FINAL DRAINAGE REPORT

Lot 3A Northcrest Center Filing No 1A

2510 CANADA DRIVE COLORADO SPRINGS, COLORADO 80922

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

Prepared by:

Kiowa Engineering Corporation
1604 South 21st Street
Colorado Springs, Colorado 80904
Ph: (719)630-7342

Kiowa Project No. 23049

March 30, 2024

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List of Figures and Tables (Refer to the Appendix Table of Contents)

STATEMENTS AND APPROVALS

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 master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

Kiowa Engineering Corporation, 1604 South 21st Street, Colorado Springs, Colorado 80904

Andrew W. McCord (PE #25057) Date
For and on Behalf of Kiowa Engineering Corporation

DEVELOPER'S STATEMENT:

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

K&S Development, LLC
Name of Developer

Authorized Signature Date

Printed Name: Sean L. Edwards

Title: Managing Member

Address: 3442 Tampa Rd,., Suite B, Palm Harbor, FL 34684

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

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

I. PURPOSE

This report is a Final Drainage Report for Lot 3A Northcrest Center Filing No 1A, at 2510 & 2522 Canada Drive Colorado Springs, Colorado 80922, for the development of a multi-unit commercial storage center, *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

This proposed development of 70 commercial storage units is located at the address of Northcrest Center in the City of Colorado Springs, Colorado in El Paso County within the Lot 3A Northcrest Center Filing No 1A Subdivision. The parcel schedule number is 53323-09-008 and the legal descriptions is Lot 3A Northcrest Center Filing No 1A. It is comprised of an earlier 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, and 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:

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

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

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

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

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

B. DESCRIPTION OF PROPERTY – EXISTING CONDITIONS

Lot 3A Northcrest Center Filing No 1A Subdivision is approximately 141,390 square feet (3.246 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.

The existing topography consists of grades between 2 and 25 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 the site within a letter entitled *Geotechnical Report* by RMG – Rocky Mountain Group dated February 23, 2021 (Ref. Appendix B). 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 nor bedrock was encountered in the borings."

"Test Borings for structures and storage yards were advanced with a power-driven, continuous-flight auger drill rig to depths of 15 and 20-feet below the existing ground surface. Pavement Borings were advanced to 5 and 10-foot depths."

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

These soils are classified within Hydrologic Soil Group A. Erosion Potential is moderate to low depending on the granularity of the subsurface soil matrix and must be actively contained during construction activities.

D. EXISTING DRAINAGE

The existing topography consists of grades between 2 and 25 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 the East Fork of Sand Creek Creek approximately one mile to the east.

Lot 3A Northcrest Center Filing No 1A does 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 A 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 70 commercial units containing approximately 63,240 square feet along with concrete and asphalt pavement for drive accesses, sidewalks, and curb and gutter. Other on-site features include approximately 25,420 square feet of landscaping, 600 linear feet of retaining wall, and 5,000 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 SUBBASINS

A. EXISTING BASINS AND SUB-BASINS

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

Basin H-1 is the entirety of the parcel representing existing conditions and consists of one on-site sub-basin. There are some off-site flows that enter the property along its westerly margin which will be discussed in Sub-Basin O-1.

Sub-basin H-1 (3.25 ac.; Q_{10} = 1.7 cfs, Q_{100} = 10.4 cfs) is the entirety of Lot 3a 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 located in Canada Drive. This public stormwater system is connected to a Public 30" CMP 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 Canada Drive. The public stormwater system ultimately flows north within Canada Drive to the East Fork of Sand Creek. Design Point 1 is the existing conditions design point representing the on-site area. The emergency flow route of this public storm inlet is due east along the north side of Constitution Avenue.

Basin O-1 contains 0.23 acres lying adjacent to and west of the site. Flows from this sub-basin enter the westerly edge of the site in a sheet flow manner from paved areas, and travel overland across the unimproved site (Q_5=0.8cfs/Q_{100}=1.6cfs).

Basin O-2 contains 0.07 acres consisting of a narrow strip of unimproved land lying between the site's north property line, and the public curb and gutter section of Bismark Road (Q_5=0.0cfs/Q_{100}=0.2cfs). Runoff descends to the public curb and gutter section in a sheet flow manner.

Basin O-3 contains 0.06 acres consisting of a narrow strip of unimproved land lying between the site's east property line, and the public curb and gutter section of Canada Drive (Q_5=0.0cfs/Q_{100}=0.2cfs). Runoff descends to the public curb and gutter section in a sheet flow manner.

Basin O-4 contains 0.07 acres consisting of a narrow strip of unimproved land lying between the site's south property line, and the public curb and gutter section of Constitution Avenue (Q_5=0.0cfs/Q_{100}=0.2cfs). Runoff descends to the public curb and gutter section in a sheet flow manner.

IV. DEVELOPED DRAINAGE BASINS AND SUB-BASINS

A. ON-SITE BASINS – DEVELOPED CONDITION

Basin D-1 contains 0.55 acres of roof and lawn area (Q_5=1.4cfs/Q_{100}=3.0cfs). Flows either sheet flow or accumulate in downspouts and are directed to a new private grassed swale (GS 'North') for water quality treatment ahead of being released to a new private Type 'C' area inlet at Design Point 1. There are no offsite flows entering this sub-basin. Concentrated and treated runoff is collected within new private inlet and storm pipe and directed to the new private EDB.

Basin D-2 contains 0.40 acres of roof and drive aisle (Q_5=3.2cfs/Q_{100}=5.9cfs). Flows either sheet flow or accumulate in downspouts and are directed to a 4' valley pan ahead of being released to a new private Type 'C' area inlet at Design Point 2. There are no offsite flows entering this sub-basin. Concentrated runoff is collected within new storm pipe and directed to the new private EDB.

Basin D-3 contains 0.08 acres of driveway and parking area (Q_5=0.3cfs/Q_{100}=0.6cfs). Flows initially sheet flow across paved surfaces and are discharged through slotted curb at the low side of the basin nearest to Canada Drive. New landscape area is planned to receive surface runoff via two-inch curb slots located every ten feet. The slotted curb incorporates a hard ledge six inches below the invert of the curb assembly for water quality treatment ahead of being released to public roadway at Design Point 3. There are no offsite flows entering this sub-basin. Concentrated and treated runoff is collected within existing public gutter at Canada Drive and conveyed south to the existing public 15' Type R curb inlet in Canada Drive.

Basin D-4 contains 0.98 acres of roof and drive aisle area in the center of the site (Q_5=4.0cfs/Q_{100}=7.3cfs). Runoff flows sheet flow and accumulate in downspouts and are directed to a new four-foot valley pan located in the center of the drive aisle and ahead of being released to a new private Type 'C' area inlet at Design Point 4. There are some offsite flows from Basin O-1 which overtop the retaining wall lying along the westerly edge of the site, and which combine with on-site flows close to the upstream end of the new private four-foot valley pan. Combined and concentrated runoff is collected within new private inlet and storm pipe and directed to the new private EDB at Forebay Two.

Basin D-5 contains 0.15 acres of roof and lawn area (Q_5=1.3cfs/Q_{100}=2.7cfs). Flows either sheet flow or accumulate in downspouts and are directed to a new private grassed swale (GS 'South') for water quality treatment ahead of being released to a new private Type 'C' area inlet at Design Point 5. There are no offsite flows entering this sub-basin. Concentrated and treated runoff is collected within pipe and directed to the new private EDB at Forebay One.

Basin D-6 contains 0.12 acres of ramp, channel and grassed area (Q_5=1.4cfs/Q_{100}=3.0cfs). Flows either sheet flow or are released under controlled conditions from one of two new private forebays (One and at Two) at Design Point 6. There are no offsite flows entering this sub-basin. Concentrated runoff is directed via trickle channels to a new private outlet structure ahead of release to public storm systems. Calculations for the three-stage release structure are provided in Appendix B.

Basin D-7 contains 0.15 acres of drive aisle, sidewalk, entrances and lawn areas which are generally below the pond's elevation, and are constrained by topography such that they cannot be directed to

the EDB (Q_5=0.2cfs/Q_{100}=0.6cfs). Flows sheet flow to lawn areas and public roadway. Some water quality treatment benefit is achieved within the receiving pervious lawn area ahead of being released to a existing roadway curb and gutter. There are no offsite flows entering this sub-basin. Concentrated and partially treated runoff is collected within existing curb and gutter and are received at the existing public 15' Type 'R'; curb inlet located along the west side of Canada Drive.

Basin D-8 contains 0.15 acres of roof and lawn area at DP 1 (Q_5=1.4cfs/Q_{100}=3.0cfs). Flows either sheet flow or accumulate in downspouts and are directed to a new private grassed swale (GS 'North') for water quality treatment ahead of being released to a new private Type 'C' area inlet at Design Point 1. There are no offsite flows entering this sub-basin. Concentrated and treated runoff is collected within pipe and directed to the new EDB.

B. OFF-SITE BASINS - DEVELOPED CONDITION

Basin O-1 contains 0.23 acres lying adjacent to and west of the site. Flows from this sub-basin enter the westerly edge of the site in a sheet flow manner from paved areas, and travel overland across the unimproved site (Q_5=0.8cfs/Q_{100}=1.6cfs). Under developed conditions, the easterly edge of the existing alleyway discharges runoff to Basin D-4. Flows combine with on-site flows and are received at the aforementioned four-foot valley pan ahead of being directed to the EDB for storage and treatment.

Basin O-2 contains 0.07 acres consisting of a narrow strip of unimproved land lying between the site's north property line, and the public curb and gutter section of Bismark Road (Q_5=0.0cfs/Q_{100}=0.2cfs). Runoff descends to the public curb and gutter section in a sheet flow manner. Under developed conditions, new five-foot public attached sidewalk is added to the roadway (Bismark Road).

Basin O-3 contains 0.06 acres consisting of a narrow strip of unimproved land lying between the site's east property line, and the public curb and gutter section of Canada Drive (Q_5=0.0cfs/Q_{100}=0.2cfs). Runoff descends to the public curb and gutter section in a sheet flow manner. Under developed conditions, new five-foot public attached sidewalk is added to the roadway (Canada Drive).

Basin O-4 contains 0.06 acres consisting of a narrow strip of unimproved land lying between the site's east property line, and the public curb and gutter section of Canada Drive (Q_5=0.0cfs/Q_{100}=0.2cfs). Runoff descends to the public curb and gutter section in a sheet flow manner. Under developed conditions, new five-foot public attached sidewalk is added to the roadway (Constitution Avenue).

There is also 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.

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. The vertical concrete walls on all four sides of the Extended Detention Basin are due to site constraints including an existing electric vault and existing easement where the pond is being constructed. The Full Spectrum Extended Detention Basin includes a 10' wide concrete maintenance access ramp that slopes to the pond's bottom.

V. 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 consists of roof or paved surface. Where possible, roof runoff is directed to perimeter grassed swales ahead of entering private storm systems. All other areas are directly connected to the extended detention basin for treatment. With this strategy, a 14% reduction in water quality capture volume is achieved. Calculations for reduction are included in Appendix C.

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 valley pans, area inlets, 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

In addition to Full Spectrum Extended Detention, two 300-foot grassed swales are proposed at the north and south margins of the site to provide some opportunities for infiltration and sediment removal. Concentrated and partially treated flows within these grassed swales are subsequently captured within separate area inlets at the bottom of the swales and directed to the extended detention basin (EDB) within private collection systems. Slotted Curb with a dropped ledge is planned along the easterly margin where topographic constraints prevent capture within the on-site private storm collection system. A small portion of the site in the extreme southeast corner lies below the pond and is allowed to sheet flow across landscaped surface to maximize opportunities for infiltration.

VI. 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 2.33acres (3.25acres * 71.7% imperviousness).

Drainage Basin Fee: $20,387/impervious acre * 2.33 impervious acres = $47,507 Bridge

Fee: $8,339/impervious acre * 2.33 impervious acres = $19,429.87

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 COST ESTIMATE

Table 1 - Northcrest Center - Private Storm Improvements

Description	Quan.	Unit	Cost	Total
PCM Grassed Swale	600	LF	$ 35	$ 21,000
Slotted Curb w/ Dropped Ledge	110	LF	$ 55	$ 6,050
Type 'C' Area Inlet (3'x3')	4	EA	$ 9,800	$ 39,200
4-ft Dia Manhole (conc)	2	EA	$ 8,322	$ 16,644
12" HDPE Dbl Smooth Pipe	50	LF	$ 41	$ 2,050
18" HDPE Dbl Smooth Pipe	152	LF	$ 56	$ 8,512
19"x30" HERCP Pipe	31	LF	$ 112	$ 3,472
			Sub-Total	$ 88,606
Inlet/Outlet Structure	1	EA	$ 15,000	$ 15,000
Forebay One	1	EA	$ 5,800	$ 5,800
Forebay Two	1	EA	$ 9,100	$ 9,100
Trickle Pan	125	LF	$ 96	$ 12,000
Detention Basin Retaining Wall	44	CY	$ 714	$ 31,416
			Sub-Total	$ 73,316
				$ 170,244

VII. CONCLUSIONS

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 3a is within compliance and standards and meets the requirements for the Northcrest Center. The difference between Basin H-1 and Basins D-1 through D-8 results in an overall increase of the 100-year storm Water volume of 4.3 cfs overall due to increased impervious surfaces.

3.09 acres (71.7% imperviousness) of on-site flows, and 0.23 acres of off-site flows drain to the Full Spectrum Detention Basin, with a total runoff of 15.4 cfs (100-yr storm) being captured.

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.

VIII. 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)

West Fork Jimmy Camp Creek Drainage Basin Planning Study, prepared by Kiowa Engineering Corporation, dated October 17, 2003.

City of Colorado Springs and El Paso County Flood Insurance Study, prepared by the Federal Emergency Management Agency, dated March 1997.

Soil Survey of El Paso County Area, Colorado, prepared by United States Department of Agriculture Soil Conservation Service, dated June 1981.

FEMA Flood Online 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

APPENDIX TABLE OF CONTENTS

APPENDIX A

Figure 1: Vicinity Map

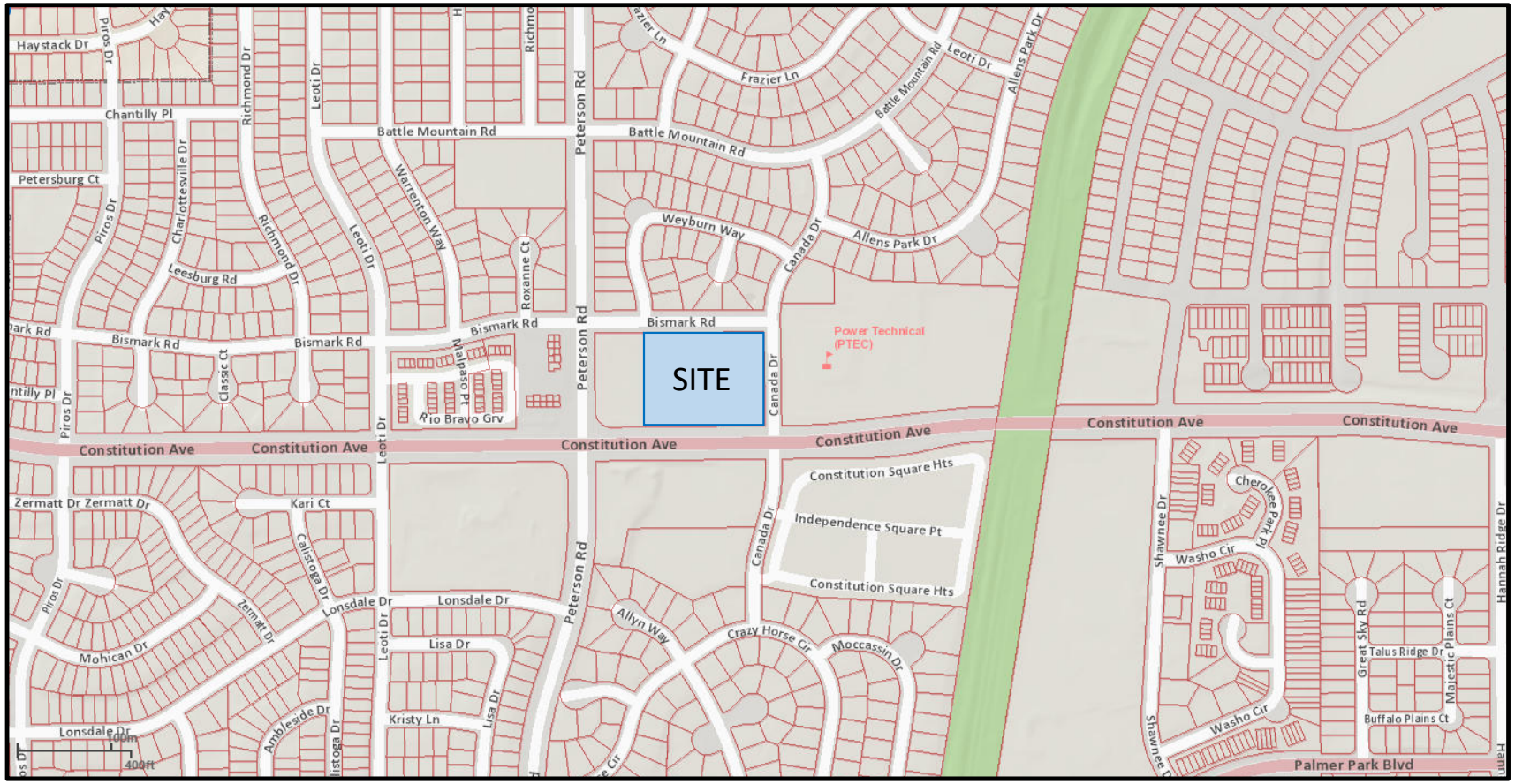
Figure 2: Soils Map

FEMA Flood Insurance Rate Map

VICINITY MAP

NORTHCREST CENTER

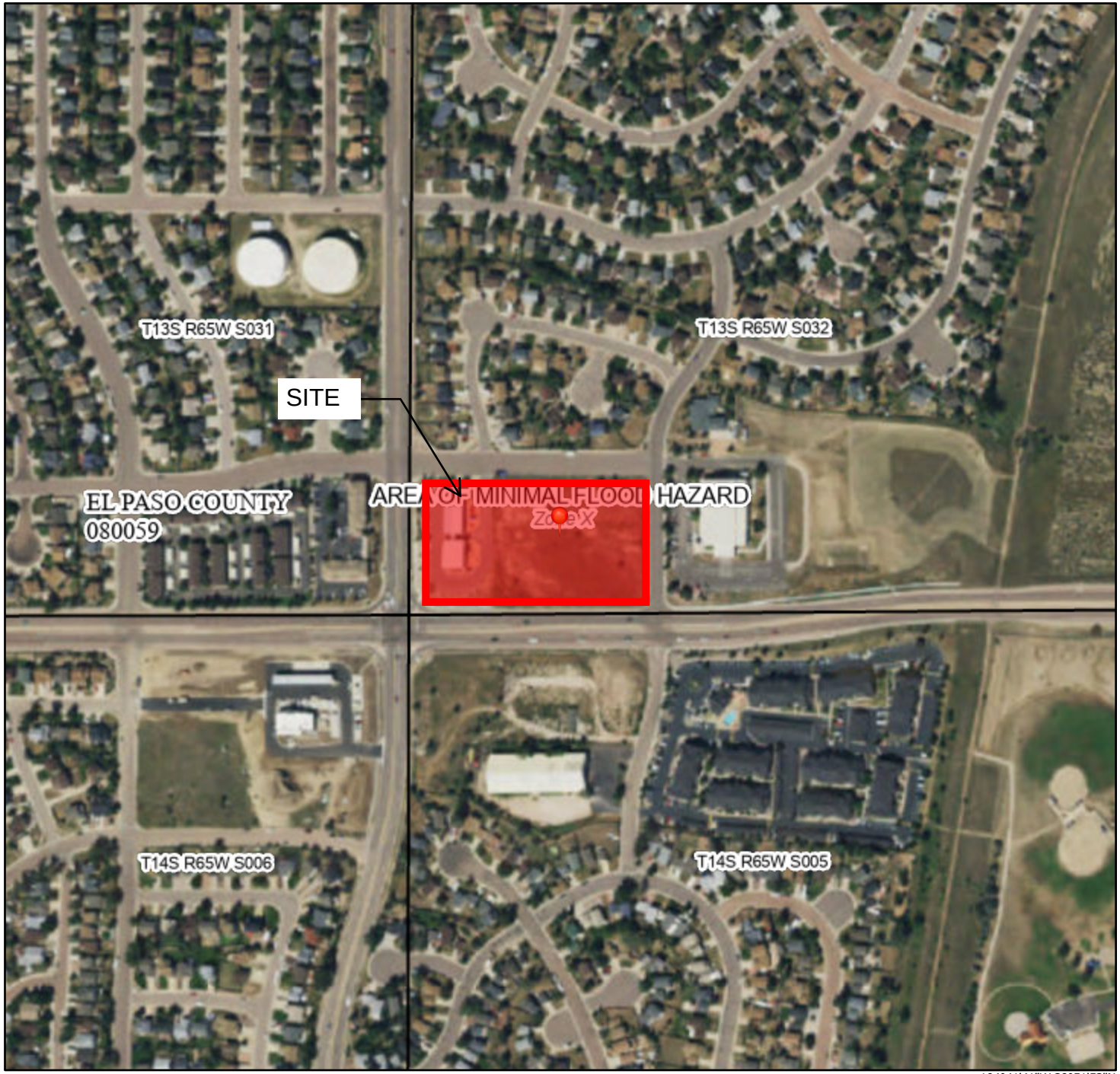
TBD BISMARK ROAD
COLORADO SPRINGS, COLORADO 80922
EL PASO COUNTY



National Flood Hazard Layer FIRMette

FEMA

104°42'18"W 38°52'21"N



104°41'41"W 38°51'53"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

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

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

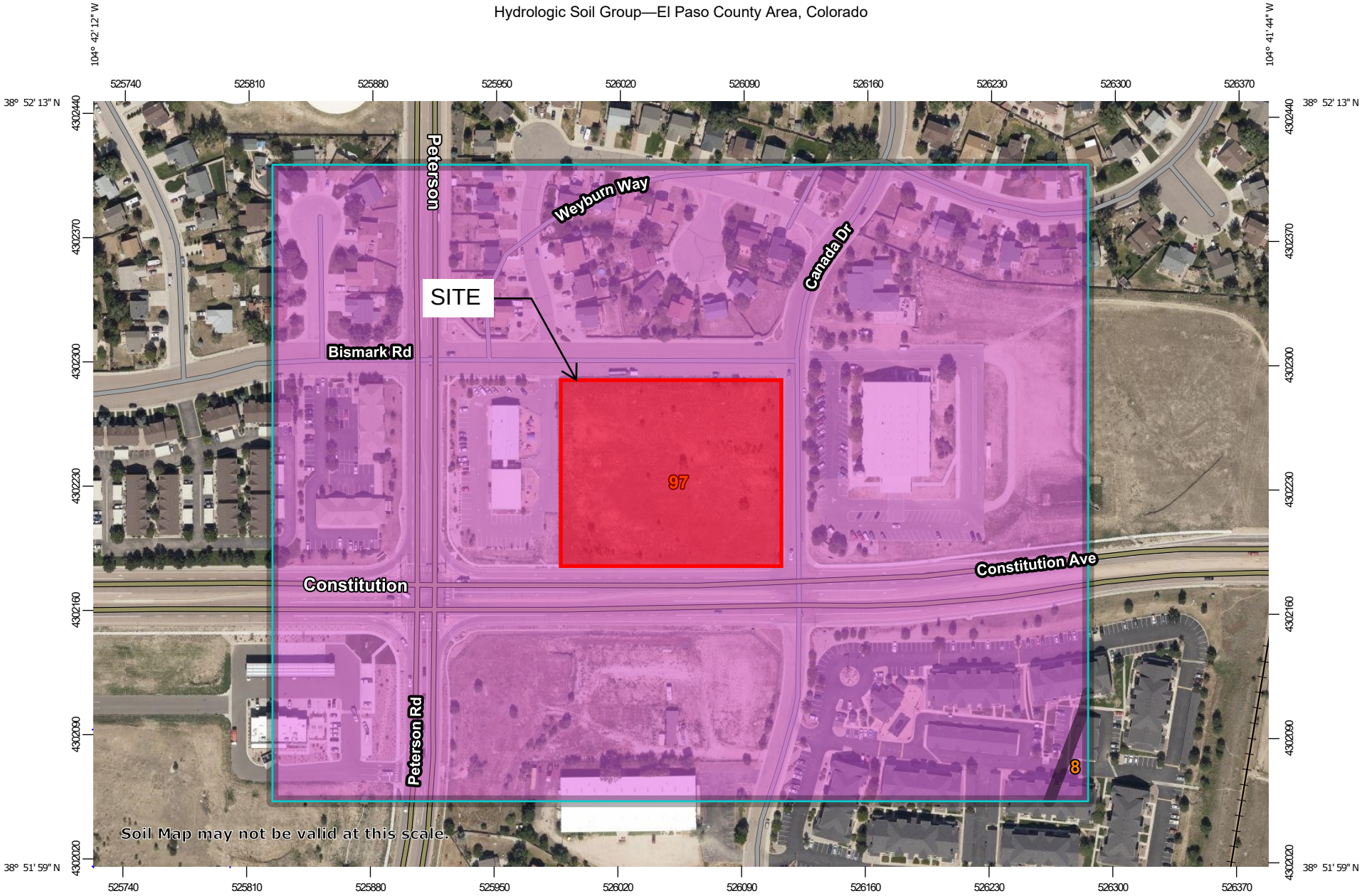
N

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

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

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 3/17/2021 at 3:21 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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



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 B

Hydrologic Calculations

Existing Condition – Runoff Co-eff, Time of Concentration and Runoff Calcs
Developed Condition – Runoff Co-eff, Time of Concentration and Runoff Calcs
Full Spectrum Detention Basin/Extended Detention Basin
Detention Volume and Emergency Spillway
Outlet Structure Calculations
Trickle Channel Capacity and Outlet Structure Sizing
Forebay Sizing Calculations
MHFD Inlet Summaries & Calculations

Runoff Coeficient and Percent Impervious Calculation
Existing Condition

EXISTING RUNOFF COEFFICIENT SUMMARY

Basin / DP	Basin or DP Area (DP contributing basins)		Soil Type	PV	Area 1 Land Use			LA	Area 2 Land Use			GR	Area 3 Land Use			RO	Area 4 Land Use			DR	Area 5 Land Use			Basin % Imperv	Basin Runoff Coefficient			
				% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp		C2	C5	C10	C100
Cheyenne Creek to Fountain Creek Tributary																											
O-1	10,178 sf	0.23ac	A	100%	0.16ac	70%	70%	2%	0.04ac	16%	0%	80%	0.03ac	14%	11%	90%		0%	0%	100%		0%	0%	**81.6%**	**0.71**	**0.73**	**0.76**	**0.83**
O-2	3,111 sf	0.07ac	A	100%		0%	0%	2%	0.07ac	100%	2%	80%		0%	0%	90%		0%	0%	100%		0%	0%	**2.0%**	**0.03**	**0.09**	**0.17**	**0.36**
O-3	2,437 sf	0.06ac	A	100%		0%	0%	2%	0.06ac	100%	2%	80%		0%	0%	90%		0%	0%	100%		0%	0%	**2.0%**	**0.03**	**0.09**	**0.17**	**0.36**
O-4	3,119 sf	0.07ac	A	100%		0%	0%	2%	0.07ac	100%	2%	80%		0%	0%	90%		0%	0%	100%		0%	0%	**2.0%**	**0.03**	**0.09**	**0.17**	**0.36**
	18,845 sf	**0.43ac**																										
H-1	141,390 sf	3.25ac	A	100%	0.05ac	2%	2%	2%	3.20ac	98%	2%	80%	0.00ac	0%	0%	90%		0%	0%	100%	0.00ac	0%	0%	**3.6%**	**0.04**	**0.10**	**0.18**	**0.37**
Summary	**141,390 sf**	**3.25ac**	**A**	**100 %**	**0.05ac**	**2%**	**2%**	**2 %**	**3.20ac**	**98%**	**2%**	**80 %**	**0.00ac**	**0%**	**0%**	**90 %**	**0.00ac**	**0%**	**0%**	**100 %**	**0.00ac**	**0%**	**0%**	**3.6%**	**0.04**	**0.10**	**0.18**	**0.37**

Basin Runoff Coefficient is a weighted average

Runoff Coefficients and Percents Impervious (DCM Table 6-6)

Hydrologic Soil Type:		**Runoff Coef Calc Method:** Weighted						
Land Use	Abb	%	C2	C5	C10	C25	C50	C100
Business: Downtown	BD	95%	0.79	0.81	0.83	0.85	0.87	0.88
Business: Suburban	BS	70%	0.45	0.49	0.53	0.58	0.60	0.62
Drives and Walks	DR	100%	0.89	0.90	0.92	0.94	0.95	0.96
Streets - Gravel (Packed)	GR	80%	0.57	0.59	0.63	0.66	0.68	0.70
Historic Flow Analysis	HI	2%	0.03	0.09	0.17	0.26	0.31	0.36
Lawns (match Historic Flow)	LA	2%	0.03	0.09	0.17	0.26	0.31	0.36
Off-site flow-Undeveloped	OF	45%	0.26	0.32	0.38	0.44	0.48	0.59
Park	PA	7%	0.05	0.12	0.20	0.30	0.34	0.39
Streets - Paved	PV	100%	0.89	0.90	0.92	0.94	0.95	0.96
Roofs	RO	90%	0.71	0.73	0.75	0.78	0.80	0.81

Equation:
Cc={C1A1+C2A2+C3A3+...Ci+Ai) / At
(City of Colorado Springs DCM Equation 6-6) Where:
Cc = composite runoff coefficient for total area
Ci = runoff coefficient for subarea (surface type or land use)
Ai = area of surface type corresponding to Ci
At = total area of all sub areas
i = number of surface types in the drainage area

Existing Time of Concentration Calculation
Existing Condition

EXISTING TIME OF CONCENTRATION SUMMARY

Sub-Basin Data						Time of Concentration Estimate												Final t_c
Basin / Design Point	Contributing Basins	Area	C_5	Up Elev	Down Elev	Initial/Overland Time (t_i)					Travel Time (t_t)						Comp. t_c	
						Length	Slope	t_i	Elev	Elev	Length	Slope	Land Type	Cv	Velocity	t_t		
Cheyenne Creek to Fountain Creek Tributary																		
O-1	Off-Site:	0.23ac	0.73	6534.00	6528.70	100lf	5.3%	3.9 min.	6528.70	6520.50	182lf	4.5%	SP	7	1.5 ft/sec	2.0 min.	6.0 min.	**6.0 min.**
O-2	Off-Site:	0.07ac	0.09	6530.00	6529.00	9lf	11.1%	2.5 min.	6529.00	6528.90	1lf	10.0%	SP	7	2.2 ft/sec	0.0 min.	5.0 min.	**5.0 min.**
O-3	Off-Site:	0.06ac	0.09	6511.00	6510.00	9lf	11.1%	2.5 min.	6510.00	6509.90	1lf	10.0%	SP	7	2.2 ft/sec	0.0 min.	5.0 min.	**5.0 min.**
O-4	Off-Site:	0.07ac	0.09	6515.00	6514.00	9lf	11.1%	2.5 min.	6514.00	6513.90	1lf	10.0%	SP	7	2.2 ft/sec	0.0 min.	5.0 min.	**5.0 min.**
H-1	On-Site:	3.25ac	0.10	6532.00	6528.00	100lf	4.0%	11.5 min.	6528.00	6508.00	457lf	4.4%	SP	7	1.5 ft/sec	5.2 min.	16.7 min.	**16.7 min.**
Summary		**3.32ac**																

Equations:

t_i (Overland) = $0.395(1.1-C_5)L^{0.5} S^{-0.333}$
(DCM Equation 6-8) Where:
C_5 = Runoff coefficient for 5-year
L = Length of overland flow (ft)
S = Average basin slope (ft/ft)

t_c (1st DP) = $(18-15i) + L_t / (60\ (24i+12)S^{0.5})$ Where:
t_c (1st DP) = First DP Time of Concentration in urban catchments
L_t = Length of Flow Path
i = imperviousness (expressed as a decimal)

$t_t = L_t / 60KS^{0.5}$ Where:
t_t = Channelized flow time (travel time)(min.)
L_t = Waterway length (ft)
K = Conveyance Factor (see DCM Table 6-7)
S = Watercourse slope (ft/ft)

City of Colorado Springs DCM Table 6-7

Type of Land Surface	Land Type	K
Grassed Waterway	GW	15
Heavy Meadow	HM	2.5
Nearly Bare Ground	NBG	10
Paved Area/Swales	PV	20
Riprap (Not Buried)	RR	6.5
Short Pasture/Lawns	SP	7
Tillage/Fields	TF	5

Runoff Calculation
Developed Condition

Basin / Design Point	Contributing Basins	Drainage Area	C_5	C_{100}	Time of Concentration	Rainfall Intensity i_5	Rainfall Intensity i_{100}	Q_5	Q_{100}	Basin / DP
Off-Site										
O-1	O-1	0.23 ac	0.73	0.83	6.0 min.	4.9 in/hr	8.2 in/hr	**0.8 cfs**	**1.6 cfs**	
O-2	O-2	0.07 ac	0.09	0.36	5.0 min.	5.2 in/hr	8.7 in/hr	**0.0 cfs**	**0.2 cfs**	
O-3	O-3	0.06 ac	0.09	0.36	5.0 min.	5.2 in/hr	8.7 in/hr	**0.0 cfs**	**0.2 cfs**	
O-4	O-4	0.07 ac	0.09	0.36	5.0 min.	5.2 in/hr	8.7 in/hr	**0.0 cfs**	**0.2 cfs**	
		0.43 ac						**0.9 cfs**	**2.2 cfs**	
On-Site										
H-1	O-4	3.25 ac	0.10	0.37	5.0 min.	5.2 in/hr	8.7 in/hr	**1.7 cfs**	**10.4 cfs**	H-1
							SUM:	**1.7 cfs**	**10.4 cfs**	

Design Point Summary			Weighted		Lagged	Rainfall Intensity		Q5	Q100
DP-1	O-1 & H-1	3.48 ac	0.14	0.35	6.0 min.	4.9 in/hr	8.2 in/hr	2.5 cfs	9.9 cfs
							Summ:	**2.7 cfs**	**12.6 cfs**

Equations (taken from Fig 6-5, City of Colorado Springs DCM):

i_2=-1.19 ln(T_c) + 6.035

i_5=-1.50 ln(T_c) + 7.583

i_{10}=-1.75 ln(T_c) + 8.847

i_{25}=-2.00 ln(T_c) + 10.111

Q = CiA

Q = Peak Runoff Rate (cubic feet/second)

C = Runoff coef representing a ratio of peak runoff rate to ave rainfall intensity for a duration equal to the runoff time of concentration.

P1	Inches
WQCV	0.60 in
2 yr	1.19 in
5 yr	1.50 in
10 yr	1.75 in

Runoff Coeficient and Percent Impervious Calculation
Developed Condition

DEVELOPED RUNOFF COEFFICIENT SUMMARY

Basin / DP	Basin or DP Area (DP contributing basins)		Soil Type	PV	Area 1 Land Use			LA	Area 2 Land Use			GR	Area 3 Land Use			RO	Area 4 Land Use			DR	Area 5 Land Use			Basin % Imperv	Basin Runoff Coefficient			
				% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp	% Imperv	Land Use Area	% Area	Comp Land Use % Imp		C2	C5	C10	C100
All Disturbed Areas																												
Non-Tributary to Detention Basin																												
O-2	3,111 sf	0.07ac	A	100%	0.04ac	62%	62%	2%	0.03ac	38%	1%	80%	0.00ac	0%	0%	90%	0.00ac	0%	0%	100%	0.00ac	0%	0%	62.5%	0.56	0.59	0.63	0.73
O-3	2,437 sf	0.06ac	A	100%	0.01ac	23%	23%	2%	0.03ac	51%	1%	80%	0.00ac	0%	0%	90%	0.00ac	0%	0%	100%	0.01ac	26%	26%	50.3%	0.45	0.49	0.54	0.66
O-4	3,119 sf	0.07ac	A	100%	0.05ac	73%	73%	2%	0.02ac	27%	1%	80%	0.00ac	0%	0%	90%	0.00ac	0%	0%	100%	0.00ac	0%	0%	74.0%	0.66	0.69	0.72	0.80
Tributary to Detention Basin																												
O-1	10,178 sf	0.23ac	A	100%	0.16ac	71%	71%	2%	0.04ac	15%	0%	80%	0.03ac	14%	11%	90%	0.00ac	0%	0%	100%	0.00ac	0%	0%	82.3%	0.71	0.73	0.77	0.83
D-1	24,289 sf	0.56ac	A	100%	0.00ac	0%	0%	2%	0.17ac	30%	1%	80%	0.00ac	0%	0%	90%	0.38ac	68%	61%	100%	0.01ac	2%	2%	64.2%	0.51	0.54	0.58	0.68
D-2	32,548 sf	0.75ac	A	100%	0.39ac	52%	52%	2%	0.02ac	3%	0%	80%	0.00ac	0%	0%	90%	0.34ac	45%	41%	100%	0.02ac	3%	3%	95.8%	0.81	0.83	0.85	0.90
D-3	3,384 sf	0.08ac	A	100%	0.07ac	85%	85%	2%	0.01ac	15%	0%	80%	0.00ac	0%	0%	90%	0.00ac	0%	0%	100%	0.00ac	0%	0%	85.5%	0.76	0.78	0.81	0.87
D-4	42,621 sf	0.98ac	A	100%	0.54ac	55%	55%	2%	0.05ac	5%	0%	80%	0.00ac	0%	0%	90%	0.38ac	38%	35%	100%	0.00ac	0%	0%	89.9%	0.77	0.78	0.80	0.86
D-5	19,996 sf	0.46ac	A	100%	0.00ac	0%	0%	2%	0.12ac	26%	1%	80%	0.00ac	0%	0%	90%	0.34ac	73%	66%	100%	0.00ac	1%	1%	67.0%	0.53	0.56	0.60	0.69
D-6	5,129 sf	0.12ac	A	100%	0.02ac	17%	17%	2%	0.10ac	83%	2%	80%	0.00ac	0%	0%	90%	0.00ac	0%	0%	100%	0.00ac	3%	3%	21.0%	0.20	0.25	0.32	0.49
D-7	6,421 sf	0.15ac	A	100%	0.07ac	50%	50%	2%	0.05ac	35%	1%	80%	0.00ac	0%	0%	90%	0.00ac	0%	0%	100%	0.00ac	2%	2%	52.4%	0.47	0.50	0.53	0.62
D-8	7,000 sf	0.16ac	A	100%	0.00ac	0%	0%	2%	0.15ac	92%	2%	80%	0.00ac	0%	0%	90%	0.00ac	0%	0%	100%	0.01ac	8%	8%	9.7%	0.10	0.15	0.23	0.41
On-Site Summary	**122,840 sf**	**3.25ac**	**A**	**100 %**	**0.99ac**	**31%**	**31%**	**2 %**	**0.36ac**	**11%**	**0%**	**80 %**	**0.00ac**	**0%**	**0%**	**90 %**	**1.43ac**	**44%**	**###**	**100 %**	**0.04ac**	**1%**	**1%**	**71.7%**	**0.60**	**0.62**	**0.64**	**0.70**
Tributary to Detention Basin:		**3.09ac**																										
DP4		**2.63ac**																										

Basin Runoff Coefficient is a weighted average

Runoff Coefficients and Percents Impervious (DCM Table 6-6)

Hydrologic Soil Type:		**Runoff Coef Calc Method:** Weighted						
Land Use	Abb	%	C2	C5	C10	C25	C50	C100
Business: Downtown	BD	95%	0.79	0.81	0.83	0.85	0.87	0.88
Business: Suburban	BS	70%	0.45	0.49	0.53	0.58	0.60	0.62
Drives and Walks	DR	100%	0.89	0.90	0.92	0.94	0.95	0.96
Streets - Gravel (Packed)	GR	80%	0.57	0.59	0.63	0.66	0.68	0.70
Historic Flow Analysis	HI	2%	0.03	0.09	0.17	0.26	0.31	0.36
Lawns (match Historic Flow)	LA	2%	0.03	0.09	0.17	0.26	0.31	0.36
Off-site flow-Undeveloped	OF	45%	0.26	0.32	0.38	0.44	0.48	0.96
Park	PA	7%	0.05	0.12	0.20	0.30	0.34	0.39
Streets - Paved	PV	100%	0.89	0.90	0.92	0.94	0.95	0.96
Roofs	RO	90%	0.71	0.73	0.75	0.78	0.80	0.81

Equation:
Cc={C1A1+C2A2+C3A3+...Ci+Ai) / At
(City of Colorado Springs DCM Equation 6-6) Where:
Cc = composite runoff coefficient for total area
Ci = runoff coefficient for subarea (surface type or land use)
Ai = area of surface type corresponding to Ci
At = total area of all sub areas
i = number of surface types in the drainage area

Time of Concentration Calculation
Developed Condition

EXISTING TIME OF CONCENTRATION SUMMARY

Sub-Basin Data						Time of Concentration Estimate												Final t_c
Basin / Design Point	Contributing Basins	Area	C_5	Up Elev	Down Elev	Initial/Overland Time (t_i)					Travel Time (t_t)						Comp.	
						Length	Slope	t_i	Elev	Elev	Length	Slope	Land Type	Cv	Velocity	t_t	t_c	
Non-Tributary to Detention																		
O-2	Off-Site:	0.07ac	0.59	6530.50	6530.00	10lf	5.0%	1.7 min.	6530.00	6511.00	390lf	4.9%	PV	20	4.4 ft/sec	1.5 min.	5.0 min.	**5.0 min.**
O-3	Off-Site:	0.06ac	0.49	6510.50	6510.00	10lf	5.0%	2.1 min.	6510.00	6507.50	290lf	0.9%	PV	20	1.9 ft/sec	2.6 min.	5.0 min.	**10.0 min.**
O-4	Off-Site:	0.07ac	0.69	6517.00	6516.50	10lf	5.0%	1.4 min.	6516.50	6508.00	390lf	2.2%	PV	20	3.0 ft/sec	2.2 min.	5.0 min.	**5.0 min.**
Tributary to Detention																		
O-1	Off-Site:	0.23ac	0.73	6534.00	6528.70	100lf	5.3%	3.9 min.	6528.70	6520.50	182lf	4.5%	SP	7	1.5 ft/sec	2.0 min.	5.9 min.	**5.9 min.**
D-1	On-Site:	0.56ac	0.54	6531.75	6525.25	100lf	6.5%	5.5 min.	6525.25	6512.50	302lf	4.2%	GW	15	3.1 ft/sec	1.6 min.	7.1 min.	**7.1 min.**
D-2	On-Site:	0.75ac	0.83	6531.75	6527.50	65lf	6.5%	2.1 min.	6527.50	6512.25	365lf	4.2%	PV	20	4.1 ft/sec	1.5 min.	5.0 min.	**5.0 min.**
D-3	On-Site:	0.08ac	0.78	6513.75	6512.75	36lf	2.8%	2.5 min.	6512.75	6509.25	20lf	17.5%	SP	7	2.9 ft/sec	0.1 min.	5.0 min.	**5.0 min.**
D-4	On-Site:	0.98ac	0.78	6528.00	6522.00	34lf	17.6%	1.3 min.	6522.00	6512.50	430lf	2.2%	PV	20	3.0 ft/sec	2.4 min.	5.0 min.	**5.0 min.**
D-5	On-Site:	0.46ac	0.56	6522.00	6520.00	24lf	8.3%	2.4 min.	6520.00	6513.75	350lf	1.8%	GW	15	2.0 ft/sec	2.9 min.	5.3 min.	**5.3 min.**
D-6	On-Site:	0.12ac	0.25	6513.75	6509.00	42lf	11.3%	4.5 min.	6509.00	6507.50	102lf	1.5%	GW	15	1.8 ft/sec	0.9 min.	5.4 min.	**5.4 min.**
D-7	On-Site:	0.15ac	0.50	6512.75	6509.50	64lf	5.1%	5.1 min.	6509.50	6507.75	165lf	1.1%	PV	20	2.1 ft/sec	1.3 min.	6.5 min.	**6.5 min.**
D-8	On-Site:	0.16ac	0.15	6513.50	6509.75	30lf	12.5%	4.1 min.	6509.75	6508.25	40lf	3.8%	SP	7	1.4 ft/sec	0.5 min.	5.0 min.	**5.0 min.**
Summary		**3.25ac**									Dev TC							

Equations:

t_i (Overland) = $0.395(1.1-C_5)L^{0.5} S^{-0.333}$
(DCM Equation 6-8) Where:
C_5 = Runoff coefficient for 5-year
L = Length of overland flow (ft)
S = Average basin slope (ft/ft)

t_c (1st DP) = $(18-15i) + L_t / (60\ (24i+12)S^{0.5})$ Where:
t_c (1st DP) = First DP Time of Concentration in urban catchments
L_t = Length of Flow Path
i = imperviousness (expressed as a decimal)

$t_t = L_t / 60KS^{0.5}$ Where:
t_t = Channelized flow time (travel time)(min.)
L_t = Waterway length (ft)
K = Conveyance Factor (see DCM Table 6-7)
S = Watercourse slope (ft/ft)

City of Colorado Springs DCM Table 6-7

Type of Land Surface	Land Type	K
Grassed Waterway	GW	15
Heavy Meadow	HM	2.5
Nearly Bare Ground	NBG	10
Paved Area/Swales	PV	20
Riprap (Not Buried)	RR	6.5
Short Pasture/Lawns	SP	7
Tillage/Fields	TF	5

Runoff Calculation
Developed Condition

Basin / Design Point	Contributing Basins	Drainage Area	C_2	C_5	C_{100}	Time of Concentration	Rainfall Intensity i_5	Rainfall Intensity i_{100}	Runoff Q_{WQCV}	Runoff Q_2	Runoff Q_5	Runoff Q_{100}	Basin / DP
Northcrest Center													
Non-Tributary Offsite Flow													
O-2	O-2	0.07 ac	0.56	0.59	0.73	5.0 min.	5.2 in/hr	8.7 in/hr	**0.1 cfs**	**0.2 cfs**	**0.2 cfs**	**0.5 cfs**	O-2
O-3	O-3	0.06 ac	0.45	0.49	0.66	10.0 min.	4.1 in/hr	6.9 in/hr	**0.0 cfs**	**0.1 cfs**	**0.1 cfs**	**0.3 cfs**	O-3
O-4	O-4	0.07 ac	0.66	0.69	0.80	5.0 min.	5.2 in/hr	8.7 in/hr	**0.1 cfs**	**0.2 cfs**	**0.3 cfs**	**0.5 cfs**	O-4
Tributary Flows (Offsite and On-Site)													
Offsite Flow	O-1	0.23 ac	0.71	0.73	0.83	5.9 min.	4.9 in/hr	8.3 in/hr	**0.3 cfs**	**0.7 cfs**	**0.8 cfs**	**1.6 cfs**	O-1
DP-1	D-1	0.56 ac	0.51	0.54	0.68	7.1 min.	4.6 in/hr	7.8 in/hr	**0.5 cfs**	**1.1 cfs**	**1.4 cfs**	**3.0 cfs**	DP-1
DP-2	D-2	0.75 ac	0.81	0.83	0.90	5.0 min.	5.2 in/hr	8.7 in/hr	**1.2 cfs**	**2.5 cfs**	**3.2 cfs**	**5.9 cfs**	DP-2
DP-3	D-3	0.08 ac	0.76	0.78	0.87	5.0 min.	5.2 in/hr	8.7 in/hr	**0.1 cfs**	**0.2 cfs**	**0.3 cfs**	**0.6 cfs**	DP-3
DP-4	D-4	0.98 ac	0.77	0.78	0.86	5.0 min.	5.2 in/hr	8.7 in/hr	**1.5 cfs**	**3.1 cfs**	**4.0 cfs**	**7.3 cfs**	DP-4
DP-5	D-5	0.46 ac	0.53	0.56	0.69	5.3 min.	5.1 in/hr	8.5 in/hr	**0.5 cfs**	**1.0 cfs**	**1.3 cfs**	**2.7 cfs**	DP-5
DP-6	D-6	0.12 ac	0.20	0.25	0.49	5.4 min.	5.0 in/hr	8.5 in/hr	**0.0 cfs**	**0.1 cfs**	**0.1 cfs**	**0.5 cfs**	DP-5
DP-7	D-7	0.15 ac	0.47	0.25	0.49	6.5 min.	4.8 in/hr	8.0 in/hr	**0.1 cfs**	**0.3 cfs**	**0.2 cfs**	**0.6 cfs**	DP-7
DP-8	D-8	0.16 ac	0.10	0.50	0.62	5.0 min.	5.2 in/hr	8.7 in/hr	**0.0 cfs**	**0.1 cfs**	**0.4 cfs**	**0.9 cfs**	DP-8
	Tributary Summary:	**3.09 ac**	**0.60**	**0.62**	**0.70**	**13.0 min.**	**Detention Basin:**		**4.2 cfs**	**8.4 cfs**	**10.9 cfs**	**20.9 cfs**	**Detained Only**

Design Point Summary			Weighted		Lagged	Rainfall Intensity		QWQCV	Q2	Q5	Q100
DP-1	D-1	0.56 ac	0.54	0.68	7.1 min.	4.6 in/hr	7.8 in/hr			**1.4 cfs**	**3.0 cfs**
DP-2	D-2 & D-3	1.30 ac	0.71	0.81	7.1 min.	4.6 in/hr	7.8 in/hr			**4.3 cfs**	**8.2 cfs**
DP-3	D-1 thru D-3	0.08 ac	0.78	0.87	7.1 min.	4.6 in/hr	7.8 in/hr			**0.3 cfs**	**0.5 cfs**
DP-4	O-1, D1 thru D-4	2.52 ac	0.74	0.83	13.0 min.	3.7 in/hr	6.3 in/hr			**6.9 cfs**	**13.1 cfs**
DP-5	D-5	0.46 ac	0.56	0.69	5.3 min.	5.1 in/hr	8.5 in/hr			**1.3 cfs**	**2.7 cfs**
DP-6	O-1, D1 thru D-6	3.09 ac	0.69	0.80	13.0 min.	3.7 in/hr	6.3 in/hr			**8.0 cfs**	**15.4 cfs**
DP-7	D-7	0.15 ac	0.25	0.49	6.5 min.	4.8 in/hr	8.0 in/hr			**0.2 cfs**	**0.6 cfs**
DP-8	D-8	0.16 ac	0.50	0.62	5.0 min.	5.2 in/hr	8.7 in/hr			**0.4 cfs**	**0.9 cfs**
ALL	**ALL**	**3.40 ac**	**0.62**	**0.70**	**13.0 min.**		**Disturbed Area Summary:**			**8.6 cfs**	**16.9 cfs**

Equations (taken from Fig 6-5, City of Colorado Springs DCM):

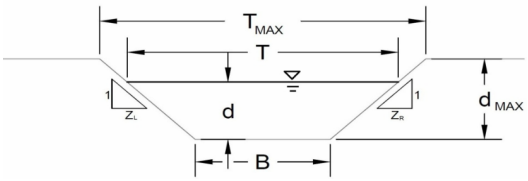
i_2=-1.19 ln(T_c) + 6.035
i_5=-1.50 ln(T_c) + 7.583
i_{10}=-1.75 ln(T_c) + 8.847
i_{25}=-2.00 ln(T_c) + 10.111
i_{50}=-2.25 ln(T_c) + 11.375
i_{100}=-2.52 ln(T_c) + 12.735

Q = CiA
Q = Peak Runoff Rate (cubic feet/second)
C = Runoff coef representing a ratio of peak runoff rate to ave rainfall intensity for a duration equal to the runoff time of concentration.
i = average rainfall intensity in inches per hour
A = Drainage area in acres

P1	Inches
WQCV	0.60 in
2 yr	1.19 in
5 yr	1.50 in
10 yr	1.75 in
25 yr	2.00 in
50 yr	2.25 in
100 yr	2.52 in

AREA INLET IN A SWALE

DP1



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses SCS Method)

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =	D	
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	see details below	
Channel Invert Slope	S_O =	0.0500	ft/ft
Bottom Width	B =	5.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Sloe	Z2 =	4.00	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} =	**7.50**	**8.00**	ft
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**0.33**	**0.50**	ft

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Top Width Criterion	Q_{allow} =	**2.9**	**5.2**	cfs
MAJOR STORM Allowable Capacity is based on Top Width Criterion	d_{allow} =	**0.31**	**0.38**	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**1.4**	**3.0**	cfs
Water Depth	d =	**0.25**	**0.32**	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'

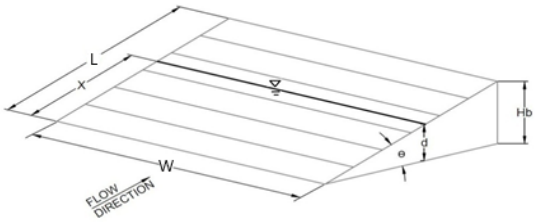
AREA INLET IN A SWALE

DP1

Inlet Design Information (Input)

Type of Inlet	User-Defined	Inlet Type =	User-Defined

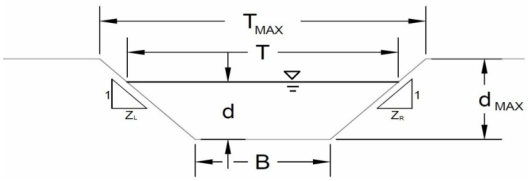
Angle of Inclined Grate (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grate	W =	3.00	ft
Length of Grate	L =	3.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grate	H_B =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	N/A	
Orifice Coefficient	C_o =	0.64	
Weir Coefficient	C_w =	2.05	



		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	0.25	0.32	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**2.4**	**3.3**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

DP2



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses 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 =	0.0400	ft/ft
Bottom Width	B =	0.00	ft
Left Side Slope	Z1 =	25.00	ft/ft
Right Side Sloe	Z2 =	25.00	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} =	**9.00**	**12.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**0.25**	**0.33**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Top Width Criterion	Q_{allow} =	**4.0**	**8.7**	**cfs**
MAJOR STORM Allowable Capacity is based on Top Width Criterion	d_{allow} =	**0.18**	**0.24**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**3.2**	**5.9**	**cfs**
Water Depth	**d** =	**0.16**	**0.21**	**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'

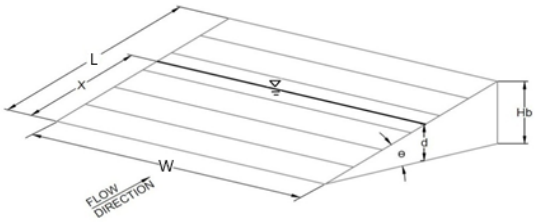
AREA INLET IN A SWALE

DP2

Inlet Design Information (Input)

Type of Inlet: CDOT Type C (Depressed)

Inlet Type = CDOT Type C (Depressed)

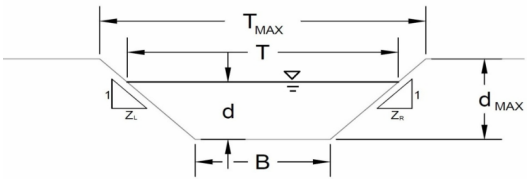


Angle of Inclined Grade (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grade	W =	3.00	ft
Length of Grade	L =	3.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grade	H_B =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	0.84	
Orifice Coefficient	C_o =	0.56	
Weir Coefficient	C_w =	1.81	

		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	1.16	1.21	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**15.4**	**15.6**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

DP4



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses 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 =	0.0214	ft/ft
Bottom Width	B =	0.00	ft
Left Side Slope	Z1 =	25.00	ft/ft
Right Side Sloe	Z2 =	25.00	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} =	**12.00**	**15.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**0.25**	**0.33**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Top Width Criterion	Q_{allow} =	**6.4**	**11.5**	**cfs**
MAJOR STORM Allowable Capacity is based on Top Width Criterion	d_{allow} =	**0.24**	**0.30**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**4.0**	**7.3**	**cfs**
Water Depth	**d** =	**0.20**	**0.25**	**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'

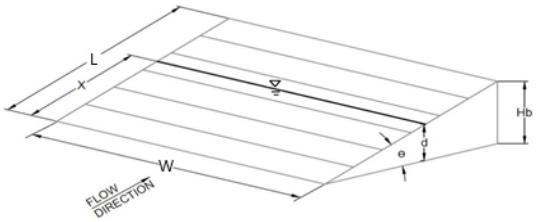
AREA INLET IN A SWALE

DP4

Inlet Design Information (Input)

Type of Inlet: CDOT Type C (Depressed)

Inlet Type = CDOT Type C (Depressed)

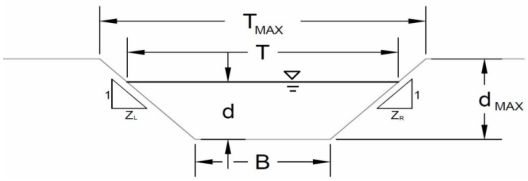


Angle of Inclined Grade (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grade	W =	3.00	ft
Length of Grade	L =	3.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grade	H_B =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	0.84	
Orifice Coefficient	C_o =	0.56	
Weir Coefficient	C_w =	1.81	

		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	1.20	1.25	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**15.6**	**15.9**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

D5



This worksheet uses the NRCS vegetal retardance method to determine Manning's n for grass-lined channels.

An override Manning's n can be entered for other channel materials.

Analysis of Trapezoidal Channel (Grass-Lined uses 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 =	0.013	
Channel Invert Slope	S_O =	75.0000	ft/ft
Bottom Width	B =	6.00	ft
Left Side Slope	Z1 =	25.00	ft/ft
Right Side Sloe	Z2 =	25.00	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} =	7.00	8.00	ft
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	0.17	0.33	ft

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Top Width Criterion	Q_{allow} =	9.0	29.7	cfs
MAJOR STORM Allowable Capacity is based on Top Width Criterion	d_{allow} =	0.02	0.04	ft

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	1.3	2.7	cfs
Water Depth	d =	0.01	0.01	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'

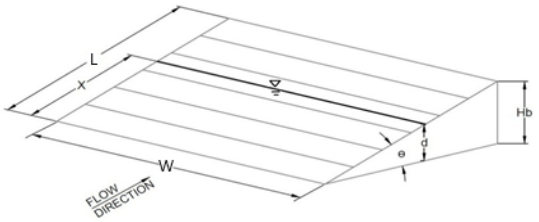
AREA INLET IN A SWALE

D5

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 =	0.00	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 =	0.00	ft
Clogging Factor	C_f =	0.50	
Grate Discharge Coefficient	C_d =	0.84	
Orifice Coefficient	C_o =	0.56	
Weir Coefficient	C_w =	1.81	



		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	1.01	1.01	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**14.3**	**14.3**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

MHFD-Inlet, Version 5.03 (August 2023)

INLET MANAGEMENT

Worksheet Protected

INLET NAME	DP1	DP2	DP4	D5
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	AREA	AREA	AREA	AREA
Hydraulic Condition	Swale	Swale	Swale	Swale
Inlet Type	User-Defined	CDOT Type C (Depressed)	CDOT Type C (Depressed)	CDOT Type C (Depressed)

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	1.4	3.2	4.0	1.3
Major Q_{Known} (cfs)	3.0	5.9	7.3	2.7

Bypass (Carry-Over) Flow from Upstream Inlets must be organized from upstream (left) to downstream (right) in order for bypass flows to be linked.

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)	0.56	0.75	0.98	0.46
Percent Impervious	64.2	95.8	89.9	67
NRCS Soil Type	A	A	A	A

Watershed Profile

Overland Slope (ft/ft)	0.050	0.021	0.021	0.015
Overland Length (ft)	300	300	300	300
Channel Slope (ft/ft)	0.050	0.021	0.021	0.015
Channel Length (ft)	300	300	300	300

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

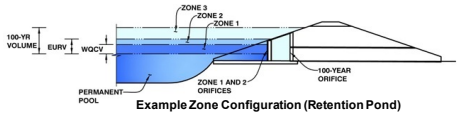
Minor Total Design Peak Flow, Q (cfs)	**1.4**	**3.2**	**4.0**	**1.3**
Major Total Design Peak Flow, Q (cfs)	**3.0**	**5.9**	**7.3**	**2.7**
Minor Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	0.0	0.0	0.0	0.0

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

Project: Northcrest Storage Center

Basin ID: EDB - Full Spectrum Canada Drive



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	EDB	
Watershed Area =	3.09	acres
Watershed Length =	400	ft
Watershed Length to Centroid =	175	ft
Watershed Slope =	0.050	ft/ft
Watershed Imperviousness =	71.70%	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) =	0.073	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.283	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.184	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.239	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.284	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	0.339	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	0.394	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.458	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.48 in.) =	0.680	acre-feet	3.48	inches
Approximate 2-yr Detention Volume =	0.185	acre-feet		
Approximate 5-yr Detention Volume =	0.241	acre-feet		
Approximate 10-yr Detention Volume =	0.289	acre-feet		
Approximate 25-yr Detention Volume =	0.345	acre-feet		
Approximate 50-yr Detention Volume =	0.379	acre-feet		
Approximate 100-yr Detention Volume =	0.412	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.073	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.210	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.130	acre-feet
Total Detention Basin Volume =	0.412	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 = 0.25 ft

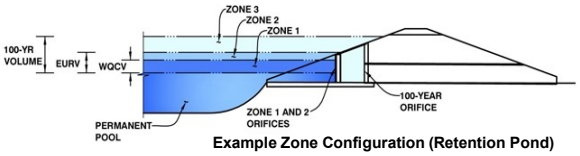
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	100	0.002		
elev 6507.75	--	0.25	--	--	--	150	0.003	31	0.001
6508	--	0.50	--	--	--	1,000	0.023	175	0.004
	--	0.75	--	--	--	2,200	0.051	575	0.013
	--	1.00	--	--	--	2,753	0.063	1,194	0.027
	--	1.25	--	--	--	3,106	0.071	1,926	0.044
6509	--	1.50	--	--	--	3,500	0.080	2,752	0.063
	--	1.75	--	--	--	3,850	0.088	3,671	0.084
	--	2.00	--	--	--	4,300	0.099	4,690	0.108
	--	2.25	--	--	--	4,475	0.103	5,787	0.133
6510	--	2.50	--	--	--	4,560	0.105	6,916	0.159
	--	2.75	--	--	--	4,610	0.106	8,062	0.185
	--	3.00	--	--	--	4,644	0.107	9,219	0.212
	--	3.25	--	--	--	4,694	0.108	10,386	0.238
6511	--	3.50	--	--	--	4,730	0.109	11,564	0.265
	--	3.75	--	--	--	4,762	0.109	12,751	0.293
	--	4.00	--	--	--	4,795	0.110	13,945	0.320
	--	4.25	--	--	--	4,829	0.111	15,148	0.348
6512	--	4.50	--	--	--	4,863	0.112	16,360	0.376
	--	4.75	--	--	--	4,897	0.112	17,580	0.404
Inv. Spillway	--	5.00	--	--	--	4,932	0.113	18,808	0.432
	--	5.25	--	--	--	4,967	0.114	20,046	0.460
6513	--	5.50	--	--	--	5,002	0.115	21,292	0.489
	--	5.75	--	--	--	5,050	0.116	22,548	0.518
F.B. 6513.50	--	6.00	--	--	--	5,100	0.117	23,817	0.547
t.o.w. 6513.75	--	6.25	--	--	--	5,150	0.118	25,098	0.576

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: Northcrest Storage Center

Basin ID: EDB - Full Spectrum Canada Drive



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.62	0.073	Orifice Plate
Zone 2 (EURV)	3.66	0.210	Rectangular Orifice
Zone 3 (100-year)	4.83	0.130	Weir&Pipe (Restrict)
Total (all zones)		0.412	

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)

Centroid 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 =	3.66	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	sq. 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	0.60	1.20	1.80	2.40			
Orifice Area (sq. inches)	0.38	0.38	0.67	0.67	0.83			

	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)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Zone 2 Rectangular	Not Selected			Zone 2 Rectangular	Not Selected	
Invert of Vertical Orifice =	3.00	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	0.03	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	3.66	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	0.08	N/A	feet
Vertical Orifice Height =	2.00	N/A	inches				
Vertical Orifice Width =	2.00		inches				

Calculated Parameters for Vertical Orifice

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			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.66	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	5.33	N/A	feet
Overflow Weir Front Edge Length =	4.00	N/A	feet	Overflow Weir Slope Length =	5.27	N/A	feet
Overflow Weir Grate Slope =	3.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	32.34	N/A	
Horiz. Length of Weir Sides =	5.00	N/A	feet	Overflow Grate Open Area w/o Debris =	16.68	N/A	ft^2
Overflow Grate Type =	Close Mesh Grate	N/A		Overflow Grate Open Area w/ Debris =	8.34	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.67	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.52	N/A	ft^2
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.29	N/A	feet
Restrictor Plate Height Above Pipe Invert =	6.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	1.23	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	4.83	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.17	feet
Spillway Crest Length =	50.00	feet	Stage at Top of Freeboard =	6.00	feet
Spillway End Slopes =	1.00	H:V	Basin Area at Top of Freeboard =	0.11	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	0.49	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 AF).*

Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.48
CUHP Runoff Volume (acre-ft) =	0.073	0.283	0.184	0.239	0.284	0.339	0.394	0.458	0.680
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.184	0.239	0.284	0.339	0.394	0.458	0.680
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.0	0.1	0.1	0.9	1.8	2.9	6.4
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.02	0.03	0.30	0.57	0.94	2.08
Peak Inflow Q (cfs) =	N/A	N/A	4.3	5.6	6.7	8.2	9.8	11.1	16.7
Peak Outflow Q (cfs) =	0.0	0.2	0.1	0.1	0.2	0.5	1.0	2.1	5.6
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.9	2.1	0.5	0.6	0.7	0.9
Structure Controlling Flow =	Plate	Overflow Weir 1	Plate	Vertical Orifice 1	Vertical Orifice 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	0.00	N/A	N/A	N/A	0.0	0.0	0.1	0.3
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	39	59	55	59	60	60	59	57	53
Time to Drain 99% of Inflow Volume (hours) =	**42**	66	60	65	67	68	67	66	64
Maximum Ponding Depth (ft) =	1.62	3.67	2.62	3.11	3.46	3.81	3.96	4.17	4.75
Area at Maximum Ponding Depth (acres) =	0.08	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Maximum Volume Stored (acre-ft) =	0.073	0.284	0.171	0.222	0.261	0.298	0.315	0.339	0.402

Presedementation / Forebay Sizing

Design Point	Forebay	100 Yr Flow	Detention WQCV	Total Req'd Forebay Vol 3.0% WQCV	Tributary Area	% Total Trib Area	Required Forebay Volume	Forebay Design Area	Forebay Design Depth	Forebay Design Volume	Discharge Design Flow 1.0% 100yr	Calc'd Open Width (1" min)	**Design Width**
DP5	One	2.7cfs	517cf	16cf	0.46ac	14.8%	2cf	32sf	1.00-ft	32 cf	0.03 cfs	2.5-inch	**2.5-inch**
DP6	Two	13.1cfs	2,968cf	89cf	2.63ac	85.2%	76cf	135sf	1.00-ft	135 cf	0.13 cfs	3.0-inch	**3.0-inch**
	Totals	15.8	3,485cf	105cf	3.09ac	14.8%							

Opening Width Equation for Rectangular Opening

$L = Q / (CH^{1.5}) \times 12 + 0.2xHx12$ (UD-BMP Spreadsheet -- EDB tab)

		Forebay	Design Point
C =	2.5	One	DP5
C =	3.0	Two	DP6

Forebay Overflow Calculation

Design Point	Forebay	Water Surf Elev	Crest Elev	Crest Length	Flow Depth	**Calc'd Flow**
DP5	One	6,511.00	6,510.0	2.0 ft	1.00 ft	6.0 cfs
DP6	Two	6,509.00	6,508.0	10.0 ft	1.00 ft	30.0 cfs

Weir Equation:

$Q = CLH^{1.5}$ C = 3.0

C = Weir coefficient (dimensionless), C = 3.0 (most cases)

L = Length of weir at Crest, in ft. Not including sideslopes.

Trickle Channel Calculation

Design Point	Location	100yr Flow	Req'd Flow 1.0% 100yr	Bottom Width	Flow Depth	Side Slope	Slope	Manning 'n'	Top Width	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	**Capacity**
DP5	One	2.7cfs	0.03	1.0 ft	0.50 ft	0.0:1	0.7%	0.013	1.0 ft	0.50 sf	2.0 ft	0.25 ft	3.8 ft/sec	**1.9 cfs**
DP6	Two	13.1cfs	0.13	1.0 ft	0.50 ft	0.0:1	0.7%	0.013	1.0 ft	0.50 sf	2.0 ft	0.25 ft	3.8 ft/sec	**1.9 cfs**

Equations:

Area (A) = $b(d)+zd^2$ Perimeter (P) = $b+2d*(1+z^2)^{0.5}$ Velocity = $(1.49/n)R_n^{2/3} S^{1/2}$ Flow = $(1.49/n)AR_n^{2/3} S^{1/2}$

b = width z = side slope S = Slope of the channel

d = depth Hydraulic Radius = A/P n = Manning's number

R_n = Hydraulic Radius (Reynold's Number)

Lot 1 Broadmoor Campus Filing No. 2
Broadmoor Exhibit Hall

Emergency Spillway Calculation:

Detention Area	100-yr Flow	120% 100yr Flow	Water Surf Elev	Crest Elev	Crest Length	Z	C	Flow Depth (H)	**Calc'd Flow**	Check
EDB	15.4 cfs	19 cfs	6,512.50	6,513.75	50.00 ft	3:1	3.0	0.25 ft	19.0	OK

Broad Crested Weir Equation (USDCM Eqn 12-20 and 12-21):

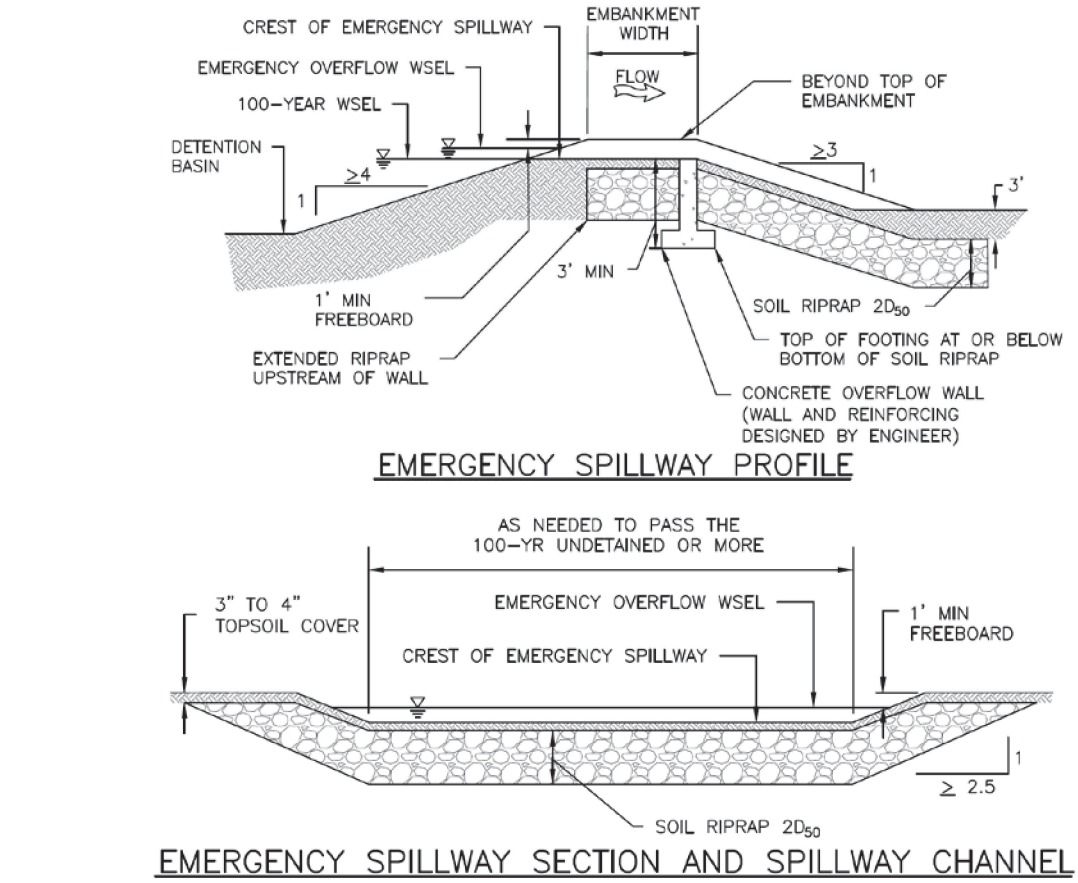
$Q = CLH^{1.5} + 2x((2/5)CZH^{5/2})$

H = Head above weir crest, in ft

C = Weir coefficient, C = 3.0 (most cases)

Z = Side slope (horizontal:vertical)

L = Length of weir at Crest, in ft. Not including sideslopes.



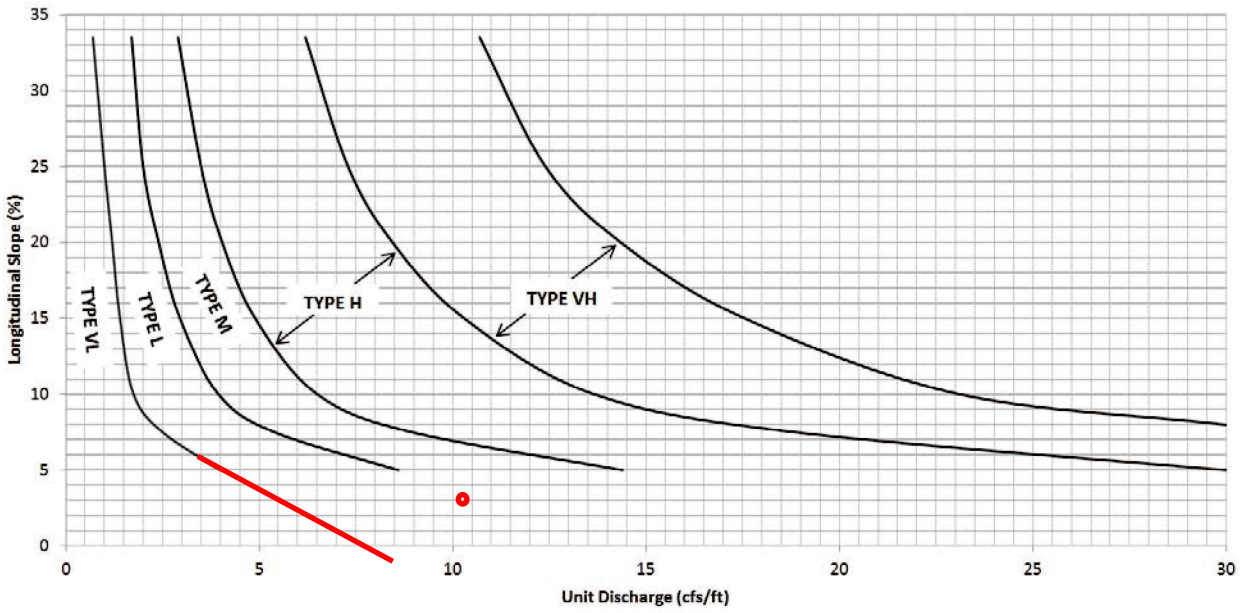
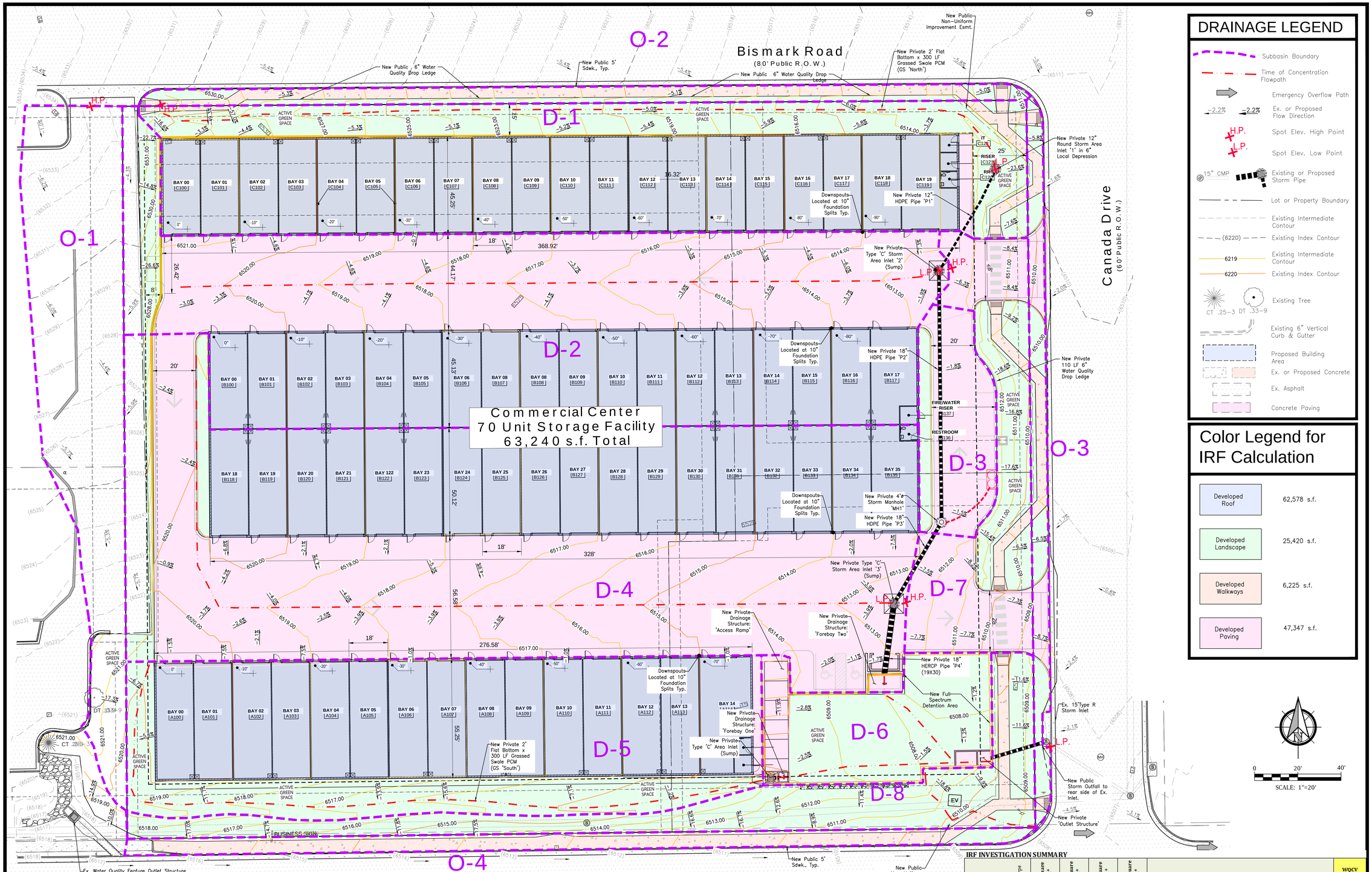


Figure 12-21. Embankment protection details and rock sizing chart (adapted from Arapahoe County)

Forebay 2 ~ 15.4 CFS (Type L) ~ Slope = 3-5%

APPENDIX C
Water Quality Calculations and Exhibit



DRAINAGE LEGEND

- Subbasin Boundary
- Time of Concentration Flowpath
- Emergency Overflow Path
- Ex. or Proposed Flow Direction
- Spot Elev. High Point
- Spot Elev. Low Point
- Existing or Proposed Storm Pipe
- Lot or Property Boundary
- Existing Intermediate Contour
- Existing Index Contour
- Existing Intermediate Contour
- Existing Index Contour
- Existing Tree
- Existing 6" Vertical Curb & Gutter
- Proposed Building Area
- Ex. or Proposed Concrete
- Ex. Asphalt
- Concrete Paving

Color Legend for IRF Calculation

Developed Roof	62,578 s.f.
Developed Landscape	25,420 s.f.
Developed Walkways	6,225 s.f.
Developed Paving	47,347 s.f.

IRF INVESTIGATION SUMMARY

Basin / DP	Soil Type	UIA Square Feet*	RPA Square Feet*	SPA Square Feet*	DCIA Square Feet*	On-Site IRF Disturbed Area Only	WQCV Event CREDIT
Family Life Services							
D-1	B	518 sf	7,189 sf	0 sf	265 sf	Roof Flows to North Margin Grassed Swale PCM 'North' (also detained)	100.0%
D-2	B	32,548 sf	0 sf	0 sf	0 sf	Roof and Drive Aisle Only (to Detention Basin)	0.0%
D-3	B	2,930 sf	2,225 sf	502 sf	0 sf	Wash Area and Turnout - Slotted Curb at Low Side (not detained)	100.0%
D-4	B	42,621 sf	0 sf	0 sf	1 sf	Roof and Drive Aisle Only (to Detention Basin)	0.0%
D-5	B	7,637 sf	5,070 sf	0 sf	12 sf	Roof Flows to South Margin Meandering Grassed Swale PCM 'South' (detained)	100.0%
D-6	B	0 sf	0 sf	0 sf	5,278 sf	Detention Basin Only (grass bottom)	0.0%
D-7	B	976 sf	935 sf	0 sf	2,282 sf	Site Exit Drive below captured grade (not detained)	100.0%
D-8	B	550 sf	6,450 sf	0 sf	3 sf	Extreme Southeast Corner. New UIA/RPA Transfer at Sidewalk (not detained)	100.0%
Summary		87,781 sf	21,870 sf	502 sf	7,842 sf	WQCV Reduction:	14.0%
Percentage of Total:		74.4%	18.5%	0.4%	6.6%		

Kiowa Engineering Corporation
1604 South 21st Street
Colorado Springs, Colorado 80904
(719) 630-7342

Northcrest Center
Site Drainage Analysis
Infiltration Reduction Factors
City of Colorado Springs, Colorado

Project No.:	23049
Date:	03/29/2024
Design:	MJK
Drawn:	MJK
Check:	AMcC
Revisions:	

Sheet
IRF
1 of 2 Sheets

2024-Mar-29, Fri

Cheyenne Mountain Zoo Campus Analysis
IRF Reduction Summary
Existing Condition

IRF INVESTIGATION SUMMARY

Basin / DP	Soil Type	UIA Square Feet*	RPA Square Feet*	SPA Square Feet *	DCIA Square Feet*	On-Site IRF Disturbed Area Only	WQCV Event CREDIT
Family Life Services							
D-1	B	518 sf	7,189 sf	0 sf	265 sf	Roof Flows to North Margin Grassed Swale PCM 'North' (also detained)	100.0%
D-2	B	32,548 sf	0 sf	0 sf	0 sf	Roof and Drive Aisle Only (to Detention Basin)	0.0%
D-3	B	2,930 sf	2,225 sf	502 sf	0 sf	Wash Area and Turnout - Slotted Curb at Low Side (not detained)	100.0%
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D-6	B	0 sf	0 sf	0 sf	5,278 sf	Detention Basin Only (grass bottom)	0.0%
D-7	B	976 sf	935 sf	0 sf	2,282 sf	Site Exit Drive below captured grade (not detained)	100.0%
D-8	B	550 sf	6,450 sf	0 sf	3 sf	Extreme Southeast Corner. New UIA/RPA Transfer at Sidewalk (not detained)	100.0%
Summary		87,781 sf	21,870 sf	502 sf	7,842 sf	WQCV Reduction:	14.0%
Percentage of Total:		74.4%	18.5%	0.4%	6.6%		

* UIA acres - are equated with rooftops, concreted: drives, walks and asphaltic pavements
* RPA acres - are equated with vegetative hillsides which receive flows intitially part of UIA
* DCIA acres - flows which are low in the sub-basin, and which do not enter or reenter an RPA.
* SPA acres - are equated with raw undeveloped portions of the overall property. N/A

Design Procedure Form: Runoff Reduction

UD-BMP (Version 3.07, March 2018) **Sheet 1 of 1**

Designer:	**AWMc**
Company:	**Kiowa Engineering Corporation**
Date:	**March 28, 2024**
Project:	**Northcrest Storage Center**
Location:	**El Paso County, CO (Full Site)**

SITE INFORMATION (User Input in Blue Cells)

WQCV Rainfall Depth = 0.60 inches

Depth of Average Runoff Producing Storm, d_6 = 0.43 inches (for Watersheds Outside of the Denver Region, Figure 3-1 in USDCM Vol. 3)

Area Type	UIA:RPA	DCIA	UIA:RPA	DCIA	UIA:RPA	SPA	UIA:RPA	UIA:RPA				
Area ID	D-1	D-2	D-3	D-4	D-5	D-2 SPA	D-7	D-8				
Downstream Design Point ID	D-6	D-6	D-3	D-6	D-6	D-6	D-7	D-8				
Downstream BMP Type	EDB	EDB	None	EDB	EDB	EDB	None	None				
DCIA (ft^2)	--	32,548	--	42,621	--	--	--	--				
UIA (ft^2)	518	--	2,930	--	7,637	--	976	550				
RPA (ft^2)	6,618	--	2,225	--	5,070	--	935	6,392				
SPA (ft^2)	--	--	--	--	--	5,278	--	--				
HSG A (%)	100%	--	100%	--	100%	100%	100%	100%				
HSG B (%)	0%	--	0%	--	0%	0%	0%	0%				
HSG C/D (%)	0%	--	0%	--	0%	0%	0%	0%				
Average Slope of RPA (ft/ft)	0.050	--	0.100	--	0.120	--	0.100	0.100				
UIA:RPA Interface Width (ft)	22.00	--	32.00	--	200.00	--	20.00	25.00				

CALCULATED RUNOFF RESULTS

Area ID	D-1	D-2	D-3	D-4	D-5	D-2 SPA	D-7	D-8				
UIA:RPA Area (ft^2)	7,136	--	5,155	--	12,707	--	1,911	6,942				
L / W Ratio	14.74	--	5.03	--	0.32	--	4.78	11.11				
UIA / Area	0.0726	--	0.5684	--	0.6010	--	0.5107	0.0792				
Runoff (in)	0.00	0.50	0.00	0.50	0.00	0.00	0.00	0.00				
Runoff (ft^3)	0	1356	0	1776	0	0	0	0				
Runoff Reduction (ft^3)	22	0	122	0	318	264	41	23				

CALCULATED WQCV RESULTS

Area ID	D-1	D-2	D-3	D-4	D-5	D-2 SPA	D-7	D-8				
WQCV (ft^3)	22	1356	122	1776	318	0	41	23				
WQCV Reduction (ft^3)	22	0	122	0	318	0	41	23				
WQCV Reduction (%)	100%	0%	100%	0%	100%	0%	100%	100%				
Untreated WQCV (ft^3)	0	1356	0	1776	0	0	0	0				

CALCULATED DESIGN POINT RESULTS (sums results from all columns with the same Downstream Design Point ID)

Downstream Design Point ID	D-6	D-3	D-7	D-8								
DCIA (ft^2)	75,170	0	0	0								
UIA (ft^2)	8,155	2,930	976	550								
RPA (ft^2)	11,688	2,225	935	6,392								
SPA (ft^2)	5,278	0	0	0								
Total Area (ft^2)	100,291	5,155	1,911	6,942								
Total Impervious Area (ft^2)	83,325	2,930	976	550								
WQCV (ft^3)	3,472	122	41	23								
WQCV Reduction (ft^3)	340	122	41	23								
WQCV Reduction (%)	10%	100%	100%	100%								
Untreated WQCV (ft^3)	3,132	0	0	0								

CALCULATED SITE RESULTS (sums results from all columns in worksheet)

Total Area (ft^2)	114,299
Total Impervious Area (ft^2)	87,781
WQCV (ft^3)	3,658
WQCV Reduction (ft^3)	525
WQCV Reduction (%)	14%
Untreated WQCV (ft^3)	3,132

Design Procedure Form: Grass Swale (GS)

UD-BMP (Version 3.07, March 2018) **Sheet 1 of 1**

Designer: M Kahnke
Company: Kiowa Engineering
Date: March 28, 2024
Project: Northcrest Center
Location: Bismark Road & Canada Dr

1. Design Discharge for 2-Year Return Period	Q_2 = 1.10 cfs
2. Hydraulic Residence Time	
A) : Length of Grass Swale	L_S = 300.0 ft
B) Calculated Residence Time (based on design velocity below)	T_{HR} = 6.5 minutes
3. Longitudinal Slope (vertical distance per unit horizontal)	
A) Available Slope (based on site constraints)	S_{avail} = 0.050 ft / ft
B) Design Slope	S_D = 0.050 ft / ft
4. Swale Geometry	
A) Channel Side Slopes (Z = 4 min., horiz. distance per unit vertical)	Z = 4.00 ft / ft
B) Bottom Width of Swale (enter 0 for triangular section)	W_B = 5.00 ft
5. Vegetation A) Type of Planting (seed vs. sod, affects vegetal retardance factor)	Choose One ○ Grass From Seed ◉ Grass From Sod
6. Design Velocity (1 ft / s maximum)	V_2 = 0.77 ft / s
7. Design Flow Depth (1 foot maximum)	D_2 = 0.24 ft
A) Flow Area	A_2 = 1.4 sq ft
B) Top Width of Swale	W_T = 6.9 ft
C) Froude Number (0.50 maximum)	F = 0.30
D) Hydraulic Radius	R_H = 0.20
E) Velocity-Hydraulic Radius Product for Vegetal Retardance	VR = 0.16
F) Manning's n (based on SCS vegetal retardance curve D for sodded grass)	n = 0.151
G) Cumulative Height of Grade Control Structures Required	H_D = 0.00 ft
8. Underdrain (Is an underdrain necessary?)	Choose One ○ YES ◉ NO
9. Soil Preparation (Describe soil amendment)	
10. Irrigation	Choose One ◉ Temporary ○ Permanent

Notes: North Margin of site

Design Procedure Form: Grass Swale (GS)

UD-BMP (Version 3.07, March 2018) **Sheet 1 of 1**

Designer: M Kahnke
Company: Kiowa Engineering
Date: March 28, 2024
Project: Northcrest Center
Location: Constitution Avenue & Canada Dr

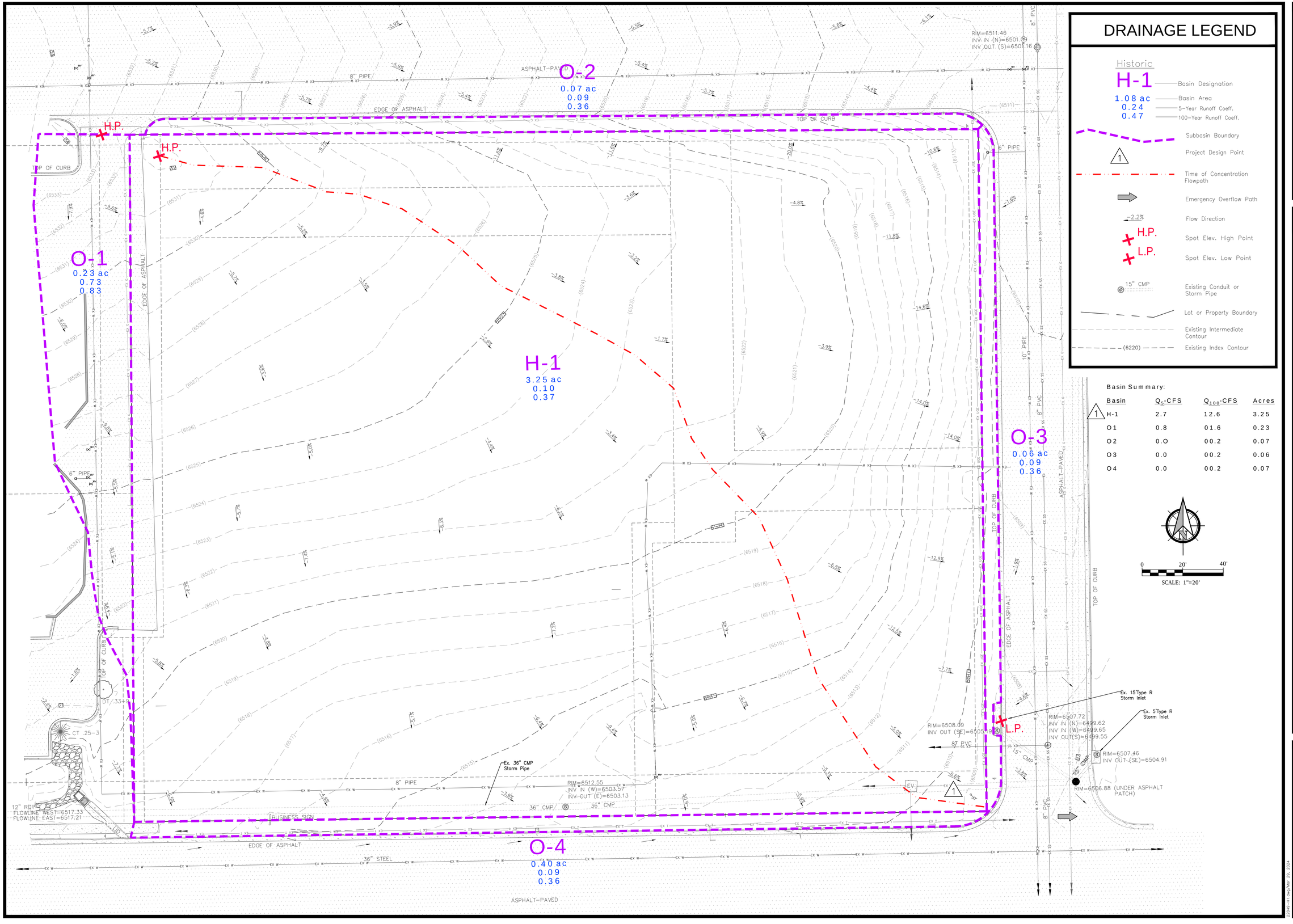
1. Design Discharge for 2-Year Return Period	Q_2 = 1.00 cfs
2. Hydraulic Residence Time	
A) : Length of Grass Swale	L_S = 300.0 ft
B) Calculated Residence Time (based on design velocity below)	T_{HR} = 7.7 minutes
3. Longitudinal Slope (vertical distance per unit horizontal)	
A) Available Slope (based on site constraints)	S_{avail} = 0.020 ft / ft
B) Design Slope	S_D = 0.020 ft / ft
4. Swale Geometry	
A) Channel Side Slopes (Z = 4 min., horiz. distance per unit vertical)	Z = 4.00 ft / ft
B) Bottom Width of Swale (enter 0 for triangular section)	W_B = 2.00 ft
5. Vegetation A) Type of Planting (seed vs. sod, affects vegetal retardance factor)	Choose One ○ Grass From Seed ◉ Grass From Sod
6. Design Velocity (1 ft / s maximum)	V_2 = 0.65 ft / s
7. Design Flow Depth (1 foot maximum)	D_2 = 0.42 ft
A) Flow Area	A_2 = 1.5 sq ft
B) Top Width of Swale	W_T = 5.4 ft
C) Froude Number (0.50 maximum)	F = 0.21
D) Hydraulic Radius	R_H = 0.28
E) Velocity-Hydraulic Radius Product for Vegetal Retardance	VR = 0.18
F) Manning's n (based on SCS vegetal retardance curve D for sodded grass)	n = 0.139
G) Cumulative Height of Grade Control Structures Required	H_D = 0.00 ft
8. Underdrain (Is an underdrain necessary?)	Choose One ○ YES ◉ NO
9. Soil Preparation (Describe soil amendment)	
10. Irrigation	Choose One ◉ Temporary ○ Permanent

Notes: South Margin of site

APPENDIX D

Existing and Proposed Drainage Plans

Sheet 1 – Historic Conditions H-1
Sheet 2 - Developed Conditions D-1



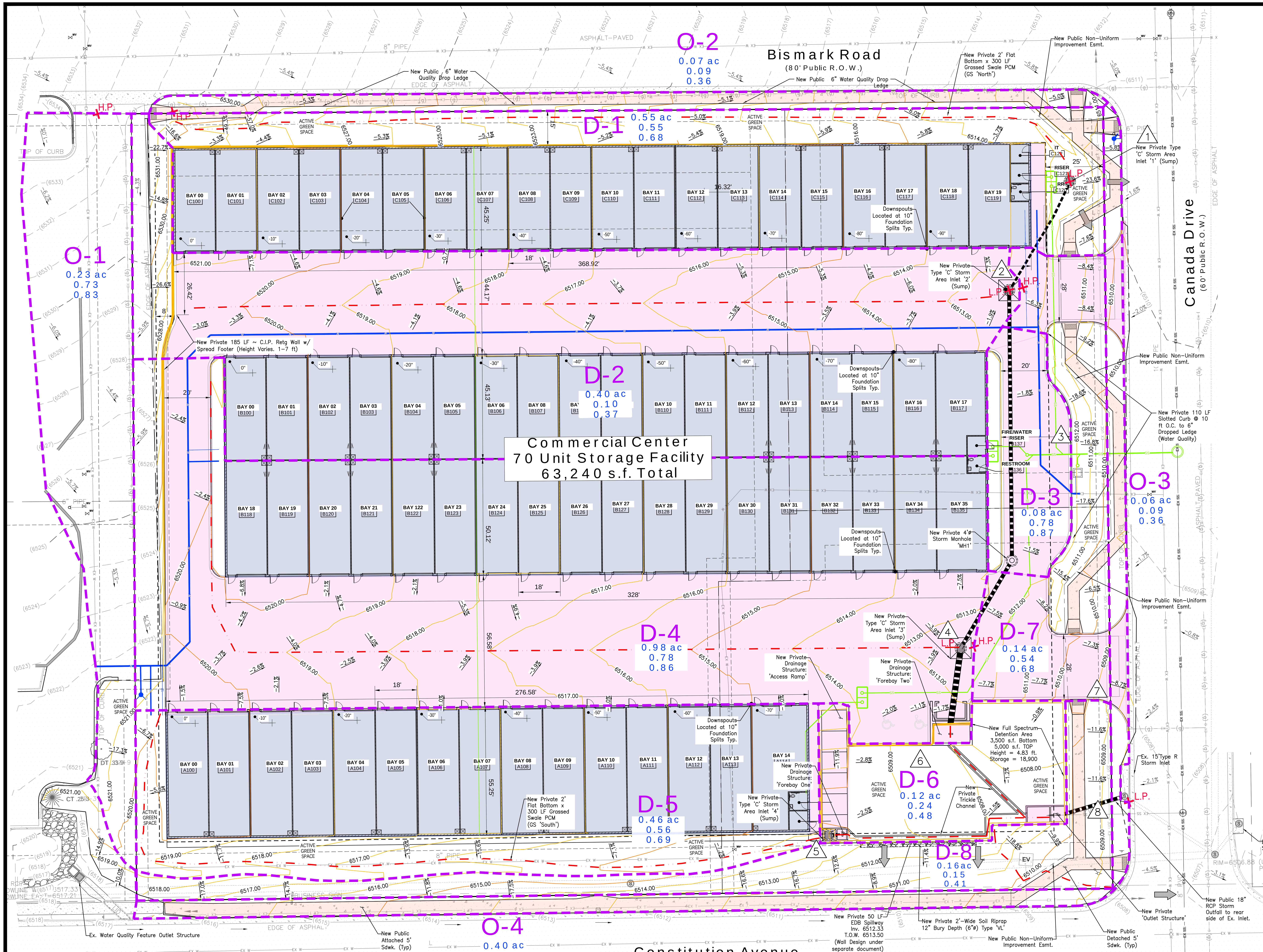
Kiowa Engineering Corporation
1604 South 21st Street
Colorado Springs, Colorado 80904
(719) 630-7342

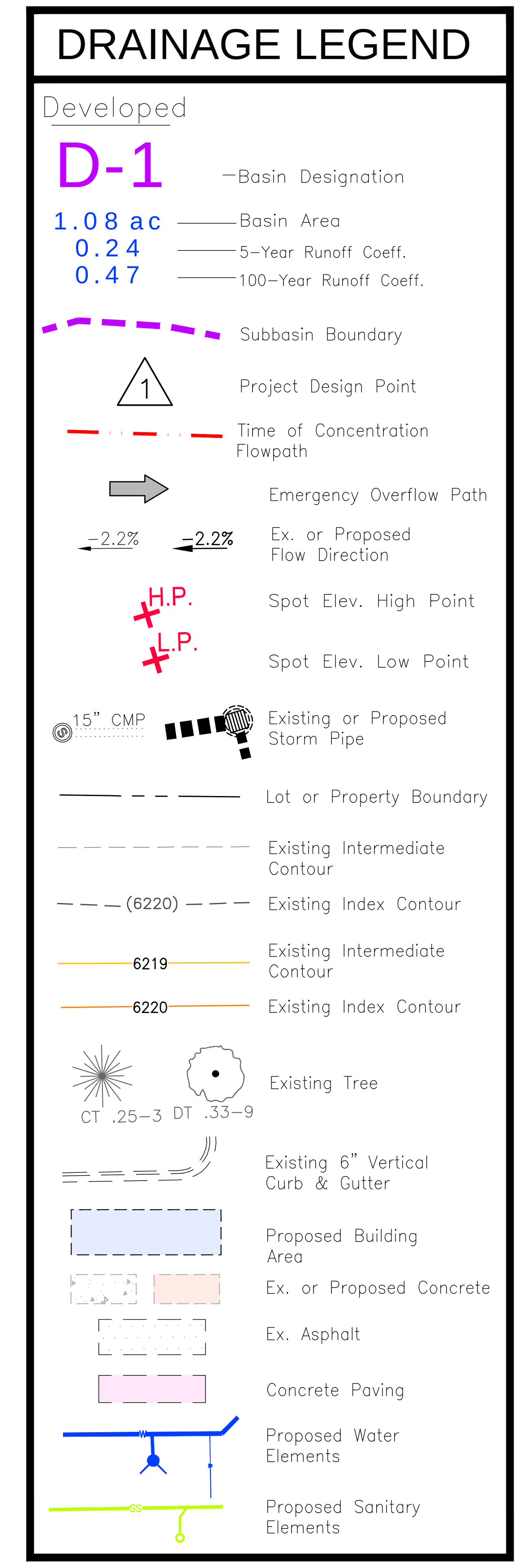
Northcrest Center
Site Drainage Analysis
HISTORIC CONDITIONS
City of Colorado Springs, Colorado

Project No.:	23049
Date:	03/29/2024
Design:	MJK
Drawn:	MJK
Check:	AMcC
Revisions:	

Sheet
H1
1 of 2 Sheets

2024-H1.dwg Mar 29, 2024





Basin / Design Point	Acres	Developed	
		Q_5	Q_{100}
O-2	0.07 ac	0.2 cfs	0.5 cfs
O-3	0.06 ac	0.1 cfs	0.3 cfs
O-4	0.07 ac	0.3 cfs	0.5 cfs
O-1	0.23 ac	0.8 cfs	1.6 cfs
DP-1	0.56 ac	1.4 cfs	3.0 cfs
DP-2	0.75 ac	3.2 cfs	5.9 cfs
DP-3	0.08 ac	0.3 cfs	0.6 cfs
DP-4	0.98 ac	4.0 cfs	7.3 cfs
DP-5	0.46 ac	1.3 cfs	2.7 cfs
DP-5	0.12 ac	0.1 cfs	0.5 cfs
DP-7	0.15 ac	0.2 cfs	0.6 cfs
DP-8	0.16 ac	0.4 cfs	0.9 cfs
Raw Summary	3.68 ac	12.4 cfs	24.2 cfs

Detained Flows (Weighted & Lagged)

System	Historic:	2.7 cfs	12.6 cfs
System	Developed:	9.6 cfs	18.8 cfs
	% Increase:	261.43%	48.83%

Design Point Summary				Weighted		Lagged	Rainfall Intensity		QWQCV	Q2	Q5	Q100
DP-1	D-1	0.56 ac		0.54	0.68	7.1 min.	4.6 in/hr	7.8 in/hr			1.4 cfs	3.0 cfs
DP-2	D-2 & D-3	1.30 ac		0.71	0.81	7.1 min.	4.6 in/hr	7.8 in/hr			4.3 cfs	8.2 cfs
DP-3	D-1 thru D-3	0.08 ac		0.78	0.87	7.1 min.	4.6 in/hr	7.8 in/hr			0.3 cfs	0.5 cfs
DP-4	O-1, D1 thru D-4	2.52 ac		0.74	0.83	13.0 min.	3.7 in/hr	6.3 in/hr			6.9 cfs	13.1 cfs
DP-5	D-5	0.46 ac		0.56	0.69	5.3 min.	5.1 in/hr	8.5 in/hr			1.3 cfs	2.7 cfs
DP-6	O-1, D1 thru D-6	3.48 ac		0.69	0.80	13.0 min.	3.7 in/hr	6.3 in/hr			9.0 cfs	17.4 cfs
DP-7	D-7	0.15 ac		0.25	0.49	6.5 min.	4.8 in/hr	8.0 in/hr			0.2 cfs	0.6 cfs
DP-8	D-8	0.16 ac		0.50	0.62	5.0 min.	5.2 in/hr	8.7 in/hr			0.4 cfs	0.9 cfs
ALL	ALL	3.79 ac		0.62	0.70	13.0 min.		Disturbed Area Summary:			9.6 cfs	18.8 cfs

Kiowa Engineering Corporation
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Northcrest Center
Site Drainage Analysis
DEVELOPED CONDITIONS
City of Colorado Springs, Colorado

Project No.:	23049
Date:	03/29/2024
Design:	MJK
Drawn:	MJK
Check:	AMcC
Revisions:	

Sheet
D1
1 of 2 Sheets

23049-D1.dwg/Mar 29, 2024