LOTS 3, 4, AND 5 NORTHCREST CENTER FILING NO 2
PHASE 1 SUBDIVISION
REFERRED TO AS: "NORTHCREST CENTER"
FINAL DRAINAGE REPORT

2510 & 2522 CANADA DRIVE
COLORADO SPRINGS, COLORADO
80922

PREPARED FOR: LEISURE CONSTRUCTION
3443 TAMPA ROAD, SUITE B
PALM HARBOR, FL 34684
(727) 242-5121

PCD FILE NO. PPR-21-036

January 7, 2022

Prepared by
Scott Marvel, P.E.
Rocky Mountain Group
2910 Austin Bluffs Blvd. | Colorado Springs, CO 80918 | 719-434-5638

SIGNATURE PAGE

LOTS 3, 4, AND 5 NORTHCREST CENTER FILING NO 2 PHASE 1 SUBDIVISION

ENGINEER'S STATEMENT

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the applicable master plan of the drainage basin. I accept responsibility for any liability caused by negligent acts, errors or omissions on my part in preparing this report.

SIGNATURE (Affix Seal): _____

Scott Marvel, P.E. No.: 52138 Date:

DEVELOPER'S STATEMENT

I, the owner/developer have read and will comply with all of the requirements specified in this drainage report and plan.

_____
Name of Developer

_____
Authorized Signature Date

_____
Printed Name

_____
Title

_____
Address

EL PASO COUNTY:

Filed in accordance with the requirements of the Drainage Criteria Manual, Volumes 1 and 2, El Paso County Engineering Criteria Manual and Land Development Code as amended.

_____ _____
Jennifer Irvine, P.E. Date
County Engineer / ECM Administrator

Conditions:

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APPENDICES

I. PURPOSE

This report is a Final Drainage Report for Lots 3, 4 & 5 Northcrest Center Subdivision, a currently unaddressed set of lots, for the development for a multi-unit commercial development, Northcrest Center.

The purpose of this report is to identify on-site and off-site drainage patterns, assess stormwater conditions per delineated basin and sub-basins, demonstrate adequate design standards for storm water flow and release into the existing storm water system or right-of-way, and provide a narrative for any other drainage considerations related to the development of this parcel.

II. GENERAL LOCATION AND DESCRIPTION

A. LOCATION

The proposed development of thirteen 2,280 square foot commercial buildings, is located at the address of Northcrest Center (formerly Lots 3, 4, & 5) in the City of Colorado Springs, Colorado in El Paso County within the Northcrest Center Subdivision. The parcel schedule numbers are 5332309004, 5332309006, and 5332309005 and the legal descriptions are Lot 3 Northcrest Center, A Vacation & Replat Of Tract B Northcrest Fil No 2 Phase 1, Lot 5 Northcrest Center, A Vacation & Replat Of Tract B Northcrest Fil No 2 Phase 1, and Lot 4 Northcrest Center, A Vacation & Replat Of Tract B Northcrest Fil No 2 Phase 1. The parcel is located to the north of Constitution Avenue, west of Canada Drive, east of Peterson Road, and south of Bismark Road.

The surrounding parcels are as follows:

North of Lots 3, 4 & 5 Northcrest Center, A Vacation & Replat of Tract B Northcrest Fil No 2 Phase 1 (Northcrest Center (formerly Lots 3, 4, & 5)) from west to east:

2508 Weyburn Way, Schedule No. 5332308031, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 15 Constitution Hills Fil No 8

2507 Weyburn Way, Schedule No. 5332308032, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 14 Constitution Hills Fil No 8

2630 Tibburn Way, Schedule No. 5332308040, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 6 Constitution Hills Fil No 8

2610 Tibburn Way, Schedule No. 5332308041, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 5 Constitution Hills Fil No 8

2605 Tibburn Way, Schedule No. 5332308042, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 4 Constitution Hills Fil No 8

2624 Tibburn Way, Schedule No. 5332308043, Zoning RS-6000 CAD-O, Plat No. 10281, Lot 3 Constitution Hills Fil No 8

East of Lots 3, 4 & 5 Northcrest Center, A Vacation & Replat of Tract B Northcrest Fil No 2 Phase 1 (Northcrest Center (formerly Lots 3, 4, & 5)) from north to south:

2535 Canada Drive, Schedule No. 5332310002, Zoning RS-6000 CAD-O, Plat No. 8956, Lot 1 Living Waters Sub

2525 Canada Drive, Schedule No. 5332310003, Zoning PUD CAD-O, Plat No. 8956, Lot 2 Living Waters Sub

2455 Canada Drive, Schedule No. 5405207050, Zoning RM-30 CAD-O, Plat No. 7588, Lot 2 Northcrest Fil No 4

South of Lots 3, 4 & 5 Northcrest Center, A Vacation & Replat of Tract B Northcrest Fil No 2 Phase 1 (Northcrest Center (formerly Lots 3, 4, & 5)) from west to east:

6855 Constitution Avenue, Schedule No. 5405218002, Zoning CC CAD-O, Plat No. 9808, Lot 1 Eight Line Sub

West of Lots 3, 4 & 5 Northcrest Center, A Vacation & Replat of Tract B Northcrest Fil No 2 Phase 1 (Northcrest Center (formerly Lots 3, 4, & 5)) from north to south:

6805 Bismark Road, Schedule No. 5332309007, Zoning CC CAD-O, Plat No. 7776, Lots 1 & 2 Northcrest Center, A Vacation & Replat of Tract B Northcrest Fil No 2 Phase 1

B. DESCRIPTION OF PROPERTY – EXISTING CONDITIONS

Lots 3, 4, and 5 (Northcrest Center (formerly Lots 3, 4, & 5)) is approximately 144,776 square feet combined (3.32 acres) and is located on the north side of Constitution Avenue, east side of Peterson Road, West of Canada Drive, and south of Bismark Road. The parcels fall within the SW 1/4 of Section 32, Township 13 South, Range 65 West of the 6th P.M. of Colorado Springs, El Paso County, Colorado.

The property currently consists of undeveloped natural vegetation. There is existing curb and gutter along Bismark Drive, Canada Drive, and Constitution Avenue.

The existing percent imperviousness is approximately 1.5 percent on Lots 3, 4, and 5.

The existing topography consists of grades between 5.3 and 19.17 percent. Drainage patterns sheet flow across the parcel southeasterly to the corner of Canada Drive and Constitution Avenue.

C. EXISTING SOILS

The soils indicative to the site are classified as Truckton sandy loam by the USDA Soil Conservation Service and are listed as NRCS (National Resources Conservation Service) Hydrologic Soil Group A. A USDA Soil Map is provided in the Appendix.

A subsurface soils investigation was conducted for Commercial Development Site Constitution and Peterson, with a letter entitled *Geotechnical Report* by RMG – Rocky Mountain Group dated

February 23, 2021. The investigation "revealed similar substance subsurface soil conditions across the site, being primarily silty sand extending from the ground surface to the extent of the test borings. Neither expansive clay soil not bedrock were encountered in the borings."

The study found that "groundwater was not encountered in the test borings during field exploration."

D. EXISTING DRAINAGE

The existing topography consists of grades between 5.3 and 19.17 percent within the entire parcel that ultimately flows southeast. The existing imperviousness of the lot is approximately 1.5 percent. The existing vegetation consists of native grasses and has been identified via site visits and aerial photography as well as survey data and pictures.

The existing drainage pattern from storm runoff is generally characterized as overland flow to the southeast of the parcel across pervious landscaped yard. The runoff from this parcel and the surrounding neighborhood flows via curb and gutter in the public right of way of Bismark Road, Constitution Avenue, and Canada Drive. The runoff flows south on Canada Drive into the existing Public 15' CDOT Type R Curb Inlet located at the northwest corner of the intersection of Canada Drive and Constitution Avenue. This Public Storm Inlet is a branch of the Public 24" RCP Storm Main that flows west to east along the north side of Constitution Avenue and ultimately outfalls into Jimmy Camp Creek.

Lots 3, 4, and 5 do not lie within a designated floodplain according to information published in the Federal Emergency Management Agency Floodplain Map No. 08041C0752G, dated December 7, 2018. The FEMA Floodplain map is provided in Appendix C showing it lies within Zone X, a minimal flood hazard area.

There are no known non-stormwater discharges that contribute to the storm water systems on site and downstream, both private and public.

E. DESCRIPTION OF PROPERTY – PROPOSED CONDITIONS

The proposed development consists of thirteen 2,280 square foot commercial units and approximately 69,000 square feet of concrete and asphalt pavement for drive accesses, sidewalks, and curb and gutter. Other on-site features includes approximately 29,000 square feet of landscaping, 760 linear feet of retaining wall, and 2,800 square feet for a full spectrum detention pond.

There is no existing access point to the property. Two new curb cuts are proposed along Canada Drive.

III. DRAINAGE BASINS AND SUB-BASINS

A. EXISTING MAJOR DRAINAGE BASIN AND SUB-BASINS

The parcel is delineated into sub-basins according to the existing and proposed grading for existing and developed conditions.

Basin E is the entirety of the parcel representing existing conditions and consists of one on-site sub-basin. There are no off-site flows that enter the property due to the slope of the existing drive aisle between this lot and the neighboring lot.

Sub-basin E-1 (3.24 ac.; Q_5 = 0.81 cfs, Q_{100} = 5.27 cfs) is the entirety of Lots 3, 4, and 5 to be replatted via vacation into a single lot which contains natural vegetation that flows to the right of ways of Bismark Road, Canada Drive, and Constitution Ave. Those right of ways have curb and gutter directly adjacent to the lot that flow to a Public 15' CDOT Type R Curb Inlet. This public stormwater system is connected to a Public 24" RCP Storm Main that runs west to east along the south side of the lot within Constitution Avenue. The Public 15' & 5' CDOT Type R Curb Inlets located at the northwest and northeast corners, respectively, of the intersection of Canada Drive and Constitutions Avenue are branches that connect to the public stormwater main within Constitution Avenue. The public stormwater system ultimately flows to the East Fork Sand Creek.

EP1 is the existing conditions design point representing the Public 15' CDOT Type R Curb Inlet at the northwest corner at the intersection of Canada Drive and Constitution Avenue where sub-basin E-1 flows over the pervious lot containing native grasses and vegetation to the public roadways. The emergency flow route of this public storm inlet is due east along the north side of Constitution Avenue.

B. DEVELOPED MAJOR DRAINAGE BASIN AND SUB-BASINS

Basin D is the entirety of the developed parcel representing developed conditions and consists of nine sub-basins. Some off-site flows will enter the proposed site from the western paved drive access currently serving the existing school.

Sub-basin D-1 (0.27 ac. ; Q_5 = 0.39 cfs, Q_{100} = 1.03 cfs) is the northwestern area of the development consisting of an asphalt drive access off of the common drive access for this property and the neighboring lot from Bismark Road as well as enclosed storage and large vehicle parking area that consists of compacted gravel. The sub-basin is sloped southeast and overland flow is directed to a concrete drainage pan within the drive aisle and channeled to a Private 3'x3' CDOT Type C Depressed Inlet with Grate.

DP1 is the Design Point representing the Private 3'x3' CDOT Type C Depressed Inlet with Grate for Sub-basin D-1. The Private Storm Inlet flows downstream to subsequent Design Points via the Private Storm Sewer system. The emergency flow route for DP1 is an overflow condition of the Private Storm Inlet that would cause storm water pooling within the northern drive aisle and would flow due east into Canada Drive and ultimately to the Public 15' CDOT Type R Curb Inlet at the northwest corner of the intersection of Canada Drive and Constitution Avenue.

Sub-basin D-2 (0.51 ac. ; Q_5 = 1.04 cfs, Q_{100} = 2.36 cfs) is the middle-north area of the development consisting of an asphalt drive access off of the common drive access for this property as well as enclosed storage and large vehicle parking area that consists of compacted gravel. The sub-basin is sloped southeast and overland flow is directed to the concrete drain pan within the drive aisle and channeled to a Private 3'x3' CDOT Type C Depressed Inlet with Grate, the second in a series of storm inlets in the northern area.

DP2 is the Design Point representing the Private 3'x3' CDOT Type C Depressed Inlet with Grate for Sub-basin D-2. The Private Storm Inlet flows downstream to subsequent Design Points via the Private Storm Sewer system. The emergency flow route for DP2 is an overflow condition of the Private Storm Inlet that would cause storm water pooling within the northern drive aisle and would flow due east into Canada Drive and ultimately to the Public 15' CDOT Type R Curb Inlet at the northwest corner of the intersection of Canada Drive and Constitution Avenue.

Sub-basin D-3 (0.50 ac. ; Q_5 = 1.02 cfs, Q_{100} = 2.32 cfs) is the northeast area of the development consisting of an asphalt drive access off of the common drive access for this property as well as enclosed storage and large vehicle parking area that consists of compacted gravel. The sub-basin is sloped southeast and overland flow is directed towards the drive access and directed off-site. The sub-basin flows to Design Point 8 via the adjacent roadways' curb and gutter, ultimately to the Public 15' CDOT Type R Curb Inlet at the northwest corner of the intersection of Canada Drive and Constitution Avenue.

DP3 is the Design Point representing the discharge point at the top of the drive access. The emergency flow route also follows the proposed flow direction directly east that into Canada Drive and ultimately to the Public 15' CDOT Type R Curb Inlet at the northwest corner of the intersection of Canada Drive and Constitution Avenue.

Sub-basin D-4 (0.68 ac. ; Q_5 = 2.57 cfs, Q_{100} = 4.78 cfs) is the roof of the proposed building within the center of the lot. This sub-basin captures stormwater runoff from the roof and distributes it to roof drains along the northern edge of the building. Roof drains will be connected to the underground storm drain line under the concrete drainage pan within the north drive aisle. Runoff from this sub-basin is only included in the detention basin design point DP4.

DP4 is the Design Point representing the proposed roof runoff.

Sub-basin D-5 (0.50 ac. ; Q_5 = 2.27 cfs, Q_{100} = 4.10 cfs) is the southernt area of the development consisting of the south frontage parking lot. The sub-basin is generally sloped southeast within the parking lot with storm water conveyances via overland flow and curb and gutter. The sub-basin flows to a proposed Private 10' CDOT Type R Curb Inlet and conveys it to the Full Spectrum Extended Detention Basin via the Private Storm Sewer system.

DP5 is the Design Point representing the Private 10' CDOT Type R Curb Inlet for Sub-basin D-5. The Private Storm Inlet flows downstream to the Full Spectrum Extended Detention Basin via the Private Storm Sewer system. The emergency flow route for DP5 is to the east following proposed curb and gutter into Canada Drive and ultimately to the Public 15' CDOT Type R Curb Inlet at the northwest corner of the intersection of Canada Drive and Constitution Avenue.

Sub-basin D-6 (0.30 ac. ; Q_5 = 1.35 cfs, Q_{100} = 2.43 cfs) is the tributary area within the property boundary that consists of the common drive access off of Bismark Road to be extended to the south parking lot frontage of the development. This sub-basin previously flowed southeast to the public storm system and is proposed to flow southeast to the proposed curb inlet within the south parking lot, DP-6. The existing drainage pattern along the western property line will be preserved to accomplish this.

DP6 is the Design Point representing the Private 10' CDOT Type R Curb Inlet for Sub-basin D-6. The Private Storm Inlet flows downstream to the Full Spectrum Extended Detention Basin via the Private Storm Sewer system. The emergency flow route for DP6 is to the east following proposed curb and gutter into Canada Drive and ultimately to the Public 15' CDOT Type R Curb Inlet at the northwest corner of the intersection of Canada Drive and Constitution Avenue.

Sub-basin D-7 (0.07 ac. ; Q_5 = 0.07 cfs, Q_{100} = 0.25 cfs) accounts for the tributary area of the development that consists of the Full Spectrum Extended Detention Basin footprint. Runoff in this area is directly collected by the basin.

DP7 is the Design Point representing the Full Spectrum Extended Detention Basin that is designed to detain a major storm event for the developed lot and provide Water Quality. The EDB is proposed to consist of 6.0-foot high structural walls with a detention volume of 15,672 cubic feet. The EDB consists of a forebay, concrete trickle channel, micropool, and outlet structure with an engineered orifice plate to comply with release rates for Water Quality Capture Volume, Excess Urban Runoff Volume, and the 100-Year Major Storm Event. The emergency spillway of the detention basin is via a 10' wide wall notch in the westerly wall that discharges into a riprap lined slope flowing due south to Constitution Avenue, ultimately flowing into the existing Public 15' CDOT Type R Curb Inlet (DP7) at the northwest corner of the intersection of Canada Drive and Constitution Avenue.

Sub-basin D-8 (0.68 ac. ; Q_5 = 1.12 cfs, Q_{100} = 2.94 cfs) is the tributary area within the property boundary that flows toward the adjacent right of ways of Bismark Road, Canada Drive, and Constitution Avenue. The sub-basin consists mostly of proposed landscaped areas, public concrete sidewalk, and ingress/egress curb cuts. The sub-basin flows to Design Point 8 via the adjacent roadways' curb and gutter, ultimately to the Public 15' CDOT Type R Curb Inlet at the northwest corner of the intersection of Canada Drive and Constitution Avenue.

DP8 is the Design Point representing the Public 15' CDOT Type R Curb Inlet at the northwest corner of the intersection of Canada Drive and Constitution Avenue. This Public Storm Inlet is a branch line of the Public Storm Main that runs west to east within Constitution Avenue and is the ultimate recipient of storm water flow from the developed lot as it is proposed to connect to the outlet structure of the EDB (DP7). The emergency flow route of this public storm inlet is due east along the north side of Constitution Avenue.

There is an existing Water Quality Capture Volume BMP/control measure constructed for the neighboring lot (Northcrest Center Fil No 2 Lots 1 & 2). This feature will not see additional runoff due to the proposed development, and was not evaluated for its current conditions.

The difference between Basin E and Basin D results in an overall increase of the 100-year storm Water volume overall due to increased impervious surfaces.

A Full Spectrum Extended Detention Basin is proposed for the site to provide water quality and detention prior to attenuated storm water release to the public storm system.

2.03 acres (74.8% imperviousness) of on-site flows, and 0.30 acres of off-site flows drain to the Full Spectrum Detention Basin, with a total runoff of 14.95 cfs (100yr storm) being captured.

can only be 0.65 ac or less to meet exclusion

The remaining on-site 1.29 acres flows over landscaped and paved areas, and public concrete sidewalk, to the respective roadways, ultimately to the public storm system. The developed conditions yield a major storm runoff of 5.26 cfs that flows directly to the public storm system for the 100yr storm. This is directly comparable to the existing drainage condition that yielded 5.27 cfs of storm water runoff for a major storm event. This is a slight decrease in runoff directly captured by the existing drainage system.

It is anticipated that there will be no negative impact to downstream developments or infrastructure as a result of this development.

IV. DRAINAGE DESIGN CRITERIA

A. REGULATIONS

The hydrological and hydraulic calculations and design of the site conform to the City of Colorado Springs Drainage Criteria Manuals I and II (latest revision, May 2014) as well as the Mile High Flood District Drainage Criteria manuals revised August 2018.

B. DEVELOPMENT CRITERIA REFERENCE AND CONSTRAINTS

The parcel falls within the Sand Creek major drainage basin (East Fork Sand Creek) designated by the City of Colorado Springs Water Resources Engineering Department with the ultimate receiving waters of Arkansas River. The drainage on this parcel will have no effect on downstream infrastructure or facilities, streets, utilities, transit, or further development of adjacent lots. Relevant criteria for the calculations shown further include equations and design criteria for the rational method, volumes and runoff of carious storm events.

C. HYDROLOGICAL CRITERIA

The rational method was used to calculate the peak runoff of the delineated sub-basins using the manuals referenced prior with the C, I, and P1 values from the Design Criteria Manual Volume I, Chapter 6 as well as the Colorado Springs designated IDF curve values. Specific calculations and tables are provided further with inputs including design rainfall, sub-basin acreage and percent imperviousness, runoff coefficients, one-hour rainfall depths, rainfall intensities, time of concentration, and peak discharge of various storm events. The default rainfall intensities and volumes use runoff coefficients based on soil types. Weighted runoff coefficients were calculated for each basin and sub-basin due to the mix of impervious surfaces, shown in the Appendix exhibits.

D. FOUR-STEP PROCESS

The selection of appropriate control measures is based on the characteristics of the site and potential pollutants. The Four-Step Process provides a method of going through the selection process. The following applies the four-step process to the Development Plan for the Northcrest Center.

Step 1: Employ Runoff Reduction Practices

The Development Plan including the Landscape Plan utilizes landscaping areas for plantings and grass or mulch wherever possible without obstructing utilities or drainageways. Given the proposed land use, the majority of the site is to be paved for vehicular use. Within the mostly-impervious site, the storm water runoff is kept to the site limits where possible by use of grading, a private storm system and all other areas are to be landscaped, including the right of way landscape buffer areas.

Step 2: Provide Water Quality Capture Volume

The Development Plan and Final Drainage Report indicate the use of a storm water detention pond as a control measure for capturing storm water runoff and properly treating the storm water prior to release either via percolation into the soil or attenuated to the public storm system. The detention pond is to be installed and the configuration is sized for capture of the WQCV as well as the EURV and full-spectrum detention, and 100-year detention.

Step 3: Stabilize Drainageways

The drainage within the site is stabilized by way of pavement with features such as drainage pans, curb and gutter, and sloped pavement to direct storm water to the private storm system. There are no unpaved or unstabilized drainageways on this site.

Step 4: Implement Site Specific and Other Source Control BMPs

No control measures beyond the Full Spectrum Extended Detention Basin are proposed as there are no unusual land uses that would result in the need for other source control BMPs.

V. DRAINAGE INFRASTRUCTURE COSTS AND FEES

A. DRAINAGE AND BRIDGE FEES

The development falls within the Sand Creek drainage basin (FOFO4000) which has a drainage basin fee of $20,387 per impervious acre and a bridge fee of $8,339 per impervious acre according to the 2021 El Paso County Drainage Basin Fees document. The development has a total impervious acreage of 2.48acres (3.24acres * 76.6% imperviousness).

Drainage Basin Fee: $20,387/impervious acre * 2.48 impervious acres = $50,559.76

Bridge Fee: $8,339/impervious acre * 2.48 impervious acres = $20,680.72

Since the site is already platted, drainage fees are assumed to have already been paid. Since this development is increasing imperviousness, the County shall review their records and make a decision on fee requirements.

Any outstanding fees must be paid prior to plat recordation.

B. STORM DRAIN SYSTEM QUANTITIES AND COSTS ESTIMATE

The following summarizes the Engineer's Opinion of Probable Cost for the proposed storm facilities for the development (installation plus materials).

Private System

Description	Quantity	Unit	Unit Price	Cost
Earthwork for cut of Pond (Less than 1,000)	612	CY	$ 8	$ 4,896
Concrete Drainage Channel	2	CY	$ 590	$ 1,180
12" RCP	230	LF	$ 55	$ 12,650
18" RCP	226	LF	$ 65	$ 14,690
24" RCP	74	LF	$ 78	$ 5,772
Curb Inlet (Type R) L=10' 5' ≤ Depth < 10'	2	EA	$ 8,136	$ 16,272
Pond Outlet Structure	1	EA	$ 10,000	$ 10,000
Grated Inlet (Type C) Depth < 5'	2	EA	$ 4,802	$ 9,604
Storm Sewer Manhole, Box Base	1	EA	$ 12,034	$ 12,034

Total Cost	**$ 87,098.0**
Engineering Contingency (10%)	**$ 7,098.0**
Grand Total (w/ Contingency)	**$ 95,807.80**
Non-Reimbursable	**$ 95,807.80**

VI. CONCLUSIONS

A. COMPLIANCE WITH STANDARDS

The criteria used to design the storm water runoff volumes are formulas and figures within the City of Colorado Springs Drainage Manuals as well as the Mile High Flood District Drainage Criteria manual. Grading practices for optimal drainage shall comply with the geotechnical investigative report and City standards. The development of Lots 3-5 is within compliance and standards and meets the requirements for the Northcrest Center.

The proposed grading and drainage is within substantial conformance for the master drainage plan for the Subdivision and Drainage Basin. There is no impact on major drainageway planning studies within the larger drainage basin. This development will not adversely affect downstream development.

VII. REFERENCES

Colorado Springs Drainage Manual Volumes I & II (May 2014)

Colorado Urban Drainage and Flood Control District Drainage Criteria Manual, Volume I (August 2018)

Colorado Urban Drainage and Flood Control District Drainage Criteria Manual, Volume III (April 2018)

Urban Storm Drainage Criteria Manual, Volume III (November, 2015)

FEMA Flood Map Service Center

United States Department of Agriculture National Resources Conservation Service

Subsurface Soil Investigation prepared by RMG-Rocky Mountain Group Engineers dated February 23, 2021

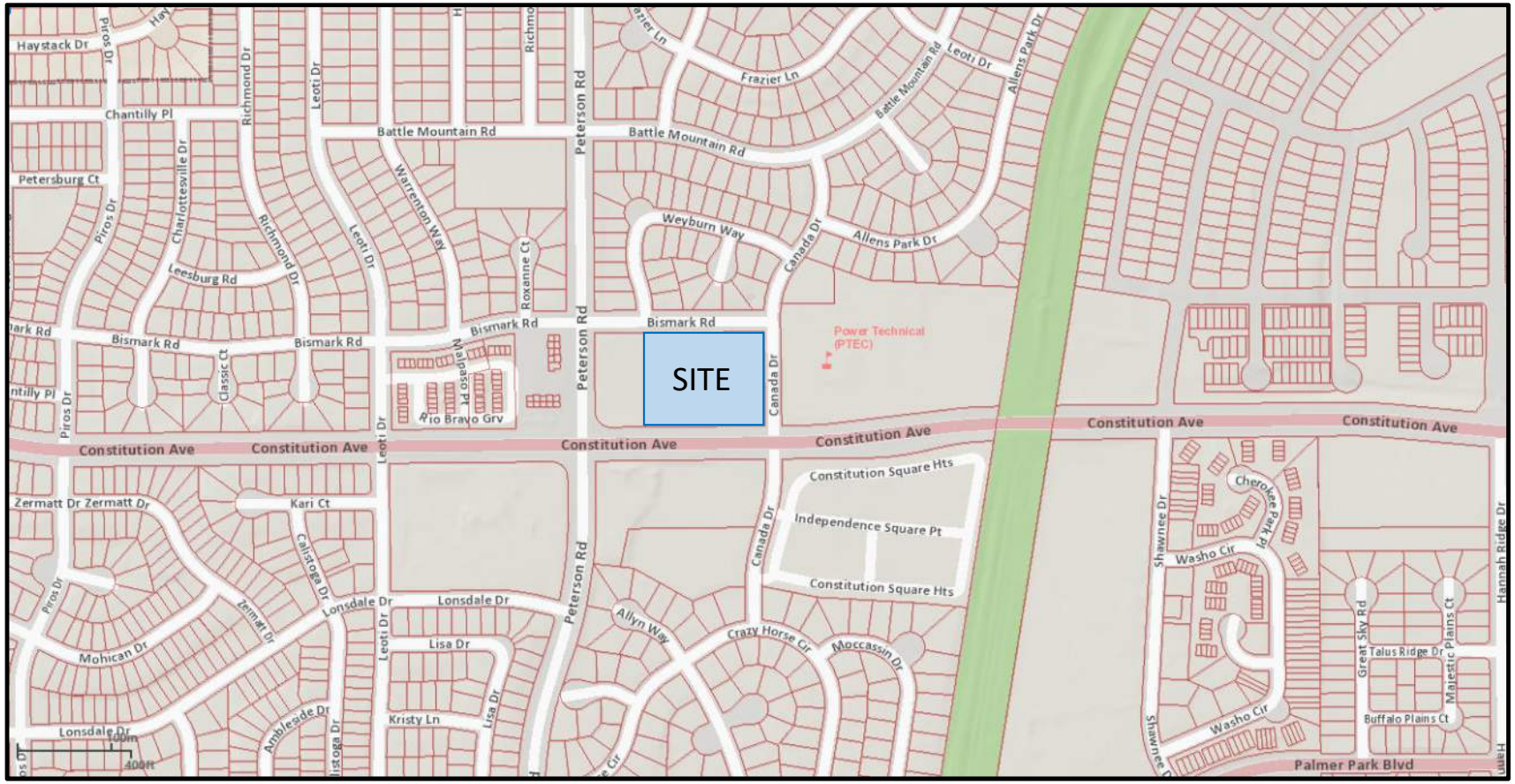
VIII. Appendices

APPENDIX A – VICINITY MAP

VICINITY MAP

NORTHCREST CENTER

TBD BISMARK ROAD
COLORADO SPRINGS, COLORADO 80922
EL PASO COUNTY



APPENDIX B – HYDROLOGIC AND HYDRAULIC COMPUTATIONS

HYDROLOGY
EXISTING CONDITIONS

Project: Northcrest Center PEMBs Development - EXISTING CONDITIONS
Engineer: Scott Marvel, PE
Date: 10/18/2021
Address: TBD Bismark Rd. Colorado Springs, Colorado

Sub-Basin:	E-1	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	26.01				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
2.157273203	2.69510908	3.1444606	3.5938121	4.0431636	4.5233433

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_c * A_i$	5 Yr: $C_c * A_i$	10 Yr: $C_c * A_i$	25 Yr: $C_c * A_i$	50 Yr: $C_c * A_i$	100 Yr: $C_c * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	0	0.000	0.71	0.73	0.75	0.78	0.80	0.81	0.000	0.000	0.000	0.000	0.000	0.000	**0.033**	**0.093**	**0.162**	**0.261**	**0.310**	**0.359**
Pavement	2155	0.049	0.89	0.90	0.92	0.94	0.95	0.96	0.044	0.045	0.046	0.047	0.047	0.047						
Lawn	139193	3.195	0.02	0.08	0.15	0.25	0.30	0.35	0.064	0.256	0.479	0.799	0.959	1.118						
A_t :	141348.11	3.245																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
0.23	**0.81**	**1.65**	**3.04**	**4.07**	**5.27**

Design Points

Design Point	Q_5	Q_{10}	Q_{100}
EX DP1	0.81	1.65	5.27
Total Site	**0.81**	**1.65**	**5.27**

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	E-1	
C_5:	**0.09**	[Table 6-6. Runoff Coefficients for Rational Method]
L:	**550**	ft
S:	**0.045**	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots . C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	0	0.00	0.73
Pavement	2155	0.05	0.90
Lawn	139193	3.20	0.08
A_t :	141348	3.24	

C_c = (0.90*0.04 + 0.08*3.20) / 3.24 = **0.09**

t_i = (0.395*(1.1-C_5)*sqrt(L))/(S^0.33)

t_i = (0.395*(1.1-0.09)*sqrt(550))/(**0.045** ^0.33) = **25.96** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

* For buried riprap, select C_v value based on type of vegetative cover.

$V = C_v S_w^{0.5}$

$V = (20)(0.006)^{0.5}$ = **1.55** ft/s

Flow Distance: **5.00** ft

t_t = L/V = 3.23 sec.
0.05 min.

$t_c = t_i + t_t$ = **26.01** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **26.01** min.

HYDROLOGY
DEVELOPED CONDITIONS

Project: Northcrest Center PEMBs Commercial Development - DEVELOPED CONDITIONS
Engineer: Scott Marvel, PE
Date: 1/6/2022
Address: TBD Bismark Road

Sub-Basin:	D-1	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	9.58				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
3.346577254	4.194231833	4.8934371	5.5926424	6.2918477	7.0418695

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_i * A_i$	5 Yr: $C_i * A_i$	10 Yr: $C_i * A_i$	25 Yr: $C_i * A_i$	50 Yr: $C_i * A_i$	100 Yr: $C_i * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	0	0.000	0.71	0.73	0.75	0.78	0.80	0.81	0.000	0.000	0.000	0.000	0.000	0.000	**0.301**	**0.345**	**0.399**	**0.473**	**0.510**	**0.547**
Pavement	3755	0.086	0.89	0.90	0.92	0.94	0.95	0.96	0.077	0.078	0.079	0.081	0.082	0.083						
Lawn & Gravel	7870	0.181	0.02	0.08	0.15	0.25	0.30	0.35	0.004	0.014	0.027	0.045	0.054	0.063						
A_t:	11625	0.27																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
0.27	**0.39**	**0.52**	**0.71**	**0.86**	**1.03**

Sub-Basin:	D-2	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	9.25				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
3.388291575	4.24681291	4.9547817	5.6627505	6.3707194	7.1302057

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_i * A_i$	5 Yr: $C_i * A_i$	10 Yr: $C_i * A_i$	25 Yr: $C_i * A_i$	50 Yr: $C_i * A_i$	100 Yr: $C_i * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	0	0.000	0.71	0.73	0.75	0.78	0.80	0.81	0.000	0.000	0.000	0.000	0.000	0.000	**0.447**	**0.483**	**0.528**	**0.589**	**0.619**	**0.650**
Pavement	10897	0.250	0.89	0.90	0.92	0.94	0.95	0.96	0.223	0.225	0.230	0.235	0.238	0.240						
Lawn	11281	0.259	0.02	0.08	0.15	0.25	0.30	0.35	0.005	0.021	0.039	0.065	0.078	0.091						
A_t:	22178	0.51																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
0.77	**1.04**	**1.33**	**1.70**	**2.01**	**2.36**

Sub-Basin:	D-3	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	9.16				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
3.399563077	4.261020686	4.9713575	5.6816942	6.392031	7.1540748

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_i * A_i$	5 Yr: $C_i * A_i$	10 Yr: $C_i * A_i$	25 Yr: $C_i * A_i$	50 Yr: $C_i * A_i$	100 Yr: $C_i * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	0	0.000	0.71	0.73	0.75	0.78	0.80	0.81	0.000	0.000	0.000	0.000	0.000	0.000	**0.442**	**0.478**	**0.524**	**0.585**	**0.616**	**0.646**
Pavement	10602	0.243	0.89	0.90	0.92	0.94	0.95	0.96	0.217	0.219	0.224	0.229	0.231	0.234						
Lawn	11230	0.258	0.02	0.08	0.15	0.25	0.30	0.35	0.005	0.021	0.039	0.064	0.077	0.090						
A_t:	21832	0.50																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
0.75	**1.02**	**1.31**	**1.67**	**1.97**	**2.32**

Sub-Basin:	D-4	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	5.00				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
4.119768884	5.168843131	6.0304837	6.8921242	7.7537647	8.6792165

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_i * A_i$	5 Yr: $C_i * A_i$	10 Yr: $C_i * A_i$	25 Yr: $C_i * A_i$	50 Yr: $C_i * A_i$	100 Yr: $C_i * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	29640	0.680	0.71	0.73	0.75	0.78	0.80	0.81	0.483	0.497	0.510	0.531	0.544	0.551	**0.710**	**0.730**	**0.750**	**0.780**	**0.800**	**0.810**
Pavement	0	0.000	0.89	0.90	0.92	0.94	0.95	0.96	0.000	0.000	0.000	0.000	0.000	0.000						
Lawn	0	0.000	0.02	0.08	0.15	0.25	0.30	0.35	0.000	0.000	0.000	0.000	0.000	0.000						
A_t:	29640	0.68																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
1.99	**2.57**	**3.08**	**3.66**	**4.22**	**4.78**

Sub-Basin:	D-5	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	5.00				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
4.119768884	5.168843131	6.0304837	6.8921242	7.7537647	8.6792165

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_i * A_i$	5 Yr: $C_i * A_i$	10 Yr: $C_i * A_i$	25 Yr: $C_i * A_i$	50 Yr: $C_i * A_i$	100 Yr: $C_i * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	0	0.000	0.71	0.73	0.75	0.78	0.80	0.81	0.000	0.000	0.000	0.000	0.000	0.000	**0.865**	**0.877**	**0.898**	**0.920**	**0.932**	**0.943**
Pavement	21226	0.487	0.89	0.90	0.92	0.94	0.95	0.96	0.434	0.439	0.448	0.458	0.463	0.468						
Lawn	620	0.014	0.02	0.08	0.15	0.25	0.30	0.35	0.000	0.001	0.002	0.004	0.004	0.005						
A_t:	21846	0.50																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
1.79	**2.27**	**2.72**	**3.18**	**3.62**	**4.10**

Sub-Basin:	D-6	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	5.00				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
4.119768884	5.168843131	6.0304837	6.8921242	7.7537647	8.6792165

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_c * A_i$	5 Yr: $C_c * A_i$	10 Yr: $C_c * A_i$	25 Yr: $C_c * A_i$	50 Yr: $C_c * A_i$	100 Yr: $C_c * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	0	0.000	0.71	0.73	0.75	0.78	0.80	0.81	0.000	0.000	0.000	0.000	0.000	0.000	**0.860**	**0.872**	**0.894**	**0.916**	**0.928**	**0.939**
Pavement	12562	0.288	0.89	0.90	0.92	0.94	0.95	0.96	0.257	0.260	0.265	0.271	0.274	0.277						
Lawn	446	0.010	0.02	0.08	0.15	0.25	0.30	0.35	0.000	0.001	0.002	0.003	0.003	0.004						
A_t:	13008	0.30																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
1.06	**1.35**	**1.61**	**1.89**	**2.15**	**2.43**

Sub-Basin:	D-7	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	6.84				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
3.746018264	4.697728904	5.4808504	6.2639719	7.0470934	7.8877446

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_c * A_i$	5 Yr: $C_c * A_i$	10 Yr: $C_c * A_i$	25 Yr: $C_c * A_i$	50 Yr: $C_c * A_i$	100 Yr: $C_c * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	0	0.000	0.71	0.73	0.75	0.78	0.80	0.81	0.000	0.000	0.000	0.000	0.000	0.000	**0.147**	**0.200**	**0.262**	**0.351**	**0.395**	**0.439**
Pavement	455	0.010	0.89	0.90	0.92	0.94	0.95	0.96	0.009	0.009	0.010	0.010	0.010	0.010						
Lawn	2660	0.061	0.02	0.08	0.15	0.25	0.30	0.35	0.001	0.005	0.009	0.015	0.018	0.021						
A_t:	3115	0.07																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
0.04	**0.07**	**0.10**	**0.16**	**0.20**	**0.25**

Sub-Basin:	D-8	(IDF Curve Equations from Figure 6-5 of the DCM Volume 1)			
t_c Duration:	6.94				
I_2	I_5	I_{10}	I_{25}	I_{50}	I_{100}
3.729162586	4.676482252	5.4560626	6.235643	7.0152234	7.8520502

Hydrologic Soil Type:	A

Coefficient (Table 6-6)

Land Use or Surface Characteristic	Square Feet	Acreage	Coefficient $_2$	Coefficient $_5$	Coefficient $_{10}$	Coefficient $_{25}$	Coefficient $_{50}$	Coefficient $_{100}$	2 Yr: $C_c * A_i$	5 Yr: $C_c * A_i$	10 Yr: $C_c * A_i$	25 Yr: $C_c * A_i$	50 Yr: $C_c * A_i$	100 Yr: $C_c * A_i$	2 Yr C_c	5 Yr C_c	10 Yr C_c	25 Yr C_c	50 Yr C_c	100 Yr C_c
Roof	0	0.000	0.71	0.73	0.75	0.78	0.80	0.81	0.000	0.000	0.000	0.000	0.000	0.000	**0.310**	**0.354**	**0.407**	**0.480**	**0.517**	**0.554**
Pavement	9816	0.225	0.89	0.90	0.92	0.94	0.95	0.96	0.201	0.203	0.207	0.212	0.214	0.216						
Lawn	19604	0.450	0.02	0.08	0.15	0.25	0.30	0.35	0.009	0.036	0.068	0.113	0.135	0.158						
A_t:	29420	0.68																		

Q Peak Flow (cfs)

2 Year Q	5 Year Q	10 Year Q	25 Year Q	50 Year Q	100 Year Q
0.78	**1.12**	**1.50**	**2.02**	**2.45**	**2.94**

Design Points

Design Point	Q_5	Q_{100}
DP1	0.39	1.03
DP2	1.04	2.36
DP3	1.02	2.32
DP4	2.57	4.78
DP5	2.27	4.10
DP6	1.35	2.43
DP7	0.07	0.25
DP8	1.12	2.94
TOTAL	9.82	20.21
TOTAL ON-SITE	7.68	14.96
TOTAL OFF-SITE	2.14	5.25

SEE IRF CALCULATIONS FOR EFFECTIVE SITE IMPERVIOUSNESS

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	D-1	
C_5:	**0.48**	[Table 6-6. Runoff Coefficients for Rational Method]
L:	**145**	ft
S:	**0.03**	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	0	0.00	0.73
Pavement	3755	0.09	0.90
Lawn	7870	0.18	0.08
A_t :	11625	0.27	

$C_c = (0.90*0.16 + 0.08*0.17) / 0.33 =$ **0.48**

$t_i = (0.395*(1.1-C_5)*sqrt(L))/(S^0.33)$

$t_i = (0.395*(1.1-0.48)*sqrt(145))/(\mathbf{0.055}\ ^0.33) =$ **9.42** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

* For buried riprap, select C_v value based on type of vegetative cover.

$V = C_v S_w^{0.5}$

$V = (20)(0.025)^{0.5} =$ **3.16** ft/s

Flow Distance: **30.00** ft

$t_t = L/V =$ 9.49 sec.
0.16 min.

$t_c = t_i + t_t$ = **9.58** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **9.58** min.

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	D-2	
C_5:	**0.48**	[Table 6-6. Runoff Coefficients for Rational Method]
L:	**124**	ft
S:	**0.03**	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	0	0.00	0.73
Pavement	10897	0.25	0.90
Lawn	11281	0.26	0.08
A_t :	22178	0.51	

$C_c = (0.90*0.16 + 0.08*0.26) / 0.42 =$ **0.48**

$t_i = (0.395*(1.1-C_5)*\text{sqrt}(L))/(S\text{^}0.33)$

$t_i = (0.395*(1.1-0.39)*\text{sqrt}(124))/(\mathbf{0.03}\text{^}0.33) =$ **8.63** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

$V = C_v S_w^{0.5}$

$V = (20)(0.025)^{0.5} =$ **3.16** ft/s

Flow Distance: **116.00** ft

$t_t = L/V =$ 36.68 sec.
0.61 min.

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

* For buried riprap, select C_v value based on type of vegetative cover.

$t_c = t_i + t_t =$ **9.25** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **9.25** min.

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	D-3	
C_5:	**0.48**	[Table 6-6. Runoff Coefficients for Rational Method]
L:	**124**	ft
S:	**0.03**	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots . C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	0	0.00	0.73
Pavement	10602	0.24	0.90
Lawn	11230	0.26	0.08
A_t :	21832	0.50	

C_c = (0.90*0.59 + 0.08*0.00) / 0.59 = **0.48**

t_i = (0.395*(1.1-C_5)*sqrt(L))/(S^0.33)

t_i = (0.395*(1.1-0.90)*sqrt(124))/(***0.03*** ^0.33) = **8.70** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

$V = C_v S_w^{0.5}$

$V = (20)(0.025)^{0.5}$ = **3.16** ft/s

Flow Distance: **87.00** ft

t_t = L/V = 27.51 sec.
0.46 min.

$t_c = t_i + t_t$ = **9.16** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **9.16** min.

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \quad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	D-4	
C_5:	0.73	[Table 6-6. Runoff Coefficients for Rational Method]
L:	80	ft
S:	0.083	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + ...C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	29640	0.68	0.73
Pavement	0	0.00	0.90
Lawn	0	0.000	0.08
A_t :	29640	0.68	

C_c = (0.68*0.00 + 0.90*0.34 + 0.08*0.011) / 0.68 = **0.73**

t_i = (0.395*(1.1-C_5)*sqrt(L))/(S^0.33)
t_i = (0.395*(1.1- **0.87**)*sqrt(90))/(**0.035** ^0.33) = **2.97** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \quad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

$V = C_v S_w^{0.5}$
$V = (20)(0.042)^{0.5}$ = **0.00** ft/s

Flow Distance: **0.00** ft

t_t = L/V = 0.00 sec.
0.00 min.

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

$t_c = t_i + t_t$ = **2.97** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **5.00** min.

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	D-5	
C_5:	0.88	[Table 6-6. Runoff Coefficients for Rational Method]
L:	250	ft
S:	0.035	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	0	0.00	0.73
Pavement	21226	0.49	0.90
Lawn	620	0.014	0.08
A_t :	21846	0.502	

C_c = (0.73*0.0 + 0.90*0.49 + 0.08*0.014) / 0.50 = **0.88**

t_i = (0.395*(1.1-C_5)*sqrt(L))/(S^0.33)

t_i = (0.395*(1.1- ***0.88***)*sqrt(125))/(***0.035*** ^0.033) = **4.22** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

$V = C_v S_w^{0.5}$

$V = (20)(0.035)^{0.5}$ = **3.74** ft/s

Flow Distance: **20.00** ft

t_t = L/V = 5.35 sec.
0.09 min.

$t_c = t_i + t_t$ = **4.30** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **5.00** min.

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	D-6	
C_5:	0.87	[Table 6-6. Runoff Coefficients for Rational Method]
L:	60	ft
S:	0.07	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots . C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	0	0.00	0.73
Pavement	12562	0.29	0.90
Lawn	446	0.01	0.08
A_t :	13008	0.30	

$C_c = (0.90*0.29 + 0.08*0.01) / 0.30 =$ **0.87**

$t_i = (0.395*(1.1-C_5)*\text{sqrt}(L))/(S\text{^}0.33)$

$t_i = (0.395*(1.1-$ ***0.33*** $)*\text{sqrt}(7))/($ ***0.1*** $\text{^}0.33) =$ **1.68** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

$V = C_v S_w^{0.5}$

$V = (20)(0.053)^{0.5} =$ **4.60** ft/s

Flow Distance: **230.00** ft

$t_t = L/V =$ 49.95 sec.
0.83 min.

$t_c = t_i + t_t$ = **2.51** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **5.00** min.

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	D-7	
C_5:	0.20	[Table 6-6. Runoff Coefficients for Rational Method]
L:	15	ft
S:	0.01	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	0	0.00	0.73
Pavement	455	0.01	0.90
Lawn	2660	0.06	0.08
A_t :	3115	0.07	

$C_c = (0.73*0.0 + 0.90*0.10 + 0.08*0.45) / 0.55 =$ **0.20**

$t_i = (0.395*(1.1-C_5)*\text{sqrt}(L))/(S\text{^}0.33)$

$t_i = (0.395*(1.1-$ ***0.20*** $)*\text{sqrt}(15))/($ ***0.01*** $\text{^}0.33) =$ **6.29** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

$V = C_v S_w^{0.5}$

$V = (20)(0.01)^{0.5} =$ **2.00** ft/s

Flow Distance: **66.00** ft

$t_t = L/V =$ 33.00 sec.
0.55 min.

$t_c = t_i + t_t$ = **6.84** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **6.84** min.

Time of Concentration $t_c = t_i + t_t$

3.2.1 - Overland (Initial) Flow Time

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

Sub-Basin or DP:	D-8	
C_5:	0.35	[Table 6-6. Runoff Coefficients for Rational Method]
L:	46	ft
S:	0.25	ft/ft

Composite Runoff Coefficient Calculation:

$C_c = (C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots C_i A_i) / A_t$

Land Use or Surface Characteristic	Square Feet	Acreage	C_5
Roof	0	0.00	0.73
Pavement	9816	0.23	0.90
Lawn	19604	0.45	0.08
A_t :	29420	0.68	

$C_c = (0.73*0.0 + 0.90*0.23 + 0.08*0.45) / 0.68 =$ **0.35**

$t_i = (0.395*(1.1-C_5)*\text{sqrt}(L))/(S\text{^}0.33)$

$t_i = (0.395*(1.1-$ ***0.35*** $)*\text{sqrt}(46))/($ ***0.25*** $\text{^}0.33) =$ **3.16** mins

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)
C_v = conveyance coefficient (from Table 6-7)
S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

$V = C_v S_w^{0.5}$

$V = (20)(0.02)^{0.5} =$ **2.83** ft/s

Flow Distance: **642.00** ft

$t_t = L/V =$ 226.98 sec.
3.78 min.

$t_c = t_i + t_t$ = **6.94** min.

3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

Final t_c: **6.94** min.

IMPERVIOUSNESS

runoff reduction doesnt really work at this site and hasnt been shown on the figure so this page can be removed.
unresolved.

Worksheet Protected

Site-Level Low Impact Development (LID) Design Effective Impervious Calculator

LID Credit by Impervious Reduction Factor (IRF) Method

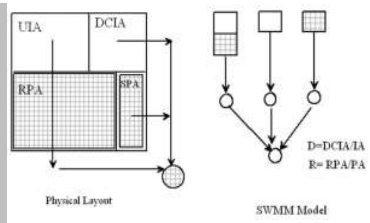
UD-BMP (Version 3.06, November 2016)

User Input

Calculated cells

***Design Storm: 1-Hour Rain Depth	WQCV Event	0.60	inches
***Minor Storm: 1-Hour Rain Depth	2-Year Event	1.19	inches
***Major Storm: 1-Hour Rain Depth	100-Year Event	2.52	inches
Optional User Defined Storm	CUHP		
(CUHP) NOAA 1 Hour Rainfall Depth and Frequency for User Defined Storm	100-Year Event		
Max Intensity for Optional User Defined Storm	0		

Designer: Scott Marvel, PE
Company: RMG - Rocky Mountain Group
Date: January 7, 2022
Project: Northcrest Center
Location: Colorado Springs, CO - El Paso County



SITE INFORMATION (USER-INPUT)

Sub-basin Identifier	D-1	D-2	D-4	D-5	D-6	D-7								
Receiving Pervious Area Soil Type	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam								
Total Area (ac., Sum of DCIA, UIA, RPA, & SPA)	0.27	0.51	0.68	0.50	0.30	0.07								
Directly Connected Impervious Area (DCIA, acres)	0.086	0.197	0.680	0.495	0.275	0.010								
Unconnected Impervious Area (UIA, acres)	0.000	0.000	0.000	0.000	0.000	0.000								
Receiving Pervious Area (RPA, acres)	0.000	0.000	0.000	0.000	0.000	0.000								
Separate Pervious Area (SPA, acres)	0.181	0.312	0.000	0.006	0.027	0.061								
RPA Treatment Type: Conveyance (C), Volume (V), or Permeable Pavement (PP)	V	V	V	V	V	V								

CALCULATED RESULTS (OUTPUT)

Total Calculated Area (ac, check against input)	0.267	0.509	0.680	0.501	0.302	0.072								
Directly Connected Impervious Area (DCIA, %)	32.3%	38.7%	100.0%	98.7%	91.0%	14.6%								
Unconnected Impervious Area (UIA, %)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%								
Receiving Pervious Area (RPA, %)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%								
Separate Pervious Area (SPA, %)	67.7%	61.3%	0.0%	1.3%	9.0%	85.4%								
A_R (RPA / UIA)	0.000	0.000	0.000	0.000	0.000	0.000								
I_a Check	1.000	1.000	1.000	1.000	1.000	1.000								
f / I for WQCV Event:	1.7	1.7	1.7	1.7	1.7	1.7								
f / I for 2-Year Event:	0.5	0.5	0.5	0.5	0.5	0.5								
f / I for 100-Year Event:	0.3	0.3	0.3	0.3	0.3	0.3								
f / I for Optional User Defined Storm CUHP:														
IRF for WQCV Event:	0.00	0.00	0.00	0.00	0.00	0.00								
IRF for 2-Year Event:	1.00	1.00	1.00	1.00	1.00	1.00								
IRF for 100-Year Event:	1.00	1.00	1.00	1.00	1.00	1.00								
IRF for Optional User Defined Storm CUHP:														
Total Site Imperviousness: I_{total}	32.3%	38.7%	100.0%	98.7%	91.0%	14.6%								
Effective Imperviousness for WQCV Event:	32.3%	38.7%	100.0%	98.7%	91.0%	14.6%								
Effective Imperviousness for 2-Year Event:	32.3%	38.7%	100.0%	98.7%	91.0%	14.6%								
Effective Imperviousness for 100-Year Event:	32.3%	38.7%	100.0%	98.7%	91.0%	14.6%								
Effective Imperviousness for Optional User Defined Storm CUHP:														

LID / EFFECTIVE IMPERVIOUSNESS CREDITS

WQCV Event CREDIT: Reduce Detention By:	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
This line only for 10-Year Event	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
100-Year Event CREDIT**: Reduce Detention By:	0.0%	0.1%	0.0%	0.0%	0.1%	2.0%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
User Defined CUHP CREDIT: Reduce Detention By:														

Total Site Imperviousness:	74.8%
Total Site Effective Imperviousness for WQCV Event:	74.8%
Total Site Effective Imperviousness for 2-Year Event:	74.8%
Total Site Effective Imperviousness for 100-Year Event:	74.8%
Total Site Effective Imperviousness for Optional User Defined Storm CUHP:	

Notes:

* Use Green-Ampt average infiltration rate values from Table 3-3.

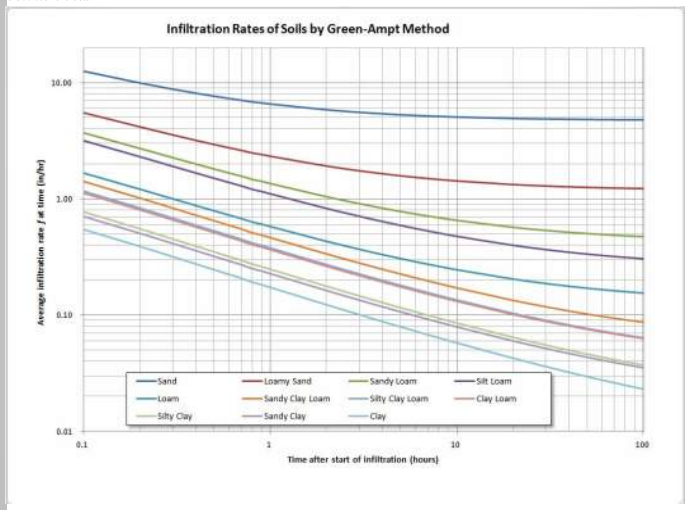
** Flood control detention volume credits based on empirical equations from Storage Chapter of USDCM.

*** Method assumes that 1-hour rainfall depth is equivalent to 1-hour intensity for calculation purposed

Table 3-3. Infiltration Rates (*f*) for IRF Calculations[1]

Soil Type	Hydrologic Soil Group	WQCV Event (in/hr)	Minor Storm Event (in/hr)	Major Storm Event (in/hr)	Optional User Defined Event (in/hr)
Clay	D	0.12	0.22	0.23	#N/A
Sandy Clay	D	0.16	0.25	0.29	#N/A
Silty Clay	D	0.18	0.29	0.29	#N/A
Clay Loam	D	0.26	0.29	0.29	#N/A
Silty Clay Loam	D	0.27	0.39	0.40	#N/A
Sandy Clay Loam	D	0.34	0.38	0.38	#N/A
Loam	C	0.43	0.42	0.47	#N/A
Silt Loam	C	0.83	0.51	0.76	#N/A
Sandy Loam	C	1.04	0.51	0.78	#N/A
Loamy Sand	B	1.92	0.67	0.98	#N/A
Sand	A	5.85	0.67	1.44	#N/A

[1] Infiltration Rates are based on the Green-Ampt method and are calculated as the average infiltration rate over the duration of the storm.



DETENTION BASIN

will review pond calcs following deviation determination

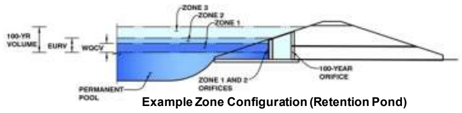
provide forebay sizing and spillway riprap gradation calcs.

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.04 (February 2021)

Project: **Northcrest Center PEMBs Development**

Basin ID: **EDB , Full Spectrum Extended Detention Basin**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	**EDB**	
Watershed Area =	2.33	acres
Watershed Length =	400	ft
Watershed Length to Centroid =	175	ft
Watershed Slope =	0.050	ft/ft
Watershed Imperviousness =	74.80%	percent
Percentage Hydrologic Soil Group A =	100.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.058	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.225	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.148	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.193	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.228	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	0.272	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	0.314	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.364	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.48 in.) =	0.536	acre-feet	3.48	inches
Approximate 2-yr Detention Volume =	0.147	acre-feet		
Approximate 5-yr Detention Volume =	0.192	acre-feet		
Approximate 10-yr Detention Volume =	0.230	acre-feet		
Approximate 25-yr Detention Volume =	0.274	acre-feet		
Approximate 50-yr Detention Volume =	0.300	acre-feet		
Approximate 100-yr Detention Volume =	0.325	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.058	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.167	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.100	acre-feet
Total Detention Basin Volume =	0.325	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = 0.50 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	2,451	0.056		
	--	0.50	--	--	--	2,478	0.057	1,232	0.028
	--	1.00	--	--	--	2,505	0.057	2,478	0.057
	--	1.50	--	--	--	2,532	0.058	3,737	0.086
	--	2.00	--	--	--	2,558	0.059	5,009	0.115
	--	2.50	--	--	--	2,585	0.059	6,295	0.145
	--	3.00	--	--	--	2,612	0.060	7,595	0.174
	--	3.50	--	--	--	2,639	0.061	8,907	0.204
	--	4.00	--	--	--	2,666	0.061	10,233	0.235
	--	4.50	--	--	--	2,693	0.062	11,573	0.266
	--	5.00	--	--	--	2,719	0.062	12,926	0.297
	--	5.50	--	--	--	2,746	0.063	14,292	0.328
	--	6.00	--	--	--	2,773	0.064	15,672	0.360
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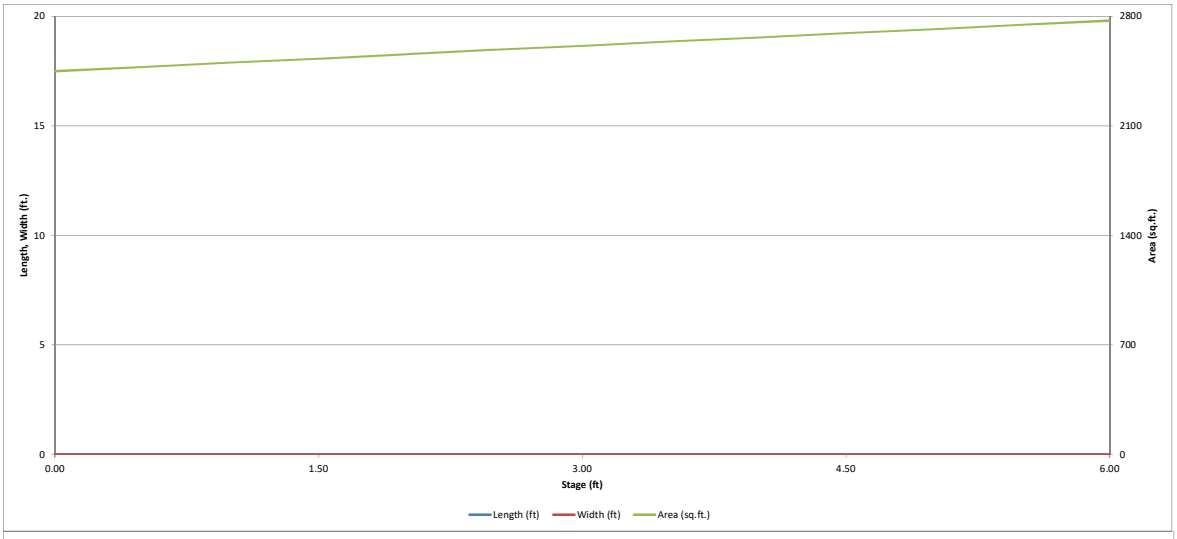
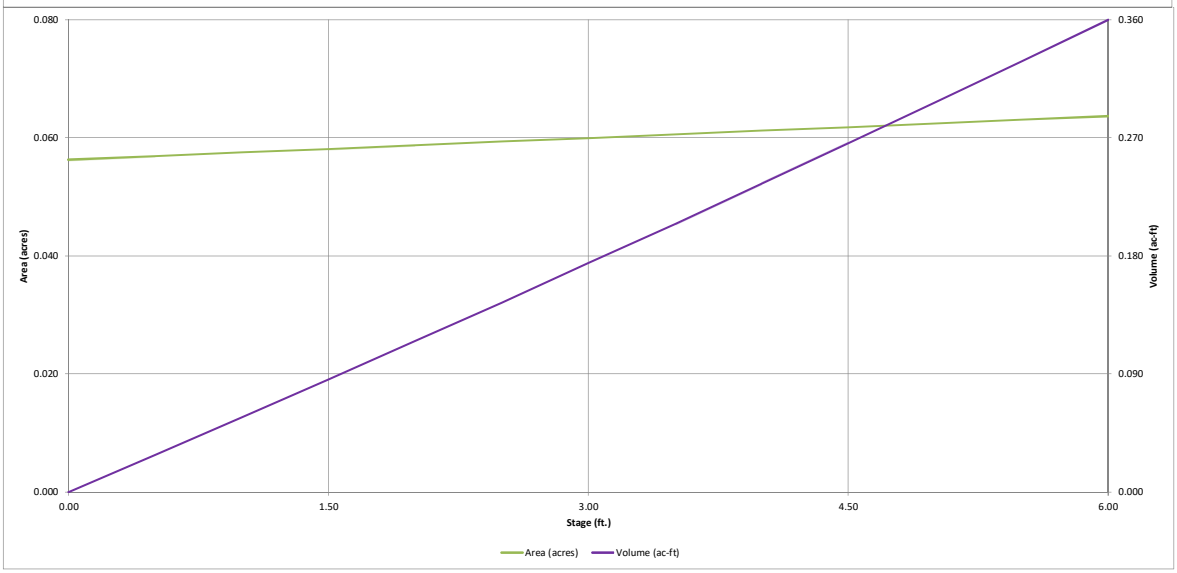
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.04 (February 2021)



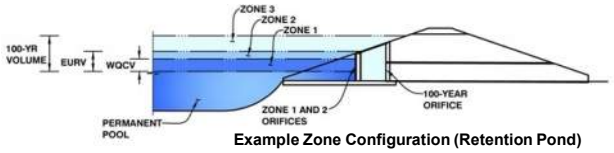


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.04 (February 2021)

Project: Northcrest Center PEMBs Development

Basin ID: EDB , Full Spectrum Extended Detention Basin



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.02	0.058	Orifice Plate
Zone 2 (EURV)	3.84	0.167	Orifice Plate
Zone 3 (100-year)	5.46	0.100	Weir&Pipe (Restrict)
Total (all zones)		0.325	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	N/A	ft^2
Depth at top of Zone using Orifice Plate =	3.84	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	N/A	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	N/A	inches	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.00	2.00	0.00	0.00	0.00	0.00	0.00
Orifice Area (sq. inches)	0.60	1.23	1.23					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected				
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A
Vertical Orifice Diameter =	N/A	N/A	inches			

Calculated Parameters for Vertical Orif

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir (and No Outlet Pipe)

	Zone 3 Weir	Not Selected				
Overflow Weir Front Edge Height, Ho =	3.90	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.90	N/A
Overflow Weir Front Edge Length =	4.00	N/A	feet	Overflow Weir Slope Length =	4.00	N/A
Overflow Weir Grate Slope =	0.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	103.75	N/A
Horiz. Length of Weir Sides =	4.00	N/A	feet	Overflow Grate Open Area w/o Debris =	11.14	N/A
Overflow Grate Type =	Type C Grate	N/A		Overflow Grate Open Area w/ Debris =	11.14	N/A
Debris Clogging % =	0%	N/A	%			

Calculated Parameters for Overflow W

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected				
Depth to Invert of Outlet Pipe =	2.50	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.11	N/A
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.10	N/A
Restrictor Plate Height Above Pipe Invert =	2.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	0.68	N/A

Calculated Parameters for Outlet Pipe w/ Flow Restriction Pla

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	5.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.42	feet
Spillway Crest Length =	10.00	feet	Stage at Top of Freeboard =	6.00	feet
Spillway End Slopes =	0.00	H:V	Basin Area at Top of Freeboard =	0.06	acres
Freeboard above Max Water Surface =	0.58	feet	Basin Volume at Top of Freeboard =	0.36	acre-ft

Calculated Parameters for Spillway

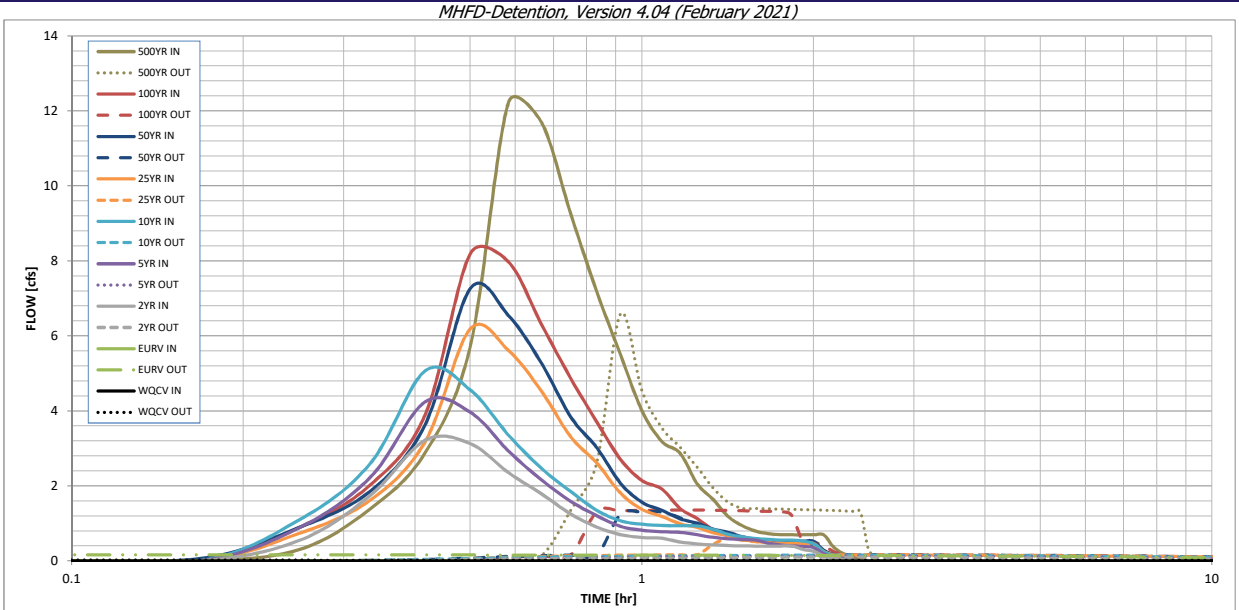
Routed Hydrograph Results

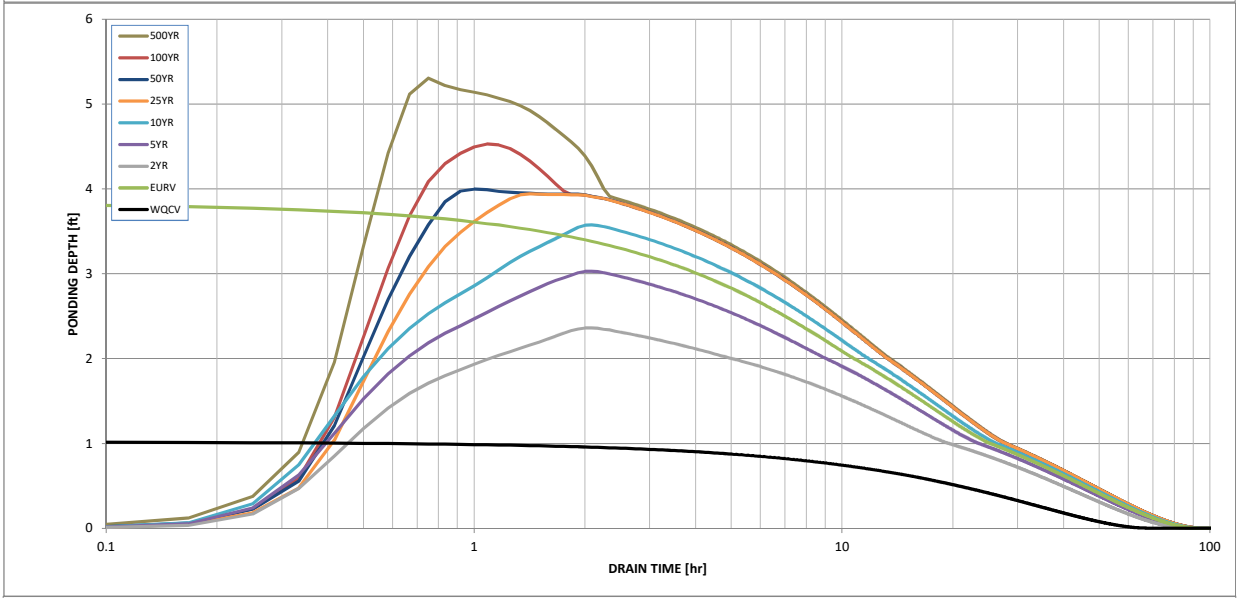
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AI

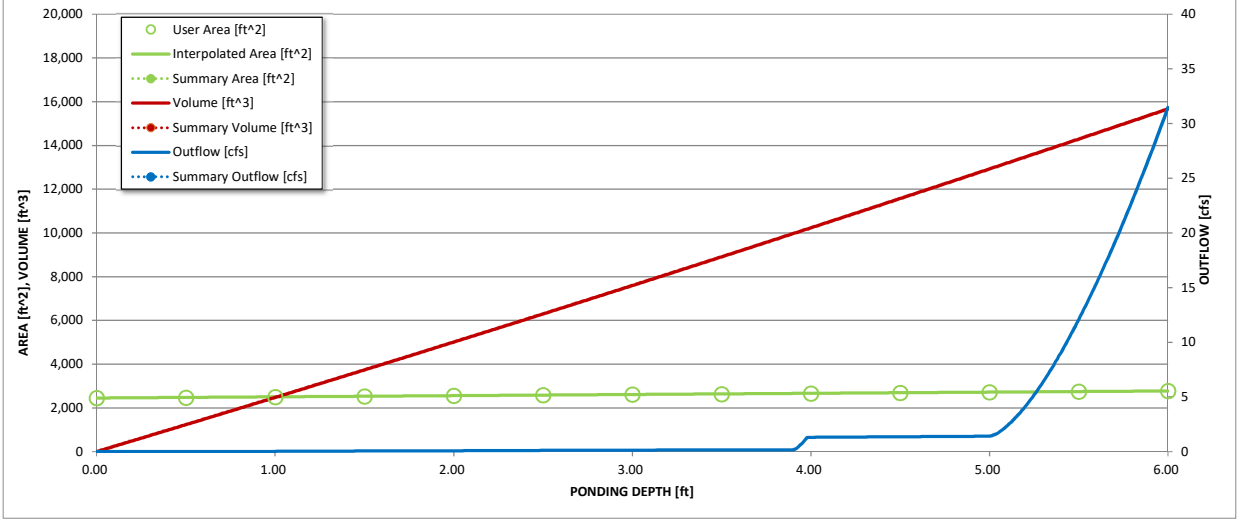
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52
CUHP Runoff Volume (acre-ft) =	0.058	0.225	0.148	0.193	0.228	0.272	0.314	0.364
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.148	0.193	0.228	0.272	0.314	0.364
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.0	0.1	0.1	0.6	1.2	2.0
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A	0.2	0.8	1.7	3.0	4.1	5.3
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.10	0.35	0.71	1.30	1.75	2.26
Peak Inflow Q (cfs) =	N/A	N/A	3.2	4.2	5.1	6.2	7.3	8.2
Peak Outflow Q (cfs) =	0.0	0.2	0.1	0.1	0.2	0.6	1.3	1.4
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.2	0.1	0.2	0.3	0.3
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Plate	Overflow Weir 1	Outlet Plate 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	0.0	0.1	0.1
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	57	70	69	70	71	70	69	66
Time to Drain 99% of Inflow Volume (hours) =	**62**	80	77	79	81	81	80	79
Maximum Ponding Depth (ft) =	1.02	3.84	2.36	3.03	3.58	3.94	4.00	4.53
Area at Maximum Ponding Depth (acres) =	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Maximum Volume Stored (acre-ft) =	0.058	0.225	0.136	0.176	0.209	0.231	0.234	0.267

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.04 (February 2021)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

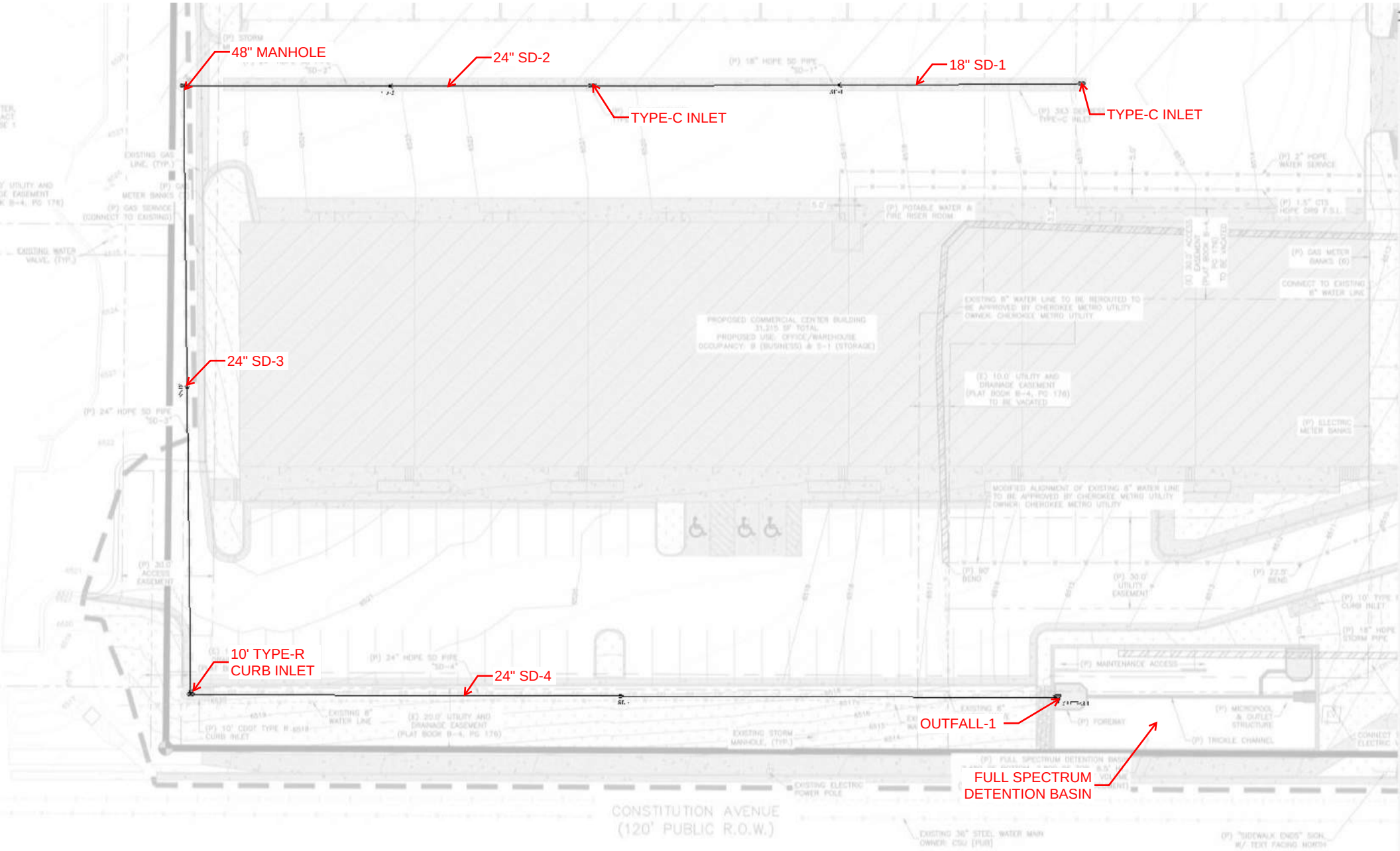
Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.30
	0:15:00	0.00	0.00	0.54	0.88	1.09	0.73	0.89	0.89	1.39
	0:20:00	0.00	0.00	1.74	2.22	2.59	1.61	1.86	2.02	2.89
	0:25:00	0.00	0.00	3.22	4.24	5.07	3.18	3.64	3.90	5.73
	0:30:00	0.00	0.00	3.13	3.97	4.56	6.19	7.27	8.20	12.22
	0:35:00	0.00	0.00	2.36	2.93	3.36	5.62	6.55	7.98	11.69
	0:40:00	0.00	0.00	1.79	2.16	2.47	4.52	5.27	6.31	9.26
	0:45:00	0.00	0.00	1.25	1.59	1.85	3.31	3.84	4.87	7.18
	0:50:00	0.00	0.00	0.90	1.21	1.35	2.61	3.02	3.71	5.51
	0:55:00	0.00	0.00	0.70	0.93	1.07	1.81	2.08	2.71	4.01
	1:00:00	0.00	0.00	0.63	0.82	0.98	1.38	1.57	2.15	3.19
	1:05:00	0.00	0.00	0.60	0.78	0.95	1.19	1.35	1.92	2.87
	1:10:00	0.00	0.00	0.51	0.76	0.94	0.99	1.12	1.40	2.06
	1:15:00	0.00	0.00	0.46	0.70	0.94	0.89	1.01	1.13	1.64
	1:20:00	0.00	0.00	0.43	0.63	0.84	0.75	0.85	0.83	1.19
	1:25:00	0.00	0.00	0.41	0.59	0.71	0.68	0.77	0.67	0.94
	1:30:00	0.00	0.00	0.40	0.57	0.64	0.58	0.65	0.57	0.79
	1:35:00	0.00	0.00	0.40	0.56	0.60	0.52	0.59	0.53	0.73
	1:40:00	0.00	0.00	0.40	0.47	0.57	0.49	0.55	0.51	0.71
	1:45:00	0.00	0.00	0.40	0.43	0.56	0.48	0.54	0.51	0.70
	1:50:00	0.00	0.00	0.40	0.40	0.56	0.47	0.53	0.51	0.70
	1:55:00	0.00	0.00	0.31	0.39	0.53	0.47	0.53	0.51	0.70
	2:00:00	0.00	0.00	0.26	0.36	0.46	0.47	0.53	0.51	0.70
	2:05:00	0.00	0.00	0.14	0.19	0.25	0.26	0.29	0.27	0.38
	2:10:00	0.00	0.00	0.07	0.11	0.14	0.14	0.16	0.15	0.21
	2:15:00	0.00	0.00	0.03	0.05	0.07	0.07	0.08	0.08	0.10
	2:20:00	0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.03	0.05
	2:25:00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
	2:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STORM SEWER PIPE

MHFD UD-SEWER MODEL
5-YR STORM



Program: UDSEWER Math Model Interface 2.1.1.4 **Run Date:** 1/7/2022 1:02:07 PM	**UDSewer Results Summary** **Project Title:** Northcrest Center **Project Description:** Storm Sewer Pipes

System Input Summary

Rainfall Parameters

Rainfall Return Period: 5
Rainfall Calculation Method: Formula

One Hour Depth (in):
Rainfall Constant "A": 28.5
Rainfall Constant "B": 10
Rainfall Constant "C": 0.786

Rational Method Constraints

Minimum Urban Runoff Coeff.: 0.20
Maximum Rural Overland Len. (ft): 500
Maximum Urban Overland Len. (ft): 300
Used UDFCD Tc. Maximum: Yes

Sizer Constraints

Minimum Sewer Size (in): 12.00
Maximum Depth to Rise Ratio: 0.80
Maximum Flow Velocity (fps): 18.0
Minimum Flow Velocity (fps): 2.0

Backwater Calculations:

Tailwater Elevation (ft): 0.67

Manhole Input Summary:

		Given Flow		Sub Basin Information						
Element Name	**Ground Elevation (ft)**	**Total Known Flow (cfs)**	**Local Contribution (cfs)**	**Drainage Area (Ac.)**	**Runoff Coefficient**	**5yr Coefficient**	**Overland Length (ft)**	**Overland Slope (%)**	**Gutter Length (ft)**	**Gutter Velocity (fps)**
OUTFALL 1	6515.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD-4	6515.60	5.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD-3	6520.95	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD-2	6520.69	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD-1	6515.83	2.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Manhole Output Summary:

	Local Contribution					Total Design Flow				
Element Name	Overland Time (min)	Gutter Time (min)	Basin Tc (min)	Intensity (in/hr)	Local Contrib (cfs)	Coeff. Area	Intensity (in/hr)	Manhole Tc (min)	Peak Flow (cfs)	Comment
OUTFALL 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SD-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.35	
SD-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	
SD-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	
SD-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.75	

Sewer Input Summary:

		Elevation			Loss Coefficients			Given Dimensions		
Element Name	Sewer Length (ft)	Downstream Invert (ft)	Slope (%)	Upstream Invert (ft)	Mannings n	Bend Loss	Lateral Loss	Cross Section	Rise (ft or in)	Span (ft or in)
SD-4	276.00	6509.67	0.2	6510.22	0.013	0.03	1.00	CIRCULAR	24.00 in	24.00 in
SD-3	195.00	6510.11	0.2	6510.50	0.013	1.32	0.25	CIRCULAR	24.00 in	24.00 in
SD-2	131.00	6510.60	0.2	6510.86	0.013	1.32	0.25	CIRCULAR	24.00 in	24.00 in
SD-1	156.00	6510.96	0.2	6511.27	0.013	0.05	1.00	CIRCULAR	18.00 in	18.00 in

Sewer Flow Summary:

	Full Flow Capacity		Critical Flow		Normal Flow						
Element Name	Flow (cfs)	Velocity (fps)	Depth (in)	Velocity (fps)	Depth (in)	Velocity (fps)	Froude Number	Flow Condition	Flow (cfs)	Surcharged Length (ft)	Comment
SD-4	10.14	3.23	9.79	4.44	12.39	3.27	0.64	Subcritical	5.35	0.00	
SD-3	10.14	3.23	8.42	4.07	10.47	3.04	0.66	Subcritical	4.00	0.00	
SD-2	10.14	3.23	8.42	4.07	10.47	3.04	0.66	Subcritical	4.00	0.00	
SD-1	4.71	2.67	7.55	3.91	9.88	2.77	0.60	Subcritical	2.75	0.00	

- A Froude number of 0 indicates that pressured flow occurs (adverse slope or undersized pipe).
- If the sewer is not pressurized, full flow represents the maximum gravity flow in the sewer.
- If the sewer is pressurized, full flow represents the pressurized flow conditions.

Sewer Sizing Summary:

			Existing		Calculated		Used			
Element Name	Peak Flow (cfs)	Cross Section	Rise	Span	Rise	Span	Rise	Span	Area (ft^2)	Comment
SD-4	5.35	CIRCULAR	24.00 in	24.00 in	21.00 in	21.00 in	24.00 in	24.00 in	3.14	
SD-3	4.00	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
SD-2	4.00	CIRCULAR	24.00 in	24.00 in	18.00 in	18.00 in	24.00 in	24.00 in	3.14	
SD-1	2.75	CIRCULAR	18.00 in	18.00 in	15.00 in	15.00 in	18.00 in	18.00 in	1.77	

- Calculated diameter was determined by sewer hydraulic capacity rounded up to the nearest commercially available size.

- Sewer sizes should not decrease downstream.
- All hydraulics where calculated using the 'Used' parameters.

Grade Line Summary:

Tailwater Elevation (ft): 0.67

	Invert Elev.		Downstream Manhole Losses		HGL		EGL		
Element Name	Downstream (ft)	Upstream (ft)	Bend Loss (ft)	Lateral Loss (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)	Friction Loss (ft)	Upstream (ft)
SD-4	6509.67	6510.22	0.00	0.00	6510.49	6511.47	6510.79	0.78	6511.57
SD-3	6510.11	6510.50	0.03	0.04	6511.61	6511.69	6511.65	0.11	6511.75
SD-2	6510.60	6510.86	0.03	0.02	6511.74	6511.85	6511.81	0.14	6511.95
SD-1	6510.96	6511.27	0.00	0.00	6511.86	6512.11	6511.95	0.27	6512.22

- Bend and Lateral losses only apply when there is an outgoing sewer. The system outfall, sewer #0, is not considered a sewer.
- Bend loss = Bend K * V_fi ^ 2/(2*g)
- Lateral loss = V_fo ^ 2/(2*g)- Junction Loss K * V_fi ^ 2/(2*g).
- Friction loss is always Upstream EGL - Downstream EGL.

Excavation Estimate:

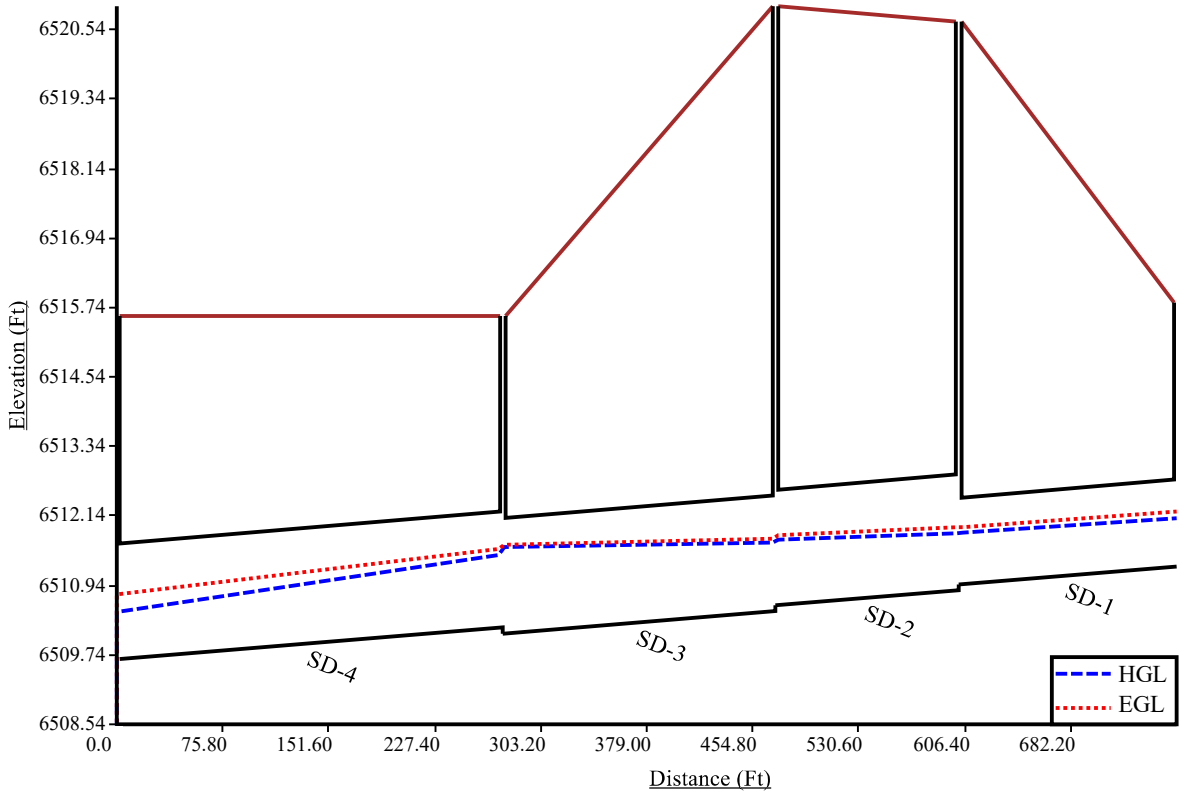
The trench side slope is 1.0 ft/ft
The minimum trench width is 2.00 ft

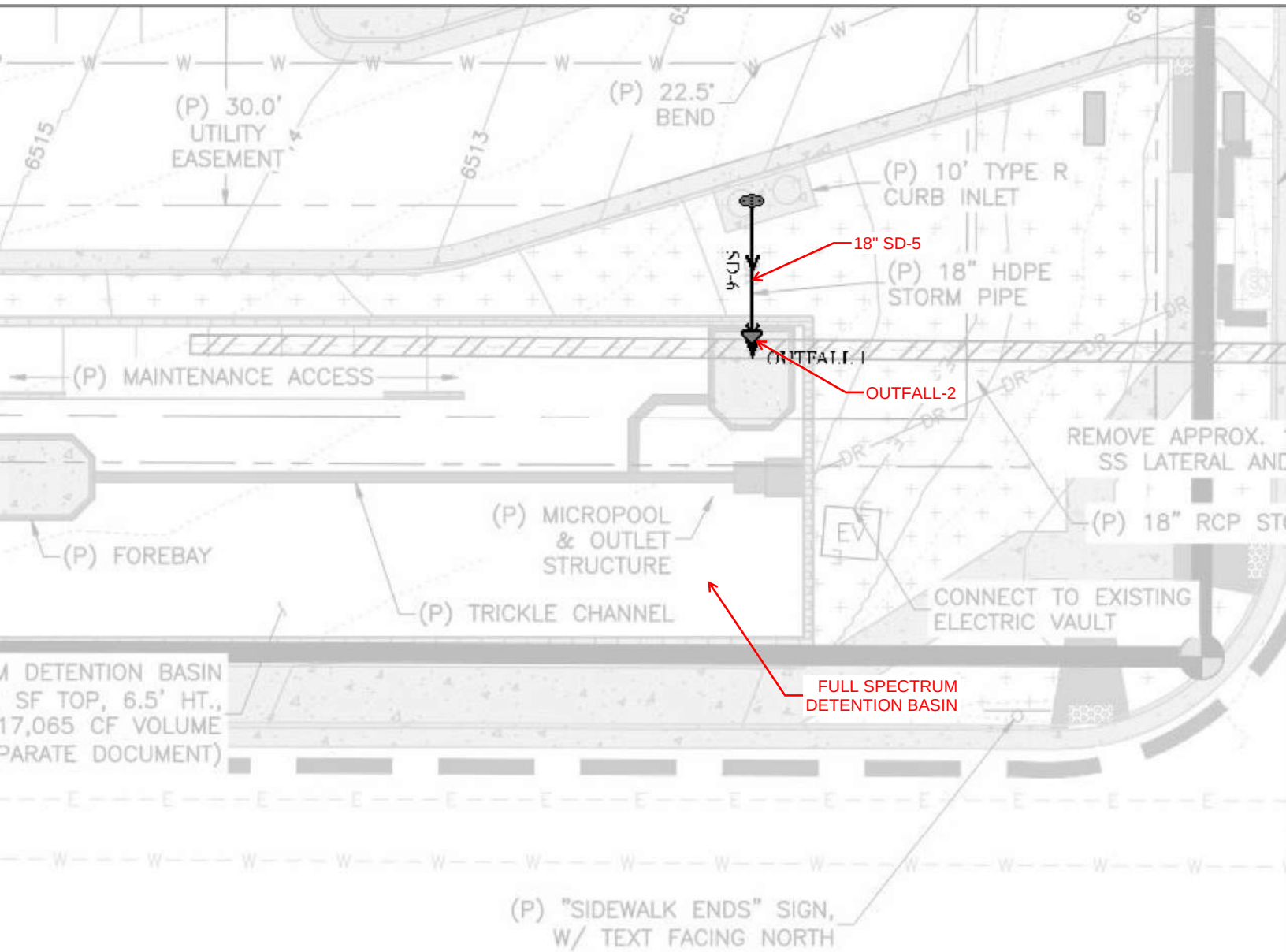
					Downstream			Upstream				
Element Name	Length (ft)	Wall (in)	Bedding (in)	Bottom Width (ft)	Top Width (ft)	Trench Depth (ft)	Cover (ft)	Top Width (ft)	Trench Depth (ft)	Cover (ft)	Volume (cu. yd)	Comment
SD-4	276.00	3.00	4.00	5.50	10.86	6.51	3.68	9.76	5.96	3.13	410.54	
SD-3	195.00	3.00	4.00	5.50	9.98	6.07	3.24	19.90	11.03	8.20	545.09	
SD-2	131.00	3.00	4.00	5.50	19.70	10.93	8.10	18.66	10.41	7.58	512.05	
SD-1	156.00	2.50	4.00	4.92	18.96	10.27	8.02	8.62	5.10	2.85	370.65	

Total earth volume for sewer trenches = 1838 cubic yards.

- The trench was estimated to have a bottom width equal to the outer pipe diameter plus 36 inches.
- If the calculated width of the trench bottom is less than the minimum acceptable width, the minimum acceptable width was used.
- The sewer wall thickness is equal to: (equivalent diameter in inches/12)+1 inches
- The sewer bedding thickness is equal to:
  - Four inches for pipes less than 33 inches.
  - Six inches for pipes less than 60 inches.
  - Eight inches for all larger sizes.

SD Profile_SD-1 to Outfall




(P) 30.0' UTILITY EASEMENT
(P) 22.5° BEND
(P) 10' TYPE R CURB INLET
18" SD-5
(P) 18" HDPE STORM PIPE
OUTFALL-2
(P) MAINTENANCE ACCESS
REMOVE APPROX.
SS LATERAL AND
(P) 18" RCP ST
(P) MICROPOOL & OUTLET STRUCTURE
(P) FOREBAY
(P) TRICKLE CHANNEL
CONNECT TO EXISTING ELECTRIC VAULT
FULL SPECTRUM DETENTION BASIN
(P) "SIDEWALK ENDS" SIGN, W/ TEXT FACING NORTH

Program: UDSEWER Math Model Interface 2.1.1.4 **Run Date:** 1/8/2022 6:35:32 AM	**UDSewer Results Summary** **Project Title:** Northcrest Center **Project Description:** Storm Sewer Pipes

System Input Summary

Rainfall Parameters

Rainfall Return Period: 5
Rainfall Calculation Method: Formula

One Hour Depth (in):
Rainfall Constant "A": 28.5
Rainfall Constant "B": 10
Rainfall Constant "C": 0.786

Rational Method Constraints

Minimum Urban Runoff Coeff.: 0.20
Maximum Rural Overland Len. (ft): 500
Maximum Urban Overland Len. (ft): 300
Used UDFCD Tc. Maximum: Yes

Sizer Constraints

Minimum Sewer Size (in): 12.00
Maximum Depth to Rise Ratio: 0.80
Maximum Flow Velocity (fps): 18.0
Minimum Flow Velocity (fps): 2.0

Backwater Calculations:

Tailwater Elevation (ft): 0.67

Manhole Input Summary:

		Given Flow		Sub Basin Information						
Element Name	**Ground Elevation (ft)**	**Total Known Flow (cfs)**	**Local Contribution (cfs)**	**Drainage Area (Ac.)**	**Runoff Coefficient**	**5yr Coefficient**	**Overland Length (ft)**	**Overland Slope (%)**	**Gutter Length (ft)**	**Gutter Velocity (fps)**
OUTFALL 2	6515.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD-5	6511.70	2.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Manhole Output Summary:

	Local Contribution					Total Design Flow				
Element Name	Overland Time (min)	Gutter Time (min)	Basin Tc (min)	Intensity (in/hr)	Local Contrib (cfs)	Coeff. Area	Intensity (in/hr)	Manhole Tc (min)	Peak Flow (cfs)	Comment
OUTFALL 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SD-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.27	

Sewer Input Summary:

		Elevation			Loss Coefficients			Given Dimensions		
Element Name	Sewer Length (ft)	Downstream Invert (ft)	Slope (%)	Upstream Invert (ft)	Mannings n	Bend Loss	Lateral Loss	Cross Section	Rise (ft or in)	Span (ft or in)
SD-5	11.00	6509.67	0.1	6509.68	0.013	0.03	1.00	CIRCULAR	18.00 in	18.00 in

---

Sewer Flow Summary:

	Full Flow Capacity		Critical Flow		Normal Flow						
Element Name	Flow (cfs)	Velocity (fps)	Depth (in)	Velocity (fps)	Depth (in)	Velocity (fps)	Froude Number	Flow Condition	Flow (cfs)	Surcharged Length (ft)	Comment
SD-5	3.33	1.88	6.83	3.69	10.90	2.03	0.41	Subcritical	2.27	0.00	

- A Froude number of 0 indicates that pressured flow occurs (adverse slope or undersized pipe).
- If the sewer is not pressurized, full flow represents the maximum gravity flow in the sewer.
- If the sewer is pressurized, full flow represents the pressurized flow conditions.

Sewer Sizing Summary:

			Existing		Calculated		Used			
Element Name	Peak Flow (cfs)	Cross Section	Rise	Span	Rise	Span	Rise	Span	Area (ft^2)	Comment
SD-5	2.27	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	

- Calculated diameter was determined by sewer hydraulic capacity rounded up to the nearest commercially available size.
- Sewer sizes should not decrease downstream.
- All hydraulics where calculated using the 'Used' parameters.

Grade Line Summary:

Tailwater Elevation (ft): 0.67

	Invert Elev.		Downstream Manhole Losses		HGL		EGL		
Element	Downstream	Upstream	Bend	Lateral	Downstream	Upstream	Downstream	Friction	Upstream

Name	(ft)	(ft)	Loss (ft)	Loss (ft)	(ft)	(ft)	(ft)	Loss (ft)	(ft)
SD-5	6509.67	6509.68	0.00	0.00	6510.24	6510.36	6510.45	0.04	6510.49

- Bend and Lateral losses only apply when there is an outgoing sewer. The system outfall, sewer #0, is not considered a sewer.
- Bend loss = Bend K * V_fi ^ 2/(2*g)
- Lateral loss = V_fo ^ 2/(2*g)- Junction Loss K * V_fi ^ 2/(2*g).
- Friction loss is always Upstream EGL - Downstream EGL.

Excavation Estimate:

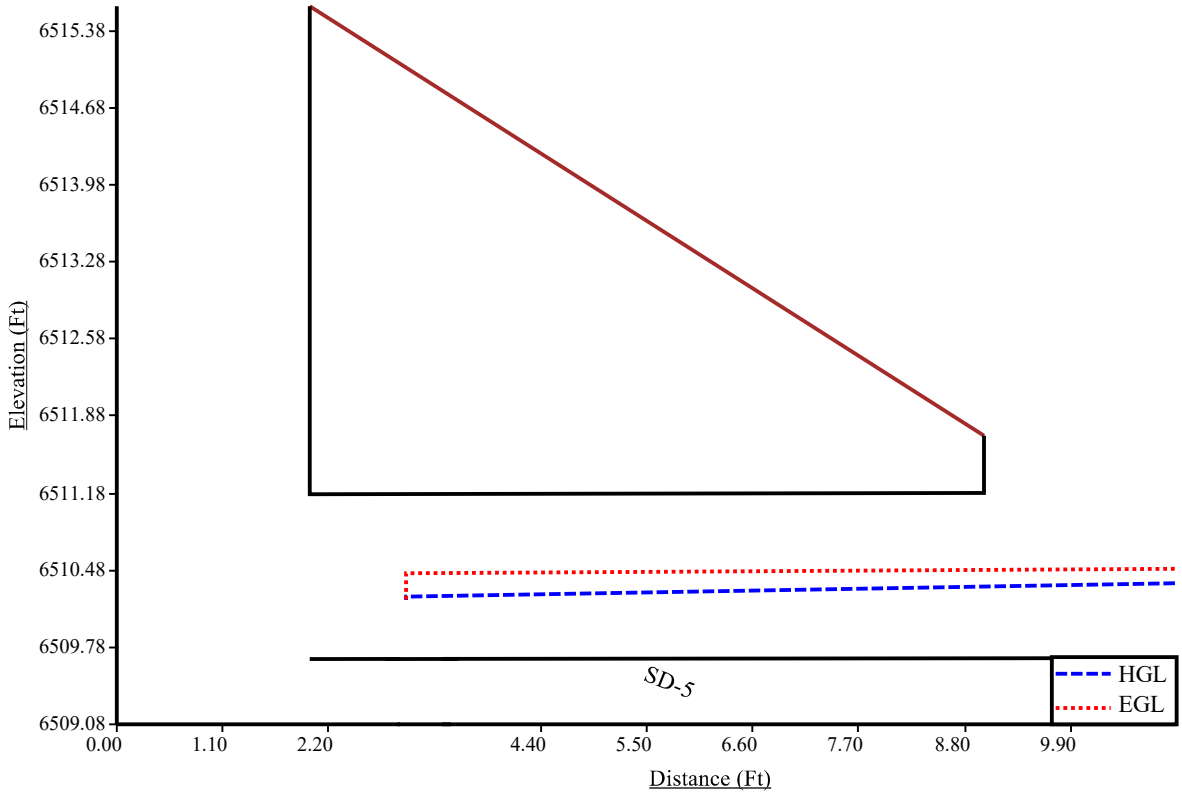
The trench side slope is 1.0 ft/ft
The minimum trench width is 2.00 ft

					Downstream			Upstream				
Element Name	Length (ft)	Wall (in)	Bedding (in)	Bottom Width (ft)	Top Width (ft)	Trench Depth (ft)	Cover (ft)	Top Width (ft)	Trench Depth (ft)	Cover (ft)	Volume (cu. yd)	Comment
SD-5	11.00	2.50	4.00	4.92	11.36	6.47	4.22	4.92	2.56	0.31	10.85	Sewer Too Shallow

Total earth volume for sewer trenches = 11 cubic yards.

- The trench was estimated to have a bottom width equal to the outer pipe diameter plus 36 inches.
- If the calculated width of the trench bottom is less than the minimum acceptable width, the minimum acceptable width was used.
- The sewer wall thickness is equal to: (equivalent diameter in inches/12)+1 inches
- The sewer bedding thickness is equal to:
  - Four inches for pipes less than 33 inches.
  - Six inches for pipes less than 60 inches.
  - Eight inches for all larger sizes.

SD Profile_SD-5 to Outfall2



INLETS

MHFD-Inlet, Version 5.01 (April 2021)

INLET MANAGEMENT

Worksheet Protected

INLET NAME	DP1	DP2	DP6	DP5
Site Type (Urban or Rural)				
Inlet Application (Street or Area)	AREA	AREA	STREET	STREET
Hydraulic Condition	Swale	Swale	On Grade	On Grade
Inlet Type	CDOT Type C (Depressed)	CDOT Type C (Depressed)	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	0.4	1.0	1.4	2.3
Major Q_{Known} (cfs)	1.0	2.4	2.4	4.1

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)				
Percent Impervious				
NRCS Soil Type				

Watershed Profile

Overland Slope (ft/ft)				
Overland Length (ft)				
Channel Slope (ft/ft)				
Channel Length (ft)				

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)				
One-Hour Precipitation, P_1 (inches)				

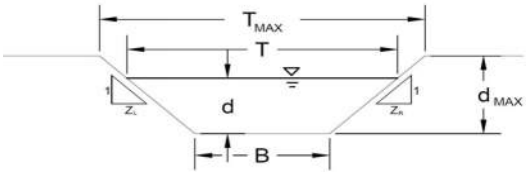
CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	**0.4**	**1.0**	**1.4**	**2.3**
Major Total Design Peak Flow, Q (cfs)	**1.0**	**2.4**	**2.4**	**4.1**
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0	0.0

AREA INLET IN A SWALE

NORTHCREST CENTER PEMBs - EL PASO COUNTY

DP1



This worksheet uses the NRCS vegetal retardance method to determine Manning's n.

For more information see Section 7.2.3 of the USDCM.

Analysis of Trapezoidal Grass-Lined Channel Using SCS Method

	NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =		
	Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.012	
	Channel Invert Slope	S_O =	0.0300	ft/ft
	Bottom Width	B =	4.00	ft
Warning 01	Left Side Slope	Z1 =	0.02	ft/ft
Warning 01	Right Side Sloe	Z2 =	0.02	ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:
- Non-Cohesive
- Cohesive
- Paved

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	**30.00**	**30.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**0.50**	**0.50**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**23.4**	**23.4**	**cfs**
MAJOR STORM Allowable Capacity is based on Depth Criterion	d_{allow} =	**0.50**	**0.50**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**0.4**	**1.0**	**cfs**
Water Depth	**d** =	**0.04**	**0.07**	**ft**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'
Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

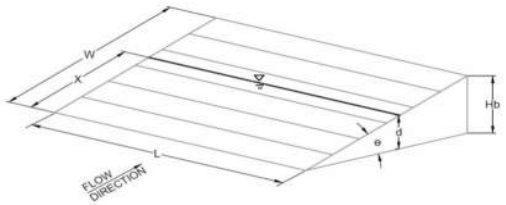
AREA INLET IN A SWALE

NORTHCREST CENTER PEMBs - EL PASO COUNTY

DP1

Inlet Design Information (Input)

Type of Inlet	CDOT Type C (Depressed)	Inlet Type =	CDOT Type C (Depressed)	
Angle of Inclined Grate (must be <= 30 degrees)		θ =	1.19	degrees
Width of Grate		W =	3.00	ft
Length of Grate		L =	3.00	ft
Open Area Ratio		A_{RATIO} =	0.70	
Height of Inclined Grate		H_B =	0.06	ft
Clogging Factor		C_f =	0.50	
Grate Discharge Coefficient		C_d =	0.79	
Orifice Coefficient		C_o =	0.52	
Weir Coefficient		C_w =	1.68	



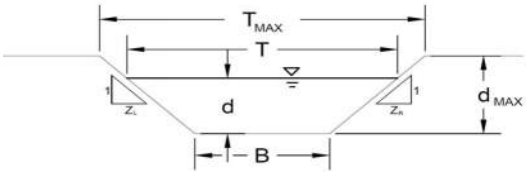
		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	1.04	1.07	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**15.6**	**16.3**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

Warning 01: Sideslope steepness exceeds USDCM Volume I recommendation.
Warning 02: Depth (d) exceeds USDCM Volume I recommendation.

AREA INLET IN A SWALE

NORTHCREST CENTER PEMBs - EL PASO COUNTY

DP2



This worksheet uses the NRCS vegetal retardance method to determine Manning's n.

For more information see Section 7.2.3 of the USDCM.

Analysis of Trapezoidal Grass-Lined Channel Using SCS Method

	NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =		
	Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.012	
	Channel Invert Slope	S_O =	0.0300	ft/ft
	Bottom Width	B =	4.00	ft
Warning 01	Left Side Slope	Z1 =	0.02	ft/ft
Warning 01	Right Side Sloe	Z2 =	0.02	ft/ft

Check one of the following soil types:

Soil Type:	Max. Velocity (V_{MAX})	Max Froude No. (F_{MAX})
Non-Cohesive	5.0 fps	0.60
Cohesive	7.0 fps	0.80
Paved	N/A	N/A

Choose One:
- Non-Cohesive
- Cohesive
- Paved

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	**30.00**	**30.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**0.50**	**0.50**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**23.4**	**23.4**	**cfs**
MAJOR STORM Allowable Capacity is based on Depth Criterion	d_{allow} =	**0.50**	**0.50**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**1.0**	**2.4**	**cfs**
Water Depth	**d** =	**0.07**	**0.12**	**ft**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

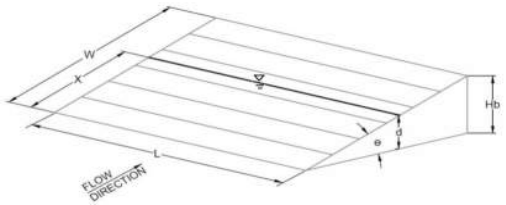
AREA INLET IN A SWALE

NORTHCREST CENTER PEMBs - EL PASO COUNTY

DP2

Inlet Design Information (Input)

Type of Inlet	CDOT Type C (Depressed)	Inlet Type =	CDOT Type C (Depressed)	
Angle of Inclined Grate (must be <= 30 degrees)		θ =	1.19	degrees
Width of Grate		W =	3.00	ft
Length of Grate		L =	3.00	ft
Open Area Ratio		A_{RATIO} =	0.70	
Height of Inclined Grate		H_B =	0.06	ft
Clogging Factor		C_f =	0.50	
Grate Discharge Coefficient		C_d =	0.79	
Orifice Coefficient		C_o =	0.52	
Weir Coefficient		C_w =	1.68	



		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	1.07	1.12	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**16.4**	**17.4**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

Warning 01: Sideslope steepness exceeds USDCM Volume I recommendation.
Warning 02: Depth (d) exceeds USDCM Volume I recommendation.

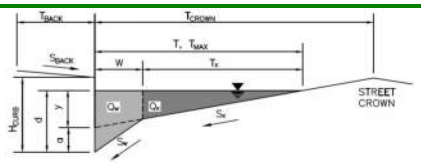
MHFD-Inlet, Version 5.01 (April 2021)

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: **NORTHCREST CENTER PEMBs - EL PASO COUNTY**

Inlet ID: **DP6**



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	0.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	12.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.040	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.042	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	4.0	5.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)		☐	☐	

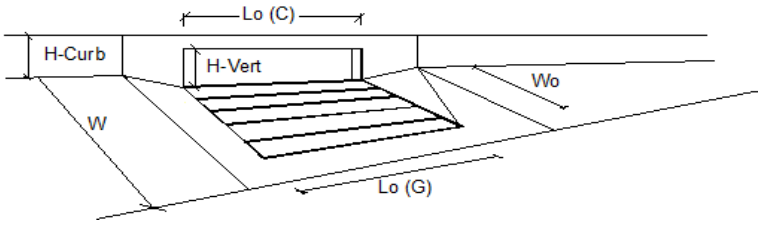
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**2.2**	**3.4**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 5.01 (April 2021)



Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT Type R Curb Opening)	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	

Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**1.3**	**2.4**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**100**	**%**

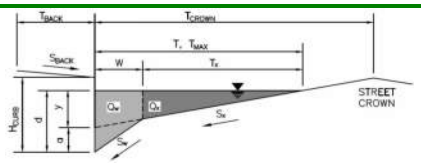
MHFD-Inlet, Version 5.01 (April 2021)

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: **NORTHCREST CENTER PEMBs - EL PASO COUNTY**

Inlet ID: **DP5**



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	0.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	60.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.040	ft/ft
Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)	S_W =	0.083	ft/ft
Street Longitudinal Slope - Enter 0 for sump condition	S_O =	0.035	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	5.0	6.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Allow Flow Depth at Street Crown (check box for yes, leave blank for no)		☐	☐	

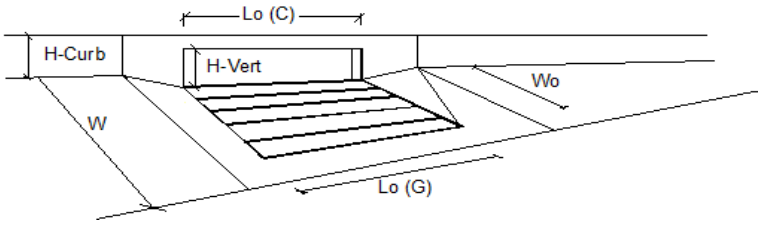
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**3.1**	**4.6**	**cfs**

Minor storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

Major storm max. allowable capacity GOOD - greater than the design flow given on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

MHFD-Inlet, Version 5.01 (April 2021)



Design Information (Input)		MINOR	MAJOR	
Type of Inlet (CDOT Type R Curb Opening)	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =	0.10	0.10	

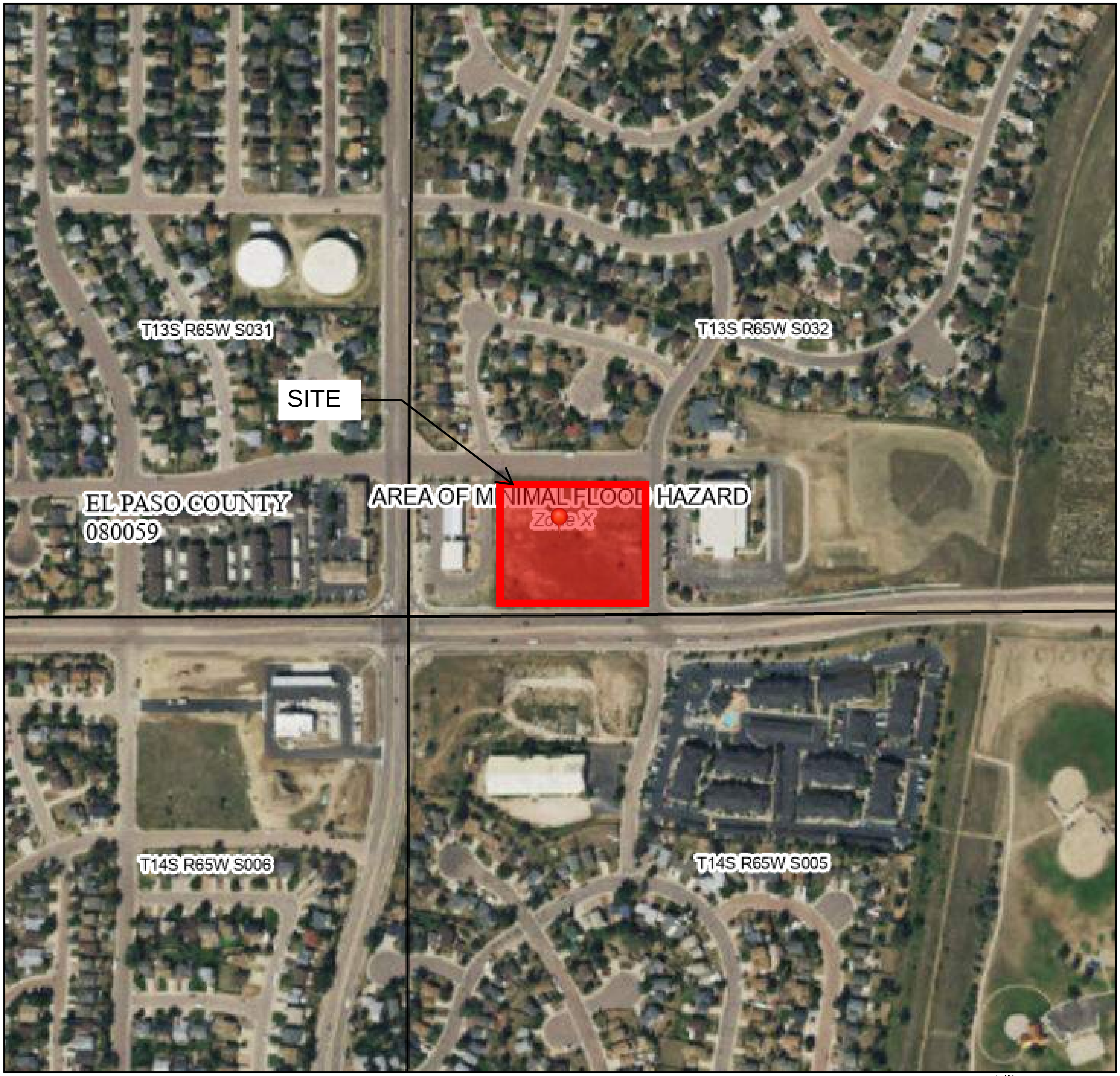
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**2.3**	**4.1**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**100**	**%**

APPENDIX C – FEMA FLOODPLAIN MAP

1DWLRQDO)ORRG +D]DUG /D\HU)LU0HWWH

FEMA

/HJHQG



)HHW

6((),6 5(3257)25'(7$,/('/(*(1'$1',1'(;0$3)25),50 3$1(/ /$<287

63(&,$/)/22' +$=$5' $5($6 — :LWKRXW %DVH)ORRG (OHYDWLRQ %)(=RQH $ 9 $ — :LWK %)(RU 'HSWK =RQH $($2 $+ 9($5 — 5HJXODWRU\ )ORRGZD\

27+(5 $5($6 2))/22' +$=$5' — $QQXDO &KDQFH)ORRG +D]DUG $UHDV RI DQQXDO FKDQFH IORRG ZLWK DYHUDJH GHSWK OHVV WKDQ RQH IRRW RU ZLWK GUDLQDJH DUHDV RI OHVV WKDQ RQH VTXDUH PLOH =RQH ; —)XWXUH &RQGLWLRQV $QQXDO &KDQFH)ORRG +D]DUG =RQH ; — $UHD ZLWK 5HGXFHG)ORRG 5LVN GXH WR /HYHH 6HH 1RWHV =RQH ; — $UHD ZLWK)ORRG 5LVN GXH WR /HYHH =RQH '

27+(5 $5($6 — $UHD RI 0LQLPDO)ORRG +D]DUG =RQH ; — (IIHFWLYH /205V — $UHD RI 8QGHWHUPLQHG)ORRG +D]DUG =RQH '

*(1(5$/ 6758&785(6 — &KDQQHO &XOYHUW RU 6WRUP 6HZHU — /HYHH 'LNH RU)ORRGZDOO

27+(5)($785(6 — &URVV 6HFWLRQV ZLWK $QQXDO &KDQFH :DWHU 6XUIDFH (OHYDWLRQ — &RDVWDO 7UDQVHFW — %DVH)ORRG (OHYDWLRQ /LQH %)(— /LPLW RI 6WXG\ — -XULVGLFWLRQ %RXQGDU\ — &RDVWDO 7UDQVHFW %DVHOLQH — 3URILOH %DVHOLQH — +\GURJUDSKLF)HDWXUH

0$3 3$1(/6 — 'LJLWDO 'DWD $YDLODEOH — 1R 'LJLWDO 'DWD $YDLODEOH — 8QPDSSHG

7KH SLQ GLVSOD\HG RQ WKH PDS LV DQ DSSUR[LPDWH SRLQW VHOHFWHG E\ WKH XVHU DQG GRHV QRW UHSUHVHQW DQ DXWKRULWDWLYH SURSHUW\ ORFDWLRQ

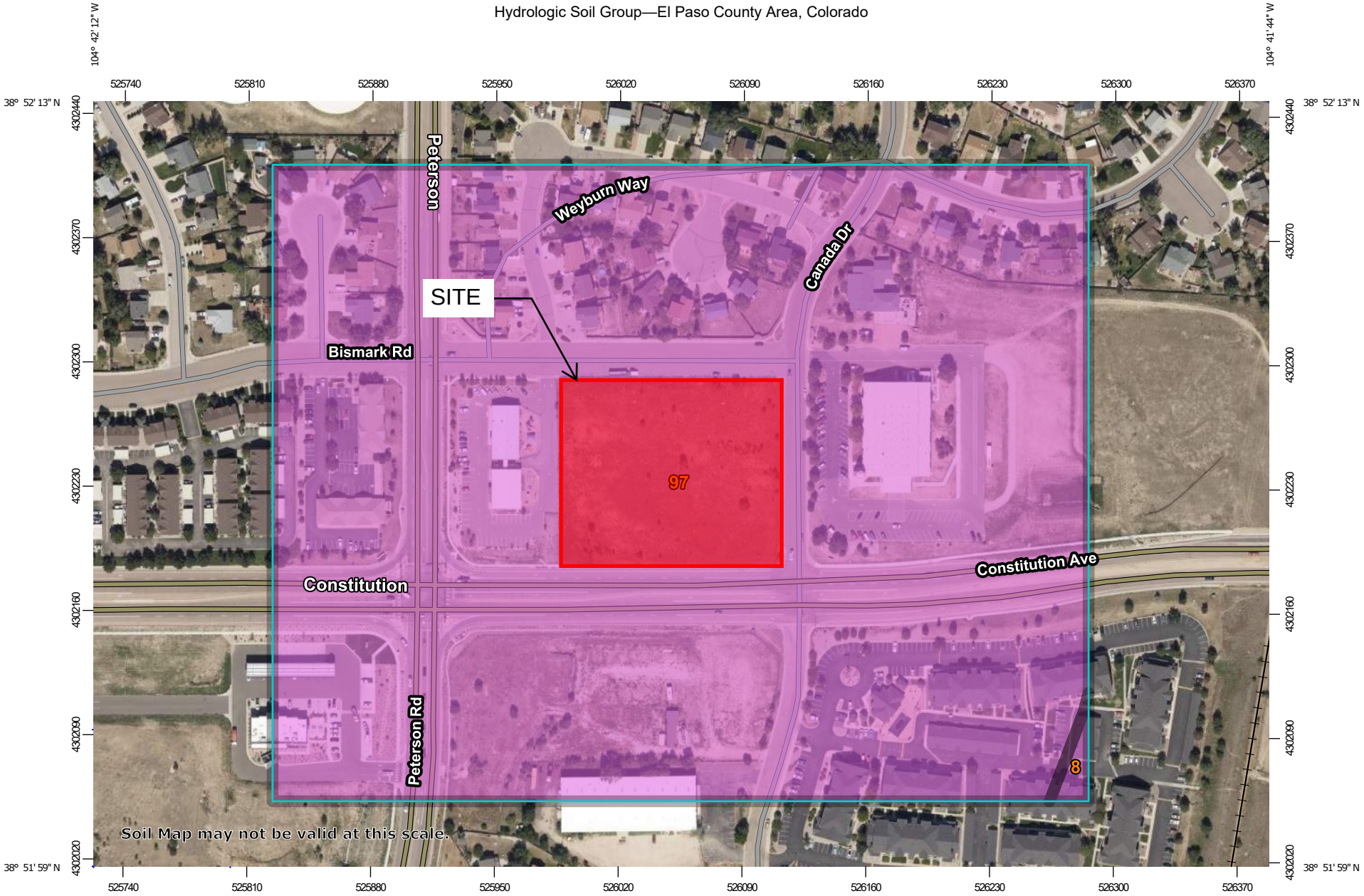
7KLV PDS FRPSOLHV ZLWK)(0$V VWDQGDUGV IRU WKH XVH RI GLJLWDO IORRG PDSV LI LW LV QRW YRLG DV GHVFULEHG EHORZ 7KH EDVHPDS VKRZQ FRPSOLHV ZLWK)(0$V EDVHPDS DFFXUDF\ VWDQGDUGV

7KH IORRG KD]DUG LQIRUPDWLRQ LV GHULYHG GLUHFWO\ IURP WKH DXWKRULWDWLYH 1)+/ ZHE VHUYLFHV SURYLGHG E\ )(0$ 7KLV PDS ZDV H[SRUWHG RQ 'DWH 30 DQG GRHV QRW UHIOHFW FKDQJHV RU DPHQGPHQWV VXEVHTXHQW WR WKLV GDWH DQG WLPH 7KH 1)+/ DQG HIIHFWLYH LQIRUPDWLRQ PD\ FKDQJH RU EHFRPH VXSHUVHGHG E\ QHZ GDWD RYHU WLPH

7KLV PDS LPDJH LV YRLG LI WKH RQH RU PRUH RI WKH IROORZLQJ PDS HOHPHQWV GR QRW DSSHDU EDVHPDS LPDJHU\ IORRG]RQH ODEHOV OHJHQG VFDOH EDU PDS FUHDWLRQ GDWH FRPPXQLW\ LGHQWLILHUV),50 SDQHO QXPEHU DQG),50 HIIHFWLYH GDWH 0DS LPDJHV IRU XQPDSSHG DQG XQPRGHUQL]HG DUHDV FDQQRW EH XVHG IRU UHJXODWRU\ SXUSRVHV

%DVHPDS 86*6 1DWLRQDO 0DS 2UWKRLPDJHU\ 'DWD UHIUHVKHG 2FWREHU

APPENDIX D – USGS SOILS SURVEY MAP



Map Scale: 1:3,040 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 45 90 180 270

Feet: 0 100 200 400 600

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

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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

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

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

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

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

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

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 18, Jun 5, 2020

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

Date(s) aerial images were photographed: Aug 19, 2018—Sep 23, 2018

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
8	Blakeland loamy sand, 1 to 9 percent slopes	A	0.2	0.4%
97	Truckton sandy loam, 3 to 9 percent slopes	A	40.9	99.6%
Totals for Area of Interest			**41.1**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX E – DRAINAGE PLANS

LEGEND

DESCRIPTION	SYMBOL
EX. CONTOUR	
DRAINAGE SUB-BASIN BOUNDARY	
TIME OF CONCENTRATION PATH	

DESCRIPTION	SYMBOL
BASIN IDENTIFIER	E-1
AREA IN ACRES	X.XX AC
DESIGN POINT ID	DP1
FLOW ARROW	
PROPERTY LINE	

Graphic Scale
0 10 20 40
In Feet: 1" = 20'

DESIGN POINT	FLOW (CFS)
1	Q_5 = 0.81 Q_{100} = 5.27

BASIN SUMMARY

BASIN	Q(5)-CFS	Q(100)-CFS	ACRES(AC)
E-1	0.81	5.27	3.24

TOC PATH

E-1
3.24 AC

DP1

EXISTING STORM MANHOLE, (TYP.)

EXISTING 15" TYPE R STORM INLET

EXISTING 5' TYPE R STORM INLET

EV

4.5%

0.8%

ROCKY MOUNTAIN GROUP
Architectural Structural Forensics
Geotechnical Materials Testing Civil Planning
ARCHITECTS RMG ENGINEERS
SOUTHERN COLORADO
2910 Austin Bluffs Parkway, Colorado Springs, CO. 80918
(719) 548-0600 ~ WWW.RMGENGINEER.COM
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

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FOR CIVIL ONLY

NORTHCREST PEMB DEVELOPMENT
PETERSON ROAD AND CONSTITUTION AVENUE
COLORADO SPRINGS, COLORADO
LEISURE CONSTRUCTION

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SHEET NAME
EXISTING CONDITIONS
SUB-BASIN HYDROLOGY

PROJECT STATUS
DESIGN DEVELOPMENT

ENG:	SAM
DRAWN:	ARP
CHECKED:	SAM
DATE	10/13/2021

#	REVISION	DATE
	---	---
	---	---
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JOB NO.
180649

SHEET NO.
C-EX-01

LAST SAVED: 10/19/2021 3:45:48 PM PATH: \\kcd.rmgengineers.com\DFS\Team\Projects\Site Specific\2020\Leisure Construction-180649\Peterson and constitution-180649\Civil\3D\Drawings\From RMG\Sheet Sets\Sub-Basin Analysis\180649-Constitution Avenue Project-EX Sub Basin Analysis.dwg

Basin D-3 Stormwater needs to be treated.

LEGEND

DESCRIPTION	SYMBOL
PROP. STRUCTURE/BUILDING	
UNCONNECTED IMPERVIOUS AREA (UIA)	
RECEIVING PERVIOUS AREA (RPA)	
TIME OF CONCENTRATION PATH	
EX. CONTOUR	
PROP. CONTOUR	
DRAINAGE SUB-BASIN BOUNDARY	

DESCRIPTION	SYMBOL
BASIN IDENTIFIER	D-1
AREA IN ACRES	X.XX AC
DESIGN POINT ID	DP1
FLOW ARROW	
PROPERTY LINE	

DESIGN POINT	FLOW (CFS)
DP-1	Q_5 = 0.39 Q_{100} = 1.03
DP-2	Q_5 = 1.04 Q_{100} = 2.36
DP-3	Q_5 = 1.02 Q_{100} = 2.32
DP-4	Q_5 = 2.57 Q_{100} = 4.78
DP-5	Q_5 = 2.27 Q_{100} = 4.10
DP-6	Q_5 = 1.35 Q_{100} = 2.43
DP-7	Q_5 = 0.07 Q_{100} = 0.25
DP-8	Q_5 = 1.12 Q_{100} = 2.94

BASIN SUMMARY

BASIN	Q(5)-CFS	Q(100)-CFS	ACRES(AC)
D-1	0.39	1.03	0.27
D-2	1.04	2.36	0.51
D-3	1.02	2.32	0.50
D-4	2.57	4.78	0.68
D-5	2.27	4.10	0.50
D-6	1.35	2.43	0.30
D-7	0.07	0.25	0.07
D-8	1.12	2.94	0.68

Graphic Scale
0 10 20 40
In Feet: 1" = 20'

BISMARK ROAD
(80' PUBLIC R.O.W.)

CANADA DRIVE
(60' PUBLIC R.O.W.)

D-7 T.O.C. PATHWAY TO EX. PUBLIC STORM INLET

(P) ATTACHED 6' WIDE CONCRETE SIDEWALK, TYP.

(P) NON-UNIFORM PUBLIC IMPROVEMENT EASEMENT

D-1 T.O.C. PATHWAY

D-2 T.O.C. PATHWAY

D-3 T.O.C. PATHWAY

COMPACTED GRAVEL SURFACE, ALL UNITS

(P) 6' MAX HT. BRICK WALLS W/ SLIDING GATE (TYP.)

LANDSCAPING

D-1 0.27 AC

D-2 0.51 AC

D-3 0.50 AC

(P) STORM MH (48")

(P) 24" HDPE SD PIPE "SD-2"

(P) 18" HDPE SD PIPE "SD-1"

DP1

DP2

DP3

(P) 3X3 DEPRESSED TYPE-C INLET

(P) 30.0' PUBLIC ACCESS EASEMENT

(P) NON-UNIFORM PUBLIC IMPROVEMENT EASEMENT

D-8 T.O.C. PATHWAY TO ADJ. PARCEL WAT. QUALITY BMP

ASPHALT PAVEMENT

DOWNSPOUT (1)

DOWNSPOUTS (2/3)

DOWNSPOUTS (4/5)

DOWNSPOUT (6)

DOWNSPOUT (7)

DOWNSPOUTS (8/9)

DOWNSPOUTS (10/11)

DOWNSPOUTS (12/13)

DOWNSPOUT (14)

DP4

D-4 0.68 AC

PROPOSED 13 UNIT COMMERCIAL CENTER
29,640 SF TOTAL

8,151 SF – OFFICES
21,489 SF – WAREHOUSES

D-6 0.30 AC

(P) 24" HDPE SD PIPE "SD-3"

D-4 T.O.C. PATHWAY

D-5 T.O.C. PATHWAY (ROOF DRAIN)

D-5 0.50 AC

(P) PEDESTRIAN SIDEWALK

UIA (549 SF)

RPA (476 SF)

100-yr+ overflows will not follow the proposed spillway route south.

(P) 18" HDPE SD PIPE "SD-5"

DP5

DP8

(P) 10' TYPE R CURB INLET

EXISTING CURB CUT TO CAPTURE STORMWATER FLOWS FROM ADJACENT SITE

(P) 10' CDOT TYPE R CURB INLET

(P) 24" HDPE SD PIPE "SD-4"

(P) 31.5' DRAINAGE EASEMENT

(P) MAINTENANCE ACCESS

(P) 25.0' PUBLIC ACCESS EASEMENT

DP6

D-8 0.68 AC

D-7 0.07 AC

DP7

(P) 18" RCP STORM PIPE

(P) 36.0' DRAINAGE EASEMENT

EXISTING 15" TYPE R STORM INLET

EXISTING 5' TYPE R STORM INLET

LANDSCAPING (NATIVE SEED & PLANTINGS, SEE LANDSCAPING PLAN)

EXISTING STORM MANHOLE, (TYP.)

EXISTING WATER QUALITY FEATURE OUTLET STRUCTURE

(P) DRAINAGE EASEMENT AROUND BASIN, AND CONNECTING TO ACCESS EASEMENT

(P) FOREBAY

(P) TRICKLE CHANNEL

(P) FULL SPECTRUM DETENTION BASIN
2,450 SF BOTTOM, 2,800 SF TOP, 6.0' HT.,
15,672 CF VOLUME
(SEE WALL DESIGN BY SEPARATE DOCUMENT)

(P) MICROPOOL

(P) STORM OUTLET STRUCTURE

(P) NON-UNIFORM PUBLIC IMPROVEMENT EASEMENT

(P) DETACHED 5' WIDE CONCRETE SIDEWALK, TYP.

Increasing Basin D-8 area puts you over the 20%, up to 1ac exclusion. Consider adjusting landscaping grades or using a small drainage ditch and cross pans to direct water to the EDB and not offsite.

Sidewalks should be included in D-8.

ROCKY MOUNTAIN GROUP
Architects
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Geotechnical
Materials Testing
Civil Planning
RMG ARCHITECTS ENGINEERS
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Southern Colorado, Denver Metro, Northern Colorado

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NORTHCREST PEMB DEVELOPMENT
2510 & 2522 CANADA DRIVE
COLORADO SPRINGS, COLORADO
LEISURE CONSTRUCTION

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SHEET NAME: DEVELOPED CONDITIONS SUB-BASINS HYDROLOGY

PROJECT STATUS: DESIGN DEVELOPMENT

ENG:	SAM
DRAWN:	ARP
CHECKED:	SAM
DATE	01/25/2022

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JOB NO. 180649

SHEET NO. C-EX-02

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