Galloway
6162 S. Willow Drive, Suite 320
Greenwood Village, CO 80111
303.770.8884 • GallowayUS.com

Novemeber 12, 2021

Town of Monument, Colorado
Planning Department
645 Beacon Lite Road
Monument, Colorado 80132

RE: Drainage Compliance Letter for QuikTrip Store #4299

Dear Town of Monument,

This letter accompanies the Planned Development submittal for the proposed QuikTrip located at the southwest corner of the Baptist Road and Terrazzo Drive intersection, located in the northeast quarter of Section 35, Township 11 South, Range 67 West of the 6th Principal Meridian, Town of Monument, County of El Paso, State of Colorado. The site is bordered to the north by Baptist Road, the east by Terrazzo Drive, to the south by the proposed roadway Squadron Drive, and to the west by Parcel 4 with Reception Number 200152234.

According to the FEMA FIRM Map for the area (see the appendix), this subject site is located in Zone X (Panel No. 08041C0286G, effective December 7,2018), which is an area with low annual chances of flood. The site is currently undeveloped meadow/pasture that generally slopes (ranging from 3% to 8%) from the northeast to the southwest. Soils on-site are comprised primarily of Pring coarse sandy loam, being of Hydrologic Soil Group B. This soil is described as being well-drained with a low runoff classification.

The intent of this letter is to demonstrate that the proposed development of this vacant lot is in conformance with the current Urban Drainage Flood Control District Drainage Criteria Manual, City of Colorado Springs Drainage Criteria Manual, Volume 1 & 2, dated May 2014, and the existing drainage report titled *Preliminary Drainage Report, PD Site Plan Lots 1-7, Falcon Commerce Center, Monument, Colorado* (herein referred to as the *Drainage Report*), dated September 3, 2020 and prepared by Kiowa Engineering. This site is part of the overall Falcon Commerce Center development, and will have water quality and detention provided by the overall development.

Existing flow patterns route all runoff to the southwest of the property where it discharges into Squadron Drive and continues west through means of curb and gutter. There are three Type D-10-R Curb Inlets located downstream of the subject site that currently collect this sites runoff. The intent shown within the *Drainage* Report is for this site to connect to a 36” RCP stub that has been provided immediately north of Squadron Drive. Ultimately all runoff is collected by the storm sewer system located in Squadron Drive and is routed to the regional full spectrum drainage facility. According to the *Drainage Report*, the storm sewer system that will route the subject site and adjacent lots runoff has been designed to accommodate fully developed flows from the overall Falcon Commerce Center development. This site is designated as basin C-16 within the *Drainage Report*, and was analyzed with an impervious percentage of 85%.

Improvements to this site include the construction of a fuel service center, auto fuel dispensers, diesel fuel dispensers, and all associated utilities and pavement. The site is planned to be subdivided into two separate lots, one parcel developed and utilized by QuikTrip at approximately 329,216 square feet, and the other parcel at approximately 194,210 square feet. It is the intent that when this site is developed that the proposed drainage patterns will match the existing patterns of the site and drain from the southeast to the northwest. Developed runoff will be collected by various curb inlets located throughout the proposed site and routed by means of underground pipe to the 36” RCP that has been provided by the overall developer. All proposed storm sewer pipes have been sized using StormCAD

and all inlet capacities have been verified with *UD-Inlet v4.06,* please see the appendices for excerpts from these programs.

Based on preliminary calculations the proposed improvements result in an impervious percentage of approximately 44.7%, significantly lower than the 85% that this parcel was assumed to be for detention design. It should be noted that the imperviousness of 44.7% is analyzing the second subdivided parcel as undeveloped land, however, if this second parcel was analyzed as future commercial with 95% imperviousness, the overall site imperviousness is calculated as approximately 77.1%, still below the 85% imperviousness that was used in the regional detention facility design.

Impervious Percentages Existing vs. Proposed	
Situation	Percent Impervious
Pond Design	85%
Proposed w/ Lot 2 undeveloped	44.7%
Future w/ Lot 2 Commercial	77.1%

In conclusion, based on the drainage patterns being maintained between existing and proposed conditions, and the proposed site having a lower imperviousness than what was used to design the regional detention facility, the proposed QuikTrip development will not result in any adverse impacts to the existing downstream storm sewer system and detention facility.

This letter verifies that the proposed site plan is within accordance with the current Urban Drainage and Flood Control District Drainage Criteria Manual, the City of Colorado Springs Drainage Criteria Manual, Volumes 1 & 2, and the existing drainage report titled *Preliminary Drainage Report, PD Site Plan Lots 1-7, Falcon Commerce Center, Monument, Colorado*, dated September 3, 2020, prepared by Kiowa Engineering.

Sincerely,
GALLOWAY

Jenny Romano, PE
Civil Project Engineer
JennyRomano@GallowayUS.com
(303) 770-8884

Duncan Rady, EIT
Civil Design Engineer
DuncanRady@GallowayUS.com
(303) 770-8884

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 established criteria 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.

_____ Seal
Name

Developer's Statement:

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

_____
Business Name

By:_____

Title:_____

Address:_____

_____

_____

References

1. Urban Storm Drainage Criteria Manual, Volumes 1 to 3, Mile High Flood District, August 2018.

2. City of Colorado Springs Drainage Criteria Manual, Volumes 1 & 2, City of Colorado Springs, May 2014.

3. Preliminary Drainage Report, PD Site Plan Lots 1-7, Falcon Commerce Center, Monument, Colorado, prepared by Kiowa Engineering Corporation, dated September 3, 2020.

Attachments

- Soils Map
- Firm Panel
- Existing Drainage Report
- Hydrologic Computations
- Hydraulic Computations
- Existing Drainage Map
- Proposed Drainage Map

VICINITY MAP

QT4299 - Monument, CO

National Flood Hazard Layer FIRMette

FEMA

104°51'39"W 39°3'34"N

104°51'2"W 39°3'6"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 9/14/2021 at 3:05 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.

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

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

Custom Soil Resource Report for El Paso County Area, Colorado

September 13, 2021

Preface

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

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

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

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

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

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

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

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

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

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

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

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

Soil Map

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

Custom Soil Resource Report
Soil Map

Map Scale: 1:1,870 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 25 50 100 150

Feet: 0 50 100 200 300

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

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
71	Pring coarse sandy loam, 3 to 8 percent slopes	12.0	100.0%
Totals for Area of Interest		**12.0**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

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

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

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

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

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

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

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

El Paso County Area, Colorado

71—Pring coarse sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 369k
Elevation: 6,800 to 7,600 feet
Farmland classification: Not prime farmland

Map Unit Composition

Pring and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pring

Setting

Landform: Hills
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Arkosic alluvium derived from sedimentary rock

Typical profile

A - 0 to 14 inches: coarse sandy loam
C - 14 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: R048AY222CO
Hydric soil rating: No

Minor Components

Pleasant

Percent of map unit:
Landform: Depressions
Hydric soil rating: Yes

Other soils

Percent of map unit:
Hydric soil rating: No

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

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

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Preliminary Drainage Report
PD Site Plan Lots 1-7
Falcon Commerce Center
Monument, Colorado

Prepared for:
Forest Lakes, LLC
1123 Emerson Ave, Suite 204
Evanston, Illinois 60201

Prepared by:

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

Kiowa Project No. 19036

September 3, 2020

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 Town/City/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 negligent acts, errors or omissions on my part in preparing this report.

_____

Matthew W. Erichsen, PE (PE #36713) Seal

For and on Behalf of Kiowa Engineering Corporation

DEVELOPER'S STATEMENT:

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

Business Name: Forest Lakes LLC

Authorized Signature: _____ Date: _____

Title: _____

Address: 1123 Emerson Ave, Suite 204
Evanston, Illinois 60201

Town of Monument:

Filed in accordance with Section 17.45 of the Zoning Ordinance for the Town of Monument, and Section 16.12.060 of the Subdivision Code for the Town of Monument, revised February, 2007.

_____ _____

Director of Development Services Date

Conditions:

I. GENERAL DESCRIPTION

The purpose of this Preliminary Drainage Report is to address and discuss the drainage patterns and impacts associated with Phase 1 of the proposed development of the Falcon Commerce Center (FCC) site. The overall site is located west of Interstate 25, south of Baptist Road, east of Woodcarver Road, Santa Fe trail and the Union Pacific Railroad; and north of the United States Air Force Academy (USAFA). The Phase 1 portion of the site is located in the northwest corner of the Falcon Commerce Center site. The property is located in the east half of Section 35 and the west half of Section 36, Township 11 South, Range 67 West of the Sixth Principal Meridian, El Paso County, Colorado. The location of the site is shown on the Vicinity Map (Figure 1) and is hatched on the Drainage Plan exhibits. The site is bounded on the north by Baptist Road, the Pilot Travel Center Filing No. 1 and undeveloped property; on the east by Interstate 25 and CDOT owned property; on the south by the USAFA and on the west by Woodcarver Road, property developed by Woodcarver Properties, the Union Pacific Railroad and undeveloped property. The subject site will include seven lots, the widening of Terrazzo Drive to the west and extension to the south, extension of Squadron drive from Terrazzo Drive to Woodcarver Road. The overall site is undeveloped, however the abandoned Old Denver Highway and old/abandoned railroad grade cross through the property from north to south. The total area of the property is approximately 32.04 acres.

The site is planned to be developed with mixed use commercial and a distribution center. The proposed distribution center will be submitting a more detailed drainage report for the development of that lot (Lot 7). The improvements associated with the development include:

- Widening Terrazzo Drive to the west to its full street section and extend the road south to Squadron Drive including utility improvements.
- Construct Squadron Drive from Terrazzo Drive west to Woodcarver Road including utility improvements.
- Construct eastbound right turn land on Baptist Road at Terrazzo Drive.
- Improve Woodcarver Road from Squadron Drive to the south end of the existing roundabout at Baptist Road.
- Construct the future condition storm sewer system from Squadron Drive to the proposed sub-regional detention basin.
- Construct the regional detention basin for the overall development at the south end of the development (north of Jackson Creek).

There are no irrigation facilities located within the property.

II. SOIL CONDITIONS

Soils within the property are classified to be within Hydrologic Soils Group B based on the NRCS Soil Survey for the El Paso County area. Soils on the site are predominantly Pring coarse sandy loam and Peyton-Pring complex (Soil Group B). For the site drainage calculations, the soils were assumed to be Hydrologic Soil Group B. The existing vegetative cover within the development is in fair condition with mostly native grasses and scattered trees throughout the site. The existing ground slopes within a majority of the property range from 2 to 8 percent.

III. DRAINAGE CRITERIA

Hydrologic and hydraulic calculations for the site were performed using the methods outlined in the *City of Colorado Springs Drainage Criteria Manual Volumes 1 and 2*. Topography for the site was compiled using two-foot contour interval and is presented on the Drainage Plan. The hydrological calculations were made for the proposed site conditions. The MDDP is reference for the existing

condition drainage plan. The Preliminary Drainage Plan (Exhibits A, B and C) present the proposed drainage patterns for the site, including the sub-basins. The peak flow rates for the sub-basins were estimated using the Rational Method. The 5-year (Minor Storm) and 100-year (Major Storm) recurrence intervals were determined. The one-hour rainfall depths were determined from Table 6-2 of the City's Drainage Criteria Manual, Volume 1.

Hydraulic calculations are provided for the proposed drainage facilities. UDFCD spreadsheets were used to design the inlets, water quality and detention facility. The UD-Inlet spreadsheet was used for inlet capacity calculations and UD-Detention spreadsheet was used for water quality and detention design. The UD-Sewer software has been used to analyze and size the storm sewer system along with determining the Hydraulic Grade Line location.

IV. EXISTING DRAINAGE CONDITIONS

The existing drainage patterns for the subject site were reviewed and described as part of the Falcon Commerce Center Master Development Drainage Plan. Refer to that document for detailed description and calculations.

The subject site is located to the north of Jackson Creek and within the Jackson Creek drainage basin just upstream of its confluence with Monument Creek. The majority of the subject site presently drains by sheet flow to the south and southwest towards low points along Woodcarver Road and the existing railroad right of way. Existing site runoff leaves the site on the west side in a couple locations. Under or across Woodcarver Road (Design Points EXE and EXD) and on the southwest side at a low point in the Santa Fe Trail into the railroad ROW (Design Point E7). The location of these design points and the drainage patterns is described and presented in the MDDP.

Along both sides of Jackson Creek, a 300-ft buffer is shown for the Preble's Meadow Jumping Mouse (PMJM). The proposed detention basin is located outside the buffer. The detention basin outfall will extend into the PMJM buffer and will require coordination and approval through the United States Fish and Wildlife Service. Refer to the MDDP for the analysis of the existing drainage patterns.

V. PROPOSED DRAINAGE CONDITIONS

The proposed drainage patterns for the overall development were analyzed and are presented in the Falcon Commerce Center MDDP. This section provides a detailed description of the proposed drainage conditions for the PD Site Plan area. Refer to the FCC MDDP for more information on the overall development.

The proposed drainage patterns for the site subject to development will generally include sheet flow and gutter flow to proposed inlets which will collect the flows. A storm sewer system will be installed to convey these flows to the south end of the site to the proposed sub-regional stormwater quality and detention basin will be constructed. This detention basin will be designed for the overall site development as a Full Spectrum Detention (FSD) basin. It will include forebays, trickle channel, FSD outlet structure, emergency spillway and outlet pipe. The outlet pipe will discharge the flows to the existing Jackson Creek drainageway to the south of the site within the PMJM habitat buffer. The Drainage Plan – Proposed Condition for the site (Exhibits A, B and C) are provided at the end of this report.

The proposed development will include both public and private facilities. The public drainage facilities are planned to be maintained by the Town and include the inlets within the public roadways, the storm sewer system downstream of those inlets (Storm Sewer System 1) and the sub-regional detention basin. Following is a description of the on-site storm sewer system and the drainage sub-basins. The proposed drainage basins and runoff calculations are the same for both the MDDP and this drainage report.

Storm Sewer System 1: Storm Sewer System 1 will convey a majority of the flows from the overall development to the sub-regional detention basin. Storm 1 begins to the north of Squadron Drive where a stub will be constructed into the future lots. From there the storm sewer routes west along Squadron to the west end of the development and Lot 7, near a low point in the roadway. Curb inlets will be located in Squadron Drive at the low point to capture flows and route to Storm 1. Storm 1 will continue south following the west/south side of the development to the sub-regional detention basin. A drainage easement will be added along the length of the storm sewer in areas where it is not located within the street right of way. Future storm sewer laterals from the overall development will connect to Storm 1. The storm sewer is sized for the fully developed flows from the overall development. The storm sewer will begin as a 36-inch pipe at the upstream end and discharge into the detention basin as a 72-inch pipe.

Sub-basin C-1: The sub-basin is located along the southwest corner of the site and consists of the sub-regional detention basin for the site. It will be constructed as a Full Spectrum Detention (FSD) basin to provide both stormwater quality and detention for the site runoff. Refer to the Water Quality and Detention Design section for additional information on the FSD design. The runoff from this basin will sheet flow to the trickle channel located along the bottom of the detention basin. The trickle channel will convey the flows to the outlet structure which will release flows at historic levels to the outlet pipe and Jackson Creek.

Sub-basin C-8: The sub-basin is located at the southwest corner of the Phase 1 site. It is planned to be developed as industrial or commercial area in the future. The runoff from the basin will be captured and routed into Storm Sewer System 1.

Sub-basin C-9, C-10, C-11: The sub-basins are located on the west portion of the site and will be part of a distribution center with buildings, parking lot, drive aisles, landscaping and driveway connections to Squadron Drive. The gutter flows from basin C-13 are planned to be captured by an on-grade inlet in Squadron Drive before entering the site. The runoff from the basin will be captured and routed to Storm Sewer System 1.

Sub-basin C-12, C-13, C-14, C-15: The sub-basins are located on the northwest portion of the site and include a portion of Terrazzo Drive, Squadron Drive and landscaping. The runoff from the basins will drain by sheet flow and gutter flow to the west where a low point will be located in Squadron Drive near Woodcarver Road. Flows from Basin C-13 will be routed to Storm Sewer System 1 with an on-grade inlet prior to the driveway connection to the south. Inlets 22 and 26 in sump condition will be located at the low point and designed to capture the 100-year storm. A pipe will route the flow from the inlets to Storm Sewer System 1.

Sub-basin C-16: The sub-basin is located on the northwest portion of the site and is planned to include commercial, retail and restaurants with buildings, parking lot, drive aisles, landscaping and driveway connections to Squadron and Terrazzo Drive. The runoff from the basin will be captured and routed to Storm Sewer System 1 in Squadron Drive.

Sub-basin C-24, C-25: The sub-basins are located in the center of the site and to the south of Phase 1. The basins include the temporary gravel access road to the existing wastewater treatment plant which is along the future alignment of Terrazzo Drive. The runoff from the basins have been calculated assuming the fully developed condition. A roadside swale will be added along the east side of the temporary access drive to route flows south The flows on the west side of the access drive will sheet flows west.

Sub-basin C-27: The sub-basin is located on the east portion of the site and includes a small portion of the Terrazzo Road extension. In the future, the area is planned to include commercial, office, and industrial areas with buildings drive aisles, and landscaping. The runoff from the basin has been

calculated assuming fully developed condition. Runoff from the basin which is a part of Phase 1 will drain by gutter flow south to the intersection with Squadron and then flow southeast into the grassed area until the area is developed in the future.

Sub-basin D-1: The sub-basin is located on the west side of the site. The majority of the basin is will be pervious land sloping to the west and runoff will drain into the Woodcarver Road roadside ditch. The runoff will then follow existing condition drainage patterns to the south and ultimately to Monument Creek.

Sub-basin E-17: The sub-basin is located north of the site and includes the south portion of Baptist Road to the west of the Pilot Travel Center and east of the existing round-about. The flows will sheet flow and gutter flow into an existing 10-ft curb inlet along Baptist road. These flows are routed northwest with an existing storm sewer and will not enter the site.

Sub-basin E-18: The sub-basin is located west of the site and includes a portion of Baptist Road and the east half of Woodcarver Road. The flows from this basin will sheet and gutter flow to proposed on-grade inlet (Inlet 50) located along Woodcarver Road to the north of Terrazzo Drive. Inlet 50 will route flows into the proposed roadside ditch and culvert along Woodcarver Road. The flows will then follow existing drainage patterns. The runoff from this basin will not flow to the proposed sub-regional detention basin.

Sub-basin E-19: The sub-basin is located west of the site and includes the west half of Woodcarver Road. The flows from this basin will sheet and gutter flow to the south end of the basin where the flows will enter an existing roadside ditch and follow existing drainage patterns. An 18-inch culvert exists under the existing driveway to the west property (Pioneer Sand and Gravel site). This culvert will be replaced as part of the Phase 1 development.

Sub-Basin OS-1: The drainage basin is located to the northwest corner of the site and includes undeveloped land, the east side of Woodcarver Road and a portion of the existing roundabout. The majority of the basin sheet flows southwest to the intersection of Squadron Drive and Woodcarver Road where the runoff will flow into the roadside swale through the proposed culvert under Squadron Drive and flow along the east side of Woodcarver Road. Flows from the roundabout and Woodcarver Road will also flow into this roadside swale. The roadside swale continues south adjacent to Woodcarver Road, ultimately flowing into Monument Creek. The runoff from this basin does not flow to the proposed sub-regional detention basin.

VI. WATER QUALITY AND DETENTION DESIGN

The development of the property will include storm water quality and detention improvements meeting the requirements of the Town of Monument and the City of Colorado Spring's Drainage Criteria Manual (Volume 1 and 2). A Full Spectrum Detention (FSD) basin will be constructed in the southwest corner of the site to provide both stormwater quality and detention improvements for the overall development. The FSD will include forebays, trickle channel, FSD outlet structure, emergency spillway and outlet pipe. The outlet structure has been designed to control the release the of the WQCV, EURV and multiple storm return periods up to the 100 year event at a flow rate equal to or less than the calculated existing condition flows into Jackson Creek from the area. The water quality orifice plate will be a 5-hole plate sized to drain the WQCV in approximately 40 hours and to drain the EURV in approximately 72 hours. The emergency spillway will be constructed along the south side of the detention area to release flows in excess of the 100-year event and in an emergency situation to the existing grassed area to the south of the site and to Jackson Creek. The spillway will extend to the toe of the proposed slope and edge of the PMJM buffer area. The UD-Detention workbook along with Mile High Flood District equations have been used to design the facility. Refer

to the Appendix for the calculations and for a detailed summary of the maximum allowable detention release rates.

The maximum allowable detention release rates were calculated to result in a proposed condition flow at Jackson Creek at the existing railroad tracks which is equal to or less than the existing condition. The common Design Points between the existing and proposed conditions are DP E4 and DP 42 respectively. This meant the need to over detain to account for the runoff from Basins EX-D and EX-E which flow directly to Monument Creek. In the proposed condition, the runoff from those basins will be routed through the sub-regional detention basin and into Jackson Creek. This results in a lower overall flow reaching Monument Creek than in the existing condition

The detailed final design of the FSD detention basin will require a separate drainage report and construction documents.

- Tributary Area = 135.0 acres
- Percent Impervious = 78.3%
- WQCV = 3.57 ac-ft
- EURV = 11.70 ac-ft
- 100-Year Volume = 21.74ac-ft
- Emergency Spillway width = 100-ft

VII. FLOODPLAIN

The subject property is not located within a FEMA regulated floodplain based on Flood Insurance Rate Map 08041C0286 G (effective date of December 7, 2018). The proposed storm sewer outfall for the detention basin will be included a portion of the Zone A floodplain along Jackson Creek.

VIII. SUMMARY

This Preliminary Drainage Report has been prepared in general conformance with the Town of Monument standards and the *City of Colorado Springs Drainage Criteria Manual Volumes 1 and 2*. The proposed stormwater management design for the subject site has been designed to properly convey and treat stormwater based on the requirements and guidance provided in the criteria manuals.

IX. REFERENCES

1) Falcon Commerce Center Master Development Drainage Plan, prepared by Kiowa Engineering Corporation, dated August 24, 2020.

2) City of Colorado Springs, Drainage Criteria Manual, Volumes 1 and 2 dated May 2014.

3) Urban Storm Drainage Criteria Manual, Vol. 1, 2 and 3, and Design Workbooks/Spreadsheets, Urban Drainage and Flood Control District, latest revisions.

4) Monument Creek Drainage Basin Planning Study, City of Colorado Springs and El Paso County, prepared by CH2M Hill and Kiowa Engineering Corporation.

5) Final Drainage Report for Baptist Road West, prepared by Felsburg Holt & Ullevig, dated March 19, 2015.

6) Preliminary and Final Drainage Report for Pilot Travel Center Filing No. 1, prepared by Drexel, Barrell & Co. dated July 13, 2017.

7) Hydrology Report I-25 North Design Build, prepared by RESPEC Consulting & Services, dated August 2012, revised September 14, 2012.

APPENDIX TABLE OF CONTENTS

APPENDIX A

Figure 1: Vicinity Map

Soils Map

FEMA Flood Insurance Rate Map

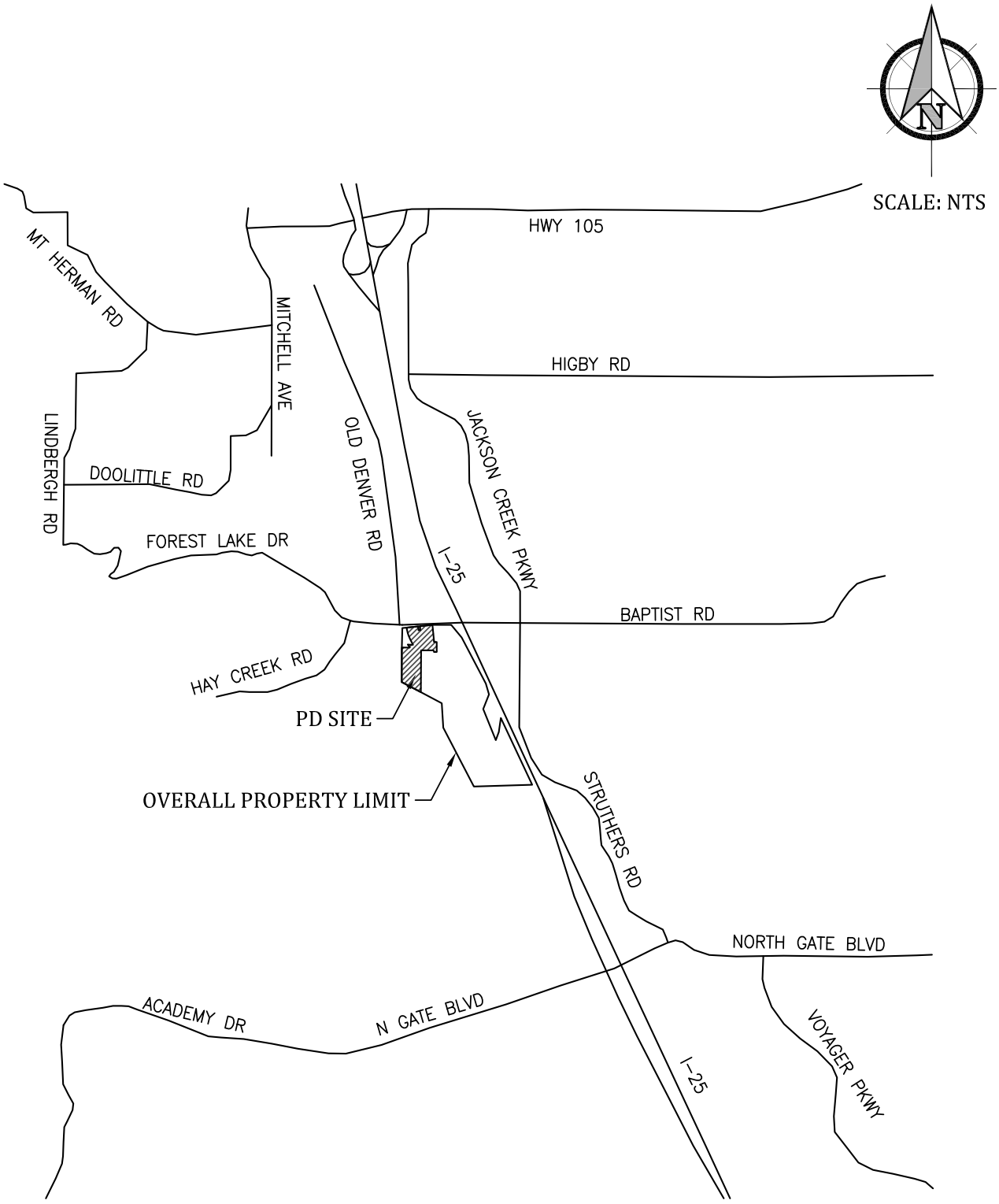
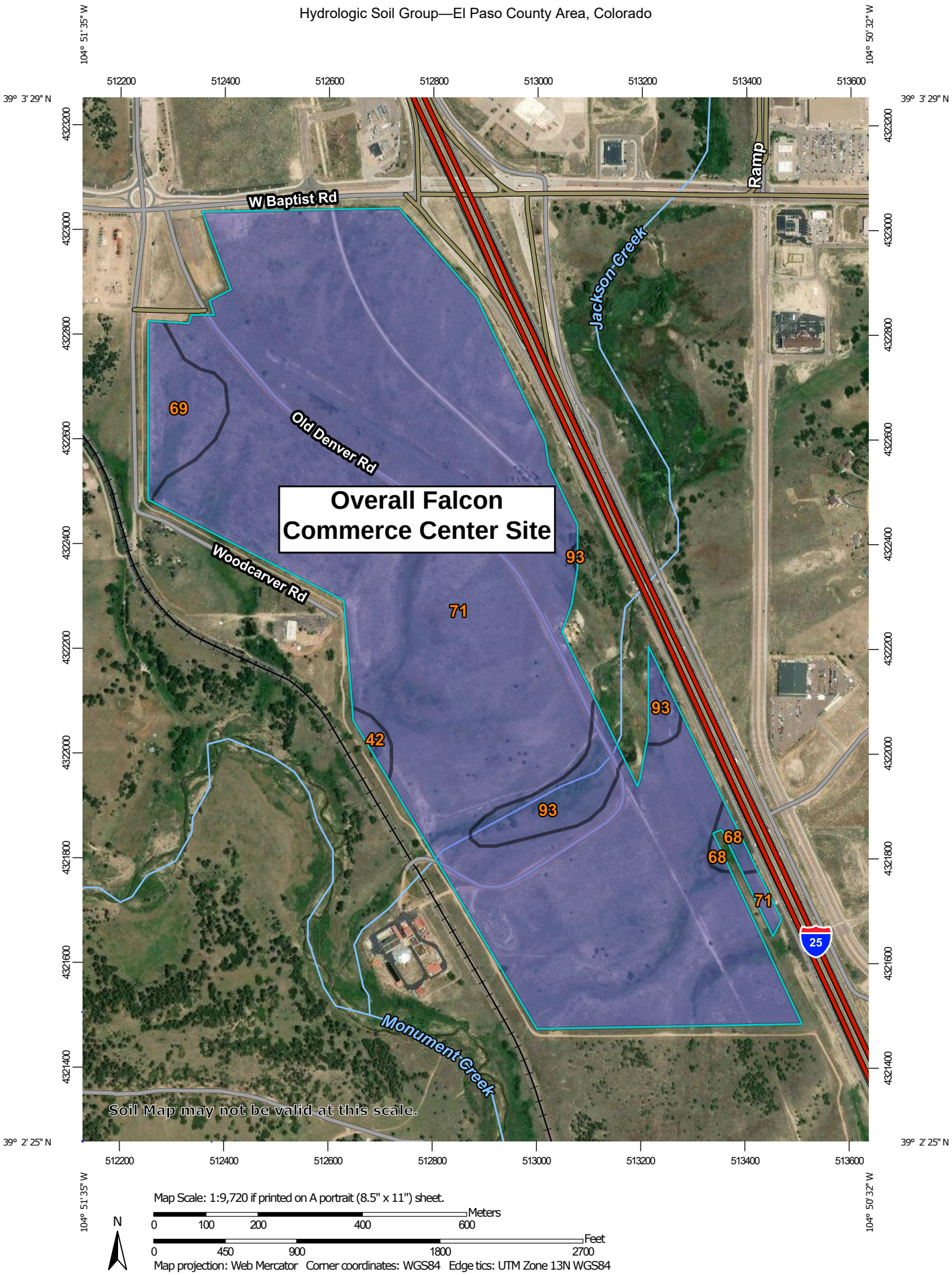


FIGURE 1
VICINITY MAP
FALCON COMMERCE CENTER



Map Scale: 1:9,720 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 450 900 1800 2700

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 16, Sep 10, 2018

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

Date(s) aerial images were photographed: Jul 4, 2010—Oct 16, 2017

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
42	Kettle-Rock outcrop complex	B	1.1	0.5%
68	Peyton-Pring complex, 3 to 8 percent slopes	B	1.3	0.6%
69	Peyton-Pring complex, 8 to 15 percent slopes	B	7.8	3.5%
71	Pring coarse sandy loam, 3 to 8 percent slopes	B	205.4	91.5%
93	Tomah-Crowfoot complex, 8 to 15 percent slopes	B	8.7	3.9%
Totals for Area of Interest			**224.4**	**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

National Flood Hazard Layer FIRMette

FEMA

Feet
0 250 500 1,000 1,500 2,000
1:6,000

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 / 17.5 — Cross Sections with 1% Annual Chance / 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.

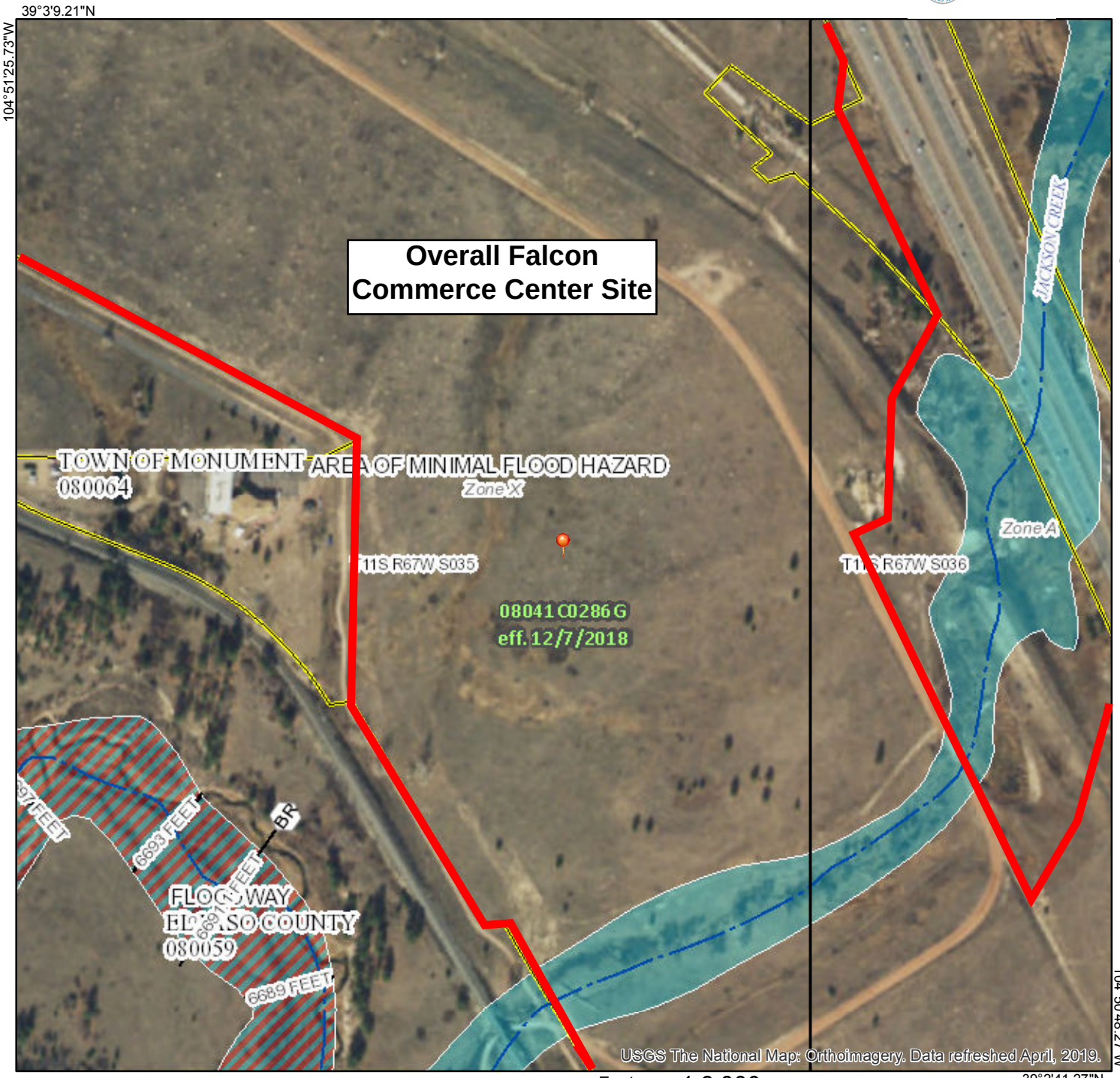
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 7/18/2019 at 11:07:10 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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

National Flood Hazard Layer FIRMette

FEMA



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 / 17.5 — Cross Sections with 1% Annual Chance 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 7/18/2019 at 11:10:36 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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

APPENDIX B

Hydrologic Calculations – Proposed Conditions

Runoff Coefficient and Percent Impervious Calculations
Time of Concentration and Drainage Basin Runoff Calculations

Falcon Commerce Canter - MDDP

Runoff Coeficient and Percent Impervious Calculation - Proposed Condition

Basin / DP	Basin or DP Area (DP contributing basins)		Soil Type	US1	Area 1 Land Use			US2	Area 2 Land Use			GR	Area 3 Land Use			LA	Area 4 Land Use			HI	Area 5 LandUse			Basin % Imperv	Basin Runoff Coef	
				% 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		C_5	C_{100}
C-1	422,482 sf	9.70ac	AB	85%	0.00ac	0%	0%	75%		0%	0%	80%		0%	0%	0%	9.70ac	100%	0%	2%		0%	0%	**0.0%**	**0.08**	**0.35**
C-2	516,368 sf	11.85ac	AB	85%	11.85ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-3	442,716 sf	10.16ac	AB	85%	10.16ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-4	121,502 sf	2.79ac	AB	85%	2.79ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-5	381,247 sf	8.75ac	AB	85%	8.75ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-6	255,584 sf	5.87ac	AB	85%	5.87ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-7	356,419 sf	8.18ac	AB	85%	8.18ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-8	123,101 sf	2.83ac	AB	85%	2.83ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-9	138,561 sf	3.18ac	AB	85%	3.18ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-10	302,974 sf	6.96ac	AB	85%	6.96ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-11	148,880 sf	3.42ac	AB	85%	3.42ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-12	7,451 sf	0.17ac	AB	85%	0.00ac	0%	0%	75%	0.17ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-13	16,061 sf	0.37ac	AB	85%	0.00ac	0%	0%	75%	0.37ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-14	88,545 sf	2.03ac	AB	85%	0.00ac	0%	0%	75%	1.72ac	84%	63%	80%	0.32ac	16%	12%	0%		0%	0%	2%		0%	0%	**75.8%**	**0.55**	**0.66**
C-15	32,493 sf	0.75ac	AB	85%	0.00ac	0%	0%	75%	0.75ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-16	556,153 sf	12.77ac	AB	85%	12.77ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-20	26,181 sf	0.60ac	AB	85%	0.00ac	0%	0%	75%	0.60ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-21	25,073 sf	0.58ac	AB	85%	0.00ac	0%	0%	75%	0.58ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-22	452,831 sf	10.40ac	AB	85%	10.40ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-23	322,059 sf	7.39ac	AB	85%	7.39ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-24	32,559 sf	0.75ac	AB	85%	0.00ac	0%	0%	75%	0.75ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-25	32,412 sf	0.74ac	AB	85%	0.00ac	0%	0%	75%	0.74ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-26	287,907 sf	6.61ac	AB	85%	6.61ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-27	301,760 sf	6.93ac	AB	85%	6.93ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-30	69,387 sf	1.59ac	AB	85%	0.00ac	0%	0%	75%	1.59ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-31	70,440 sf	1.62ac	AB	85%	0.00ac	0%	0%	75%	1.62ac	100%	75%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**75.0%**	**0.54**	**0.66**
C-32	350,897 sf	8.06ac	AB	85%	8.06ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
C-40	359,359 sf	8.25ac	AB	85%		0%	0%	75%	2.17ac	26%	20%	80%		0%	0%	0%		0%	0%	2%	6.08ac	74%	1%	**21.2%**	**0.20**	**0.44**
C-41	967,143 sf	22.20ac	AB	85%		0%	0%	75%	1.27ac	6%	4%	80%	0.70ac	3%	3%	0%		0%	0%	2%	20.23ac	91%	2%	**8.6%**	**0.13**	**0.40**
C-42	1,166,143 sf	26.77ac	AB	85%		0%	0%	75%		0%	0%	80%	1.55ac	6%	5%	0%		0%	0%	2%	25.22ac	94%	2%	**6.5%**	**0.11**	**0.39**
D-1	51,488 sf	1.18ac	AB	85%		0%	0%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%	1.18ac	100%	2%	**2.0%**	**0.08**	**0.36**
D-2	241,038 sf	5.53ac	AB	85%		0%	0%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%	5.53ac	100%	2%	**2.0%**	**0.08**	**0.36**
E-17	45,254 sf	1.04ac	AB	85%	0.95ac	91%	77%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%	0.09ac	9%	0%	**77.7%**	**0.57**	**0.68**
E-18	15,713 sf	0.36ac	AB	85%	0.36ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
E-19	14,814 sf	0.34ac	AB	85%	0.34ac	100%	85%	75%		0%	0%	80%		0%	0%	0%		0%	0%	2%		0%	0%	**85.0%**	**0.66**	**0.75**
OS-1	187,521 sf	4.30ac	AB	85%		0%	0%	75%		0%	0%	80%	0.32ac	7%	6%	0%		0%	0%	2%	3.98ac	93%	2%	**7.8%**	**0.12**	**0.39**
OS-2	551,784 sf	12.67ac	AB	85%	0.00ac	0%	0%	75%	8.47ac	67%	50%	80%		0%	0%	0%		0%	0%	2%	4.20ac	33%	1%	**50.8%**	**0.35**	**0.53**
DP13	C1-C32	135.03ac	AB	85%	116.14ac	86%	73%	75%	8.88ac	7%	5%	80%	0.32ac	0%	0%	0%	9.70ac	7%	0%	2%	0.00ac	0%	0%	**78.2%**	**0.57**	**0.68**
DP42	C-40,41,42	57.22ac	AB	85%	0.00ac	0%	0%	75%	3.44ac	6%	5%	80%	2.25ac	4%	3%	0%	0.00ac	0%	0%	2%	51.53ac	90%	2%	**9.5%**	**0.13**	**0.40**

Falcon Commerce Canter - MDDP
Runoff Coeficient and Percent Impervious Calculation - Proposed Condition

Basin Runoff Coef is based on % Impervious Calculation

Runoff Coefficients and Percents Impervious						
Hydrologic Soil Type:	**AB**	**Runoff Coef Method**			%Imp	
Land Use	Abb	%	C_5	C_{10}	C_{100}	Weighted
Commercial Area	CO	95%	0.81	0.83	0.88	%Imp
Streets - Gravel (Packed)	GR	80%	0.59	0.63	0.70	AB
Historic Flow Analysis	HI	2%	0.09	0.17	0.36	CD
Lawns	LA	0%	0.08	0.15	0.35	D
Off-site flow-Undeveloped	OF	45%	0.32	0.38	0.51	
Park	PA	7%	0.12	0.20	0.39	
Streets - Paved	PV	100%	0.90	0.92	0.96	
Roofs	RO	90%	0.73	0.75	0.81	
User Input 1	US1	85%	0.66	0.69	0.75	
User Input 2	US2	75%	0.54	0.58	0.66	

Based on Table 6-6: Runoff Coefficients for Rational Method from City of Colo Springs DCM

*Planned commercial areas are assumed to be 85% impervious

*Street right of way areas are planned to have an average impervious area of 75% based on the typical street section.

Falcon Commerce Center - MDDP
Time of Concentration Calculation - Proposed Condition

Sub-Basin Data				Time of Concentration Estimate												
Basin / Design Point	Contributing Basins	Area	C_5	Initial/Overland Time (t_i)			Travel Time (t_t)						Comp.			Final t_c
				Length	Slope	t_i	Length	Slope	Land Type	Cv	Velocity	t_t	t_c			
C-1		9.70ac	0.08	50lf	25.0%	4.5 min.	100lf	25.0%	PV	20	10.0 ft/sec	0.2 min.	5.0 min.			**5.0 min.**
C-2		11.85ac	0.66	50lf	3.0%	4.0 min.	960lf	2.8%	PV	20	3.3 ft/sec	4.8 min.	8.8 min.			**8.8 min.**
C-3		10.16ac	0.66	50lf	12.0%	2.5 min.	650lf	2.8%	PV	20	3.3 ft/sec	3.2 min.	5.7 min.			**5.7 min.**
C-4		2.79ac	0.66	50lf	3.0%	4.0 min.	600lf	2.7%	PV	20	3.3 ft/sec	3.1 min.	7.0 min.			**7.0 min.**
C-5		8.75ac	0.66	50lf	2.8%	4.1 min.	850lf	2.8%	PV	20	3.3 ft/sec	4.2 min.	8.3 min.			**8.3 min.**
C-6		5.87ac	0.66	50lf	2.6%	4.2 min.	680lf	2.6%	PV	20	3.2 ft/sec	3.5 min.	7.7 min.			**7.7 min.**
C-7		8.18ac	0.66	50lf	25.0%	2.0 min.	750lf	3.5%	PV	20	3.7 ft/sec	3.3 min.	5.3 min.			**5.3 min.**
C-8		2.83ac	0.66	50lf	4.0%	3.6 min.	250lf	4.0%	PV	20	4.0 ft/sec	1.0 min.	5.0 min.			**5.0 min.**
C-9		3.18ac	0.66	40lf	1.5%	4.5 min.	250lf	2.6%	PV	20	3.2 ft/sec	1.3 min.	5.8 min.			**5.8 min.**
C-10		6.96ac	0.66	25lf	2.5%	3.0 min.	1100lf	3.5%	PV	20	3.7 ft/sec	4.9 min.	7.9 min.			**7.9 min.**
C-11		3.42ac	0.66	25lf	2.5%	3.0 min.	300lf	4.0%	PV	20	4.0 ft/sec	1.3 min.	5.0 min.			**5.0 min.**
C-12		0.17ac	0.54	25lf	2.5%	3.8 min.	100lf	1.0%	PV	20	2.0 ft/sec	0.8 min.	5.0 min.			**5.0 min.**
C-13		0.37ac	0.54	25lf	2.5%	3.8 min.	900lf	2.8%	PV	20	3.3 ft/sec	4.5 min.	8.3 min.			**8.3 min.**
C-14		2.03ac	0.55	25lf	2.5%	3.7 min.	1050lf	3.2%	PV	20	3.6 ft/sec	4.9 min.	8.6 min.			**8.6 min.**
C-15		0.75ac	0.54	25lf	2.5%	3.8 min.	500lf	2.2%	PV	20	3.0 ft/sec	2.8 min.	6.6 min.			**6.6 min.**
C-16		12.77ac	0.66	50lf	2.4%	4.3 min.	980lf	2.5%	PV	20	3.2 ft/sec	5.2 min.	9.5 min.			**9.5 min.**
C-20		0.60ac	0.54	25lf	2.5%	3.8 min.	620lf	1.0%	PV	20	2.0 ft/sec	5.2 min.	8.9 min.			**8.9 min.**
C-21		0.58ac	0.54	25lf	2.5%	3.8 min.	600lf	1.0%	PV	20	2.0 ft/sec	5.0 min.	8.8 min.			**8.8 min.**
C-22		10.40ac	0.66	50lf	2.2%	4.4 min.	770lf	2.2%	PV	20	3.0 ft/sec	4.3 min.	8.7 min.			**8.7 min.**
C-23		7.39ac	0.66	50lf	2.2%	4.4 min.	800lf	1.0%	PV	20	2.0 ft/sec	6.7 min.	11.1 min.			**11.1 min.**
C-24		0.75ac	0.54	25lf	2.5%	3.8 min.	725lf	4.0%	PV	20	4.0 ft/sec	3.0 min.	6.8 min.			**6.8 min.**
C-25		0.74ac	0.54	25lf	2.5%	3.8 min.	700lf	4.0%	PV	20	4.0 ft/sec	2.9 min.	6.7 min.			**6.7 min.**
C-26		6.61ac	0.66	50lf	3.0%	4.0 min.	650lf	2.8%	PV	20	3.3 ft/sec	3.2 min.	7.2 min.			**7.2 min.**
C-27		6.93ac	0.66	50lf	4.0%	3.6 min.	630lf	3.2%	PV	20	3.6 ft/sec	2.9 min.	6.6 min.			**6.6 min.**
C-30		1.59ac	0.54	25lf	2.5%	3.8 min.	1500lf	2.5%	PV	20	3.2 ft/sec	7.9 min.	11.7 min.			**11.7 min.**
C-31		1.62ac	0.54	25lf	2.5%	3.8 min.	1550lf	2.5%	PV	20	3.2 ft/sec	8.2 min.	11.9 min.			**11.9 min.**
C-32		8.06ac	0.66	50lf	4.0%	3.6 min.	840lf	2.2%	PV	20	3.0 ft/sec	4.7 min.	8.3 min.			**8.3 min.**
C-40		8.25ac	0.20	300lf	3.0%	19.7 min.	1515lf	2.2%	GW	15	2.2 ft/sec	11.3 min.	31.1 min.			**31.1 min.**
C-41		22.20ac	0.13	300lf	2.5%	22.7 min.	1150lf	2.4%	GW	15	2.3 ft/sec	8.2 min.	31.0 min.			**31.0 min.**
C-42		26.77ac	0.11	300lf	2.0%	24.9 min.	1300lf	2.5%	GW	15	2.4 ft/sec	9.1 min.	34.0 min.			**34.0 min.**
D-1		1.18ac	0.08	40lf	5.0%	6.9 min.	800lf	2.6%	GW	15	2.4 ft/sec	5.5 min.	12.4 min.			**12.4 min.**
D-2		5.53ac	0.08	40lf	5.0%	6.9 min.	900lf	4.0%	GW	15	3.0 ft/sec	5.0 min.	11.9 min.			**11.9 min.**
E-17		1.04ac	0.57	30lf	2.0%	4.2 min.	830lf	2.2%	PV	20	3.0 ft/sec	4.7 min.	8.9 min.			**8.9 min.**
E-18		0.36ac	0.66	30lf	2.0%	3.5 min.	840lf	2.9%	PV	20	3.4 ft/sec	4.1 min.	7.6 min.			**7.6 min.**
E-19		0.34ac	0.66	30lf	2.0%	3.5 min.	900lf	2.9%	PV	20	3.4 ft/sec	4.4 min.	7.9 min.			**7.9 min.**

Falcon Commerce Center - MDDP
Time of Concentration Calculation - Proposed Condition

OS-1		4.87ac	0.12	170lf	5.9%	12.9 min.	460lf	1.7%	SP	7	0.9 ft/sec	8.4 min.	21.3 min.			**21.3 min.**

Equations:

t_i (Overland) = $0.395(1.1-C_5)L^{0.5} S^{-0.333}$

C_5 = Runoff coefficient for 5-year

L = Length of overland flow (ft)

S = Slope of flow path (ft/ft)

tc Check = (L/180)+10 (Developed Cond. Only)

L = Overall Length

Velocity (Travel Time) = $CvS^{0.5}$

Cv = Conveyance Coef (see table)

S = Watercourse slope (ft/ft)

Table 6-7: Conveyance Coef (City CS DCM, Vol 1)

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

Falcon Commerce Center - MDDP
Runoff Calculation - Proposed Condition

Design Storm: 5 Year

		Direct Runoff							Total Runoff				Street/Chan		Pipe			Travel Time			
Street	**Design Point**	Area Designation	Area	C	T_c	C*A (acre)	i (in/hr)	Q	T_c	Sum C*A	i (in/hr)	Q	Slope	Q	Q	Slope	Pipe Size	L (ft)	Vel (ft/s)	T_t	Remarks
		C-1	9.70 ac	0.08	5.0min	0.73	5.2	3.8 cfs			---	---								---	
		C-2	11.85 ac	0.66	8.8min	7.78	4.3	33.7 cfs			---	---								---	
		C-3	10.16 ac	0.66	5.7min	6.67	5.0	33.1 cfs			---	---								---	
		C-4	2.79 ac	0.66	7.0min	1.83	4.7	8.5 cfs			---	---								---	
		C-5	8.75 ac	0.66	8.3min	5.74	4.4	25.3 cfs			---	---								---	
		C-6	5.87 ac	0.66	7.7min	3.85	4.5	17.4 cfs			---	---								---	
		C-7	8.18 ac	0.66	5.3min	5.37	5.1	27.3 cfs			---	---								---	
		C-8	2.83 ac	0.66	5.0min	1.85	5.2	9.6 cfs			---	---								---	
		C-9	3.18 ac	0.66	5.8min	2.09	5.0	10.3 cfs			---	---								---	
		C-10	6.96 ac	0.66	7.9min	4.57	4.5	20.5 cfs			---	---								---	
		C-11	3.42 ac	0.66	5.0min	2.24	5.2	11.6 cfs			---	---								---	
		C-12	0.17 ac	0.54	5.0min	0.09	5.2	0.5 cfs			---	---								---	
		C-13	0.37 ac	0.54	8.3min	0.20	4.4	0.9 cfs			---	---								---	
		C-14	2.03 ac	0.55	8.6min	1.11	4.4	4.8 cfs			---	---								---	
		C-15	0.75 ac	0.54	6.6min	0.40	4.8	1.9 cfs			---	---								---	
		C-16	12.77 ac	0.66	9.5min	8.38	4.2	35.3 cfs			---	---			35.3 cfs	1.5%	36-in	290'	11.7	0.4min	to DP2
		C-20	0.60 ac	0.54	8.9min	0.32	4.3	1.4 cfs			---	---								---	
		C-21	0.58 ac	0.54	8.8min	0.31	4.3	1.3 cfs			---	---								---	
		C-22	10.40 ac	0.66	8.7min	6.82	4.3	29.6 cfs			---	---								---	
		C-23	7.39 ac	0.66	11.1min	4.85	4.0	19.3 cfs			---	---						550'	10	0.9min	to DP23
		C-24	0.75 ac	0.54	6.8min	0.40	4.7	1.9 cfs			---	---								---	
		C-25	0.74 ac	0.54	6.7min	0.40	4.7	1.9 cfs			---	---								---	
		C-26	6.61 ac	0.66	7.2min	4.34	4.6	20.0 cfs			---	---								---	
		C-27	6.93 ac	0.66	6.6min	4.55	4.8	21.7 cfs			---	---						710'	10	1.2min	to DP20
		C-30	1.59 ac	0.54	11.7min	0.86	3.9	3.3 cfs			---	---								---	
		C-31	1.62 ac	0.54	11.9min	0.87	3.9	3.4 cfs			---	---								---	
		C-32	8.06 ac	0.66	8.3min	5.29	4.4	23.3 cfs			---	---			23.3 cfs	1.8%	30-in	730'	11.2	1.1min	to DP30
		C-40	8.25 ac	0.20	31.1min	1.68	2.4	4.1 cfs			---	---								---	
		C-41	22.20 ac	0.13	31.0min	2.82	2.4	6.9 cfs			---	---								---	
		C-42	26.77 ac	0.11	34.0min	3.00	2.3	6.9 cfs			---	---								---	
		D-1	1.18 ac	0.08	12.4min	0.10	3.8	0.4 cfs			---	---								---	
		D-2	5.53 ac	0.08	11.9min	0.45	3.9	1.7 cfs			---	---								---	
		E-17	1.04 ac	0.57	8.9min	0.59	4.3	2.5 cfs			---	---								---	
		E-18	0.36 ac	0.66	7.6min	0.24	4.5	1.1 cfs			---	---								---	
		E-19	0.34 ac	0.66	7.9min	0.22	4.5	1.0 cfs			---	---								---	
		OS-1	4.30 ac	0.12	21.3min	0.52	3.0	1.6 cfs			---	---								---	
		OS-2	12.67 ac					0.4 cfs	Detention outlet flow, See PTC FDR											---	
	DP1	C-14+C-15	2.78 ac						11.5min	1.52	3.9	5.9 cfs			5.9 cfs	1.5%	36-in	37'	7.3	0.1min	to DP3

Falcon Commerce Center - MDDP
Runoff Calculation - Proposed Condition

Design Storm: 5 Year

		Direct Runoff							Total Runoff				Street/Chan		Pipe			Travel Time			
Street	**Design Point**	Area Designation	Area	C	T_c	C*A (acre)	i (in/hr)	Q	T_c	Sum C*A	i (in/hr)	Q	Slope	Q	Q	Slope	Pipe Size	L (ft)	Vel (ft/s)	T_t	Remarks
	DP2	C-13+C-16	13.14 ac						9.9min	8.58	4.1	35.6 cfs									to DP4
	DP3	DP1+C-12	2.95 ac						11.6min	1.61	3.9	6.3 cfs			6.3 cfs	1.5%	18-in	56'	10.5	0.1min	to DP4
	DP4	DP2+DP3	16.09 ac						11.7min	10.19	3.9	39.7 cfs			39.7 cfs	2.5%	36-in	290'	10.5	0.5min	to DP5
	DP5	DP4+C-11	19.50 ac						12.1min	12.43	3.8	47.8 cfs			47.8 cfs	1.0%	42-in	433'	15.9	0.5min	to DP6
	DP6	DP5+C-10	26.46 ac						12.6min	17.00	3.8	64.4 cfs			64.4 cfs	2.3%	42-in	295'	13.6	0.4min	to DP7
	DP7	DP6+C-9	29.64 ac						12.9min	19.08	3.7	71.4 cfs			71.4 cfs	1.2%	54-in	663'	8.4	1.3min	to DP8
	DP8	DP7+C-7+C-8	40.65 ac						14.2min	26.31	3.6	94.7 cfs			94.7 cfs	0.4%	60-in	266'	15.0	0.3min	to DP9
	DP9	DP8+C-6	46.52 ac						14.5min	30.16	3.6	107.6 cfs			107.6 cfs	1.2%	72-in	430'	10.8	0.7min	to DP10
	DP10	DP9+C-5	55.27 ac						15.2min	35.91	3.5	125.7 cfs			125.7 cfs	1.6%	72-in	101'	10.8	0.2min	to DP11
	DP11	DP10+DP26+C-4	92.05 ac						15.4min	59.74	3.5	208.2 cfs			208.2 cfs	1.0%	72-in	88'	20.2	0.1min	to DP12
	DP12	DP11+C-3	102.21 ac						15.4min	66.41	3.5	231.0 cfs			231.0 cfs	1.3%	36-in	547'	13.4	0.7min	to FB/DP13
	DP13	DP12+DP30+C1+C2	135.03 ac						16.1min	81.94	3.4	279.7 cfs								---	to JC
	DP20	C-27+C-26	13.54 ac						7.7min	8.89	4.5	40.1 cfs								---	to DP21
	DP21	DP20+C-25	14.28 ac						7.7min	9.29	4.5	41.9 cfs			41.9 cfs	2.0%	36-in	37'	12.4	0.0min	to DP22
	DP22	DP21+C-24	15.03 ac						7.8min	9.69	4.5	43.6 cfs								---	to DP25
	DP23	C-22+C-23	17.79 ac						12.0min	11.68	3.9	45.0 cfs								---	to DP24
	DP24	DP23+C-21	18.36 ac						12.0min	11.99	3.9	46.2 cfs			46.2 cfs	1.4%	42-in	37'	16.2	0.0min	to DP25
	DP25	DP22+DP24	33.39 ac						12.0min	21.68	3.9	83.5 cfs			83.5 cfs	2.0%	48-in	13'	16.2	0.0min	to DP26
	DP26	DP25+C-20	33.99 ac						12.1min	22.00	3.8	84.7 cfs			84.7 cfs	2.0%	48-in	710'	16.2	0.7min	to DP11
	DP30	C-30+C-31+C-32	11.27 ac						11.9min	7.02	3.9	27.1 cfs			27.1 cfs	1.5%	32-in	328'	10.7	0.5min	to FB/DP13
	DP40	C40+OS2 (Detent)	20.92 ac						31.1min	1.68	2.4	4.5 cfs	Added flow out of PTC detention basin					1310'	3.0	7.3min	
	DP41	DP40+C-41	43.12 ac						38.3min	4.50	2.1	9.9 cfs	Added flow out of PTC detention basin					1280'	4.0	5.3min	
	DP42	DP41+C-42	69.89 ac						43.7min	7.50	1.9	14.8 cfs	Added flow out of PTC detention basin							---	
	DP50	E-18+OS-1	4.67 ac						21.3min	0.76	3.0	2.3 cfs								---	

NOTE: PTC FDR is Pilot Travel Center Final Drainage Report, prepared by Drexel, Barrell & Co. July 13, 2017.

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_{100}=-2.52 ln(T_c) + 12.735

Q = CiA

Q = Peak Runoff Rate (cubic feet/second)

C = Runoff coef representing a ration 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

Falcon Commerce Center - MDDP
Runoff Calculation - Proposed Condition

Design Storm: 100 Year

		Direct Runoff							Total Runoff				Street/Chan		Pipe			Travel Time			
Street	**Design Point**	Area Designation	Area	C	T_c	C*A (acre)	i (in/hr)	Q	T_c	Sum C*A	i (in/hr)	Q	Slope	Q	Q	Slope	Pipe Size	L (ft)	Vel (ft/s)	T_t	Remarks
		C-1	9.70 ac	0.35	5.0min	3.39	8.7	29.5 cfs			---	---								---	
		C-2	11.85 ac	0.75	8.8min	8.90	7.3	64.7 cfs			---	---								---	
		C-3	10.16 ac	0.75	5.7min	7.63	8.3	63.6 cfs			---	---								---	
		C-4	2.79 ac	0.75	7.0min	2.09	7.8	16.4 cfs			---	---								---	
		C-5	8.75 ac	0.75	8.3min	6.57	7.4	48.6 cfs			---	---								---	
		C-6	5.87 ac	0.75	7.7min	4.41	7.6	33.5 cfs			---	---								---	
		C-7	8.18 ac	0.75	5.3min	6.14	8.5	52.4 cfs			---	---								---	
		C-8	2.83 ac	0.75	5.0min	2.12	8.7	18.4 cfs			---	---								---	
		C-9	3.18 ac	0.75	5.8min	2.39	8.3	19.9 cfs			---	---								---	
		C-10	6.96 ac	0.75	7.9min	5.22	7.5	39.3 cfs			---	---								---	
		C-11	3.42 ac	0.75	5.0min	2.57	8.7	22.3 cfs			---	---								---	
		C-12	0.17 ac	0.66	5.0min	0.11	8.7	1.0 cfs			---	---								---	
		C-13	0.37 ac	0.66	8.3min	0.24	7.4	1.8 cfs			---	---								---	
		C-14	2.03 ac	0.66	8.6min	1.35	7.3	9.9 cfs			---	---								---	
		[illegible]																			
		C-16	12.77 ac	0.75	9.5min	9.59	7.1	67.8 cfs			---	---			67.8 cfs	1.5%	36-in	290'	11.7	0.4min	to DP2
		[illegible]																			
		C-21	0.58 ac	0.66	8.8min	0.38	7.3	2.7 cfs			---	---								---	
		C-22	10.40 ac	0.75	8.7min	7.81	7.3	56.8 cfs			---	---								---	
		C-23	7.39 ac	0.75	11.1min	5.55	6.7	37.0 cfs			---	---						550'	10	0.9min	to DP23
		C-24	0.75 ac	0.66	6.8min	0.49	7.9	3.9 cfs			---	---								---	
		C-25	0.74 ac	0.66	6.7min	0.49	7.9	3.9 cfs			---	---								---	
		C-26	6.61 ac	0.75	7.2min	4.96	7.8	38.5 cfs			---	---								---	
		C-27	6.93 ac	0.75	6.6min	5.20	8.0	41.6 cfs			---	---						710'	10	1.2min	to DP20
		C-30	1.59 ac	0.66	11.7min	1.05	6.5	6.8 cfs			---	---								---	
		C-31	1.62 ac	0.66	11.9min	1.06	6.5	6.9 cfs			---	---								---	
		C-32	8.06 ac	0.75	8.3min	6.05	7.4	44.7 cfs			---	---			44.7 cfs	1.8%	30-in	730'	11.2	1.1min	to DP30
		C-40	8.25 ac	0.44	31.1min	3.67	4.1	15.0 cfs			---	---								---	
		C-41	22.20 ac	0.40	31.0min	8.82	4.1	36.0 cfs			---	---								---	
		C-42	26.77 ac	0.39	34.0min	10.36	3.8	39.9 cfs			---	---								---	
		D-1	1.18 ac	0.36	12.4min	0.43	6.4	2.7 cfs			---	---								---	
		D-2	5.53 ac	0.36	11.9min	2.00	6.5	13.0 cfs			---	---								---	
		E-17	1.04 ac	0.68	8.9min	0.71	7.2	5.1 cfs			---	---								---	
		E-18	0.36 ac	0.75	7.6min	0.27	7.6	2.1 cfs			---	---								---	
		E-19	0.34 ac	0.75	7.9min	0.26	7.5	1.9 cfs			---	---								---	
		OS-1	4.30 ac	0.39	21.3min	1.69	5.0	8.5 cfs			---	---								---	
		OS-2	12.67 ac					20.8 cfs	Detention outlet flow, See PTC FDR											---	
	DP1	C-14+C-15	2.78 ac						11.5min	1.84	6.6	12.1 cfs			12.1 cfs	1.5%	36-in	37'	7.3	0.1min	to DP3

Falcon Commerce Center - MDDP
Runoff Calculation - Proposed Condition

Design Storm: 100 Year

		Direct Runoff							Total Runoff				Street/Chan		Pipe			Travel Time			
Street	**Design Point**	Area Designation	Area	C	T_c	C*A (acre)	i (in/hr)	Q	T_c	Sum C*A	i (in/hr)	Q	Slope	Q	Q	Slope	Pipe Size	L (ft)	Vel (ft/s)	T_t	Remarks
	DP2	C-13+C-16	13.14 ac						9.9min	9.83	7.0	68.5 cfs								---	to DP4
	DP3	DP1+C-12	2.95 ac						11.6min	1.95	6.6	12.8 cfs			12.8 cfs	1.5%	18-in	56'	10.5	0.1min	to DP4
	DP4	DP2+DP3	16.09 ac						11.7min	11.78	6.5	77.1 cfs			77.1 cfs	2.5%	36-in	290'	15.9	0.3min	to DP5
	DP5	DP4+C-11	19.50 ac						12.0min	14.35	6.5	93.0 cfs			93.0 cfs	1.0%	42-in	433'	13.6	0.5min	to DP6
	DP6	DP5+C-10	26.46 ac						12.5min	19.57	6.4	124.7 cfs			124.7 cfs	2.3%	42-in	295'	8.4	0.6min	to DP7
	DP7	DP6+C-9	29.64 ac						13.1min	21.96	6.3	137.4 cfs			137.4 cfs	1.2%	54-in	663'	15.0	0.7min	to DP8
	DP8	DP7+C-7+C-8	40.65 ac						13.8min	30.22	6.1	184.9 cfs			184.9 cfs	0.4%	60-in	266'	10.8	0.4min	to DP9
	DP9	DP8+C-6	46.52 ac						14.2min	34.63	6.0	209.3 cfs			209.3 cfs	1.2%	72-in	430'	10.8	0.7min	to DP10
	DP10	DP9+C-5	55.27 ac						14.9min	41.20	5.9	244.3 cfs			244.3 cfs	1.6%	72-in	101'	20.2	0.1min	to DP11
	DP11	DP10+DP26+C-4	92.05 ac						15.0min	68.57	5.9	405.7 cfs			405.7 cfs	1.0%	72-in	88'	5.0	0.3min	to DP12
	DP12	DP11+C-3	102.21 ac						15.3min	76.20	5.9	447.1 cfs			447.1 cfs	1.3%	36-in	547'	13.4	0.7min	to FB/DP13
	DP13	DP12+DP30+C1+C2	135.03 ac						15.9min	96.66	5.8	556.4 cfs								---	to JC
	DP20	C-27+C-26	13.54 ac						7.7min	10.16	7.6	77.0 cfs								---	to DP21
	DP21	DP20+C-25	14.28 ac						7.7min	10.65	7.6	80.7 cfs			80.7 cfs	2.0%	36-in	37'	13.4	0.0min	to DP22
	DP22	DP21+C-24	15.03 ac						7.8min	11.14	7.6	84.3 cfs								---	to DP25
	DP23	C-22+C-23	17.79 ac						12.0min	13.36	6.5	86.5 cfs								---	to DP24
	DP24	DP23+C-21	18.36 ac						12.0min	13.74	6.5	88.9 cfs			88.9 cfs	1.4%	42-in	37'	12.4	0.0min	to DP25
	DP25	DP22+DP24	33.39 ac						12.0min	24.88	6.5	160.8 cfs			160.8 cfs	2.0%	48-in	13'	16.2	0.0min	to DP26
	DP26	DP25+C-20	33.99 ac						12.1min	25.28	6.5	163.3 cfs			163.3 cfs	2.0%	48-in	710'	16.2	0.7min	to DP11
	DP30	C-30+C-31+C-32	11.27 ac						11.9min	8.16	6.5	52.9 cfs			52.9 cfs	1.5%	32-in	328'	10.7	0.5min	to FB/DP13
	DP40	C40+OS2 (Detent)	20.92 ac						31.1min	3.67	4.1	35.8 cfs	Added flow out of PTC detention basin					1310'	4.0	5.5min	
	DP41	DP40+C-41	43.12 ac						36.5min	12.49	3.7	66.6 cfs	Added flow out of PTC detention basin					1280'	5.0	4.3min	
	DP42	DP41+C-42	69.89 ac						40.8min	22.85	3.4	98.2 cfs	Added flow out of PTC detention basin							---	
	DP50	E-18+OS-1	4.67 ac						21.3min	1.96	5.0	9.9 cfs								---	

NOTE: PTC FDR is Pilot Travel Center Final Drainage Report, prepared by Drexel, Barrell & Co. July 13, 2017.

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_{100}=-2.52 ln(T_c) + 12.735

Q = CiA

Q = Peak Runoff Rate (cubic feet/second)

C = Runoff coef representing a ration 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

APPENDIX B.1

Supporting Hydrologic Tables and Figures

For Colorado Springs and much of the Fountain Creek watershed, the 1-hour depths are fairly uniform and are summarized in Table 6-2. Depending on the location of the project, rainfall depths may be calculated using the described method and the NOAA Atlas maps shown in Figures 6-6 through 6-17.

Table 6-2. Rainfall Depths for Colorado Springs

Return Period	1-Hour Depth	6-Hour Depth	24-Hour Depth
2	1.19	1.70	2.10
5	1.50	2.10	2.70
10	1.75	2.40	3.20
25	2.00	2.90	3.60
50	2.25	3.20	4.20
100	2.52	3.50	4.60

Where Z= 6,840 ft/100

These depths can be applied to the design storms or converted to intensities (inches/hour) for the Rational Method as described below. However, as the basin area increases, it is unlikely that the reported point rainfalls will occur uniformly over the entire basin. To account for this characteristic of rain storms an adjustment factor, the Depth Area Reduction Factor (DARF) is applied. This adjustment to rainfall depth and its effect on design storms is also described below. The UDFCD UD-Rain spreadsheet, available on UDFCD's website, also provides tools to calculate point rainfall depths and Intensity-Duration-Frequency curves[2] and should produce similar depth calculation results.

2.2 Design Storms

Design storms are used as input into rainfall/runoff models and provide a representation of the typical temporal distribution of rainfall events when the creation or routing of runoff hydrographs is required. It has long been observed that rainstorms in the Front Range of Colorado tend to occur as either short-duration, high-intensity, localized, convective thunderstorms (cloud bursts) or longer-duration, lower-intensity, broader, frontal (general) storms. The significance of these two types of events is primarily determined by the size of the drainage basin being studied. Thunderstorms can create high rates of runoff within a relatively small area, quickly, but their influence may not be significant very far downstream. Frontal storms may not create high rates of runoff within smaller drainage basins due to their lower intensity, but tend to produce larger flood flows that can be hazardous over a broader area and extend further downstream.

- **Thunderstorms**: Based on the extensive evaluation of rain storms completed in the Carlton study (Carlton 2011), it was determined that typical thunderstorms have a duration of about 2 hours. The study evaluated over 300,000 storm cells using gage-adjusted NEXRAD data, collected over a 14-year period (1994 to 2008). Storms lasting longer than 3 hours were rarely found. Therefore, the results of the Carlton study have been used to define the shorter duration design storms.

  To determine the temporal distribution of thunderstorms, 22 gage-adjusted NEXRAD storm cells were studied in detail. Through a process described in a technical memorandum prepared by the City of Colorado Springs (City of Colorado Springs 2012), the results of this analysis were interpreted and normalized to the 1-hour rainfall depth to create the distribution shown in Table 6-3 with a 5 minute time interval for drainage basins up to 1 square mile in size. This distribution represents the rainfall

Table 6-6. Runoff Coefficients for Rational Method
(Source: UDFCD 2001)

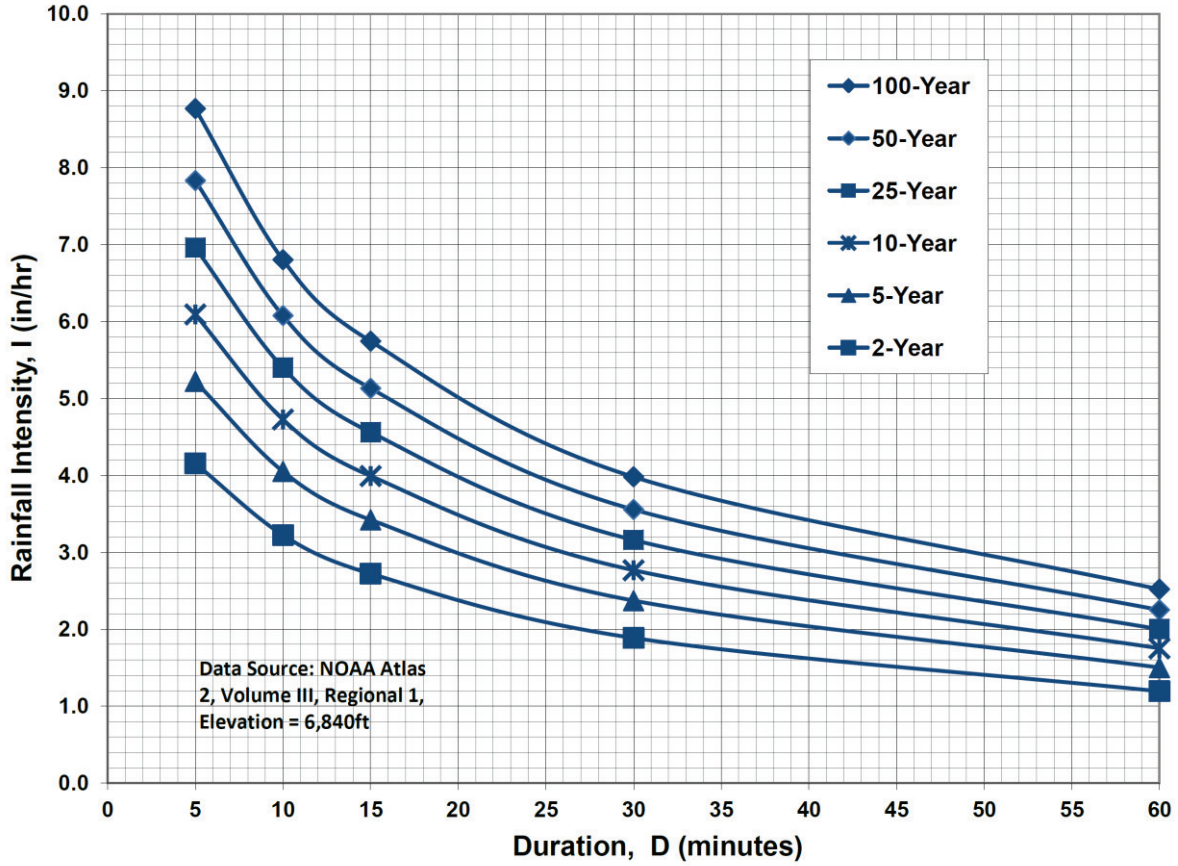
Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
Business													
Commercial Areas	95	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.89
Neighborhood Areas	70	0.45	0.49	0.49	0.53	0.53	0.57	0.58	0.62	0.60	0.65	0.62	0.68
Residential													
1/8 Acre or less	65	0.41	0.45	0.45	0.49	0.49	0.54	0.54	0.59	0.57	0.62	0.59	0.65
1/4 Acre	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
1/3 Acre	30	0.18	0.22	0.25	0.30	0.32	0.38	0.39	0.47	0.43	0.52	0.47	0.57
1/2 Acre	25	0.15	0.20	0.22	0.28	0.30	0.36	0.37	0.46	0.41	0.51	0.46	0.56
1 Acre	20	0.12	0.17	0.20	0.26	0.27	0.34	0.35	0.44	0.40	0.50	0.44	0.55
Industrial													
Light Areas	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Heavy Areas	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Parks and Cemeteries	7	0.05	0.09	0.12	0.19	0.20	0.29	0.30	0.40	0.34	0.46	0.39	0.52
Playgrounds	13	0.07	0.13	0.16	0.23	0.24	0.31	0.32	0.42	0.37	0.48	0.41	0.54
Railroad Yard Areas	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
Undeveloped Areas													
Historic Flow Analysis--Greenbelts, Agriculture	2	0.03	0.05	0.09	0.16	0.17	0.26	0.26	0.38	0.31	0.45	0.36	0.51
Pasture/Meadow	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Forest	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Exposed Rock	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Offsite Flow Analysis (when landuse is undefined)	45	0.26	0.31	0.32	0.37	0.38	0.44	0.44	0.51	0.48	0.55	0.51	0.59
Streets													
Paved	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Gravel	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Drive and Walks	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Roofs	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Lawns	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50

3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration (t_c) consists of an initial time or overland flow time (t_i) plus the travel time (t_t) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion (t_t) of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_{5} = -1.50 \ln(D) + 7.583$

$I_{2} = -1.19 \ln(D) + 6.035$

Note: Values calculated by equations may not precisely duplicate values read from figure.

APPENDIX C

Water Quality and Detention Calculations

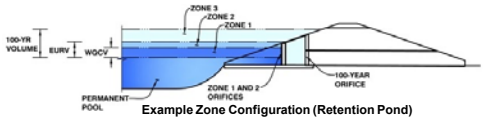
Runoff Summary and Maximum Detention Release Rates

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)

Project: **Falcon Commerce Center MDDP**

Basin ID: **Sub-Regional Detention Basin (Volume shown for Total Detention Basin Volume is not correct because Overtdetaining is planned)**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	**EDB**	
Watershed Area =	135.00	acres
Watershed Length =	2,800	ft
Watershed Length to Centroid =	1,500	ft
Watershed Slope =	0.030	ft/ft
Watershed Imperviousness =	78.20%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	100.0%	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) =	3.571	acre-feet	acre-feet
Excess Urban Runoff Volume (EURV) =	11.697	acre-feet	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	10.451	acre-feet	1.19 inches
5-yr Runoff Volume (P1 = 1.5 in.) =	13.869	acre-feet	1.50 inches
10-yr Runoff Volume (P1 = 1.75 in.) =	16.707	acre-feet	1.75 inches
25-yr Runoff Volume (P1 = 2 in.) =	19.888	acre-feet	2.00 inches
50-yr Runoff Volume (P1 = 2.25 in.) =	22.824	acre-feet	2.25 inches
100-yr Runoff Volume (P1 = 2.52 in.) =	26.203	acre-feet	2.52 inches
500-yr Runoff Volume (P1 = 3.1 in.) =	33.118	acre-feet	3.10 inches
Approximate 2-yr Detention Volume =	9.245	acre-feet	
Approximate 5-yr Detention Volume =	12.206	acre-feet	
Approximate 10-yr Detention Volume =	15.196	acre-feet	
Approximate 25-yr Detention Volume =	16.290	acre-feet	
Approximate 50-yr Detention Volume =	16.924	acre-feet	
Approximate 100-yr Detention Volume =	17.883	acre-feet	

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	3.571	acre-feet
Zone 2 Volume (EURV - Zone 1) =	8.126	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	6.186	acre-feet
Total Detention Basin Volume =	17.883	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	

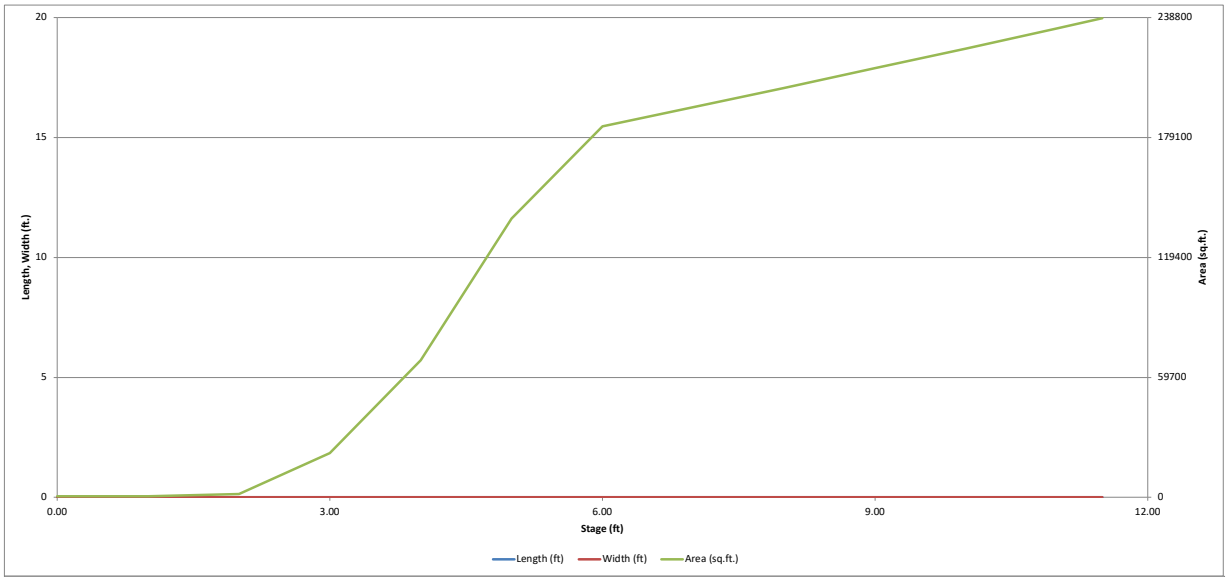
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	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

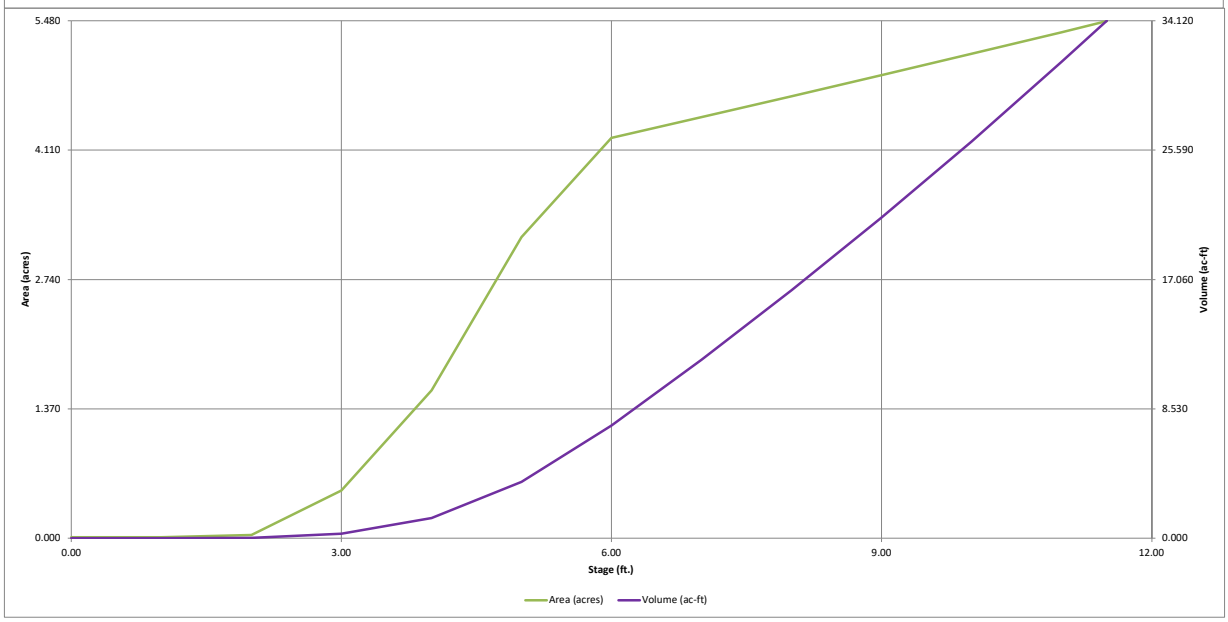
Depth Increment = ft

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	--	--	--	475	0.011		
	--	1.00	--	--	--	475	0.011	475	0.011
	--	2.00	--	--	--	1,600	0.037	1,512	0.035
	--	3.00	--	--	--	22,029	0.506	13,327	0.306
	--	4.00	--	--	--	68,279	1.567	58,481	1.343
	--	5.00	--	--	--	138,865	3.188	162,052	3.720
	--	6.00	--	--	--	184,678	4.240	323,824	7.434
	--	7.00	--	--	--	194,243	4.459	513,284	11.783
	--	8.00	--	--	--	203,894	4.681	712,353	16.353
	--	9.00	--	--	--	213,652	4.905	921,126	21.146
	--	10.00	--	--	--	223,488	5.131	1,139,696	26.164
	--	11.00	--	--	--	233,450	5.359	1,368,165	31.409
	--	11.50	--	--	--	238,455	5.474	1,486,141	34.117

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.03 (May 2020)



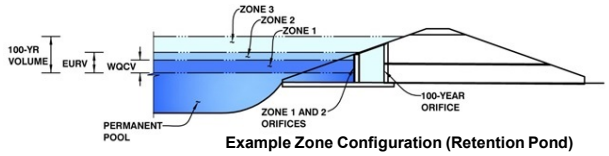


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.03 (May 2020)

Project: Falcon Commerce Center MDDP

Basin ID: Sub-Regional Detention Basin (Volume shown for Total Detention Basin Volume is not correct because Overtdetaining is planned)



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	4.96	3.571	Orifice Plate
Zone 2 (EURV)	6.99	8.126	Orifice Plate
Zone 3 (100-year)	8.33	6.186	Weir&Pipe (Restrict)
Total (all zones)		17.883	

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

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)

Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain

Underdrain Orifice Area = ft^2

Underdrain Orifice Centroid = feet

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 =	8.00	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	2.00	3.50	5.00	6.50			
Orifice Area (sq. inches)	6.00	7.00	18.00	36.00	36.00			

	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)

	Not Selected	Not Selected		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			Zone 3 Weir	Not Selected
Overflow Weir Front Edge Height, Ho =	8.10	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	8.10	N/A
Overflow Weir Front Edge Length =	10.00	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 =	7.26	N/A
Horiz. Length of Weir Sides =	4.00	N/A	feet	Overflow Grate Open Area w/o Debris =	28.00	N/A
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	14.00	N/A
Debris Clogging % =	50%	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			Zone 3 Restrictor	Not Selected
Depth to Invert of Outlet Pipe =	0.50	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	3.86	N/A
Outlet Pipe Diameter =	30.00	N/A	inches	Outlet Orifice Centroid =	1.02	N/A
Restrictor Plate Height Above Pipe Invert =	22.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	2.06	N/A

Calculated Parameters for Outlet Pipe w/ Flow Restriction Pla

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	9.50	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	1.25	feet
Spillway Crest Length =	120.00	feet	Stage at Top of Freeboard =	10.75	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	5.30	acres
Freeboard above Max Water Surface =	0.00	feet	Basin Volume at Top of Freeboard =	30.08	acre-ft

Calculated Parameters for Spillway

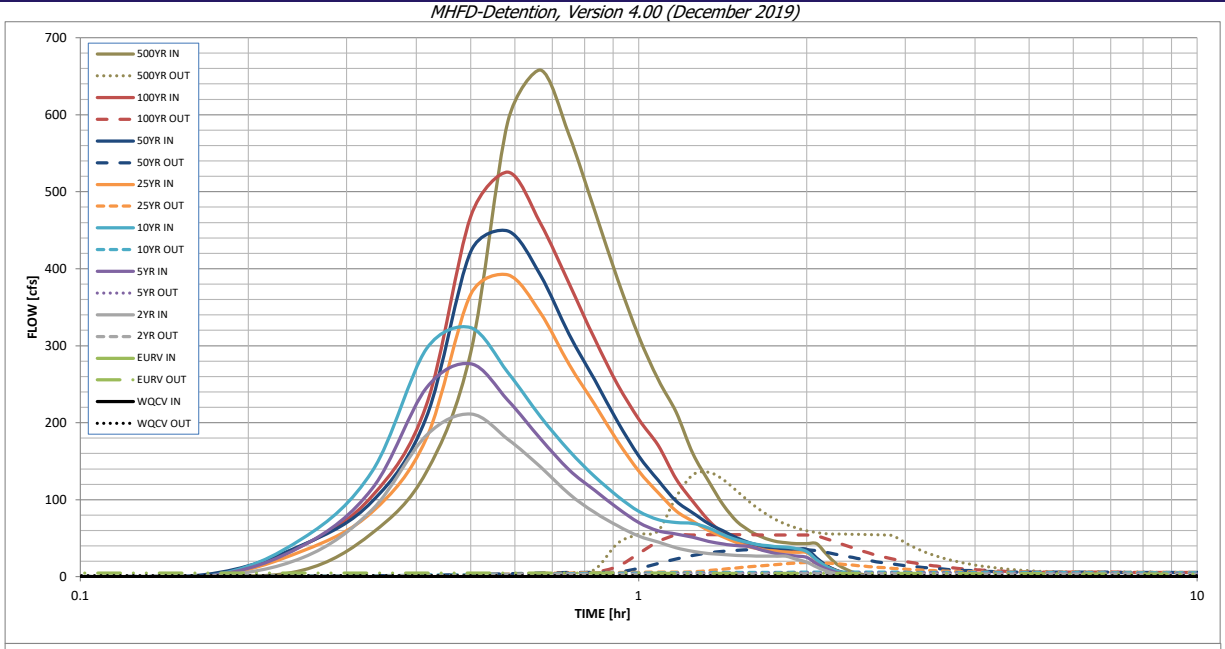
Routed Hydrograph Results

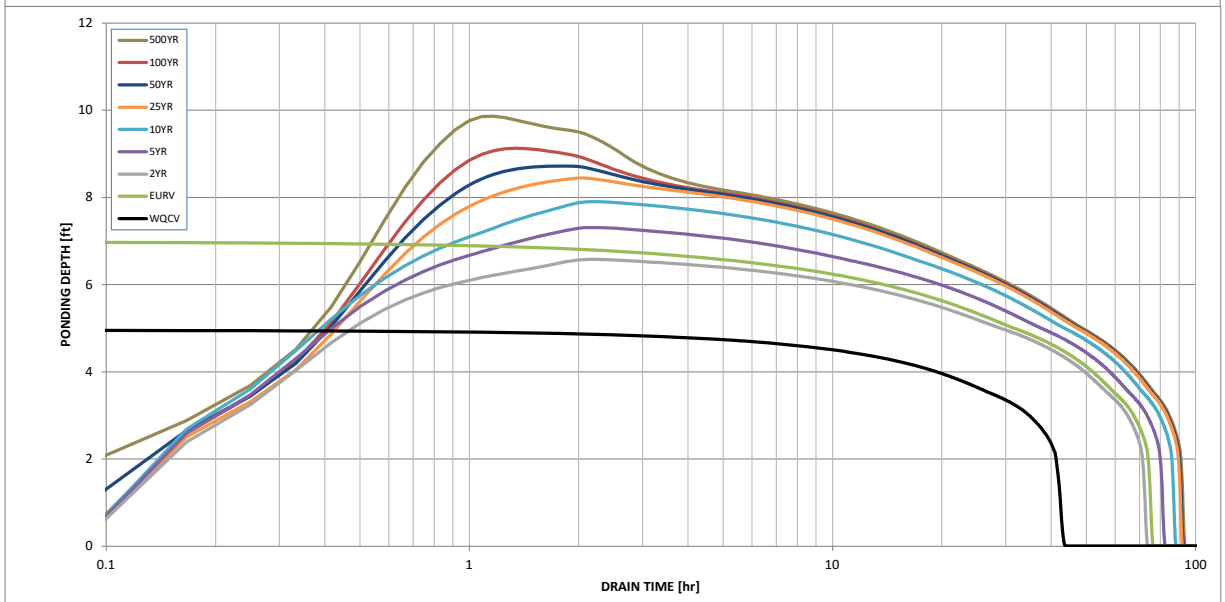
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AI

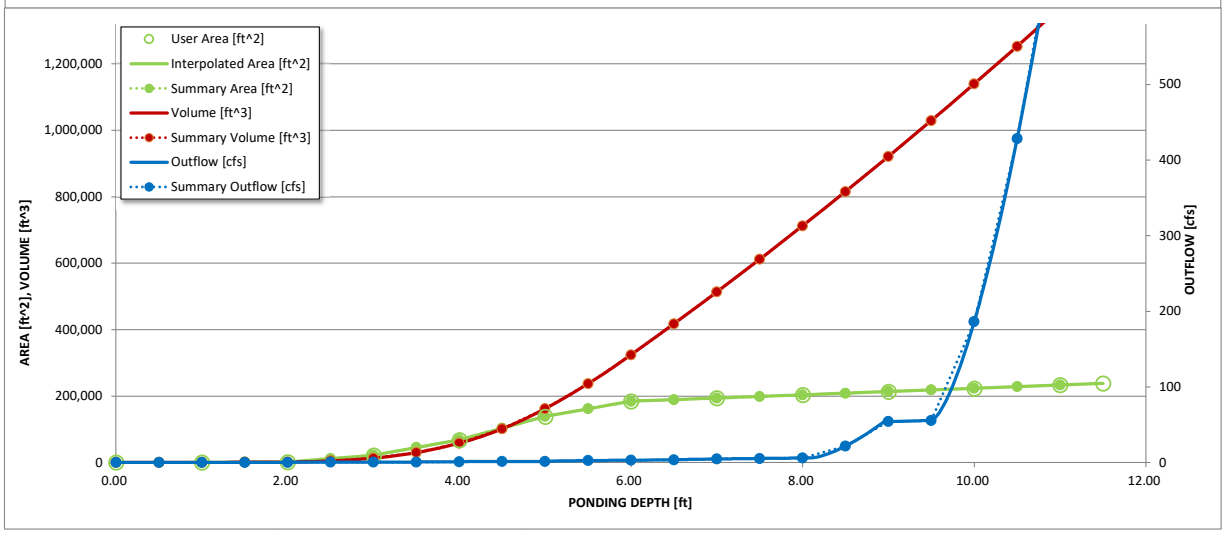
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52
CUHP Runoff Volume (acre-ft) =	3.571	11.697	10.451	13.869	16.707	19.888	22.824	26.203
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	10.451	13.869	16.707	19.888	22.824	26.203
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	17.5	48.2	72.5	129.3	162.0	205.9
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A						
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.13	0.36	0.54	0.96	1.20	1.53
Peak Inflow Q (cfs) =	N/A	N/A	211.3	276.6	323.3	391.9	449.2	525.3
Peak Outflow Q (cfs) =	1.6	4.7	3.9	5.2	5.9	18.5	35.8	54.5
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.1	0.1	0.1	0.2	0.3
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	0.4	1.0	1.7
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) =	39	67	65	71	76	78	77	75
Time to Drain 99% of Inflow Volume (hours) =	**41**	72	70	77	83	86	85	85
Maximum Ponding Depth (ft) =	4.96	6.99	6.58	7.31	7.90	8.44	8.71	9.12
Area at Maximum Ponding Depth (acres) =	3.12	4.46	4.36	4.53	4.66	4.78	4.84	4.93
Maximum Volume Stored (acre-ft) =	3.594	11.739	9.886	13.131	15.840	18.435	19.733	21.736

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.00 (December 2019)







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	2.78	0.28	8.35
	0:15:00	0.00	0.00	24.67	40.18	49.67	33.32	41.46	40.52	56.78
	0:20:00	0.00	0.00	87.18	114.31	137.04	84.27	97.68	104.91	135.66
	0:25:00	0.00	0.00	183.45	244.93	295.50	179.20	206.56	222.32	290.97
	0:30:00	0.00	0.00	211.34	276.58	323.31	366.59	422.14	467.72	591.09
	0:35:00	0.00	0.00	178.64	229.08	265.31	391.92	449.18	525.33	658.09
	0:40:00	0.00	0.00	142.57	179.33	208.16	342.69	391.69	459.09	574.02
	0:45:00	0.00	0.00	107.83	138.87	163.80	276.09	315.28	381.36	476.19
	0:50:00	0.00	0.00	83.53	112.28	130.38	224.36	256.09	309.17	386.39
	0:55:00	0.00	0.00	66.18	89.02	104.68	176.14	201.33	249.71	312.36
	1:00:00	0.00	0.00	52.81	70.38	85.05	137.21	157.04	204.60	256.00
	1:05:00	0.00	0.00	45.18	59.77	74.25	109.22	125.15	170.54	213.76
	1:10:00	0.00	0.00	37.70	55.59	70.57	85.48	98.16	126.82	159.99
	1:15:00	0.00	0.00	32.85	51.10	69.34	72.15	83.02	97.91	124.45
	1:20:00	0.00	0.00	30.22	45.98	63.48	60.09	69.07	73.28	93.28
	1:25:00	0.00	0.00	28.66	42.47	54.48	51.80	59.44	56.35	71.74
	1:30:00	0.00	0.00	27.73	40.32	47.92	44.09	50.45	46.65	59.36
	1:35:00	0.00	0.00	27.07	39.05	43.74	38.58	44.01	40.23	51.16
	1:40:00	0.00	0.00	26.69	34.41	41.11	35.25	40.12	36.47	46.37
	1:45:00	0.00	0.00	26.57	30.58	39.43	33.25	37.78	34.70	44.08
	1:50:00	0.00	0.00	26.57	28.30	38.34	32.18	36.53	34.00	43.15
	1:55:00	0.00	0.00	22.46	26.91	36.44	31.61	35.86	33.81	42.90
	2:00:00	0.00	0.00	18.90	25.07	32.70	31.34	35.54	33.81	42.90
	2:05:00	0.00	0.00	12.57	16.85	21.96	21.55	24.43	23.29	29.53
	2:10:00	0.00	0.00	7.55	10.13	13.35	13.16	14.92	14.22	18.03
	2:15:00	0.00	0.00	4.47	6.03	7.96	7.94	9.00	8.58	10.87
	2:20:00	0.00	0.00	2.40	3.43	4.46	4.52	5.12	4.87	6.17
	2:25:00	0.00	0.00	1.18	1.86	2.33	2.49	2.82	2.68	3.39
	2:30:00	0.00	0.00	0.46	0.78	0.93	1.07	1.20	1.14	1.44
	2:35:00	0.00	0.00	0.11	0.17	0.19	0.23	0.26	0.25	0.31
	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

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.03 (May 2020)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]
	0.00	475	0.011	0	0.000	0.00
	0.50	475	0.011	238	0.005	0.14
	1.00	475	0.011	475	0.011	0.20
	1.50	1,038	0.024	853	0.020	0.25
	2.00	1,600	0.037	1,512	0.035	0.28
	2.50	11,814	0.271	4,866	0.112	0.48
	3.00	22,029	0.506	13,327	0.306	0.58
	3.50	45,154	1.037	30,122	0.692	0.66
	4.00	68,279	1.567	58,481	1.343	1.16
	4.50	103,572	2.378	101,443	2.329	1.40
	5.00	138,865	3.188	162,052	3.720	1.59
	5.50	161,771	3.714	237,211	5.446	2.61
	6.00	184,678	4.240	323,824	7.434	3.11
	6.50	189,460	4.349	417,358	9.581	3.52
	7.00	194,243	4.459	513,284	11.783	4.73
	7.50	199,068	4.570	611,612	14.041	5.41
	8.00	203,894	4.681	712,353	16.353	5.98
	8.50	208,773	4.793	815,520	18.722	21.76
	9.00	213,652	4.905	921,126	21.146	54.10
	9.50	218,570	5.018	1,029,181	23.627	55.68
	10.00	223,488	5.131	1,139,696	26.164	186.18
	10.50	228,469	5.245	1,252,685	28.758	428.29
	11.00	233,450	5.359	1,368,165	31.409	747.96

For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

Falcon Commerce Center - MDDP
Runoff Summary and Maximum Detention Release Rates

Existing Site Runoff from Site

	Design Point	Q_5	Q_{100}
To Monument Creek	DP EX-D	4.4 cfs	32.1 cfs
To Monument Creek	DP EX-E	6.8 cfs	32.2 cfs
To Jackson Creek	EP E4	27.2 cfs	153.8 cfs
Total Runoff Ultimately to Monument Creek	EX-D, EX-E, E4	38.5 cfs	218.1 cfs
To Site Low Point (Infiltrates)	DP E7	8.5 cfs	65.6 cfs

Regional Detention Basin Release Rates

				Total Runoff					
Storm Event	**Design Point**	C	A	T_c	Sum C*A	i (in/hr)	Q	Ex. Pilot Detent Q	Total Q
2 Year	E4	0.05	111.51ac	49.0min	6.09	1.4	8.6 cfs		
10 Year	E4	0.22		47.0min	24.35	2.1	51.4 cfs		
25 Year	E4	0.31		45.0min	34.12	2.5	85.2 cfs		
50 Year	E4	0.36		43.0min	39.81	2.9	115.9 cfs		
2 Year	42	0.05	57.22ac	40.5min	3.06	1.6	5.0 cfs	0.3 cfs	5.3 cfs
10 Year	42	0.22		37.5min	12.37	2.5	31.0 cfs	0.5 cfs	31.5 cfs
25 Year	42	0.30		37.0min	17.40	2.9	50.3 cfs	4.8 cfs	55.1 cfs
50 Year	42	0.36		36.0min	20.33	3.3	67.3 cfs	12.1 cfs	79.4 cfs

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

$i_2 = -1.19 \ln(T_c) + 6.035$ $i_{25} = -2.00 \ln(T_c) + 10.111$

$i_{10} = -1.75 \ln(T_c) + 8.847$ $i_{50} = -2.25 \ln(T_c) + 11.375$

Maximum Detention Release Rates at Common Design Point: Jackson Creek at Santa Fe Trail

	Design Point	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Existing Condition	E4	8.6 cfs	27.2 cfs	51.4 cfs	85.2 cfs	115.9 cfs	153.8 cfs
Proposed Condition: Flow to DP (not including Detention)	42	5.3 cfs	14.8 cfs	31.5 cfs	55.1 cfs	79.4 cfs	98.2 cfs
Maximum Detention Release Rate		**3.3 cfs**	**12.5 cfs**	**19.9 cfs**	**30.2 cfs**	**36.5 cfs**	**55.6 cfs**
Proposed Condition: Total Flow to DP	42	8.6 cfs	27.2 cfs	51.4 cfs	85.2 cfs	115.9 cfs	153.8 cfs

Falcon Commerce Center
Detention Calculations

Presedementation / Forebay Sizing

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 30" Max	Forebay Design Volume	Discharge Design Flow 2.0% 100yr	Calc'd Open Width (1" min)	**Design Width**
NW - DP12	447.1cfs	155,685cf	4,671cf	102.19ac	81.5%	3,809cf	1,550sf	2.50-ft	3,875 cf	8.94 cfs	15.0-inch	**15.0-inch**
North - C2	64.7cfs			11.85ac	9.5%	442cf	320sf	1.50-ft	480 cf	1.29 cfs	6.4-inch	**7.0-inch**
East - DP30	52.9cfs			11.27ac	9.0%	420cf	330sf	1.50-ft	495 cf	1.06 cfs	5.9-inch	**6.0-inch**
					0.0%	---			---	---	---	
Totals		155,685cf	4,671cf	125.31ac	100.0%							

Opening Width Equation for Rectangular Opening

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

C = 3.0

Trickle Channel Calculation

Location	100yr Flow	Req'd Flow 1.0% 100yr	Bottom Width	Max. Flow Depth	Side Slope	Slope	Manning 'n'	Top Width	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	**Capacity**
NW - DP12	447.1cfs	4.5cfs	6.0 ft	0.50 ft	0.0:1	0.5%	0.013	6.0 ft	3.00 sf	7.0 ft	0.43 ft	4.6 ft/sec	**13.8 cfs**
North - C2	64.7cfs	0.6cfs	6.0 ft	0.50 ft	0.0:1	0.5%	0.013	6.0 ft	3.00 sf	7.0 ft	0.43 ft	4.6 ft/sec	**13.8 cfs**
East - DP30	52.9cfs	0.5cfs	4.0 ft	0.50 ft	0.0:1	0.5%	0.013	4.0 ft	2.00 sf	5.0 ft	0.40 ft	4.4 ft/sec	**8.8 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; d = depth; Hydraulic Radius = A/P; S = Slope of the channel; n = Manning's number; R_n = Hydraulic Radius (Reynold's Number)

Detention Basin Outlet - Initial Surcharge Sizing

Detention Basin	WQCV	Initial Surcharge Volume: Minimum Required 0.3% WQCV	Minimum Required Min. Depth	Design Area	Design Depth	Design Volume
DP13	155,685 cf	467 cf	4.0-in	475 sf	12.0-in	475 cf

Notes: ISV depth shall be 4" to 12" deep. Can not extend into trickle channel. (Section 4.1.3 ISV - City of Colo Springs DCM, Volume 1)

Emergency Spillway Calculation

Detention Area	100-yr Flow	Water Surf Elev	Crest Elev	Crest Length	Z	C	Flow Depth (H)	**Calc'd Flow**	Check
Detention-DP13	556 cfs	101.5	100.0	100 ft	4:1	3.0	1.50 ft	578 cfs	OK

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

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

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

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

H = Head above weir crest, in ft

Z = Side slope (horizontal:vertical)

Figure 13-12c. Emergency Spillway Protection

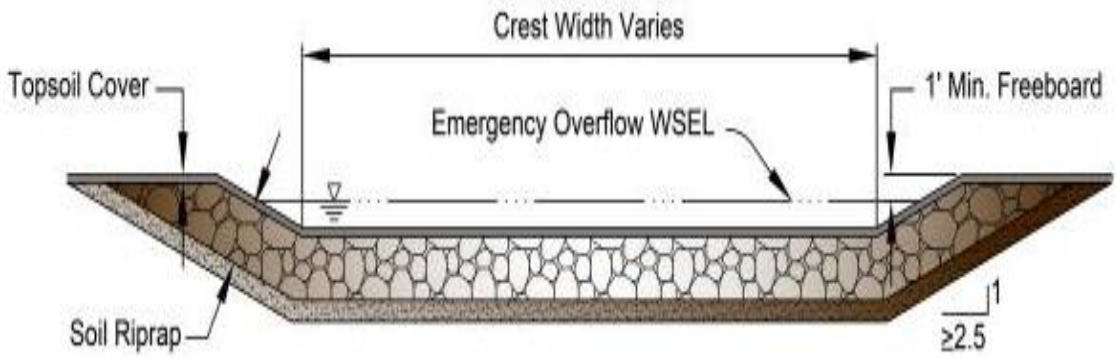
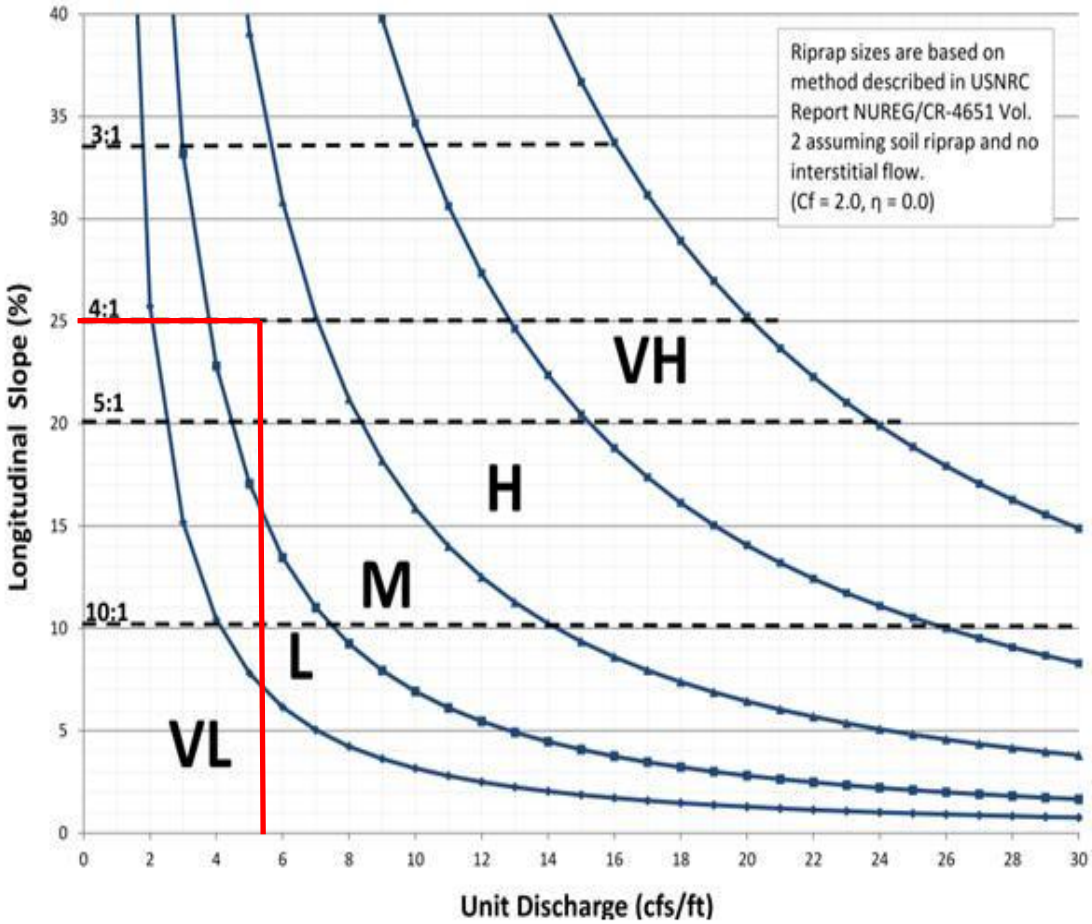


Figure 13-12d. Riprap Types for Emergency Spillway Protection



APPENDIX D

Hydraulic Calculations

Inlet Summary and Calculations
Pipe Sizing Calculations and UD-Sewer Output

Version 4.05 Released March 2017

INLET MANAGEMENT

Worksheet Protected

INLET NAME	Inlet 22	Inlet 26	Inlet 23	Inlet 50
Site Type (Urban or Rural)	URBAN	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET	STREET
Hydraulic Condition	In Sump	In Sump	On Grade	On Grade
Inlet Type	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{Known} (cfs)	5.9	0.5	0.9	1.1
Major Q_{Known} (cfs)	12.1	1.0	1.8	2.1

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)	**5.9**	**0.5**	**0.9**	**1.1**
Major Total Design Peak Flow, Q (cfs)	**12.1**	**1.0**	**1.8**	**2.1**
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	0.0	0.0
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	0.0	0.0

Minor Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A	N/A
C_5	N/A	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A	N/A

Major Storm (Calculated) Analysis of Flow Time

C	N/A	N/A	N/A	N/A
C_5	N/A	N/A	N/A	N/A
Overland Flow Velocity, Vi	N/A	N/A	N/A	N/A
Channel Flow Velocity, Vt	N/A	N/A	N/A	N/A
Overland Flow Time, Ti	N/A	N/A	N/A	N/A
Channel Travel Time, Tt	N/A	N/A	N/A	N/A
Calculated Time of Concentration, T_c	N/A	N/A	N/A	N/A
Regional T_c	N/A	N/A	N/A	N/A
Recommended T_c	N/A	N/A	N/A	N/A
T_c selected by User	N/A	N/A	N/A	N/A
Design Rainfall Intensity, I	N/A	N/A	N/A	N/A
Calculated Local Peak Flow, Q_p	N/A	N/A	N/A	N/A

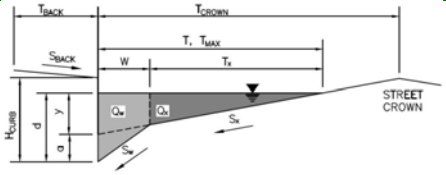
Version 4.05 Released March 2017

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

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

Project: Falcon Commerce Center MDDP

Inlet ID: Inlet 22



Gutter Geometry (Enter data in the blue cells)

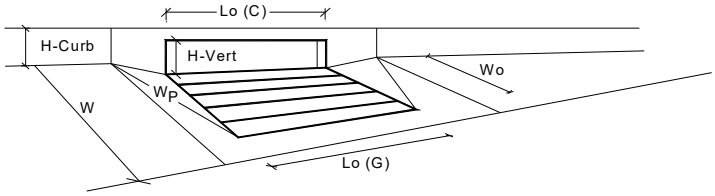
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	10.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	24.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	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 =	0.000	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} =	24.0	24.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

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

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	1	1	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	6.0	7.3	inches
Grate Information		MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	10.00	10.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.33	0.44	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.57	0.69	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.93	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**8.3**	**13.4**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	5.9	12.1	cfs

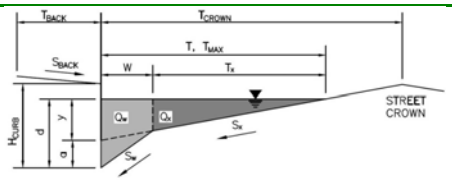
Version 4.05 Released March 2017

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

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

Project: Falcon Commerce Center MDDP

Inlet ID: Inlet 23



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	10.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	25.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	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 =	0.020	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.020	

		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	24.0	24.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

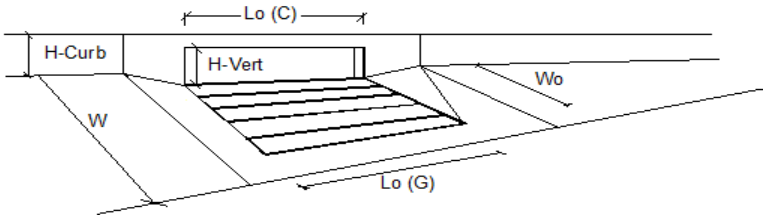
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**15.6**	**29.9**	**cfs**

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

Version 4.05 Released March 2017



Design Information (Input)		MINOR	MAJOR	
Type of Inlet	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 =**	**0.9**	**1.8**	**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**	**%**

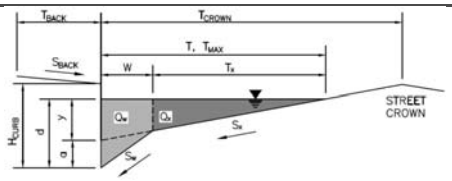
Version 4.05 Released March 2017

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

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

Project: Falcon Commerce Center MDDP

Inlet ID: Inlet 26



Gutter Geometry (Enter data in the blue cells)

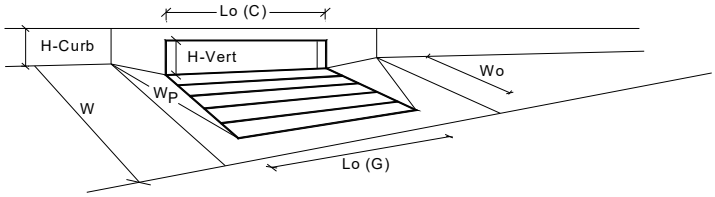
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	10.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	24.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	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 =	0.000	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} =	24.0	24.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

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

INLET IN A SUMP OR SAG LOCATION

Version 4.05 Released March 2017



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	7.3	inches
Grate Information			MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)			MINOR	MAJOR	
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.33	0.44	ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.77	0.93	
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	1.00	1.00	
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A	
			MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**5.4**	**8.1**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	0.5	1.0	cfs

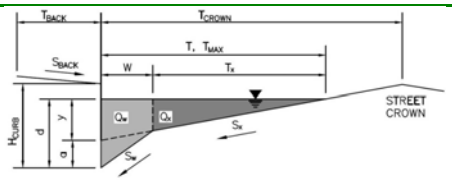
Version 4.05 Released March 2017

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

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

Project: Falcon Commerce Center MDDP

Inlet ID: Inlet 50



Gutter Geometry (Enter data in the blue cells)

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} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.016	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	16.0	ft
Gutter Width	W =	2.00	ft
Street Transverse Slope	S_X =	0.020	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 =	0.029	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} =	16.0	16.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	12.0	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

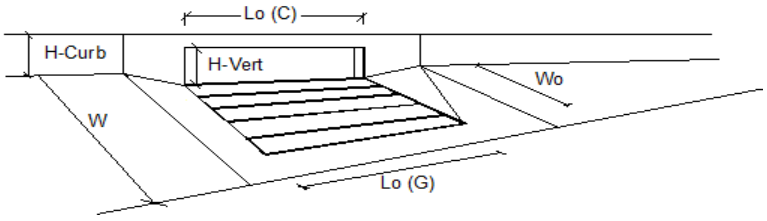
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**15.9**	**15.9**	**cfs**

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

Version 4.05 Released March 2017

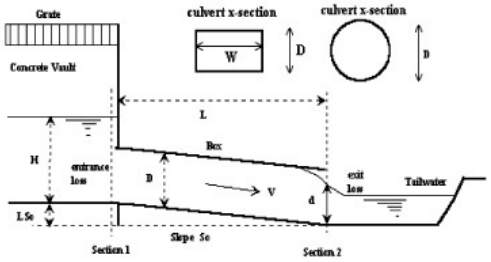


Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	2	2	
Length of a Single Unit Inlet (Grate or Curb Opening)	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 =**	**1.1**	**2.1**	**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**	**%**

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Falcon Commerce Center
Basin ID: Pipe S97
Status:



Design Information (Input):

Circular Culvert:	Barrel Diameter in Inches	D =	24	inches
	Inlet Edge Type (choose from pull-down list)		Square End Projection	
OR:				
Box Culvert:	Barrel Height (Rise) in Feet	Height (Rise) =		ft.
	Barrel Width (Span) in Feet	Width (Span) =		ft.
	Inlet Edge Type (choose from pull-down list)		Square Edge w/ 30-78 deg. Flared Wingwall	
	Number of Barrels	No =	1	
	Inlet Elevation at Culvert Invert	Inlet Elev =	100	ft. elev.
	Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Slope =	0.0075	ft vert. / ft horiz.
	Culvert Length in Feet	L =	80	ft.
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	K_b =	0	
	Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.50
Friction Loss Coefficient	K_f =	0.99
Sum of All Loss Coefficients	K_s =	2.49
Orifice Inlet Condition Coefficient	C_d =	0.85
Minimum Energy Condition Coefficient	KE_{low} =	0.0598

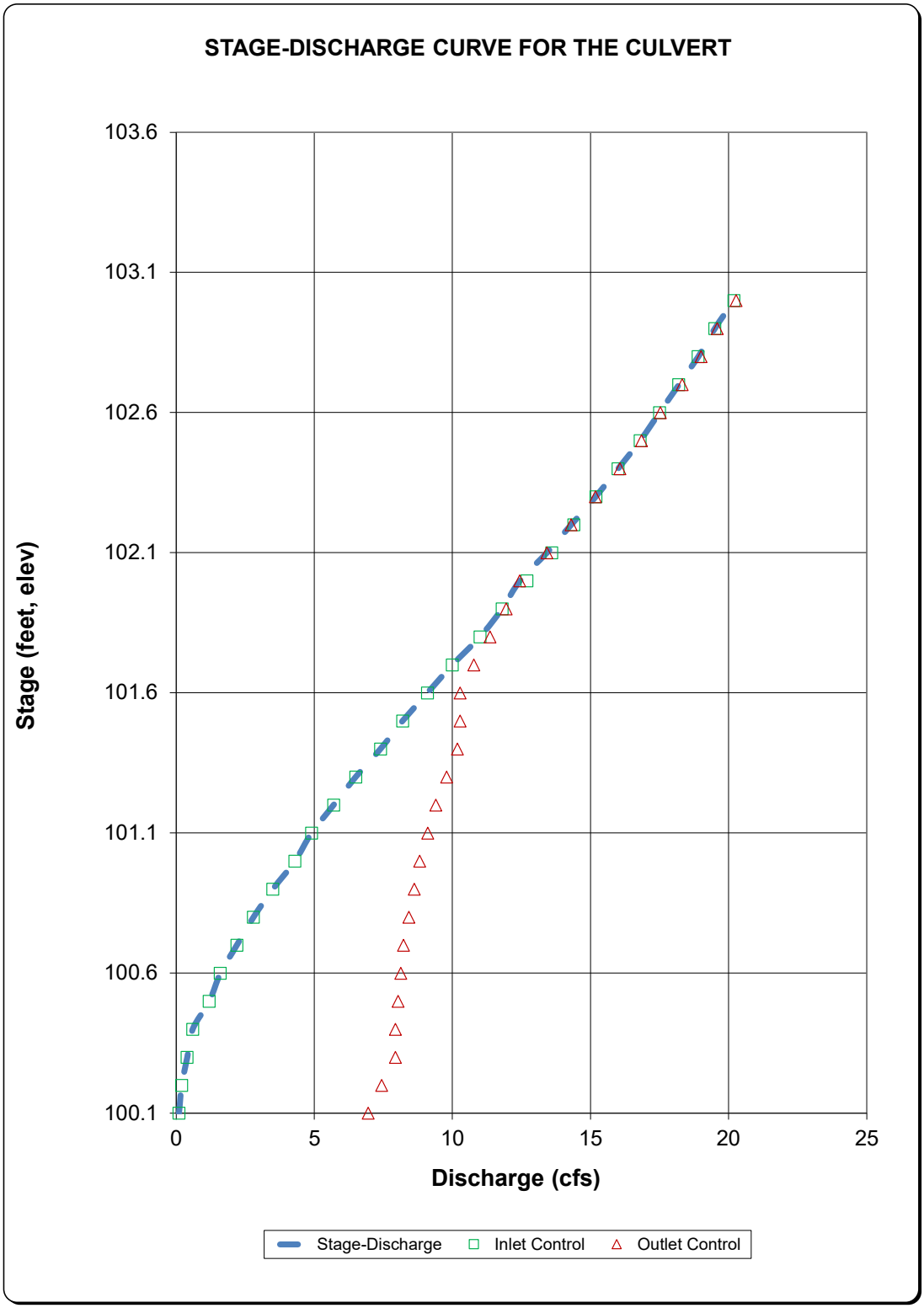
Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
100.10	99.70	0.10	6.96	**0.10**	Min. Energy. Eqn.	INLET
100.20	99.70	0.20	7.44	**0.20**	Min. Energy. Eqn.	INLET
100.30	99.70	0.40	7.93	**0.40**	Min. Energy. Eqn.	INLET
100.40	99.70	0.60	7.93	**0.60**	Min. Energy. Eqn.	INLET
100.50	99.70	1.20	8.03	**1.20**	Min. Energy. Eqn.	INLET
100.60	99.70	1.60	8.13	**1.60**	Min. Energy. Eqn.	INLET
100.70	99.70	2.20	8.23	**2.20**	Min. Energy. Eqn.	INLET
100.80	99.70	2.80	8.42	**2.80**	Min. Energy. Eqn.	INLET
100.90	99.70	3.50	8.62	**3.50**	Min. Energy. Eqn.	INLET
101.00	99.70	4.30	8.82	**4.30**	Min. Energy. Eqn.	INLET
101.10	99.70	4.90	9.11	**4.90**	Regression Eqn.	INLET
101.20	99.70	5.70	9.40	**5.70**	Regression Eqn.	INLET
101.30	99.70	6.50	9.80	**6.50**	Regression Eqn.	INLET
101.40	99.70	7.40	10.19	**7.40**	Regression Eqn.	INLET
101.50	99.70	8.20	10.29	**8.20**	Regression Eqn.	INLET
101.60	99.70	9.10	10.29	**9.10**	Regression Eqn.	INLET
101.70	99.70	10.00	10.78	**10.00**	Regression Eqn.	INLET
101.80	99.70	11.00	11.36	**11.00**	Regression Eqn.	INLET
101.90	99.70	11.80	11.95	**11.80**	Regression Eqn.	INLET
102.00	99.70	12.70	12.44	**12.44**	Regression Eqn.	OUTLET
102.10	99.70	13.60	13.42	**13.42**	Regression Eqn.	OUTLET
102.20	99.70	14.40	14.30	**14.30**	Regression Eqn.	OUTLET
102.30	99.70	15.20	15.18	**15.18**	Regression Eqn.	OUTLET
102.40	99.70	16.00	16.07	**16.00**	Regression Eqn.	INLET
102.50	99.70	16.80	16.85	**16.80**	Regression Eqn.	INLET
102.60	99.70	17.50	17.53	**17.50**	Regression Eqn.	INLET
102.70	99.70	18.20	18.32	**18.20**	Regression Eqn.	INLET
102.80	99.70	18.90	19.00	**18.90**	Regression Eqn.	INLET
102.90	99.70	19.50	19.59	**19.50**	Regression Eqn.	INLET
103.00	99.70	20.20	20.28	**20.20**	Regression Eqn.	INLET

Processing Time: 01.61 Seconds

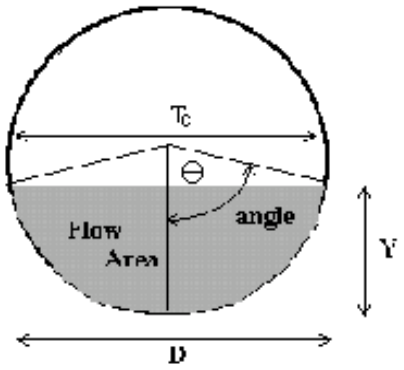
CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Falcon Commerce Center
Basin ID: Pipe S97



CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

Project: Falcon Commerce Center
Pipe ID: Pipe S98



Design Information (Input)			
Pipe Invert Slope	So =	0.0100	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	18.00	inches
Design discharge	**Q =**	**2.10**	**cfs**

Full-flow Capacity (Calculated)			
Full-flow area	Af =	1.77	sq ft
Full-flow wetted perimeter	Pf =	4.71	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	10.53	cfs

Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.17	radians
Flow area	An =	0.45	sq ft
Top width	Tn =	1.38	ft
Wetted perimeter	Pn =	1.75	ft
Flow depth	Yn =	0.45	ft
Flow velocity	Vn =	4.65	fps
Discharge	Qn =	2.10	cfs
Percent Full Flow	Flow =	19.9%	of full flow
Normal Depth Froude Number	Fr_n =	1.43	supercritical

Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	1.30	radians
Critical flow area	Ac =	0.58	sq ft
Critical top width	Tc =	1.44	ft
Critical flow depth	Yc =	0.55	ft
Critical flow velocity	Vc =	3.60	fps
Critical Depth Froude Number	Fr_c =	1.00	

Program: UDSEWER Math Model Interface 2.1.1.4 **Run Date:** 8/20/2020 7:00:10 PM	**UDSewer Results Summary** **Project Title:** 19036 Falcon Commerce Center **Project Description:** Default system

System Input Summary

Rainfall Parameters

Rainfall Return Period: 100
Rainfall Calculation Method: Formula

One Hour Depth (in): 1.00
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: No

Sizer Constraints

Minimum Sewer Size (in): 12.00
Maximum Depth to Rise Ratio: 0.90
Maximum Flow Velocity (fps): 18.0
Minimum Flow Velocity (fps): 3.0

Backwater Calculations:

Tailwater Elevation (ft): 6719.85

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	6717.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S52	6735.75	447.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

S51	6742.80	42.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S50-3	6742.98	405.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S50-2	6748.87	405.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S50-1	6752.73	405.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S50	6759.67	405.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S70	6778.00	163.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S69	6778.00	160.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S65	6784.00	84.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S64	6784.00	80.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S63	6784.00	3.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S68	6778.00	88.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S47	6763.83	244.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAT 6	6763.00	35.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S45	6762.87	209.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAT 5	6769.00	24.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S43	6763.66	184.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAT 4	6769.00	47.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S40	6770.82	137.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S31	6781.25	124.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S30	6784.16	93.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAT 1	6790.00	15.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S28	6793.60	77.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S26	6793.00	12.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S22	6793.00	12.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S21	6795.07	68.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S20-1	6799.44	67.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S20	6800.47	67.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAT 2	6782.50	31.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LAT 3	6779.00	13.40	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	96.12	4.65	0.04	447.10	Surface Water Present (Upstream)
S52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	447.10	Surface Water Present (Downstream)
S51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.70	
S50-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	405.70	
S50-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	405.70	
S50-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	405.70	

S50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	405.70	
S70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	163.30	
S69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	160.80	
S65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84.30	
S64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	80.70	
S63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.90	
S68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	88.90	
S47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	244.30	
LAT 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.50	
S45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	209.30	
LAT 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.40	
S43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	184.90	
LAT 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.20	
S40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	137.40	
S31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	124.70	
S30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.00	
LAT 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.60	
S28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	77.10	
S26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.80	
S22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.10	
S21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.50	
S20-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	67.80	
S20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	67.80	
LAT 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.50	
LAT 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.40	

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)**
S52	34.70	6719.05	1.3	6719.50	0.013	0.03	1.00	CIRCULAR	72.00 in	72.00 in
S51	200.00	6722.53	1.0	6724.53	0.013	1.00	0.00	CIRCULAR	36.00 in	36.00 in
S50-3	75.00	6724.97	1.1	6725.79	0.013	0.27	0.25	CIRCULAR	72.00 in	72.00 in
S50-2	75.00	6730.76	1.1	6731.58	0.013	0.05	1.00	CIRCULAR	72.00 in	72.00 in
S50-1	75.00	6736.61	1.0	6737.36	0.013	0.05	1.00	CIRCULAR	72.00 in	72.00 in
S50	322.38	6742.36	1.0	6745.58	0.013	0.05	1.00	CIRCULAR	72.00 in	72.00 in
S70	706.00	6747.58	1.8	6760.29	0.013	0.21	0.00	CIRCULAR	48.00 in	48.00 in
S69	14.00	6761.00	1.6	6761.22	0.013	0.05	1.00	CIRCULAR	48.00 in	48.00 in
S65	577.00	6764.46	2.0	6776.00	0.013	1.32	0.25	CIRCULAR	42.00 in	42.00 in
S64	37.50	6776.50	1.5	6777.06	0.013	1.32	0.00	CIRCULAR	36.00 in	36.00 in
S63	13.00	6776.51	1.5	6776.70	0.013	1.32	0.00	CIRCULAR	18.00 in	18.00 in
S68	37.00	6762.21	1.5	6762.76	0.013	0.05	0.00	CIRCULAR	42.00 in	42.00 in

S47	263.20	6745.75	1.0	6748.38	0.013	0.43	0.52	CIRCULAR	72.00 in	72.00 in
LAT 6	50.00	6751.88	1.0	6752.38	0.013	0.69	0.00	CIRCULAR	30.00 in	30.00 in
S45	156.04	6749.39	0.8	6750.64	0.013	0.05	1.00	CIRCULAR	72.00 in	72.00 in
LAT 5	300.00	6753.64	1.5	6758.14	0.013	0.52	0.00	CIRCULAR	36.00 in	36.00 in
S43	365.32	6751.79	0.4	6753.25	0.013	0.05	0.32	CIRCULAR	60.00 in	60.00 in
LAT 4	300.00	6755.25	1.5	6759.75	0.013	0.53	0.00	CIRCULAR	36.00 in	36.00 in
S40	663.06	6753.89	1.2	6761.85	0.013	0.05	0.32	CIRCULAR	54.00 in	54.00 in
S31	294.78	6763.77	2.3	6770.55	0.013	0.53	1.00	CIRCULAR	42.00 in	42.00 in
S30	433.65	6773.04	1.0	6777.38	0.013	0.05	0.25	CIRCULAR	42.00 in	42.00 in
LAT 1	120.00	6778.88	1.5	6780.68	0.013	0.97	0.00	CIRCULAR	24.00 in	24.00 in
S28	289.83	6777.87	2.5	6785.12	0.013	0.05	0.27	CIRCULAR	36.00 in	36.00 in
S26	60.00	6786.62	1.5	6787.52	0.013	1.14	0.00	CIRCULAR	18.00 in	18.00 in
S22	40.00	6787.82	1.0	6788.22	0.013	1.14	0.00	CIRCULAR	18.00 in	18.00 in
S21	107.74	6786.63	1.8	6788.57	0.013	0.80	0.25	CIRCULAR	36.00 in	36.00 in
S20-1	221.44	6788.82	1.6	6792.36	0.013	0.05	0.25	CIRCULAR	36.00 in	36.00 in
S20	67.00	6792.64	1.5	6793.64	0.013	1.00	1.00	CIRCULAR	36.00 in	36.00 in
LAT 2	40.00	6771.55	1.5	6772.15	0.013	1.32	0.00	CIRCULAR	30.00 in	30.00 in
LAT 3	50.00	6764.35	1.5	6765.10	0.013	1.32	0.00	CIRCULAR	24.00 in	24.00 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**
S52	484.17	17.12	66.26	16.42	54.60	19.44	1.62	Supercritical	447.10	0.00	Velocity is Too High
S51	66.88	9.46	25.54	7.96	20.90	10.03	1.47	Pressurized	42.70	200.00	
S50-3	445.37	15.75	64.32	15.22	53.95	17.85	1.51	Supercritical	405.70	0.00	
S50-2	445.37	15.75	64.32	15.22	53.95	17.85	1.51	Supercritical	405.70	0.00	
S50-1	424.65	15.02	64.32	15.22	56.32	17.10	1.38	Supercritical	405.70	0.00	
S50	424.65	15.02	64.32	15.22	56.32	17.10	1.38	Supercritical	405.70	0.00	
S70	193.24	15.38	44.25	13.48	33.84	17.25	1.89	Supercritical Jump	163.30	171.68	
S69	182.19	14.50	44.07	13.31	35.03	16.36	1.73	Supercritical	160.80	0.00	
S65	142.67	14.83	34.33	10.01	23.23	15.44	2.17	Supercritical Jump	84.30	210.47	
S64	81.91	11.59	33.32	11.82	29.04	13.21	1.45	Pressurized	80.70	37.50	
S63	12.90	7.30	9.06	4.37	6.79	6.39	1.74	Pressurized	3.90	13.00	
S68	123.55	12.84	35.14	10.34	26.38	13.98	1.80	Pressurized	88.90	37.00	
S47	424.65	15.02	51.38	11.32	39.17	15.54	1.69	Pressurized	244.30	263.20	
LAT 6	41.13	8.38	24.26	8.35	21.50	9.43	1.28	Pressurized	35.50	50.00	
S45	379.82	13.43	47.48	10.58	38.15	13.76	1.52	Pressurized	209.30	156.04	
LAT 5	81.91	11.59	19.11	6.40	13.47	10.11	1.95	Supercritical	24.40	183.02	

								Jump			
S43	165.16	8.41	60.00	9.42	60.00	9.42	0.00	Pressurized	184.90	365.32	
LAT 4	81.91	11.59	26.85	8.35	19.60	12.00	1.84	Pressurized	47.20	300.00	
S40	216.00	13.58	41.36	10.51	31.28	14.39	1.73	Supercritical Jump	137.40	500.99	
S31	152.99	15.90	39.35	13.31	28.81	17.73	2.12	Supercritical	124.70	0.00	
S30	100.88	10.49	35.80	10.64	31.80	11.90	1.30	Pressurized	93.00	433.65	
LAT 1	27.78	8.84	17.09	6.52	12.86	9.10	1.73	Pressurized	15.60	120.00	
S28	105.74	14.96	32.90	11.38	22.81	16.32	2.25	Supercritical Jump	77.10	111.40	
S26	12.90	7.30	16.13	7.67	14.63	8.32	1.28	Pressurized	12.80	60.00	
S22	10.53	5.96	18.00	6.85	18.00	6.85	0.00	Pressurized	12.10	40.00	
S21	89.73	12.69	31.64	10.41	23.55	13.98	1.88	Pressurized	68.50	107.74	
S20-1	84.59	11.97	31.52	10.33	24.39	13.30	1.74	Pressurized	67.80	221.44	
S20	81.91	11.59	31.52	10.33	24.98	12.95	1.66	Pressurized	67.80	67.00	
LAT 2	50.37	10.26	22.94	7.82	17.19	10.83	1.76	Pressurized	31.50	40.00	
LAT 3	27.78	8.84	15.81	6.10	11.75	8.76	1.77	Pressurized	13.40	50.00	

- 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**
S52	447.10	CIRCULAR	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	28.27	
S51	42.70	CIRCULAR	36.00 in	36.00 in	33.00 in	33.00 in	36.00 in	36.00 in	7.07	
S50-3	405.70	CIRCULAR	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	28.27	
S50-2	405.70	CIRCULAR	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	28.27	
S50-1	405.70	CIRCULAR	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	28.27	
S50	405.70	CIRCULAR	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	72.00 in	28.27	
S70	163.30	CIRCULAR	48.00 in	48.00 in	48.00 in	48.00 in	48.00 in	48.00 in	12.57	
S69	160.80	CIRCULAR	48.00 in	48.00 in	48.00 in	48.00 in	48.00 in	48.00 in	12.57	
S65	84.30	CIRCULAR	42.00 in	42.00 in	36.00 in	36.00 in	42.00 in	42.00 in	9.62	
S64	80.70	CIRCULAR	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	7.07	
S63	3.90	CIRCULAR	18.00 in	18.00 in	12.00 in	12.00 in	18.00 in	18.00 in	1.77	
S68	88.90	CIRCULAR	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	9.62	
S47	244.30	CIRCULAR	72.00 in	72.00 in	60.00 in	60.00 in	72.00 in	72.00 in	28.27	
LAT 6	35.50	CIRCULAR	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	30.00 in	4.91	
S45	209.30	CIRCULAR	72.00 in	72.00 in	60.00 in	60.00 in	72.00 in	72.00 in	28.27	
LAT 5	24.40	CIRCULAR	36.00 in	36.00 in	24.00 in	24.00 in	36.00 in	36.00 in	7.07	
S43	184.90	CIRCULAR	60.00 in	60.00 in	66.00 in	66.00 in	60.00 in	60.00 in	19.63	Existing height is smaller

										than the suggested height. Existing width is smaller than the suggested width. Exceeds max. Depth/Rise
LAT 4	47.20	CIRCULAR	36.00 in	36.00 in	30.00 in	30.00 in	36.00 in	36.00 in	7.07	
S40	137.40	CIRCULAR	54.00 in	54.00 in	48.00 in	48.00 in	54.00 in	54.00 in	15.90	
S31	124.70	CIRCULAR	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	9.62	
S30	93.00	CIRCULAR	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	9.62	
LAT 1	15.60	CIRCULAR	24.00 in	24.00 in	21.00 in	21.00 in	24.00 in	24.00 in	3.14	
S28	77.10	CIRCULAR	36.00 in	36.00 in	33.00 in	33.00 in	36.00 in	36.00 in	7.07	
S26	12.80	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	
S22	12.10	CIRCULAR	18.00 in	18.00 in	21.00 in	21.00 in	18.00 in	18.00 in	1.77	Existing height is smaller than the suggested height. Existing width is smaller than the suggested width. Exceeds max. Depth/Rise
S21	68.50	CIRCULAR	36.00 in	36.00 in	33.00 in	33.00 in	36.00 in	36.00 in	7.07	
S20-1	67.80	CIRCULAR	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	7.07	
S20	67.80	CIRCULAR	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	36.00 in	7.07	
LAT 2	31.50	CIRCULAR	30.00 in	30.00 in	27.00 in	27.00 in	30.00 in	30.00 in	4.91	
LAT 3	13.40	CIRCULAR	24.00 in	24.00 in	21.00 in	21.00 in	24.00 in	24.00 in	3.14	

- 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): 6719.85

	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)**
S52	6719.05	6719.50	0.00	0.00	6723.60	6725.58	6729.46	0.00	6729.46
S51	6722.53	6724.53	0.57	0.00	6729.46	6730.28	6730.03	0.82	6730.85
S50-3	6724.97	6725.79	0.86	3.08	6729.53	6731.15	6734.41	0.34	6734.75
S50-2	6730.76	6731.58	0.16	0.00	6735.25	6736.94	6740.20	0.34	6740.54
S50-1	6736.61	6737.36	0.16	0.00	6741.30	6742.72	6745.84	0.47	6746.32
S50	6742.36	6745.58	0.16	0.00	6747.05	6750.94	6751.59	2.95	6754.54
S70	6747.58	6760.29	0.55	0.00	6752.47	6763.98	6755.09	11.71	6766.80
S69	6761.00	6761.22	0.13	0.08	6764.18	6765.53	6768.07	0.00	6768.07
S65	6764.46	6776.00	1.57	2.24	6770.70	6778.86	6771.89	8.53	6780.42
S64	6776.50	6777.06	2.67	0.00	6781.53	6782.08	6783.56	0.55	6784.10
S63	6776.51	6776.70	0.10	0.00	6780.44	6780.46	6780.52	0.02	6780.54

S68	6762.21	6762.76	0.07	0.00	6766.81	6767.10	6768.14	0.29	6768.43
S47	6745.75	6748.38	0.50	2.59	6756.47	6757.34	6757.63	0.87	6758.50
LAT 6	6751.88	6752.38	0.56	0.00	6758.25	6758.62	6759.06	0.37	6759.43
S45	6749.39	6750.64	0.04	0.31	6758.00	6758.38	6758.85	0.38	6759.23
LAT 5	6753.64	6758.14	0.10	0.00	6759.14	6759.73	6759.33	1.04	6760.37
S43	6751.79	6753.25	0.07	0.41	6758.86	6760.69	6760.24	1.83	6762.07
LAT 4	6755.25	6759.75	0.37	0.00	6761.74	6763.24	6762.43	1.49	6763.93
S40	6753.89	6761.85	0.06	1.01	6761.97	6765.30	6763.13	3.88	6767.01
S31	6763.77	6770.55	1.38	0.00	6766.68	6773.83	6771.05	5.53	6776.58
S30	6773.04	6777.38	0.07	2.25	6777.45	6781.13	6778.90	3.69	6782.58
LAT 1	6778.88	6780.68	0.37	0.00	6782.57	6783.14	6782.96	0.57	6783.52
S28	6777.87	6785.12	0.09	0.95	6782.18	6787.86	6784.03	5.85	6789.87
S26	6786.62	6787.52	0.93	0.00	6789.99	6790.87	6790.80	0.89	6791.69
S22	6787.82	6788.22	0.83	0.00	6791.79	6792.32	6792.52	0.53	6793.05
S21	6786.63	6788.57	1.17	1.48	6791.06	6792.20	6792.52	1.13	6793.65
S20-1	6788.82	6792.36	0.07	1.10	6793.40	6795.67	6794.83	2.28	6797.10
S20	6792.64	6793.64	1.43	0.00	6797.10	6797.79	6798.53	0.69	6799.22
LAT 2	6771.55	6772.15	0.84	0.00	6776.79	6777.02	6777.43	0.23	6777.66
LAT 3	6764.35	6765.10	0.37	0.00	6767.10	6767.28	6767.39	0.17	6767.56

- 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**
S52	34.70	7.00	8.00	10.17	0.00	0.00	0.00	27.50	17.50	9.67	162.59	Sewer Too Shallow
S51	200.00	4.00	6.00	6.67	24.44	14.05	9.89	34.54	19.10	14.94	1830.55	
S50-3	75.00	7.00	8.00	10.17	16.57	12.04	4.20	29.38	18.44	10.61	572.73	
S50-2	75.00	7.00	8.00	10.17	19.45	13.48	5.64	29.58	18.54	10.71	612.85	
S50-1	75.00	7.00	8.00	10.17	19.52	13.51	5.68	25.74	16.62	8.79	540.03	
S50	322.38	7.00	8.00	10.17	15.75	11.62	3.79	23.18	15.34	7.51	1935.80	
S70	706.00	5.00	6.00	7.83	21.18	13.00	7.67	32.42	18.63	13.29	5797.19	
S69	14.00	5.00	6.00	7.83	31.01	17.92	12.59	30.56	17.70	12.36	140.62	
S65	577.00	4.50	6.00	7.25	24.58	14.42	9.67	13.50	8.88	4.13	2710.84	
S64	37.50	4.00	6.00	6.67	13.01	8.34	4.17	11.88	7.77	3.61	86.27	
S63	13.00	2.50	4.00	4.92	14.49	8.04	5.79	14.10	7.84	5.59	29.39	

S68	37.00	4.50	6.00	7.25	29.09	16.67	11.92	27.98	16.12	11.37	318.18	
S47	263.20	7.00	8.00	10.17	22.84	15.17	7.34	25.90	16.70	8.87	2076.82	
LAT 6	50.00	3.50	6.00	6.08	22.40	12.74	9.16	19.74	11.41	7.83	240.85	
S45	156.04	7.00	8.00	10.17	23.88	15.69	7.85	19.46	13.48	5.65	1055.08	
LAT 5	300.00	4.00	6.00	6.67	16.46	10.06	5.90	19.72	11.69	7.53	1175.66	
S43	365.32	6.00	8.00	9.00	18.16	12.25	5.58	16.82	11.58	4.91	1696.02	
LAT 4	300.00	4.00	6.00	6.67	14.82	9.24	5.08	16.50	10.08	5.92	942.43	
S40	663.06	5.50	8.00	8.42	16.03	10.89	4.81	14.44	10.10	4.01	2458.38	
S31	294.78	4.50	6.00	7.25	11.60	7.92	3.17	18.90	11.58	6.83	982.79	
S30	433.65	4.50	6.00	7.25	13.91	9.08	4.33	11.06	7.66	2.91	1092.70	
LAT 1	120.00	3.00	4.00	5.50	9.56	5.86	3.03	17.64	9.90	7.07	283.74	
S28	289.83	4.00	6.00	6.67	10.57	7.12	2.95	14.96	9.31	5.15	700.72	
S26	60.00	2.50	4.00	4.92	13.46	7.52	5.27	10.46	6.02	3.77	102.80	
S22	40.00	2.50	4.00	4.92	9.86	5.72	3.47	9.06	5.32	3.07	47.92	
S21	107.74	4.00	6.00	6.67	11.94	7.80	3.64	11.00	7.33	3.17	224.56	
S20-1	221.44	4.00	6.00	6.67	10.51	7.09	2.92	12.16	7.91	3.75	456.12	
S20	67.00	4.00	6.00	6.67	11.61	7.64	3.47	11.66	7.66	3.50	141.88	
LAT 2	40.00	3.50	6.00	6.08	17.90	10.49	6.91	19.20	11.14	7.56	155.20	
LAT 3	50.00	3.00	4.00	5.50	11.94	7.05	4.22	26.80	14.48	11.65	224.30	

Total earth volume for sewer trenches = 28795 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.

3.2.2 Low Tailwater Basin

The design of low tailwater riprap basins is necessary when the receiving channel may have little or no flow or tailwater at time when the pipe or culvert is in operation. Figure 9-37 provides a plan and profile view of a typical low tailwater riprap basin.

By providing a low tailwater basin at the end of a storm drain conduit or culvert, the kinetic energy of the discharge dissipates under controlled conditions without causing scour at the channel bottom.

Low tailwater is defined as being equal to or less than ⅓ of the height of the storm drain, that is:

$$y_t \le \frac{D}{3} \quad \text{or} \quad y_t \le \frac{H}{3}$$

Where:

y_t = tailwater depth at design flow (feet) <0.83'

D = diameter of circular pipe (feet) =2.5'

H = height of rectangular pipe (feet)

Rock Size
The procedure for determining the required riprap size downstream of a conduit outlet is in Section 3.2.3.

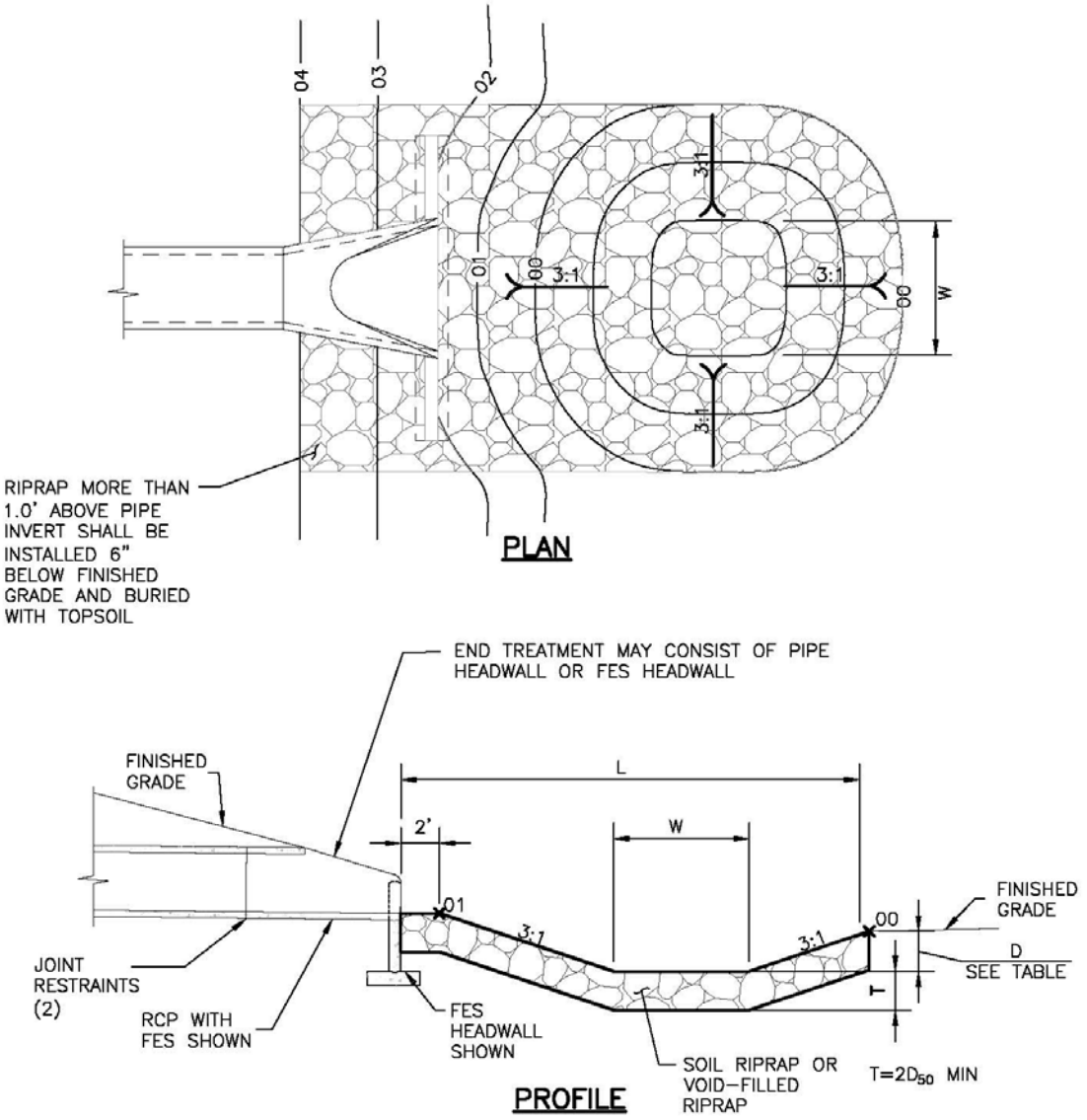
After selecting the riprap size, the minimum thickness of the riprap layer, T, in feet, in the basin is defined as: From figure 9-38, Type H Riprap required, D50=18"

$$T = 2D_{50}$$ =2*18"=3.0' Equation 9-15

Basin Geometry
Figure 9-37 includes a layout of a standard low tailwater riprap basin with the geometry parameters provided. The minimum length of the basin (L) and the width of the bottom of the basin (W1) are provided in a table at the bottom of Figure 9-37. All slopes in the low tailwater basin shall be 3(H):1(V), minimum.

Other Design Requirements
Extend riprap up the outlet embankment slope to the mid-pipe level, minimum. It is recommended that riprap that extends more than 1 foot above the outlet pipe invert be installed 6 inches below finished grade and buried with topsoil.

Provide pipe end treatment in the form of a pipe headwall or a flared-end section headwall. See Section 3.1 for options.



30" RCP
D=1.5'
W=6'
L=20'

PIPE SIZE OR BOX HEIGHT	D	W*	L
18" – 24"	1'–0"	4'	15'
30" – 36"	1'–6"	6'	20'
42" – 48"	2'–0"	7'	24'
54" – 60"	2'–6"	8'	28'
66" – 72"	3'–0"	9'	32'

* IF OUTLET PIPE IS A BOX CULVERT WITH A WIDTH GREATER THAN W, THEN W = CULVERT WIDTH

Figure 9-37. Low tailwater riprap basin

3.2.3 Rock Sizing for Riprap Apron and Low Tailwater Basin

Scour resulting from highly turbulent, rapidly decelerating flow is a common problem at conduit outlets. The following section summarizes the method for sizing riprap protection for both riprap aprons (Section 3.2.1) and low tailwater basins (Section 3.2.2).

Use Figure 9-38 to determine the required rock size for circular conduits and Figure 9-39 for rectangular conduits. Figure 9-38 is valid for $Q/D_c^{2.5}$ of 6.0 or less and Figure 9-39 is valid for $Q/WH^{1.5}$ of 8.0 or less. The parameters in these two figures are: Q/Dc^2.5=55.6cfs/(2.5'^2.5)=5.63<6 -Use figure 9-38

1. $Q/D^{1.5}$ or $Q/WH^{0.5}$ in which Q is the design discharge in cfs, D_c is the diameter of a circular conduit in feet, and W and H are the width and height of a rectangular conduit in feet.

2. Y_t/D_c or Y_t/H in which Y_t is the tailwater depth in feet, D_c is the diameter of a circular conduit in feet, and H is the height of a rectangular conduit in feet. In cases where Y_t is unknown or a hydraulic jump is suspected downstream of the outlet, use $Y_t/D_t = Y_t/H = 0.40$ when using Figures 9-38 and 9-39.

3. The riprap size requirements in Figures 9-38 and 9-39 are based on the non-dimensional parametric Equations 9-16 and 9-17 (Steven, Simons, and Watts 1971 and Smith 1975).

Circular culvert:

$$d_{50} = \frac{0.023Q}{Y_t^{1.2} D_c^{0.3}} \qquad \text{Equation 9-16}$$

Rectangular culvert:

$$d_{50} = \frac{0.014H^{0.5}Q}{Y_t W} \qquad \text{Equation 9-17}$$

These rock size requirements assume that the flow in the culvert is subcritical. It is possible to use Equations 9-16 and 9-17 when the flow in the culvert is supercritical (and less than full) if the value of D_c or H is modified for use in Figures 9-38 and 9-39. Note that rock sizes referenced in these figures are defined in the *Open Channels* chapter. Whenever the flow is supercritical in the culvert, substitute D_a for D_c and H_a for H, in which D_a is defined as:

$$D_a = \frac{(D_c + Y_n)}{2} \qquad \text{Equation 9-18}$$

Where the maximum value of D_a shall not exceed D_c, and

$$H_a = \frac{(H + Y_n)}{2}$$ Equation 9-19

Where the maximum value of H_a shall not exceed H, and:

D_a = parameter to use in place of D in Figure 9-38 when flow is supercritical (ft)

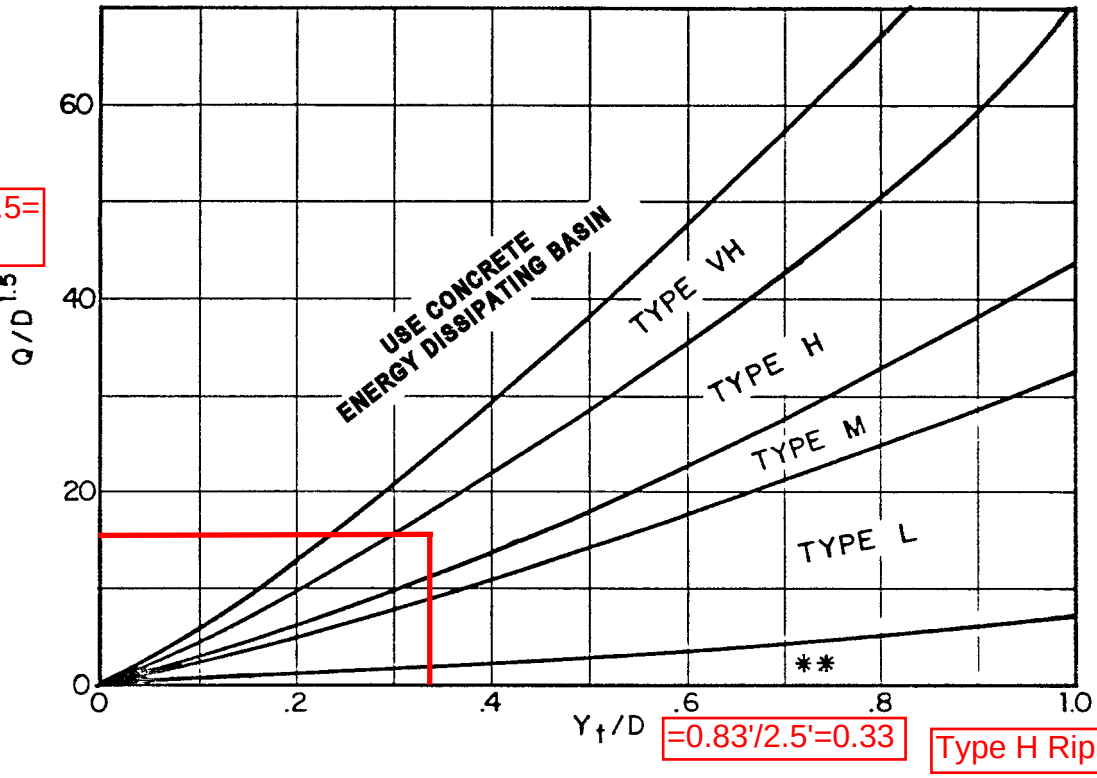
D_c = diameter of circular culvert (ft)

H_a = parameter to use in place of H in Figure 9-39 when flow is supercritical (ft)

H = height of rectangular culvert (ft)

Y_n = normal depth of supercritical flow in the culvert (ft)

55.6cfs/2.5^1.5=
14.07=



=0.83'/2.5'=0.33

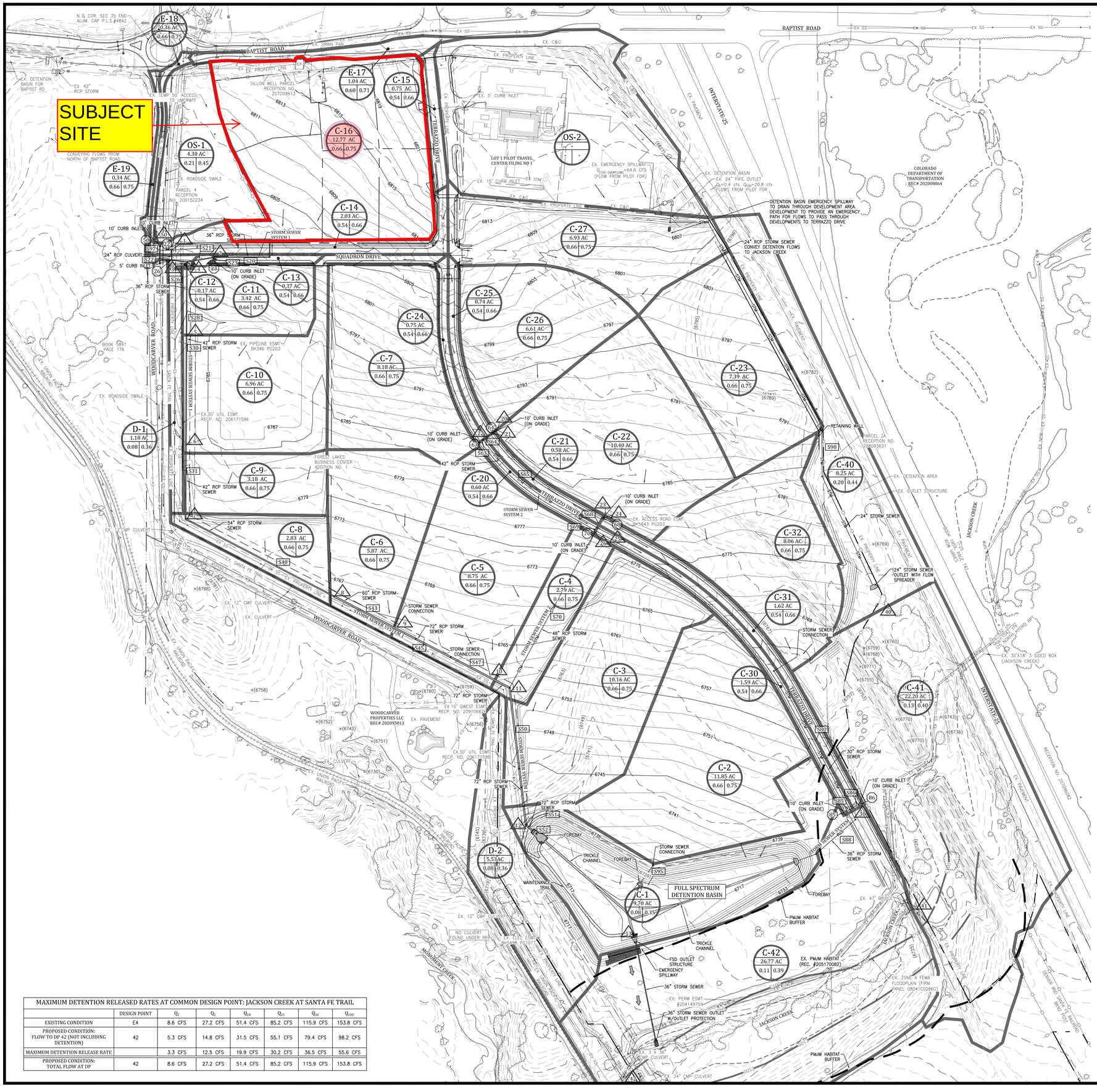
Type H Riprap required

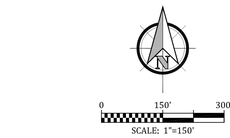
Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

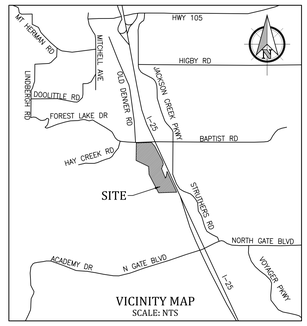
Figure 9-38. Riprap erosion protection at circular conduit outlet (valid for Q/D2.5 ≤ 6.0)

APPENDIX E

For Reference – MDDP Drainage Plan - Proposed Condition







LEGEND

- A — PROPOSED BASIN DESIGNATION
- 1.84 AC — DRAINAGE BASIN ACRES
- C5 RUNOFF COEF 0.76 — 0.83 C100 RUNOFF COEFFICIENT
- DIRECTIONAL FLOW ARROW
- DRAINAGE BASIN BOUNDARY
- 10 — HYDRAULIC STRUCTURE IDENTIFIER
- S10 — STORM SEWER IDENTIFIER
- 1 — DESIGN POINT
- STORMWATER FLOW PATH
- PROPOSED BUILDING
- EXISTING BUILDING
- R.O.W. / PROPERTY LINE
- EXISTING EASEMENT
- EXISTING STORM SEWER
- (6020) EXISTING CONTOURS
- 6020 PROPOSED CONTOURS
- 2.3% EXISTING FLOW DIRECTION AND SLOPE
- 2.3% PROPOSED FLOW DIRECTION AND SLOPE
- 4:1 PROPOSED SLOPE
- 100 EXISTING 100 YEAR FLOODPLAIN
- PROPOSED STORM SEWER PIPE AND MANHOLE
- PROPOSED DRAINAGE INLET
- PROPOSED DETENTION OUTLET STRUCTURE
- PLANNING/LAND USE AREAS

SUB-BASIN AND DESIGN POINT DISCHARGES

BASIN & DESIGN POINT	CONTRIBUTING BASINS	5-YR FLOW	100-YR FLOW
C-1		3.8 cfs	29.5 cfs
C-2		33.7 cfs	64.7 cfs
C-3		33.1 cfs	63.6 cfs
C-4		6.5 cfs	16.4 cfs
C-5		25.3 cfs	48.6 cfs
C-7		27.3 cfs	52.4 cfs
C-8		9.6 cfs	18.4 cfs
C-9		10.3 cfs	19.9 cfs
C-10		20.5 cfs	39.3 cfs
C-11		11.6 cfs	22.3 cfs
C-12		0.5 cfs	1.0 cfs
C-13		0.9 cfs	1.8 cfs
C-14		4.8 cfs	9.9 cfs
C-15		1.9 cfs	3.9 cfs
C-16		35.3 cfs	67.8 cfs
C-20		1.4 cfs	2.8 cfs
C-21		1.3 cfs	2.7 cfs
C-22		29.6 cfs	56.8 cfs
C-23		19.3 cfs	37.0 cfs
C-24		1.9 cfs	3.9 cfs
C-25		1.9 cfs	3.9 cfs
C-26		20.0 cfs	38.5 cfs
C-27		21.7 cfs	41.6 cfs
C-30		3.3 cfs	6.8 cfs
C-31		3.4 cfs	6.9 cfs
C-32		23.3 cfs	44.7 cfs
C-40		4.1 cfs	15.0 cfs
C-41		6.9 cfs	36.0 cfs
C-42		6.9 cfs	39.9 cfs
D-1		0.4 cfs	2.7 cfs
D-2		1.7 cfs	13.0 cfs
E-17		2.5 cfs	5.1 cfs
E-18		1.1 cfs	2.1 cfs
E-19		1.0 cfs	1.9 cfs
OS-1		1.6 cfs	8.5 cfs
OS-2		0.4 cfs	20.8 cfs
DP1	C-14+C-15	5.9 cfs	12.1 cfs
DP2	C-13+C-16	35.6 cfs	68.5 cfs
DP3	DP1+C-12	6.3 cfs	12.8 cfs
DP4	DP2+DP3	39.7 cfs	77.1 cfs
DP5	DP4+C-11	47.8 cfs	93.0 cfs
DP6	DP5+C-10	64.4 cfs	124.7 cfs
DP7	DP6+C-9	71.4 cfs	137.4 cfs
DP8	DP7+C-7+C-8	94.7 cfs	184.9 cfs
DP9	DP8+C-6	107.6 cfs	209.3 cfs
DP10	DP9+C-5	125.7 cfs	244.3 cfs
DP11	DP10+DP26+C-4	208.2 cfs	405.7 cfs
DP12	DP11+C-3	231.0 cfs	447.1 cfs
DP13	DP12+DP30+C1+C2	279.7 cfs	556.4 cfs
DP20	C-27+C-26	40.1 cfs	77.0 cfs
DP21	DP20+C-25	41.9 cfs	80.7 cfs
DP22	DP21+C-24	43.6 cfs	84.3 cfs
DP23	C-22+C-23	45.0 cfs	86.5 cfs
DP24	DP23+C-21	46.2 cfs	88.9 cfs
DP25	DP22+DP24	83.5 cfs	160.8 cfs
DP26	DP25+C-20	84.7 cfs	163.3 cfs
DP30	C-30+C-31+C-32	27.1 cfs	52.9 cfs
DP40	C40+OS2 (Detent)	4.5 cfs	35.8 cfs
DP41	DP40+C-41	9.9 cfs	66.6 cfs
DP42	DP41+C-42	14.8 cfs	98.2 cfs
DP50	E-18+OS-1	2.3 cfs	9.9 cfs

MAXIMUM DETENTION RELEASED RATES AT COMMON DESIGN POINT: JACKSON CREEK AT SANTA FE TRAIL

	DESIGN POINT	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
EXISTING CONDITION	E4	8.6 CFS	27.2 CFS	51.4 CFS	85.2 CFS	115.9 CFS	153.8 CFS
PROPOSED CONDITION: FLOW TO DP 42 (NOT INCLUDING DETENTION)	42	5.3 CFS	14.8 CFS	31.5 CFS	55.1 CFS	79.4 CFS	98.2 CFS
MAXIMUM DETENTION RELEASE RATE		3.3 CFS	12.5 CFS	19.9 CFS	30.2 CFS	36.5 CFS	55.6 CFS
PROPOSED CONDITION: TOTAL FLOW AT DP	42	8.6 CFS	27.2 CFS	51.4 CFS	85.2 CFS	115.9 CFS	153.8 CFS

DETENTION BASIN

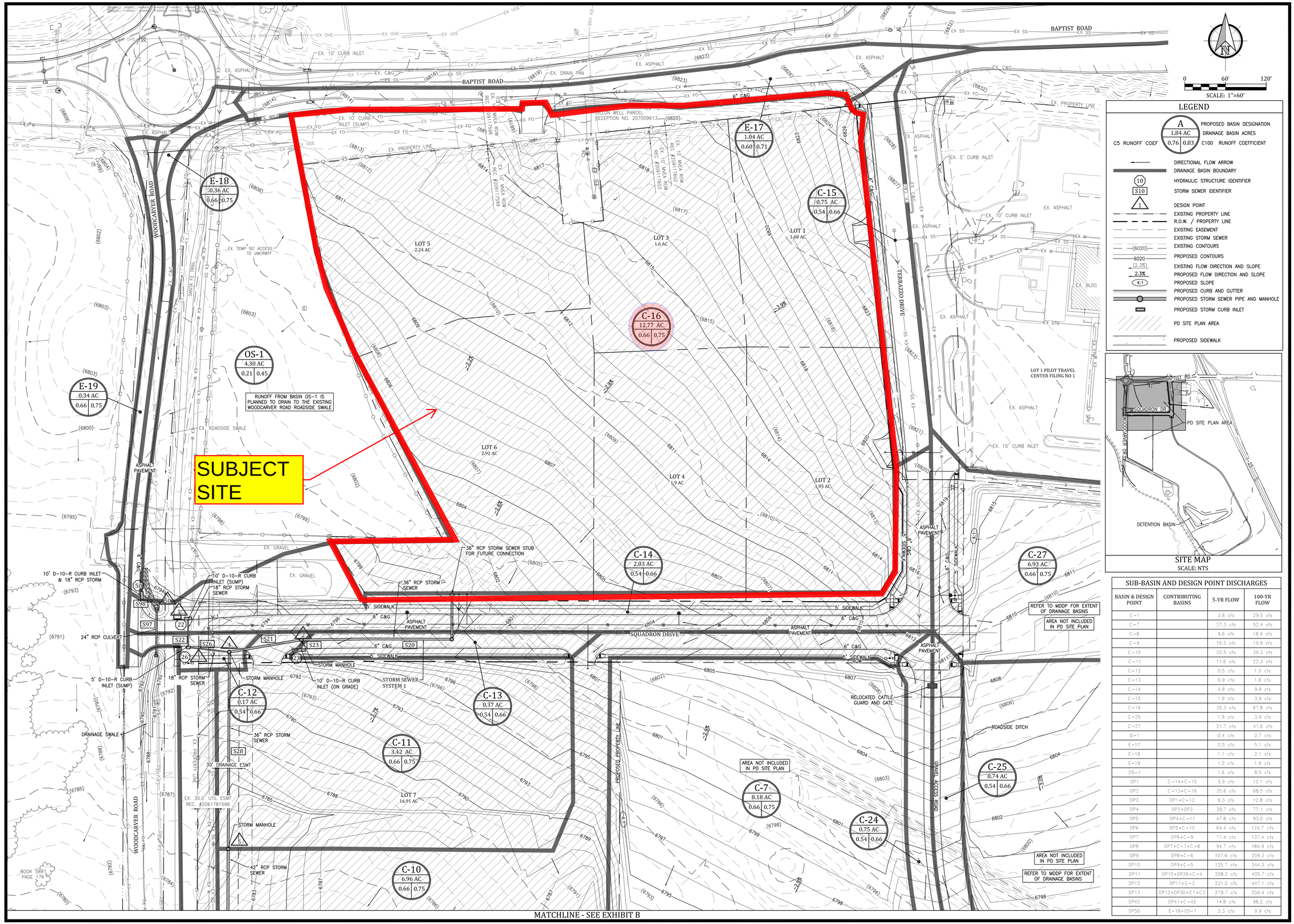
	REQUIRED STORAGE VOLUME
WQCV	3.57 AC-FT
EURV	11.70 AC-FT
100-YR	21.74 AC-FT
SPILLWAY CREST ELEVATION=6721.5	
TOP OF EMBANKMENT MINIMUM ELEVATION: 6724.0	

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

EXHIBIT B
FALCON COMMERCE CENTER
MASTER DEVELOPMENT DRAINAGE PLAN
DRAINAGE PLAN - PROPOSED CONDITION
DATE: SEPTEMBER 4, 2020

APPENDIX F

Proposed Condition Drainage Plan



0 60' 120'
SCALE: 1"=60'

LEGEND

- A / 1.84 AC / 0.76 | 0.83 — PROPOSED BASIN DESIGNATION; DRAINAGE BASIN ACRES; C5 RUNOFF COEF; C100 RUNOFF COEFFICIENT
- DIRECTIONAL FLOW ARROW
- DRAINAGE BASIN BOUNDARY
- 10 / S10 — HYDRAULIC STRUCTURE IDENTIFIER
- STORM SEWER IDENTIFIER
- 1 — DESIGN POINT
- EXISTING PROPERTY LINE
- R.O.W. / PROPERTY LINE
- EXISTING EASEMENT
- EXISTING STORM SEWER
- (6020) — EXISTING CONTOURS
- 6020 — PROPOSED CONTOURS
- (2.3%) — EXISTING FLOW DIRECTION AND SLOPE
- 2.3% — PROPOSED FLOW DIRECTION AND SLOPE
- 4:1 — PROPOSED SLOPE
- PROPOSED CURB AND GUTTER
- PROPOSED STORM SEWER PIPE AND MANHOLE
- PROPOSED STORM CURB INLET
- PD SITE PLAN AREA
- PROPOSED SIDEWALK

SITE MAP
SCALE: NTS

SUB-BASIN AND DESIGN POINT DISCHARGES

BASIN & DESIGN POINT	CONTRIBUTING BASINS	5-YR FLOW	100-YR FLOW
C-1		3.8 cfs	29.5 cfs
C-7		27.3 cfs	52.4 cfs
C-8		9.6 cfs	18.4 cfs
C-9		10.3 cfs	19.9 cfs
C-10		20.5 cfs	39.3 cfs
C-11		11.6 cfs	22.3 cfs
C-12		0.5 cfs	1.0 cfs
C-13		0.9 cfs	1.8 cfs
C-14		4.8 cfs	9.9 cfs
C-15		1.9 cfs	3.9 cfs
C-16		35.3 cfs	67.8 cfs
C-25		1.9 cfs	3.9 cfs
C-27		21.7 cfs	41.6 cfs
D-1		0.4 cfs	2.7 cfs
E-17		2.5 cfs	5.1 cfs
E-18		1.1 cfs	2.1 cfs
E-19		1.0 cfs	1.9 cfs
OS-1		1.6 cfs	8.5 cfs
DP1	C-14+C-15	5.9 cfs	12.1 cfs
DP2	C-13+C-16	35.6 cfs	68.5 cfs
DP3	DP1+C-12	6.3 cfs	12.8 cfs
DP4	DP2+DP3	39.7 cfs	77.1 cfs
DP5	DP4+C-11	47.8 cfs	93.0 cfs
DP6	DP5+C-10	64.4 cfs	124.7 cfs
DP7	DP6+C-9	71.4 cfs	137.4 cfs
DP8	DP7+C-7+C-8	94.7 cfs	184.9 cfs
DP9	DP8+C-6	107.6 cfs	209.3 cfs
DP10	DP9+C-5	125.7 cfs	244.3 cfs
DP11	DP10+DP26+C-4	208.2 cfs	405.7 cfs
DP12	DP11+C-3	231.0 cfs	447.1 cfs
DP13	DP12+DP30+C1+C2	279.7 cfs	556.4 cfs
DP42	DP41+C-42	14.8 cfs	98.2 cfs
DP50	E-18+OS-1	2.3 cfs	9.9 cfs

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

FALCON COMMERCE CENTER
PD SITE PLAN-LOTS 1-7
PRELIMINARY DRAINAGE PLAN
MONUMENT, COLORADO

Project No.:	19036
Date:	September 3, 2020
Design:	MWE/MTR
Drawn:	MTR
Check:	MWE
Revisions:	

EXHIBIT
A

FALCON COMMERCE CENTER MASTER DRANAGE PLAN FOR ALL SURROUNDING AREAS SOUTH OF BAPTIST ROAD

LEGEND

- WATER LINE
- SANITARY SEWER LINE
- UNDERGROUND ELECTRIC LINE
- UNDERGROUND TELEPHONE LINE
- MAJOR CONTOUR (EXISTING)
- MINOR CONTOUR (EXISTING)

TERRAZZO DR. (R.O.W. VARIES)

EX-1
523,426 SF
12.02 ACRES
IMPERV= 0 SF
PERVIOUS= 523,426 SF
C(5)=0.08
C(100)=0.35
Q(5)=3.37 CFS
Q(100)=24.80 CFS

OS 1
26,571 SF
0.61 ACRES
IMPERV= 3,049 SF
PERVIOUS= 23,522 SF
C(5)=0.17
C(100)=0.42
Q(5)=0.41 CFS
Q(100)=1.77 CFS

OLD DENVER RD. (50' R.O.W.)

WOODCARVER RD. (R.O.W. VARIES)

BAPTIST RD. (R.O.W. VARIES)

BAPTIST RD (R.O.W. VARIES)

50 25 0 50 100

PROJECT NO.:######

QuikTrip No. 4299

S.W.C. OF BAPTIST RD & TERRAZZO DR.
MONUMENT, COLORADO

PROTOTYPE:	P-107 (08/01/21)
DIVISION:	83
VERSION:	001
DESIGNED BY:	DLR
DRAWN BY:	DLR
REVIEWED BY:	ACJ

REV	DATE	DESCRIPTION

ORIGINAL ISSUE DATE: X/XX/2021

SHEET TITLE:
PRE-DEVELOPED DRAINAGE

SHEET NUMBER:
1

FILE LOCATION:H:\Quiktrip\QKT004299-Monument, CO\OCIV\2-Plan\83-4299_Civil.dwg TAB NAME:Pre Dev Map USER:Duncan_Rody SAVED:9/14/2021 3:07 PM PLOTTED:9/14/2021 3:08 PM

COMPOSITE % IMPERVIOUS CALCULATIONS - EXISTING

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 9/14/21

Basin ID	Total Area (ac)	Paved Roads			Agriculture			Roofs			Basins Total Weighted % Imp.
		% Imp.	Area (ac)	Weighted % Imp.	% Imp.	Area (ac)	Weighted % Imp.	% Imp.	Area (ac)	Weighted % Imp.	
EX-1	12.02	100	0.00	0.0	2	12.02	2.0	90	0.00	0.00	2.0
OS-1	0.61	100	0.07	11.5	2	0.54	1.8	90	0.00	0.00	13.3
Total	12.63									Total:	2.5

COMPOSITE % IMPERVIOUS CALCULATIONS - EXISTING

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 9/14/21

Basin ID	Total Area (ac)	Paved Roads (I = 100%)					Agriculture (I = 2%)					Roofs (I = 90%)					Basins Total Weighted C	
		C		Area (ac)	Weighted C		C		Area (ac)	Weighted C		C		Area (ac)	Weighted C			
		5yr	100yr		5yr	100yr	5yr	100yr		5yr	100yr	5yr	100yr		5yr	100yr	5yr	100yr
EX-1	12.02	0.90	0.96	0.00	0.00	0.00	0.08	0.35	12.02	0.08	0.35	0.73	0.81	0.00	0.00	0.00	0.08	0.35
OS-1	0.61	0.90	0.96	0.07	0.10	0.11	0.08	0.35	0.54	0.07	0.31	0.73	0.81	0.00	0.00	0.00	0.17	0.42
Total	12.63															Total:	0.08	0.35

STANDARD FORM SF-2
TIME OF CONCENTRATION - EXISTING

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 9/14/21

SUB-BASIN DATA						INITIAL/OVERLAND (T_i)			TRAVEL TIME (T_t)					Tc CHECK (URBANIZED BASINS)			FINAL
BASIN ID	D.A. (AC)	Hydrologic Soils Group	Impervious (%)	C_5	C_{100}	L (FT)	S (%)	T_i (MIN)	L (FT)	S (%)	Cv	VEL. (FPS)	T_t (MIN)	COMP. T_c (MIN)	TOTAL LENGTH (FT)	Urbanized T_c (MIN)	T_c (MIN)
EX-1	12.02	B	2.0	0.08	0.35	300	3.5	21.3	624	3.0	7.0	1.2	8.6	29.9	924.0	15.1	15.1
OS-1	0.61	B	13.3	0.17	0.42	74	6.6	7.8	139	1.5	7.0	0.9	2.7	10.5	213.0	11.2	10.5

NOTES:

T_i = (0.395*(1.1 - C_5)*(L)^0.5)/((S)^0.33), S in ft/ft

T_t=L/60V (Velocity From Fig. 501)

Velocity V=Cv*S^0.5, S in ft/ft

Tc Check = 10+L/180

For Urbanized basins a minimum T_c of 5.0 minutes is required.

For non-urbanized basins a minimum T_c of 10.0 minutes is required

Type of Land Surface	Cv
Heavy Meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

STANDARD FORM SF-3
STORM DRAINAGE SYSTEM DESIGN - EXISTING
(RATIONAL METHOD PROCEDURE)

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs
Design Storm: 5-Year

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 9/14/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
		Basin ID	Area (Ac)	Runoff Coeff.	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (min)	
	1	EX-1	12.02	0.08	15.1	0.96	3.51	3.4				3.37									To Squadron Drive Inlets
	1	OS-1	0.61	0.17	10.5	0.10	4.05	0.4				0.41									To Squadron Drive Inlets

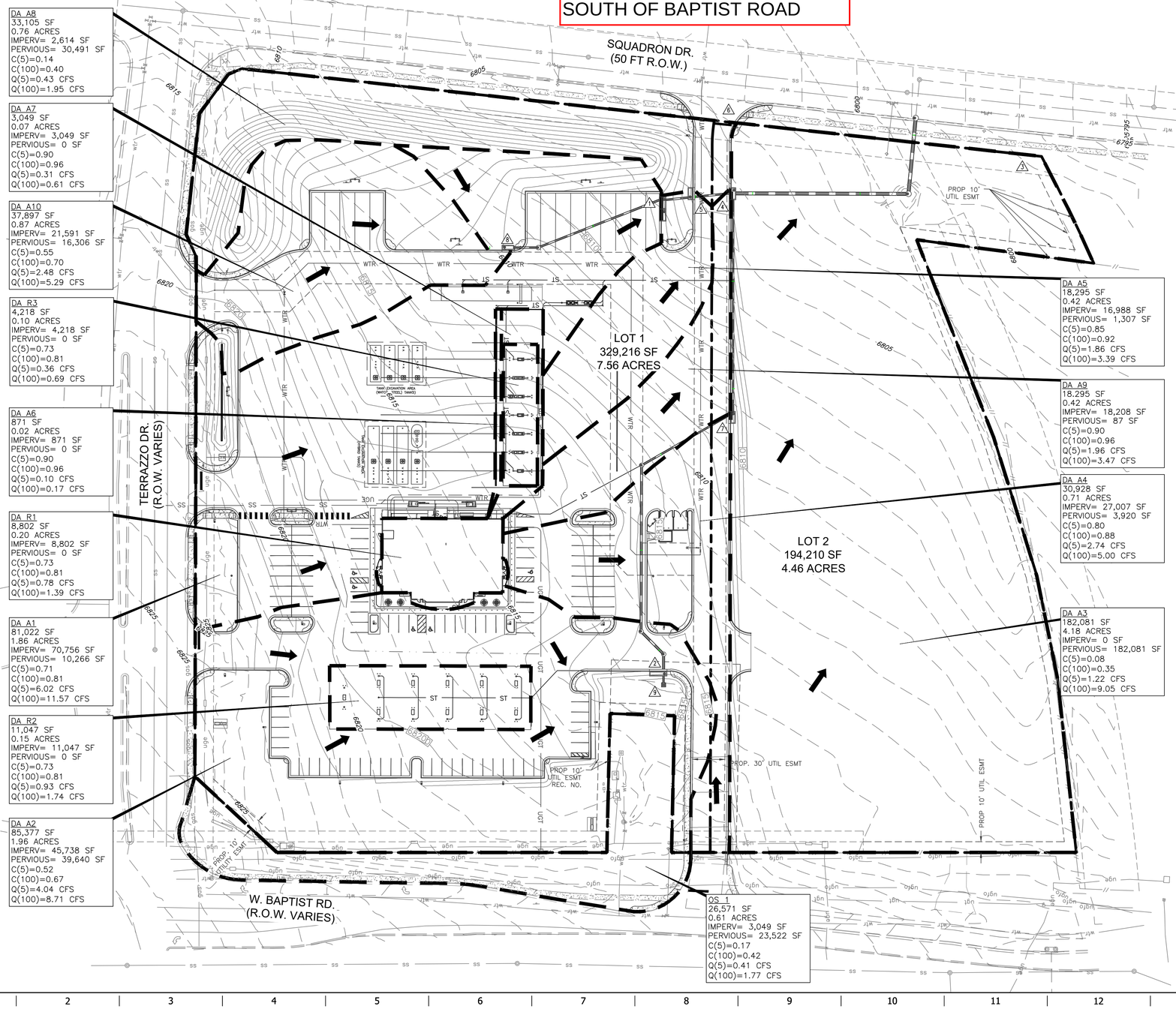
STANDARD FORM SF-3
STORM DRAINAGE SYSTEM DESIGN - EXISTING
(RATIONAL METHOD PROCEDURE)

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs
Design Storm: 100-Year

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 9/14/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
		Basin ID	Area (Ac)	Runoff Coeff.	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (min)	
	1	EX-1	12.02	0.35	15.1	4.21	5.89	24.8				24.80									To Squadron Drive Inlets
	1	OS-1	0.61	0.42	10.5	0.26	6.81	1.8				1.77									To Squadron Drive Inlets

FALCON COMMERCE CENTER MASTER DRAINAGE PLAN FOR ALL SURROUNDING AREAS SOUTH OF BAPTIST ROAD



LEGEND

- WTR — WATER LINE
- SS — SANITARY SEWER LINE
- UGET — UNDERGROUND ELECTRIC LINE
- UGT — UNDERGROUND TELEPHONE LINE
- ST — STORM PIPE (≤ 10")
- STORM PIPE (≥ 12")
- XXX — MAJOR CONTOUR
- XXX — MINOR CONTOUR
- CONCRETE CURB AND GUTTER
- BASIN BOUNDARY

DESIGN POINT SUMMARY TABLE

BASIN & DESIGN POINT	CONTRIBUTING BASINS	Q_5 (cfs)	Q_{100} (cfs)
DA A1		6.02	11.57
DA A2		4.04	8.71
DA A3		1.22	9.05
DA A4		2.74	5.00
DA A5		1.86	3.39
DA A6		0.10	0.17
DA A7		0.31	0.61
DA A8		0.43	1.95
DA A9		1.96	3.47
DA A10		2.48	5.29
DA R1		0.78	1.39
DA R2		0.93	1.74
DA R3		0.36	0.69
OS-1		0.41	1.77
DP1	DA (A1+A10)	8.50	16.86
DP2	DA A2	4.04	8.71
DP3	DA A3	1.22	9.05
DP4	DA (A1+A10+A5+A9+A4+A2+A6+A7+R1+R2+R3+OS-1)	19.51	43.80
DP5	DA (A1+A10+A5)		
DP6	DA A8	0.43	1.95
DP7	DA (A2+ R1+R2+A4)	8.48	16.83
DP8	DA A10	2.48	5.29
DP9	OS-1	0.41	1.77

50 25 0 50 100

SCALE: 1"=50'-0"

PROJECT NO.:QKT004299

QuikTrip No. 4299

S.W.C. OF BAPTIST RD & TERRAZZO DR.
MONUMENT, COLORADO

PROTOTYPE: P-107 (08/01/21)
DIVISION: 83
VERSION: 001
DESIGNED BY: DLR
DRAWN BY: DLR
REVIEWED BY: ACJ

REV	DATE	DESCRIPTION

ORIGINAL ISSUE DATE: 9/24/2021

SHEET TITLE:
GRADING_DRAINAGE PLAN

SHEET NUMBER:
13

FILE LOCATION:H:\Quiktrip\QKT004299-Monument, CO\0CIV\2-Plan\83-4299_Civil.dwg TAB NAME:Grading_Drainage (PUD) USER:Duncan_Rody SAVED:11/11/2021 3:12 PM PLOTTED:11/11/2021 3:20 PM

COMPOSITE % IMPERVIOUS CALCULATIONS - PROPOSED

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 11/11/21

Basin ID	Total Area (ac)	Paved Roads			Agriculture			Roofs			Basins Total Weighted % Imp.
		% Imp.	Area (ac)	Weighted % Imp.	% Imp.	Area (ac)	Weighted % Imp.	% Imp.	Area (ac)	Weighted % Imp.	
DA A1	1.86	100	1.42	76.3	2	0.44	0.5	90	0.00	0.00	76.8
DA A2	1.96	100	1.05	53.6	2	0.91	0.9	90	0.00	0.00	54.5
DA A3	4.18	100	0.00	0.0	2	4.18	2.0	90	0.00	0.00	2.0
DA A4	0.71	100	0.62	87.32	2	0.09	0.30	90	0.00	0.00	87.6
DA A5	0.42	100	0.39	92.86	2	0.03	0.10	90	0.00	0.00	93.0
DA A6	0.02	100	0.02	100.0	2	0.00	0.0	90	0.00	0.00	100.0
DA A7	0.07	100	0.07	100.0	2	0.00	0.0	90	0.00	0.00	100.0
DA A8	0.76	100	0.06	7.9	2	0.70	1.8	90	0.00	0.00	9.7
DA A9	0.42	100	0.42	99.5	2	0.00	0.0	90	0.00	0.00	99.5
DA A10	0.87	100	0.50	57.5	2	0.37	0.9	90	0.00	0.00	58.4
DA R1	0.20	100	0.00	0.0	2	0.00	0.0	90	0.20	90.00	90.0
DA R2	0.25	100	0.00	0.0	2	0.00	0.0	90	0.25	90.00	90.0
DA R3	0.10	100	0.00	0.0	2	0.00	0.0	90	0.10	90.00	90.0
OS-1	0.61	100	0.07	11.5	2	0.54	1.8	90	0.00	0.00	13.3
Total On-Site	11.82									Total:	43.8
Total Off-Site	0.61									Total:	13.3

COMPOSITE % IMPERVIOUS CALCULATIONS - PROPOSED

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 11/11/21

Basin ID	Total Area (ac)	Paved Roads (I = 100%)					Agriculture (I = 2%)					Roofs (I = 90%)					Basins Total Weighted C	
		C		Area (ac)	Weighted C		C		Area (ac)	Weighted C		C		Area (ac)	Weighted C			
		5yr	100yr		5yr	100yr	5yr	100yr		5yr	100yr	5yr	100yr		5yr	100yr	5yr	100yr
DA A1	1.86	0.90	0.96	1.42	0.69	0.73	0.08	0.35	0.44	0.02	0.08	0.73	0.81	0.00	0.00	0.00	0.71	0.81
DA A2	1.96	0.90	0.96	1.05	0.48	0.51	0.08	0.35	0.91	0.04	0.16	0.73	0.81	0.00	0.00	0.00	0.52	0.67
DA A3	4.18	0.90	0.96	0.00	0.00	0.00	0.08	0.35	4.18	0.08	0.35	0.73	0.81	0.00	0.00	0.00	0.08	0.35
DA A4	0.71	0.90	0.96	0.62	0.79	0.84	0.08	0.35	0.09	0.01	0.04	0.73	0.81	0.00	0.00	0.00	0.80	0.88
DA A5	0.42	0.90	0.96	0.39	0.84	0.89	0.08	0.35	0.03	0.01	0.03	0.73	0.81	0.00	0.00	0.00	0.85	0.92
DA A6	0.02	0.90	0.96	0.02	0.90	0.96	0.08	0.35	0.00	0.00	0.00	0.73	0.81	0.00	0.00	0.00	0.90	0.96
DA A7	0.07	0.90	0.96	0.07	0.90	0.96	0.08	0.35	0.00	0.00	0.00	0.73	0.81	0.00	0.00	0.00	0.90	0.96
DA A8	0.76	0.90	0.96	0.06	0.07	0.08	0.08	0.35	0.70	0.07	0.32	0.73	0.81	0.00	0.00	0.00	0.14	0.40
DA A9	0.42	0.90	0.96	0.42	0.90	0.96	0.08	0.35	0.00	0.00	0.00	0.73	0.81	0.00	0.00	0.00	0.90	0.96
DA A10	0.87	0.90	0.96	0.50	0.52	0.55	0.08	0.35	0.37	0.03	0.15	0.73	0.81	0.00	0.00	0.00	0.55	0.70
DA R1	0.20	0.90	0.96	0.00	0.00	0.00	0.08	0.35	0.00	0.00	0.00	0.73	0.81	0.20	0.73	0.81	0.73	0.81
DA R2	0.25	0.90	0.96	0.00	0.00	0.00	0.08	0.35	0.00	0.00	0.00	0.73	0.81	0.25	0.73	0.81	0.73	0.81
DA R3	0.10	0.90	0.96	0.00	0.00	0.00	0.08	0.35	0.00	0.00	0.00	0.73	0.81	0.10	0.73	0.81	0.73	0.81
OS-1	0.61	0.90	0.96	0.07	0.10	0.11	0.08	0.35	0.54	0.07	0.31	0.73	0.81	0.00	0.00	0.00	0.17	0.42
Total Off-Site	12.43															Total:	0.41	0.60

STANDARD FORM SF-2
TIME OF CONCENTRATION - PROPOSED

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: ######

SUB-BASIN DATA						INITIAL/OVERLAND (T_i)			TRAVEL TIME (T_t)					Tc CHECK (URBANIZED BASINS)			FINAL
BASIN ID	D.A. (AC)	Hydrologic Soils Group	Impervious (%)	C_5	C_{100}	L (FT)	S (%)	T_i (MIN)	L (FT)	S (%)	Cv	VEL. (FPS)	T_t (MIN)	COMP. T_c (MIN)	TOTAL LENGTH (FT)	Urbanized T_c (MIN)	T_c (MIN)
DA A1	1.86	B	76.8	0.71	0.81	100	3.0	5.0	530	3.0	20.0	3.5	2.5	7.5	630.0	13.5	7.5
DA A2	1.96	B	54.5	0.52	0.67	100	1.5	9.3	324	2.0	20.0	2.8	1.9	11.2	424.0	12.4	11.2
DA A3	4.18	B	2.0	0.08	0.35	300	3.0	22.4	309	4.0	20.0	4.0	1.3	23.7	609.0	13.4	13.4
DA A4	0.71	B	87.6	0.80	0.88	100	3.0	3.8	310	1.0	20.0	2.0	2.6	6.4	410.0	12.3	6.4
DA A5	0.42	B	93.0	0.85	0.92	100	5.0	2.7	204	5.0	20.0	4.5	0.8	3.4	304.0	11.7	5.0
DA A6	0.02	B	100.0	0.90	0.96	-	-	0.0			20.0	0.0	0.0	0.0	0.0	10.0	5.0
DA A7	0.07	B	100.0	0.90	0.96	-	-	0.0			20.0	0.0	0.0	0.0	0.0	10.0	5.0
DA A8	0.76	B	9.7	0.14	0.40	100	7.5	9.0	496	2.0	20.0	2.8	2.9	11.9	596.0	13.3	11.9
DA A9	0.42	B	99.5	0.90	0.96	100	4.0	2.3	329	4.0	20.0	4.0	1.4	3.7	429.0	12.4	5.0
DA A10	0.87	B	58.4	0.55	0.70	-	-	0.0			20.0	0.0	0.0	0.0	0.0	10.0	5.0
DA R1	0.20	B	90.0	0.73	0.81	-	-	0.0			20.0	0.0	0.0	0.0	0.0	10.0	5.0
DA R2	0.25	B	90.0	0.73	0.81	-	-	0.0			20.0	0.0	0.0	0.0	0.0	10.0	5.0
DA R3	0.10	B	90.0	0.73	0.81	-	-	0.0			20.0	0.0	0.0	0.0	0.0	10.0	5.0
OS-1	0.61	B	13.3	0.17	0.42	74	6.6	7.8	139	1.5	7.0	0.9	2.7	10.5	213.0	11.2	10.5

NOTES:

$T_i = (0.395*(1.1 - C_5)*(L)^{0.5})/((S)^{0.33})$, S in ft/ft

T_t=L/60V (Velocity From Fig. 501)

Velocity V=Cv*S^0.5, S in ft/ft

Tc Check = 10+L/180

For Urbanized basins a minimum T_c of 5.0 minutes is required.

For non-urbanized basins a minimum T_c of 10.0 minutes is required

STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN - PROPOSED

(RATIONAL METHOD PROCEDURE)

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs
Design Storm: 5-Year

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 11/11/21

		DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			
STREET	Design Point	Basin ID	Area (Ac)	Runoff Coeff.	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (min)	REMARKS
	DP1	DA A1	1.86	0.71	7.5	1.32	4.56	6.0				6.02									Curb Inlet
	DP2	DA A2	1.96	0.52	11.2	1.02	3.96	4.0				4.04									Curb Inlet
	DP3	DA A3	4.18	0.08	13.4	0.33	3.69	1.2				1.22									Curb Inlet
	DP7	DA A4	0.71	0.80	6.4	0.57	4.80	2.7				2.74									Curb Inlet
	DP5	DA A5	0.42	0.85	5.0	0.36	5.17	1.9				1.86									Curb Inlet
	-	DA A6	0.02	0.90	5.0	0.02	5.17	0.1				0.10									Trench Drain
	-	DA A7	0.07	0.90	5.0	0.06	5.17	0.3				0.31									Trench Drain
	DP6	DA A8	0.76	0.14	11.9	0.11	3.87	0.4				0.43									Curb Inlet
	DP4	DA A9	0.42	0.90	5.0	0.38	5.17	2.0				1.96									Curb Inlet
	DP8	DA A10	0.87	0.55	5.0	0.48	5.17	2.5				2.48									Curb Inlet
	-	DA R1	0.20	0.73	5.0	0.15	5.17	0.8				0.78									Roof Drains
	-	DA R2	0.25	0.73	5.0	0.18	5.17	0.9				0.93									Roof Drains
	-	DA R3	0.10	0.73	5.0	0.07	5.17	0.4				0.36									Roof Drains
	DP9	OS-1	0.61	0.17	10.5	0.10	4.05	0.4				0.41									Curb Inlet

STANDARD FORM SF-3
STORM DRAINAGE SYSTEM DESIGN - PROPOSED
(RATIONAL METHOD PROCEDURE)

Subdivision: Falcon Commerce Center
Location: CO, Colorado Springs
Design Storm: 100-Year

Project Name: QuikTrip #4299
Project No.: QKT004299
Calculated By: DLR
Checked By: ACJ
Date: 11/11/21

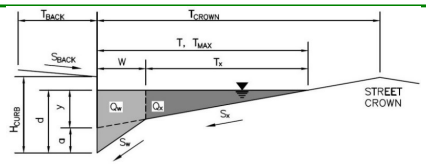
STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
		Basin ID	Area (Ac)	Runoff Coeff.	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Tc (min)	C*A (Ac)	I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	Tt (min)	
	DP1	DA A1	1.86	0.81	7.5	1.51	7.66	11.6				11.57									Curb Inlet
	DP2	DA A2	1.96	0.67	11.2	1.31	6.65	8.7				8.71									Curb Inlet
	DP3	DA A3	4.18	0.35	13.4	1.46	6.20	9.1				9.05									Curb Inlet
	DP7	DA A4	0.71	0.88	6.4	0.62	8.06	5.0				5.00									Curb Inlet
	DP5	DA A5	0.42	0.92	5.0	0.39	8.68	3.4				3.39									Curb Inlet
	-	DA A6	0.02	0.96	5.0	0.02	8.68	0.2				0.17									Trench Drain
	-	DA A7	0.07	0.96	5.0	0.07	8.68	0.6				0.61									Trench Drain
	DP6	DA A8	0.76	0.40	11.9	0.30	6.49	1.9				1.95									Curb Inlet
	DP4	DA A9	0.42	0.96	5.0	0.40	8.68	3.5				3.47									Curb Inlet
	DP8	DA A10	0.87	0.70	5.0	0.61	8.68	5.3				5.29									Curb Inlet
	-	DA R1	0.20	0.81	5.0	0.16	8.68	1.4				1.39									Roof Drains
	-	DA R2	0.25	0.81	5.0	0.20	8.68	1.7				1.74									Roof Drains
	-	DA R3	0.10	0.81	5.0	0.08	8.68	0.7				0.69									Roof Drains
	DP9	OS-1	0.61	0.42	10.5	0.26	6.81	1.8				1.77									Curb Inlet

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

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

Project:

Inlet ID: **Inlet A1**



Gutter Geometry:

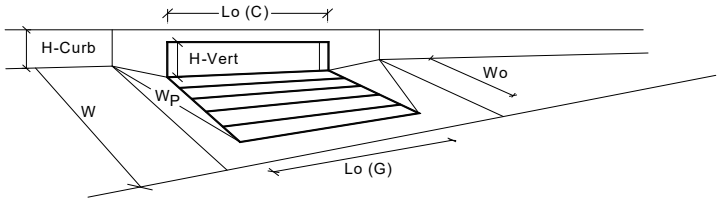
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	500.0	ft
Warning 1 Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.027	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 =	0.000	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} =	50.0	50.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

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

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.01 (April 2021)



Design Information (Input)	CDOT Type R Curb Opening		MINOR	MAJOR	
Type of Inlet		Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	3	3	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information			MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate		L_o (G) =	N/A	N/A	feet
Width of a Unit Grate		W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)		A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C_o (G) =	N/A	N/A	
Curb Opening Information			MINOR	MAJOR	
Length of a Unit Curb Opening		L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W_p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)			MINOR	MAJOR	
Depth for Grate Midwidth		d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d_{Curb} =	0.42	0.42	ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.57	0.57	
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	0.79	0.79	
Grated Inlet Performance Reduction Factor for Long Inlets		RF_{Grate} =	N/A	N/A	
			MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)		**Q_a =**	**14.9**	**14.9**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	6.1	13.0	cfs

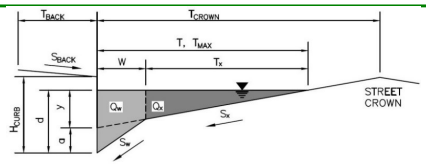
Warning 5: The width of unit is greater than the gutter width.

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

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

Project:

Inlet ID: **Inlet A2**



Gutter Geometry:

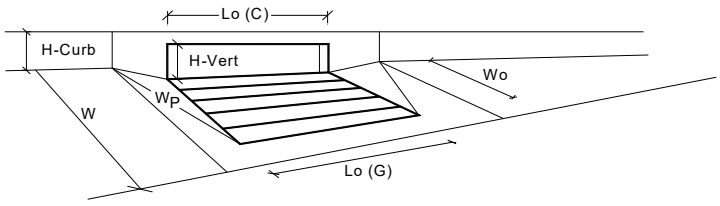
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	35.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.010	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 =	0.000	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} =	35.0	35.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	6.0	inches
Check boxes are not applicable in SUMP conditions		☐	☐	

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

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.01 (April 2021)



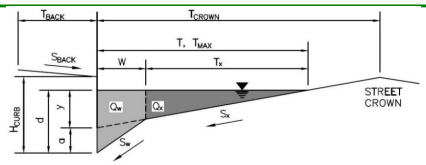
Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)	a_{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)	No =	3	3	
Water Depth at Flowline (outside of local depression)	Ponding Depth =	5.1	5.1	inches
Grate Information		MINOR	MAJOR	☐ Override Depths
Length of a Unit Grate	L_o (G) =	N/A	N/A	feet
Width of a Unit Grate	W_o =	N/A	N/A	feet
Area Opening Ratio for a Grate (typical values 0.15-0.90)	A_{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)	C_f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)	C_w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)	C_o (G) =	N/A	N/A	
Curb Opening Information		MINOR	MAJOR	
Length of a Unit Curb Opening	L_o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches	H_{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches	H_{throat} =	6.00	6.00	inches
Angle of Throat (see USDCM Figure ST-5)	Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)	W_p =	1.00	1.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)	C_f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)	C_w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)	C_o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)		MINOR	MAJOR	
Depth for Grate Midwidth	d_{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation	d_{Curb} =	0.34	0.34	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.48	0.48	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.73	0.73	
Grated Inlet Performance Reduction Factor for Long Inlets	RF_{Grate} =	N/A	N/A	
		MINOR	MAJOR	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**10.1**	**10.1**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	4.0	8.7	cfs

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

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

Project:

Inlet ID: **Inlet A4**



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		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} =	35.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.020	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 =	0.005	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} =	35.0	35.0	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)		☐	☐	

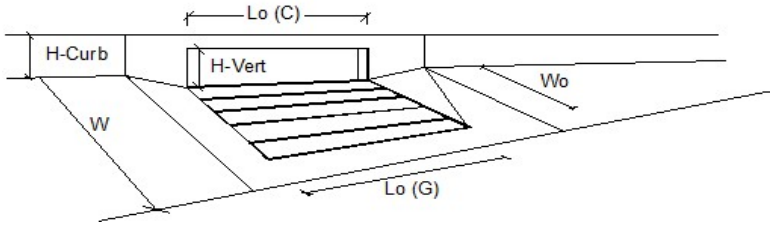
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**13.8**	**13.8**	**cfs**

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	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	

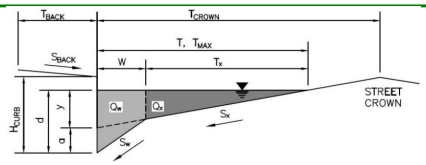
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**2.7**	**4.5**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.5**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**90**	**%**

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

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

Project:

Inlet ID: **Inlet A5**



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		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} =	17.5	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.007	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 =	0.038	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} =	17.5	17.5	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)		☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	1.49	1.49	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	1.0	1.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	0.91	0.91	inches
Water Depth at Gutter Flowline	d =	2.40	2.40	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	16.5	16.5	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.213	0.213	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	3.2	3.2	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	0.9	0.9	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**4.0**	**4.0**	**cfs**
Flow Velocity within the Gutter Section	V =	1.3	1.3	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.3	0.3	

Maximum Capacity for 1/2 Street based on Allowable Depth

		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	59.7	59.7	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\,TH}$ =	58.7	58.7	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.051	0.051	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\,TH}$	$Q_{X\,TH}$ =	93.3	93.3	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	54.6	54.6	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	5.0	5.0	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	59.5	59.5	cfs
Average Flow Velocity Within the Gutter Section	V =	2.7	2.7	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	1.4	1.4	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d ≥ 6") Storm	R =	0.62	0.62	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**36.7**	**36.7**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	4.89	4.89	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	2.49	2.49	inches

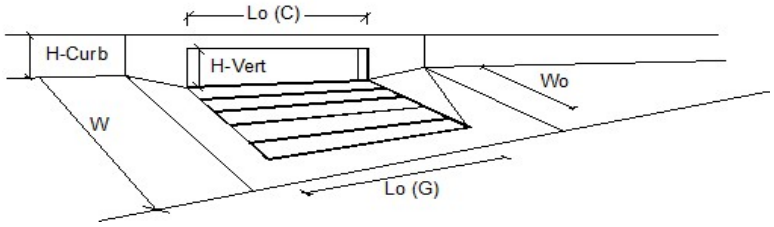
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**4.0**	**4.0**	**cfs**

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)



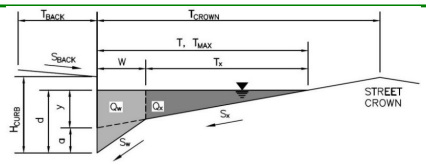
Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	10.00	10.00	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	
Design Discharge for Half of Street (from *Inlet Management*)	Q_o =	1.9	3.4	cfs
Water Spread Width	T =	12.8	16.4	ft
Water Depth at Flowline (outside of local depression)	d =	2.0	2.3	inches
Water Depth at Street Crown (or at T_{MAX})	d_{CROWN} =	0.0	0.0	inches
Ratio of Gutter Flow to Design Flow	E_o =	0.312	0.232	
Discharge outside the Gutter Section W, carried in Section T_x	Q_x =	1.3	2.6	cfs
Discharge within the Gutter Section W	Q_w =	0.6	0.8	cfs
Discharge Behind the Curb Face	Q_{BACK} =	0.0	0.0	cfs
Flow Area within the Gutter Section W	A_W =	0.13	0.15	sq ft
Velocity within the Gutter Section W	V_W =	4.6	5.2	fps
Water Depth for Design Condition	d_{LOCAL} =	5.0	5.3	inches
Grate Analysis (Calculated)		MINOR	MAJOR	
Total Length of Inlet Grate Opening	L =	N/A	N/A	ft
Ratio of Grate Flow to Design Flow	$E_{o\text{-}GRATE}$ =	N/A	N/A	
Under No-Clogging Condition		MINOR	MAJOR	
Minimum Velocity Where Grate Splash-Over Begins	V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow	R_f =	N/A	N/A	
Interception Rate of Side Flow	R_x =	N/A	N/A	
Interception Capacity	Q_i =	N/A	N/A	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient for Multiple-unit Grate Inlet	GrateCoef =	N/A	N/A	
Clogging Factor for Multiple-unit Grate Inlet	GrateClog =	N/A	N/A	
Effective (unclogged) Length of Multiple-unit Grate Inlet	L_e =	N/A	N/A	ft
Minimum Velocity Where Grate Splash-Over Begins	V_o =	N/A	N/A	fps
Interception Rate of Frontal Flow	R_f =	N/A	N/A	
Interception Rate of Side Flow	R_x =	N/A	N/A	
Actual Interception Capacity	**Q_a =**	**N/A**	**N/A**	**cfs**
Carry-Over Flow = Q_o-Q_a (to be applied to curb opening or next d/s inlet)	**Q_b =**	**N/A**	**N/A**	**cfs**
Curb or Slotted Inlet Opening Analysis (Calculated)		MINOR	MAJOR	
Equivalent Slope S_e (based on grate carry-over)	S_e =	0.109	0.083	ft/ft
Required Length L_T to Have 100% Interception	L_T =	8.02	12.36	ft
Under No-Clogging Condition		MINOR	MAJOR	
Effective Length of Curb Opening or Slotted Inlet (minimum of L, L_T)	L =	8.02	10.00	ft
Interception Capacity	Q_i =	1.9	3.2	cfs
Under Clogging Condition		MINOR	MAJOR	
Clogging Coefficient	CurbCoef =	1.25	1.25	
Clogging Factor for Multiple-unit Curb Opening or Slotted Inlet	CurbClog =	0.06	0.06	
Effective (Unclogged) Length	L_e =	8.75	8.75	ft
Actual Interception Capacity	**Q_a =**	**1.9**	**3.1**	**cfs**
Carry-Over Flow = $Q_{b(GRATE)}$-Q_a	**Q_b =**	**0.0**	**0.2**	**cfs**
Summary		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**1.9**	**3.1**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.2**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**93**	**%**

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

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

Project:

Inlet ID: **Inlet A9**



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		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} =	17.5	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.007	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 =	0.038	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} =	17.5	17.5	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)		☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	1.49	1.49	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	1.0	1.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	0.91	0.91	inches
Water Depth at Gutter Flowline	d =	2.40	2.40	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	16.5	16.5	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.213	0.213	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	3.2	3.2	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	0.9	0.9	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**4.0**	**4.0**	**cfs**
Flow Velocity within the Gutter Section	V =	1.3	1.3	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.3	0.3	

Maximum Capacity for 1/2 Street based on Allowable Depth

		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	59.7	59.7	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\,TH}$ =	58.7	58.7	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.051	0.051	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\,TH}$	$Q_{X\,TH}$ =	93.3	93.3	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	54.6	54.6	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	5.0	5.0	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	59.5	59.5	cfs
Average Flow Velocity Within the Gutter Section	V =	2.7	2.7	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	1.4	1.4	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d ≥ 6") Storm	R =	0.62	0.62	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**36.7**	**36.7**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	4.89	4.89	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	2.49	2.49	inches

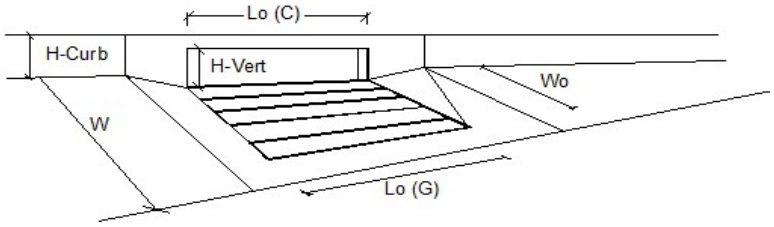
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**4.0**	**4.0**	**cfs**

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	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 =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =	10.00	10.00	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	

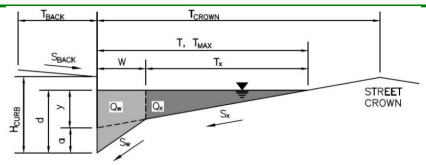
Street Hydraulics: OK - Q < Allowable Street Capacity'		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**	**2.0**	**3.5**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**0.5**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**100**	**87**	**%**

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

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

Project:

Inlet ID: **Inlet A10**



Gutter Geometry:

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =		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} =	50.0	ft
Gutter Width	W =	1.00	ft
Street Transverse Slope	S_X =	0.005	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 =	0.020	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} =	50.0	50.0	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)		☐	☐	

Maximum Capacity for 1/2 Street based On Allowable Spread

		Minor Storm	Major Storm	
Water Depth without Gutter Depression (Eq. ST-2)	y =	3.00	3.00	inches
Vertical Depth between Gutter Lip and Gutter Flowline (usually 2")	d_C =	1.0	1.0	inches
Gutter Depression (d_C - (W * S_x * 12))	a =	0.94	0.94	inches
Water Depth at Gutter Flowline	d =	3.94	3.94	inches
Allowable Spread for Discharge outside the Gutter Section W (T - W)	T_X =	49.0	49.0	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.066	0.066	
Discharge outside the Gutter Section W, carried in Section T_X	Q_X =	23.3	23.3	cfs
Discharge within the Gutter Section W (Q_T - Q_X)	Q_W =	1.6	1.6	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Maximum Flow Based On Allowable Spread	**Q_T =**	**24.9**	**24.9**	**cfs**
Flow Velocity within the Gutter Section	V =	1.4	1.4	fps
V*d Product: Flow Velocity times Gutter Flowline Depth	V*d =	0.5	0.5	

Maximum Capacity for 1/2 Street based on Allowable Depth

		Minor Storm	Major Storm	
Theoretical Water Spread	T_{TH} =	84.4	84.4	ft
Theoretical Spread for Discharge outside the Gutter Section W (T - W)	$T_{X\,TH}$ =	83.4	83.4	ft
Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)	E_O =	0.036	0.036	
Theoretical Discharge outside the Gutter Section W, carried in Section $T_{X\,TH}$	$Q_{X\,TH}$ =	96.1	96.1	cfs
Actual Discharge outside the Gutter Section W, (limited by distance T_{CROWN})	Q_X =	87.0	87.0	cfs
Discharge within the Gutter Section W (Q_d - Q_X)	Q_W =	3.6	3.6	cfs
Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)	Q_{BACK} =	0.0	0.0	cfs
Total Discharge for Major & Minor Storm (Pre-Safety Factor)	Q =	90.6	90.6	cfs
Average Flow Velocity Within the Gutter Section	V =	2.0	2.0	fps
V*d Product: Flow Velocity Times Gutter Flowline Depth	V*d =	1.0	1.0	
Slope-Based Depth Safety Reduction Factor for Major & Minor (d ≥ 6") Storm	R =	1.00	1.00	
Max Flow Based on Allowable Depth (Safety Factor Applied)	**Q_d =**	**90.6**	**90.6**	**cfs**
Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)	d =	6.00	6.00	inches
Resultant Flow Depth at Street Crown (Safety Factor Applied)	d_{CROWN} =	2.07	2.07	inches

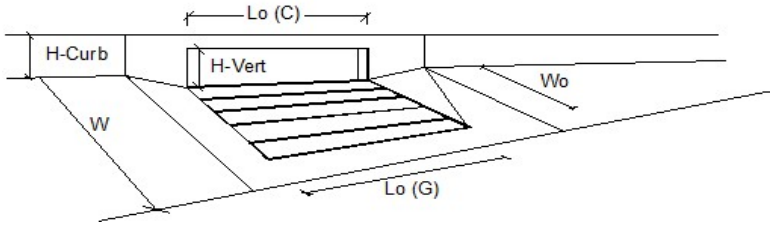
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Spread Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**24.9**	**24.9**	**cfs**

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	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 =**	**2.4**	**3.9**	**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**	**0.0**	**1.4**	**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**	**98**	**73**	**%**

Inlet DA 11 - 12" WIDE TRENCH GRATE INFLOW CALCULATIONS

32.88	INSERT GRATE INTAKE AREA (IN^2 / FT) IN CELL TO LEFT
165.0	INSERT LENGTH OF TRENCH DRAIN RUN TO LEFT IN FEET

HEAD (IN)	HEAD (FT)	OPEN AREA (IN^2 / FT)	OPEN AREA (FT^2 / FT)	MAX INFLOW (GPM/FT)	MAX FLOW RATE (CFS/FT)	TOTAL CAPTURE OF TRENCH RUN (CFS)
0.125	0.010	32.88	0.228	54	0.121	20.0
0.250	0.021	32.88	0.228	77	0.172	28.3
0.500	0.042	32.88	0.228	109	0.243	40.1
0.750	0.063	32.88	0.228	133	0.297	49.1
1.000	0.083	32.88	0.228	154	0.343	56.7
1.250	0.104	32.88	0.228	172	0.384	63.3
1.500	0.125	32.88	0.228	189	0.421	69.4
1.750	0.146	32.88	0.228	204	0.454	75.0
2.000	0.167	32.88	0.228	218	0.486	80.1
2.250	0.188	32.88	0.228	231	0.515	85.0
2.500	0.208	32.88	0.228	244	0.543	89.6
2.750	0.229	32.88	0.228	256	0.569	94.0
3.000	0.250	32.88	0.228	267	0.595	98.1
4.000	0.333	32.88	0.228	308	0.687	113.3
5.000	0.417	32.88	0.228	345	0.768	126.7
6.000	0.500	32.88	0.228	377	0.841	138.8
7.000	0.583	32.88	0.228	408	0.909	149.9
8.000	0.667	32.88	0.228	436	0.971	160.3
9.000	0.750	32.88	0.228	462	1.030	170.0

Formula used for calculations is:

$$Q = 448.2 * C_d * A * (2*g*h)^{0.5}$$

where
- Q = flow rate (gpm)
- C_d = discharge coefficient (0.6 assumed)
- A = open area of grate
- g = gravitational acceleration (32 ft/sec/sec)
- h = head above grate (in)

Inlet DA 12 - 6" WIDE TRENCH GRATE INFLOW CALCULATIONS

14.55	INSERT GRATE INTAKE AREA (IN^2 / FT) IN CELL TO LEFT
205.0	INSERT LENGTH OF TRENCH DRAIN RUN TO LEFT IN FEET

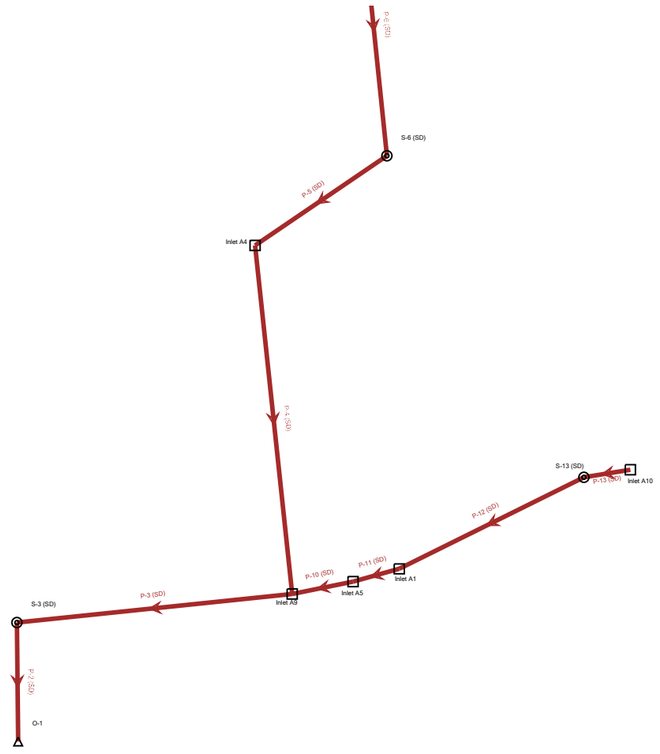
HEAD (IN)	HEAD (FT)	OPEN AREA (IN^2 / FT)	OPEN AREA (FT^2 / FT)	MAX INFLOW (GPM/FT)	MAX FLOW RATE (CFS/FT)	TOTAL CAPTURE OF TRENCH RUN (CFS)
0.125	0.010	14.55	0.101	24	0.054	11.0
0.250	0.021	14.55	0.101	34	0.076	15.6
0.500	0.042	14.55	0.101	48	0.107	22.0
0.750	0.063	14.55	0.101	59	0.132	27.0
1.000	0.083	14.55	0.101	68	0.152	31.2
1.250	0.104	14.55	0.101	76	0.170	34.8
1.500	0.125	14.55	0.101	84	0.186	38.2
1.750	0.146	14.55	0.101	90	0.201	41.2
2.000	0.167	14.55	0.101	96	0.215	44.1
2.250	0.188	14.55	0.101	102	0.228	46.7
2.500	0.208	14.55	0.101	108	0.240	49.3
2.750	0.229	14.55	0.101	113	0.252	51.7
3.000	0.250	14.55	0.101	118	0.263	54.0
4.000	0.333	14.55	0.101	136	0.304	62.3
5.000	0.417	14.55	0.101	152	0.340	69.7
6.000	0.500	14.55	0.101	167	0.372	76.3
7.000	0.583	14.55	0.101	180	0.402	82.4
8.000	0.667	14.55	0.101	193	0.430	88.1
9.000	0.750	14.55	0.101	205	0.456	93.5

Formula used for calculations is:

$$Q = 448.2 * C_d * A * (2*g*h)^{0.5}$$

where
- Q = flow rate (gpm)
- C_d = discharge coefficient (0.6 assumed)
- A = open area of grate
- g = gravitational acceleration (32 ft/sec/sec)
- h = head above grate (in)

Scenario: 100 Year



5 YEAR

FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (Unified) (ft)	Slope (Calculated) (ft/ft)	Flow (cfs)	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Froude Number (Normal)	Time (Pipe Flow) (hours)
P-6 (SD)	S-6 (SD)	6,805.56	S-7 (SD)	6,808.66	154.9	-0.020	5.33	19.31	9.34	2.613	0.005
P-7 (SD)	S-7 (SD)	6,808.86	S-8 (SD)	6,809.16	29.8	-0.010	5.33	13.65	7.25	1.817	0.001
P-8 (SD)	S-8 (SD)	6,809.36	Inlet A2	6,809.53	17.0	-0.010	5.33	4.63	6.79	1.196	0.001
P-9 (SD)	Inlet A2	6,809.73	CB-1	6,809.85	11.8	-0.010	0.40	4.63	3.61	1.709	0.001
P-5 (SD)	Inlet A4	6,802.99	S-6 (SD)	6,805.37	95.0	-0.025	6.11	21.59	10.51	2.919	0.003
P-4 (SD)	Inlet A9	6,797.28	Inlet A4	6,802.50	208.6	-0.025	8.81	46.49	11.38	3.079	0.005
P-13 (SD)	S-13 (SD)	6,802.14	Inlet A10	6,802.70	28.0	-0.020	2.40	19.31	7.44	2.611	0.001
P-12 (SD)	Inlet A1	6,799.49	S-13 (SD)	6,801.95	122.7	-0.020	2.40	19.31	7.44	2.611	0.005
P-11 (SD)	Inlet A5	6,798.72	Inlet A1	6,799.30	28.6	-0.020	8.50	19.31	10.58	2.546	0.001
P-10 (SD)	Inlet A9	6,797.78	Inlet A5	6,798.52	37.0	-0.020	10.40	19.31	11.13	2.485	0.001
P-3 (SD)	S-3 (SD)	6,793.81	Inlet A9	6,796.28	164.7	-0.015	21.98	81.68	9.80	1.955	0.005
P-2 (SD)	O-1	6,792.55	S-3 (SD)	6,793.62	70.8	-0.015	21.98	81.68	9.80	1.955	0.002

100 YEAR

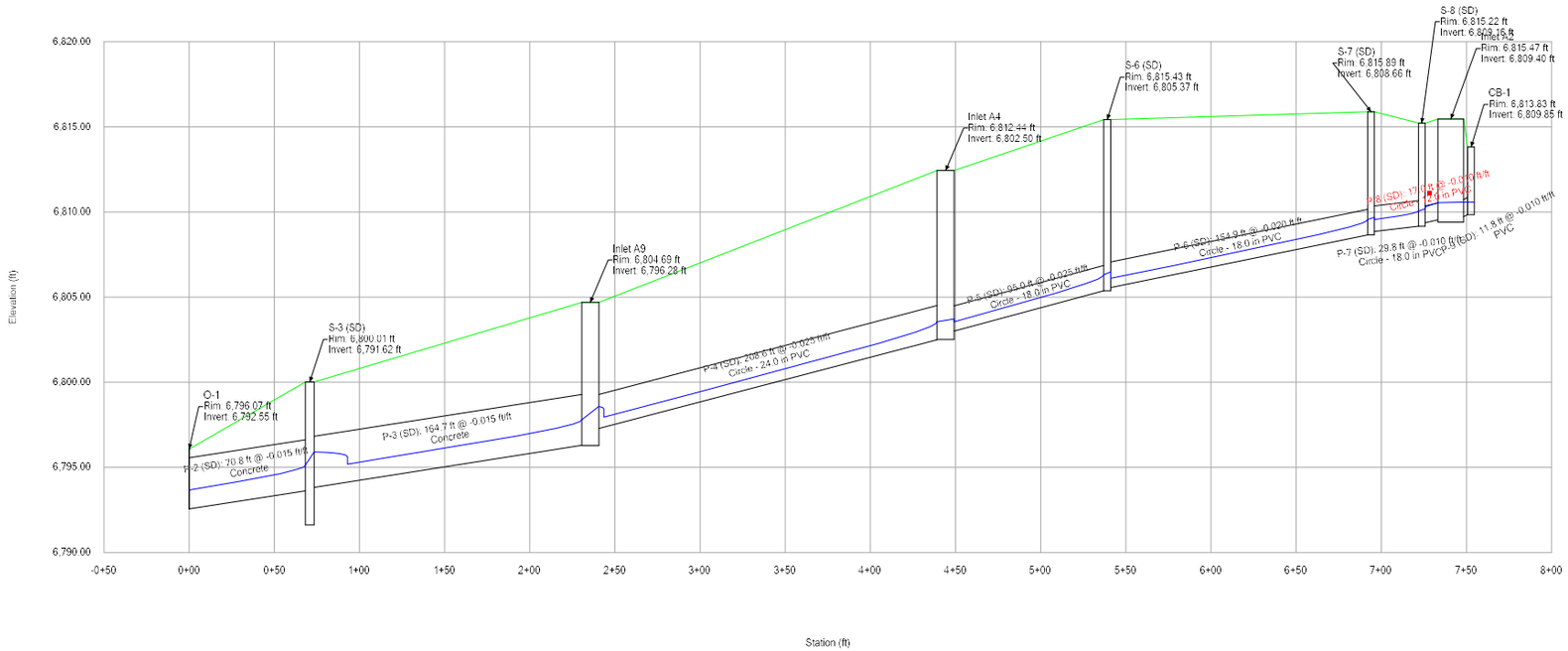
FlexTable: Conduit Table

Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Length (Unified) (ft)	Slope (Calculated) (ft/ft)	Flow (cfs)	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Froude Number (Normal)	Time (Pipe Flow) (hours)
P-6 (SD)	S-6 (SD)	6,805.56	S-7 (SD)	6,808.66	154.9	-0.020	12.22	19.31	11.56	2.413	0.004
P-7 (SD)	S-7 (SD)	6,808.86	S-8 (SD)	6,809.16	29.8	-0.010	12.22	13.65	8.74	1.496	0.001
P-8 (SD)	S-8 (SD)	6,809.36	Inlet A2	6,809.53	17.0	-0.010	12.22	4.63	15.56	2.743	0.000
P-9 (SD)	Inlet A2	6,809.73	CB-1	6,809.85	11.8	-0.010	1.77	4.63	2.25	1.702	0.001
P-5 (SD)	Inlet A4	6,802.99	S-6 (SD)	6,805.37	95.0	-0.025	13.61	21.59	12.91	2.700	0.002
P-4 (SD)	Inlet A9	6,797.28	Inlet A4	6,802.50	208.6	-0.025	18.11	46.49	13.88	3.015	0.004
P-13 (SD)	S-13 (SD)	6,802.14	Inlet A10	6,802.70	28.0	-0.020	3.90	19.31	8.56	2.625	0.001
P-12 (SD)	Inlet A1	6,799.49	S-13 (SD)	6,801.95	122.7	-0.020	3.90	19.31	8.56	2.625	0.004
P-11 (SD)	Inlet A5	6,798.72	Inlet A1	6,799.30	28.6	-0.020	18.30	19.31	10.36	2.020	0.001
P-10 (SD)	Inlet A9	6,797.78	Inlet A5	6,798.52	37.0	-0.020	21.40	19.31	12.11	1.743	0.001
P-3 (SD)	S-3 (SD)	6,793.81	Inlet A9	6,796.28	164.7	-0.015	44.98	81.68	11.83	1.852	0.004
P-2 (SD)	O-1	6,792.55	S-3 (SD)	6,793.62	70.8	-0.015	44.98	81.68	11.83	1.852	0.002

5 YEAR

Profile Report

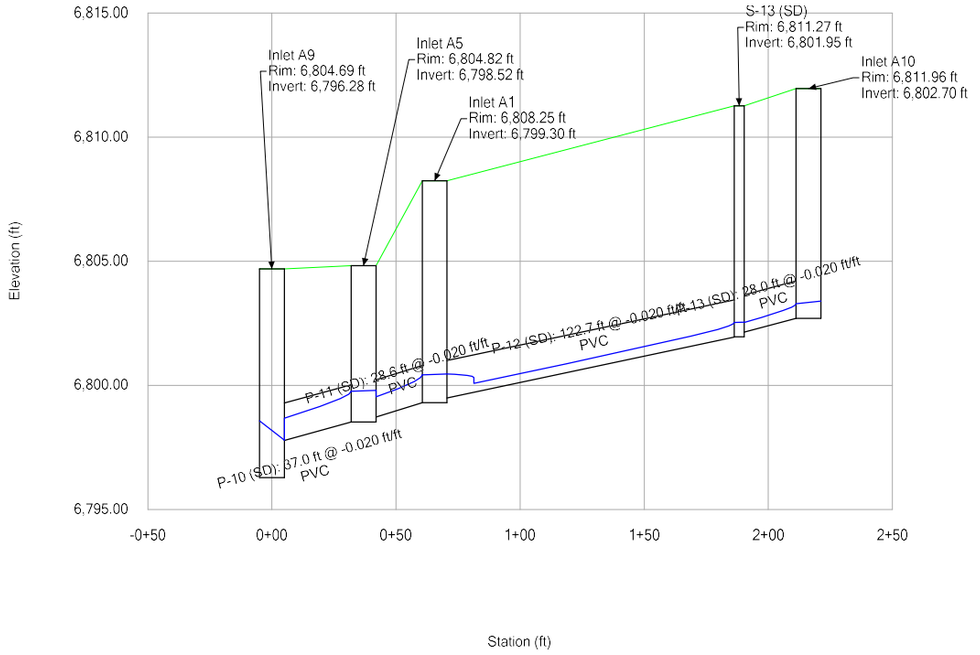
Engineering Profile - Storm Line A (83-4299.stsw)



5 YEAR

Profile Report

Engineering Profile - Storm Line B (83-4299.stsw)

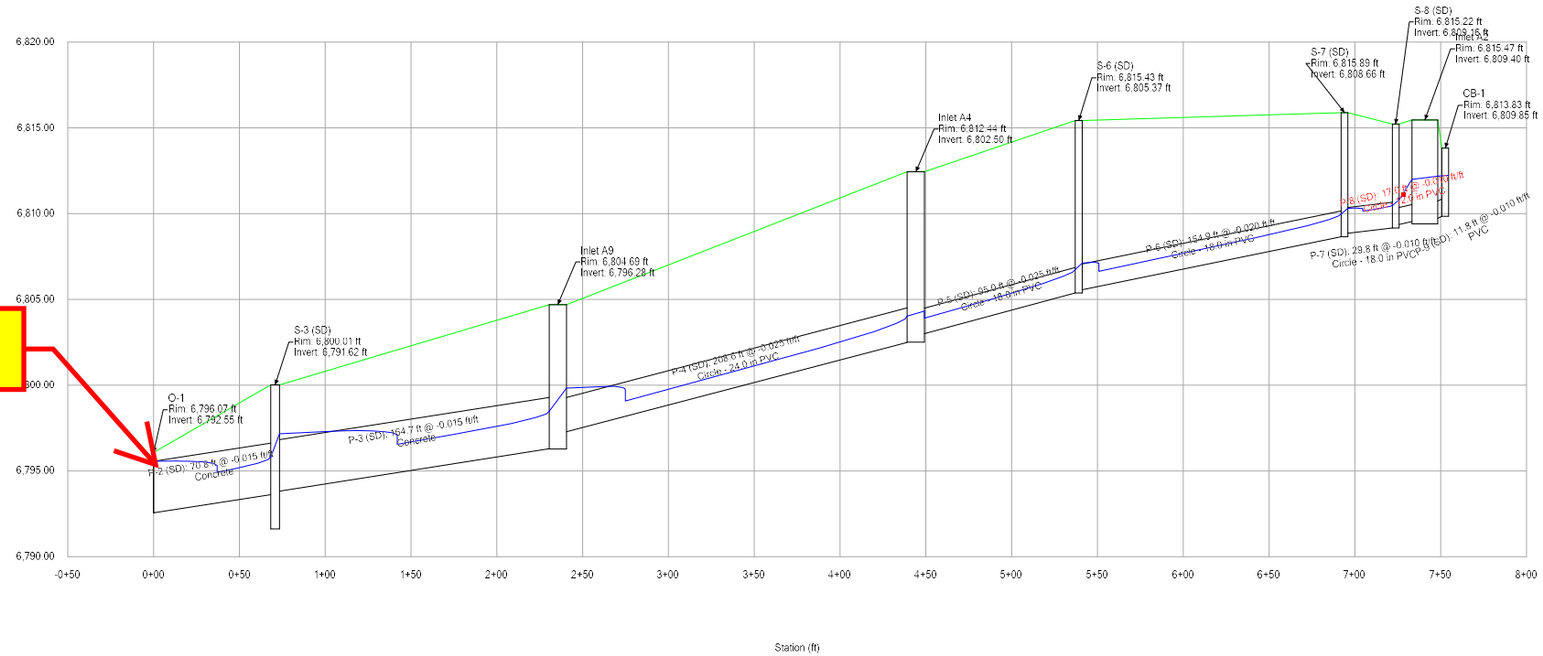


100 YEAR

Profile Report

Engineering Profile - Storm Line A (83-4299.stsw)

TAILWATER SET TO PIPE CROWN



100 YEAR

Profile Report

Engineering Profile - Storm Line B (83-4299.stsw)