Final Drainage Report
The Glen at Widefield Filing No. 9
El Paso County, Colorado

Prepared for:
Widefield Investment Group
3 Widefield Boulevard
Colorado Springs, Colorado 80911

Prepared by:

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

Kiowa Project No. 17038

June 8, 2018

PCD Project No. SF-18-005

TABLE OF CONTENTS

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

STATEMENTS AND APPROVALS

ENGINEER'S STATEMENT:

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

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

____________________________________ __________________

Richard N. Wray (PE #19310) Date

For and on Behalf of Kiowa Engineering Corporation

DEVELOPER'S STATEMENT:

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

By: ____________________________________ __________________

J. Mark Watson, President Date

Glen Development Company

Print Name: ______________________________

Address: Glen Development

3 Widefield Boulevard

Colorado Springs, Colorado 80911

EL PASO COUNTY:

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

____________________________________ __________________

Jennifer Irvine, P.E. Date

El Paso County Engineer/ECM Administrator

I. GENERAL LOCATION AND DESCRIPTION

The Glen at Widefield Filing No. 9 subdivision will be developed as a single-family residential subdivision located in the Widefield area of El Paso County. The subject property is located to the west of Marksheffel Road and north of proposed Mesa Ridge Parkway. The site is located in the southwest portion of Section 22, Township 15 South, Range 65 West of the 6th Principal Meridian, in El Paso County, Colorado. The site is bounded to the west by the Glen at Widefield Filing No. 6 and the West Fork Jimmy Camp Creek; to the south by the Glen at Widefield Filing No. 7, to the east by Marksheffel Road and to the north by unplatted land. The property covers approximately 24.94 acres and is currently undeveloped. A vicinity map of the site is shown on Figure 1 included in the Appendix.

The existing vegetative cover within the development is in poor to fair condition with minimal grasses throughout the site. The existing ground slopes within the property range from 0.2 to 9 percent. Soils within the subject site are classified to be within Hydrologic Soils Group B/D (Nelson Tassel sandy loam #56) as shown in the El Paso County Soils Survey. For the purposes of computing the existing and proposed hydrology for the site, Hydrologic Soil Group C was used.

The West Fork Jimmy Camp Creek is located along the west side of the site. The West Fork receives runoff from offsite basins to the north of the site, the Glen at Widefield Filing No.'s 5, 6 and 7, Mesa Ridge Parkway and its associated drainage channel, and from the majority of the Glen at Widefield East (future filings). The West Fork conveys the flow south of Mesa Ridge Parkway to where it crosses Marksheffel Road, and ultimately to the Jimmy Camp Creek main branch. Jimmy Camp Creek is a tributary to Fountain Creek.

There are no active irrigation ditches or facilities within or adjacent to the site, only abandoned irrigation ditch laterals in the northwest portion of the site that served a previous sod farm.

Existing utilities within or adjacent to the site include a water line and sanitary sewer line along the north side of Mesa Ridge Parkway that terminate at the Jimmy Camp Lift Station located just west of Spring Glen Drive at the south entrance to the site. There is also a gas main that runs along the easterly property boundary.

II. MAJOR DRAINAGE BASINS AND SUBBASINS

The site lies within the West Fork Jimmy Camp Creek drainage basin. The majority of the site presently drains towards the south and southwest by sheet flow to the West Fork Jimmy Camp Creek just upstream of Mesa Ridge Parkway (Sub-basins EX-1 through EX-4). The northeast portion of the site drains east and south by sheet flow to the existing roadside ditch along Marksheffel Road across from Peaceful Valley Road (Sub-basin EX-5). The remaining portion of the site, or southeast corner, drains by sheet flow to the existing roadside ditch along Marksheffel Road approximately 400 feet north of Mesa Ridge Parkway (Sub-basin EX-6). The existing drainage patterns for the site are shown on Sheet 1 provided in a map pocket at the end of this report.

The reports and plans that were reviewed in the process of preparing this drainage report are included in the References section. The Glen at Widefield East area was studied as a part of the *Master Development Drainage Plan for the Glen at Widefield (MDDP)* and the *West Fork Jimmy Camp Creek Drainage Basin Planning Study (DBPS).* The detention basin shown on the west side of the creek (DP 3101) was designed and constructed as part of the Filing No. 6 improvements. Two additional regional detention basins were identified for the site in the *MDDP*: one to serve the westerly side of the site with flows released west to the West Fork Jimmy Camp Creek (DP 3091), and the other to serve the easterly side of the site with flows released east across Marksheffel Road to a channel along the north side of Peaceful Valley Road and ultimately to the Jimmy Camp Creek main branch (DP

4021). The detention basin shown in the *MDDP* and *DBPS* at DP 3091 was designed and constructed as part of the Glen at Widefield Filing No. 7 improvements. However, due to the proposed grading and drainage patterns north of Filing No. 7, two additional detention basins to serve the westerly side of the site are proposed: one for Filing No. 8 and one for Filing No. 9 (included in this report), which will be located north of the Filing No. 8 area. The detention basin shown in the *MDDP* and *DBPS* at DP 4021 will be designed and constructed to serve future filings within the Glen at Widefield East area.

Other off-site improvements to the West Fork identified in the *MDDP* and *DBPS* include placing buried riprap at outside bends and construction of check structures between the existing retention pond (known as Spring Lake Reservoir) and the southern property boundary. Installation of a riprap spillway with a low flow outlet structure at Spring Lake Reservoir was also recommended. The water in Spring Lake Reservoir is believed to be owned by the Fountain Mutual Irrigation Ditch Company. The bank linings and improvements to Spring Lake Reservoir and just downstream of the reservoir as discussed in the *Amended MDDP* were constructed when the Glen at Widefield Filing No. 6 area was developed.

Additional off-site improvements include the widening of Mesa Ridge Parkway from Powers Boulevard to Autumn Glen Avenue, the extension of Mesa Ridge Parkway from Autumn Glen Avenue to Marksheffel Road, and a new bridge with channel improvements at the West Fork Jimmy Camp Creek crossing. The roadway and bridge improvements, as well as channel improvements just upstream of Mesa Ridge Parkway (as outlined in the *Amended MDDP*), are currently being constructed by the Glen Development Company as part of a separate project.

As stated in the *Amended MDDP*, poor soils were discovered in the vicinity of the creek. This condition made large portions of Filing No. 6 and Filing No. 7 unsuitable for development. This poor soils condition is also the case for Filing No. 9 and future filings along the east side of the creek. In conformance with the *Amended MDDP*, the creek improvements formerly recommended between Spring Lake Reservoir and Mesa Ridge Parkway (not already included with the Filing No. 6 or Mesa Ridge Parkway improvements) are no longer necessary, and will therefore not be constructed. Not only does the creek appear to be well vegetated and substantially stable, there will be no increase in channel erosion as a result of this development. The portion of the Glen at Widefield property adjacent to the West Fork will remain as open space for this project, and similar to the detention basins constructed to serve Filing No. 6, Filing No. 7, and Filing No. 8, the proposed Detention Basin 'A' to serve the Filing No. 9 area will release runoff at or below historic rates. If this land *is* developed in the future, a re-evaluation of the West Fork will be required at that time to determine what channel improvements are needed.

According to the *DBPS*, several detention basins are called for along the creek to maintain historic conditions at the confluence with Jimmy Camp Creek. Similar to the Fi[illegible] and Filing No. 8 areas, the detention basin that is proposed to serve the Filir[illegible]l so that development of the basin would not adversely impact any impr[illegible]ays downstream.

Show the 36" RCP & provide a callout label on the drainage map. Unresolved. This isn't shown on the existing drainage map.

Offsite runoff enters the site from the north by means of a 36" RCP that [illegible]ork Jimmy Camp Creek by future permanent drainage easement. Offsite Ba[illegible] by sheet flow from undeveloped land north of the site to the north property boundary, where it combines with runoff from Sub-basin EX-5 and is conveyed by sheet flow to the roadside ditch along Marksheffel Road across from Peaceful Valley Road.

The subject property limits are shown on Flood Insurance Rate Maps (FIRMs) 08041C0956 F and 08041C0957 F (both with effective dates of March 17, 1997) that are included in the Appendix. The portion of the property that will remain as open space for this project (and therefore contains no buildable lots) is located within a FEMA regulated floodplain based on Flood Insurance Rate Map 08041C0956 F. The FIRMs also show that the portion of the property to be developed with buildable lots is located outside of the FEMA regulated floodplain in an unshaded Zone X area, which is described as “Areas determined to be outside the 500-year floodplain”.

III. DRAINAGE DESIGN CRITERIA

Hydrologic and hydraulic calculations for the site were performed using the methods outlined in the *El Paso County Drainage Criteria Manual*. Topography for the site was compiled using a two-foot contour interval and is presented on the Drainage Plan. The hydrologic calculations were made for the existing and proposed site conditions. The Drainage Plan presents the 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 depth was determined from Table 6-2 of the *Drainage Criteria Manual*. These depths are shown in the runoff calculations spreadsheet. The peak flow data generated using the rational method was used to verify street capacities and to size inlets and storm sewers within the subdivision. The drainage basin area, time of concentration, and rainfall intensity were determined for each of the sub-basins within the property. The onsite soils were assumed to be Hydrologic Soil Group C, based on the *Soil Survey* and the result of proposed earth-moving operations. For existing conditions, runoff coefficients were determined using a land use of pasture/meadow. The land use for the proposed development will be residential with a density of approximately 4 lots per acre.

The onsite hydraulic structures were sized using the methods outlined in the *El Paso County Drainage Criteria Manual*. The hydraulic capacities of the streets and curb inlets were determined using the UD-Inlet spreadsheet developed by the UDFCD, considering the County criteria for the Minor (5-year) and Major (100-year) storms. Colorado Department of Transportation (CDOT) Type R curb inlets will be used within the site. Ramp curbs will be used throughout the development, except along Spring Glen Drive and between curb returns and at curb inlets, where a 6-inch vertical curb will be used. Storm sewer pipes were initially sized based on their full-flow capacity using the Manning’s equation. The UDSewer program was then used to verify storm sewer pipe sizes and perform hydraulic grade line (HGL) and energy grade line (EGL) calculations for the 5-year and 100-year storm events. Hydraulic calculations are provided in Appendix C for the proposed street, inlet and pipe capacities, pipe outlet erosion protection and open channel.

The on-site detention basin is planned to be an Extended Detention Basin that uses Full Spectrum Detention. The UD-Detention spreadsheets created by UDFCD were used to size and design the detention basin with water quality enhancement, per the County’s recommendation. The supporting calculations associated with the sizing of the hydraulic facility for this development are included in Appendix B of this report.

IV. DRAINAGE FACILITY DESIGN

The drainage of the site will be accomplished through a combination of sheet flow, gutter flow and storm sewer flow. Curb inlets will be placed at intersections throughout the site (where needed to decrease the amount of gutter flow for the minor and major storms) and at a low point along Spring Glen Drive to accept the developed runoff and convey it to the proposed detention basin prior to being discharged to the West Fork Jimmy Camp Creek. Riprap outlet protection will be placed at the end of the detention basin outlet pipe to reduce erosion.

The proposed drainage patterns for the site are shown on the Final Drainage Plan for the developed condition (Sheet 2) provided in the map pocket at the end of this report. The hydrologic and hydraulic calculations are provided in the Appendix, refer to the Drainage Design Criteria section for additional information on the hydrologic and hydraulic calculations.

The evaluation related to the sizing of the onsite drainage improvements were carried out in accordance with the City Storm Drainage Criteria Manual. The capacities of the proposed onsite facilities were calculated in accordance with the Criteria Manual.

The primary stormwater conveyance facility will be a storm sewer system ranging in size from an 18-inch diameter reinforced concrete pipe (RCP) to a 24-inch reinforced concrete pipe (RCP) conveying the runoff to the detention basin. Offsite runoff will be conveyed from basin OS-1 by means of the 24-inch RCP while on site runoff will sheet and gutter flow until finally being conveyed by 24-inch RCP to Detention Basin A. The detention basin will include a concrete-lined presedimentation forebay at the proposed storm sewer outlet, a concrete trickle channel, a micropool and water quality orifice plate onto an outlet structure, an emergency spillway and a maintenance access trail. The detention basin will be a private facility and will be maintained by the Glen at Widefield Filing No. 9 Homeowner's Association.

Following is a description of the on-site storm sewer system:

The system will begin with a 25' and 35' Type R curb inlet connected to an 24-inch storm sewer at the low point of Spring Glen Drive within Sub-basin A-5. The 24-inch storm sewer will convey captured runoff west to Detention Basin A, at which point it enters the basin's forebay.

The system will begin with a 10' curb inlet connected to an 18-inch storm sewer at the low point of Peach Leaf Drive within Sub-basin B-4. The 18-inch storm sewer will convey captured runoff south to the existing storm sewer system from Filing No. 8. To the southeast of Golden Buffs Drive a 10' curb inlet will be located along Peachleaf Drive and be connected to an 18-inch storm sewer that will convey captured runoff northwest to the system at Golden Buffs Drive and Peachleaf Drive. The storm sewer system will continue south in Golden Buffs Drive as a 30-inch storm sewer, where a 15' curb inlet just south of Peachleaf Drive will connect to it. At Golden Buffs Drive and Bigtooth Maple Drive, three 10' curb inlets and one 15' curb inlet will be connected to the system, where it will continue in a southerly direction in a 36-inch storm sewer to the low point in Spring Glen Drive where two 25' curb inlets (both in a sump condition) will intercept 100-year flows. The captured flow will then be conveyed to the detention basin in a 43-inch by 68-inch HERCP.

Following is a description of the on-site drainage sub-basins:

<u>Sub-basin A-1</u> is approximately 4.76 acres in area and is located at the west end of Bittercress Place. Undeveloped runoff from this basin will sheet flow south and southwest and will be conveyed directly to the West Fork Jimmy Camp Creek (DP 1).

<u>Sub-basin A-2</u> is approximately 1.12 acres in area and is located west of Spring Glen Drive and on the south side of Bittercress Place. Runoff from this basin will sheet flow and gutter flow north and east towards Spring Glen Drive (DP 2).

<u>Sub-basin A-3</u> is approximately 2.43 acres in area and is located west of Spring Glen Drive and on the north side of Bittercress Place. Runoff from this basin will sheet flow and gutter flow south and east towards Spring Glen Drive (DP 3).

<u>Sub-basin A-4</u> is approximately 0.71 acres in area and is located directly north of sub-basin A-3. Runoff from this basin will sheet flow east towards Spring Glen Drive and gutter flow south once gathered in Spring Glen Drive.

<u>Sub-basin A-5</u> is approximately 0.88 acres in area and is located on the west side of Spring Glen Drive. Runoff from this basin will gather flow from sub-basins A2, A3, and A4 (DP 4) and gutter flow to a 10' curb inlet for Detention Basin A (DP 5).

Sub-basin A-6 is approximately 1.53 acres in area and is located east of Spring Glen Drive and north of Bittercress Place. Undeveloped runoff from this basin will sheet flow west towards Spring Glen Drive until it gutter flows south (DP 6).

Sub-basin A-7 is approximately 3.28 acres in area and is located east of Spring Glen Drive and includes the north half of Bittercress Place. Runoff from this basin will sheet flow and gutter flow west towards Spring Glen Drive (DP 7).

Sub-basin A-8 is approximately 0.75 acres in area and is located east of Spring Glen Drive and includes part of the south half of Bittercress Place. Runoff from this basin will flow west towards Spring Glen Drive (DP 8).

Sub-basin A-9 is approximately 1.29 acres in area and is located between Peachleaf Drive and Bigtooth Maple Drive just south of Bittercress Place. Runoff from this basin will flow west towards Bigtooth Maple Drive and gutter flow north towards Bittercress Place (DP 9).

Sub-basin A-10 is approximately 0.94 acres in area and is located between Bigtooth Maple Drive and Spring Glen Drive just south of Bittercress Place. Runoff from this basin will sheet flow north east and gutter flow north on Bigtooth Maple Drive. The runoff will collect at the intersection of Bigtooth Maple Drive and Bittercress Place where it will combine with runoff from sub-basins A8 (DP 8) and A9 (DP 9) and gutter flow west towards Spring Glen Drive (DP 10).

Sub-basin A-11 is approximately 1.49 acres in area and is located on the east side of Spring Glen Drive. Runoff from this basin will gather flow from sub-basins A6, A7, A8, A9, and A10 (DP 11) and gutter flow to a 15' curb inlet for Detention Basin A (DP 12).

Sub-basin A-12 is approximately 0.64 acres in area and is located west of Spring Glen Drive at its low point and represents the area directly tributary to and including Detention Basin 'A'.

Since water quality capture volume (WQCV) will be required for the proposed development, the full spectrum Detention Basin 'A' will also be used for stormwater quality treatment. The required WQCV for a 40-hour drain time is 0.20 acre-feet. The required excess urban runoff volume (EURV) for a 72-hour drain time is 0.45 acre-feet. The storage volume required for detention is 1.135 acre-feet, which includes 1.035 acre-feet for the 100-year storm event plus one-half of the WQCV in accordance with County criteria. The proposed outlet structure will include an external micropool and one chamber that controls the release of the WQCV and the EURV. An orifice plate will drain the WQCV and EURV into the chamber of the outlet structure. Approximately Q_{100}=43.9 cfs (DP-14) will drain to the proposed detention basin. 100-year storm event or greater flows will spill over the top of the chamber through a steel grate. Runoff released from the detention basin will be restricted to 22.1 cfs for the 100-year storm event. A proposed 30-inch RCP equipped with a restrictor plate will convey runoff released from the detention basin to the West Fork Jimmy Camp Creek. If the outlet structure becomes plugged, a 50-foot wide emergency spillway will convey the runoff to the West Fork. Detention Basin A will be owned and maintained by XXX.

Following is a description of the offsite drainage sub-basins:

Sub-basin E-8 is approximately 8.78 acres in area and is located west of the site and north of future Detention Basin 'A'. Undeveloped runoff from this basin will sheet flow southwest and combine with flow released from sub-basin OS-1 (DP 13), where it will become open channel flow that will be conveyed directly to the West Fork Jimmy Camp Creek (DP 102).

Sub-basin E-9 is approximately 3.63 acres in area and is located west of the site and south of future Detention Basin 'A'. Undeveloped runoff from this basin will sheet flow southwest and combine with flow released from proposed Detention Basin 'A', where it will become open channel flow that will be conveyed directly to the West Fork Jimmy Camp Creek (DP 103).

Update.

Provide sub-basin narrative for the 'B' basins within Filing 9. If the system design of Filing 8 accounted for these then make sure to note on the narrative.

this sub-basin and design point are not identified in the proposed drainage map.

Sub-basin OS-1 is approximately 76.2 acres in area and is located to the north of The Glen at Widefield Filing No. 9. Runoff from this basin will be collected and routed through 48" RCP and emptied into sub-basin E-8 (DP 13) where it will become open channel flow and will be conveyed directly to the West Fork Jimmy Camp Creek (DP 102).

A. STORMWATER DETENTION AND WATER QUALITY DESIGN

Storm water quality measures are required by the County in Volume 2 of the County's Drainage Criteria Manual. The water quality measures to be instituted for the development will include:

1. Water quality enhancement of the detention basin. A presedimentation forebay will be installed at the on-site storm sewer outlet into the detention basin. The outlet structure will include a water quality orifice plate and a micropool.

B. COST OF PROPOSED DRAINAGE FACILITIES

Table 2 presents a cost estimate for the construction of drainage improvements (public and private) for The Glen at Widefield Filing No. 9 development.

C. DRAINAGE AND BRIDGE FEES

The site lies within the West Fork Jimmy Camp Creek Drainage Basin. The current drainage basin fee associated with the West Fork Jimmy Camp Creek Drainage Basin is $11,775 per impervious acre. The current bridge fee associated with the West Fork Jimmy Camp Creek Drainage Basin is $3,484 per impervious acre. The Glen at Widefield Filing No. 9 subdivision encompasses 15.05 acres. Table 1 details the fees due as part of this development.

V. CONCLUSIONS

The Glen at Widefield Filing No. 9 will be a single-lot family residential subdivision covering approximately 15.05 acres. Onsite drainage will include the use of curb inlets and storm sewers to route the runoff from the site to the Extended Detention Basin 'A'. Detained runoff from the site will be conveyed to the West Fork Jimmy Camp Creek. With detention serving the site and a large portion of either side of the creek not developed, the development of the Glen at Widefield Filing No. 9 property will not adversely impact or deteriorate improvements or natural drainageways downstream of the property.

VI. REFERENCES

1) Preliminary Drainage Report, The Glen at Widefield East, prepared by Kiowa Engineering Corporation, dated December 16, 2015.

2) Final Drainage Report, The Glen at Widefield Filing No. 7, prepared by Kiowa Engineering Corporation, dated January 11, 2016.

3) Amended Master Development Drainage Plan, The Glen at Widefield, prepared by Kiowa Engineering Corporation, dated June 21, 2007.

4) Final Drainage Report, The Glen at Widefield Filing No. 6, prepared by Kiowa Engineering Corporation, dated December 6, 2007.

5) Preliminary and Final Drainage Report, Mesa Ridge Parkway Final Design, prepared by Kiowa Engineering Corporation, dated November 29, 2010.

6) Mesa Ridge Parkway Roadway Design, Autumn Glen Avenue to Marksheffel Road and Widening from Powers Boulevard to Autumn Glen Avenue, prepared by Kiowa Engineering Corporation, dated December 8, 2010.

7) Master Development Drainage Plan for the Glen at Widefield, prepared by Kiowa Engineering Corporation, dated December 10, 1999.

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

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

10) El Paso County Drainage Criteria Manual (Volumes 1 and 2) and Engineering Criteria Manual, current editions.

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

APPENDIX TABLE OF CONTENTS

APPENDIX

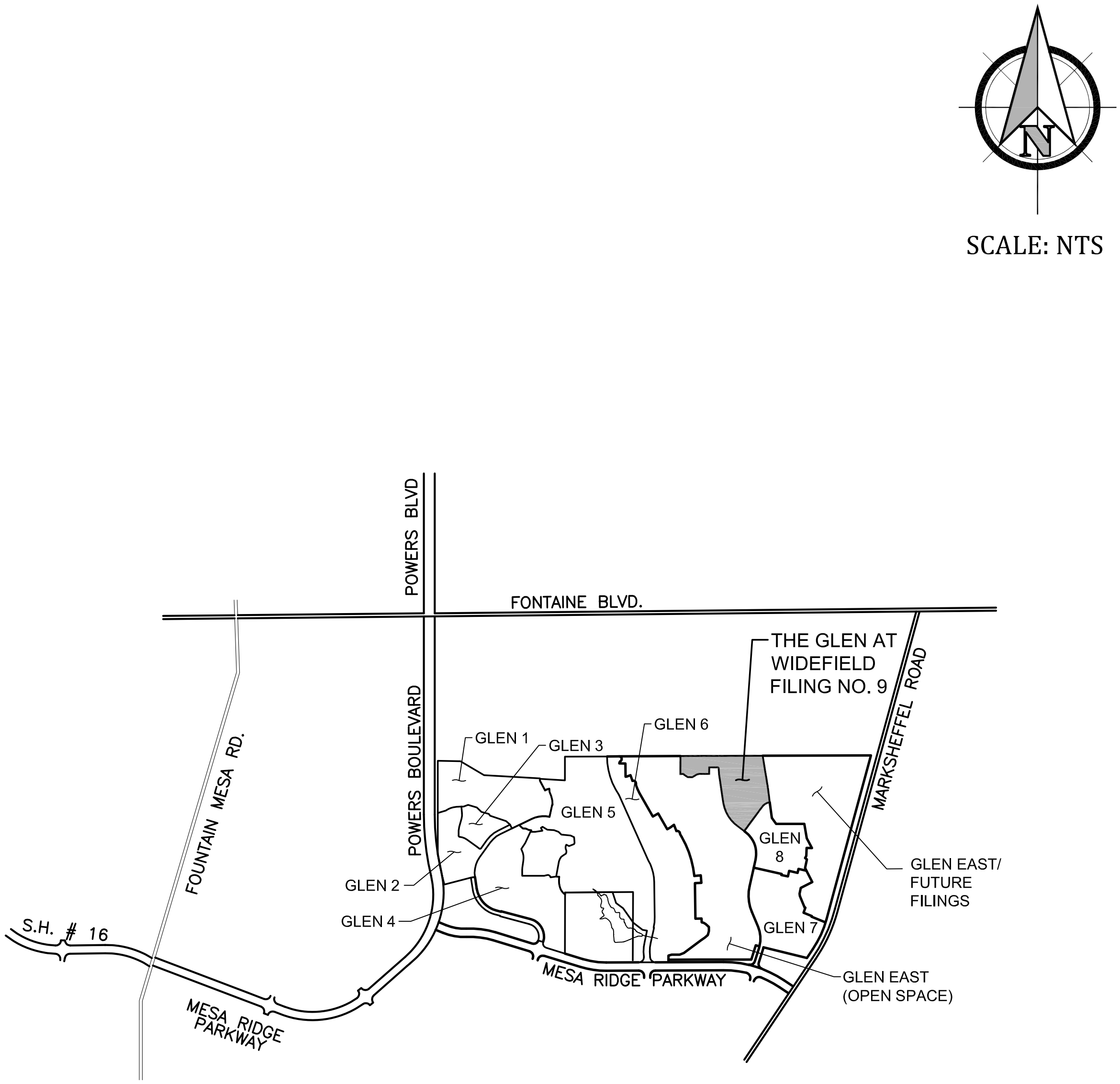
Figure 1: Vicinity Map

Figure 2: Soils Map

FEMA Flood Insurance Rate Map (Panels 956 and 957)

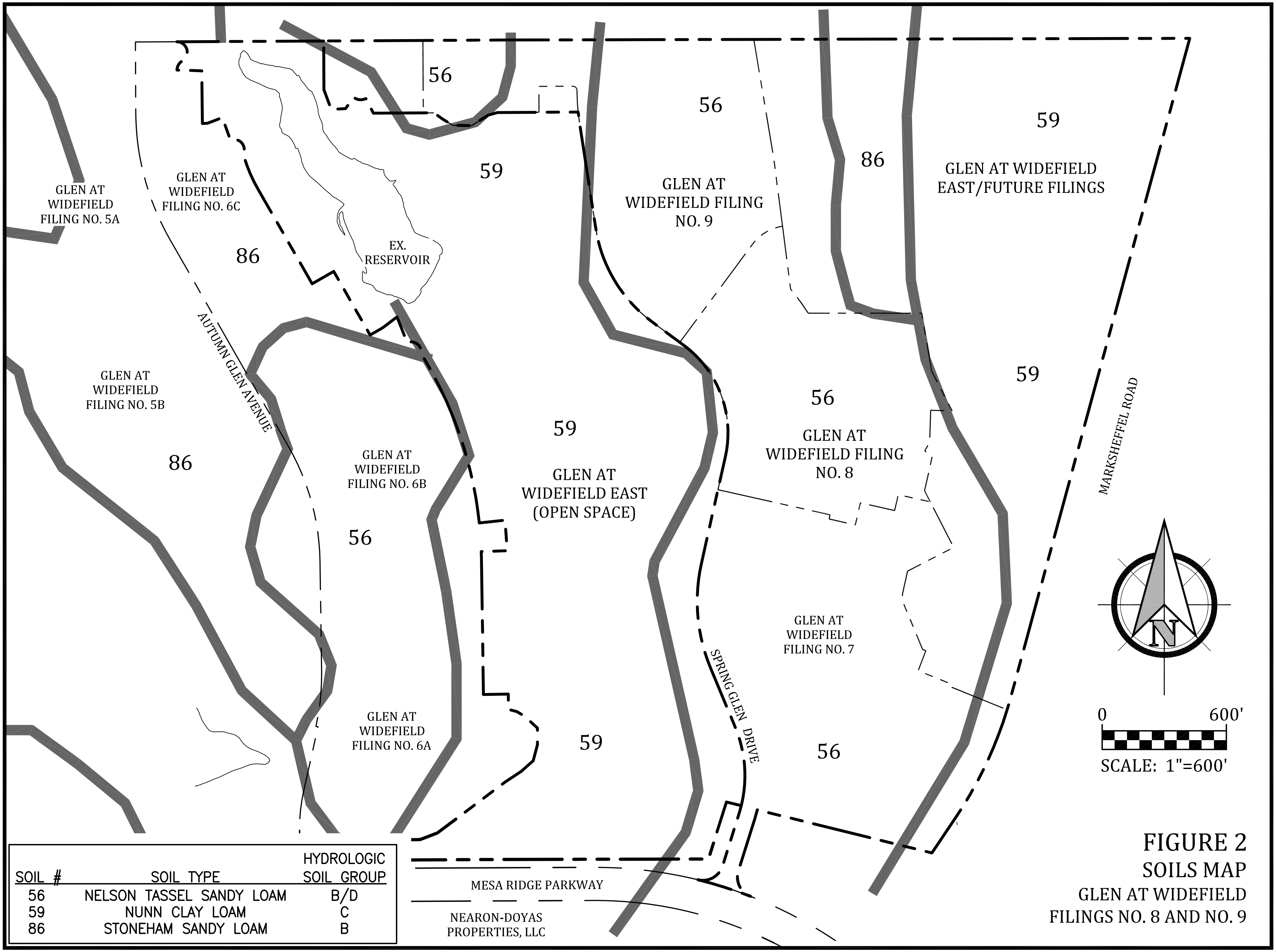
Table 1: Impervious Area and Drainage Basin & Bridge Fee Calc

Table 2: Opinion of Cost – Drainage Facilities



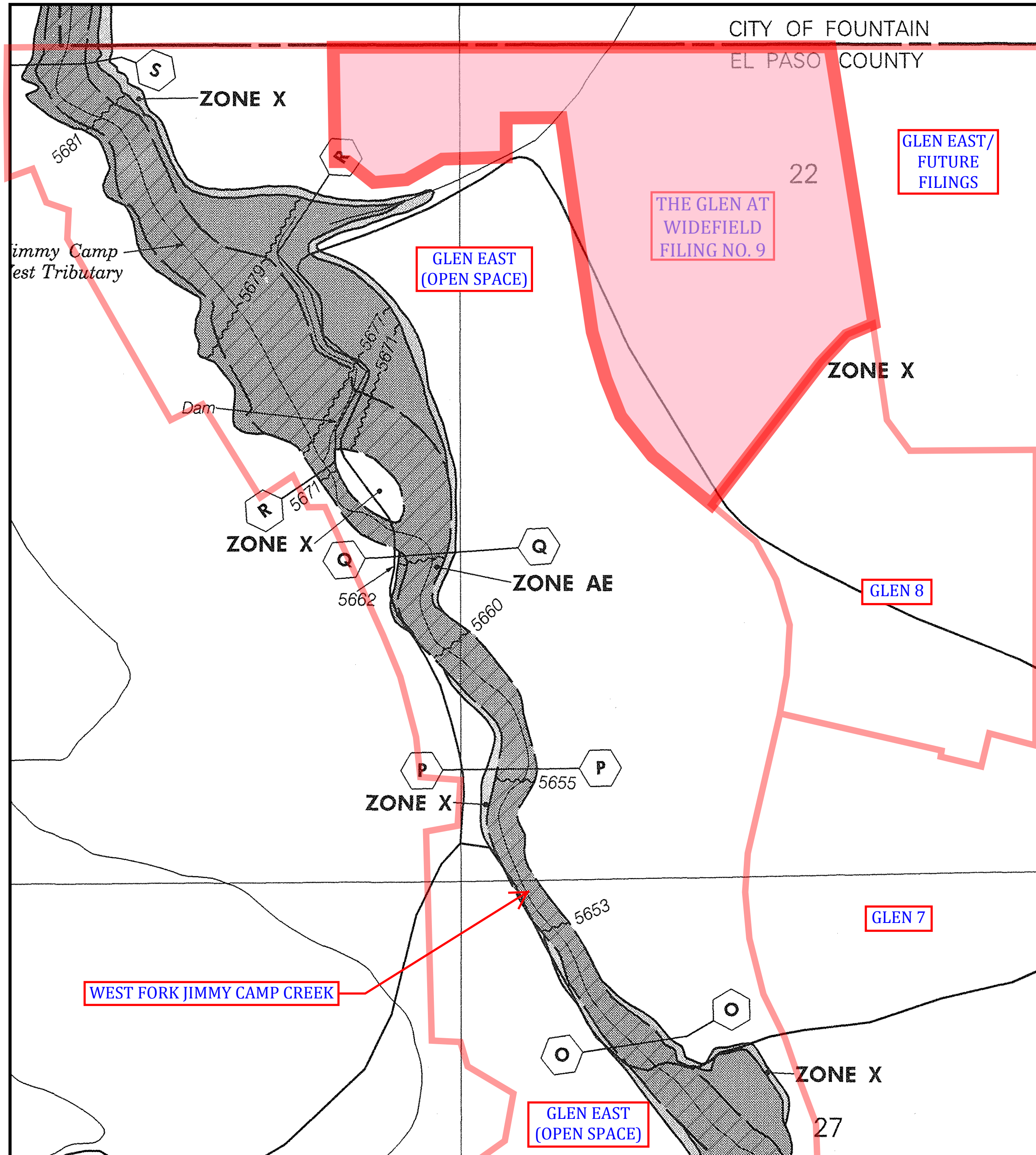
16014 Drainage Plan.dwg/Mar 08, 2016

FIGURE 1
VICINITY MAP
THE GLEN AT WIDEFIELD FILING NO. 9



SOIL #	SOIL TYPE	HYDROLOGIC SOIL GROUP
56	NELSON TASSEL SANDY LOAM	B/D
59	NUNN CLAY LOAM	C
86	STONEHAM SANDY LOAM	B

FIGURE 2
SOILS MAP
GLEN AT WIDEFIELD
FILINGS NO. 8 AND NO. 9



APPROXIMATE SCALE IN FEET

500 0 500

Refer to Panel 957 for area to the east

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 956 OF 1300

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

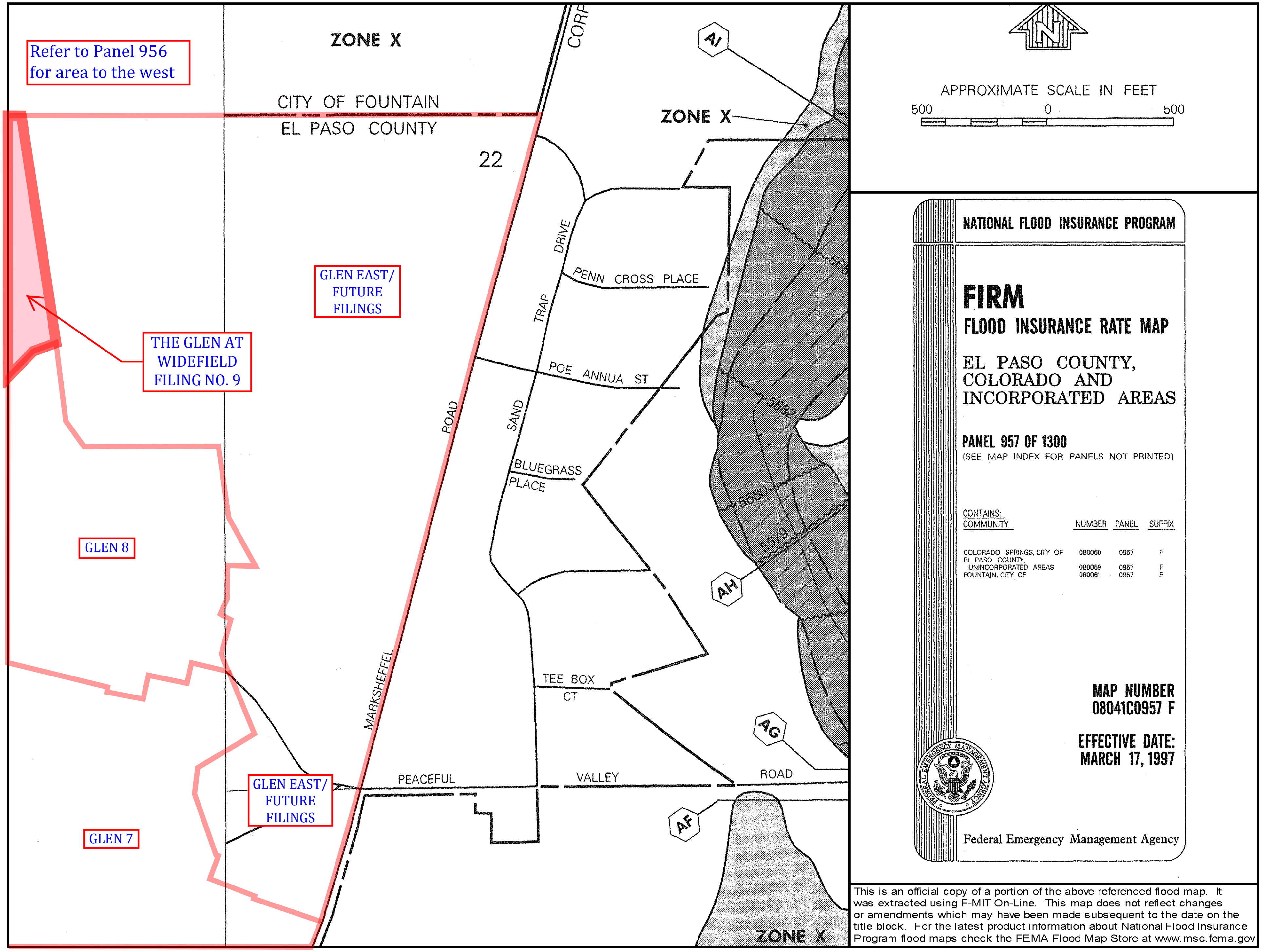
COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0956	F
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0956	F
FOUNTAIN, CITY OF	080061	0956	F

MAP NUMBER
08041C0956 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



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Glen at Widefield Filing No. 9
Drainage Basin and Bridge Fees

Table 1: Impervious Area and Drainage Basin & Bridge Fee Calculation

Total Lots =	106 lots
Total Development Area =	24.938 ac
Total Undeveloped Acres =	0.000 ac
Total Developed Area =	**24.938 ac**
Building/Patio/Drive Per Lot =	2,146 sf
Total Building/Patio/Drive Area =	5.222 ac
Total Street/Sidewalk Area =	5.853 ac
Total Impervious Area =	11.075 ac
% Impervious Area =	**44.41 %**

Area does not match the plat (Filing 9 minus Tracts A, B and D is approximately 28.4 ac)

West Fork Jimmy Camp Creek Drainage Basin

Drainage Basin Fee and Bridge Fee Calculations			
Drainage Basin Fee =	$11,775 / ac	**Drainage Basin Fee =**	**$ 130,410.74**
Bridge Fee =	$3,484 / ac	**Bridge Fee =**	**$ 38,586.07**

Less Previous Drainage Fee Credit (Carry Over from Glen at Widefield Filing No. 7)	**$0.00**	$ 0.00
Drainage Basin Fee Reimbursement	**$0.00**	
Total Drainage Basin Fee Credit Available	**$0.00**	

	Drainage Basin	Bridge
Total Fees Due for the Glen at Widefield Filing No. 9	**$130,410.74**	**$ 38,586.07**

Table 2: Opinion of Cost - Public Drainage Facilities

Item	Quantity	Unit	Unit Cost	**Item Total**
Drainage Structures				
Reinforced Concrete Pipe (RCP)	0	LF	$ 0.00	$ 0.00
18" Reinforced Concrete Pipe	520	LF	$ 69.00	$ 35,880.00
24" Reinforced Concrete Pipe	82	LF	$ 84.00	$ 6,888.00
Flared End Section (FES) RCP 24"	1	EA	$ 900.00	$ 900.00
Flared End Section (FES) RCP 30"	1	EA	$ 1,000.00	$ 1,000.00
Flared End Section (FES) HERCP 43"x68"	1	EA	$ 1,500.00	$ 1,500.00
Curb Inlet (Type R) L=5', Depth < 5 feet	1	EA	$ 3,791.00	$ 3,791.00
Curb Inlet (Type R) L =10', Depth < 5 feet	5	EA	$ 5,528.00	$ 27,640.00
Curb Inlet (Type R) L =10' , 5'-10' Depth	1	EA	$ 6,694.00	$ 6,694.00
Curb Inlet (Type R) L =10' , 10'-15' Depth	2	EA	$ 7,500.00	$ 15,000.00
Curb Inlet (Type R) L =15' , Depth < 5 feet	2	EA	$ 7,923.00	$ 15,846.00
Curb Inlet (Type R) L =25', <5' Depth	1	EA	$ 9,000.00	$ 9,000.00
Curb Inlet (Type R) L =25', 5' - 10' Depth	2	EA	$ 10,000.00	$ 20,000.00
Storm Sewer Manhole, Slab Base, Depth < 15 feet	3	EA	$ 4,575.00	$ 13,725.00
Geotextile (Erosion Control)	0	SY	$ 5.00	$ 0.00
Rip Rap, d50 Size from 6" to 24"	20	CY	$ 98.00	$ 1,960.00
Channel Lining, Concrete (Trickle Channel)	20	CY	$ 450.00	$ 9,000.00
Channel Lining, Rip Rap	62	CY	$ 98.00	$ 6,076.00
Concrete Cutoff Wall (30" RCP FES)	1	EA	$ 500.00	$ 500.00
Detention Outlet Structure	1	EA	$ 12,000.00	$ 12,000.00
Detention Emergency Spillway	1	EA	$ 18,300.00	$ 18,300.00
Presedimentation Forebay	1	EA	$ 7,000.00	$ 7,000.00
Gravel Maintenance Access Trail	1,055	SY	$ 20.00	$ 21,100.00
Type II Bedding	28	CY	$ 35.00	$ 980.00
Detention Basin Seeding and Mulch	3	AC	$ 520.00	$ 1,528.80
			Estimated Storm Drainage Facilities Cost	**$ 273,222.80**
			Engineering 10%	$ 27,322.28
			Contingency 5%	$ 13,661.14
			Total Estimated Cost	**$ 314,206.22**

APPENDIX A

Hydrologic Calculations

Existing Condition – Runoff Coef, Time of Concentration and Runoff Calcs
Developed Condition – Runoff Coef, Time of Concentration and Runoff Calcs

KIOWA ENGINEERING CORPORATION

JOB 14044 - GLEN AT WIDEFIELD EAST

SHEET NO. 1 OF 2

CALCULATED BY CJC DATE 4/24/15

CHECKED BY DATE

SCALE

RUNOFF COEFF. CALC'S. – EXISTING CONDITION

USE UNDEVELOPED - "PASTURE/MEADOW" LAND USE :

B SOILS - $C_5 = 0.08$ $C_{100} = 0.35$

B/D SOILS - $C_5 = 0.15$ $C_{100} = 0.50$ (ASSUME C/D SOILS)

C SOILS - $C_5 = 0.15$ $C_{100} = 0.50$

BASIN EX-1 : TYPE C AND B/D SOILS

AREA = 48.60 Ac (AREAS FROM CAD, TYP.)

$C_5 = 0.15$

$C_{100} = 0.50$

BASIN EX-2 : TYPE C AND B/D SOILS

AREA = 33.12 AC

$C_5 = 0.15$

$C_{100} = 0.50$

BASIN EX-3 : TYPE C AND B/D SOILS

AREA = 61.01 Ac

$C_5 = 0.15$

$C_{100} = 0.50$

BASIN EX-4 : TYPE C AND B/D SOILS

AREA = 10.51 Ac

$C_5 = 0.15$

$C_{100} = 0.50$

BASIN EX-5 : TYPE B SOIL – 12.2 AC ±
TYPE C SOIL – 39.3 AC ±
TYPE B/D SOIL – 23.2 AC ±
FROM SOILS MAP

AREA = 74.74 Ac

$$C_{5,WTD} = \frac{0.08(12.2) + 0.15(39.3 + 23.2)}{74.74} = 0.14$$

$$C_{100,WTD} = \frac{0.35(12.2) + 0.50(39.3 + 23.2)}{74.74} = 0.48$$

KIOWA ENGINEERING CORPORATION

JOB 14044 - GLEN AT WIDEFIELD EAST

SHEET NO. 2 OF 2

CALCULATED BY CJC DATE 4/24/15

CHECKED BY ______ DATE ______

SCALE ______

BASIN EX-6 = TYPE C AND B/D SOILS

AREA = 8.83 AC

$C_5 = 0.15$

$C_{100} = 0.50$

TIME OF CONCENTRATION CALC'S. - EXISTING CONDITION

BASIN OS-1 : FROM MDDP, HEC-1 MODEL INPUT : BASIN 3060

BASIN AREA (BA) = 0.119 SQ.mi. × 640 = 76.2 AC

SCS CURVE NO. (LS) = 79

SCS LAG TIME (UD) = 0.257 HRS. = $0.6\,t_c$

$t_c = 1.6\,(0.257)(60\ \text{min/hr}) = 24.7\ \text{min.}$

BASIN OS-2 = BA = 0.19 sq.mi. × 640 = 121.6 AC (BASIN 4010)

LS = 86

UD = 0.497 HRS.

$t_c = 1.6\,(0.497)(60) = 47.7\ \text{min.}$

The Glen at Widefield
Existing Condition
Runoff Coefficient and Percent Impervious Calculation

Basin / DP	Basin or DP Area (DP contributing basins)		Soil Type	PV	Area 1 Land Use			HI	Area 2 Land Use			US1	Area 3 Land Use			US2	Area 4 Land Use			RO	Area 5 Land Use			Basin % Imperv	Basin Runoff	
				% 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}
EX-1	2,117,068 sf	48.60ac	C	100%		0%	0%	0%	48.60ac	100%	0%	85%		0%	0%	78%		0%	0%	90%		0%	0%	**0.0%**	**0.15**	**0.50**
EX-2	1,442,826 sf	33.12ac	C	100%		0%	0%	0%	33.12ac	100%	0%	85%		0%	0%	78%		0%	0%	90%		0%	0%	**0.0%**	**0.15**	**0.50**
EX-3	2,657,513 sf	61.01ac	C	100%		0%	0%	0%	61.01ac	100%	0%	85%		0%	0%	78%		0%	0%	90%		0%	0%	**0.0%**	**0.15**	**0.50**
EX-4	457,877 sf	10.51ac	C	100%		0%	0%	0%	10.51ac	100%	0%	85%		0%	0%	78%		0%	0%	90%		0%	0%	**0.0%**	**0.15**	**0.50**
EX-5	3,255,509 sf	74.74ac	C	100%		0%	0%	0%	74.74ac	100%	0%	85%		0%	0%	78%		0%	0%	90%		0%	0%	**0.0%**	**0.14**	**0.48**
EX-6	384,815 sf	8.83ac	C	100%		0%	0%	0%	8.83ac	100%	0%	85%		0%	0%	78%		0%	0%	90%		0%	0%	**0.0%**	**0.15**	**0.50**

Basin Runoff Coefficient is based on UDFCD % Imperviousness Calculation								
Runoff Coefficients and Percents Impervious								
Hydrologic Soil Type:	**C**	**Runoff Coef Calc Method**						%Imp
Land Use	Abb	%	C_2	C_5	C_{10}	C_{25}	C_{50}	C_{100}
Commercial Area	CO	95%	0.80	0.82	0.84	0.87	0.89	0.89
Drives and Walks	DR	90%	0.73	0.75	0.77	0.80	0.83	0.83
Streets - Gravel (Packed)	GR	40%	0.28	0.35	0.42	0.50	0.55	0.58
Undevelop-Pasture/Meadow	HI	0%	0.04	0.15	0.25	0.37	0.44	0.50
Lawns	LA	0%	0.04	0.15	0.25	0.37	0.44	0.50
Off-site flow-Undeveloped	OF	45%	0.31	0.37	0.44	0.51	0.56	0.59
Park	PA	7%	0.09	0.19	0.29	0.40	0.47	0.52
Playground	PL	13%	0.13	0.23	0.32	0.42	0.49	0.54
Streets - Paved	PV	100%	0.89	0.90	0.92	0.94	0.96	0.96
Roofs	RO	90%	0.73	0.75	0.77	0.80	0.83	0.83
User Input 1	US1	85%	0.66	0.68	0.71	0.75	0.78	0.79
User Input 2	US2	78%	0.57	0.60	0.64	0.68	0.72	0.73

Weighted
%Imp
A
B
C
D

Equations (% Impervious Calculation):

$C_A = K_A + (1.31\,i^3 - 1.44\,i^2 + 1.135\,i - 0.12)$ [Eqn RO-6]

$C_{CD} = K_{CD} + (0.858\,i^3 - 0.786\,i^2 + 0.774\,i + 0.04)$ [Eqn RO-7]

$C_B = (C_A + C_{CD}) / 2$

I = % imperviousness/100 as a decimal (See Table RO-3)

C_A = Runoff coefficient for NRCS Type A Soils

C_B = Runoff coefficient for NRCS Type B Soils

C_{CD} = Runoff coefficient for NRCS Type C and D Soils

Correction Factors - Table RO-4

K_A = For Type A Soils

K_A (2-yr)= 0

K_A (5-yr)= -0.08i + 0.09

K_A (10-yr)= -0.14i + 0.17

K_A (25-yr)= -0.19i + 0.24

K_A (50-yr)= -0.22i + 0.28

K_A (100-yr)= -0.25i + 0.32

K_{CD}=For Type C & D Soils

K_{CD} (2-yr)= 0

K_{CD} (5-yr)= -0.10i + 0.11

K_{CD} (10-yr)= -0.18i + 0.21

K_{CD} (25-yr)= -0.28i + 0.33

K_{CD} (50-yr)= -0.33i + 0.40

K_{CD} (100-yr)= -0.39i + 0.46

The Glen at Widefield
Existing Condition
Time of Concentration Calculation

Sub-Basin Data				Time of Concentration Estimate											Final t_c	Notes
Basin / Design Point	Contributing Basins	Area	C_5	Initial/Overland Time (t_i)			Travel Time (t_t)						Comp.			
				Length	Slope	t_i	Length	Slope	Land Type	Cv	Velocity	t_t	t_c			
EX-1		48.60ac	0.15	300lf	5.3%	17.3 min.	2200lf	1.9%	GW	15	2.1 ft/sec	17.7 min.	35.0 min.	**35.0 min.**	
EX-2		33.12ac	0.15	300lf	4.8%	17.9 min.	1370lf	3.2%	GW	15	2.7 ft/sec	8.5 min.	26.4 min.	**26.4 min.**	
EX-3		61.01ac	0.15			0.0 min.	2500lf	0.9%	GW	15	1.4 ft/sec	29.3 min.	29.3 min.	**29.3 min.**	
EX-4		10.51ac	0.15	300lf	4.0%	19.0 min.	900lf	4.9%	GW	15	3.3 ft/sec	4.5 min.	23.5 min.	**23.5 min.**	
EX-5		74.74ac	0.14	300lf	5.7%	17.0 min.	3250lf	1.0%	GW	15	1.5 ft/sec	36.1 min.	53.2 min.	**53.2 min.**	
EX-6		8.83ac	0.15	150lf	0.5%	26.8 min.	630lf	5.5%	GW	15	3.5 ft/sec	3.0 min.	29.8 min.	**29.8 min.**	
DP 1	OS-1	76.20ac	--	--	--	--	--	--		--	--	--	24.7 min.	**24.7 min.**	DP 3060 from MDDP
DP 2	OS-1, EX-1	124.80ac	0.15			0.0 min.	1000lf	1.0%	GW	15	1.5 ft/sec	11.1 min.	11.1 min.	**35.8 min.**	DP 1 routed to DP 2
DP 3	EX-2	33.12ac	0.15	300lf	4.8%	17.9 min.	1370lf	3.2%	GW	15	2.7 ft/sec	8.5 min.	26.4 min.	**26.4 min.**	
DP 4	OS-1, EX-1, EX-2	157.92ac	0.15			0.0 min.	300lf	0.5%	GW	15	1.1 ft/sec	4.7 min.	5.0 min.	**40.8 min.**	DP 2 and DP 3 routed to DP 4
DP 5	OS-1, EX-1, EX-2, EX-3	218.93ac	0.15			0.0 min.	800lf	1.3%	GW	15	1.7 ft/sec	7.8 min.	7.8 min.	**48.6 min.**	DP 4 routed to DP 5
DP 6	EX-4	10.51ac	0.15	300lf	4.0%	19.0 min.	900lf	4.9%	GW	15	3.3 ft/sec	4.5 min.	23.5 min.	**23.5 min.**	
DP 7	OS-1, EX-1, EX-2, EX-3, EX-4	229.44ac	0.15			0.0 min.	200lf	0.3%	GW	15	0.8 ft/sec	4.1 min.	5.0 min.	**53.6 min.**	DP 5 and DP 6 routed to DP 7
DP 8	OS-2	121.60ac	--	--	--	--	--	--		--	--	--	47.7 min.	**47.7 min.**	DP 4011 from MDDP
DP 9	OS-2, EX-5	196.34ac	0.15			0.0 min.	1550lf	0.6%	GW	15	1.1 ft/sec	23.2 min.	23.2 min.	**70.9 min.**	DP 8 routed to DP 9
DP 10	EX-6	8.83ac	0.15	150lf	0.5%	26.8 min.	630lf	5.5%	GW	15	3.5 ft/sec	3.0 min.	29.8 min.	**29.8 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)

Land Surface Type	Land Type
Grassed Waterway	GW
Heavy Meadow	HM
Nearly Bare Ground	NBG
Paved Area	PV
Riprap (Not Buried)	RR
Short Pasture/Lawns	SP
Tillage/Fields	TF

The Glen at Widefield
Existing Condition
Runoff Calculation

Basin / Design Point	Contributing Basins	Drainage Area	C_5	C_{100}	Time of Concentration	Rainfall Intensity i_5	Rainfall Intensity i_{100}	Runoff Q_5	Runoff Q_{100}	Basin / DP	Notes
EX-1		48.60 ac	0.15	0.50	35.0 min.	2.2 in/hr	3.8 in/hr	**16.4 cfs**	**91.7 cfs**	EX-1	
EX-2		33.12 ac	0.15	0.50	26.4 min.	2.7 in/hr	4.5 in/hr	**13.3 cfs**	**74.3 cfs**	EX-2	
EX-3		61.01 ac	0.15	0.50	29.3 min.	2.5 in/hr	4.2 in/hr	**23.0 cfs**	**128.9 cfs**	EX-3	
EX-4		10.51 ac	0.15	0.50	23.5 min.	2.8 in/hr	4.8 in/hr	**4.5 cfs**	**25.1 cfs**	EX-4	
EX-5		74.74 ac	0.14	0.48	53.2 min.	1.6 in/hr	2.7 in/hr	**17.0 cfs**	**97.7 cfs**	EX-5	
EX-6		8.83 ac	0.15	0.50	29.8 min.	2.5 in/hr	4.2 in/hr	**3.3 cfs**	**18.5 cfs**	EX-6	
DP 1	OS-1	76.20 ac	--	--	24.7 min.	2.8 in/hr	4.7 in/hr	**48 cfs**	**163 cfs**	DP 1	DP 3060 from MDDP
DP 2	OS-1, EX-1	124.80 ac	0.15	0.50	35.8 min.	2.2 in/hr	3.7 in/hr	**41 cfs**	**232 cfs**	DP 2	
DP 3	EX-2	33.12 ac	0.15	0.50	26.4 min.	2.7 in/hr	4.5 in/hr	**13 cfs**	**74 cfs**	DP 3	
DP 4	OS-1, EX-1, EX-2	157.92 ac	0.15	0.50	40.8 min.	2.0 in/hr	3.4 in/hr	**48 cfs**	**268 cfs**	DP 4	
DP 5	OS-1, EX-1, EX-2, EX-3	218.93 ac	0.15	0.50	48.6 min.	1.8 in/hr	2.9 in/hr	**58 cfs**	**323 cfs**	DP 5	
DP 6	EX-4	10.51 ac	0.15	0.50	23.5 min.	2.8 in/hr	4.8 in/hr	**4 cfs**	**25 cfs**	DP 6	
DP 7	OS-1, EX-1, EX-2, EX-3, EX-4	229.44 ac	0.15	0.50	53.6 min.	1.6 in/hr	2.7 in/hr	**55 cfs**	**310 cfs**	DP 7	
DP 8	OS-2	121.60 ac	--	--	47.7 min.	1.8 in/hr	3.0 in/hr	**38 cfs**	**153 cfs**	DP 8	DP 4011 from MDDP
DP 9	OS-2, EX-5	196.34 ac	0.15	0.50	70.9 min.	1.2 in/hr	2.0 in/hr	**35 cfs**	**196 cfs**	DP 9	
DP 10	EX-6	8.83 ac	0.15	0.50	29.8 min.	2.5 in/hr	4.2 in/hr	**3 cfs**	**18 cfs**	DP 10	

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

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

Q = CiA
Q = Peak Runoff Rate (cubic feet/second)
C = Runoff coef representing a 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

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

RUNOFF COEFFICIENT CALC'S. - DEVELOPED CONDITION
(RESIDENTIAL AREAS)

A-BASINS: A = 10.17 AC. / 33 LOTS > 3.24 LOTS/AC.
A = 7.98 AC. / 30 LOTS > 3.76 LOTS/AC.
> 3.5 LOTS/AC.

BY INTERPOLATING FROM TABLE 6-6, I = 35%

$\Rightarrow C_5 = 0.33$, $C_{100} = 0.57$ > SOIL GROUP C

B-BASINS: A = 20.05 AC. / 81 LOTS > 4.04 LOTS/AC.
A = 6.86 AC. / 30 LOTS > 4.37 LOTS/AC.
> 4.2 LOTS/AC.

FROM TABLE 6-6, I = 41%

$\Rightarrow C_5 = 0.35$, $C_{100} = 0.58$ > SOIL GROUP C

C-BASINS: A = 46.12 AC. / 200 LOTS > 4.34 LOTS/AC.
A = 35.29 AC. / 148 LOTS > 4.19 LOTS/AC.
> 4.3 LOTS/AC.

FROM TABLE 6-6, I = 42%

$\Rightarrow C_5 = 0.31$, $C_{100} = 0.50$ > SOIL GROUP B

KIOWA ENGINEERING CORPORATION

JOB 14044 - GLEN AT WIDEFIELD EAST

SHEET NO. 2 OF 2

CALCULATED BY CJC DATE 5/19/15

CHECKED BY DATE

SCALE

RUNOFF COEFFICIENT CALC'S. - DEVELOPED CONDITION (CONT'D.):

(RESIDENTIAL AREAS)

D- BASINS: A = 38.97 AC., 147 LOTS > 3.77 LOTS/AC.

A = 3.52 AC., 13 LOTS > 3.69 LOTS/AC.

> 3.7 LOTS/AC.

FROM TABLE 6-6, I = 37%

$\Rightarrow C_5 = 0.34$, $C_{100} = 0.58$ > SOIL GROUP C

E- BASINS: A = 2.81 AC., 7 LOTS > 2.49 LOTS/AC.

A = 1.6 AC., 4 LOTS > 2.5 LOTS/AC.

> 2.5 LOTS/AC.

FROM TABLE 6-6, I = 28%

$\Rightarrow C_5 = 0.30$, $C_{100} = 0.56$ > SOIL GROUP C

The Glen at Widefield Filing No. 9

Developed Condition

Runoff Coefficient and Percent Impervious Calculation

Basin	DP	Basin or DP Area (DP contributing basins)		Soil Type	PV	Area 1 Land Use			LA	Area 2 Land Use			RS2	Area 3 Land Use			RS1	Area 4 Land Use			Basin % Imperv	Basin Runoff Coeficient	
					% 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}
A-1	DP 1	207,218 sf	4.76ac	C	100%		0%	0%	0%	0.58ac	12%	0%	46%		0%	0%	35%	4.18ac	88%	31%	30.7%	0.31	0.57
A-2	DP 2	48,865 sf	1.12ac	C	100%		0%	0%	0%		0%	0%	46%		0%	0%	35%	1.12ac	100%	35%	35.0%	0.33	0.57
A-3	DP 3	105,749 sf	2.43ac	C	100%		0%	0%	0%		0%	0%	46%		0%	0%	35%	2.43ac	100%	35%	35.0%	0.33	0.57
A-4		30,939 sf	0.71ac	C	100%	0.09ac	13%	13%	0%	0.62ac	87%	0%	46%		0%	0%	35%		0%	0%	12.7%	0.22	0.54
A-5		38,440 sf	0.88ac	C	100%	0.57ac	65%	65%	0%	0.31ac	35%	0%	46%		0%	0%	35%		0%	0%	64.9%	0.61	0.74
A-6	DP 6	66,445 sf	1.53ac	C	100%	0.10ac	6%	6%	0%	1.43ac	94%	0%	46%		0%	0%	35%		0%	0%	6.3%	0.19	0.52
A-7	DP 7	142,805 sf	3.28ac	C	100%		0%	0%	0%	0.42ac	13%	0%	46%		0%	0%	35%	2.86ac	87%	31%	30.5%	0.31	0.57
A-8	DP 8	32,545 sf	0.75ac	C	100%		0%	0%	0%	0.08ac	11%	0%	46%		0%	0%	35%	0.66ac	89%	31%	31.1%	0.31	0.57
A-9	DP 9	56,113 sf	1.29ac	C	100%		0%	0%	0%		0%	0%	46%		0%	0%	35%	1.29ac	100%	35%	35.0%	0.33	0.57
A-10		40,968 sf	0.94ac	C	100%		0%	0%	0%		0%	0%	46%		0%	0%	35%	0.94ac	100%	35%	35.0%	0.33	0.57
A-11		64,924 sf	1.49ac	C	100%	0.91ac	61%	61%	0%	0.58ac	39%	0%	46%		0%	0%	35%		0%	0%	61.1%	0.46	0.64
A-12		27,745 sf	0.64ac	C	100%		0%	0%	0%	0.64ac	100%	0%	46%		0%	0%	35%		0%	0%	0.0%	0.15	0.50
	DP 4	A2, A3, A4	4.26ac	C	100%	0.09ac	2%	2%	0%	0.62ac	15%	0%	46%		0%	0%	35%	3.55ac	83%	29%	31.3%	0.31	0.57
	DP 5	A2, A3, A4, A5	5.14ac	C	100%	0.66ac	13%	13%	0%	0.93ac	18%	0%	46%		0%	0%	35%	3.55ac	69%	24%	37.0%	0.34	0.58
	DP 10	A8 - A10	2.98ac	C	100%	0.00ac	0%	0%	0%	0.08ac	3%	0%	46%		0%	0%	35%	2.89ac	97%	34%	34.0%	0.32	0.57
	DP 11	A6 - A10	7.78ac	C	100%	0.10ac	1%	1%	0%	1.93ac	25%	0%	46%		0%	0%	35%	5.75ac	74%	26%	27.1%	0.29	0.56
	DP 12	A6 - A11	9.27ac	C	100%	1.01ac	11%	11%	0%	2.51ac	27%	0%	46%		0%	0%	35%	5.75ac	62%	22%	32.6%	0.32	0.57
	DP 13	OS-1	76.20ac																				
	DP 14	A2 - A11	14.41ac	C	100%	1.67ac	12%	12%	0%	3.44ac	24%	0%	46%		0%	0%	35%	9.30ac	65%	23%	34.2%	0.32	0.57
	DP 14.1	A2 - A12	15.05ac	C	100%	1.67ac	11%	11%	0%	4.08ac	27%	0%	46%		0%	0%	35%	9.30ac	62%	22%	32.7%	0.32	0.57

Basin Runoff Coefficient is based on UDFCD % Imperviousness Calculation

Runoff Coefficients and Percents Impervious

Hydrologic Soil Type:	B	Runoff Coef Calc Method					%Imp
Land Use	Abb	%	C_2	C_5	C_{10}	C_{25}	C_{50}	C_{100}
Commercial Area	CO	95%	0.79	0.81	0.83	0.85	0.87	0.88
Drives and Walks	DR	90%	0.71	0.73	0.75	0.78	0.80	0.81
Streets - Gravel (Packed)	GR	40%	0.23	0.30	0.36	0.42	0.46	0.50
Undevelop-Historic Flow	HI	2%	0.03	0.08	0.17	0.26	0.31	0.36
Lawns	LA	0%	0.02	0.08	0.15	0.25	0.30	0.35
Off-site flow-Undeveloped	OF	45%	0.26	0.32	0.38	0.44	0.48	0.51
Park	PA	7%	0.05	0.12	0.20	0.29	0.34	0.39
Playground	PL	13%	0.07	0.16	0.24	0.32	0.37	0.42
Streets - Paved	PV	100%	0.89	0.90	0.92	0.94	0.95	0.96
Roofs	RO	90%	0.71	0.73	0.75	0.78	0.80	0.81
Residential: 3.5 Lots/Acre	RS1	35%	0.20	0.27	0.34	0.41	0.45	0.48
Residential: 1/5 Acre	RS2	46%	0.27	0.33	0.39	0.45	0.48	0.51

Equations (% Impervious Calculation):

$C_A = K_A + (1.31\,i^3 - 1.44\,i^2 + 1.135\,i - 0.12)$ [Eqn RO-6]

$C_{CD} = K_{CD} + (0.858\,i^3 - 0.786\,i^2 + 0.774\,i + 0.04)$ [Eqn RO-7]

$C_B = (C_A + C_{CD}) / 2$

I = % imperviousness/100 as a decimal (See Table RO-3)

C_A = Runoff coefficient for NRCS Type A Soils

C_B = Runoff coefficient for NRCS Type B Soils

C_{CD} = Runoff coefficient for NRCS Type C and D Soils

Correction Factors - Table RO-4

K_A = For Type A Soils

K_A (2-yr)= 0

K_A (5-yr)= -0.08i + 0.09

K_A (10-yr)= -0.14i + 0.17

K_A (25-yr)= -0.19i + 0.24

K_A (50-yr)= -0.22i + 0.28

K_A (100-yr)= -0.25i + 0.32

K_{CD}=For Type C & D Soils

K_{CD} (2-yr)= 0

K_{CD} (5-yr)= -0.10i + 0.11

K_{CD} (10-yr)= -0.18i + 0.21

K_{CD} (25-yr)= -0.28i + 0.33

K_{CD} (50-yr)= -0.33i + 0.40

K_{CD} (100-yr)= -0.39i + 0.46

The Glen at Widefield Filing No. 9
Developed Condition
Time of Concentration Calculation

Sub-Basin Data					Time of Concentration Estimate										Min. Tc in Urban			
					Initial/Overland Time (t_i)			Travel Time (t_t)						Comp.	Tc Check (urban)			
Basin	Design Point	Contributing Basins	Area	C_5	Length	Slope	t_i	Length	Slope	Land Type	Cv	Velocity	t_t	t_c	Total Length	t_c Check	Final t_c	Notes
A-1	DP 1		4.76ac	0.31	70lf	4.0%	7.6 min.	660lf	2.5%	GW	15	2.4 ft/sec	4.6 min.	12.3 min.	730lf	14.1 min.	**12.3 min.**	
A-2	DP 2		1.12ac	0.33	70lf	2.0%	9.4 min.	610lf	2.5%	PV	20	3.2 ft/sec	3.2 min.	12.6 min.	680lf	13.8 min.	**12.6 min.**	
A-3	DP 3		2.43ac	0.33	100lf	4.5%	8.6 min.	570lf	2.5%	PV	20	3.2 ft/sec	3.0 min.	11.6 min.	670lf	13.7 min.	**11.6 min.**	
A-4			0.71ac	0.22	100lf	7.0%	8.4 min.	540lf	3.3%	GW	15	2.7 ft/sec	3.3 min.	11.7 min.	640lf	13.6 min.	**11.7 min.**	
A-5			0.88ac	0.61			0.0 min.	515lf	1.2%	PV	20	2.2 ft/sec	3.9 min.	5.0 min.	515lf	12.9 min.	**5.0 min.**	
A-6	DP 6		1.53ac	0.19	100lf	1.1%	16.2 min.	980lf	4.0%	GW	15	3.0 ft/sec	5.4 min.	21.6 min.	1080lf	16.0 min.	**16.0 min.**	
A-7	DP 7		3.28ac	0.31	100lf	2.5%	10.7 min.	900lf	4.0%	PV	20	4.0 ft/sec	3.8 min.	14.5 min.	1000lf	15.6 min.	**14.5 min.**	
A-8	DP 8		0.75ac	0.31	100lf	2.5%	10.7 min.	630lf	4.0%	PV	20	4.0 ft/sec	2.6 min.	13.3 min.	730lf	14.1 min.	**13.3 min.**	
A-9	DP 9		1.29ac	0.33	100lf	2.0%	11.2 min.	240lf	1.6%	PV	20	2.5 ft/sec	1.6 min.	12.8 min.	340lf	11.9 min.	**11.9 min.**	
A-10			0.94ac	0.33	100lf	2.0%	11.2 min.	375lf	1.6%	PV	20	2.5 ft/sec	2.5 min.	13.7 min.	475lf	12.6 min.	**12.6 min.**	
A-11			1.49ac	0.46			0.0 min.	505lf	1.2%	PV	20	2.2 ft/sec	3.8 min.	5.0 min.	505lf	12.8 min.	**5.0 min.**	
A-12			0.64ac	0.15	20lf	25.0%	2.7 min.	80lf	0.5%	PV	20	1.4 ft/sec	0.9 min.	5.0 min.	100lf	10.6 min.	**5.0 min.**	
	DP 4	A2, A3, A4	4.26ac	0.31	100lf	4.3%	8.9 min.	640lf	2.4%	PV	20	3.1 ft/sec	3.4 min.	12.3 min.	740lf	14.1 min.	**12.3 min.**	
	DP 5	A2, A3, A4, A5	5.14ac	0.34	100lf	4.3%	8.6 min.	1090lf	1.9%	PV	20	2.8 ft/sec	6.6 min.	15.2 min.	1190lf	16.6 min.	**15.2 min.**	
	DP 10	A8 - A10	2.98ac	0.32	100lf	2.5%	10.5 min.	800lf	4.0%	PV	20	4.0 ft/sec	3.3 min.	13.8 min.	900lf	15.0 min.	**13.8 min.**	
	DP 11	A6 - A10	7.78ac	0.29	100lf	1.1%	14.3 min.	1030lf	3.9%	PV	20	3.9 ft/sec	4.3 min.	18.7 min.	1130lf	16.3 min.	**16.3 min.**	
	DP 12	A6 - A11	9.27ac	0.32	100lf	1.1%	13.9 min.	1480lf	3.1%	PV	20	3.5 ft/sec	7.0 min.	20.9 min.	1580lf	18.8 min.	**18.8 min.**	
	DP 13	OS-1	76.20ac	--	--	--	--	--	--	--	--	--	--	--	--	--	**25.2 min.**	Basin OS-1 Routed to DP13
	DP 14	A2 - A11	14.41ac	0.32	100lf	1.1%	13.8 min.	1520lf	3.0%	PV	20	3.5 ft/sec	7.3 min.	21.1 min.	1620lf	19.0 min.	**19.0 min.**	
	DP 14.1	A2 - A12	15.05ac	0.32	100lf	1.1%	13.9 min.	1670lf	2.8%	PV	20	3.3 ft/sec	8.3 min.	22.2 min.	1770lf	19.8 min.	**19.8 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)

Land Surface Type	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

The Glen at Widefield Filing No. 9
Developed Condition
Runoff Calculation

Basin	Design Point	Contributing Basins	Drainage Area	C_5	C_{100}	Time of Concentration	Rainfall Intensity i_5	Rainfall Intensity i_{100}	Runoff Q_5	Runoff Q_{100}	Basin / DP	Notes
A-1	DP 1		4.76 ac	0.31	0.57	12.3 min.	3.8 in/hr	6.4 in/hr	**5.6 cfs**	**17.4 cfs**	A-1	
A-2	DP 2		1.12 ac	0.33	0.57	12.6 min.	3.8 in/hr	6.3 in/hr	**1.4 cfs**	**4.1 cfs**	A-2	
A-3	DP 3		2.43 ac	0.33	0.57	11.6 min.	3.9 in/hr	6.6 in/hr	**3.1 cfs**	**9.2 cfs**	A-3	
A-4			0.71 ac	0.22	0.54	11.7 min.	3.9 in/hr	6.5 in/hr	**0.6 cfs**	**2.5 cfs**	A-4	
A-5			0.88 ac	0.61	0.74	5.0 min.	5.2 in/hr	8.7 in/hr	**2.8 cfs**	**5.7 cfs**	A-5	
A-6	DP 6		1.53 ac	0.19	0.52	16.0 min.	3.4 in/hr	5.7 in/hr	**1.0 cfs**	**4.6 cfs**	A-6	
A-7	DP 7		3.28 ac	0.31	0.57	14.5 min.	3.6 in/hr	6.0 in/hr	**3.6 cfs**	**11.2 cfs**	A-7	
A-8	DP 8		0.75 ac	0.31	0.57	13.3 min.	3.7 in/hr	6.2 in/hr	**0.9 cfs**	**2.6 cfs**	A-8	
A-9	DP 9		1.29 ac	0.33	0.57	11.9 min.	3.9 in/hr	6.5 in/hr	**1.6 cfs**	**4.8 cfs**	A-9	
A-10			0.94 ac	0.33	0.57	12.6 min.	3.8 in/hr	6.3 in/hr	**1.2 cfs**	**3.4 cfs**	A-10	
A-11			1.49 ac	0.46	0.64	5.0 min.	5.2 in/hr	8.7 in/hr	**3.6 cfs**	**8.2 cfs**	A-11	
A-12			0.64 ac	0.15	0.50	5.0 min.	5.2 in/hr	8.7 in/hr	**0.5 cfs**	**2.8 cfs**	A-12	
	DP 4	A2, A3, A4	4.26 ac	0.31	0.57	12.3 min.	3.8 in/hr	6.4 in/hr	**5.0 cfs**	**15.5 cfs**	DP 4	
	DP 5	A2, A3, A4, A5	5.14 ac	0.34	0.58	15.2 min.	3.5 in/hr	5.9 in/hr	**6.0 cfs**	**17.5 cfs**	DP 5	
	DP 10	A8 - A10	2.98 ac	0.32	0.57	13.8 min.	3.6 in/hr	6.1 in/hr	**3.5 cfs**	**10.4 cfs**	DP 10	
	DP 11	A6 - A10	7.78 ac	0.29	0.56	16.3 min.	3.4 in/hr	5.7 in/hr	**7.7 cfs**	**25.0 cfs**	DP 11	
	DP 12	A6 - A11	9.27 ac	0.32	0.57	18.8 min.	3.2 in/hr	5.3 in/hr	**9.3 cfs**	**28.3 cfs**	DP 12	
	DP 13	OS-1	76.20 ac	--	--	25.2 min.	2.7 in/hr	4.6 in/hr	**50.0 cfs**	**165.0 cfs**	DP 13	Flow From Basin OS-1
	DP 14	A2 - A11	14.41 ac	0.32	0.57	19.0 min.	3.2 in/hr	5.3 in/hr	**14.7 cfs**	**43.9 cfs**	DP 14	
	DP 14.1	A2 - A12	15.05 ac	0.32	0.57	19.8 min.	3.1 in/hr	5.2 in/hr	**14.8 cfs**	**44.8 cfs**	DP 14.1	

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

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

Q = CiA
Q = Peak Runoff Rate (cubic feet/second)
C = Runoff coef representing a 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

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

APPENDIX A.1

Supporting Hydrologic Tables and Figures

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.

Table 6-7. Conveyance Coefficient, C_v

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

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

The travel time is calculated by dividing the flow distance (in feet) by the velocity calculated using Equation 6-9 and converting units to minutes.

The time of concentration (t_c) is then the sum of the overland flow time (t_i) and the travel time (t_t) per Equation 6-7.

3.2.3 First Design Point Time of Concentration in Urban Catchments

Using this procedure, the time of concentration at the first design point (typically the first inlet in the system) in an urbanized catchment should not exceed the time of concentration calculated using Equation 6-10. The first design point is defined as the point where runoff first enters the storm sewer system.

$$t_c = \frac{L}{180} + 10 \quad \text{(Eq. 6-10)}$$

Where:

t_c = maximum time of concentration at the first design point in an urban watershed (min)

L = waterway length (ft)

Equation 6-10 was developed using the rainfall-runoff data collected in the Denver region and, in essence, represents regional "calibration" of the Rational Method. Normally, Equation 6-10 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, the time of concentration is calculated by accumulating the travel times in downstream drainageway reaches.

3.2.4 Minimum Time of Concentration

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

3.2.5 Post-Development Time of Concentration

As Equation 6-8 indicates, the time of concentration is a function of the 5-year runoff coefficient for a drainage basin. Typically, higher levels of imperviousness (higher 5-year runoff coefficients) correspond to shorter times of concentration, and lower levels of imperviousness correspond to longer times of

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

APPENDIX B

Detention Basin Calculations

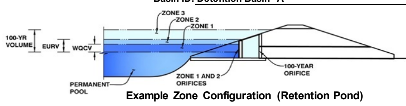
Full Spectrum Detention Basin/Extended Detention Basin
Detention Volume and Emergency Spillway
Outlet Structure Calculations
Trickle Channel Capacity and Outlet Structure Sizing
Trash Rack and Safety Grate Sizing
Forebay Sizing Calculations

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: The Glen at Widefield Filing No. 9

Basin ID: Detention Basin "A"



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	15.05	acres		
Watershed Length =	1,000	ft		
Watershed Slope =	0.030	ft/ft		
Watershed Imperviousness =	32.70%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	0.0%	percent		
Percentage Hydrologic Soil Groups C/D =	100.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.200	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.450	acre-feet		
2-yr Runoff Volume (P1 = 1.19 in.) =	0.414	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.673	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.945	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	1.454	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	1.818	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	2.279	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.2 in.) =	3.233	acre-feet	3.20	inches
Approximate 2-yr Detention Volume =	0.388	acre-feet		
Approximate 5-yr Detention Volume =	0.635	acre-feet		
Approximate 10-yr Detention Volume =	0.733	acre-feet		
Approximate 25-yr Detention Volume =	0.819	acre-feet		
Approximate 50-yr Detention Volume =	0.855	acre-feet		
Approximate 100-yr Detention Volume =	1.035	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.200	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.250	acre-feet
Zone 3 (100yr + 1 / 2 WQCV - Zones 1 & 2) =	0.685	acre-feet
Total Detention Basin Volume =	1.135	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	--	--	--	26	0.001		
	--	0.67	--	--	--	26	0.001	17	0.000
	--	1.00	--	--	--	12,400	0.285	1,945	0.045
	--	2.00	--	--	--	14,300	0.328	15,274	0.351
	--	3.00	--	--	--	16,200	0.372	30,667	0.704
	--	4.00	--	--	--	18,300	0.420	47,917	1.100
	--	5.00	--	--	--	20,450	0.469	67,292	1.545
	--	6.00	--	--	--	22,700	0.521	88,867	2.040
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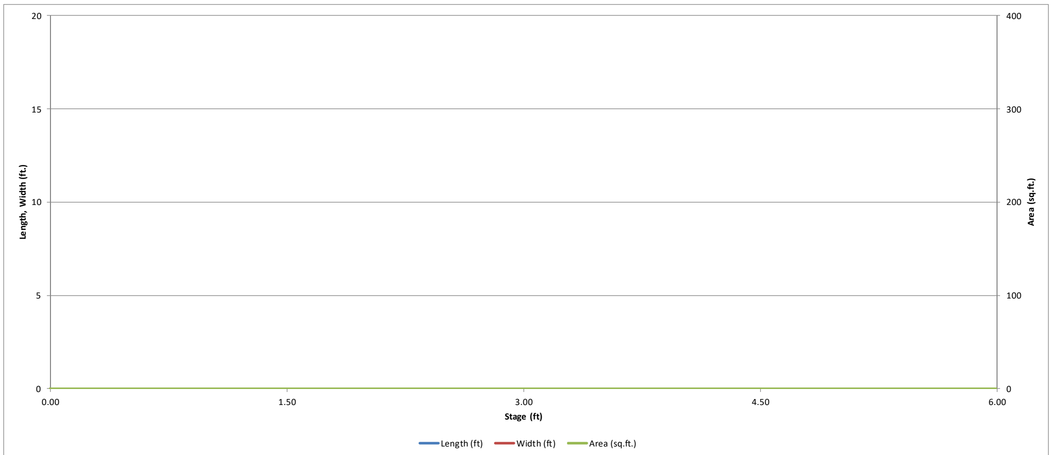
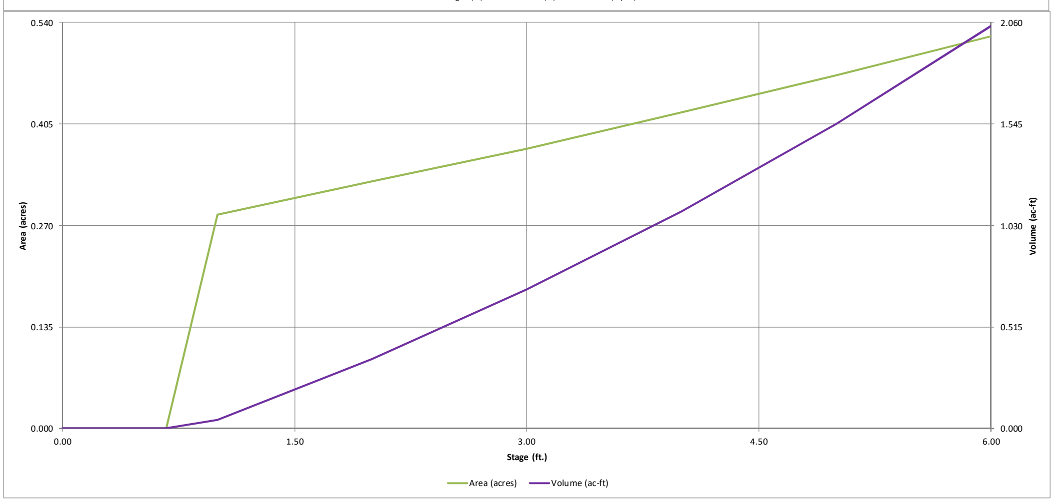
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



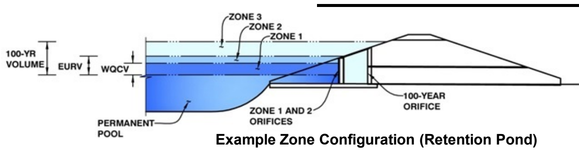


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project:

Basin ID:



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.52	0.200	Orifice Plate
Zone 2 (EURV)	2.29	0.250	Orifice Plate
(100+1/2WQCV)	4.09	0.685	Weir&Pipe (Restrict)
		1.135	Total

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	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)
Depth at top of Zone using Orifice Plate =	2.29	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	9.20	inches
Orifice Plate: Orifice Area per Row =	N/A	inches

Calculated Parameters for Plate

WQ Orifice Area per Row =	N/A	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.76	1.53					
Orifice Area (sq. inches)	1.10	1.10	1.10					

	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	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	2.29	N/A	ft (relative to basin bottom
Overflow Weir Front Edge Length =	6.00	N/A	feet
Overflow Weir Slope =	4.00	N/A	H:V (enter zero for flat gr
Horiz. Length of Weir Sides =	5.00	N/A	feet
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected

≥ 4

Pipe Dia and height above pipe invert does not match the construction plans. Update one or the other to match.

Unresolved. Construction Drawings show a 30" dia w/ 15" above invert.

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

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.33	N/A	ft (distance below basin bo
Outlet Pipe Diameter =	24.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	17.70		inches

Outlet Orifice Centroid =	0.82	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	2.07	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	4.50	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	50.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

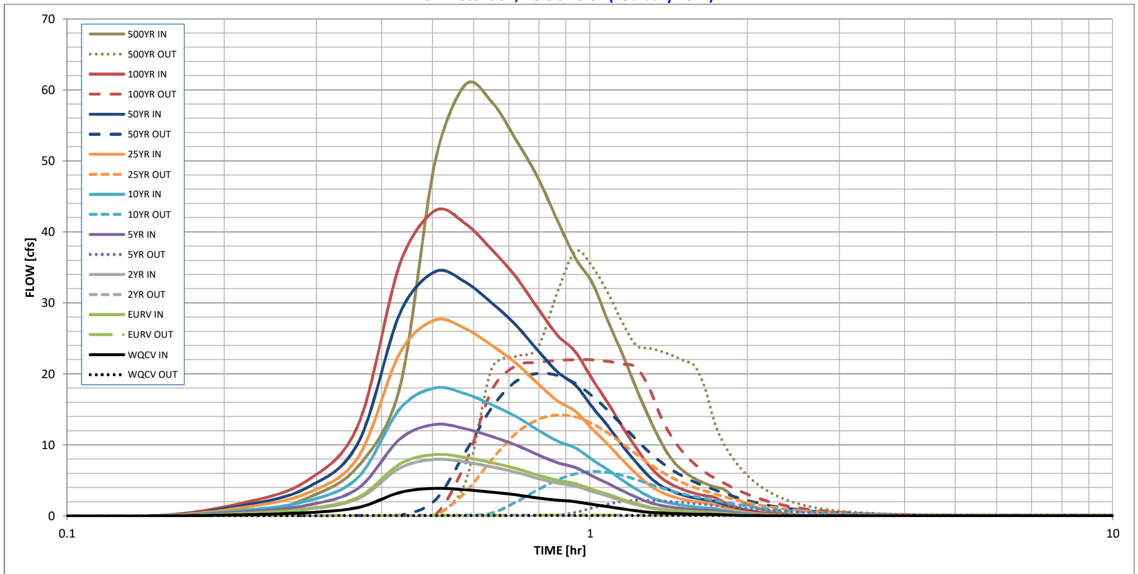
Spillway Design Flow Depth=	0.42	feet
Stage at Top of Freeboard =	5.92	feet
Basin Area at Top of Freeboard =	0.52	acres

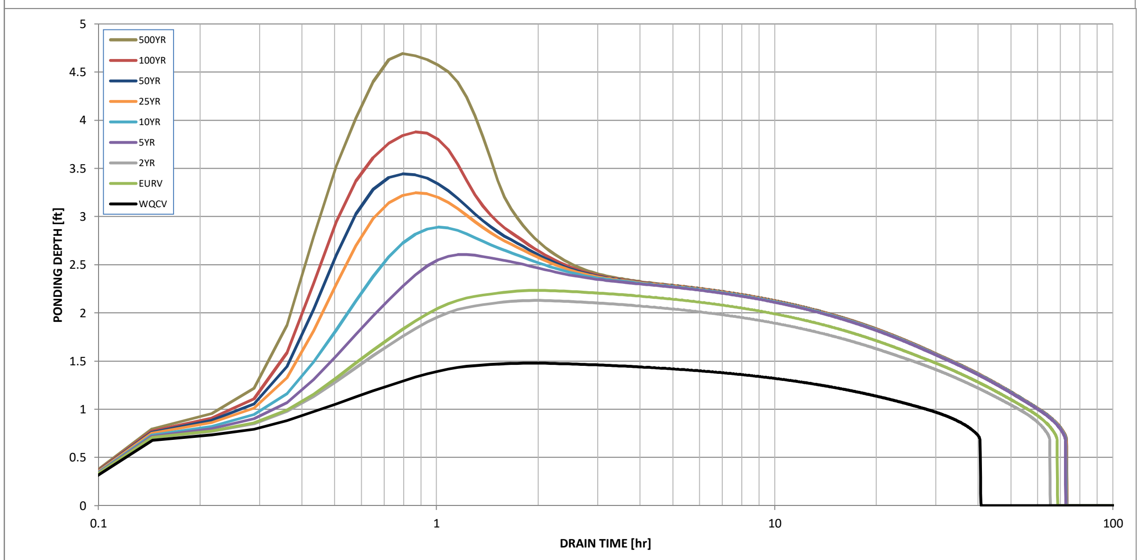
Routed Hydrograph Results

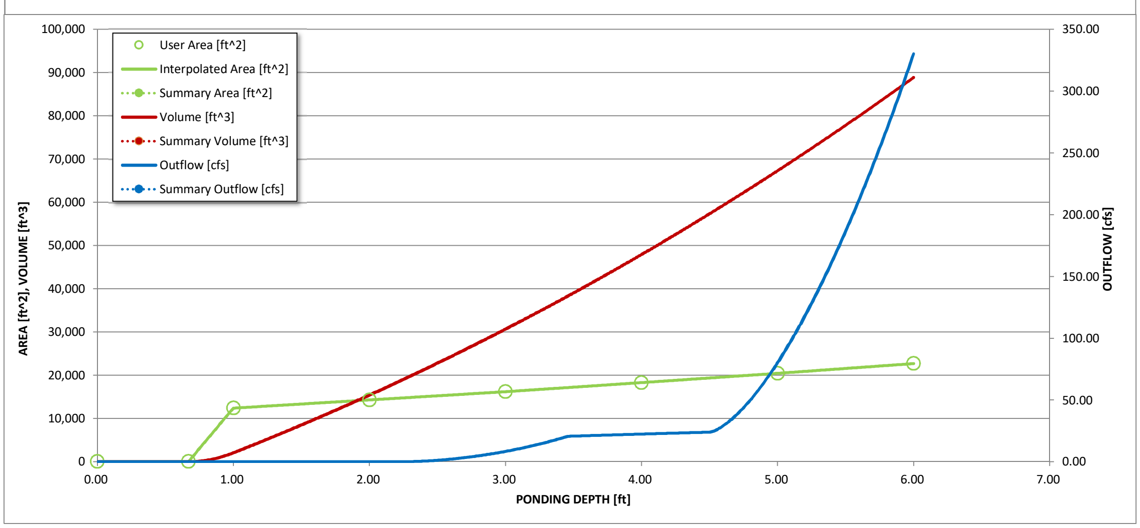
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.20
Calculated Runoff Volume (acre-ft) =	0.200	0.450	0.414	0.673	0.945	1.454	1.818	2.279	3.233
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.200	0.449	0.414	0.672	0.944	1.453	1.817	2.277	3.232
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.02	0.15	0.41	0.93	1.23	1.59	2.34
Predevelopment Peak Q (cfs) =	0.0	0.0	0.3	2.3	6.1	14.0	18.5	23.9	35.2
Peak Inflow Q (cfs) =	3.9	8.7	8.0	12.9	18.0	27.6	34.4	43.0	60.7
Peak Outflow Q (cfs) =	0.1	0.1	0.1	2.2	6.3	14.2	20.1	22.0	37.3
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.0	1.0	1.0	1.1	0.9	1.1
Structure Controlling Flow =	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	0.1	0.3	0.7	0.9	1.0	1.1
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	39	64	61	67	65	61	59	56	51
Time to Drain 99% of Inflow Volume (hours) =	40	67	64	70	70	68	67	66	64
Maximum Ponding Depth (ft) =	1.48	2.23	2.13	2.61	2.89	3.25	3.44	3.88	4.69
Area at Maximum Ponding Depth (acres) =	0.31	0.34	0.33	0.35	0.37	0.38	0.39	0.41	0.45
Maximum Volume Stored (acre-ft) =	0.186	0.431	0.394	0.559	0.660	0.795	0.872	1.046	1.402

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







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:

Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

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

Time Interval: 4.33 min

Hydrograph Constant: 1.154

SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK
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]
0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:04:20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:08:40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0:12:59	0.18	0.39	0.36	0.57	0.79	1.20	1.48	1.84	2.56
0:17:19	0.47	1.04	0.96	1.54	2.14	3.26	4.05	5.04	7.07
0:21:39	1.21	2.66	2.46	3.95	5.50	8.36	10.39	12.94	18.14
0:25:59	3.32	7.33	6.76	10.85	15.10	22.97	28.54	35.51	49.77
0:30:19	3.88	8.65	7.97	12.88	18.02	27.59	34.41	43.00	60.73
0:34:38	3.69	8.25	7.60	12.29	17.22	26.40	32.95	41.20	58.28
0:38:58	3.36	7.51	6.92	11.19	15.67	24.03	29.99	37.50	53.04
0:43:18	2.98	6.69	6.16	10.00	14.03	21.54	26.91	33.69	47.73
0:47:38	2.55	5.77	5.31	8.63	12.14	18.69	23.38	29.32	41.67
0:51:58	2.23	5.03	4.63	7.52	10.56	16.25	20.30	25.50	36.33
0:56:17	2.02	4.55	4.19	6.82	9.58	14.73	18.42	23.11	32.85
1:00:37	1.64	3.74	3.44	5.63	7.93	12.25	15.35	19.28	27.47
1:04:57	1.33	3.05	2.80	4.60	6.50	10.08	12.65	15.92	22.73
1:09:17	1.00	2.33	2.14	3.54	5.04	7.86	9.90	12.50	17.94
1:13:37	0.73	1.73	1.58	2.64	3.77	5.95	7.53	9.55	13.80
1:17:56	0.54	1.26	1.15	1.91	2.73	4.35	5.53	7.05	10.26
1:22:16	0.42	0.98	0.90	1.48	2.10	3.32	4.20	5.34	7.72
1:26:36	0.35	0.80	0.74	1.22	1.73	2.71	3.42	4.33	6.24
1:30:56	0.30	0.68	0.63	1.03	1.46	2.29	2.89	3.66	5.25
1:35:16	0.26	0.60	0.55	0.91	1.28	2.01	2.53	3.19	4.58
1:39:35	0.24	0.54	0.50	0.82	1.16	1.80	2.27	2.86	4.10
1:43:55	0.22	0.50	0.46	0.75	1.06	1.66	2.08	2.63	3.76
1:48:15	0.16	0.37	0.34	0.55	0.78	1.22	1.54	1.94	2.79
1:52:35	0.12	0.27	0.25	0.41	0.57	0.89	1.12	1.41	2.02
1:56:55	0.09	0.20	0.18	0.30	0.42	0.66	0.82	1.04	1.49
2:01:14	0.06	0.14	0.13	0.22	0.31	0.48	0.61	0.77	1.11
2:05:34	0.04	0.10	0.09	0.16	0.22	0.35	0.44	0.56	0.81
2:09:54	0.03	0.07	0.07	0.11	0.16	0.25	0.31	0.40	0.58
2:14:14	0.02	0.05	0.05	0.08	0.11	0.18	0.23	0.29	0.42
2:18:34	0.01	0.03	0.03	0.05	0.08	0.12	0.16	0.20	0.29
2:22:53	0.01	0.02	0.02	0.03	0.05	0.08	0.10	0.13	0.19
2:27:13	0.00	0.01	0.01	0.02	0.02	0.04	0.05	0.07	0.10
2:31:33	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.05
2:35:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
2:40:13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:44:32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:48:52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:53:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:57:32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:01:52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:06:11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:10:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:14:51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:19:11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:23:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:27:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:32:10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:36:30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:40:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:45:10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:49:29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:53:49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:58:09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:02:29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:06:49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:11:08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:15:28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:19:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:24:08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:28:28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:32:47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:37:07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:41:27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:45:47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:50:07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:54:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:58:46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:03:06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:07:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:11:46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

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]

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).

The Glen at Widefield Filing No. 9

Detention Volume Calculations

Detention Basin 'A' Earthwork

Elevation	Area (A)	Avg. Area	Volume	Depth	Cumulative Volume		Elev.
5666	26sf			0.0 ft	**0cf**	**0.00ac-ft**	5666
5666.67	26sf	26sf	17cf	0.7 ft	**17cf**	**0.00ac-ft**	5666.67
5667	12,400sf	6,213sf	2,050cf	1.0 ft	**2,068cf**	**0.05ac-ft**	5667
5668	14,300sf	13,350sf	13,350cf	2.0 ft	**15,418cf**	**0.35ac-ft**	5668
5669	16,200sf	15,250sf	15,250cf	3.0 ft	**30,668cf**	**0.70ac-ft**	5669
5670	18,300sf	17,250sf	17,250cf	4.0 ft	**47,918cf**	**1.10ac-ft**	5670
5671	20,450sf	19,375sf	19,375cf	5.0 ft	**67,293cf**	**1.54ac-ft**	5671
5672	22,700sf	21,575sf	21,575cf	6.0 ft	**88,868cf**	**2.04ac-ft**	5672

Average End Area Formula: V = (A1+A2)/2 x Elev Difference

WQCV =	8,581 cf	0.20 ac-ft	5667.49 ft
EURV =	19,689 cf	0.45 ac-ft	5668.28 ft
100yr Volume =	45,085 cf	1.04 ac-ft	5669.84 ft
100yr Volume + 1/2 WQCV =	49,441 cf	1.14 ac-ft	5670.08 ft
Detention Freeboard Depth =			0.42 ft
Spillway Crest =	57,605 cf	1.32 ac-ft	5670.50 ft
Spillway 100yr Flow Depth =	67,293 cf	1.54 ac-ft	5671.00 ft
Spillway Freeboard Depth =			1.00 ft
Top of Embankment =	88,868 cf	2.04 ac-ft	5672.00 ft

Emergency Spillway Calculation

Detention Area	100-yr Flow	120% 100yr Flow	Water Surf Elev	Crest Elev	Crest Length	d (rad)	Flow Depth	**Calc'd Flow**
A	44.8 cfs	53.8 cfs	5,671.00	5,670.5	50.0 ft	2.63	0.50 ft	55.1 cfs

Weir Equation:

$Q = CLH^{1.5} + CH^{5/2} \tan(d/2)$

H = Depth of flow over the crest, in ft

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

C = 3.0

d = Angle of triangle weir portion (radians)

d = 2.63 radians for 4:1 side slope

d = 2.49 radians for 3:1 side slope

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

Outlet Struct Capacity = Inlet Capacity Calculation at the depth to the spillway crest plus flow depth.

Update heading to Filing 9.

Trickle Channel Capacity Calculation

Description	Design Flow	Bottom Width	Channel Side Slope		Flow Depth	Channel Slope	Manning "n"	Top Width	Channel Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	Channel Flow Capacity
			Left	Right									
Trickle Channel	1.5 cfs	1.3 ft	0:1	0:1	0.50 ft	0.5%	0.015	1.3 ft	0.63 sf	2.3 ft	0.28 ft	3.0 ft/sec	**1.9 cfs**

Equations:
Area (A) = $b(d)+zd^2$
b = width
d = depth

Perimeter (P) = $b+2d*(1+z^2)^{0.5}$
z = side slope
Hydraulic Radius = A/P

Velocity = $(1.49/n)R_n^{2/3}S^{1/2}$
S = Slope of the channel
n = Manning's number
R_n = Hydraulic Radius (Reynold's Number)
Flow = $(1.49/n)AR_n^{2/3}S^{1/2}$

Outlet Structure Major Storm Grate/Box Calculation

Detention Area	100-yr Flow	120% 100yr Flow	Water Surf Elev	Crest Elev	Calc'd Crest Length	d (rad)	Flow Depth	**Calc'd Flow**	**Crest Length Used***
A	44.8 cfs	53.8 cfs	71.00	70.5	0.0 ft	2.63	0.50 ft	2.0 cfs	**8.0 ft**

Weir Equation:
$Q = CLH^{1.5} + CH^{5/2}\tan(d/2)$
C = Weir coefficient (dimensionless), C = 3.0 (most cases)
C = 3.0
L = Length of weir at Crest, in ft. Not including sideslopes.
Outlet Struct Capacity = Inlet Capacity Calculation at the depth to the spillway crest plus flow depth.

H = Depth of flow over the crest, in ft
d = Angle of triangle weir portion (radians)
d = 2.63 radians for 4:1 side slope
d = 2.49 radians for 3:1 side slope

*Weir calculation shows that sides alone have enough capacity to convey 100-yr flow, but bars for grate will result in a longer required weir length: 32 bars x 1/4" thick = 8 in. or 0.67 ft. So, 0.0 ft (calc'd crest length) + 0.67 ft (additional length needed for bars) = 0.67 ft. Then apply a 50% debris clogging factor: 0.67 ft x 2 = 1.33 ft. However, 1.33 ft is an impractical structure width, so use 4.0 ft as a minimum crest length. Now check the maximum velocity through the grate using a 4.0 ft crest length:

Check Major Storm Grate Conditions

Maximum velocity through grate = 2.0 ft/sec
Q_{100} = 42.9 cfs
Open area of grate required = Q_{100} / V_{max} = 42.9 cfs / 2.0 ft/sec = 21.45 sf
Grate has an 70% open area (area of bars = 30% of total grate area)
Total grate area required = 21.45 sf / 0.70 = 30.6 sf
Actual outlet structure opening for grate (from weir calculation) = 4 ft x 4 ft = **16 sf** (16 sf < 30.3 sf, so 4' crest length is too short)
30.6 sf / 4 ft = 7.7 ft min. crest length, use **8.0 ft**
Check velocity through grate using outlet structure opening of 8.0 ft x 4.0 ft = 32 sf:
Actual velocity through grate = 42.9 cfs / (32 sf x 0.70) = **1.9 ft/sec** (1.9 ft/sec < 2.0 ft/sec, okay)

Therefore, use **8.0 ft** for crest length.

Grate	Safety Grate or Trash Rack	Type of Grate (see below)	R Value		Outlet Diameter or Min. Dimension	A_{ot} Total Outlet/ Orifice Area	A_t/A_{ot}	Minimum Gross Grate Area
			Table	User Input				
A1	Trash	WS	0.60		1.2-in	0.0229sf	34.39	1.31sf
A2	Safety	Other	N/A	0.70	17.7-in	2.48sf	8.58	30.38sf

A_t / A_{ot} = Ratio of Total Grate Open Area to Total Outlet Area (taken from UDSCM Fig OS-1: Trash Rack Sizing)

A_t = Total Grate Open Area (R-Value x Grate Area) (Example: 1'Wx6'H Well Screen=1'x6'x0.60=3.6ft^2)

A_{ot} = Total Outlet Area (Example: If orifice plate includes 3-1"dia holes A_{ot}=2.356in^2=0.016ft^2)

Safety Grate: A_t / A_{ot} = 77e$^{-0.124D}$ -- (Outlet Diameter or Minimum Dimension less than 24-inches)

Trash Rack: A_t / A_{ot} = 38.5e$^{-0.095D}$ (Outlet Diameter or Minimum Dimension less than 24-inches)

Outlet Diameter is orifice plate hole size of pipe out of structure

Safety
Trash

Minimum Gross Grate Area: Calculated from outside dimension of grate

R Value = Net Open Area / Gross Rack Area

Type of Grate	Abbreviation	R-Value
Bar Grate 2" O.C. Cross Rods	BG 2	0.71
Bar Grate 4" O.C. Cross Rods	BG 4	0.77
Well Screen	WS	0.60
Other	Other	

Grate A1: 1.31 sf / **1.86' high** = 0.70 ft (8.5 in). Use **15" wide opening** to match opening needed for WQ plate.

Grate A2: 30.38 sf / **5' wide opening** = 6.08 ft (6' - 1") min. for length. However, use **6'-1" length** to satisfy maximum velocity through grate requirement (see Major Storm Grate Conditions calculations).

Presedementation / Forebay Sizing

Forebay Location	100 Yr Flow	Detention WQCV	Total Detention Forebay Vol (3% WQCV)	Tributary Area	% of Total Trib Area	Required Forebay Volume	Forebay Area	Forebay Depth	Forebay Volume	Required Forebay Volume	Discharge Design Flow (2% 100yr)	Calculated Opening Width (1" min)
Det A	44.8cfs	8,712 cf	261cf	15.05ac	100.0%	261cf	180sf	1.50-ft	270 cf	261cf	0.90 cfs	5.6-inch

Opening Width Equation for Rectangular Opening

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

C = 3.0

Forebay Overflow Calculation

Description	Water Surf Elev	Crest Elev	Crest Length	Flow Depth	**Calc'd Flow**
Det A	69.09	68.4	8.3 ft	0.67 ft	13.6 cfs

Weir Equation:

$Q = CLH^{1.5}$

C = 3.0

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

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

APPENDIX B.1
Supporting Detention Basin Tables and Figures

beneficial if a project is being phased or when adequate land is not available to combine all of the elements in one facility.

4.1.1 Flood Control Volume

UDFCD has developed empirical equations for estimating the total required storage volume that can be applied to on-site, multi-level ponds or to on-site or sub-regional FSD ponds. The empirical equations include:

$$V_i = K_i A \quad \text{Equation 13-1}$$

For NRCS soil types B, C and D.

$$K_{100} = (1.78 \cdot I - 0.002\, I^2 - 3.56) / 900 \quad \text{Equation 13-2}$$

$$K_5 = (0.77 \cdot I - 2.65) / 1{,}000 \quad \text{Equation 13-3}$$

For NRCS soil Type A:

$$K_{100A} = (-0.00005501 \cdot I^2 + 0.030148 \cdot I - 0.12) / 12 \quad \text{Equation 13-4}$$

Where:

V_i = required volume, with i= year storm, acre-feet

K_i = empirical volume coefficient, with i= year storm

i = return period for storm event, years

I = fully developed tributary basin imperviousness, %

A = tributary drainage basin area, acres

These equations can be applied to calculate the total detention storage for drainage basins up to about 130 acres. When more than one soil type or land use is present in the drainage basin, the storage volume must be weighted by the proportionate areas of each soil type and/or land use. For FSDs, the EURV need not be added to this volume. See UDFCD Manual Volume 2, Storage Chapter for a full description of this method.

4.1.2 EURV

UDFCD has developed empirical equations for estimating the EURV portion of the storage volume that can be applied to on-site, sub-regional or regional FSD ponds.

The empirical equations are as follows:

For NRCS Soil Group A:

$$EURV_A = 1.1\,(2.0491(I/100) - 0.1113) \quad \text{Equation 13-5}$$

For NRCS Soil Group B:

$$EURV_B = 1.1\,(1.2846(I/100) - 0.0461) \quad \text{Equation 13-6}$$

For NRCS Soil Group C/D:

$$EURV_{CD} = 1.1\,(1.1381(I/100) - 0.0339)$$ Equation 13-7

Where:

$EURV_K$ = Excess Urban Runoff Volume in watershed inches, K=A, B or C/D soil group

I = drainage basin imperviousness, %

These equations apply to all FSDs and the EURV need not be added to the flood control volume or to the WQCV. When more than one soil type or land use is present in the drainage basin, the EURV must be weighted by the proportionate areas of each soil type and/or land use. If hydrologic routing is used to size the flood control volume, the EURV remains the same as calculated by these equations and is included in the pond's stage/storage configuration for modeling.

4.1.3 Initial Surcharge Volume

The initial surcharge volume is at least 0.3 percent of the WQCV and should be 4- to 12-inches deep. The initial surcharge volume is included in the WQCV and does not increase the required total storage volume.

4.1.4 Design Worksheets

The Full Spectrum Worksheet in the UD-Detention Spreadsheet performs all of these calculations for the standard designs. For multi-level ponds, the flood control volumes are calculated for the two design storm frequencies: the major storm and the minor storm.

4.2 Allowable Release Rates

Allowable release rates from detention facilities vary with the type of facility and with the storage volume type, as follows:

- **Flood Storage Volume**: The flood storage release rates are determined by the allowable release rates that are intended to approximate storm event runoff rates from the undeveloped upstream drainage basin.

- **EURV**: The EURV release rate is determined based on a72-hour drain time. The purpose of this slow release rate is to mitigate the impacts of increased runoff volumes due to development by reducing the potential for downstream erosion.

- **WQCV**: The WQCV release rate is determined based on a 40-hour drain time for extended detention basins. The purpose of this slow release rate is to provide time for pollutants to settle, The WQCV is incorporated into the EURV and works with it to release less erosive flows. The method for determining this design rate is described in Chapter 3 of Volume 2 of this Manual.

4.2.1 Flood Storage Release Rates

Allowable releases rates from the flood storage element of detention may be based on generalized average unit runoff rates or estimates of pre-development runoff rates. Allowable unit release rates (cfs/ac) may be used for any type of detention, however, when a hydrograph routing method is applied (for regional or

Safety Grates

Safety grates are intended to keep people and animals from inadvertently entering a storm drain. They are sometimes required even when debris entering a storm drain is not a concern. The grate on top of the outlet drop box is considered a safety grate and should be designed accordingly. The danger associated with outlet structures is the potential associated with pinning a person or animal to unexposed outlet pipe or grate. See the *Culverts and Bridges* chapter of Volume 2 of this manual for design criteria related to safety grates.

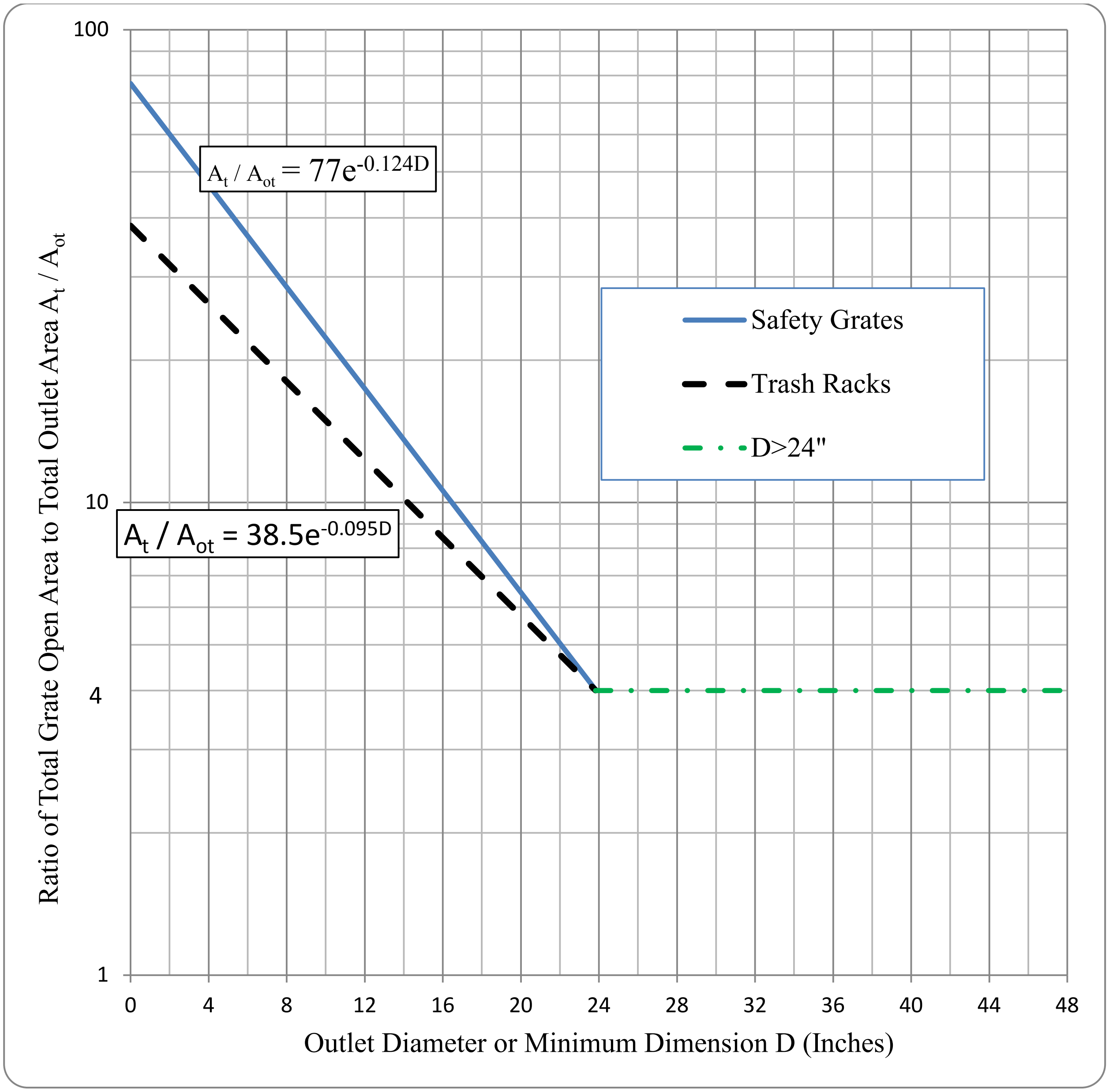
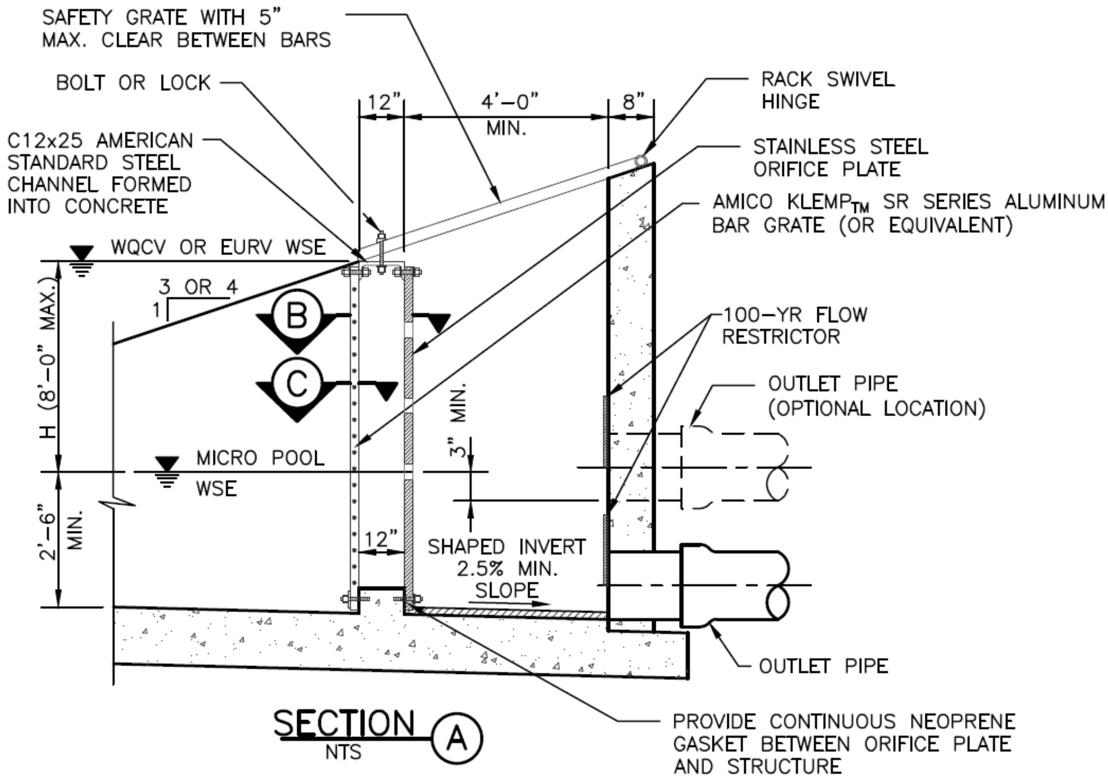
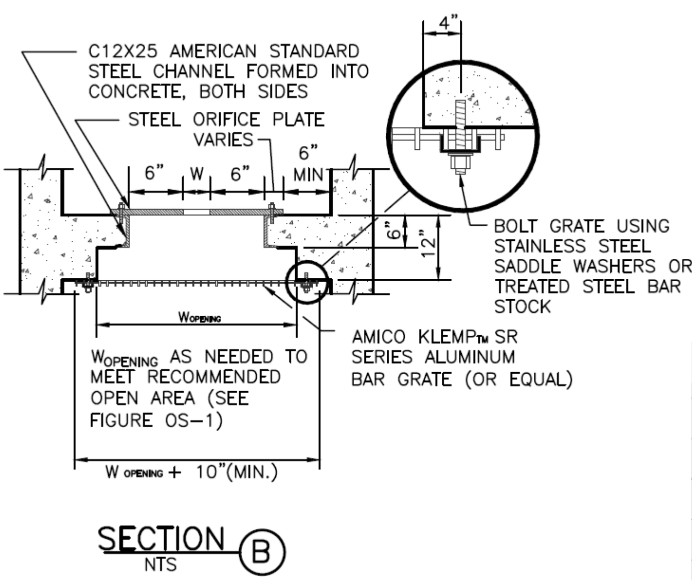


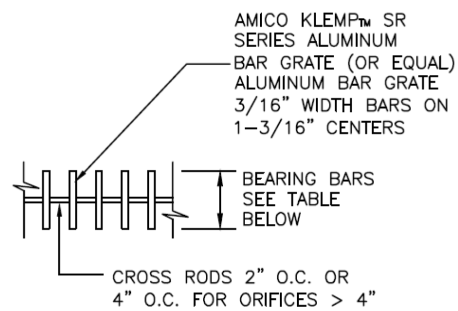
Figure OS-1. Trash Rack Sizing

Table OS-2. Thickness of steel water quality plate

Steel plate thickness (in inches) based on design depth and span of plate											
		Head (feet)									
		3	4	5	6	7	8	9	10	11	12
Span (feet)	1	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875
	2	0.1875	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
	3	0.2500	0.2500	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.5000
	4	0.2500	0.3750	0.3750	0.3750	0.3750	0.5000	0.5000	0.5000	0.5000	0.5000







WATER DEPTH ABOVE LOWEST OPENING, H	MINIMUM BEARING BAR SIZE, BARS ALIGNED VERTICALLY
2.0 FT.	1" x 3/16"
3.0 FT.	1-1/4" x 3/16"
4.0 FT.	1-3/4" x 3/16"
5.0 FT.	2" x 3/16"
6.0 FT.	2-1/4" x 3/16"

R VALUE=(NET OPEN AREA)/GROSS RACK AREA)
=0.71 FOR CROSS RODS ON 2" CENTERS
=0.77 FOR CROSS RODS ON 4" CENTERS

SECTION C
NTS

Figure OS-6. Typical outlet structure with bar grate trash rack

Figure 13-9. Concept for Integral Forebay at Pipe Outfall

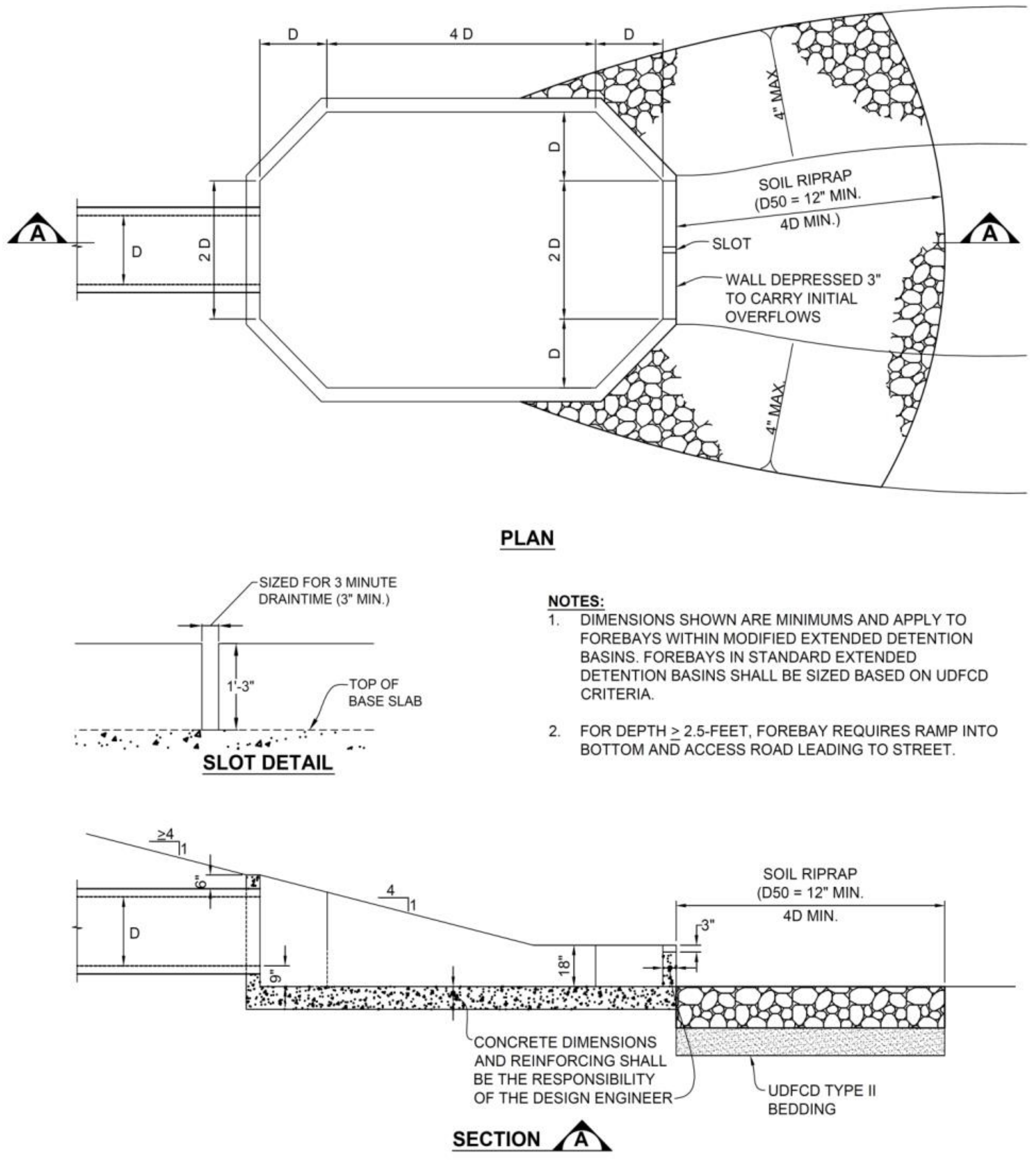
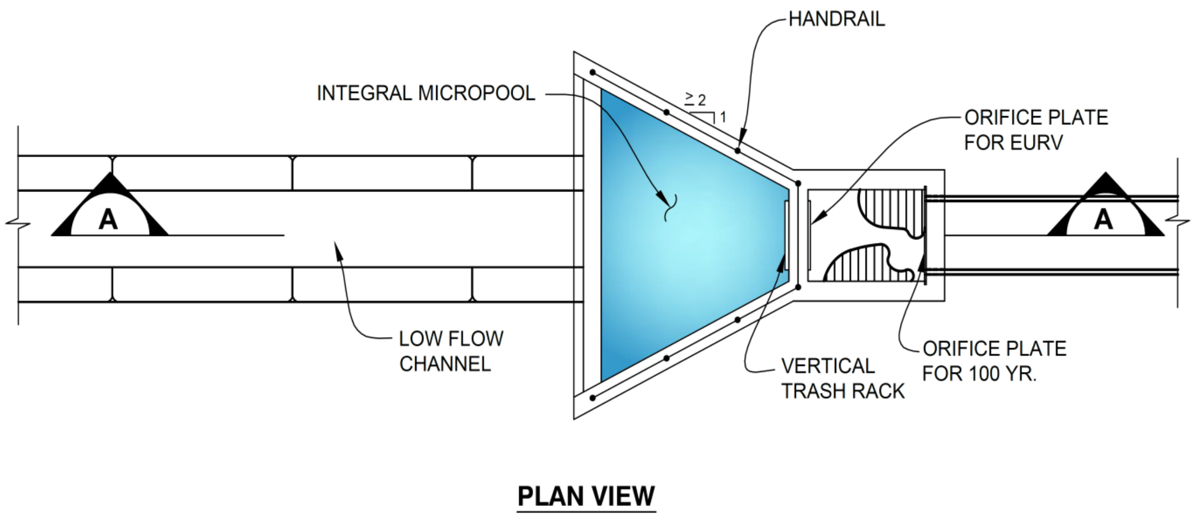


Figure 13-11. Concept for Outlet Structure with Flared Wingwalls and Handrail
(Integral Micropool Shown)



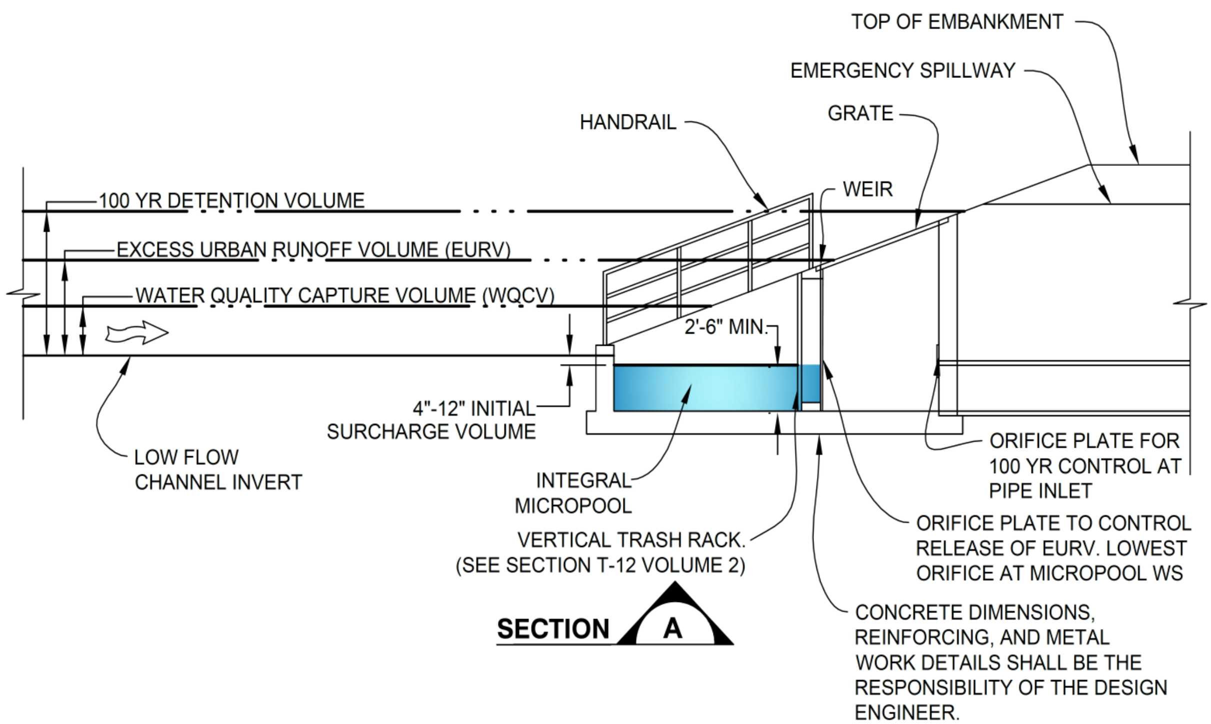


Figure 13-12c. Emergency Spillway Protection

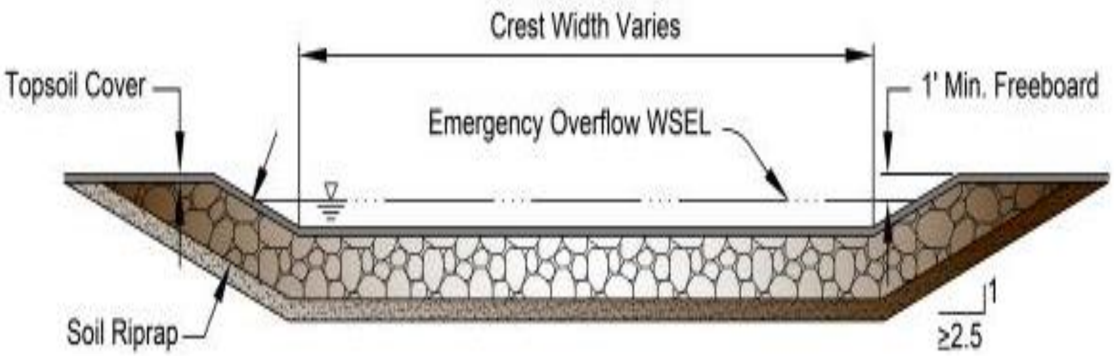
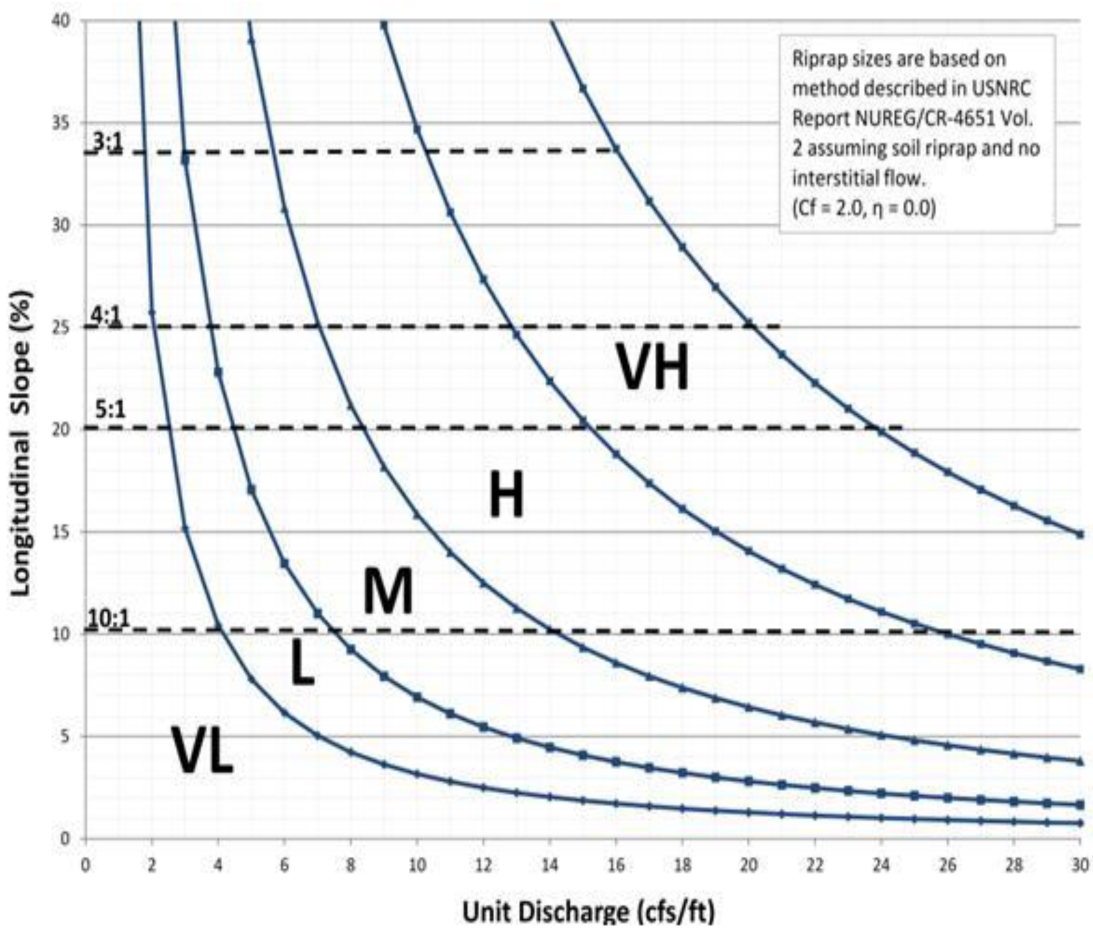


Figure 13-12d. Riprap Types for Emergency Spillway Protection



Hydraulic Calculations will be reviewed with the resubmittal since the proposed condition hydrologic calculations are missing.
Unresolved. Pipe Sizing Calculations included were for Filing 8.

APPENDIX C

Hydraulic Calculations

Inlet Summary and Calculations
Street Capacity Calculations – UD Inlet
Inlet Capacity Calculations – UD Inlet
Pipe Sizing Calculations
UDSewer Plan Schematic
UDSewer Input and Output Tables: 5-year and 100-year Storm Events
Pipe Outlet Erosion Protection Calculations
Open Channel Calculations

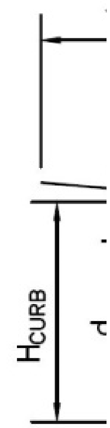
Version 4.05 Released March 2017

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

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

Project: Enter Your Project Name Here

Inlet ID: Basin A-2 Inlet



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	8.0	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} =	17.0	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 =	0.025	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

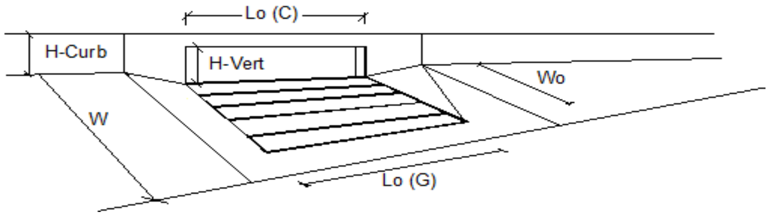
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	15.8	15.8	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.6	7.8	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	Q_{allow} =	**8.8**	**14.3**	**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 =			
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =			inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =			
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =			ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =			ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =			
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =			

		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**			**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**			**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**			**%**

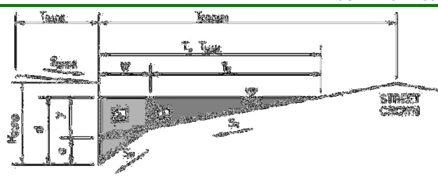
Version 4.05 Released March 2017

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

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

Project: Enter Your Project Name Here

Inlet ID: Basin A-3 Inlet



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	8.0	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} =	17.0	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 =	0.025	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} =	15.8	15.8	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.6	7.8	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

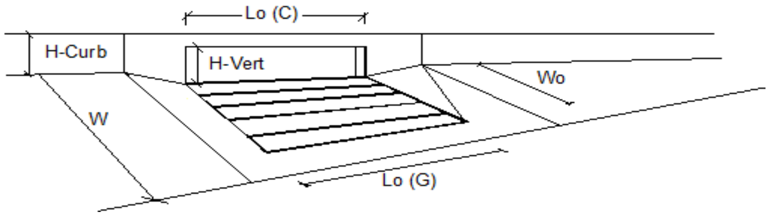
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	**Q_{allow} =**	**8.8**	**14.3**	**cfs**

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 =			
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =			inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =			
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =			ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =			ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =			
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =			

		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**			**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**			**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**			**%**

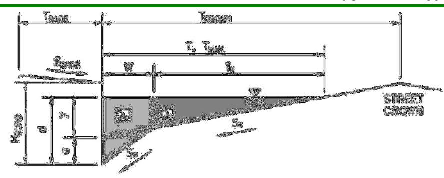
Version 4.05 Released March 2017

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

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

Project: Enter Your Project Name Here

Inlet ID: Basin A-4 Inlet



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	20.0	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} =	20.0	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 =	0.012	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

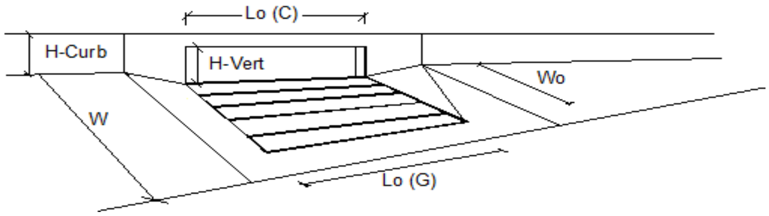
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	20.0	20.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	10.8	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	Q_{allow} =	**15.1**	**17.9**	**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



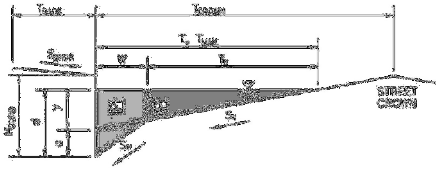
Design Information (Input)		MINOR	MAJOR	
Type of Inlet	Type =			
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =			inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =			
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =			ft
Width of a Unit Grate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

		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**			**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**			**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**			**%**

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

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

Project: Enter Your Project Name Here
Inlet ID: Basin A-7 Inlet



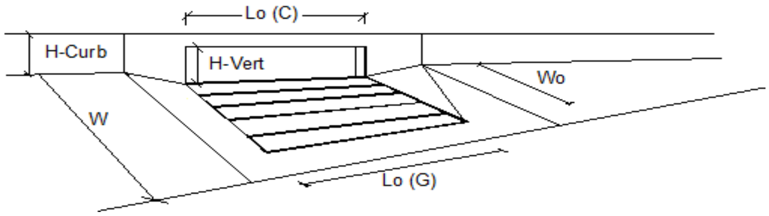
Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	8.0		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} =	17.0		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 =	0.040		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} =	15.8	15.8	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.6	7.8	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} =**	**11.0**	**18.2**	**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 =			
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =			inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =			
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =			ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =			ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =			
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =			

		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**			**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**			**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**			**%**

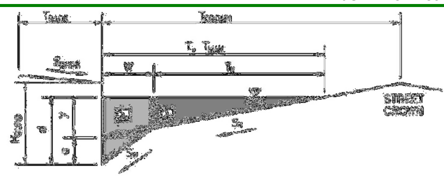
Version 4.05 Released March 2017

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

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

Project: Enter Your Project Name Here

Inlet ID: Basin A-8 Inlet



Gutter Geometry (Enter data in the blue cells)

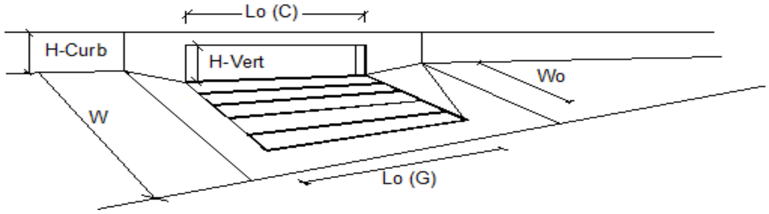
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	8.0		ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020		ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020		
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00		inches
Distance from Curb Face to Street Crown	T_{CROWN} =	17.0		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 =	0.040		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} =	15.8	15.8	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.6	7.8	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} =	**11.0**	**18.2**	**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 =			
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =			inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =			
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =			ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =			ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =			
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =			

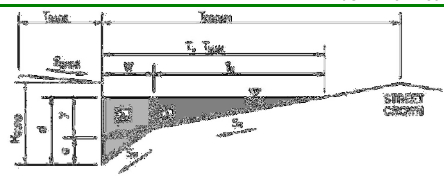
		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**			**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**			**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**			**%**

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: Enter Your Project Name Here
Inlet ID: Basin A-9 Inlet



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	8.0	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} =	17.0	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 =	0.016	ft/ft
Manning's Roughness for Street Section (typically between 0.012 and 0.020)	n_{STREET} =	0.016	

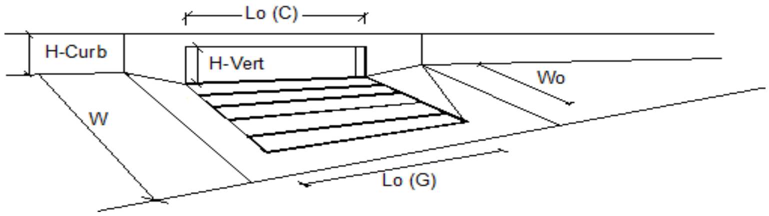
		Minor Storm	Major Storm	
Max. Allowable Spread for Minor & Major Storm	T_{MAX} =	15.8	15.8	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.6	7.8	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	Q_{allow} =	**7.0**	**11.5**	**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 =			
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =			inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =			
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =			ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =			ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =			
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =			
		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**			**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**			**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**			**%**

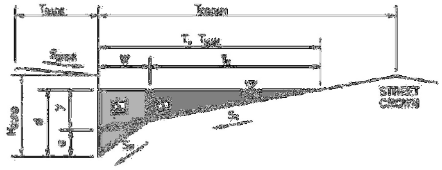
Version 4.05 Released March 2017

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

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

Project: Enter Your Project Name Here

Inlet ID: Basin A-10 Inlet



Gutter Geometry (Enter data in the blue cells)

Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	8.0	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} =	17.0	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 =	0.040	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} =	15.8	15.8	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	4.6	7.8	inches
Allow Flow Depth at Street Crown (leave blank for no)		☐	☐	check = yes

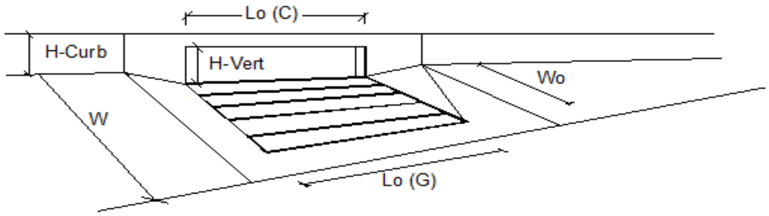
		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion				
MAJOR STORM Allowable Capacity is based on Spread Criterion	Q_{allow} =	**11.0**	**18.2**	**cfs**

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 =			
Local Depression (additional to continuous gutter depression 'a')	a_{LOCAL} =			inches
Total Number of Units in the Inlet (Grate or Curb Opening)	No =			
Length of a Single Unit Inlet (Grate or Curb Opening)	L_o =			ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)	W_o =			ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)	C_f-G =			
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)	C_f-C =			

		MINOR	MAJOR	
Total Inlet Interception Capacity	**Q =**			**cfs**
Total Inlet Carry-Over Flow (flow bypassing inlet)	**Q_b =**			**cfs**
Capture Percentage = Q_a/Q_o =	**C% =**			**%**

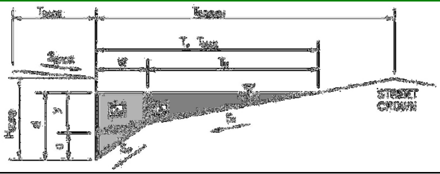
Version 4.05 Released March 2017

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

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

Project: Enter Your Project Name Here

Inlet ID: Design Point 5 Inlet



Gutter Geometry (Enter data in the blue cells)

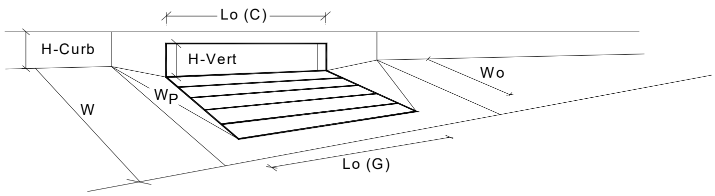
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	20.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	20.0	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} =	20.0	20.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	10.8	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



			MINOR	MAJOR	
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	10.0	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) =	15.00	15.00	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	0.67	ft
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination}$ =	0.57	0.94	
Curb Opening Performance Reduction Factor for Long Inlets		RF_{Curb} =	0.79	0.97	
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 =	**9.7**	**32.4**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)		$Q_{PEAK\ REQUIRED}$ =	6.0	22.9	cfs

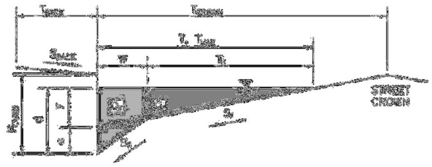
Version 4.05 Released March 2017

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

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

Project: Enter Your Project Name Here

Inlet ID: Design Point 12 Inlet



Gutter Geometry (Enter data in the blue cells)

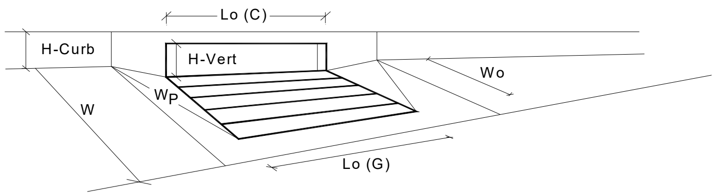
Maximum Allowable Width for Spread Behind Curb	T_{BACK} =	20.0	ft
Side Slope Behind Curb (leave blank for no conveyance credit behind curb)	S_{BACK} =	0.020	ft/ft
Manning's Roughness Behind Curb (typically between 0.012 and 0.020)	n_{BACK} =	0.020	
Height of Curb at Gutter Flow Line	H_{CURB} =	6.00	inches
Distance from Curb Face to Street Crown	T_{CROWN} =	20.0	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} =	20.0	20.0	ft
Max. Allowable Depth at Gutter Flowline for Minor & Major Storm	d_{MAX} =	6.0	10.8	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



		MINOR	MAJOR	
Design Information (Input)	CDOT Type R Curb Opening			
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	10.8	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) =	15.00	15.00	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	0.73	ft
Combination Inlet Performance Reduction Factor for Long Inlets	$RF_{Combination}$ =	0.57	1.00	
Curb Opening Performance Reduction Factor for Long Inlets	RF_{Curb} =	0.79	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 =	**9.7**	**35.9**	**cfs**
Inlet Capacity IS GOOD for Minor and Major Storms(>Q PEAK)	$Q_{PEAK\ REQUIRED}$ =	9.3	22.9	cfs

The Glen at Widefield Filing No. 9

Pipe Diameter Calculations

Pipe #	5yr Flow	100yr Flow	Design Flow	Contributing Flows	Manning 'n'	Pipe Slope	Calculated Pipe Diameter	**Pipe Diameter**	Minimum Slope of Pipe	A (sf)	Wp (ft)	Rh (ft)	Full Pipe Flow Velocity	Head above Pipe Flowline	H	Pipe Inlet Control Capacity	**Mannings Pipe Capacity**	Capacity Check	Notes
Outfall	14.8 cfs	44.8 cfs	44.8 cfs	Entire Area	0.013	**1.2%**	30-inch	**30-inch**	1.19%	4.91 sf	7.9 ft	0.6 ft	9.2 ft/sec	4.4 ft	3.1 ft ----	45.1 cfs ----	**45.1 cfs**	OK	

Equations:

Pipe Dia=$((2.16Qn)/(S^{0.5}))^{0.375}$

Q = Discharge in cubic feet per second

n = Manning's roughness coefficient

RCP=0.013, CMP=0.024, HDPE (smooth)=0.012

S = Slope of the pipe

R_h = Hydraulic Radius

Flow Velocity = $(1.49/n)R_h^{2/3} S^{1/2}$

Pipe Capacity = $(1.49/n)AR_h^{2/3} S^{1/2}$

A = Cross-sectional area of pipe

A=p $(D^2/4)$

D = Inside Diameter of Pipe

$R_h = A_w/W_p$

$A_w = p(d^2/4)$

A_w = Water Cross Sectional Area

d = Flow Depth Within Pipe

W_p = pd (For Capacity Calculation)

W_p=Wetted Perimeter of Pipe

Orifice Equation:

$Q = CA(2gH)^{0.5}$

C = Orifice coefficient (dimensionless)

C = 0.65

A = Cross-sectional area of opening, in sf

g = Gravitational accel constant, 32.2 ft/sec^2

H = Head above centerline of pipe, ft

Provide the pipe sizing calculation for the Filing 9 system. Update the drainage map to include the pipe ID.

The Glen at Widefield Filing No. 8

Pipe Diameter Calculations

Pipe #	5yr Flow[1]	100yr Flow[1]	Design Flow	Contributing Flows	Manning 'n'	Pipe Slope	Calculated Pipe Diameter	**Pipe Diameter[2]**	Minimum Slope of Pipe	Full Pipe Flow Velocity	Head above Pipe Flowline	H	Pipe Inlet Control Capacity	**Mannings Pipe Capacity**	Capacity Check
S1	3.8 cfs	7.7 cfs	3.8 cfs	Inlet 1	0.013	**1.0%**	12-inch	**18-inch**	0.13%	6.0 ft/sec	3.3 ft	2.5 ft	14.6 cfs	**10.5 cfs**	OK
S2	4.9 cfs	9.3 cfs	4.9 cfs	Inlet 2	0.013	**1.87%**	12-inch	**18-inch**	0.22%	8.2 ft/sec	3.3 ft	2.5 ft	14.6 cfs	**14.4 cfs**	OK
S3	8.2 cfs	17.6 cfs	8.2 cfs	Inlet 2,3	0.013	**0.83%**	17-inch	**24-inch**	0.13%	6.6 ft/sec	3.3 ft	2.3 ft	24.6 cfs	**20.7 cfs**	OK
S4	2.0 cfs	3.5 cfs	2.0 cfs	Inlet 4	0.013	**2.99%**	8-inch	**18-inch**	0.04%	10.3 ft/sec	3.3 ft	2.5 ft	14.6 cfs	**18.2 cfs**	OK
S5	14.0 cfs	28.8 cfs	14.0 cfs	Inlets 1,2,3,4	0.013	**1.89%**	18-inch	**30-inch**	0.12%	11.5 ft/sec	3.3 ft	2.0 ft	36.2 cfs	**56.5 cfs**	OK
S6	3.2 cfs	7.3 cfs	3.2 cfs	Inlet 5	0.013	**0.67%**	12-inch	**18-inch**	0.09%	4.9 ft/sec	3.3 ft	2.5 ft	14.6 cfs	**8.6 cfs**	OK
S7	17.2 cfs	36.1 cfs	17.2 cfs	Inlets 1,2,3,4,5	0.013	**3.5%**	17-inch	**30-inch**	0.18%	15.7 ft/sec	4.4 ft	3.2 ft	45.4 cfs	**76.9 cfs**	OK
S8	3.5 cfs	13.1 cfs	3.5 cfs	Inlet 6	0.013	**1.95%**	11-inch	**18-inch**	0.11%	8.3 ft/sec	3.3 ft	2.5 ft	14.6 cfs	**14.7 cfs**	OK
S9	20.7 cfs	49.2 cfs	20.7 cfs	Inlets 1 through 6	0.013	**2.95%**	19-inch	**30-inch**	0.25%	14.4 ft/sec	6.6 ft	5.4 ft	59.2 cfs	**70.6 cfs**	OK
S10	3.7 cfs	7.5 cfs	3.7 cfs	Inlet 7	0.013	**0.7%**	13-inch	**18-inch**	0.12%	5.0 ft/sec	3.3 ft	2.5 ft	14.6 cfs	**8.8 cfs**	OK
S11	1.4 cfs	13.1 cfs	1.4 cfs	Inlet 8	0.013	**4.53%**	6-inch	**18-inch**	0.02%	12.7 ft/sec	3.3 ft	2.5 ft	14.6 cfs	**22.4 cfs**	OK
S12	6.0 cfs	21.6 cfs	6.0 cfs	Inlets 8,9	0.013	**0.48%**	17-inch	**24-inch**	0.07%	5.0 ft/sec	3.8 ft	2.8 ft	27.4 cfs	**15.7 cfs**	OK
S13	9.1 cfs	28.3 cfs	9.1 cfs	Inlets 8,9,10	0.013	**0.84%**	18-inch	**30-inch**	0.05%	7.7 ft/sec	3.3 ft	2.0 ft	36.2 cfs	**37.7 cfs**	OK
S14	33.5 cfs	85.0 cfs	33.5 cfs	Inlets 1 through 10	0.013	**0.5%**	32-inch	**36-inch**	0.25%	6.7 ft/sec	4.4 ft	2.9 ft	62.8 cfs	**47.3 cfs**	OK
S15	3.1 cfs	17.9 cfs	17.9 cfs	Inlet 11	0.013	**1.0%**	22-inch	**24-inch**	0.63%	7.2 ft/sec	3.3 ft	2.3 ft	24.6 cfs	**22.7 cfs**	OK
S16	38.8 cfs	117.2 cfs	117.2 cfs	Inlets 1 through 12	0.013	**1.0%**	44-inch	**54-inch**	0.36%	12.4 ft/sec	5.5 ft	3.3 ft	149.6 cfs	**197.2 cfs**	OK

Equations:

Pipe Dia=$((2.16Qn)/(S^{0.5}))^{0.375}$

Q = Discharge in cubic feet per second

n = Manning's roughness coefficient

RCP=0.013, CMP=0.024, HDPE (smooth)=0.012

S = Slope of the pipe

R_h = Hydraulic Radius

Flow Velocity = $(1.49/n)R_h^{2/3} S^{1/2}$

Pipe Capacity = $(1.49/n)AR_h^{2/3} S^{1/2}$

A = Cross-sectional area of pipe

A=p $(D^2/4)$

D = Inside Diameter of Pipe

$R_h = A_w/W_p$

$A_w = p(d^2/4)$

A_w = Water Cross Sectional Area

d = Flow Depth Within Pipe

W_p = pd (For Capacity Calculation)

W_p=Wetted Perimeter of Pipe

Orifice Equation:

$Q = CA(2gH)^{0.5}$

C = Orifice coefficient (dimensionless)

C = 0.65

A = Cross-sectional area of opening, in sf

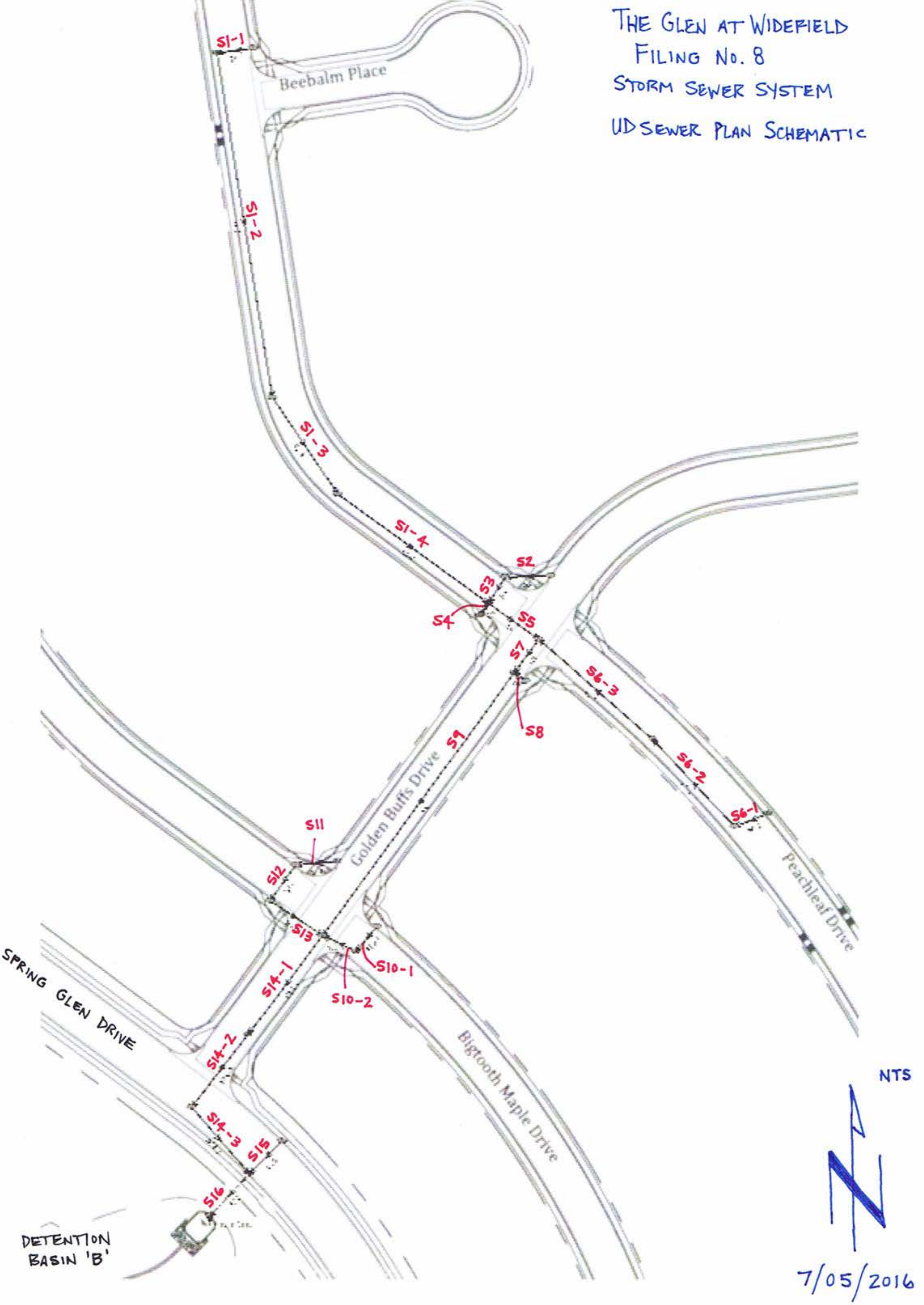
g = Gravitational accel constant, 32.2 ft/sec^2

H = Head above centerline of pipe, ft

[1] 5-year and 100-year flows assume a no-clogging condition for inlet.

[2] 43" x 68" HERCP (54" dia. equivalent) used for Pipe # S16.

THE GLEN AT WIDEFIELD
FILING NO. 8
STORM SEWER SYSTEM
UD SEWER PLAN SCHEMATIC



7/05/2016

The Glen at Widefield Filing No. 8
Storm Sewer System
UDSewer Input Data

Manhole ID Number	Manhole Name	Ground Elevation ft	Outgoing Sewer ID Number	Number of Incoming Sewers	First Incoming Sewer ID	Second Incoming Sewer ID	Third Incoming Sewer ID	Fourth Incoming Sewer ID
Outfall	Outfall	5664.4	---	1	1			
1	S16	5666.6	Outfall	2	2	4		
2	S14-3	5667.5	1	1	3			
3	S14-2	5668.2	2	1	24			
4	S15	5666.6	1	0				
5	S9	5681.81	24	2	6	18		
6	S7	5683.08	5	2	7	10		
7	S6-3	5684.21	6	1	8			
8	S6-2	5685.42	7	1	9			
9	S6-1	5684.97	8	0				
10	S5	5683.62	6	3	11	15	17	
11	S1-4	5685.9	10	1	12			
12	S1-3	5686.7	11	1	13			
13	S1-2	5690.8	12	1	14			
14	S1-1	5690.38	13	0				
15	S3	5683.11	10	1	16			
16	S2	5684.25	15	0				
17	S4	5683.11	10	0				
18	S8	5681.29	5	0				
19	S10-2	5673.19	24	1	20			
20	S10-1	5672.81	19	0				
21	S13	5672.69	24	1	22			
22	S12	5672.69	21	1	23			
23	S11	5673.81	22	0				
24	S14-1	5672.4	3	3	5	19	21	

The Glen at Widefield Filing No. 8
Storm Sewer System
UDSewer Input Data

Manhole ID Number	Manhole Name	Known 5 year Flow cfs	Known 100 year Flow cfs	Basin Area acre	Design Runoff Coeff	5-yr Runoff Coef	Overland Flow Length ft	Overland Flow Slope percent	Gutter Flow Length ft	Gutter Flow Velocity fps
Outfall	Outfall	33.4	97							
1	S16	33.4	97							
2	S14-3	27.4	62.6							
3	S14-2	27.4	62.6							
4	S15	4.1	17.9							
5	S9	17.6	38.8							
6	S7	14.1	30							
7	S6-3	2.2	3.9							
8	S6-2	2.2	3.9							
9	S6-1	2.2	3.9							
10	S5	11.9	26.1							
11	S1-4	3.2	7							
12	S1-3	3.2	7							
13	S1-2	3.2	7							
14	S1-1	3.2	7							
15	S3	6.9	15.9							
16	S2	4.1	8.5							
17	S4	1.8	3.2							
18	S8	3.5	8.8							
19	S10-2	2.5	4							
20	S10-1	2.5	4							
21	S13	7.3	19.8							
22	S12	5.1	16.1							
23	S11	1	8.2							
24	S14-1	27.4	62.6							

The Glen at Widefield Filing No. 8

Storm Sewer System

UDSewer Input Data

Sewer ID Number	Sewer Name	Length ft	Slope percent	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Manning's N	Bend Loss Coef	Lateral Loss Coef	Shape 1,2 or 3	Existing Sewer Dia (inch) Rise (inch) Height (ft)	Span (inch) Width (Ft)
1	S16	45	1	5661.35	5660.9	0.013	0	0	1	43	68
2	S14-3	60	0.5	5662.2	5661.9	0.013	0.84	0.26	1	36	
3	S14-2	60	0.5	5662.6	5662.3	0.013	0.7	1	1	36	
4	S15	41.5	1	5663.37	5662.95	0.013	0.03	0	1	24	
5	S9	272.3	2.95	5675.61	5667.58	0.013	0.03	0.25	1	30	
6	S7	36.9	3.5	5678.08	5676.79	0.013	0.03	0.25	1	30	
7	S6-3	102.4	1	5680.2	5679.18	0.013	1	0	1	18	
8	S6-2	114.5	1	5681.44	5680.29	0.013	0.04	0	1	18	
9	S6-1	28.5	0.67	5681.73	5681.54	0.013	0.7	0	1	18	
10	S5	50.2	1.89	5679.13	5678.18	0.013	1	0.25	1	30	
11	S1-4	183.2	1	5682.06	5680.23	0.013	0.03	0.25	1	18	
12	S1-3	68.9	1.2	5682.99	5682.16	0.013	0.1	1	1	18	
13	S1-2	300.8	1.2	5686.7	5683.09	0.013	0.11	1	1	18	
14	S1-1	27.7	1.19	5687.13	5686.8	0.013	1	0	1	18	
15	S3	27.7	0.83	5679.46	5679.23	0.013	1	0	1	24	
16	S2	26.7	1.87	5680.66	5680.16	0.013	0.29	0	1	18	
17	S4	7.7	2.99	5680.06	5679.83	0.013	1	0	1	18	
18	S8	7.7	1.95	5678.04	5677.89	0.013	1	0	1	18	
19	S10-2	28.8	0.7	5668.77	5668.57	0.013	0.73	0	1	18	
20	S10-1	28.6	0.7	5669.57	5669.37	0.013	0.68	0	1	18	
21	S13	47.7	0.84	5667.97	5667.57	0.013	1	0	1	30	
22	S12	35.3	0.48	5668.74	5668.57	0.013	1	0	1	24	
23	S11	26.7	4.53	5670.55	5669.34	0.013	0.29	0	1	18	
24	S14-1	120.9	3.61	5667.07	5662.71	0.013	0.05	1	1	36	

Program:
UDSEWER Math Model Interface 2.2.1.2
Run Date:
6/28/2016 14:12

UDSewer Results Summary

Project Title: Glen at Widefield Filing No. 8
Project Description: Storm Sewer System

System Input Summary

Rainfall Parameters

Rainfall Return Period: 5
Rainfall Calculation Method: Formula

One Hour Depth (in): 1.50
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): 18.00
Maximum Depth to Rise Ratio: 0.90
Maximum Flow Velocity (fps): 18.0
Minimum Flow Velocity (fps): 2.0

Backwater Calculations:

Tailwater Elevation (ft): 5661.40

The Glen at Widefield Filing No. 8
Storm Sewer System
UDSewer Output Data
5-year Storm

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
S16	200.61	14.36	19.73	6.24	14.89	9.21	1.73	Supercritical	33.4	0	
S14-3	47.29	6.69	20.3	6.67	19.67	6.94	1.06	Supercritical	27.4	0	
S14-2	47.29	6.69	20.3	6.67	19.67	6.94	1.06	Supercritical	27.4	0	
S14-1	127.07	17.98	20.3	6.67	11.35	14.34	3.05	Supercritical	27.4	0	
S10-2	8.81	4.99	7.18	3.8	6.56	4.29	1.19	Supercritical	2.5	0	
S10-1	8.81	4.99	7.18	3.8	6.56	4.29	1.19	Supercritical	2.5	0	
S9	70.64	14.39	17.04	6.12	10.21	11.95	2.67	Supercritical	17.6	0	
S7	76.94	15.67	15.17	5.66	8.7	11.94	2.92	Supercritical	14.1	0	
S5	56.54	11.52	13.88	5.36	9.34	9.12	2.14	Supercritical	11.9	0	
S3	20.67	6.58	11.18	4.81	9.55	5.92	1.35	Supercritical	6.9	0	
S2	14.4	8.15	9.3	4.45	6.57	7.02	1.95	Supercritical	4.1	0	
S1-4	10.53	5.96	8.17	4.1	6.81	5.23	1.42	Supercritical	3.2	0	
S1-3	11.54	6.53	8.17	4.1	6.48	5.59	1.56	Supercritical	3.2	0	
S1-2	11.54	6.53	8.17	4.1	6.48	5.59	1.56	Supercritical	3.2	0	
S1-1	11.49	6.5	8.17	4.1	6.5	5.57	1.55	Supercritical	3.2	0	
S4	18.21	10.31	6.06	3.45	3.82	6.57	2.45	Supercritical	1.8	0	
S6-3	10.53	5.96	6.72	3.65	5.58	4.71	1.43	Supercritical	2.2	0	
S6-2	10.53	5.96	6.72	3.65	5.58	4.71	1.43	Supercritical	2.2	0	
S6-1	8.62	4.88	6.72	3.65	6.2	4.08	1.17	Supercritical	2.2	0	
S8	14.71	8.32	8.56	4.22	5.98	6.82	2	Supercritical	3.5	0	
S13	37.69	7.68	10.76	4.61	8.95	5.94	1.43	Supercritical	7.3	0	
S12	15.72	5	9.55	4.38	9.4	4.47	1.03	Supercritical	5.1	0	
S11	22.42	12.69	4.47	2.92	2.59	6.39	2.92	Supercritical	1	0	
S15	22.8	7.26	8.52	4.1	6.89	5.5	1.51	Supercritical	4.1	0	

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.

The Glen at Widefield Filing No. 8
Storm Sewer System
UDSewer Output Data
5-year Storm

Grade Line Summary:

Tailwater Elevation (ft): 5661.40

	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)
S16	5660.9	5661.35	0	0	5662.14	5662.99	5663.46	0.14	5663.6
S14-3	5661.9	5662.2	0.2	0.03	5663.54	5663.89	5664.29	0.3	5664.58
S14-2	5662.3	5662.6	0.16	0	5664.26	5664.29	5664.75	0.24	5664.98
S14-1	5662.71	5667.07	0.01	0	5664.3	5668.76	5666.84	2.61	5669.45
S10-2	5668.57	5668.77	0.02	0	5669.04	5669.37	5669.48	0.12	5669.59
S10-1	5669.37	5669.57	0.02	0	5669.92	5670.17	5670.2	0.19	5670.39
S9	5667.58	5675.61	0.01	0.18	5668.96	5677.03	5670.65	6.97	5677.61
S7	5676.79	5678.08	0.01	0.17	5677.51	5679.34	5679.73	0.12	5679.84
S5	5678.18	5679.13	0.09	0.11	5679.54	5680.29	5680.25	0.48	5680.73
S3	5679.23	5679.46	0.07	0	5680.68	5680.68	5680.81	0.06	5680.87
S2	5680.16	5680.66	0.02	0	5680.71	5681.44	5681.47	0.27	5681.74
S1-4	5680.23	5682.06	0	0.08	5680.8	5682.74	5681.22	1.78	5683
S1-3	5682.16	5682.99	0.01	0	5682.75	5683.67	5683.19	0.74	5683.93
S1-2	5683.09	5686.7	0.01	0	5683.68	5687.38	5684.11	3.53	5687.64
S1-1	5686.8	5687.13	0.05	0	5687.43	5687.81	5687.82	0.25	5688.07
S4	5679.83	5680.06	0.02	0	5680.3	5680.73	5680.82	0	5680.82
S6-3	5679.18	5680.2	0.02	0	5679.64	5680.76	5679.99	0.98	5680.97
S6-2	5680.3	5681.44	0	0	5680.76	5682	5681.1	1.1	5682.21
S6-1	5681.54	5681.73	0.02	0	5682.06	5682.29	5682.31	0.18	5682.5
S8	5677.89	5678.04	0.06	0	5678.46	5678.75	5678.96	0.07	5679.03
S13	5667.57	5667.97	0.03	0	5669.43	5669.43	5669.49	0.04	5669.53
S12	5668.57	5668.74	0.04	0	5669.47	5669.54	5669.66	0.17	5669.83
S11	5669.34	5670.55	0	0	5669.56	5670.92	5670.19	0.86	5671.06
S15	5662.95	5663.37	0	0	5663.53	5664.08	5663.99	0.35	5664.34

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.

Program:
UDSEWER Math Model Interface 2.2.1.2
Run Date:
6/28/2016 14:51

UDSewer Results Summary

Project Title: Glen at Widefield Filing No. 8
Project Description: Storm Sewer System

System Input Summary

Rainfall Parameters

Rainfall Return Period: 100
Rainfall Calculation Method: Formula

One Hour Depth (in): 2.52
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): 18.00
Maximum Depth to Rise Ratio: 0.90
Maximum Flow Velocity (fps): 18.0
Minimum Flow Velocity (fps): 2.0

Backwater Calculations:

Tailwater Elevation (ft): 5661.90

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
S16	200.61	14.36	34.42	8.86	26.34	12.34	1.67	Supercritical	97	0	
S14-3	47.29	6.69	36	8.86	36	8.86	0	Pressurized	62.6	60	
S14-2	47.29	6.69	36	8.86	36	8.86	0	Pressurized	62.6	60	
S14-1	127.07	17.98	30.56	9.79	17.84	17.91	2.92	Supercritical Jump	62.6	70.76	
S10-2	8.81	4.99	9.18	4.41	8.51	4.87	1.16	Pressurized	4	28.8	
S10-1	8.81	4.99	9.18	4.41	8.51	4.87	1.16	Pressurized	4	28.6	
S9	70.64	14.39	25.23	8.81	15.87	14.73	2.53	Supercritical Jump	38.8	52.45	
S7	76.94	15.67	22.4	7.63	13.01	14.7	2.86	Supercritical	30	0	
S5	56.54	11.52	20.9	7.15	14.32	11.29	2.07	Pressurized	26.1	50.2	
S3	20.67	6.58	17.25	6.58	15.79	7.26	1.19	Pressurized	15.9	27.7	
S2	14.4	8.15	13.55	5.96	9.95	8.49	1.82	Pressurized	8.5	26.7	
S1-4	10.53	5.96	12.29	5.45	10.72	6.38	1.3	Supercritical Jump	7	135.95	
S1-3	11.54	6.53	12.29	5.45	10.12	6.84	1.45	Supercritical	7	0	
S1-2	11.54	6.53	12.29	5.45	10.12	6.84	1.45	Supercritical	7	0	
S1-1	11.49	6.5	12.29	5.45	10.15	6.82	1.45	Supercritical	7	0	
S4	18.21	10.31	8.17	4.1	5.11	7.76	2.47	Pressurized	3.2	7.7	
S6-3	10.53	5.96	9.06	4.37	7.58	5.51	1.41	Supercritical Jump	3.9	64.08	
S6-2	10.53	5.96	9.06	4.37	7.58	5.51	1.41	Supercritical	3.9	0	
S6-1	8.62	4.88	9.06	4.37	8.49	4.76	1.13	Supercritical	3.9	0	
S8	14.71	8.32	13.78	6.06	10.03	8.69	1.86	Supercritical	8.8	0	
S13	37.69	7.68	18.12	6.39	15.45	7.77	1.36	Pressurized	19.8	47.7	
S12	15.72	5	24	5.12	24	5.12	0	Pressurized	16.1	35.3	
S11	22.42	12.69	13.31	5.85	7.53	11.7	3	Pressurized	8.2	26.7	
S15	22.8	7.26	18.29	6.97	16.02	8.03	1.3	Supercritical	17.9	0	

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.

Grade Line Summary:

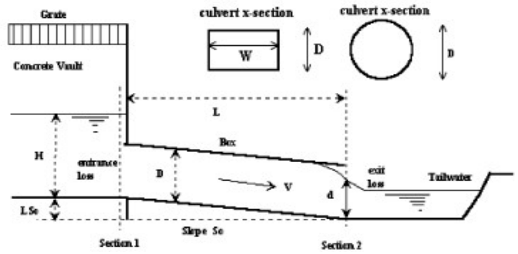
Tailwater Elevation (ft): 5661.90

	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)
S16	5660.9	5661.35	0	0	5663.32	5664.22	5665.16	0.28	5665.44
S14-3	5661.9	5662.2	1.02	0.43	5665.68	5666.2	5666.89	0.53	5667.42
S14-2	5662.3	5662.6	0.85	0	5667.05	5667.58	5668.27	0.53	5668.8
S14-1	5662.71	5667.07	0.06	0	5667.64	5669.62	5668.86	2.25	5671.1
S10-2	5668.57	5668.77	0.06	0	5671.08	5671.12	5671.16	0.04	5671.2
S10-1	5669.37	5669.57	0.05	0	5671.18	5671.22	5671.26	0.04	5671.3
S9	5667.58	5675.61	0.05	0.98	5671.16	5677.71	5672.13	6.79	5678.92
S7	5676.79	5678.08	0.03	0.83	5678.57	5680.65	5681.23	0	5681.23
S5	5678.18	5679.13	0.44	0.47	5681.7	5681.9	5682.14	0.2	5682.34
S3	5679.23	5679.46	0.4	0	5682.34	5682.48	5682.74	0.14	5682.87
S2	5680.16	5680.66	0.1	0	5682.62	5682.79	5682.98	0.17	5683.15
S1-4	5680.23	5682.06	0.01	0.38	5682.49	5683.08	5682.73	0.81	5683.54
S1-3	5682.16	5682.99	0.02	0	5683.11	5684.01	5683.73	0.74	5684.47
S1-2	5683.09	5686.7	0.03	0	5684.04	5687.72	5684.66	3.52	5688.18
S1-1	5686.8	5687.13	0.24	0	5688.16	5688.16	5688.43	0.19	5688.61
S4	5679.83	5680.06	0.05	0	5682.34	5682.35	5682.39	0.01	5682.4
S6-3	5679.18	5680.2	0.08	0	5681.23	5681.26	5681.3	0.09	5681.39
S6-2	5680.3	5681.44	0	0	5681.26	5682.2	5681.4	1.09	5682.49
S6-1	5681.54	5681.73	0.05	0	5682.25	5682.49	5682.6	0.18	5682.78
S8	5677.89	5678.04	0.39	0	5678.73	5679.51	5679.9	0	5679.9
S13	5667.57	5667.97	0.25	0	5671.1	5671.21	5671.36	0.11	5671.47
S12	5668.57	5668.74	0.41	0	5671.62	5671.8	5672.03	0.18	5672.21
S11	5669.34	5670.55	0.1	0	5671.97	5672.13	5672.3	0.16	5672.47
S15	5662.95	5663.37	0.03	0	5664.24	5664.89	5665.46	0.19	5665.65

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.

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

Project: **Glen at Widefield Filing No. 8**
Basin ID: **Detention Basin 'B' Outlet Pipe**
Status:



Design Information (Input):

Circular Culvert:	Barrel Diameter in Inches	D =	30	inches
	Inlet Edge Type (choose from pull-down list)		Square End with Headwall	
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 =	5658.04	ft. elev.
	Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Outlet Elev =	5657.88	ft. elev.
	Culvert Length in Feet	L =	52	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 =	0.48
Sum of All Loss Coefficients	K_s =	1.98
Orifice Inlet Condition Coefficient	C_d =	0.85
Minimum Energy Condition Coefficient	KE_{low} =	0.0152

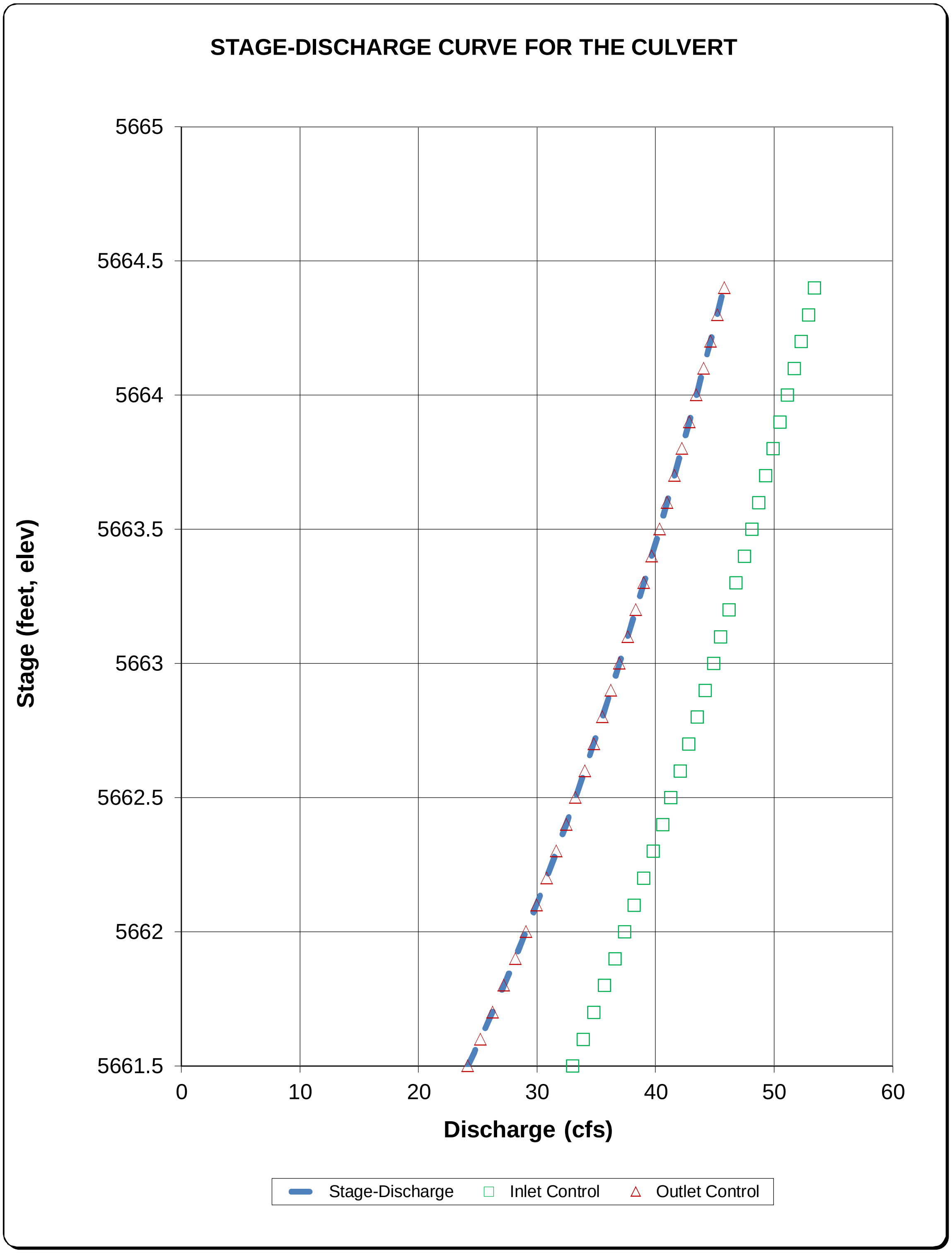
Calculations of Culvert Capacity (output):

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
5661.50	5660.38	33.00	24.16	**24.16**	Regression Eqn.	OUTLET
5661.60	5660.38	33.90	25.22	**25.22**	Regression Eqn.	OUTLET
5661.70	5660.38	34.80	26.23	**26.23**	Regression Eqn.	OUTLET
5661.80	5660.38	35.70	27.21	**27.21**	Regression Eqn.	OUTLET
5661.90	5660.38	36.60	28.16	**28.16**	Regression Eqn.	OUTLET
5662.00	5660.38	37.40	29.07	**29.07**	Regression Eqn.	OUTLET
5662.10	5660.38	38.20	29.95	**29.95**	Regression Eqn.	OUTLET
5662.20	5660.38	39.00	30.81	**30.81**	Regression Eqn.	OUTLET
5662.30	5660.38	39.80	31.64	**31.64**	Regression Eqn.	OUTLET
5662.40	5660.38	40.60	32.46	**32.46**	Regression Eqn.	OUTLET
5662.50	5660.38	41.30	33.25	**33.25**	Regression Eqn.	OUTLET
5662.60	5660.38	42.10	34.03	**34.03**	Regression Eqn.	OUTLET
5662.70	5660.38	42.80	34.78	**34.78**	Regression Eqn.	OUTLET
5662.80	5660.38	43.50	35.53	**35.53**	Regression Eqn.	OUTLET
5662.90	5660.38	44.20	36.24	**36.24**	Regression Eqn.	OUTLET
5663.00	5660.38	44.90	36.96	**36.96**	Regression Eqn.	OUTLET
5663.10	5660.38	45.50	37.65	**37.65**	Regression Eqn.	OUTLET
5663.20	5660.38	46.20	38.35	**38.35**	Regression Eqn.	OUTLET
5663.30	5660.38	46.80	39.02	**39.02**	Regression Eqn.	OUTLET
5663.40	5660.38	47.50	39.68	**39.68**	Regression Eqn.	OUTLET
5663.50	5660.38	48.10	40.34	**40.34**	Regression Eqn.	OUTLET
5663.60	5660.38	48.70	40.98	**40.98**	Regression Eqn.	OUTLET
5663.70	5660.38	49.30	41.60	**41.60**	Regression Eqn.	OUTLET
5663.80	5660.38	49.90	42.23	**42.23**	Regression Eqn.	OUTLET
5663.90	5660.38	50.50	42.84	**42.84**	Regression Eqn.	OUTLET
5664.00	5660.38	51.10	43.45	**43.45**	Regression Eqn.	OUTLET
5664.10	5660.38	51.70	44.04	**44.04**	Regression Eqn.	OUTLET
5664.20	5660.38	52.30	44.63	**44.63**	Regression Eqn.	OUTLET
5664.30	5660.38	52.90	45.21	**45.21**	Regression Eqn.	OUTLET
5664.40	5660.38	53.40	45.78	**45.78**	Regression Eqn.	OUTLET

Processing Time: 16.70 Seconds

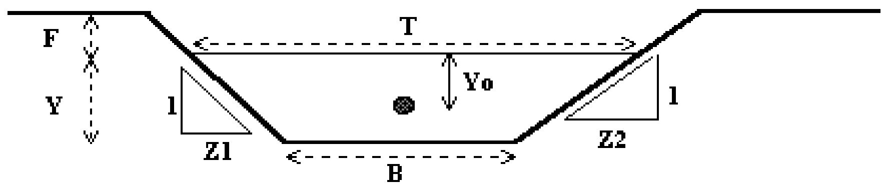
CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Glen at Widefield Filing No. 8
Basin ID: Detention Basin 'B' Outlet Pipe



Normal Flow Analysis - Trapezoidal Channel

Project:	**Glen at Widefield Filing No. 9**
Channel ID:	**Detention Basin A Open Channel to West Fork Jimmy Camp Creek**



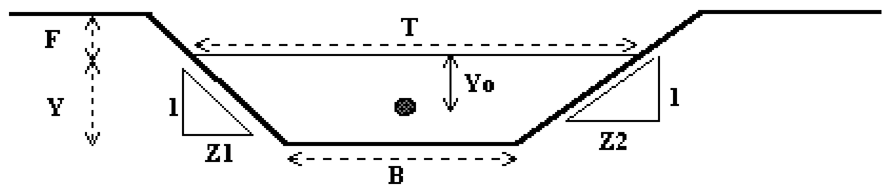
Design Information (Input)			
Channel Invert Slope	So =	0.0042	ft/ft
Manning's n	n =	0.035	
Bottom Width	B =	6.00	ft
Left Side Slope	Z1 =	6.00	ft/ft
Right Side Slope	Z2 =	4.00	ft/ft
Freeboard Height	F =	1.00	ft
Design Water Depth	Y =	**3.00**	ft

Normal Flow Condtion (Calculated)			
Discharge	**Q =**	**249.57**	cfs
Froude Number	**Fr =**	**0.53**	
Flow Velocity	**V =**	**3.96**	fps
Flow Area	A =	63.00	sq ft
Top Width	T =	36.00	ft
Wetted Perimeter	P =	36.62	ft
Hydraulic Radius	R =	1.72	ft
Hydraulic Depth	D =	1.75	ft
Specific Energy	Es =	3.24	ft
Centroid of Flow Area	Yo =	1.14	ft
Specific Force	Fs =	6.38	kip

Critical Flow Analysis - Trapezoidal Channel

Project: **Glen at Widefield Filing No. 9**

Channel ID: **Detention Basin A Open Channel to West Fork Jimmy Camp Creek**

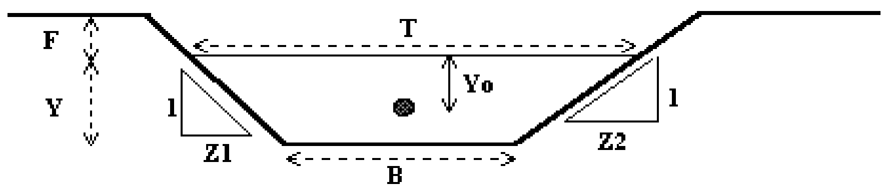


Design Information (Input)			
Bottom Width	B =	6.00	ft
Left Side Slope	Z1 =	6.00	ft/ft
Right Side Slope	Z2 =	4.00	ft/ft
Design Discharge	Q =	**249.00**	cfs

Critical Flow Condition (Calculated)			
Critical Flow Depth	**Y =**	**2.21**	ft
Critical Flow Area	A =	37.82	sq ft
Critical Top Width	T =	28.15	ft
Critical Hydraulic Depth	D =	1.34	ft
Critical Flow Velocity	V =	6.58	fps
Froude Number	**Fr =**	**1.00**	
Critical Wetted Perimeter	P =	28.61	ft
Critical Hydraulic Radius	R =	1.32	ft
Critical (min) Specific Energy	Esc =	2.89	ft
Centroid on the Critical Flow Area	Yoc =	0.68	ft
Critical (min) Specific Force	Fsc =	4.78	kip

Normal Flow Analysis - Trapezoidal Channel

Project:	**Glen at Widefield Filing No. 9**
Channel ID:	**Offsite Runoff Open Channel to West Fork Jimmy Camp Creek**



Design Information (Input)

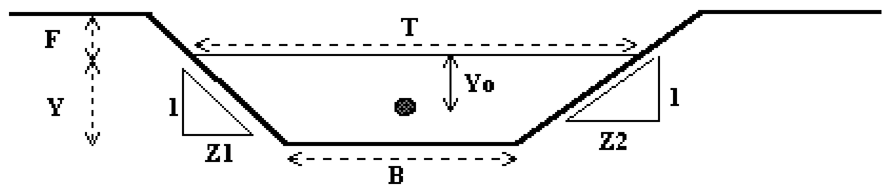
Channel Invert Slope	So =	0.0033	ft/ft
Manning's n	n =	0.035	
Bottom Width	B =	6.00	ft
Left Side Slope	Z1 =	6.00	ft/ft
Right Side Slope	Z2 =	4.00	ft/ft
Freeboard Height	F =	1.00	ft
Design Water Depth	Y =	**3.00**	ft

Normal Flow Condtion (Calculated)

Discharge	**Q =**	**221.22**	cfs
Froude Number	**Fr =**	**0.47**	
Flow Velocity	**V =**	**3.51**	fps
Flow Area	A =	63.00	sq ft
Top Width	T =	36.00	ft
Wetted Perimeter	P =	36.62	ft
Hydraulic Radius	R =	1.72	ft
Hydraulic Depth	D =	1.75	ft
Specific Energy	Es =	3.19	ft
Centroid of Flow Area	Yo =	1.14	ft
Specific Force	Fs =	5.97	kip

Critical Flow Analysis - Trapezoidal Channel

Project: Glen at Widefield Filing No. 9
Channel ID: Offsite Runoff Open Channel to West Fork Jimmy Camp Creek



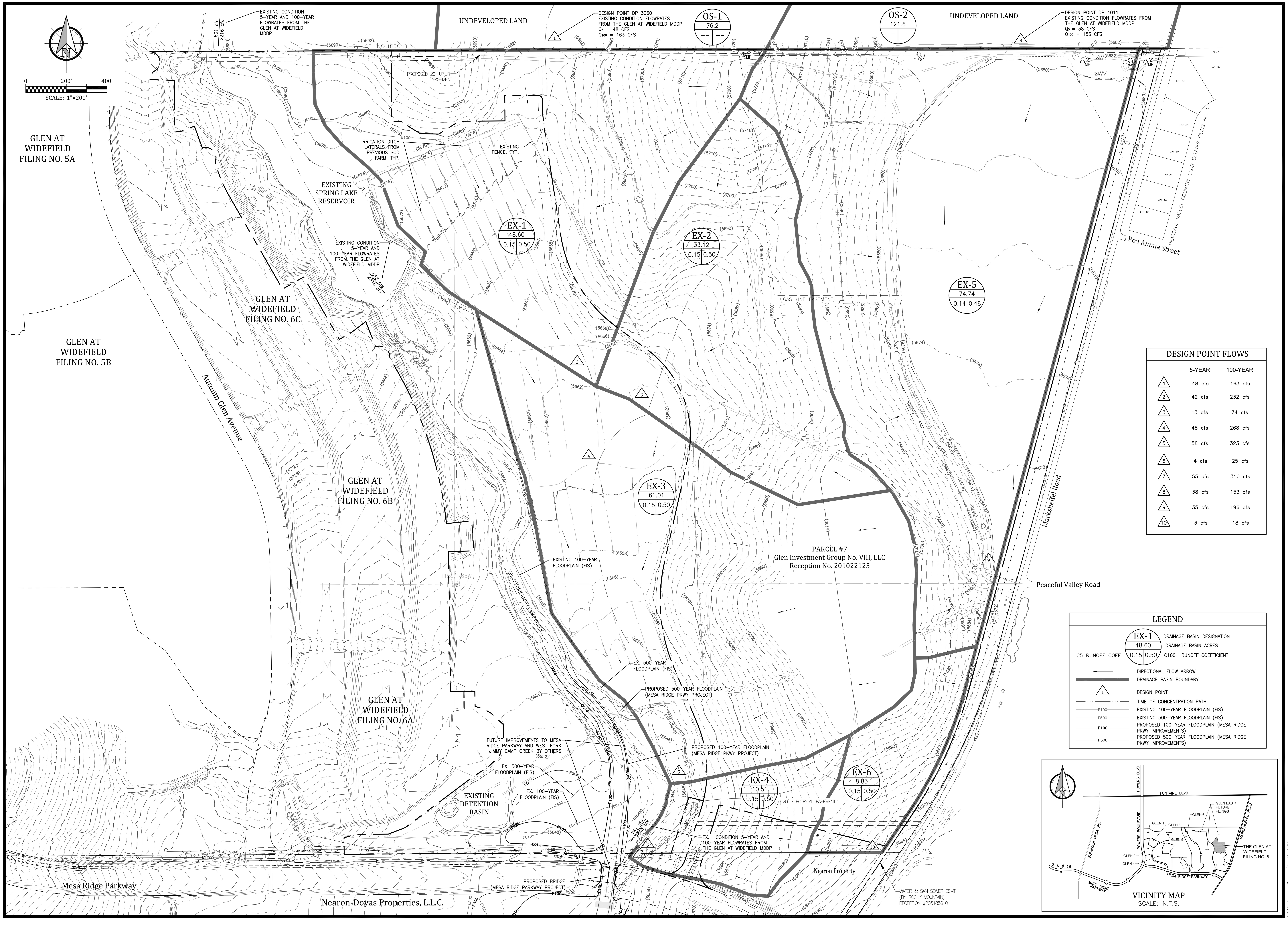
Design Information (Input)			
Bottom Width	B =	6.00	ft
Left Side Slope	Z1 =	6.00	ft/ft
Right Side Slope	Z2 =	4.00	ft/ft
Design Discharge	Q =	**220.00**	cfs

Critical Flow Condition (Calculated)			
Critical Flow Depth	**Y =**	**2.08**	ft
Critical Flow Area	A =	34.25	sq ft
Critical Top Width	T =	26.85	ft
Critical Hydraulic Depth	D =	1.28	ft
Critical Flow Velocity	V =	6.42	fps
Froude Number	**Fr =**	**1.00**	
Critical Wetted Perimeter	P =	27.28	ft
Critical Hydraulic Radius	R =	1.26	ft
Critical (min) Specific Energy	Esc =	2.73	ft
Centroid on the Critical Flow Area	Yoc =	0.65	ft
Critical (min) Specific Force	Fsc =	4.12	kip

APPENDIX D

Existing and Proposed Drainage Plans

Sheet 1 - Drainage Plan Existing Condition
Sheet 2 - Final Drainage Plan Developed Condition



DESIGN POINT FLOWS

	5-YEAR	100-YEAR
1	48 cfs	163 cfs
2	42 cfs	232 cfs
3	13 cfs	74 cfs
4	48 cfs	268 cfs
5	58 cfs	323 cfs
6	4 cfs	25 cfs
7	55 cfs	310 cfs
8	38 cfs	153 cfs
9	35 cfs	196 cfs
10	3 cfs	18 cfs

LEGEND

EX-1 — DRAINAGE BASIN DESIGNATION
48.60 — DRAINAGE BASIN ACRES
C5 RUNOFF COEF 0.15 | 0.50 C100 RUNOFF COEFFICIENT
DIRECTIONAL FLOW ARROW
DRAINAGE BASIN BOUNDARY
DESIGN POINT
TIME OF CONCENTRATION PATH
E100 EXISTING 100-YEAR FLOODPLAIN (FIS)
E500 EXISTING 500-YEAR FLOODPLAIN (FIS)
P100 PROPOSED 100-YEAR FLOODPLAIN (MESA RIDGE PKWY IMPROVEMENTS)
P500 PROPOSED 500-YEAR FLOODPLAIN (MESA RIDGE PKWY IMPROVEMENTS)

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

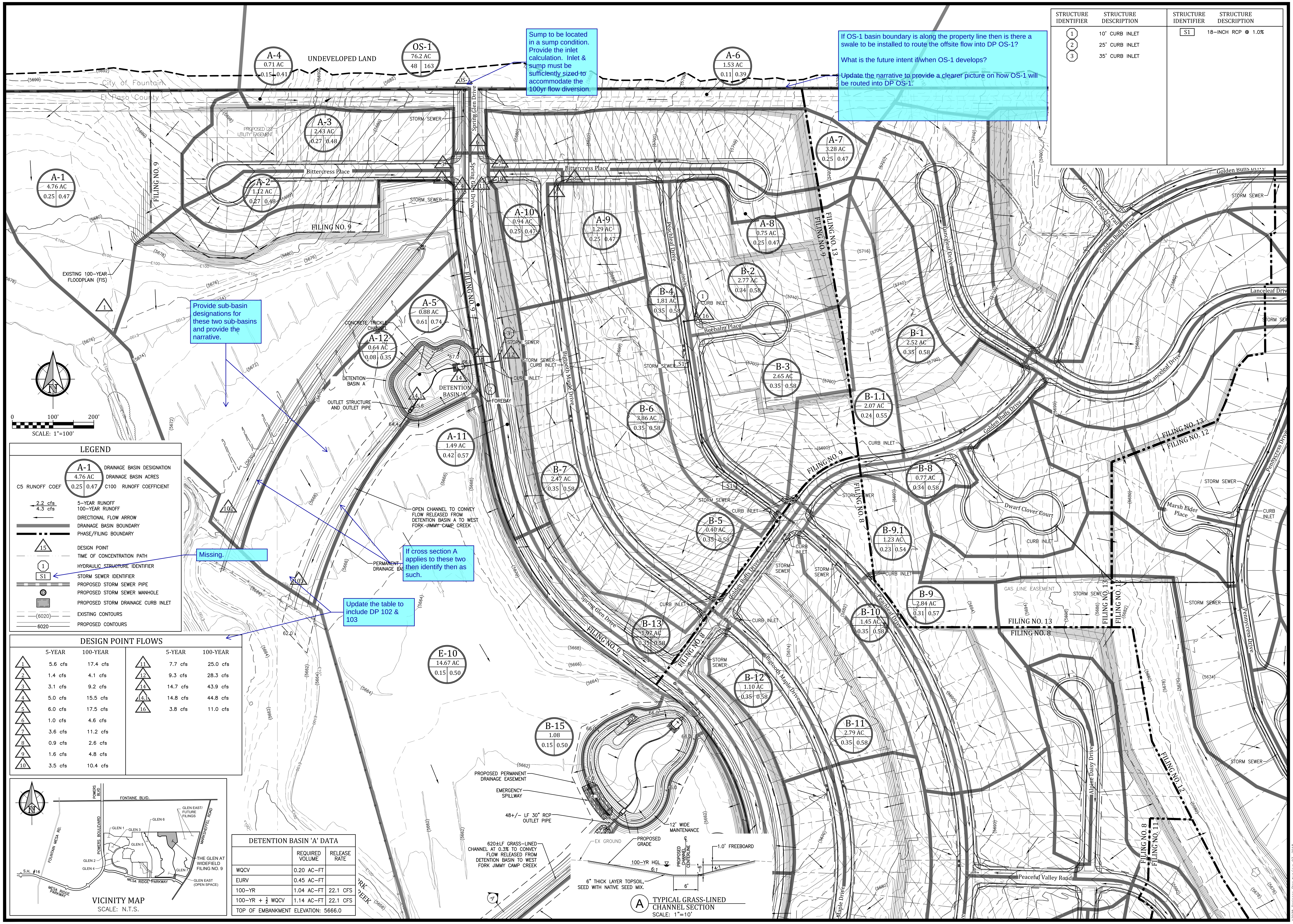
WIDEFIELD Investment Group

GLEN AT WIDEFIELD EAST
DRAINAGE PLAN
EXISTING CONDITION
EL PASO COUNTY, COLORADO

Project No.:	16014
Date:	August 22, 2016
Design:	CJC
Drawn:	CJC
Check:	AWMc
Revisions:	

SHEET
1

16014 Drainage Plan.dwg/Aug 19, 2016



LEGEND

A-1 / 4.76 AC / 0.25 | 0.47	DRAINAGE BASIN DESIGNATION; DRAINAGE BASIN ACRES; C5 RUNOFF COEF; C100 RUNOFF COEFFICIENT
2.2 cfs / 4.3 cfs	5-YEAR RUNOFF / 100-YEAR RUNOFF
	DIRECTIONAL FLOW ARROW
	DRAINAGE BASIN BOUNDARY
	PHASE/FILING BOUNDARY
15	DESIGN POINT
	TIME OF CONCENTRATION PATH
1	HYDRAULIC STRUCTURE IDENTIFIER
S1	STORM SEWER IDENTIFIER
	PROPOSED STORM SEWER PIPE
D	PROPOSED STORM SEWER MANHOLE
	PROPOSED STORM DRAINAGE CURB INLET
(6020)	EXISTING CONTOURS
6020	PROPOSED CONTOURS

DESIGN POINT FLOWS

	5-YEAR	100-YEAR		5-YEAR	100-YEAR
1	5.6 cfs	17.4 cfs	11	7.7 cfs	25.0 cfs
2	1.4 cfs	4.1 cfs	12	9.3 cfs	28.3 cfs
3	3.1 cfs	9.2 cfs	14	14.7 cfs	43.9 cfs
4	5.0 cfs	15.5 cfs	14.1	14.8 cfs	44.8 cfs
5	6.0 cfs	17.5 cfs	16	3.8 cfs	11.0 cfs
6	1.0 cfs	4.6 cfs			
7	3.6 cfs	11.2 cfs			
8	0.9 cfs	2.6 cfs			
9	1.6 cfs	4.8 cfs			
10	3.5 cfs	10.4 cfs			

DETENTION BASIN 'A' DATA

	REQUIRED VOLUME	RELEASE RATE
WQCV	0.20 AC-FT	
EURV	0.45 AC-FT	
100-YR	1.04 AC-FT	22.1 CFS
100-YR + $\frac{1}{2}$ WQCV	1.14 AC-FT	22.1 CFS
TOP OF EMBANKMENT ELEVATION: 5666.0		

STRUCTURE IDENTIFIER	STRUCTURE DESCRIPTION	STRUCTURE IDENTIFIER	STRUCTURE DESCRIPTION
1	10' CURB INLET	S1	18-INCH RCP @ 1.0%
2	25' CURB INLET		
3	35' CURB INLET		

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

GLEN AT WIDEFIELD FILING NO. 9
FINAL DRAINAGE PLAN
DEVELOPED CONDITION
EL PASO COUNTY, COLORADO

Project No.:	17038
Date:	May 21, 2018
Design:	CJC
Drawn:	CJC
Check:	AWMc
Revisions:	

SHEET

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17038 Drainage Plan.dwg/Jun 07, 2018