DRAINAGE DESIGN CRITERIA

A. Regulations

The Site will comply with the City's and Mile High Flood District's, formerly known as Urban Drainage Flood Control District (hereinafter referred to as "MHFD"), requirements. The Site will comply with current City and MHFD criteria, including runoff reduction, water quality capture volume, stabilizing drainageways and source control BMPs, as applicable. The Site will also comply with the Louisville OSP as it relates to the extents of the Site.

B. Development Criteria References and Constraints

The principal design guidelines that will be sourced for this Site development are the City of Louisville Storm Drainage & Technical Criteria Manual (hereinafter referred to as "Louisville Criteria") and the current version of the MHFD Urban Storm Drainage Criteria Manual (hereinafter referred to as "District Manual").

The existing conditions of the adjacent properties and those relevant drainage studies that affect the Site in that the existing conditions were analyzed, and the appropriate measures taken to maintain historic runoff as it relates to the Site. The drainage design will be affected by the proposed grading, building outline and legal boundaries of the Site. These existing basins encompass the entirety of the Site and represent the previous drainage study the Site will be modifying per the proposed developments.

Existing Site constraints include Rock Creek Tributary I, the Goodhue Ditch, and various irrigation ditches or swales throughout the Site, existing structural building pads, and an overhead electric line and easement. Please see Appendix D for existing drainage. See Section IV of this report for a discussion on how the Site will take into consideration Rock Creek Tributary I and the Goodhue Ditch.

C. Hydrologic Criteria

On a regional basis for the channel design, a hydrologic stormwater routing analysis for the watershed was completed using a combination of the Colorado Urban Hydrograph Procedure (CUHP) v. 2.0.0 and the US Environmental Protection Agency Storm Water Management Model (EPA SWMM) v. 5.1. To create the Tributary I regional model, storm hydrographs produced by CUHP were integrated into EPA SWMM for routing and flood risk analysis.

The following formula, from the District Manual, was used to determine rainfall intensities:

$$I = \frac{28.5 P_1}{(10 + T_C)^{0.786}}$$

For this report, the 5-year and 100-year storm events have been analyzed. The 5-year storm is considered the minor event and the 100-year storm is considered the major event. One-hour rainfall P_1 values were taken from NOAA Atlas 14, Volume 8, and Version 2 for the Site. The P_1 values for the 5-year and 100-year storms are 1.08 inches and 2.50 inches, respectively.

CUHP and EPA SWMM were used in conjunction to analyze peak flows for the proposed roadway storm sewer analysis. While the Rational Method is often used for runoff analyses totaling under 90 acres, the CUHP method is more accurate and exceeds the minimum criteria set by the City. Utilizing catchment area, rainfall data, an assumed imperviousness for all development parcels, and infiltration parameters based on Horton's Infiltration Model, the CUHP workbook calculates hydrographs to determine the basin time to peak flow and peak runoff rate, in additional to other parameters. As a conservative approach, to accommodate future developments, most parcel areas are assumed to have between 75-85% imperviousness to account for future development. Most roadway basins were set at 75%, to account for pervious landscaping. Roadway basins containing roundabouts were assumed to be 80% to account for the increased amount of pavement. The following basins were assumed to have a lower percentage of impervious surfaces, between 2-9%, as limited development is predicted in these areas: A-1, A-2-1, D-2, F, OS-1, OS-2, and OS-3. The results from these calculations can be found in Appendix C, for reference. The CUHP results are linked to the EPA SWMM model in order to assess the proposed storm drain system.

As these criteria represent all required information for development of Project hydrology, other criteria or calculation methods outside of Louisville Criteria and the District Manual were not used in the hydrologic design for the Site.

D. Hydraulic Criteria

Storm sewer pipes and inlets were sized for the 100-yr major storm event throughout all phases of the Site; supporting calculations can be found in Appendix C. Storm sewers were evaluated using EPA SWMM 5.1. With EPA SWMM having limited capabilities to account for bypass runoff from street inlets, the MHFD-Inlet v5.02 workbook was utilized to evaluate each inlet's size and capacity. Computations from the MHFD-Inlet workbook can be found in Appendix C, showing that bypass flows were accounted for in the hydraulic analysis of all inlets.

For the proposed Site Full Spectrum Detention Facilities, the District Manual MHFD-Detention_v4.03 workbooks were used to determine required volumes and release rates for each design storm.

Per Chapter 3.0 of the District Manual; calculation of the Water Quality Capture Volume (hereinafter referred to as "WQCV") in watershed inches is given as:

$$WQCV = a (0.91 I^3 – 1.19 I^2 + 0.78 I)$$ Equation 3-1

where:
- a = 1.0 for a 40-hour drain time for extended detention.
- I = Contributing Basin Imperviousness

$$V = (WQCV * A) / 12$$ Equation 3-2

where:
- V = required storage volume (acre-feet)
- A = watershed tributary area upstream (acres)
- WQCV = Water Quality Capture Volume (watershed-inches)

The proposed storm sewer design adheres to the City of Louisville's Storm Drainage and Technical Criteria Manual (August 2013). For further details regarding the storm sewer design and computations, refer to Appendix C.

Other criteria or calculation methods outside of Louisville Criteria and the District Manual were not used in the hydraulic design for the Site.

E. Waivers from Criteria

No waivers were requested or granted. All aspects of design are intended to meet or exceed criteria.

IV. DRAINAGE FACILITY DESIGN

A. General Concept

The general drainage concept for the Site is to capture storm water runoff from the Site and roadway drainage basins and route the runoff through proposed storm sewer infrastructure to existing and proposed Full Spectrum Detention Facilities. Detained runoff will be released at specified rates through outlet structures to existing or proposed drainage infrastructure. Runoff from Basins D-2 and C-6-3 will flow off the Site per historic conditions into the drainage system associated with U.S. Highway 36. This is referenced in Appendix D.

The north portion of the Site releases per historical conditions and as shown on the Existing Drainage Plan at 96th Street. From this point, Tributary I releases to the existing dual 10'(W) x 6'(H) RCBC under the Northwest Parkway. Per the Louisville OSP, the peak discharge at this location is 842 cfs for the 100-year storm event. Proposed Site releases, as described below, will not exceed the allowable 842 cfs through the existing dual 10' x 6' RCBC in the 100-year storm event.

SWMM element Out1 represents all the Site flows contributing to Tributary I. The OSP shows a flow of 842 cfs discharging from the Site through Tributary I, but Site detention meeting MHFD standards have decreased this to below pre-developed site conditions. The SWMM model 100-year storm event flows at element Out1 were found to be 441 cfs in the pre-developed condition and 373.68 cfs in the developed condition. This shows the Site is meeting the design criteria of MHFD to release 100-year storm events at or below the pre-developed flows from the basin.

SWMM element Out2 represents all the flows contributing to the 48" RCP shown on the Grading Plan and Basin Delineation from the Via Varra & West Midway Improvements construction documents prepared by Drexell Barrell & company which are provided in Appendix B. This report calculates that off-site basin DA-1C contributes 80.5 cfs to the Northern Storm System which is the existing 48" HDPE culvert. The SWMM model 100-year storm event flows at element Out2 were found to be 65.26 cfs in the developed condition.

The aforementioned report additionally calculates that off-site basins DA-1A and DA-1B contribute 19.5 cfs to the Southern Storm System at the existing 36" HDPE storm sewer in Via Varra Road. Most of these flows from this area will be routed to the on-site pond C-2 and the only flow contributing to the Southern Storm System will be from sub-basin C-6-3 with a developed flow of 1.59 CFS. These flows are not represented in the SWMM model. See appendix B for existing offsite basins.

SWMM nodes were created corresponding to the proposed layout of the complete storm sewer system. The full SWMM modeling inputs and results can be found in Appendix C.

B. Specific Details

The following section describes in detail the proposed major drainage basins for the Phase 1 Redtail Ridge Site. See Appendix D for a detailed layout of all major basins.

Minor basins within the roadway areas are shown in the drainage plan and included in the CUHP/SWMM calculations found in Appendix C.

Calculations for all proposed Ponds as well as their respective outlet structure design can also be found in Appendix C.

Basin A is in the northwest corner of the Site located to the north of Rockcress Drive, to the east of South 88th Street, and to the south of Campus Drive, Tributary I splits the parcel from southwest to northeast dividing Sub-Basins A-1 and A-2-1. Flows from A-1 historically flow from northwest to southeast into Tributary I and flows from Sub-Basin A-2-2 historically flow from southwest to northeast into Tributary I. Sub-Basin A-3 consists of a portion of Rockcress Drive which must be discharged into Basin A.

Sub-Basin A-1 (37.99 acres, 2% imperviousness) is northwest of Tributary I. Sub-Basin A-1 is proposed to be an open space area dedicated to the City of Louisville. Stormwater runoff from Sub-Basin A-1 will continue to sheet flow as it historically does into Tributary I. Water quality should be considered for any future hardscape improvements (such as parking lots) that may be proposed in this basin.

Sub-Basin A-2-1 (14.64 acres, 2% imperviousness) is south of Tributary I. Sub-Basin A-2-1 is proposed as an undeveloped parcel where stormwater runoff will drain as it has historically and will release directly to Tributary I.

Sub-Basin A-2-2 (34.10 acres, 85% imperviousness) is southeast of Tributary I. Sub-Basin A-2-2 is proposed to be a mixed land use including parking, buildings, sidewalks, and landscaped areas. Stormwater runoff from Sub-Basin A-2 is proposed to drain to future curb, gutter, inlet, and storm sewer system that will release to the proposed full spectrum detention Pond B at a location in the downgradient area of the basin. Pond B is proposed to release flows to Tributary I.

Sub-Basin A-3 (0.62 acres, 75% imperviousness) is along the western extents of Rockcress Drive. Sub-Bain A-3 consists of roadway and detached sidewalk. Stormwater runoff from Sub-Basin A-3 is proposed to drain to future curb, gutter, inlet, and storm sewer system along Rockcress Drive that will release to a Barracuda Hydrodynamic Separator water quality device, location in the southwestern corner of Sub-Basin A-3. The flow is proposed to be released to the Rock Creek Tributary I channel after receiving water quality treatment.

In the pre-developed condition, the Health Park subdivision and the S. 88th Street roadway west of Basin A contribute 84 cfs to the School Pond at the northwest corner of Basin A.

The School Pond then releases up to a maximum of 56 cfs north into the school site through a 30" RCP storm sewer pipe north to the Bus Loop Pond, as shown on the BVSD Drainage plan provided in Appendix B. With the development of Campus Drive, the school pond will be removed and these flows are proposed to be captured at the 88th and Campus Drive intersection and will then routed to the proposed storm sewer in Campus Drive.

A 30" RCP will outlet from a manhole in the proposed Campus Drive storm sewer and release flows at an equivalent rate as the existing culvert into the Bus Loop Pond. The balance of flow not released to the Bus Loop Pond will overtop the 30" RCP in the manhole and continue east through the proposed Campus Drive storm sewer system to Pond C-1.

In the existing condition, flows from the offsite School Site Basin contribute 1.9 cfs in the 10-year event and 4.2 cfs in the 100-year event to Sub-Basin A-1. The School Site Detention Pond D releases 1.1 cfs in the 10-year event and 4.8 cfs in the 100-year event into Sub-Basin A-1 as well. With the construction of Campus Drive, these flows will be collected by the proposed storm sewer main in Campus Drive. These flows will be routed to the storm sewer in Campus drive beginning at the existing flared end section at the northwest corner of the parcel and be released into Pond C-1.

Basin B is in the central portion of the Site located to the north of Rockcress Drive, to the east of Basin A-1, to the south of Campus Drive, and to the west of Sorrel Avenue. A natural ridge in the southern portion of the parcel splits the basin into Sub-Basins B-1 draining north and B-2 draining south.

Sub-Basin B-1 (79.46 acres, 85% imperviousness) consists of buildings, roadways, sidewalks, and landscaped areas. Runoff will drain to curb, gutter, inlet, and storm sewer system that will release to a proposed Full Spectrum Detention Facility Pond B (hereinafter referred to as "Pond B") located at the northeast corner of Basin B. Pond B is planned to release north into Tributary I. Calculations for the design of Pond B as well as outlet structure design are included in Appendix C.

Sub-Basin B-2 (30.37 acres, 85% imperviousness) consists of buildings, roadways, sidewalks, and landscaped areas. Runoff will be conveyed by curb and gutter to storm inlets and drain south to proposed Full Spectrum Detention Facility Pond C-2. A storm sewer outfall stub is provided to the southeast corner of Basin B-2 to collect developed stormwater runoff from Basin B-2 and route to Pond C-2.

Basin C is in the eastern portion of the Site and generally lies east of Sorrel Avenue and west of S. 96th Street. A natural ridge in the south portion of the parcel splits the basin into Sub-Basins C-1 draining north and C-2 draining south. Basin C Sub-Basins include the portions of Campus Drive, Rockcress Drive, and Sorrel Avenue which are Tributary to Ponds C-1 and C-2.

Sub-Basin C-1 (53.21 acres, 80% imperviousness) is in the northeastern portion of Basin C between Sorrel Avenue and S. 96th Street. This Sub-Basin is proposed to be developed at 80% Imperviousness. Sub-Basin C-1 contains the Full Spectrum Detention Facility Pond C-1 (hereinafter referred to as "Pond C-1"). Basin C-1 will be developed to drain to a curb, gutter, inlet and storm sewer system that will release to Pond C-1, located at the northeast corner of the basin. Pond C-1 is a planned permanent water surface facility with stormwater detention provided above the permanent water surface. This pond will follow state permit procedure for permanent water surface facilities. The outlet of Pond C-1 will release east into Tributary I.

Sub-Basin C-2 (19.63 acres, 80% imperviousness) is the southeastern portion of Basin C between Sorrel Avenue and Northwest Parkway. This Sub-Basin is proposed to be developed at 80% Imperviousness. Runoff from Sub-Basin C-2 will be routed south through a proposed curb, gutter, inlet, and storm sewer system to Pond C-2 where it will be combined with flows from Sub-Basin C-5. The combined flows will then be detained for both the WQCV event and the major storm event. The outfall for Pond C-2 will be routed to the existing 48" RCP storm sewer releasing east under the Northwest Parkway.

Sub-Basin C-3 (14.17 acres, 79% imperviousness) is composed of the area routed to Basin C from Campus Drive and Sorrel Avenue. Stormwater runoff in Sub-Basin C-3 will be developed to drain to a curb, gutter, inlet, and storm sewer system that will release to Pond C-1.

Sub-Basin C-3-1 (1.34 acres, 80% imperviousness) is located on the west section of Campus Drive near S 88th Street. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-basin is routed by proposed curb and gutter to a 15' Type R inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-2 (1.30 acres, 80% imperviousness) is located on the west section of Campus Drive near S 88th Street. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-basin is routed by proposed curb and gutter to a 15' Type R inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-3 (0.42 acres, 75% imperviousness) is located on the west section of Campus Drive. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-basin is routed by proposed curb and gutter to a 5' Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-4 (0.44 acres, 75% imperviousness) is located on the west section of Campus Drive. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and

gutter to a 5’ Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-5 (0.73 acres, 80% imperviousness) is located on the west section of Campus Drive. The Sub-Basin consists of roadway, a roundabout and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10’ Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-6 (0.76 acres, 80% imperviousness) is located on the west section of Campus Drive. The Sub-Basin consists of roadway, a roundabout and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10’ Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-7 (0.95 acres, 80% imperviousness) is located on the west section of Campus Drive. The Sub-Basin consists of roadway, a roundabout and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10’ Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-8 (0.95 acres, 80% imperviousness) is located on the west section of Campus Drive. The Sub-Basin consists of roadway, a roundabout and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10’ Type inlet and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-15 (0.65 acres, 75% imperviousness) is located near the middle of Campus Drive. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 15’ Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-16 (0.67 acres, 75% imperviousness) is located near the middle of Campus Drive. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 15’ Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-17 (0.52 acres, 80% imperviousness) is located on the east section of Campus Drive. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10’ Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-18 (0.56 acres, 80% imperviousness) is located on the east section of Campus Drive. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type inlet (on-grade) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-19 (0.89 acres, 80% imperviousness) is located at the intersection of Campus Drive and Sorrell Ave. The Sub-Basin consists of roadway, a roundabout, and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type inlet (on-grade) and conveyed south then east through the proposed storm network to Pond C-1.

Sub-Basin C-3-20 (1.97 acres, 80% imperviousness) is located on the north section of Sorrell Ave. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (sump) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-3-21 (2.02 acres, 80% imperviousness) is located on the north section of Sorrell Ave. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (sump) and conveyed east through the proposed storm network to Pond C-1.

Sub-Basin C-4 (2.78 acres, 75% imperviousness) is composed of the northeastern portion of Campus Drive which grades preclude from being routed to Pond C-1. Stormwater runoff in Sub-Basin C-4 is to be collected by proposed curb, gutter, inlets, and storm sewer which will be treated by a Barracuda Hydrodynamic Stormwater Separator to provide water quality and then routed to Tributary I. A BMP agreement will be put together for this stormwater facility this will be finalized along with the civil construction documents for this facility.

Sub-Basin C-4-1 (1.16 acres, 75% imperviousness) is located at the northeast corner of the site near the intersection of Campus Drive and S 96th Street. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (on-grade) and conveyed south through the proposed storm network to a Barracuda Hydrodynamic Stormwater Separator for water quality treatment before being released to Tributary I.

Sub-Basin C-4-2 (1.62 acres, 75% imperviousness) is located at the northeast corner of the site near the intersection of Campus Drive and S 96th Street. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (on-grade) and conveyed south through the proposed storm network to a Barracuda

Hydrodynamic Stormwater Separator for water quality treatment before being released to Tributary I.

Sub-Basin C-5 (10.69 acres, 76% imperviousness) is composed of the area routed to Basin C from Rockcress Drive and Sorrel Avenue. Stormwater runoff in Sub-Basin C-5 will be developed to drain to a curb, gutter, inlet, and storm sewer system that will release to Pond C-2. For more detailed information pertaining to Sub-Basins C-5-1 through C-5-8 refer to the Redtail Ridge Phase 2 Drainage Report.

Sub-Basin C-5-9 (0.37 acres, 75% imperviousness) is located at the intersection of Rockcress Drive and Sorrell Ave. The Sub-Basin consists of roadway, a roundabout, and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 5' Type R inlet (sump) and conveyed east through the proposed storm network to Pond C-2.

Sub-Basin C-5-10 (0.71 acres, 75% imperviousness) is located north of the intersection of Rockcress Drive and Sorrell Ave. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (on-grade) and conveyed south then east through the proposed storm network to Pond C-2.

Sub-Basin C-5-11 (0.71 acres, 75% imperviousness) is located north of the intersection of Rockcress Drive and Sorrell Ave. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (on-grade) and conveyed south then east through the proposed storm network to Pond C-2.

Sub-Basin C-5-12 (0.97 acres, 80% imperviousness) is located at the intersection of Rockcress Drive and Sorrell Ave. The Sub-Basin consists of roadway, a roundabout, and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (on-grade) and conveyed east through the proposed storm network to Pond C-2.

Sub-Basin C-5-13 (0.96 acres, 80% imperviousness) is located at the intersection of Rockcress Drive and Sorrell Ave. The Sub-Basin consists of roadway, a roundabout, and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 15' Type R inlet (on-grade) and conveyed east through the proposed storm network to Pond C-2.

Sub-Basin C-6 (1.82 acres, 75% imperviousness) is composed of the southeastern portion of Rockcress Drive which at portion of its grades preclude from being routed to Pond C-2. Stormwater runoff in Sub-Basin C-6-1 and C-6-2 is to be collected by proposed curb, gutter, inlets, and storm sewer and will be routed to pond C-2. Sub basin C-6-3 will sheet flow off site and will then be routed to the existing 36" HDPE storm sewer releasing east in Via Varra Road.

Sub-Basin C-6-1 (0.67 acres, 75% imperviousness) is located at the southeast portion of the Site near the intersection of Rockcress Drive and Northwest Parkway. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (on-grade) and conveyed north through the proposed storm network to Pond C-2.

Sub-Basin C-6-2 (0.81 acres, 75% imperviousness) is located at the southeast portion of the Site near the intersection of Rockcress Drive and Northwest Parkway. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is routed by proposed curb and gutter to a 10' Type R inlet (on-grade) and conveyed north through the proposed storm network to Pond C-2.

Sub-Bains C-6-3 (0.34 acres, 75% imperviousness) is located at the southeast portion of the Site near the intersection of Rockcress Drive and Northwest Parkway. The Sub-Basin consists of roadway and detached sidewalk. Stormwater runoff in this Sub-Basin is sheet flows to an existing 36" HDPE storm sewer before releasing east in Via Varra Road.

Basin D is in the southern portion of the Site and generally lies south of Rockcress Drive and Basin E. Extents of proposed development and an existing ridge in Parcel E split Sub-Basins D-1, D-2, and E. Sub-Basin D-1 drains from both northwest and southeast to meet approximately in the center of the sub-basin. Sub-Basin D-2 generally drains along the existing ridge in Parcel E from northeast to southwest.

Sub-Basin D-1 (14.55 acres) contains the southeast corner of the Site, an area bounded by Rockcress Drive to the north, by property boundary to the south and by an existing ridge to the west. Flows from Sub-Basin D-1 shall be routed to storm sewer east of the intersection of Rockcress Drive and Sorrel Avenue through curb, gutter, inlets, and storm sewer. Flows will then be routed to the Full Spectrum Detention Facility Pond C-2, where flows will be detained for both the WQCV event and the major storm event. In order for the parcel to drain to Pond C-2 fill is required to be placed on the Site. If alternate parcel development plans are desired, this area may be released south to Rock Creek with the proper Jurisdictional approvals.

Sub-Basin D-2 (19.40 acres, 2% imperviousness) is proposed as open space and will drain as it does historically. The historical flows for Basin D-2 generally flow from northeast to southwest into an empty field within the City and County of Broomfield. There appears to be an outfall crossing Northwest Parkway and Storage Tek Drive approximately 800' south from the southeast corner of the Site where runoff from D-2 eventually ends and continues downstream.

Sub-Basin D-3 (11.26 acres) contains the southeast corner of the Site, an area bounded by Rockcress Drive to the north, by property boundary to the south and Northwest Parkway to the west. Flows from Sub-Basin D-3 shall be routed to storm sewer east of the intersection of Rockcress Drive and Northwest Parkway via a stub out for future connection. Flows will then be routed to the Full Spectrum Detention Facility Pond C-2, where flows will be detained for both the WQCV event and the major storm event. In order for the parcel to drain to Pond C-2 fill is required to be placed on the Site. If alternate parcel development plans are desired, this area may be released south to Rock Creek with the proper Jurisdictional approvals.

Basin E (34.33 acres, 75% imperviousness) is in the southwest portion of the Site and generally lies south of Basin A and west of Sub-Basin D-2. Stormwater runoff in Basin E is proposed to drain to a curb, gutter, inlet, and storm sewer system that will release to a proposed Full Spectrum Detention Facility Pond E located in the downgradient portion of Basin E. Pond E is planned for future construction in the development of PUD-8. For more detailed information pertaining to Sub-Basins E and Pond E, refer to the Redtail Ridge Master Drainage Report.

Basin F (17.05 acres, 2% imperviousness) is in the northern portion of the Site and is existing open space and will drain as it does historically. Basin F is bound on the north by the property line and on the east, west, and south by Campus Drive. The historical flows for Basin F generally flow from the extents of the basin to the center where they meet Tributary I. Two reinforced concrete box culverts with headwalls and riprap aprons at the inlet and outlet locations are proposed for construction where Tributary I intersects Campus Drive. Both crossings are composed of a dual box system which includes one lower structure solely for flow conveyance and another raised structure which doubles as a trail underpass for maintenance vehicle and pedestrian access up to the 10-year event. The lower RCBC will have a span of 8’ with a rise of 5’ and the raised trail underpass RCBC will have a span of 10’ and rise of 8’. A trail is proposed within Basin F spanning from east to west to allow access for pedestrians and maintenance vehicles.

Basin OS-1 (77.43 acres, 9% imperviousness) is located generally west of the Site and is existing open space and roadway areas. Basin OS-1 will drain as it does historically. The historical flows for Basin OS-1 generally flow east to S. 88th Street. Flows are conveyed under 88th St. to Tributary I in Basin A via an existing 36” RCP culvert and two 18” CMP.

Basin OS-2 (33.32 acres, 6% imperviousness) is located generally north of the Site and is existing farm and residential land. Basin OS-2 will be left to drain as it does historically. The historical flows for Basin OS-2 generally flow southeast into Basin F and then Tributary I.

Basin OS-3 (19.51 acres, 5% imperviousness) is located generally north of the Site, east of OS-2, and is existing farm and residential land. Basin OS-3 will also be left to drain as it does historically, into Basin F and then Tributary I.

Table 1 below summarizes the basin and direct runoff information for both Phase 1 and Phase 2.

Table 1: Basin and Direct Runoff Summary Table

BASIN	AREA (AC)	IMP. (%)	Q2 (CFS)	Q10 (CFS)	Q100 (CFS)
A-1	37.99	2	0.24	6.87	37.40
A-2-1	18.42	2	0.08	2.19	12.21
A-2-2	30.37	85	31.92	56.46	120.74
A-3	0.62	75	0.24	0.46	1.09
B-1	78.76	85	82.82	145.97	309.64
B-2	31.01	85	33.22	59.73	123.28
C-1	53.21	80	45.87	83.88	183.61
C-2	19.63	80	22.10	41.84	88.58
C-3	14.17	79	5.22	9.54	22.53
C-4	2.78	75	1.69	1.10	7.26
C-5	10.69	76	11.41	22.05	47.94
C-6	1.82	75	1.23	2.31	5.22
D-1	25.82	70	19.16	36.96	85.60
D-2	19.40	2	0.12	3.41	18.55
E	34.33	75	28.67	53.52	120.26
F	17.05	2	0.11	3.06	16.59
OS-1	77.43	9	8.78	21.66	99.62
OS-2	32.32	6	0.71	7.20	40.72
OS-3	19.51	5	0.36	4.36	25.31

C. Goodhue Ditch

The Ditch traverses the far northeast corner of the Site and is owned by the Ditch Company. The Ditch contains a defined bed and bank with fringe wetlands along portions of the banks. The Ditch is shown on the United States Geological Survey (USGS) Louisville topographic quadrangle and on the National Hydrography Dataset (NHD) as a canal/ditch and intermittent stream.

A crossing of the Ditch by Campus Drive is planned, subject to Ditch Company's approval, with the proposed development. The Ditch will continue to outfall per historic conditions at the existing location on northeast property boundary. The Ditch Company has been contacted regarding the requirements of the proposed Ditch revisions. The proposed Ditch crossing has been designed and included in a separate plan set for approval by the Ditch Company according to the Ditch Company requirements.

Decreed flows in this section of the Ditch range between 30 cfs and 40 cfs. We have requested additional information on the specific decreed flow from the Ditch Company. Based on the Ditch crossing at the intersection of Via Varra and Northwest Parkway just

north of the Broomfield Business center, a 54" RCP has been sized for the Ditch crossing. Preliminary calculations indicate that a 54" RCP conveys 50 cfs, which was used for design on the Site. A maintenance road with a minimum 15' wide easement is required, and the roadway crossing will also incorporate the ability for maintenance equipment to cross.

As the Ditch crossing will disturb waters of the US, the Project team has engaged the services of ERO Resources Corporation to assist in obtaining the required permitting. A copy of ERO's Preconstruction Notification (hereinafter referred to as "PCN") can be found in Appendix B. Per correspondence with the Army Corps of Engineers, the Goodhue Ditch Crossing, (NWO-2020-00467-DEN) will be issued an exemption for this project. It will be considered construction of an irrigation ditch, which is exempt under Section 404(f), and does not require a permit, which is referenced in Regulatory Guidance Letter 07-02.

The Site contains several other minor irrigation swales and ditches that are internal to the Site and do not flow off-site. All other irrigation swales and ditches in the Project are non–binding and will be routed on a Site level basis per development plans for individual parcels. See Appendix D for the Existing Drainage Plan sheet.

D. Stormwater Detention and Water Quality

All on-site Detention and water quality ponds are designed to be Full Spectrum Extended Detention Basins (EDBs) per the Criteria of the District Manual Volume 3. Ponds B and C-1 are designed as permanent wet bottom EDBs, and Pond C-2 is designed as a dry bottom EDB. For detailed information about Pond C-2, refer to the Phase 2 Drainage Report. Construction Documents detail the required forebay, upper stage area, lower stage area and micro-pool area of these EDBs. Each EDB design will incorporate an outlet feature that is intended to delay the release of the WQCV over a 40-hour period. This outlet feature will also allow the major 100-year storm event to be detained and released through the top of the outlet feature. The overflow has been designed with 1.0' of freeboard to the top of the detention berm. The spillway is sized to accommodate the 100-year event total inflows to the pond and incorporate Type L buried soil riprap as the outlet protection. The three EDBs will serve as permanent, post-construction BMP to treat the WQCV in accordance with Louisville Criteria for the ponds' tributary area.

Pond B is designed with a permanent water surface elevation per the Criteria of the District Manual Volume 3. Pond B will capture the runoff from future PUDs 1 through 4, or Basins A-2-2, and B-1. Individual drainage conformance reports for the PUDs will be provided in the future adhering to design laid out in this report. Conservative estimates were made in the design process for Pond B, assuming 85% imperviousness for the 113.55 acres of contributing area to ensure the pond provides adequate storage while the PUDs' designs are finalized. Refer to the Internal Roads Drainage Report for a more detailed analysis of the contributing areas to Pond B. Aqua Engineering performed hydrologic calculations estimating the peak summertime evaporation rates and the required flowrate to replenish the pond to the permanent water surface elevations within

a given time frame. In addition to designing the domestic water tap system detailing the tap size, system function, and how the shutoff functioning operates. For detailed information about the domestic water tap system to replenish Pond B, refer to the Aqua Engineering Report. Pond B will outfall through a storm sewer system to Tributary I, just upstream of the proposed culvert under S 96th Street.

Pond C-1 is designed with a permanent water surface elevation per the Criteria of the District Manual Volume 3. Pond C-1 will capture runoff from Basins C-1 and C-3, which includes the 88th Street Culvert, West BVSD Culvert, and the BVSD Pond Bypass. Refer to the Off-Site Flows section of this report for more information pertaining to the BVSD and 88th Street culvert flows. An impervious value of 79.84% was calculated for the 67.38 acres of contributing area as design parameters for Pond C-1. Aqua Engineering performed hydrologic calculations estimating the peak summertime evaporation rates and the required flowrate to replenish the pond to the permanent water surface elevations within a given time frame. In addition to designing the domestic water tap system detailing the tap size, system function, and how the shutoff functioning operates. For detailed information about the domestic water tap system to replenish Pond B, refer to the Aqua Engineering Report. Pond C-1 will outfall through a storm sewer to Tributary I, just upstream of the location of the proposed culvert under S. 96th Street.

Pond C-2 is designed as a full spectrum EDB per the Criteria of the district Manual Volume 3. Pond C-2 will capture runoff from Basins B-2 (PUD 1), C-2, C-5, C-6-1, C-6-2, and D-1. Conservative estimates were made in the design process for Pond C-2, assuming 80% imperviousness for the 87.99 acres of contributing area to ensure the pond provides adequate storage while PUD 1's design is finalized. Pond C-2 will outfall through an existing 48" HDPE storm sewer under Northwest Parkway that flows to the Via Varra subdivision east of the Site.

Table 2 below summarizes the on-site detention for Phase 1.

Table 2: Site Detention Summary

Pond	Contributing Area (ac)	Max 100-YR Depth (ft)	Design % Imp.	WQCV (ac-ft)	EURV (ac-ft)	Required Volume (ac-ft)			Provided Volume (ac-ft)	Allowable Release Rate (cfs)			Design Release Rate (cfs)		
						2-YR	10-YR	100-YR		2-YR	10-YR	100-YR	2-YR	10-YR	100-YR
B	113.56	6.27	85.00%	3.44	9.54	5.44	10.28	16.71	19.711	N/A	34.20	176.8	5.32	8.70	86.84
C-1	67.38	3.61	79.84%	1.86	5.31	3.03	5.75	9.23	9.617	N/A	9.09	52.70	2.38	4.69	47.39
C-2	87.98	8.47	79.42%	2.35	6.76	4.11	7.35	10.93	12.758	N/A	19.89	105.7	1.39	11.5	74.27

*Allowable release rate is 90% of the predevelopment 100-yr peak runoff rate per USDCM criteria.

An ADS Barracuda Max S4 in an HP manhole is proposed in Basin C4 to provide water quality treatment for surface runoff that is not routed to a detention facility prior to releasing into Tributary I. Refer to Appendix C for construction details.

To further the MHFD goal of watershed level runoff control, this Final Master Drainage Report encourages the implementation of Low Impact Development practices and alternative water quality features per the District Manual Volume 3, Chapter 4.

The WQCV treatment system and release rate will be designed in accordance with Volume 3 of the District Manual and Chapter 6 of Louisville Criteria. The Full Spectrum Detention Facilities are designed as permanent, post-construction Best Management Practice (BMP) to treat the WQCV in accordance with Louisville Criteria for each of the facilities' tributary areas.

E. Off-site Flows

Basin D-2, which is to be left undeveloped, is the only on-site basin which will be left to flow freely off-site. This basin contains primarily landscaped areas and will continue to flow off-site per historical conditions.

Off-site Basins OS-1,OS-2, and OS-3 will be left to drain freely on-site as they do historically. OS-1 drains into Tributary I, while OS-2 and OS-3 generally drains east. A portion of the runoff from OS-2 splits to Tributary I at the southeast boundary between OS-2 and OS-3. Using HY-8 Culvert Hydraulic Analysis Program v7.3, it was confirmed that the 36" RCP and two 18" CMP culverts have capacity to convey the 100-year storm from Basin OS-1 under S. 88th St. without overtopping the road. These calculations have been included in Appendix C.

The existing pond in the northwest corner of Parcel A, known as the "School Pond", is associated with BVSD Monarch School Campuses. This pond will be removed at the time that the Campus Drive storm sewer is installed. Contributing flows to the School Pond will be rerouted from the existing flared end section and into the proposed storm sewer in Campus Drive. Currently a 30" RCP releases a maximum flow of 56 cfs (maximum pipe capacity) from the School Pond into the BVSD Monarch School Site to the north. In the proposed condition, this pipe will connect the storm sewer main in Campus Drive to the Bus Loop Pond on the School Site. The invert of the 30" RCP to the Bus Loop Pond is set lower than the invert of the main, ensuring that the 30" continues to release 56 cfs north matching the existing condition.

Currently there are two storm sewer pipes that release historical flow into vacant land south of Campus Drive. These pipes release 4.2 cfs in the 100-year event and Pond D releases 4.8 cfs in the 100-year event. Both of these pipes will be connected to the storm sewer main in the proposed condition of Campus Drive.

The existing inlets at the intersection of Rockcress Drive and Via Varra Road are contributory to the storm sewer system in Via Varra Road. This system connects to storm sewer in West Midway Blvd and ultimately releases south of Rock Creek. The proposed development will not add additional flows to this intersection, and the existing inlets are to be reset at the new curb locations in the intersection.

Stormwater drainage in Sub-Basin C-4 at the eastern section of Campus Drive will be routed by a curb, gutter, inlet, and storm sewer system south to Tributary I. Flows at and

near the intersection of Campus Drive and S. 96th Street will release into the roadside ditch fronting Fire Station 67, and travel southeast within the roadside ditch ultimately discharge into Tributary I.

Pond C-2 and Sub-Basin C-6-3 release flows to the Via Varra subdivision east of the Site. Pond C-2 releases to an existing 48" HDPE storm sewer discharging east under Northwest Parkway. In the Final Drainage Report for Parkway Circle, 96th Street & Carbon Road, the Existing Off-site Facilities Section delineates Basin DA-1C tributary to the 48" HDPE with a peak flow of 80.5 cfs. This report also indicates that the 48" HDPE is routed within the North Storm System which runs north and then east at Carbon Drive. Basins DA-1A, DA-1B release into the existing 36" HDPE system in Via Varra Road with a peak flow of 19.5 cfs. The grading plan with the storm sewer plan and a drainage basin map from this report can be found in Appendix B.

No other minor or major flows besides those listed above are anticipated to enter or exit the Site boundary. All flows exiting the Site, with the exception of the Sub-Basins D-2 and C-6-3, will be routed through proposed drainage infrastructure to existing drainage infrastructure which has the capacity available to convey these flows.

Additional roadway improvements have been proposed off-site, along S. 96th Street, Northwest Parkway, and W. Dillion Road, and are being reviewed by the City separately from this filing. An addendum to this report has been submitted for these off-site improvements, more detailed information can be found in the Redtail Ridge Off-site Roadway Improvements Drainage Report or the Master Drainage Report.

F. Rock Creek Tributary I

1. Tributary Watershed

The Tributary I Watershed is approximately 586 acres. Tributary I drains the area along U.S. Highway 36 from just West of U.S. Highway 36 to S. 96th Street, then through a narrow section from S. 96th Street to Rock Creek. The watercourse throughout consists of a well-defined channel.

The majority of the channel has a relatively wide and shallow floodplain with bank slopes which are densely vegetated with native grasses that provide significantly increased channel stability. Soils within the upper watershed vary but are considered Hydrologic soil group C.

2. CUHP and SWMM

The hydrologic stormwater routing analysis for the watershed was completed using a combination of the Colorado Urban Hydrograph Procedure (CUHP) v. 2.0.1 and the US Environmental Protection Agency Storm Water Management Model (EPA SWMM) v. 5.1. To create the Tributary I Basin regional model, storm hydrographs produced by CUHP

were integrated into EPA SWMM for routing and flood risk analysis. The SWMM has been developed utilizing the proposed Site development planning areas routed to respective full-spectrum water quality and detention facilities. In general, Site areas drain to full spectrum detention facilities, which then release flows at rates that mimic historic flows into Tributary I.

The outlet structures from the regional detention facilities are designed to be concrete structures with weir controls and an outfall pipe sized to accommodate the 100-year release rate. The outlet structures will be designed per MHFD criteria. The spillway weir overflow was sized to route pond overflows. The overflow has been designed with 1.0' of freeboard to the top of the detention berm. The spillway is sized to accommodate the 100-year event total inflows to the pond and will be protected with Type L buried soil riprap outlet protection.

To understand the effects that the proposed development and private detention ponds have on the overall Tributary I flood control system, hydrographs were compared at several locations within the Project. A summary of SWMM Hydrographs results were compared at specific nodes for the 2, 10, and 100-year events and have been included in Appendix C. Results shown in these hydrographs indicate closely matched peaks and timing for all events.

3. Hydrology Data

A detailed analysis of the OSP basin delineation was conducted in order to make comparisons of proposed to historical flow conditions. This analysis indicated a discrepancy in the Area of Basin 6-I (148-acres to 184-acres). Additionally, Basin 2-J in the OSP contained areas of the Northwest Parkway which no longer drain in the manner described in the OSP (23 acres).

Due to the discrepancies in the OSP, a pre-developed CUHP/SWMM model was created to create a more accurate representation of the Site-specific historical flow conditions. The creation of this model provides a more direct comparison for acceptable release rates of developed flows from the Site's proposed detention structures, and was the hydrologic flow condition selected to represent existing conditions for the design of Tributary I.

A summary table detailing these changes and a comparison of the 100-year pre-developed flows from these basins to existing conditions from the Louisville OSP can be found in Table 3 below.

Table 3: Existing Basin Summary Table

BASIN	OSP AREA (AC)	PRE-DEVELOPED BASIN DELINEATION AREA (AC)	OSP EXISTING PERCENT IMPERVIOUS	PRE-DEVELOPED PERCENT IMPERVIOUS	OSP EXISTING Q100 (CFS)	PRE-DEVELOPED BASIN Q100 (CFS)
4 - I	110	110	13	2	213	128
5 - I	142	142	3	2	235	126
6 - I	148	184	57	2	382	176
2 - J	104	81	44	2	306	96

See Appendix D for the Louisville OSP Existing Drainage Plan sheet.

4. Channel Geometry

Tributary I as it exists within the Site extends from the existing culvert at S. 88th Street to the downstream culvert at S. 96th Street. The proposed design for Tributary I is broken into three reaches. Tributary I will conform to a high functioning low maintenance (HFLM) stream design approach and will seek to armor the bankfull portion of the channel as needed to protect against long term erosion concerns while keeping a wide, vegetated, and shallow floodplain for larger flooding events. The design of the typical sections of this HFLM was based on MHFD criteria for natural streams.

Three typical channel sections for Tributary I were identified within the existing and proposed Project extents and titled Reach 1, Reach 2, and Reach 3. Reach 1 will be left undisturbed in the existing channel condition. Reach 2 will seek to maintain the existing channel's planform geometry and alignment but will incorporate a new typical section with an armored bankfull channel and minimal grading. Reach 3 will be realigned to mimic a portion of Reach 2's planform geometry and will incorporate a new proposed cross section with an armored bankfull channel and a wide and shallow floodplain. Details of Tributary I typical sections are included in the construction documents for Redtail Ridge Phase 1. Calculations and design of each Typical Section was performed using Hydraflow Express Extension for Autodesk AutoCAD Civil 3D Ver. 2018.3.

Reach 1 is to be left in existing conditions because low velocities and shear stresses were evaluated within this reach. With the available spread for flow through this section it was determined that native grasses would be sufficient to maintain stability of the channel following development.
Reach 2 is proposed to include four typical sections between the West Campus Dr. Culvert and the East Campus Dr. Culvert. These are broken into separate typical sections to deal with different longitudinal slopes and flow rates. All four typical sections are designed to carry the 10% 100-year flow within an armored bankfull channel and allow larger events to spread out on the adjacent floodplain up to the 100-year event. The four reaches are broken out as follows below:

- Reach 2 IN 0.2% is designed convey flows of SWMM node Reach 2 IN with a 0.2% longitudinal slope along the existing alignment of the channel.
- Reach 2 IN 1.3% is designed to convey flows of SWMM node Reach 2 IN with a 1.3% longitudinal slope along the existing alignment of the channel.
- Reach 2 Armored Bankfull is designed to convey flows of SWMM node Reach 2 IN. This section will take advantage of the existing floodplain grades and grades. It will only disturb the existing ground to establish the Bankfull channel.
- Reach 2 OUT is designed to convey flows of the SWMM node Reach 3 OUT at 1.0% longitudinal slope. The alignment of the channel will be changed here but is designed to have a similar sinuosity of the existing channel.

Reach 3 is a proposed channel between the eastern culvert under Campus Drive and the culvert under S. 96th Street. Reach 3 is similar to Reach 2 OUT but is designed to convey the SWMM flows of Reach 3 at a slope of 1.6% longitudinal slope.

Flow values in the table below are taken from the SWMM model prepared for Tributary I.

Table 4: SWMM Tributary I Reach Flows – Pre-Development (CFS)

Rock Creek Tributary I Reach	2 YR Pre -Developed Flows (CFS)	10 YR Pre -Developed Flows (CFS)	100 YR Pre -Developed Flows (CFS)	100 YR OSP Flows* (CFS)
Reach 1	0.52	20.67	124.43	170
Reach 2 In	0.84	38.19	239.44	345
Reach 2 Out	0.84	38.19	239.44	345
Reach 3	1.93	67.96	441.42	842**

*OSP values are approximate from Design Peak Flow Diagrams Drawing 6 of the OSP
**Flow includes portions of Northwest Parkway and Via Varra Subdivision

Table 5: SWMM Tributary I Reach Flows – Developed With and Without Detention (CFS)

Rock Creek Tributary I Reach	10% 100 YR With Detention Flows (CFS)	10% 100 YR Without Detention Flows (CFS)	10 YR With Detention Flows (CFS)	10 YR Without Detention Flows (CFS)	100 YR With Detention Flows (CFS)	100 YR Without Detention Flows (CFS)	100 YR OSP Flows* (CFS)
Reach 1	9.97	10.26	21.69	22.99	99.68	102.60	170
Reach 2 In	15.00	15.31	27.67	29.00	150.01	153.06	345
Reach 2 Out	20.25	20.56	34.63	35.83	202.46	205.59	345
Reach 3	32.34	69.31	38.07	301.25	323.35	693.06	842**

*OSP values are approximate from Design Peak Flow Diagrams Drawing 6 of the OSP
**Flow includes portions of Northwest Parkway and Via Varra Subdivision

Flows in the table below represent the 100-year developed site flows at each release point into the channel and the corresponding channel flow at each release/outfall point.

Table 6: Site Release/Outfall Points

Developed Site Release Point	Channel Station	Release Point Flow (CFS)	Channel Flow (CFS)
Pond B	5+00	71.6	418.9
Pond C-1	3+00	48.2	418.9

5. HEC-RAS Modeling

One-dimensional steady flow models were prepared for existing and proposed Tributary I configurations using a series of input parameters including flowrate, channel cross-section geometry, roughness coefficients, and main channel bank stations.

Cross-sections were sampled in regular intervals (roughly every 50') and at areas that were determined to have complex or important geometry. The geometry of the existing channel was modeled using topography extracted from ground survey provided by LIDAR data that was collected for the Site. Cross-sections were created in AutoCAD, which were then exported into HEC-RAS for analysis. The Manning's n roughness was chosen based on MHFD suggested values for native grasses and to represent the existing topography of natural grasses within Tributary I.

The following Manning's n values were used for native grasses within the channel:

- 0.032 when assessing Velocity, Froude No., Shear Stress
- 0.050 when assessing Water Surface Elevation and Water Depth

The following Manning's n values were used for sections where the channel bottom would be considered sand/clay:

- 0.030 when assessing Velocity, Froude No., Shear Stress
- 0.040 when assessing Water Surface Elevation and Water Depth

The following Manning's n values were used for channel bottom would be considered cobbles or riprap lined:

- 0.035 when assessing Velocity, Froude No., Shear Stress
- 0.070 when assessing Water Surface Elevation and Water Depth

The development does not plan to introduce new or different vegetative communities that would alter these coefficients.

Table 7 provides the calculated hydraulic parameters for the three proposed reaches indicating low velocities and shear stress.

Flow for the major storm event was quantified within the CUHP/EPASWMM model. Flows as listed in Table 4 of this report were used as input values within the model as steady-state flow to represent the 100-year event within Tributary I.

Boundary conditions of the HEC-RAS model were based on normal depth and the average slope of the channel. A mixed-flow analysis was performed based on the mild slopes within the existing channel geometry that are expected to have sub-critical flow and the proposed drop structure where super critical flow and hydraulic jumps are predicted to occur.

The results of the model were used to represent the proposed and existing flooding extents of the 2-year, the 10-year, and 100-year events, flooding depths, and flow velocities to determine channel stability. A Floodplain Workmap indicating cross-section locations and proposed floodplain limits as well as a copy of the HEC-RAS model results are included in Appendix E. It is noted that the resulting flow velocities and depths indicated a stable stream section except within the bankfull channel. A natural stream design, while accounting for higher velocities and shear stresses in the bankfull section will be used to mimic the current stream conditions.

6. Revegetation

The disturbed areas of Tributary I will be seeded with a seeding plan consisting of two main seed mixes, an Upland Seed Mix and a Riparian Seed Mix.

To further encourage the development of well-established vegetation, soil amendments may be incorporated along Tributary I channel slopes. Depending on growing conditions, a temporary irrigation system may be needed.

Details on the percentage of each grass in each mix, locations, and areas where the different seed mixes are to be applied will be included in the Rock Creek Tributary I Channel and Detention Pond Seeding and Vegetation Management Plan to be submitted and approved by the City prior to construction.

7. MHFD Maintenance Eligibility

The Tributary I improvements and all drainage improvements impacting Tributary I have been designed to meet MHFD maintenance eligibility requirements, as demonstrated by the hydraulic modeling results in Table 7 below. Eligibility requirements are given below as well in Tables 7 and 8.

Table 7: Tributary I Typical Channel Section Hydraulic Results Summary

REACH 1	10% Q100	Q10	Q100
Discharge (cfs)	9.97	21.69	99.68
Total Depth (ft)	0.21	0.24	0.58
Area (sf)	9.76	11.31	30.08
Slope (ft/ft)	0.013	0.013	0.013
Velocity (ft/s)	1.02	1.92	3.31

Wp (wetted perimeter - ft)	50.95	51.61	58.91
Top Width (ft)	50.94	51.59	58.86
Hydraulic Radius (A / Wp)	0.19	0.22	0.51
Shear Stress (lb/sf)	0.16	0.18	0.41

REACH 2 IN, 0.2%	**10% Q100**	**Q10**	**Q100**
Discharge (cfs)	15.00	27.67	150.01
Total Depth (ft)	0.92	1.38	2.14
Area (sf)	9.90	23.44	91.00
Slope (ft/ft)	0.002	0.002	0.002
Velocity (ft/s)	1.52	1.18	1.65
Wp (wetted perimeter - ft)	13.82	51.78	126.70
Top Width (ft)	13.52	51.45	126.35
Hydraulic Radius (A / Wp)	0.72	0.45	0.72
Shear Stress (lb/sf)	0.09	0.06	0.09

REACH 2 IN, 1.3%	**10% Q100**	**Q10**	**Q100**
Discharge (cfs)	15.00	27.67	150.01
Total Depth (ft)	0.66	0.99	1.54
Area (sf)	5.04	11.52	45.89
Slope (ft/ft)	0.013	0.013	0.013
Velocity (ft/s)	2.97	2.40	3.27
Wp (wetted perimeter - ft)	10.44	35.19	90.20
Top Width (ft)	10.28	35.00	90.00
Hydraulic Radius (A / Wp)	0.48	0.33	0.51
Shear Stress (lb/sf)	0.39	0.27	0.41

REACH 2 IN, ARMORED	**10% Q100**	**Q10**	**Q100**
Discharge (cfs)	15.00	27.67	150.01
Total Depth (ft)	1.33	1.37	1.84
Area (sf)	10.81	12.59	44.02
Slope (ft/ft)	0.014	0.014	0.014
Velocity (ft/s)	1.39	2.20	3.41
Wp (wetted perimeter - ft)	43.12	46.64	87.96
Top Width (ft)	42.74	46.26	87.57
Hydraulic Radius (A / Wp)	0.25	0.27	0.50
Shear Stress (lb/sf)	0.22	0.24	0.44

REACH 2 OUT	10% Q100	Q10	Q100
Discharge (cfs)	20.25	34.63	202.46
Total Depth (ft)	0.80	1.22	1.88
Area (sf)	5.92	12.86	56.68
Slope (ft/ft)	0.013	0.013	0.013
Velocity (ft/s)	3.42	2.69	3.57
Wp (wetted perimeter - ft)	10.06	33.49	99.98
Top Width (ft)	9.80	33.16	99.64
Hydraulic Radius (A / Wp)	0.59	0.38	0.57
Shear Stress (lb/sf)	0.48	0.32	0.47

REACH 3	10% Q100	Q10	Q100
Discharge (cfs)	32.34	38.07	323.35
Total Depth (ft)	0.87	0.95	1.89
Area (sf)	8.25	9.31	71.30
Slope (ft/ft)	0.016	0.016	0.016
Velocity (ft/s)	3.92	4.09	4.53
Wp (wetted perimeter - ft)	13.17	13.83	102.93
Top Width (ft)	12.96	13.60	102.67
Hydraulic Radius (A / Wp)	0.63	0.67	0.69
Shear Stress (lb/sf)	0.63	0.67	0.69

Table 8: MHFD Table 8-3: Design Parameters for Naturalized Channels

Design Parameters for Naturalized Channels					
Design Parameter	**MHFD Recommended Value**	**Rock Creek Tributary I Design Value**			**Comment**
Maximum 100-year Depth Outside of Bankfull Channel	5 ft	4.66 ft			Meets Criteria
Roughness Values	Per Table 8-5	Flooding Extents - n = 0.05 overbanks, n = 0.04 channel; Velocity/Shear Stress/Froude - n = 0.03 overbanks, n - 0.035 main channel			Meets Criteria
Maximum 5-year Velocity, Main Channel (Within Bankfull Channel Width) (ft./s)	5 ft/s	**Reach 1**	**Reach 2**	**Reach 3**	Channel is Lined in Reach 2 & 3 to Account for Excess Velocity
		2.98 ft/s (10-YR)	5.05 ft/s (10-YR)	4.8 ft/s (10-YR)	
Maximum 100-year Velocity, Main Channel (Within	7 ft/s	4.34 ft/s	7.69 ft/s	7.60 ft/s	Channel is Lined in Reach 2 & 3 to

Design Parameters for Naturalized Channels					
Bankfull Channel Width) (ft./s)					Account for Excess Velocity
Froude No., 5-year, Main Channel (Within Bankfull Channel Width)	0.7	0.99 (10-YR)	0.94 (10-YR)	0.92 (10-YR)	Channel is lined in Reach 2 & # to Account for Excess Froude #
Froude No., 100-year, Main Channel (Within Bankfull Channel Width)	0.8	1.3	1.14	1.05	Channel is Generally Stable in Existing Condition
Maximum Shear Stress, 100-year, Main Channel (Within Bankfull Channel Width)	1.2 lb/sf	0.78 lb/sf	2.15 lb/sf	1.96 lb/sf	Channel is Lined in Reach 2 & 3 to Account for Excess Shear Stress
Minimum Bankfull Capacity of Bankfull Channel (Based on Future Development Conditions)	70% of 2-year discharge or 10% of 100-yr discharge, whichever is greater (see above)	100% 2-year discharge	100% 2-year discharge	100% 2-year discharge	Does not meet 100-yr criteria, but designed to mimic existing geometry.

Table 9: MHFD Table 8-4: Design Parameters for Naturalized Channels Cont.

Design Parameters for Naturalized Channels					
Minimum Bankfull Channel Geometry	Per Table 8-2	Depth = 0.1', Width = 47', Terrace = 51'	Depth = 1', Width = 9', Terrace = 70'	Depth = 1', Width = 10', Terrace = 70'	Meets Criteria
Minimum Bankfull Channel Width/Depth Ratio (Equation 8-3)	9	470.0	9.3	12.5	Meets Criteria
Minimum Entrenchment Ratio (Equation 8-4)	3	3.2	16.7	15.0	Meets Criteria
Maximum Longitudinal Slope of Low Flow Channel (Assuming	0.2 percent	1.68%	2.07%	1.59%	Low Flow Channel is Lined and Vegetated

Unlined, Unvegetated Low Flow Channel)					
Bankfull Channel Sinuosity (Equation 8-5)	1.1 to 1.3	1.02	1.04	1.05	Designed to Match Existing Channel Sinuosity
Maximum Overbank Side Slope	4(H):1(V)	10(H):1(V)	33(H):1(V)	33(H):1(V)	Meets Criteria
Maximum Bankfull Side Slope	2.5(H):1(V)	100(H):1(V)	3(H):1(V)	4(H):1(V)	Meets Criteria
Minimum Radius of Curvature	2.5 times top width, Reach 1 = 100', Reach 2 = 22.5', Reach 3 = 25'	161' = 3.4x	65' = 7.2x	65' = 6.5x	Meets Criteria

- Manning's n=0.032 When Assessing Velocity, Froude No., Shear Stress
- Manning's n=0.050 When Assessing Water Surface Elevation and Water Depth

8. Culverts

Several culverts are proposed with the Project and the culvert calculating program HY-8 was used to analyze these culverts. In HY-8 the tailwater was determined through a normal depth calculation based on downstream channel geometry inputs.

Two culverts have been designed for crossing the proposed Campus Drive at Tributary I reach stations 30+00 and 7+00.

Both crossings are composed of a dual box system which includes one lower structure solely for flow conveyance and another raised structure which doubles as a trail underpass for vehicle and pedestrian access during storms up to the 10-year event. The lower RCBC will have a span of 8' with a rise of 5' and the raised trail underpass RCBC will have a span of 10' and rise of 8'.

A culvert is proposed to cross under S. 96th Street on the downstream end of Tributary I project extents. The culvert is proposed as a dual barrel RCBC running approximately 80' long with geometry of 7' (span) x 5' (rise). This culvert does not include a trail underpass.

G. Site Phasing

The overall Site storm sewer and detention pond improvement phasing is broken out by Phase below:

Redtail Ridge Subdivision Phase 1 – Parcels B, C, and F

- Campus Drive storm sewer in its entirety
- Rockcress Drive storm sewer built from Via Varra to Sorrel Avenue
- Sorrel Avenue storm sewer
- Pond C-1, Pond C-2, and Pond B
- Rock Creek Tributary I in its entirety

Redtail Ridge Subdivision Phase 2 – Parcels A, D, and E

- West extension of Rockcress Drive and the entirely of the associated storm sewer.

H. Construction Best Management Practices (BMP) Plan

Erosion and Sediment Control Measures Discussion

All areas considered for development and any disturbed areas will be included in the Stormwater Management Plan (SWMP) design. The proposed grading design for this Site will consist of both cut and fill. The predominant Construction BMP (CBMP) control measure will be several sedimentation basins located throughout the Project area to be installed as the Project phasing occurs. These basins have been sized to account for sediment yield from the basins adjacent to that area.

Initial SWMP ~ Utilizes a combination of the following:

- Stabilized staging area (SSA)
- Construction Entrance and Vehicle Tracking Control (CE) (VTC)
- Concrete Washout Area (CWA)
- Silt fence (SF) installation on the downstream portions of the Site
- Inlet protection (IP) for the existing storm drain system located adjacent to the Site
- Check Dam (CD) for open channels
- Temporary Stream Crossing (SC)
- Temporary Sediment Basin (TSB)
- Sediment Control Log (SCL)
- Project phasing to minimize the amount of open acreage.

Interim SWMP ~ Within phasing limits utilizes a combination of the following:

- Stabilized staging area (SSA)
- Construction Entrance and Vehicle Tracking Control (CE) (VTC)

- Concrete Washout Area (CWA)
- Surface roughening (SR)
- Temporary Stream Crossing (SC)
- Inlet protection (IP) for the existing storm drain system located adjacent to the Site
- Sediment Control Log (SCL)
- Silt fence (SF) installation on the downstream portions of the Site
- Maintenance of the previously installed measures

Interim SWMP ~ Utilizes a combination of sediment control measures, after the storm system has been installed, of the following:

- On-site Inlet Protection (IP)
- Check Dams within swales (CD)
- Additional Silt Fencing (SF)
- Surface roughening (SR)
- Outlet Protection (OP) for newly installed storm drain system
- Sediment Control Log (SCL)
- Maintenance of all new and previously installed measures.

Final SWMP ~ Utilizes a combination of sediment control measures, after the storm system has been installed, of the following:

- On-site Inlet Protection (IP) to remain until all disturbed areas have been re-established with 80% vegetation.
- Outlet Protection (OP)
- Erosion Control Blanket (ECB) on slopes greater than 4:1
- Seeding, Mulching, and Crimping (SMC)
- Surface Roughening (SF)
- Temporary Irrigation (TI)
- Silt Fence (SF) to remain until all disturbed areas have been re-established with 80% vegetation.
- Maintenance of all installed measures.
- Upon acceptance by the City, all temporary measures are to be removed and any disturbance caused by these removals shall be brought into compliance to achieve restoration of the area.

I. Project Schedule

The start of the project schedule is determined on the approval of the project Grading, Erosion and Sediment Control plan and supportive construction documents. At the time of approval, it is anticipated that the Initial SWMP measures will be implemented within one week. The timeline of events is determined by the date of issuance of the Grading

Permit. A pre-construction meeting will be necessary to adequately establish the final phasing areas and implementation of the SWMP measures. At the pre-construction meeting the final schedule will be determined. It is anticipated that the grading operations for the entire disturbed area will take approximately six months, weather permitting.

J. BMP Maintenance

The General Contractor will designate an on-site SWMP Manager at the time of permit issuance. The Contractor's SWMP Manager will be the responsible party for ensuring that the Site remains in compliance with the SWMP and will be the Contractor's contact person with the permitting agency for all matters pertaining to the permit. Paved areas, including streets, will be kept clean throughout build-out and will be cleaned at first notice of accidental tracking. At a minimum, the SWMP Manager will inspect all BMP's weekly and after runoff events. All necessary maintenance and repair activities will be performed within 24-hours or as directed by the permitting agency.

V. CONCLUSIONS

A. Compliance with Standards

Drainage design for the Site was performed in accordance with Louisville and MHFD Criteria. The District Manual was used for the design of the Site only when instructed to by Louisville Criteria. The control measures identified in this report are in compliance with part I.E.4.a.iv of the CDPHE Municipal Storm Sewer Systems General permit.

It is the intent of this Final Master Drainage Report to act as the master report for the entire Site. Future Development's preliminary plats, final plats, and individual Site Plans shall be required to submit their own Preliminary and Final Drainage Reports, as applicable, with subsequent development applications.

B. Drainage Concept

The proposed drainage design for the Site will effectively control and minimize any damage from storm runoff associated with the design storms. As stated, runoff will be routed through proposed curb and gutter within roadways, to proposed storm sewer inlets and pipes, and then to one of six Full Spectrum Detention Facilities. All these systems will be adequately sized for the flows associated with the Site and off-site discharges will be managed in a manner which causes no negative effects downstream.

VI. REFERENCES

1. *Boulder Valley School District Louisville Campus PUD Drainage Report*, Charles Keim & Associates, May 31, 1996
2. *City of Louisville/Bounder County Outfall System Plan*, Water Resources Consultants, INC. November 1982
3. *Executive Summary of Previous Investigations, Former ConocoPhillips Site (Storage Tek Campus),* CTL|Thompson, April 19, 2019.
4. *Flood Insurance Rate Map*, Boulder County, Colorado, Map #08013C0584J, FEMA, revised December 18, 2012.
5. Storm Drainage Design & Technical Criteria Manual, City of Louisville, August 2013
6. *Phase I Environmental Site Assessment Former Conoco Phillips Site*, CTL|Thompson, February 25, 2019.
7. MHFD / Urban Storm Drainage Criteria Manual, Volumes 1, 2, and 3 by Urban Drainage and Flood Control District, Current Version.