FINAL MASTER DRAINAGE REPORT

FOR

REDTAIL RIDGE

CITY OF LOUISVILLE
BOULDER COUNTY
STATE OF COLORADO

March 24th, 2021

Prepared for:

BRUE BAUKOL CAPITAL PARTNERS
1555 Blake Street
Suite 210
Denver, CO 80202
720-930-4711

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

Table of Contents

ENGINEER CERTIFICATION

“I hereby certify that this Final Master 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.”

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

I. EXECUTIVE SUMMARY

A. FINAL MASTER DRAINAGE REPORT FOR REDTAIL RIDGE

The purpose of this report is to outline the proposed overall project stormwater and drainage characteristics for the sustainable redevelopment of the former Storage Tek and ConocoPhillips property. 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.

This report provides design of Master Plan 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.

These improvements consist of roadway storm sewer, full spectrum detention ponds and Rock Creek Tributary I (hereinafter referred to as "Tributary I"). The construction of the overall Site is broken in to two phases that generally correlate with planned Redtail Ridge platting of Phase. 1 and Phase 2.

Phase 1 is currently proposed to 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, and Full Spectrum Detention Ponds C-1, C-2 and B. With Phase 1, all runoff from developed infrastructure is 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 and Full Spectrum Detention Ponds A-3 and E.

All proposed development within the Site will be required to follow the guidelines in this Master Study or provide alternative designs or methods that do not cause adverse impact to adjacent facilities or property owners.

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.

Surrounding the Site, the existing developments 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 08013C0584J, Boulder County, Colorado, and Incorporated Areas, December 18, 2012. 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. Most 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 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 in to 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). An excerpt of this document can be found in the appendix of this report.

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's and MHFD's 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 are 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 2.49 inches, respectively.

For the proposed roadway storm sewer analysis, Rational Method calculations were used to determine peak flow rates as the minor basins delineated for this are less than 90 acres. Utilizing catchment area, rainfall characteristics (return period), an assumed imperviousness for all development parcels, and soil type, the Rational Method workbook calculates the basin time of concentration and peak runoff. As a conservative approach, to accommodate future developments, parcel areas are assumed to have 75% imperviousness and roadway areas are designed with 90% imperviousness. These calculation results can be found in Appendix C, for reference.

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

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:

$$WQCV = a\,(0.91\,I^3 - 1.19\,I^2 + 0.78\,I) \qquad \text{Equation 3-1}$$

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

$$V = (\,WQCV * A\,) / 12 \qquad \text{Equation 3-2}$$

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

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.

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. Only runoff from Basin D-2 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' x 6' 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 418 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 77.83 cfs in the developed condition.

SWMM element Out3 represents all Site flows freely flowing off-site, which fall outside of the areas delineated in the OSP. These areas are to remain Open Space and will flow to the existing storm sewer system and pond system along US Highway 36, prior to releasing to Rock Creek. The SWMM model 100-year storm event flows at element Out3 were shown to be 20 cfs for the pre-developed Site condition, and 18.47 cfs for the developed Site 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.

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 overall 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 rational 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. Flows from A-1 historically flow from northwest to southeast in to Tributary I and flows from Sub-Basin

A-2 historically flow from southwest to northeast in to Tributary I. Sub-Basin A-3 consists of a portion of Rockcress Drive which must be discharged in to Basin A.

Sub-Basin A-1 is northwest of Tributary I. Sub-Basin A-1 is proposed to be and 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 is south of Tributary I. Sub-Basin A-2-1 is proposed as an undeveloped parcel at 2% imperviousness. Stormwater runoff from Sub-Basin A-2-1 is proposed to drain as it does historically and will release directly to Tributary I.

Sub-Basin A-2-2 is southeast of Tributary I. Sub-Basin A-2-2 is proposed as a development parcel at 85% imperviousness. 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 is along the western extents of Rockcress Drive. 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 the proposed full spectrum detention Pond A-3 at a down gradient location in the southwestern corner of Sub-Basin A-3. Flows from Pond A-3 are proposed to release to the Rock Creek Tributary I channel.

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-inch 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-inch RCP will outlet from a manhole in the proposed Campus Drive storm sewer and release flows at an equivalent rate as the existing culvert in to the Bus Loop Pond. The balance of flow not released to the Bus Loop Pond will overtop the 30-inch 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 will be developed to drain to a 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 drains south and is contributory to proposed Full Spectrum Detention Facility Pond C-2. A storm sewer outfall stub is provided to the southeast corner of Basin B2 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 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 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 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-4 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-5 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.

Sub-Basin C-6 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 aand 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.

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 contains the southeast corner of the Site, an area bounded by Rockcress Drive to the north, by property boundary to the south and east, and by an existing ridge to the west. Flows from Sub-Basin D-1 shall be routed to storm sewer at 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 will 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 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.

Basin E 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 (hereinafter referred to as "Pond E") located in the downgradient portion of Basin E. Pond E is planned to release northeast in to the proposed storm sewer for Rockcress Drive. Flows will then be routed through storm sewer to Pond C-2 where they will be detained for the WQCV event and then released to the existing 48" HDPE under the Northwest Parkway.

Basin F 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.

Basin OS-1 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 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.

TABLE 1: POND SUMMARY TABLE

POND	WATERSHED AREA (ACRE)	CONTRIBUTING BASINS	WATERSHED IMPERVIOUSNESS (%)	100 YR STORAGE PROVIDED (AC-FT)
A-3	1.89	A-3	75.00%	0.41
B	112.60	A-2-2, B-1	85.00%	25.27
C-1	67.23	C-1, C-3	79.84%	16.66
C-2	87.35	B-2, C-2, C-5, C-6, D-1	78.29%	16.51
E	35.09	E	75.00%	5.41

TABLE 2: BASIN SUMMARY TABLE

BASIN	AREA (AC)	Q5 (CFS)	Q100 (CFS)
A-1	38.09	2.95	50.90
A-2-1	14.38	0.66	11.49
A-2-2	46.77	62.18	169.17
A-3	1.89	1.40	4.27
B-1	71.01	74.73	205.33
B-2	25.45	43.84	118.62
C-1	53.21	60.47	172.59
C-2	19.63	29.00	81.75
C-3	14.07	7.19	22.12
C-4	2.78	2.44	7.32
C-5	9.44	5.42	16.8
C-6	1.82	1.92	5.7
D-1	25.81	27.59	85.58
D-2	19.34	0.99	18.47
E	35.09	47.56	139.34
F	17.05	0.89	16.45
OS-1	77.43	8.36	96.09

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 U.S. 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-feet 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 Detention and water quality ponds other than Pond C-1 on-site are designed to be Extended Detention Basins (EDBs) per the Criteria of the District Manual Volume 3. Construction Documents detail the required forebay, upper stage area, lower stage area and micro-pool area of these EDBs. Each Basin 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 will be protected with Type L buried soil riprap outlet protection.

Pond C-1 on-site is designed with a permanent pool per the Criteria of the District Manual Volume 3. Construction Documents detail the required forebay, upper stage area, lower stage area and permanent pool area of this Retention Pond. This pond will incorporate an outlet feature that is intended to delay the release of the WQCV over a 12-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 will be protected with Type L buried soil riprap outlet protection. Pond C-1 will serve as a permanent, post-

construction BMP to treat the WQCV in accordance with Louisville Criteria for the pond's tributary area. Pond C-1 will be modified as necessary to convert it to a Full Spectrum Detention Facility to detain developed flows associated with Basin C-1. Pond C-1 will outfall through storm sewer to Tributary I, just upstream of the location of the proposed culvert under S. 96th Street.

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 and OS-2 will be left to drain freely on-site as they historically do into Tributary I. 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-inch diameter 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-inch RCP to the Bus Loop Pond is set lower than the invert of the main, ensuring that the 30-inch 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 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 E-470. 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 undeveloped Sub-Basin D-2, will be routed through proposed drainage infrastructure to existing drainage infrastructure which has the capacity available to convey these flows.

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. 2.0.0 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 regional 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 these discrepancies, 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 1 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 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 low-flow portion of the channel as needed to protect against long term erosion concerns. 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 investigated within the 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 maintain the existing channel's planform geometry, but will incorporate a new typical section with an armored low flow 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 low flow channel. Tributary I typical sections are included in the construction documents for Redtail Ridge Phase 1.

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 a new armored low flow channel section to accommodate for the increased volume of flows which will be introduced to the channel following development. The low flow channel is comprised of a 1.0' foot channel bottom

width with 3:1 H:V side slopes designed to carry the approximate 2-year flow at a depth of 1.0'.

Reach 3 is a proposed channel between the eastern culvert under Campus Drive and the culvert under S. 96th Street. Reach 3 was designed to mimic the natural planform of Reach 2. The low flow channel is comprised of a 2.0' foot channel bottom width with 4:1 H:V side slopes designed to carry the approximate 2-year flow at a depth of 1.0'.

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

TABLE 4: SWMM Tributary I Reach Flows

Rock Creek Tributary I Reach	2 YR Pre - Developed Flows (CFS)	2 YR Developed Flows (CFS)	10 YR Pre - Developed Flows (CFS)	10 YR Developed Flows (CFS)	100 YR Pre - Developed Flows (CFS)	100 YR Developed Flows (CFS)	100 YR OSP Flows* (CFS)
Reach 1	0.5	2.7	21	20.7	124	96.3	170
Reach 2	0.8	2.6	38	37.3	239	215.3	345
Reach 3	2	7.8	68	45.44	441	418.9	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 developed site flows at each release point into the channel and the corresponding channel flow at each release/outfall point.

TABLE 5: Site Release/Outfall Points

Developed Site Release Point	Channel Station	Release Point Flow (CFS)	Channel Flow (CFS)
Pond A-3	55+00	2	93
Pond B	5+00	143	418.9
Pond C-1	3+00	68	418.9

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

Table 5 provides the calculated hydraulic parameters for the three proposed typical cross-sections 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, 10, 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.

TABLE 6: TRIBUTARY I CHANNEL HYDRAULIC RESULTS SUMMARY

REACH 1 TYPICAL SECTION	**Q2**	**Q10**	**Q100**
Discharge (cfs)	1.79	18.02	93.32
Total Depth (ft)	0.09	0.26	0.59
Area (sf)	1.99	9.04	28.99
Slope (ft/ft)	0.015	0.018	0.016
Velocity (ft/s)	0.91	1.99	3.21
Wp (wetted perimeter - ft.)	31.55	49.3	71.41
Top Width (ft)	31.55	49.4	71.40
Hydraulic Radius (A / Wp)	0.06	0.18	0.41
Shear Stress (lb/sf)	0.06	0.20	0.40
REACH 2 TYPICAL SECTION	**Q2**	**Q10**	**Q100**
Discharge (cfs)	2.51	34.56	197.43
Total Depth (ft)	0.76	1.58	2.33
Area (sf)	2.43	26.47	88.12
Slope (ft/ft)	0.011	0.009	0.009
Velocity (ft/s)	1.29	2.70	3.66
Wp (wetted perimeter - ft.)	6.58	69.26	97.07
Top Width (ft)	6.37	69.26	96.70
Hydraulic Radius (A / Wp)	0.37	0.38	0.91
Shear Stress (lb/sf)	0.10	0.30	0.46
REACH 3 TYPICAL SECTION	**Q2**	**Q10**	**Q100**
Discharge (cfs)	10.37	46.78	412.82
Total Depth (ft)	0.72	1.28	2.28
Area (sf)	4.16	17.77	123.23
Slope (ft/ft)	.013	.016	.013
Velocity (ft/s)	3.07	4.77	6.63
Wp (wetted perimeter - ft.)	9.43	56.03	143.25
Top Width (ft)	9.29	55.82	143.00

Hydraulic Radius (A / Wp)	0.44	0.32	0.86
Shear Stress (lb/sf)	0.51	0.98	1.48

TABLE 7: FROM DISTRICT 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 Bankfull Channel Width) (ft./s)	7 ft/s	4.34 ft/s	7.69 ft/s	7.60 ft/s	Channel is Lined in Reach 2 & 3 to 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

Design Parameters for Naturalized Channels					
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 7: FROM DISTRICT TABLE 8-3. 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 Unlined, Unvegetated Low Flow Channel)	0.2 percent	1.68%	2.07%	1.59%	Low Flow Channel is Lined and Vegetated
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 RCBC will also be a dual barrel culvert approximately 80' long and have a span of 8' with a rise of 5'. 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:

<u>Redtail Ridge Subdivision Phase 1 – Parcels B, C, and F</u>

- 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

<u>Redtail Ridge Subdivision Phase 2 – Parcels A, D, and E</u>

- Pond A-3, and Pond E
- Rockcress Drive storm sewer in its entirety

H. Construction Best Management Practices (BMP) Plan

<u>Erosion and Sediment Control Measures Discussion</u>

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 time line 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.