INNOVATIVE DESIGN. CLASSIC RESULTS.

FINAL DRAINAGE REPORT
FOR
RETREAT AT TIMBERRIDGE
FILING NO. 4

Prepared for:
TIMBERRIDGE DEVELOPMENT GROUP, LLC
2138 FLYING HORSE CLUB DRIVE
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Job No. 1185.31

PCD Project No. SF-1827

FINAL DRAINAGE REPORT FOR
RETREAT AT TIMBERRIDGE FILING NO. 4

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

COLORADO REGISTERED MARC ALAN WHORTON 37155 PROFESSIONAL ENGINEER

_______________________________ 5/21/2024
Marc A. Whorton Colorado P.E. #37155 Date

OWNER'S/DEVELOPER'S STATEMENT:
I, the owner/developer, have read and will comply with all of the requirements specified in this drainage report and plan.

Business Name: TIMBERRIDGE DEVELOPMENT GROUP, LLC

By: LOREN J. MORELAND

Title: VICE PRESIDENT

Address: 2138 Flying Horse Club Drive

Colorado Springs, CO 80921

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

_______________________________ _______________
Joshua Palmer, P.E. Date
County Engineer, / ECM Administrator

Conditions:

CLASSIC CONSULTING ENGINEERS & SURVEYORS

FINAL DRAINAGE REPORT FOR RETREAT AT TIMBERRIDGE FILING NO. 4

TABLE OF CONTENTS:

APPENDICES

PURPOSE

The purpose of this Final Drainage Report is to address on-site and off-site drainage patterns and identify specific drainage improvements and facilities required to minimize impacts to the adjacent properties.

GENERAL DESCRIPTION

The Retreat at TimberRidge Filing No. 4 is 34.471-acre site located in a portion of section 22, township 12 south, range 65 west of the sixth principal meridian. The site is bounded on the north, west and east by unplatted 5+ Ac. rural residential properties and south by Arroya Lane and future Sterling Ranch property (zoned for future urban development). The site is in the upper portion of the Sand Creek Drainage Basin. Large lot rural single family residential is proposed in this Filing.

The average soil condition reflects Hydrologic Group “B” (Pring coarse sandy loam) as determined by the “Web Soil Survey of El Paso County Area,” prepared by the Natural Resources Conservation Service (see map in Appendix).

EXISTING DRAINAGE CONDITIONS

The Retreat at TimberRidge Filing No. 4 property is located in the upper portion of the Sand Creek drainage basin on the south edge of Black Forest. The majority of the site is mainly covered with native grasses with large groupings of pine trees along the south boundary adjacent to Arroya Lane and the northeast portion of the property. Arroya Lane (private gravel roadway) borders the entire southern boundary with some private gravel drives heading north into the property.

There are several natural ravines traversing the site from east to southwest. Off-site flows from portions of Black Forest and unplatted 5 Ac.+ rural residential lots enter the site along the north and east boundary. (See off-site Drainage Map) These off-site flows travel through the natural ravines towards the southwest corner of the property where a temporary sediment basin collects on-site and these off-site flows. This temporary facility was proposed and constructed as a part of the Retreat at TimberRidge Filing No. 3 development. With the development of Filing 4, this facility will be converted into a permanent EDB. The natural ridge along the south boundary creates some minor on-site flows that bypass the previously mentioned temporary sediment basin. However, these flows travel as sideroad ditch flows along the north side of Arroya Lane and are then collected in a storm system and routed towards an off-site Rain Garden south of Arroya Lane constructed with Filing 3 development.

The following descriptions represent the pre-development flow basins for the property:

Basin EX-1 (Q_5 = 7 cfs, Q_{100} = 44 cfs) consists of a 31.6 Ac. on-site basin that makes up the majority of the property. This basin accepts off-site flows as described below and conveys the combined flows via the natural ravines on site towards the existing temporary sediment basin.

Basin OS-1 (Q_5 = 2 cfs, Q_{100} = 10 cfs) consists of a 5.5 Ac. off-site basin from the adjacent 5 Ac. + rural residential lot to the north that sheet and swale flows on-site into Basin EX-1.

Basin OS-2 (Q_5 = 3 cfs, Q_{100} = 16 cfs) consists of a 9.6 Ac. off-site basin again from the adjacent 5 Ac. + rural residential lot to the north that sheet flows on-site into Basin EX-1.

Basin OS-3 (Q_5 = 1 cfs, Q_{100} = 5 cfs) consists of a 2.5 Ac. off-site basin from the adjacent 5 Ac. + rural residential lot to the east that sheet flows on-site into Basin EX-1.

Basin EX-2 (Q_5 = 2 cfs, Q_{100} = 6 cfs) consists of 3.3 Ac. on-site basin that sheet flows towards the sideroad ditch along the north side of Arroya Lane. The collected ditch flows then travel west towards an existing Type C inlet at **Design Point E2** and are then routed via storm sewer towards the off-site Rain Garden south of Arroya Lane.

Basin EX-3 (Q_5 = 0.1 cfs, Q_{100} = 0.6 cfs) consists of a 0.22 Ac. minor basin at the extreme southeast corner of the property that sheet flows off-site to a low point that crosses Arroya Lane. These minor flows are then routed just east around the existing water tank site. These flows will ultimately be handled in the future Sterling Ranch development south of this property.

Basin EX-4 (Q_5 = 0.5 cfs, Q_{100} = 1.5 cfs) consists of 0.49 Ac. minor basin due west of the existing temporary sediment basin. These minor flows will continue to sheet flow off-site and ultimately into Arroya Lane where they are captured and treated in the previously mentioned Rain Garden south of Arroya Lane.

Design Point E1 (Q_5 = 11 cfs, Q_{100} = 69 cfs) consists of the total on-site and off-site flows combined from basins OS-1, OS-2, OS-3 and EX-1 that are tributary to the existing temporary sediment basin.

PROPOSED DRAINAGE CONDITIONS

Proposed development within the Retreat at TimberRidge Filing No. 4 will consist of 10 large lot rural residential properties ranging from 2.5 Ac. min. to 5.0 Ac. lots. These lots will have a paved street and roadside ditches. Development of these rural lots will be limited to roadways and building pads, conserving the natural feature areas. Individual home sites on these lots are to be left generally in their natural condition with minimal disturbance to existing conditions per individual lot construction. Per the El Paso County ECM, Section I.7.1.B.5, rural lots of 2.5 ac. and larger are not required to provide Water Quality Capture Volume (WQCV). However, based on the current County/Urban Drainage stormwater quality standards, a WQCV component is automatically built into the UD Detention spreadsheet utilized in the detention basin design. Thus, the existing temporary sediment basin on-site is proposed to be converted to a permanent detention/stormwater quality facility and will provide WQCV along with an Excess Urban Runoff Volume (EURV) in the lower portion of the facility storage volume with an outlet control device.

Frequent and infrequent inflows are released at rates approximating undeveloped conditions. This concept provides some mitigation of increased runoff volume by releasing a portion of the increased runoff at a low rate over an extended period of time, up to 72 hours. This means that frequent storms, smaller than the 2-year event, will be reduced to very low flows near or below the sediment carrying threshold value for downstream drainage ways. Also, by incorporating an outlet structure that limits the 100-year runoff to the undeveloped condition rate, the discharge hydrograph for storms between the 2 year and the 100-year event will approximate the hydrograph for the undeveloped conditions and will help effectively mitigate the effects of development. As reasonably possible, WQCV will be provided for all new roads and urban lots. The following describes how this development proposes to handle both the off-site and on-site drainage conditions:

The following descriptions represent the proposed developed design points for the property:

Design Point 1 (Q_5 = 7 cfs, Q_{100} = 40 cfs) represents developed flows from Basins A (11.2 Ac.), OS-1A (4.7 Ac.) and OS-2 (9.6 Ac.). These basins develop flows that are conveyed through lots 2-6 in natural ravines within private drainage easements towards the corner of lot 2. At this location a berm on lot 2 will be constructed to allow for the capture of these flows into a proposed CDOT Type D inlet. This facility will completely capture both the 5-yr. and 100-yr. developed flows. A private (District maintained) 36" RCP storm sewer will convey these flows further downstream. The emergency overflow route for this sump condition will be over the constructed berm and then routed within private drainage easements across lots 1 and 2 towards Design Point 3 and the adjacent proposed Pond 4.

Design Point 2 (Q_5 = 5 cfs, Q_{100} = 25 cfs) represents developed flows from Basins B (13.4 Ac.) and OS-3 (2.5 Ac.). These basins develop flows that are conveyed through lots 6-10 in natural ravines within private drainage easements towards Design Point 2. At this location a proposed CDOT Type D inlet will completely capture both the 5-yr. and 100-yr. developed flows with a proposed private 36" RCP storm sewer conveying these flows further downstream. The emergency overflow route for this sump condition will be over the highpoint in the sideroad ditch and directly into Basin C.

Design Point 3 (Q_5 = 2 cfs, Q_{100} = 10 cfs) represents developed flows from Basins D (4.3 Ac.) and OS-1B (0.80 Ac.). These basins develop sheet flows in a southerly direction towards Design Point 3. At this location a proposed grated inlet will be installed to completely capture both the 5-yr. and 100-yr. developed flows. A private (District maintained) 18" RCP storm pipe will then convey these flows further downstream. The emergency overflow at this sump condition will pond up 2.0' and then spill over the berm and be travel directly into the adjacent Pond 4.

Design Point 4 (Q_5 = 13 cfs, Q_{100} = 75 cfs) represents the total developed flows tributary to the proposed full spectrum private (District maintained) EDB Pond 4.

Basin E (Q_5 = 0.8 cfs, Q_{100} = 4 cfs) represents the southern portion of Lot 1 that will continue to sheet flow directly into the proposed Pond 4 and the area of the pond itself.

The following represents the proposed **Pond 4 design**:
(See MHFD-Detention Design Sheets in Appendix)

Total Tributary acreage: 48.5 Ac.	**(Basins: A, B, D, E, OS-1, OS-2 and OS-3)**
0.201 Ac.-ft. WQCV required	
0.114 Ac.-ft. EURV required	
1.216 Ac.-ft. 100-yr. Storage	
1.531 Ac.-ft. Total	
Total In-flow:	**Q_5 = 13 cfs, Q_{100} = 75 cfs**
Pre-Development Release:	**Q_5 = 11 cfs, Q_{100} = 69 cfs**
Pond Design Release:	**Q_5 = 9.5 cfs, Q_{100} = 58.2 cfs**

See detailed outlet structure design below:

Top of Micropool elev: 7248.00

Max. 100 yr. WSE: 7255.98

9'x4' Conc. Outlet box with front edge height of 3.50' above Micropool elev.

Box slope at 4:1 with 36" RCP outfall pipe with restrictor plate 21" above pipe inv.

Orifice Plate design: Bottom hole = 0.79 sq-in. and top 2 holes = 0.89 sq-in.

Hole spacing = 14.00"

Emergency Spillway: 25' wide with spillway elev. of 7256.00 and slope of 2.0% draining directly into sideroad ditch along north side of Arroya Lane.

Top of embankment = 7258.00

(Ownership and maintenance by the Retreat at TimberRidge Metro District 2)

Design Point 5 (Q_5 = 2 cfs, Q_{100} = 8 cfs) represents developed flows from Basin C (3.3 Ac.). This basin develops sheet flows in a southwesterly direction towards the sideroad ditch along the north side of Arroya Lane. These ditch flows are then conveyed westerly towards Design Point 5. At this location a proposed public 18" RCP culvert will be installed to completely convey both the 5-yr. and 100-yr. developed flows under Nature Refuge Way. These flows then travel as ditch flow towards Design Point 6.

Design Point 6 (Q_5 = 3 cfs, Q_{100} = 9 cfs) represents flows from Basin F (0.61 Ac.) and the previously mentioned developed flows from Design Point 5. At this location the existing CDOT Type C inlet (constructed with Filing 3) will completely capture both the 5-yr. and 100-yr. developed flows. These developed flows are consistent with the previously approved drainage report for Filing 3 and are conveyed further west where they combine with other developed flows within Arroya Lane and then towards the existing Rain Garden 1 south of Arroya Lane (also constructed with Filing 3). The Pond 4 emergency overflow is tributary to this design point. In an emergency situation only, a portion of this overflow may be captured by this inlet.

DETENTION / STORMWATER QUALITY FACILITES

As required, storm water quality measures will be utilized in order to reduce the amount of sediment, debris and pollutants that are allowed to enter Sand Creek. These features include but are not limited to Rain Gardens and an Extended Detention Basin. Site Planning and design techniques for this large lot rural residential development should help limit impervious area, minimize directly impervious area, lengthen time of travel and increase infiltration in order to decrease the rate and volume of stormwater runoff. The proposed Pond 4 will provide a Water Quality Capture Volume (WQCV) and Excess Urban Runoff Volume (EURV) in the lower portion of the facility storage volume that will release the more frequent storms at a slower rate to help minimize the effects of development of the property. The proposed SWQ facilities are to be private facilities with ownership and maintenance by the TimberRidge Metropolitan District 2. **All drainage facilities and storm pipes even within the public Right of Way (except the 18" RCP culvert within the Arroya Lane Right-of-Way) will also be owned and maintained by the TimberRidge Metropolitan District 2. The 18" RCP culvert within Arroya Lane will be owned and maintained by El Paso County.**

DRAINAGE CRITERIA

Hydrologic calculations were performed using the City of Colorado Springs/El Paso County Drainage Criteria Manual, as revised in November 1991 and October 1994 with County adopted Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs/El Paso County Drainage Criteria Manual as revised in May 2014. Individual on-site developed basin design used for detention/SWQ basin sizing, inlet sizing and storm system routing was calculated using the Rational Method. Runoff Coefficients are based on the imperviousness of the particular land use and the hydrologic soil type in accordance with Table 6-6. The average rainfall intensity, by recurrence interval found in the Intensity-Duration-Frequency (IDF) curves in Figure 6-5. (See Appendix)

The City of Colorado Springs/El Paso County DCM requires the Four Step Process for receiving water protection that focuses on reducing runoff volumes, treating the water quality capture volume (WQCV), stabilizing drainage ways, and implementing long-term source controls. The Four Step Process pertains to management of smaller, frequently occurring storm events, as opposed to larger storms for which drainage and flood control infrastructure are sized. Implementation of these four steps helps to achieve storm water permit requirements.

This site adheres to this **Four Step Process** as follows:

1. **Employ Runoff Reduction Practices:** Proposed rural lot impervious area (roof tops, patios, etc.) will sheet flow across lengthy landscape/natural areas within the large lots and to slow runoff and increase time of concentration prior to being conveyed to the proposed public streets or the detention facility. This will minimize directly connected impervious areas within the project site.

Reference the Water Quality Treatment Plan Map in the Appendix for the following:

Area qualifies for 20% exclusion (ECM I.7.1.C.1)	0.71 ac.
Area treated in proposed permanent Pond 4	48.5 ac.
Areas treated in existing Rain Garden Facility 1	3.91 ac.
Filing No. 4 Total platted area	**34.471 ac.**

2. **Stabilize Drainageways:** After developed flows utilize the runoff reduction practices through the large rural lot areas, developed flows will travel via roadside ditches along the public streets and eventually public storm systems. The various sideroad ditches will include the following stabilization: Seeding/matting with Permanent erosion control blanket (North American Green SC150 or equiv.), permanent TRM (North American Green P300 or equiv.), sediment control logs and permanent rock check dams, all as described on the final CDs. These collected flows are then routed directly to an existing Rain Garden and a proposed extended detention basin (full-spectrum facilities). Where developed

flows are not able to be routed to public street, sheet flows will travel across landscaped rear yards and then through undeveloped property prior to entering Sand Creek.

3. **Provide Water Quality Capture Volume (WQCV):** Runoff from this development will be treated through capture and slow release of the WQCV and excess urban runoff volume (EURV) in the existing Rain Garden (as designed, accounted for and constructed with Filing 3 – SF2241) and proposed Full-Spectrum permanent Extended Detention Basin (Pond 4) designed per current El Paso County drainage criteria. Reference Runoff Reduction Calculations in Appendix for the areas that show a 100% WQCV Reduction and meets El Paso County standards.

4. **Consider need for Industrial and Commercial BMPs**: No industrial or commercial uses are proposed within this development. However, a site-specific storm water quality and erosion control plan and narrative has been submitted along with the grading and erosion control plan. Details such as site-specific sediment and erosion control construction BMP's as well as temporary and permanent BMP's were detailed in this plan and narrative to protect receiving waters. Multiple temporary BMP's are proposed based on specific phasing of the overall development. BMP's will be constructed and maintained as the development has been graded and erosion control methods employed.

FLOODPLAIN STATEMENT

This site is NOT located within a floodplain as determined by the Flood Insurance Rate Maps (F.I.R.M.) Map Number 08041C0535G with effective date of December 7, 2018. (See Appendix).

DRAINAGE AND BRIDGE FEES

This site lies entirely within the Sand Creek Drainage Basin boundaries.

The fees are calculated using the following impervious acreage method approved by El Paso County and fees form the original Final Plat submittal date in 2018. **The Retreat at TimberRidge Filing No. 4 has a total area of 34.47 acres** with the following different land uses proposed:

1.30 Ac.	Pond Tract
21.96 Ac.	2.5 Ac. lots (1-5, 8,10) and adjacent roadway
10.02 Ac.	5.0 Ac. lots (6-7)
1.19 Ac.	Future rural Public ROW Tract
34.47 Ac.	**Total**

The percent imperviousness for this subdivision is calculated as follows:

<u>Fees for Pond Tract</u>

(Per El Paso County Percent Impervious Chart: 7**%**)

1.30 Ac. x 7% = **0.09 Impervious Ac.**

<u>Fees for 2.5 Ac. lots</u>

(Per El Paso County Percent Impervious Chart: 11**%** with 25% fee reduction for 2.5 ac. lots planned – ECM 3.10.2a) – *Reduction for Drainage Fees only*

21.96 Ac. x 11% x 75% = **1.81 Impervious Ac.** (Drainage Fees)

21.96 Ac. x 11% = **2.42 Impervious Ac.** (Bridge Fees)

<u>Fees for 5.0 Ac. lots</u>

(Per El Paso County Percent Impervious Chart: 7**%** with 25% fee reduction for 5.0 ac. lots planned – ECM 3.10.2a) – *Reduction for Drainage Fees only*

10.02 Ac. x 7% x 75% = **0.53 Impervious Ac.** (Drainage Fees)

10.02 Ac. x 7% = **0.70 Impervious Ac.** (Bridge Fees)

<u>Fees for future rural public ROW Tract</u>

(Per El Paso County Percent Impervious Chart: 55**%**)

1.19 Ac. x 55% = **0.65 Impervious Ac.**

Total Impervious Acreage: **3.08 Imp. Ac.** (Drainage Fees)

Total Impervious Acreage: **3.86 Imp. Ac.** (Bridge Fees)

The following calculations are based on the 2018 Sand Creek drainage/bridge fees:

ESTIMATED FEE TOTALS:

Drainage Fees

$ 17,197.00 x 3.08 Impervious Ac. = **$ 52,966.76**

Bridge Fees

$ 5,210.00 x 3.86 Impervious Ac. = **$ 20,110.60**

(Developer may elect to use Sand Creek Basin credits for drainage fees based on proposed improvements to Sand Creek constructed along with this filing and previous filings immediately downstream, as approved by County Staff and City/County Drainage Board)

CONSTRUCTION COST OPINION

Private Full-Spectrum Detention Facility 4

ITEM	DESCRIPTION	QUANTITY	UNIT COST	COST
1.	Concrete Forebay	1 EA	$25,000.00	$ 25,000.00
2.	Concrete Outlet Structure	1 EA	$30,000.00	$ 30,000.00
3.	Concrete Trickle Channel	160LF	$65.00/LF	$ 10,400.00
4.	Emergency Overflow Weir	75 CY	$139/CY	$ 10,425.00
5.	Outlet pipe (36” RCP)	105 LF	$151/CY	$ 15,855.00
6.	Access roads (road base)	75 CY	$66/CY	$ 4,950.00
SUB-TOTAL				$ 96,630.00
10% ENGINEERING				$ 9,663.00
5% CONTINGENCY				$ 4,831.50
TOTAL				**$ 111,124.50**

CLASSIC CONSULTING ENGINEERS & SURVEYORS

SUMMARY

The proposed Retreat at TimberRidge Filing No. 4 is within the Sand Creek Drainage Basin. Recommendations are made within this report concerning necessary improvements that will be required as a result of development of this property. The points of storm water release from the proposed site are required to be at or below the calculated historic flow quantities. The development of the proposed site does not significantly impact any downstream facility or property to an extent greater than that which currently exists in the pre-development conditions. All drainage facilities within this report were sized according to the Drainage Criteria Manuals and the full-spectrum storm water quality requirements.

PREPARED BY:

Classic Consulting Engineers & Surveyors, LLC

Marc A. Whorton, P.E.
Project Manager

maw/118531/FDR Fil. 4.doc

REFERENCES

1. City of Colorado Springs/County of El Paso Drainage Criteria Manual as revised in November 1991 and October 1994 with County adopted Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs/El Paso County Drainage Criteria Manual as revised in May 2014.

2. "Urban Storm Drainage Criteria Manual Volume 1, 2 & 3" Urban Drainage and Flood Control District, dated January 2016.

3. "Final Drainage Report for Forest Gate Subdivision" Law & Mariotti Consultants, Inc. dated October 2004.

4. "Sand Creek Drainage Basin Planning Study," Kiowa Engineering Corporation, dated March 1996.

5. "Master Development Drainage Plan for The Retreat at TimberRidge", Classic Consulting, approved March 2018.

6. "Preliminary Drainage Report for The Retreat at TimberRidge Preliminary Plan – South of Arroya Lane", Classic Consulting, approved October 2018.

7. "2018 Sterling Ranch MDDP", M&S Civil Consultants, Inc., June 2018

8. "Final Drainage Report for Retreat at TimberRidge Filing No. 1", Classic Consulting, approved November, 2020.

9. "Final Drainage Report for Retreat at TimberRidge Filing No. 2", Classic Consulting, approved September, 2022.

10. "Final Drainage Report for Retreat at TimberRidge Filing No. 3", Classic Consulting, dated January, 2024.

APPENDIX

VICINITY MAP

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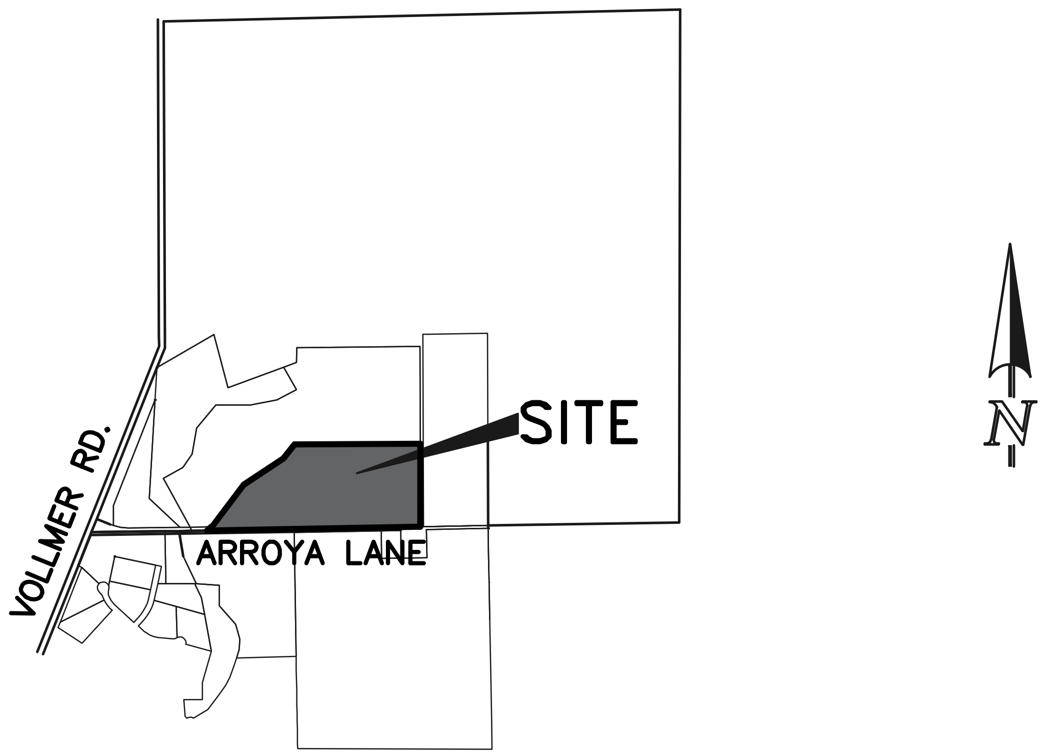
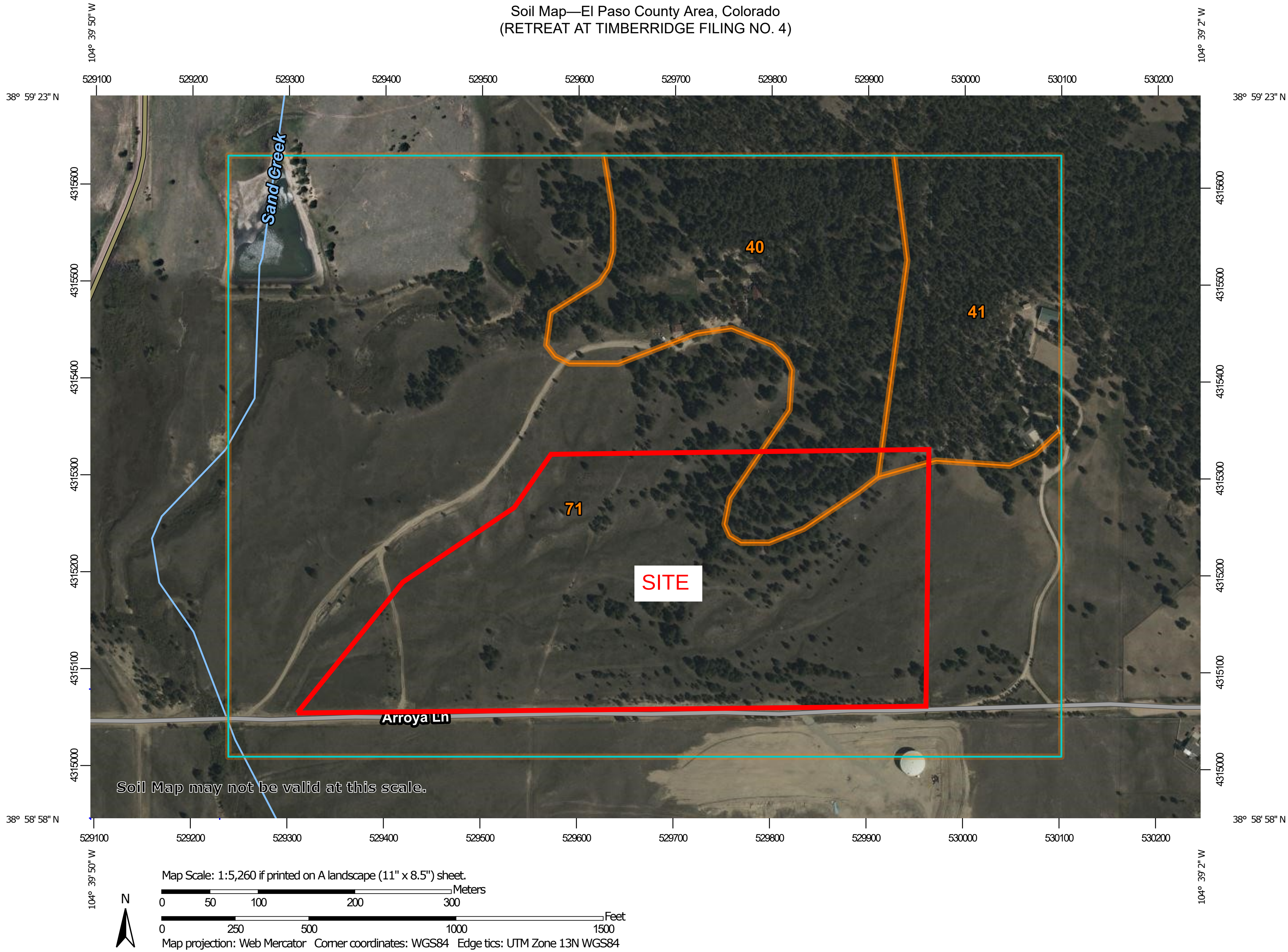


VICINITY MAP
N.T.S.

SOILS MAP (S.C.S SURVEY)


104° 39' 50" W
104° 39' 2" W
38° 59' 23" N
38° 58' 58" N
529100
529200
529300
529400
529500
529600
529700
529800
529900
530000
530100
530200
4315600
4315500
4315400
4315300
4315200
4315100
4315000
Sand Creek
40
41
71
SITE
Arroya Ln
Soil Map may not be valid at this scale.
Map Scale: 1:5,260 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 50 100 200 300
Feet
0 250 500 1000 1500
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 21, Aug 24, 2023

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

Date(s) aerial images were photographed: Sep 11, 2018—Jun 12, 2021

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
40	Kettle gravelly loamy sand, 3 to 8 percent slopes	21.2	15.9%
41	Kettle gravelly loamy sand, 8 to 40 percent slopes	13.4	10.1%
71	Pring coarse sandy loam, 3 to 8 percent slopes	98.3	74.0%
Totals for Area of Interest		**132.8**	**100.0%**

El Paso County Area, Colorado

40—Kettle gravelly loamy sand, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 368g
Elevation: 7,000 to 7,700 feet
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Kettle

Setting

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

Typical profile

E - 0 to 16 inches: gravelly loamy sand
Bt - 16 to 40 inches: gravelly sandy loam
C - 40 to 60 inches: extremely gravelly loamy sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit:
Hydric soil rating: No

Pleasant

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

Data Source Information

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 21, Aug 24, 2023

El Paso County Area, Colorado

41—Kettle gravelly loamy sand, 8 to 40 percent slopes

Map Unit Setting

National map unit symbol: 368h
Elevation: 7,000 to 7,700 feet
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Kettle

Setting

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

Typical profile

E - 0 to 16 inches: gravelly loamy sand
Bt - 16 to 40 inches: gravelly sandy loam
C - 40 to 60 inches: extremely gravelly loamy sand

Properties and qualities

Slope: 8 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit:
Hydric soil rating: No

Pleasant

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

Data Source Information

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 21, Aug 24, 2023

El Paso County Area, Colorado

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

Map Unit Setting

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

Map Unit Composition

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

Description of Pring

Setting

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

Typical profile

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

Properties and qualities

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

Interpretive groups

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

Minor Components

Pleasant

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

Other soils

Percent of map unit:
Hydric soil rating: No

Data Source Information

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 21, Aug 24, 2023

F.E.M.A. MAP

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD83, GRS80 spheroid. Differences in datum, spheroid, projection or UTM zones zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the **North American Vertical Datum of 1988 (NAVD88)**. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242 or visit its website at http://www.ngs.noaa.gov/.

Base Map information shown on this FIRM was provided in digital format by El Paso County, Colorado Springs Utilities, and Anderson Consulting Engineers, Inc. These data are current as of 2008.

This map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map. The profile baselines depicted on this map represent the hydraulic modeling baselines that match the flood profiles and Floodway Data Tables if applicable, in the FIS report. As a result, the profile baselines may deviate significantly from the new base map channel representation and may appear outside of the floodplain.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

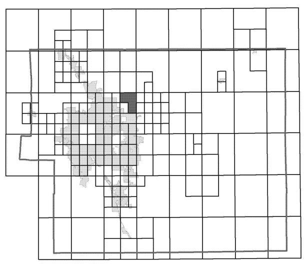
Contact **FEMA Map Service Center** (MSC) via the FEMA Map Information eXchange (FMIX) 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. The MSC may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

El Paso County Vertical Datum Offset Table

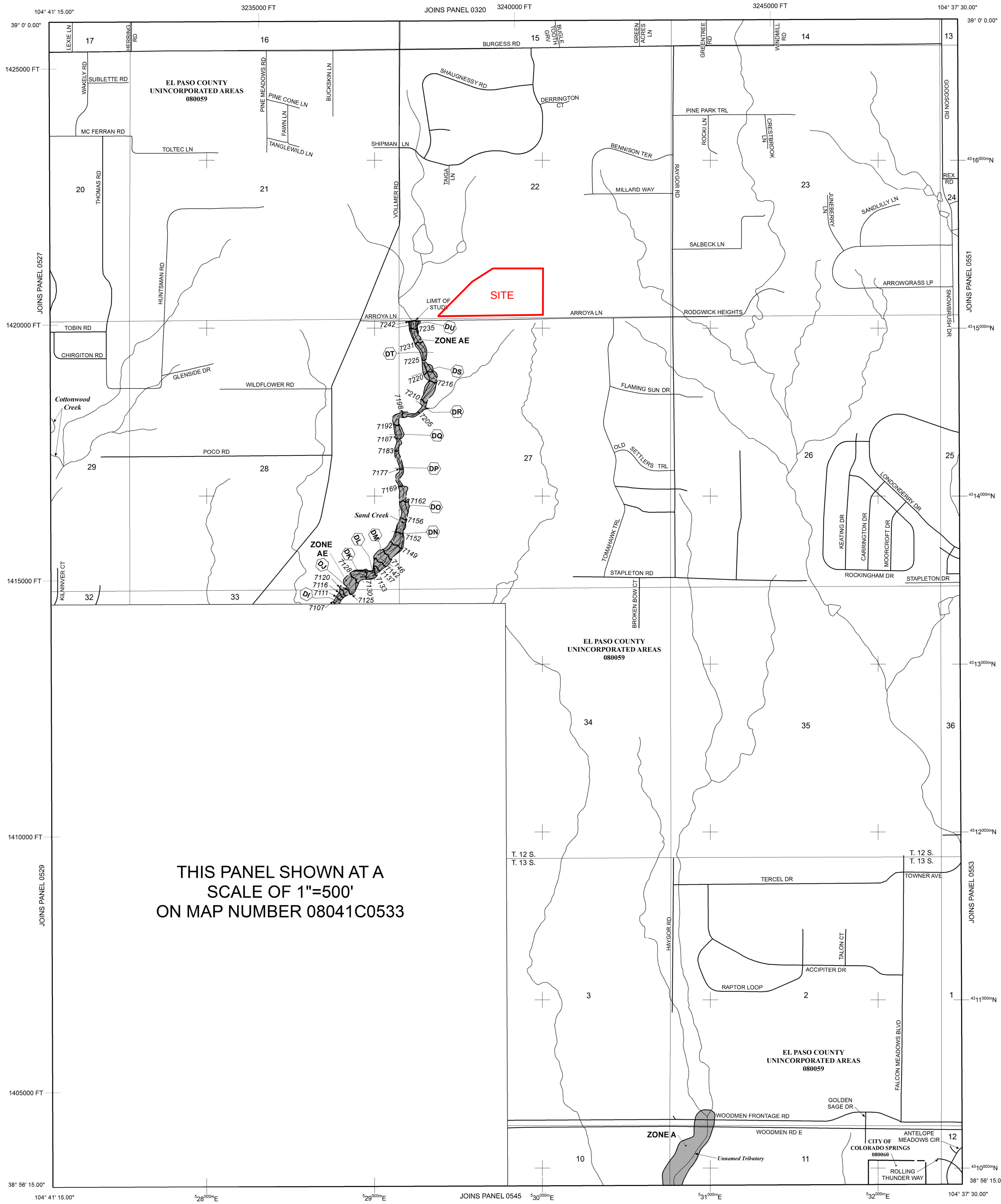
Flooding Source	Vertical Datum Offset (ft)
REFER TO SECTION 3.3 OF THE EL PASO COUNTY FLOOD INSURANCE STUDY FOR STREAM BY STREAM VERTICAL DATUM CONVERSION INFORMATION	

Panel Location Map



This Digital Flood Insurance Rate Map (DFIRM) was produced through a Cooperating Technical Partner (CTP) agreement between the State of Colorado Water Conservation Board (CWCB) and the Federal Emergency Management Agency (FEMA).

Additional Flood Hazard information and resources are available from local communities and the Colorado Water Conservation Board.



NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 12 SOUTH, RANGE 65 WEST, AND TOWNSHIP 13 SOUTH, RANGE 65 WEST.

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAS) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.
ZONE AE Base Flood Elevations determined.
ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR Special Flood Hazard Area Formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

Floodplain boundary
Floodway boundary
Zone D Boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ 513 ~~ Base Flood Elevation line and value; elevation in feet*
(EL 987) Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

A —— A Cross section line
23 - - - - 23 Transect line
97° 07' 30.00" 32° 22' 30.00" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N 1000-meter Universal Transverse Mercator grid ticks, zone 13
6000000 FT 5000-foot grid ticks: Colorado State Plane coordinate system, central zone (FIPSZONE 0502), Lambert Conformal Conic Projection
DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5 River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
MARCH 17, 1997

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
DECEMBER 7, 2018 - to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to update map format, to add roads and road names, and to incorporate previously issued Letters of Map Revision.

For community map revision history prior to countywide mapping, refer to the Community Map History Table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0535G

FIRM
FLOOD INSURANCE RATE MAP
EL PASO COUNTY, COLORADO
AND INCORPORATED AREAS

PANEL 535 OF 1300

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0535	G
EL PASO COUNTY	080059	0535	G

Notice to User: The **Map Number** shown below should be used when placing map orders: the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08041C0535G

MAP REVISED
DECEMBER 7, 2018

Federal Emergency Management Agency

HYDROLOGIC CALCULATIONS

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

Table 6-2. Rainfall Depths for Colorado Springs

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

Where Z= 6,840 ft/100

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

2.2 Design Storms

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

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

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

Table 6-6. Runoff Coefficients for Rational Method

(Source: UDFCD 2001)

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

3.2 Time of Concentration

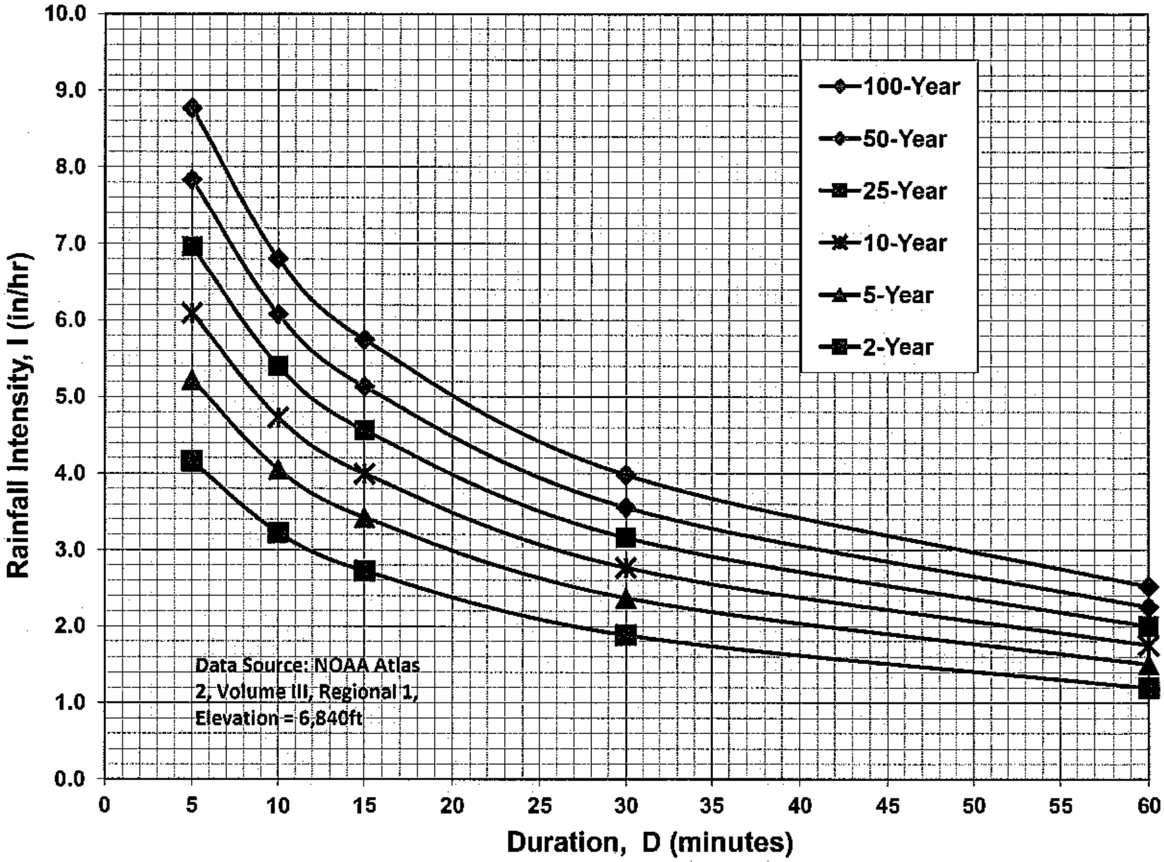
One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration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

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

Table 6-10. NRCS Curve Numbers for Frontal Storms & Thunderstorms for Developed Conditions (ARCII)

Fully Developed Urban Areas (vegetation established)[1]	Treatment	Hydrologic Condition	% I	Pre-Development CN HSG A	HSG B	HSG C	HSG D
Open space (lawns, parks, golf courses, cemeteries, etc.):							
Poor condition (grass cover < 50%)	-----	-----	---	68	79	86	89
Fair condition (grass cover 50% to 75%)	-----	-----	---	49	69	79	84
Good condition (grass cover > 75%)	-----	-----	---	39	61	74	80
Impervious areas:							
Paved parking lots, roofs, driveways, etc. (excluding right-of-way	-----	-----	---	98	98	98	98
Streets and roads:							
Paved; curbs and storm sewers (excluding right-of-way)	-----	-----	---	98	98	98	98
Paved; open ditches (including right-of-way)	-----	-----	---	83	89	92	93
Gravel (including right-of-way)	-----	-----	---	76	85	89	91
Dirt (including right-of-way)	-----	-----	---	72	82	87	89
Western desert urban areas:							
Natural desert landscaping (pervious areas only)	-----	-----	---	63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)	-----	-----	---	96	96	96	96
Urban districts:							
Commercial and business	-----	-----	85	89	92	94	95
Industrial	-----	-----	72	81	88	91	93
Residential districts by average lot size:							
1/8 acre or less (town houses)	-----	-----	65	77	85	90	92
1/4 acre	-----	-----	38	61	75	83	87
1/3 acre	-----	-----	30	57	72	81	86
1/2 acre	-----	-----	25	54	70	80	85
1 acre	-----	-----	20	51	68	79	84
2 acres	-----	-----	12	46	65	77	82
Developing Urban Areas[1]	**Treatment[2]**	**Hydrologic Condition[3]**	**% I**	**HSG A**	**HSG B**	**HSG C**	**HSG D**
Newly graded areas (pervious areas only, no vegetation)	-----	-----	---	77	86	91	94
Cultivated Agricultural Lands[1]	**Treatment**	**Hydrologic Condition**	**% I**	**HSG A**	**HSG B**	**HSG C**	**HSG D**
Fallow	Bare soil	-----	---	77	86	91	94
	Crop residue cover (CR)	Poor	---	76	85	90	93
		Good	---	74	83	88	90
Row crops	Straight row (SR)	Poor	---	72	81	88	91
		Good	---	67	78	85	89
	SR + CR	Poor	---	71	80	87	90
		Good	---	64	75	82	85
	Contoured (C)	Poor	---	70	79	84	88
		Good	---	65	75	82	86
	C + CR	Poor	---	69	78	83	87
		Good	---	64	74	81	85
	Contoured & terraced (C&T)	Poor	---	66	74	80	82
		Good	---	62	71	78	81
	C&T+ CR	Poor	---	65	73	79	81
		Good	---	61	70	77	80
Small grain	SR	Poor	---	65	76	84	88
		Good	---	63	75	83	87
	SR + CR	Poor	---	64	75	83	86
		Good	---	60	72	80	84
	C	Poor	---	63	74	82	85
		Good	---	61	73	81	84
	C + CR Poor	Poor	---	62	73	81	84
		Good	---	60	72	80	83
	C&T	Poor	---	61	72	79	82
		Good	---	59	70	78	81
	C&T+ CR	Poor	---	60	71	78	81
		Good	---	58	69	77	80

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

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

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

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

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

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

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

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

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 4*
JOB NUMBER: *1185.31*
DATE: *02/21/24*
CALCULATED BY: *MAW*

BASIN RUNOFF COEFFICIENT SUMMARY

		C VALUE DCM TABLE 6-6						C VALUE DCM TABLE 6-6						WEIGHTED "C" VALUE			WEIGHTED CA			WEIGHTED IMP.
BASIN	TOTAL AREA (AC)	LAND USE	PERCENT IMP.	AREA (AC)	C(2)	C(5)	C(100)	LAND USE	PERCENT IMP.	AREA (AC)	C(2)	C(5)	C(100)	C(2)	C(5)	C(100)	CA(2)	CA(5)	CA(100)	PERCENT
EX-1	31.60	UNDEV.	2.0%	31.60	0.03	0.09	0.36			0.00	0.02	0.08	0.35	0.03	0.09	0.36	0.95	2.84	11.38	2.0%
EX-2	3.30	UNDEV.	2.0%	2.92	0.03	0.09	0.36	PAVED RD.	100.0%	0.38	0.89	0.90	0.96	0.13	0.18	0.43	0.43	0.60	1.42	13.3%
EX-3	0.22	UNDEV.	2.0%	0.20	0.03	0.09	0.36	GRAVEL RD.	80.0%	0.02	0.57	0.59	0.70	0.08	0.14	0.39	0.02	0.03	0.09	9.1%
EX-4	0.49	UNDEV.	2.0%	0.39	0.03	0.09	0.36	PAVED RD.	100.0%	0.10	0.89	0.90	0.96	0.21	0.26	0.48	0.10	0.13	0.24	22.0%
OS-1	5.50	5 AC.+ RES,	5.0%	5.50	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.22	0.58	2.06	5.0%
OS-2	9.60	5 AC.+ RES,	5.0%	9.60	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.38	1.01	3.60	5.0%
OS-3	2.50	5 AC.+ RES,	5.0%	2.50	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.10	0.26	0.94	5.0%

JOB NAME:	*RETREAT AT TIMBERRIDGE FILING NO. 4*
JOB NUMBER:	*1185.31*
DATE:	*03/30/03*
CALC'D BY:	*MAW*

Return Period	1-Hour Depth
2	1.19
5	1.50
10	1.75
25	2.00
50	2.25
100	2.52

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

$$V = C_v S_w^{0.5}$$

Tc=L/V

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

$$t_c = \frac{L}{180} + 10$$

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

BASIN RUNOFF SUMMARY

BASIN	WEIGHTED CA(2)	CA(5)	CA(100)	OVERLAND C(5)	Length (ft)	Height (ft)	Tc (min)	STREET / CHANNEL FLOW Length (ft)	Slope (%)	Velocity (fps)	Tc (min)	Tc TOTAL (min)	INTENSITY I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	TOTAL FLOWS Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)
EX-1	0.95	2.84	11.38	0.08	300	16	18.4	1850	4.0%	2.0	15.4	33.8	1.85	2.30	3.87	2	**7**	**44**
EX-2	0.43	0.60	1.42	0.12	300	10	20.6	700	5.0%	2.2	5.2	25.8	2.17	2.71	4.54	1	**2**	**6**
EX-3	0.02	0.03	0.09	0.12	70	4	8.3					8.3	3.51	4.40	7.39	0.1	**0.1**	**0.6**
EX-4	0.10	0.13	0.24	0.12	100	3	12.3					12.3	3.05	3.82	6.41	0.3	**0.5**	**1.5**
OS-1	0.22	0.58	2.06	0.08	300	12	20.2	325	4.0%	2.0	2.7	22.9	2.31	2.89	4.85	0.5	**2**	**10**
OS-2	0.38	1.01	3.60	0.08	300	10	21.4	700	4.0%	2.0	5.8	27.3	2.10	2.62	4.40	0.8	**3**	**16**
OS-3	0.10	0.26	0.94	0.08	300	14	19.2	350	5.0%	2.2	2.6	21.8	2.37	2.96	4.97	0.2	**1**	**5**

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 4*
JOB NUMBER: *1185.31*
DATE: *02/21/24*
CALCULATED BY: *MAW*

*ALL STORM SEWER TO BE PRIVATE UNLESS OTHERWISE NOTED

SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins / Design Point	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		Facility/ Inlet Size*
					I(5)	I(100)	Q(5)	Q(100)	
E1	EX-1, OS-1, OS-2, OS-3	4.69	17.98	33.8	2.30	3.87	11	69	
E2	EX-2	0.60	1.42	25.8	2.71	4.54	2	6	

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 4*
JOB NUMBER: *1185.31*
DATE: *05/17/24*
CALCULATED BY: *MAW*

BASIN RUNOFF COEFFICIENT SUMMARY

		C VALUE DCM TABLE 6-6						C VALUE DCM TABLE 6-6						WEIGHTED "C" VALUE			WEIGHTED CA			WEIGHTED IMP.
BASIN	TOTAL AREA (AC)	LAND USE	PERCENT IMP.	AREA (AC)	C(2)	C(5)	C(100)	LAND USE	PERCENT IMP.	AREA (AC)	C(2)	C(5)	C(100)	C(2)	C(5)	C(100)	CA(2)	CA(5)	CA(100)	PERCENT
OS-1A	4.70	5 AC.+ RES,	5.0%	4.70	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.19	0.49	1.76	5.0%
OS-1B	0.80	5 AC.+ RES,	5.0%	0.80	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.03	0.08	0.30	5.0%
OS-2	9.60	5 AC.+ RES,	5.0%	9.60	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.38	1.01	3.60	5.0%
OS-3	2.50	5 AC.+ RES,	5.0%	2.50	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.10	0.26	0.94	5.0%
A	11.20	RES. 2.5 AC.	10.0%	8.10	0.06	0.13	0.40	RES. 5 AC.	5.0%	3.10	0.04	0.11	0.38	0.05	0.12	0.39	0.61	1.38	4.40	8.6%
B	13.40	RES. 2.5 AC.	10.0%	6.50	0.06	0.13	0.40	RES. 5 AC.	5.0%	6.90	0.04	0.11	0.38	0.05	0.12	0.39	0.67	1.57	5.19	7.4%
C	2.80	RES. 2.5 AC.	10.0%	2.45	0.06	0.13	0.40	PAVED ROAD	100.0%	0.35	0.89	0.90	0.96	0.16	0.23	0.47	0.46	0.63	1.32	21.3%
D	4.30	RES. 2.5 AC.	10.0%	4.30	0.06	0.13	0.40			0.00	0.05	0.12	0.39	0.06	0.13	0.40	0.26	0.56	1.72	10.0%
E	2.00	RES. 2.5 AC.	10.0%	0.85	0.06	0.13	0.40	POND TRACT	7.0%	1.15	0.05	0.12	0.39	0.05	0.12	0.39	0.11	0.25	0.79	8.3%
F	0.50	RURAL ROW	13.0%	0.40	0.07	0.16	0.41	PAVED ROAD	100.0%	0.10	0.05	0.12	0.39	0.07	0.15	0.41	0.03	0.08	0.20	30.4%

TOTAL AREA TRIBUTARY TO PROP. ON-SITE POND **48.50** **7.1%**

Basins tributaty to proposed on-site Pond
Basin tributary to exist. Rain Garden within RTR Fil. 3

JOB NAME:	*RETREAT AT TIMBERRIDGE FILING NO. 4*
JOB NUMBER:	*1185.31*
DATE:	*05/17/24*
CALC'D BY:	*MAW*

Return Period	1-Hour Depth
2	1.19
5	1.50
10	1.75
25	2.00
50	2.25
100	2.52

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

$$V = C_v S_w^{0.5}$$

Tc=L/V

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

$$t_c = \frac{L}{180} + 10$$

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

BASIN RUNOFF SUMMARY

BASIN	WEIGHTED			OVERLAND				STREET / CHANNEL FLOW				Tc	INTENSITY			TOTAL FLOWS		
	CA(2)	CA(5)	CA(100)	C(5)	Length *(ft)*	Height *(ft)*	Tc *(min)*	Length *(ft)*	Slope *(%)*	Velocity *(fps)*	Tc *(min)*	TOTAL *(min)*	I(2) *(in/hr)*	I(5) *(in/hr)*	I(100) *(in/hr)*	Q(2) *(cfs)*	Q(5) *(cfs)*	Q(100) *(cfs)*
OS-1A	0.19	0.49	1.76	0.08	300	12	20.2	325	4.0%	2.0	2.7	22.9	2.31	2.89	4.85	0.4	**1**	**9**
OS-1B	0.03	0.08	0.30	0.08	200	8	16.5					16.5	2.70	3.38	5.67	0.1	**0.3**	**1.7**
OS-2	0.38	1.01	3.60	0.08	300	10	21.4	700	4.0%	2.0	5.8	27.3	2.10	2.62	4.40	0.8	**3**	**16**
OS-3	0.10	0.26	0.94	0.08	300	14	19.2	350	5.0%	2.2	2.6	21.8	2.37	2.96	4.97	0.2	**1**	**5**
A	0.61	1.38	4.40	0.08	300	14	19.2	1200	3.0%	1.7	11.5	30.7	1.96	2.44	4.10	1.2	**3**	**18**
B	0.67	1.57	5.19	0.08	300	16	18.4	1400	4.0%	2.0	11.7	30.0	1.99	2.48	4.16	1.3	**4**	**22**
C	0.46	0.63	1.32	0.08	300	13	19.7	200	1.5%	1.2	2.7	22.4	2.34	2.92	4.90	1	**2**	**6**
D	0.26	0.56	1.72	0.08	300	12	20.2	140	1.0%	2.0	1.2	21.4	2.39	2.99	5.02	1	**2**	**9**
E	0.11	0.25	0.79	0.08	300	16	18.4	140	1.0%	2.0	1.2	19.5	2.50	3.13	5.25	0.3	**0.8**	**4**
F	0.03	0.08	0.20	0.08	20	0.8	5.2	470	5.0%	2.2	3.5	8.7	3.46	4.34	7.28	0.1	**0.3**	**1**

JOB NAME: *RETREAT AT TIMBERRIDGE FILING NO. 4*
JOB NUMBER: *1185.31*
DATE: *05/17/24*
CALCULATED BY: *MAW*

*ALL STORM SEWER TO BE PRIVATE UNLESS OTHERWISE NOTED

SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins / Design Point	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		Facility/ Inlet Size*
					I(5)	I(100)	Q(5)	Q(100)	
1	OS-1A, OS-2, A	2.88	9.77	30.7	2.44	4.10	7	40	TYPE D INLET
2	OS-3, B	1.83	6.13	30.0	2.48	4.16	5	25	TYPE D INLET
3	OS-1B, D	0.64	2.02	22.9	2.89	4.85	2	10	GRATED INLET
4 (TOTAL POND INFLOW)	**DP-1, DP-2, DP-3, E**	**5.60**	**18.70**	**31.8**	**2.39**	**4.01**	**13**	**75**	**PROP. POND**
5	C	0.63	1.32	22.4	2.92	4.90	2	6	18" RCP CULVT
6	**DP-5, F**	**0.71**	**1.52**	**25.8**	**2.71**	**4.55**	**2**	**6**	**EXIST. TYPE C CDOT INLET**

JOB NAME: ***RETREAT AT TIMBERRIDGE FILING NO. 4***
JOB NUMBER: ***1185.31***
DATE: ***03/01/24***
CALCULATED BY: ***MAW***

* PIPES ARE LISTED AT MAXIMUM SIZE REQUIRED TO ACCOMMODATE Q100 FLOWS AT MINIMUM SLOPE.
REFER TO INDIVIDUAL PIPE SHEETS FOR HYDRAULIC INFORMATION.
PIPES ARE TO BE PRIVATE UNLESS OTHERWISE NOTED.
PRIVATE STORM MATERIALS TO BE RCP OR DOUBLE WALL POLYPROPYLENE (DWPP) TO BE SELECTED BY CONTRACTOR

PIPE ROUTING SUMMARY

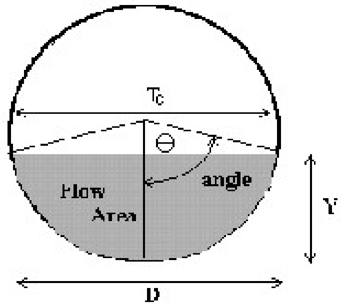
Pipe Run	Contributing Basin / Design Point / Pipe Run	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		
					I(5)	I(100)	Q(5)	Q(100)	Pipe Size*
1	DP-1	2.88	9.76	30.7	2.44	4.10	7	40	PROP. 36" RCP
2	DP-2	1.83	6.13	30.0	2.48	4.16	5	25	PROP. 36" RCP
3	PR-1, PR-2	4.71	15.88	31.3	2.42	4.05	11	64	PROP. 42" RCP
4	DP-3	0.65	2.03	22.9	2.89	4.85	2	10	PROP. 18" RCP
5	**PR-3, PR-4 (42" RCP OUTFALL)**	**5.36**	**17.91**	**31.3**	**2.42**	**4.05**	**13**	**73**	**PROP. 42" RCP**

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 4

Pipe ID: Pipe Run 1



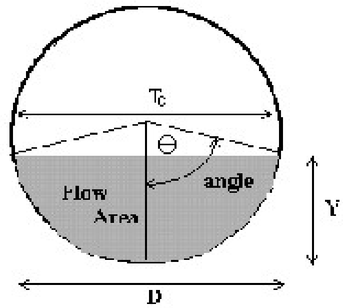
Design Information (Input)			
Pipe Invert Slope	So =	0.0100	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	36.00	inches
Design discharge	Q =	40.00	cfs
Full-Flow Capacity (Calculated)			
Full-flow area	Af =	7.07	sq ft
Full-flow wetted perimeter	Pf =	9.42	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	66.88	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.69	radians
Flow area	An =	4.05	sq ft
Top width	Tn =	2.98	ft
Wetted perimeter	Pn =	5.06	ft
Flow depth	Yn =	1.67	ft
Flow velocity	Vn =	9.88	fps
Discharge	Qn =	40.00	cfs
Percent of Full Flow	Flow =	59.8%	of full flow
Normal Depth Froude Number	Fr_n =	1.49	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	1.95	radians
Critical flow area	Ac =	5.17	sq ft
Critical top width	Tc =	2.78	ft
Critical flow depth	Yc =	2.06	ft
Critical flow velocity	Vc =	7.73	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 4

Pipe ID: Pipe Run 2

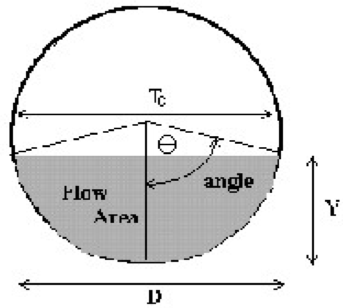


Design Information (Input)			
Pipe Invert Slope	So =	0.0100	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	36.00	inches
Design discharge	Q =	25.00	cfs
Full-Flow Capacity (Calculated)			
Full-flow area	Af =	7.07	sq ft
Full-flow wetted perimeter	Pf =	9.42	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	66.88	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.42	radians
Flow area	An =	2.85	sq ft
Top width	Tn =	2.96	ft
Wetted perimeter	Pn =	4.25	ft
Flow depth	Yn =	1.27	ft
Flow velocity	Vn =	8.78	fps
Discharge	Qn =	25.00	cfs
Percent of Full Flow	Flow =	37.4%	of full flow
Normal Depth Froude Number	Fr_n =	1.58	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	1.65	radians
Critical flow area	Ac =	3.87	sq ft
Critical top width	Tc =	2.99	ft
Critical flow depth	Yc =	1.61	ft
Critical flow velocity	Vc =	6.46	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 4
Pipe ID: Pipe Run 3

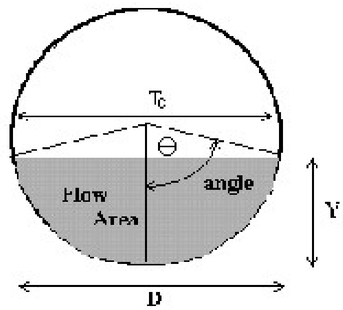


Design Information (Input)			
Pipe Invert Slope	So =	0.0340	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	42.00	inches
Design discharge	Q =	64.00	cfs
Full-Flow Capacity (Calculated)			
Full-flow area	Af =	9.62	sq ft
Full-flow wetted perimeter	Pf =	11.00	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	186.01	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.38	radians
Flow area	An =	3.65	sq ft
Top width	Tn =	3.44	ft
Wetted perimeter	Pn =	4.83	ft
Flow depth	Yn =	1.42	ft
Flow velocity	Vn =	17.54	fps
Discharge	Qn =	64.00	cfs
Percent of Full Flow	Flow =	34.4%	of full flow
Normal Depth Froude Number	Fr_n =	3.00	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.02	radians
Critical flow area	Ac =	7.38	sq ft
Critical top width	Tc =	3.16	ft
Critical flow depth	Yc =	2.51	ft
Critical flow velocity	Vc =	8.68	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 4
Pipe ID: Pipe Run 3



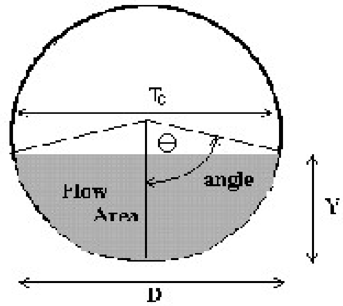
Design Information (Input)			
Pipe Invert Slope	So =	0.0358	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	42.00	inches
Design discharge	Q =	64.00	cfs
Full-Flow Capacity (Calculated)			
Full-flow area	Af =	9.62	sq ft
Full-flow wetted perimeter	Pf =	11.00	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	190.88	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.37	radians
Flow area	An =	3.58	sq ft
Top width	Tn =	3.43	ft
Wetted perimeter	Pn =	4.79	ft
Flow depth	Yn =	1.40	ft
Flow velocity	Vn =	17.87	fps
Discharge	Qn =	64.00	cfs
Percent of Full Flow	Flow =	33.5%	of full flow
Normal Depth Froude Number	Fr_n =	3.08	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.02	radians
Critical flow area	Ac =	7.38	sq ft
Critical top width	Tc =	3.16	ft
Critical flow depth	Yc =	2.51	ft
Critical flow velocity	Vc =	8.68	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 4

Pipe ID: Pipe Run 4

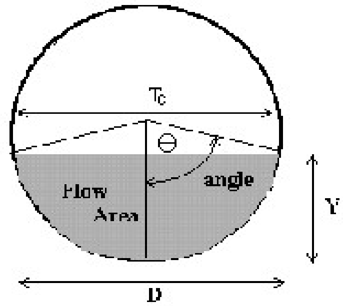


Design Information (Input)			
Pipe Invert Slope	So =	0.0400	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	18.00	inches
Design discharge	Q =	10.00	cfs
Full-Flow Capacity (Calculated)			
Full-flow area	Af =	1.77	sq ft
Full-flow wetted perimeter	Pf =	4.71	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	21.07	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.54	radians
Flow area	An =	0.85	sq ft
Top width	Tn =	1.50	ft
Wetted perimeter	Pn =	2.31	ft
Flow depth	Yn =	0.73	ft
Flow velocity	Vn =	11.77	fps
Discharge	Qn =	10.00	cfs
Percent of Full Flow	Flow =	47.5%	of full flow
Normal Depth Froude Number	Fr_n =	2.75	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.25	radians
Critical flow area	Ac =	1.54	sq ft
Critical top width	Tc =	1.17	ft
Critical flow depth	Yc =	1.22	ft
Critical flow velocity	Vc =	6.50	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 4
Pipe ID: Pipe Run 5



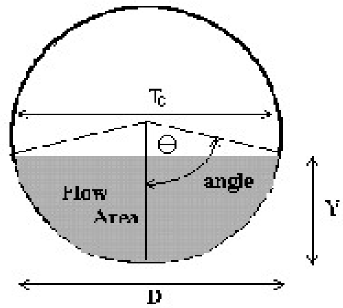
Design Information (Input)			
Pipe Invert Slope	So =	0.0100	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	42.00	inches
Design discharge	Q =	73.00	cfs
Full-Flow Capacity (Calculated)			
Full-flow area	Af =	9.62	sq ft
Full-flow wetted perimeter	Pf =	11.00	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	100.88	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.83	radians
Flow area	An =	6.39	sq ft
Top width	Tn =	3.38	ft
Wetted perimeter	Pn =	6.42	ft
Flow depth	Yn =	2.21	ft
Flow velocity	Vn =	11.42	fps
Discharge	Qn =	73.01	cfs
Percent of Full Flow	Flow =	72.4%	of full flow
Normal Depth Froude Number	Fr_n =	1.46	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.13	radians
Critical flow area	Ac =	7.89	sq ft
Critical top width	Tc =	2.97	ft
Critical flow depth	Yc =	2.68	ft
Critical flow velocity	Vc =	9.25	fps
Critical Depth Froude Number	Fr_c =	1.00	

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

MHFD-Culvert, Version 4.00 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 4

Pipe ID: 36" Pond Outfall Pipe



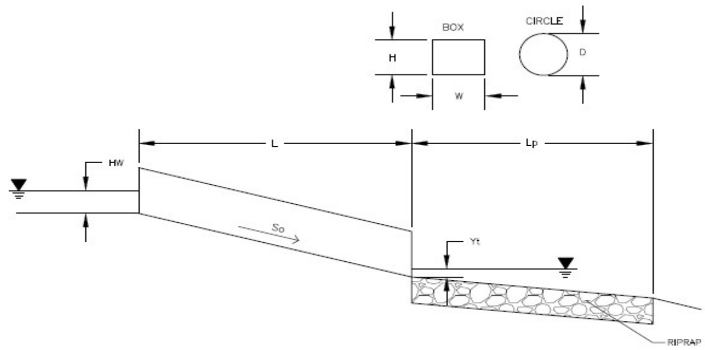
Design Information (Input)			
Pipe Invert Slope	So =	0.0382	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	36.00	inches
Design discharge	Q =	58.20	cfs
Full-Flow Capacity (Calculated)			
Full-flow area	Af =	7.07	sq ft
Full-flow wetted perimeter	Pf =	9.42	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	130.71	cfs
Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.51	radians
Flow area	An =	3.24	sq ft
Top width	Tn =	2.99	ft
Wetted perimeter	Pn =	4.52	ft
Flow depth	Yn =	1.40	ft
Flow velocity	Vn =	17.96	fps
Discharge	Qn =	58.20	cfs
Percent of Full Flow	Flow =	44.5%	of full flow
Normal Depth Froude Number	Fr_n =	3.04	supercritical
Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.27	radians
Critical flow area	Ac =	6.22	sq ft
Critical top width	Tc =	2.29	ft
Critical flow depth	Yc =	2.47	ft
Critical flow velocity	Vc =	9.35	fps
Critical Depth Froude Number	Fr_c =	1.00	

DETERMINATION OF CULVERT HEADWATER AND OUTLET PROTECTION

MHFD-Culvert, Version 4.00 (May 2020)

Project: RETREAT AT TIMBERRIDGE FILING NO. 4

ID: PIPE RUN 6 (18" RCP CULVERT)



Soil Type:
Choose One:
(●) Sandy
( ) Non-Sandy

Supercritical Flow! Using Adjusted Diameter to calculate protection type.

Design Information:

Design Discharge	Q =	8	cfs
Circular Culvert:			
Barrel Diameter in Inches	D =	18	inches
Inlet Edge Type (Choose from pull-down list)		Grooved Edge Projecting	
OR:			
Box Culvert:		**OR**	
Barrel Height (Rise) in Feet	H (Rise) =		ft
Barrel Width (Span) in Feet	W (Span) =		ft
Inlet Edge Type (Choose from pull-down list)			
Number of Barrels	# Barrels =	1	
Inlet Elevation	Elev IN =	7273.68	ft
Outlet Elevation **OR** Slope	So =	0.03	ft/ft
Culvert Length	L =	75.83	ft
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	k_b =	0	
Exit Loss Coefficient	k_x =	1	
Tailwater Surface Elevation	$Y_{t,\ Elevation}$ =		ft
Max Allowable Channel Velocity	V =	5	ft/s

Calculated Results:

Culvert Cross Sectional Area Available	A =	1.77	ft^2
Culvert Normal Depth	Y_n =	0.70	ft
Culvert Critical Depth	Y_c =	1.10	ft
Froude Number	Fr =	2.40	**Supercritical!**
Entrance Loss Coefficient	k_e =	0.20	
Friction Loss Coefficient	k_f =	1.37	
Sum of All Loss Coefficients	k_s =	2.57	ft
Headwater:			
Inlet Control Headwater	HW_I =	1.67	ft
Outlet Control Headwater	HW_O =	N/A	ft
Design Headwater Elevation	**HW =**	**7275.35**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/D =**	**1.11**	

Outlet Control Headwater Approximation Method Inaccurate for Low Flow - Backwater Calculations Required

Outlet Protection:			
Flow/(Diameter^2.5)	Q/D^2.5 =	2.90	$ft^{0.5}/s$
Tailwater Surface Height	Y_t =	0.60	ft
Tailwater/Diameter	Yt/D =	0.40	
Expansion Factor	1/(2*tan(Θ)) =	4.51	
Flow Area at Max Channel Velocity	A_t =	1.60	ft^2
Width of Equivalent Conduit for Multiple Barrels	W_{eq} =	-	ft
Length of Riprap Protection	**L_p =**	**6**	**ft**
Width of Riprap Protection at Downstream End	**T =**	**3**	**ft**
Adjusted Diameter for Supercritical Flow	Da =	1.10	ft
Minimum Theoretical Riprap Size	d_{50} min=	4	in
Nominal Riprap Size	d_{50} nominal=	6	in
MHFD Riprap Type	**Type =**	**VL**	

Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Friday, Mar 1 2024

Pipe Run 6 (18 In. RCP Culvert)

Invert Elev Dn (ft)	=	7271.40
Pipe Length (ft)	=	75.83
Slope (%)	=	3.01
Invert Elev Up (ft)	=	7273.68
Rise (in)	=	18.0
Shape	=	Circular
Span (in)	=	18.0
No. Barrels	=	1
n-Value	=	0.013
Culvert Type	=	Circular Concrete
Culvert Entrance	=	Square edge w/headwall (C)
Coeff. K,M,c,Y,k	=	0.0098, 2, 0.0398, 0.67, 0.5

Embankment

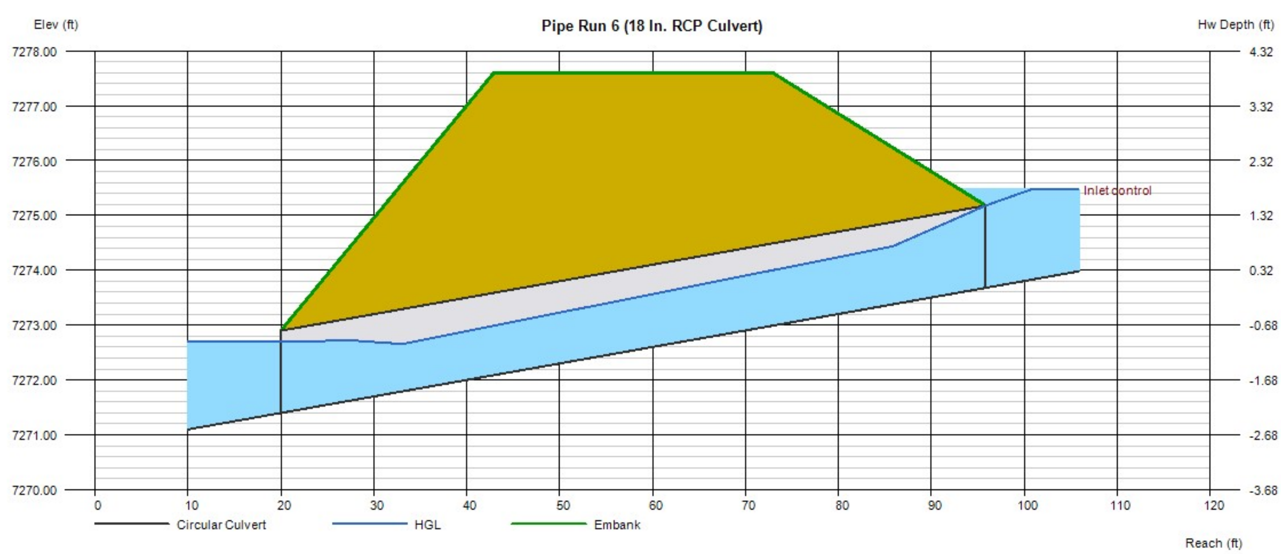
Top Elevation (ft)	=	7277.60
Top Width (ft)	=	30.00
Crest Width (ft)	=	50.00

Calculations

Qmin (cfs)	=	8.00
Qmax (cfs)	=	8.00
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	8.00
Qpipe (cfs)	=	8.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	4.92
Veloc Up (ft/s)	=	5.79
HGL Dn (ft)	=	7272.70
HGL Up (ft)	=	7274.78
Hw Elev (ft)	=	7275.48
Hw/D (ft)	=	1.20
Flow Regime	=	Inlet Control



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, May 20 2024

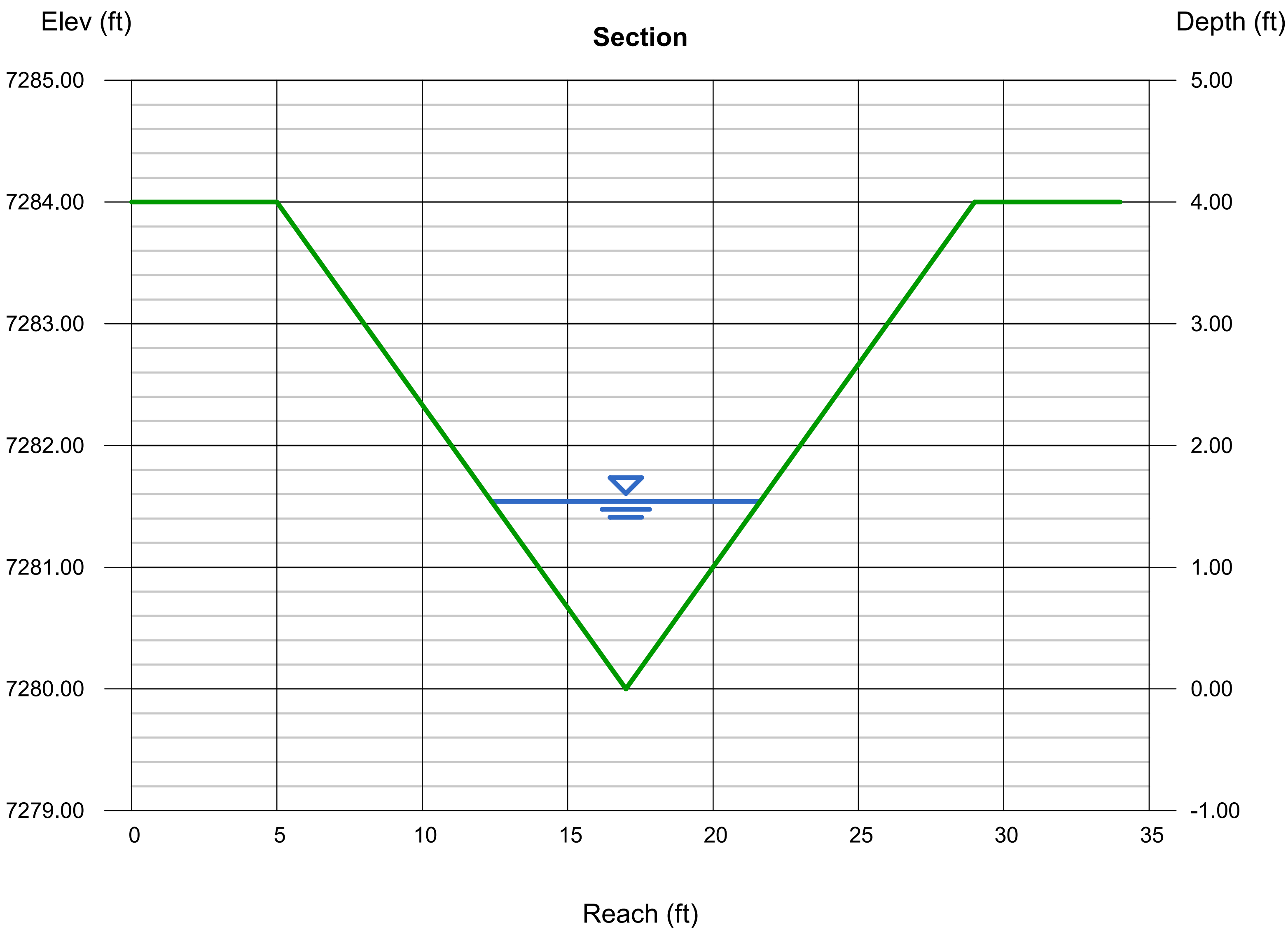
Diversion Channel across Lots 2&3 (private)

Triangular
Side Slopes (z:1) = 3.00, 3.00
Total Depth (ft) = 4.00

Invert Elev (ft) = 7280.00
Slope (%) = 2.70
N-Value = 0.035

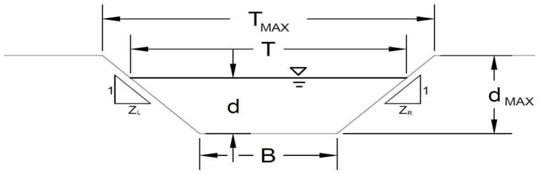
Calculations
Compute by: Known Q
Known Q (cfs) = 40.00

Highlighted
Depth (ft) = 1.54
Q (cfs) = 40.00
Area (sqft) = 7.11
Velocity (ft/s) = 5.62
Wetted Perim (ft) = 9.74
Crit Depth, Yc (ft) = 1.62
Top Width (ft) = 9.24
EGL (ft) = 2.03



AREA INLET IN A SWALE

RETREAT AT TIMBERRIDGE FILING NO. 4
DP-1



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

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

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

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =		
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.035	
Channel Invert Slope	S_O =	0.0050	ft/ft
Bottom Width	B =	3.00	ft
Left Side Slope	Z1 =	3.00	ft/ft
Right Side Sloe	Z2 =	4.00	ft/ft

Check one of the following soil types:

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

Choose One:
- Non-Cohesive
- Cohesive
- Paved

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	**18.00**	**36.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**2.00**	**4.00**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**65.6**	**337.3**	**cfs**
MAJOR STORM Allowable Capacity is based on Depth Criterion	d_{allow} =	**2.00**	**4.00**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**7.0**	**40.0**	**cfs**
Water Depth	d =	**0.70**	**1.61**	**ft**

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

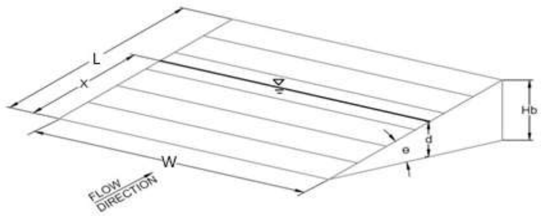
AREA INLET IN A SWALE

RETREAT AT TIMBERRIDGE FILING NO. 4

DP-1

Inlet Design Information (Input)

Type of Inlet	CDOT Type D (In Series)	Inlet Type =	CDOT Type D (In Series)
Angle of Inclined Grate (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grate	W =	3.00	ft
Length of Grate	L =	6.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grate	H_B =	0.00	ft
Clogging Factor	C_f =	0.38	
Grate Discharge Coefficient	C_d =	0.78	
Orifice Coefficient	C_o =	0.52	
Weir Coefficient	C_w =	1.67	

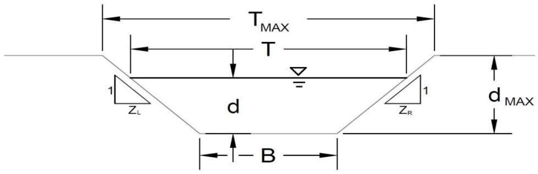


		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	0.70	1.61	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**17.5**	**41.6**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

RETREAT AT TIMBERRIDGE FILING NO. 4

DP-2



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

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

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

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =		
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.035	
Channel Invert Slope	S_O =	0.0100	ft/ft
Bottom Width	B =	3.00	ft
Left Side Slope	Z1 =	4.00	ft/ft
Right Side Sloe	Z2 =	4.00	ft/ft

Check one of the following soil types:

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

Choose One:
- ○ **Non-Cohesive**
- ○ **Cohesive**
- ○ **Paved**

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	**T_{MAX} =**	**68.00**	**92.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	**d_{MAX} =**	**2.00**	**4.00**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion	**Q_{allow} =**	**101.5**	**532.6**	**cfs**
MAJOR STORM Allowable Capacity is based on Depth Criterion	**d_{allow} =**	**2.00**	**4.00**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	**Q_o =**	**5.0**	**25.0**	**cfs**
Water Depth	**d =**	**0.49**	**1.07**	**ft**

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

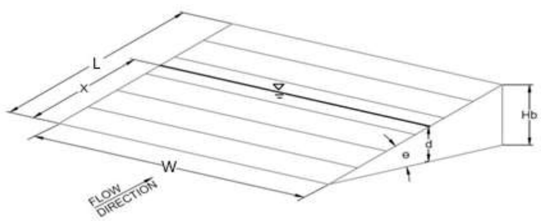
AREA INLET IN A SWALE

RETREAT AT TIMBERRIDGE FILING NO. 4

DP-2

Inlet Design Information (Input)

Type of Inlet: CDOT Type D (In Series) — Inlet Type = CDOT Type D (In Series)



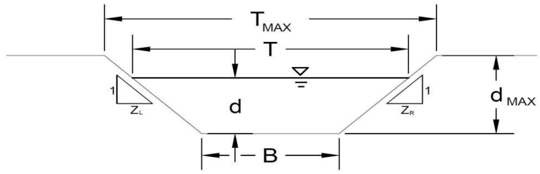
Angle of Inclined Grate (must be <= 30 degrees)	θ =	0.00	degrees
Width of Grate	W =	3.00	ft
Length of Grate	L =	6.00	ft
Open Area Ratio	A_{RATIO} =	0.70	
Height of Inclined Grate	H_B =	0.00	ft
Clogging Factor	C_f =	0.38	
Grate Discharge Coefficient	C_d =	0.78	
Orifice Coefficient	C_o =	0.52	
Weir Coefficient	C_w =	1.67	

		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	0.49	1.07	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**10.1**	**32.8**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

AREA INLET IN A SWALE

RETREAT AT TIMBERRIDGE FILING NO. 4

DP-3



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

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

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

NRCS Vegetal Retardance (A, B, C, D, or E)	A, B, C, D, or E =		
Manning's n (Leave cell D16 blank to manually enter an n value)	n =	0.035	
Channel Invert Slope	S_O =	0.0100	ft/ft
Bottom Width	B =	3.00	ft
Left Side Slope	Z1 =	3.00	ft/ft
Right Side Sloe	Z2 =	3.00	ft/ft

Check one of the following soil types:

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

Choose One:
- ○ **Non-Cohesive**
- ⦿ **Cohesive**
- ○ **Paved**

		Minor Storm	Major Storm	
Maximum Allowable Top Width of Channel for Minor & Major Storm	T_{MAX} =	**17.00**	**35.00**	**ft**
Maximum Allowable Water Depth in Channel for Minor & Major Storm	d_{MAX} =	**1.00**	**2.00**	**ft**

Allowable Channel Capacity Based On Channel Geometry

		Minor Storm	Major Storm	
MINOR STORM Allowable Capacity is based on Depth Criterion	Q_{allow} =	**19.0**	**84.1**	**cfs**
MAJOR STORM Allowable Capacity is based on Depth Criterion	d_{allow} =	**1.00**	**2.00**	**ft**

Water Depth in Channel Based On Design Peak Flow

Design Peak Flow	Q_o =	**2.0**	**10.0**	**cfs**
Water Depth	d =	**0.31**	**0.73**	**ft**

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

MHFD-Inlet, Version 5.03 (August 2023)

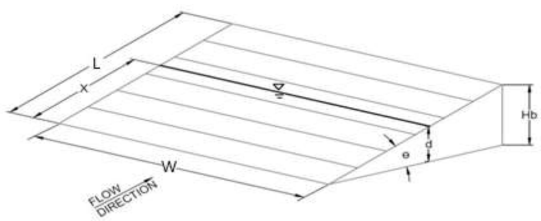
AREA INLET IN A SWALE

RETREAT AT TIMBERRIDGE FILING NO. 4

DP-3

Inlet Design Information (Input)

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



		MINOR	MAJOR	
Water Depth at Inlet (for depressed inlets, 1 foot is added for depression)	d =	0.31	0.73	
Total Inlet Interception Capacity (assumes clogged condition)	**Q_a =**	**3.1**	**11.4**	**cfs**
Bypassed Flow	**Q_b =**	**0.0**	**0.0**	**cfs**
Capture Percentage = Qa/Qo	**C% =**	**100**	**100**	**%**

EDB 4 EMERGENCY OVERFLOW
PROTECTION CALCULATIONS

Figure 13-12c. Emergency Spillway Protection

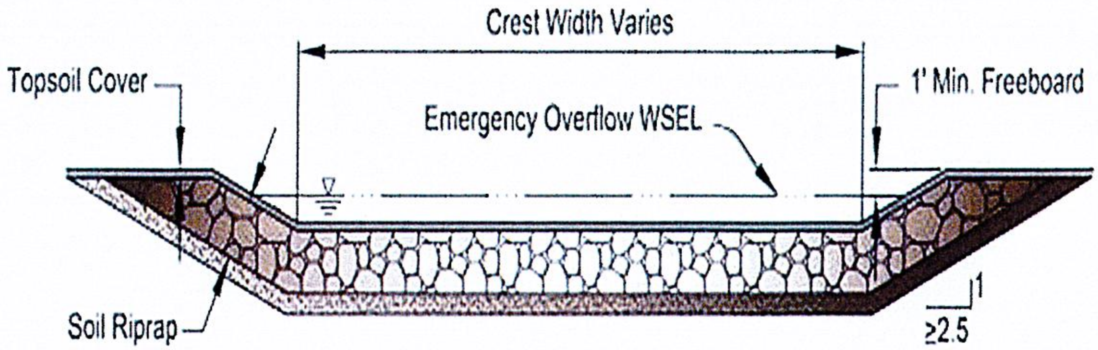
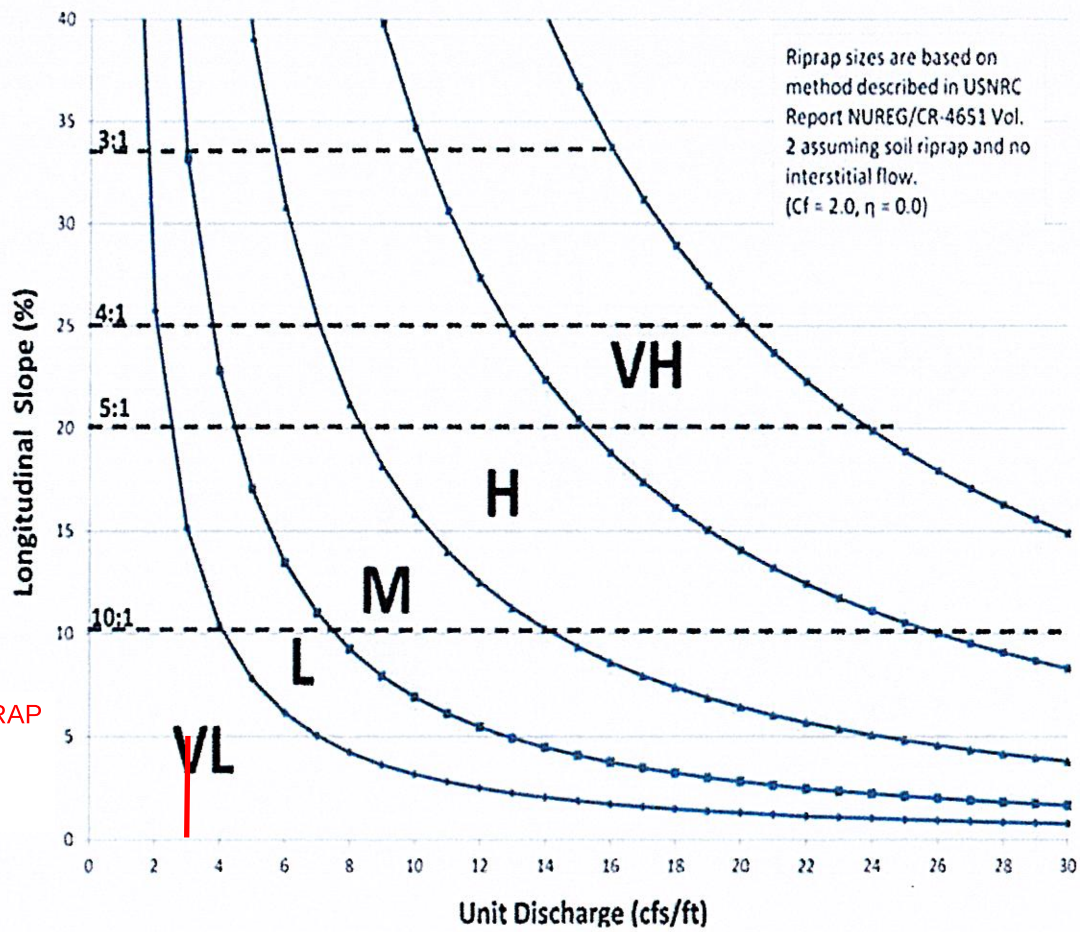


Figure 13-12d. Riprap Types for Emergency Spillway Protection

TYPE VL RIP-RAP
PROTECTION
REQUIRED



100-YR. TOTAL IN-FLOW
= 75 CFS

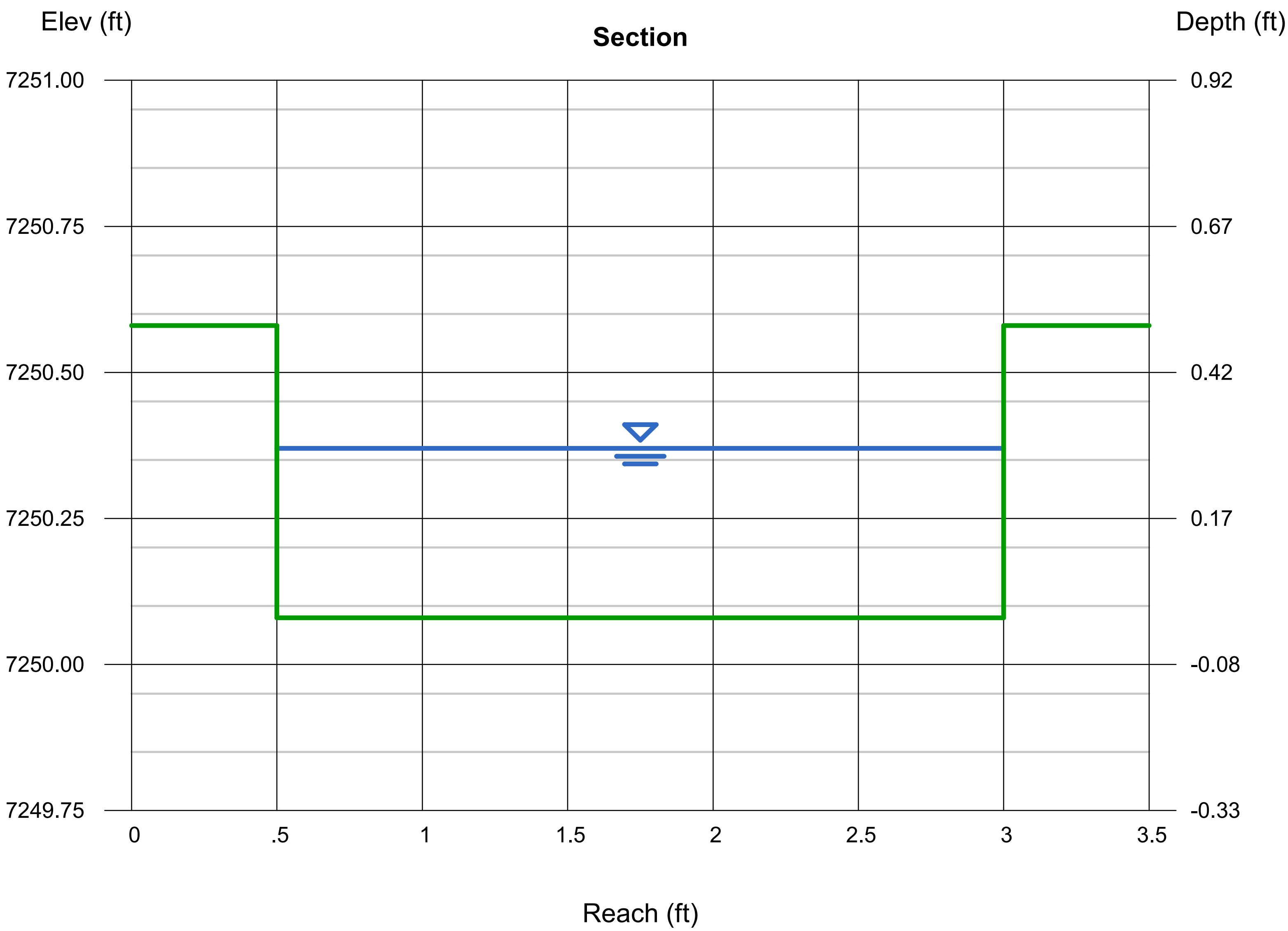
DISCHARGE
WIDTH = 25'

UNIT DISCHARGE
MAX. = 3.0 CFS/FT.

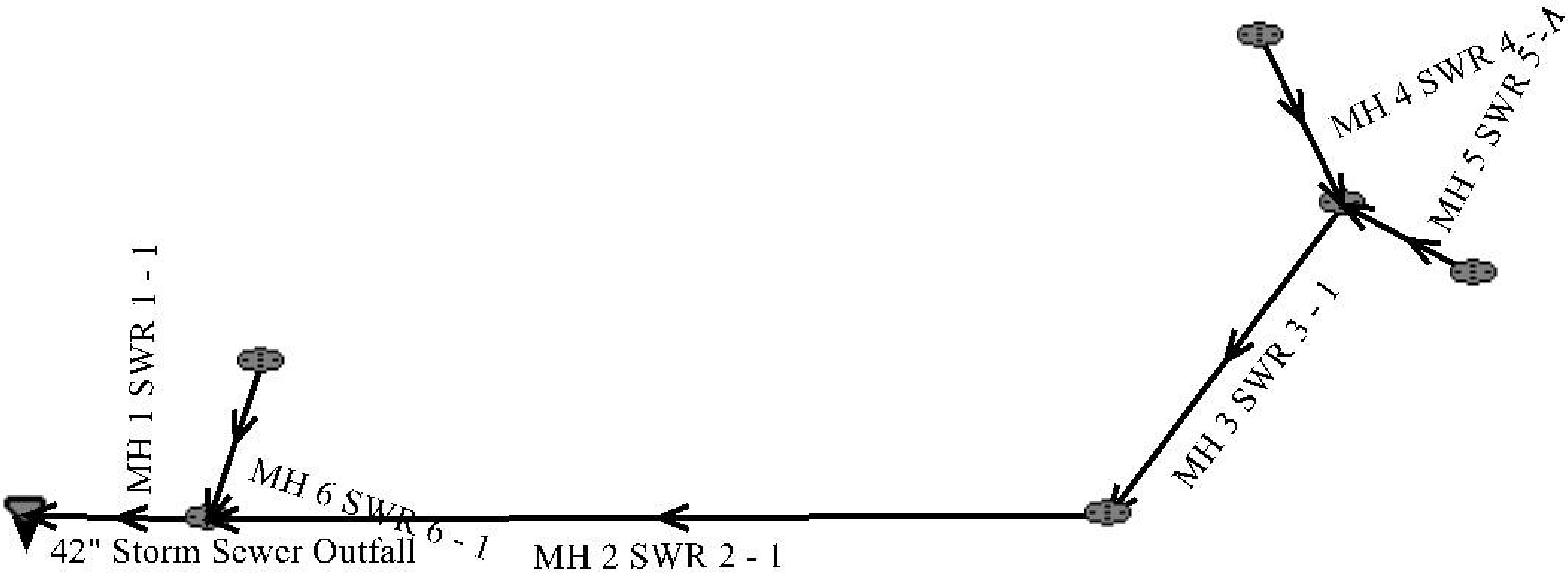
Channel Report

EDB 4 Trickle Channel Calculations

Rectangular		**Highlighted**	
Bottom Width (ft)	= 2.50	Depth (ft)	= 0.29
Total Depth (ft)	= 0.50	Q (cfs)	= 3.000
		Area (sqft)	= 0.73
Invert Elev (ft)	= 7250.08	Velocity (ft/s)	= 4.14
Slope (%)	= 1.00	Wetted Perim (ft)	= 3.08
N-Value	= 0.013	Crit Depth, Yc (ft)	= 0.36
		Top Width (ft)	= 2.50
Calculations		EGL (ft)	= 0.56
Compute by:	Known Q		
Known Q (cfs)	= 3.00		



100 Yr. HGL Calculations
Map Layout



System Input Summary

Rainfall Parameters

Rainfall Return Period: 100
Rainfall Calculation Method: Table

Time	Intensity
5	8.68
10	6.93
20	5.19
30	4.16
40	3.44
60	2.42
120	0.67

Rational Method Constraints

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

Sizer Constraints

Minimum Sewer Size (in): 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): 7254.11

Manhole Input Summary:

		Given Flow		Sub Basin Information						
Element Name	**Ground Elevation (ft)**	**Total Known Flow (cfs)**	**Local Contribution (cfs)**	**Drainage Area (Ac.)**	**Runoff Coefficient**	**5yr Coefficient**	**Overland Length (ft)**	**Overland Slope (%)**	**Gutter Length (ft)**	**Gutter Velocity (fps)**
42" Storm Sewer Outfall	7255.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 1 SWR 1 - 1	7260.50	73.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 6 SWR 6 - 1	7258.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 2 SWR 2 - 1	7280.22	64.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 3 SWR 3 - 1	7281.84	64.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 5 SWR 5 - 1	7275.98	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 4 SWR 4 - 1	7275.53	40.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Manhole Output Summary:

	Local Contribution					Total Design Flow				
Element Name	Overland Time (min)	Gutter Time (min)	Basin Tc (min)	Intensity (in/hr)	Local Contrib (cfs)	Coeff. Area	Intensity (in/hr)	Manhole Tc (min)	Peak Flow (cfs)	Comment
42" Storm Sewer Outfall	0.00	0.00	0.00	0.00	0.00	606.19	0.12	0.07	73.00	
MH 1 SWR 1 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73.00	
MH 6 SWR 6 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	
MH 2 SWR 2 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.00	
MH 3 SWR 3 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.00	
MH 5 SWR 5 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	
MH 4 SWR 4 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	

Sewer Input Summary:

		Elevation			Loss Coefficients			Given Dimensions		
Element Name	Sewer Length (ft)	Downstream Invert (ft)	Slope (%)	Upstream Invert (ft)	Mannings n	Bend Loss	Lateral Loss	Cross Section	Rise (ft or in)	Span (ft or in)
MH 1 SWR 1 - 1	31.58	7251.00	1.0	7251.32	0.013	0.03	1.00	CIRCULAR	42.00 in	42.00 in
MH 6 SWR 6 - 1	16.63	7253.32	4.0	7253.98	0.013	0.46	0.00	CIRCULAR	18.00 in	18.00 in
MH 2 SWR 2 - 1	349.42	7252.82	3.6	7265.33	0.013	0.05	1.00	CIRCULAR	42.00 in	42.00 in
MH 3 SWR 3 - 1	100.00	7266.83	3.4	7270.23	0.013	0.63	1.00	CIRCULAR	42.00 in	42.00 in
MH 5 SWR 5 - 1	42.30	7270.73	1.0	7271.15	0.013	1.32	1.00	CIRCULAR	36.00 in	36.00 in

MH 4 SWR 4 - 1	43.64	7270.73	1.0	7271.15	0.013	0.63	1.00	CIRCULAR	36.00 in	36.00 in

Sewer Flow Summary:

	Full Flow Capacity		Critical Flow		Normal Flow						
Element Name	**Flow (cfs)**	**Velocity (fps)**	**Depth (in)**	**Velocity (fps)**	**Depth (in)**	**Velocity (fps)**	**Froude Number**	**Flow Condition**	**Flow (cfs)**	**Surcharged Length (ft)**	**Comment**
MH 1 SWR 1 - 1	100.88	10.49	32.11	9.25	26.48	11.42	1.46	Supercritical	73.00	0.00	
MH 6 SWR 6 - 1	20.99	11.88	14.63	6.50	8.75	11.73	2.74	Supercritical	10.00	0.00	
MH 2 SWR 2 - 1	190.88	19.84	30.09	8.68	16.75	17.87	3.08	Supercritical	64.00	0.00	
MH 3 SWR 3 - 1	186.01	19.33	30.09	8.68	16.99	17.54	3.00	Supercritical	64.00	0.00	
MH 5 SWR 5 - 1	66.63	9.43	19.35	6.46	15.28	8.75	1.57	Pressurized	25.00	42.30	
MH 4 SWR 4 - 1	65.60	9.28	24.71	7.73	20.30	9.74	1.46	Supercritical Jump	40.00	30.14	

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

Sewer Sizing Summary:

			Existing		Calculated		Used			
Element Name	Peak Flow (cfs)	Cross Section	Rise	Span	Rise	Span	Rise	Span	Area (ft^2)	Comment
MH 1 SWR 1 - 1	73.00	CIRCULAR	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	42.00 in	9.62	
MH 6 SWR 6 - 1	10.00	CIRCULAR	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	18.00 in	1.77	
MH 2 SWR 2 - 1	64.00	CIRCULAR	42.00 in	42.00 in	30.00 in	30.00 in	42.00 in	42.00 in	9.62	
MH 3 SWR 3 - 1	64.00	CIRCULAR	42.00 in	42.00 in	30.00 in	30.00 in	42.00 in	42.00 in	9.62	
MH 5 SWR 5 - 1	25.00	CIRCULAR	36.00 in	36.00 in	27.00 in	27.00 in	36.00 in	36.00 in	7.07	
MH 4 SWR 4 - 1	40.00	CIRCULAR	36.00 in	36.00 in	30.00 in	30.00 in	36.00 in	36.00 in	7.07	

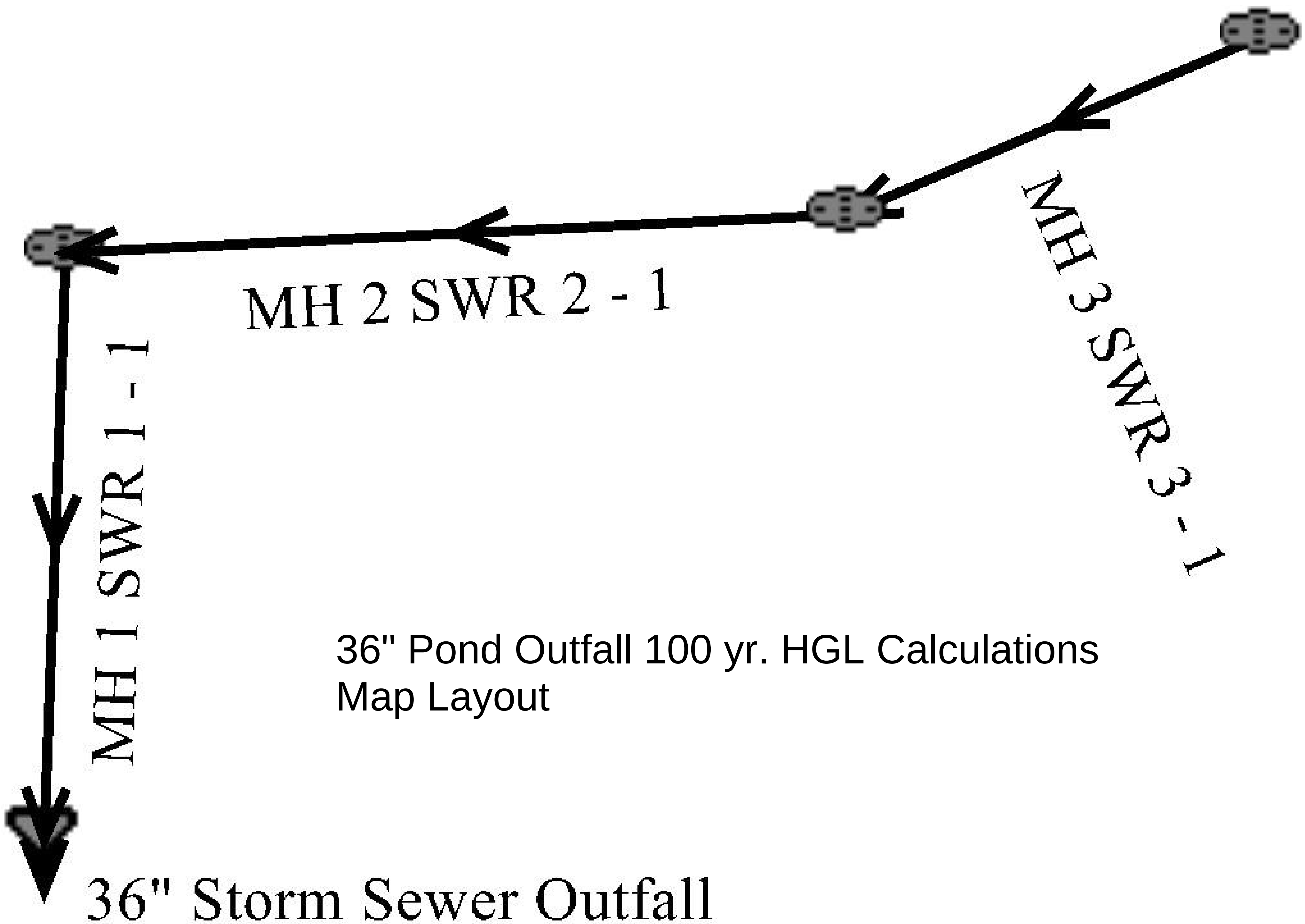
- Calculated diameter was determined by sewer hydraulic capacity rounded up to the nearest commercially available size.
- Sewer sizes should not decrease downstream.
- All hydraulics where calculated using the 'Used' parameters.

Grade Line Summary:

Tailwater Elevation (ft): 7254.11

	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)**
MH 1 SWR 1 - 1	7251.00	7251.32	0.00	0.00	7254.11	7254.11	7255.23	0.10	7255.33
MH 6 SWR 6 - 1	7253.32	7253.98	0.23	0.00	7254.34	7255.69	7256.19	0.00	7256.19
MH 2 SWR 2 - 1	7252.82	7265.33	0.03	0.21	7254.35	7267.84	7259.18	9.83	7269.01
MH 3 SWR 3 - 1	7266.83	7270.23	0.43	0.00	7268.27	7272.74	7273.02	0.88	7273.91
MH 5 SWR 5 - 1	7270.73	7271.15	0.26	0.49	7274.46	7274.52	7274.66	0.06	7274.71
MH 4 SWR 4 - 1	7270.73	7271.15	0.31	0.19	7273.91	7274.00	7274.41	0.11	7274.52

- 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.



36" Pond Outfall 100 yr. HGL Calculations
Map Layout

36” Pond Outfall - 100yr HGL

System Input Summary

Rainfall Parameters

Rainfall Return Period: 100
Rainfall Calculation Method: Table

Time	Intensity
5	8.68
10	6.93
20	5.19
30	4.16
40	3.44
60	2.42
120	0.67

Rational Method Constraints

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

Sizer Constraints

Minimum Sewer Size (in): 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): 7234.00

Manhole Input Summary:

		Given Flow		Sub Basin Information						
Element Name	**Ground Elevation (ft)**	**Total Known Flow (cfs)**	**Local Contribution (cfs)**	**Drainage Area (Ac.)**	**Runoff Coefficient**	**5yr Coefficient**	**Overland Length (ft)**	**Overland Slope (%)**	**Gutter Length (ft)**	**Gutter Velocity (fps)**
36" Storm Sewer Outfall	7211.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 1 SWR 1 - 1	7240.05	58.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 2 SWR 2 - 1	7246.00	58.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MH 3 SWR 3 - 1	7251.50	58.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Manhole Output Summary:

	Local Contribution					Total Design Flow				
Element Name	Overland Time (min)	Gutter Time (min)	Basin Tc (min)	Intensity (in/hr)	Local Contrib (cfs)	Coeff. Area	Intensity (in/hr)	Manhole Tc (min)	Peak Flow (cfs)	Comment
36" Storm Sewer Outfall	0.00	0.00	0.00	0.00	0.00	191.14	0.30	0.18	58.20	Surface Water Present (Upstream)
MH 1 SWR 1 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.20	Surface Water Present (Downstream)
MH 2 SWR 2 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.20	
MH 3 SWR 3 - 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.20	

Sewer Input Summary:

		Elevation			Loss Coefficients			Given Dimensions		
Element Name	Sewer Length (ft)	Downstream Invert (ft)	Slope (%)	Upstream Invert (ft)	Mannings n	Bend Loss	Lateral Loss	Cross Section	Rise (ft or in)	Span (ft or in)
MH 1 SWR 1 - 1	86.65	7230.45	2.8	7232.88	0.013	0.03	1.00	CIRCULAR	36.00 in	36.00 in
MH 2 SWR 2 - 1	196.07	7233.38	2.7	7238.67	0.013	1.32	1.00	CIRCULAR	36.00 in	36.00 in
MH 3 SWR 3 - 1	126.43	7240.17	3.8	7245.00	0.013	0.20	1.00	CIRCULAR	36.00 in	36.00 in

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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**
MH 1 SWR 1 - 1	111.91	15.83	29.62	9.35	18.42	15.99	2.56	Supercritical Jump	58.20	26.74	
MH 2 SWR 2 - 1	109.89	15.55	29.62	9.35	18.63	15.77	2.50	Supercritical Jump	58.20	34.36	
MH 3 SWR 3 - 1	130.72	18.49	29.62	9.35	16.83	17.96	3.04	Supercritical	58.20	0.00	

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

Sewer Sizing Summary:

			Existing		Calculated		Used			
Element Name	**Peak Flow (cfs)**	**Cross Section**	**Rise**	**Span**	**Rise**	**Span**	**Rise**	**Span**	**Area (ft^2)**	**Comment**
MH 1 SWR 1 - 1	58.20	CIRCULAR	36.00 in	36.00 in	30.00 in	30.00 in	36.00 in	36.00 in	7.07	
MH 2 SWR 2 - 1	58.20	CIRCULAR	36.00 in	36.00 in	30.00 in	30.00 in	36.00 in	36.00 in	7.07	
MH 3 SWR 3 - 1	58.20	CIRCULAR	36.00 in	36.00 in	27.00 in	27.00 in	36.00 in	36.00 in	7.07	

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

Grade Line Summary:

Tailwater Elevation (ft): 7234.00

	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)**
MH 1 SWR 1 - 1	7230.45	7232.88	0.00	0.00	7234.00	7235.35	7235.05	1.65	7236.71
MH 2 SWR 2 - 1	7233.38	7238.67	1.39	0.00	7237.04	7241.14	7238.10	4.40	7242.50
MH 3 SWR 3 - 1	7240.17	7245.00	0.21	0.00	7241.57	7247.47	7246.58	2.25	7248.83

- 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.

STORMWATER QUALITY CALCULATIONS

Design Procedure Form: Extended Detention Basin (EDB)

UD-BMP (Version 3.07, March 2018)

Designer:	**MARC A. WHORTON, P.E.**
Company:	**CLASSIC CONSULTING**
Date:	**May 17, 2024**
Project:	**RETREAT AT TIMBERRIDGE FILING NO. 4**
Location:	**POND 4**

1. Basin Storage Volume	
A) Effective Imperviousness of Tributary Area, I_a	I_a = 7.1 %
B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)	i = 0.071
C) Contributing Watershed Area	Area = 48.500 ac
D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm	d_6 = 0.42 in
E) Design Concept (Select EURV when also designing for flood control)	Choose One ○ Water Quality Capture Volume (WQCV) ◉ Excess Urban Runoff Volume (EURV)
F) Design Volume (WQCV) Based on 40-hour Drain Time ($V_{DESIGN} = (1.0 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i) / 12 * Area$)	V_{DESIGN}= ac-ft
G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume ($V_{WQCV\ OTHER} = (d_6*(V_{DESIGN}/0.43))$	$V_{DESIGN\ OTHER}$= 0.196 ac-ft
H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)	$V_{DESIGN\ USER}$= ac-ft
I) NRCS Hydrologic Soil Groups of Tributary Watershed i) Percentage of Watershed consisting of Type A Soils ii) Percentage of Watershed consisting of Type B Soils iii) Percentage of Watershed consisting of Type C/D Soils	 HSG_A = 0 % HSG_B = 100 % $HSG_{C/D}$ = 0 %
J) Excess Urban Runoff Volume (EURV) Design Volume For HSG A: $EURV_A = 1.68 * i^{1.28}$ For HSG B: $EURV_B = 1.36 * i^{1.08}$ For HSG C/D: $EURV_{C/D} = 1.20 * i^{1.08}$	$EURV_{DESIGN}$ = 0.316 ac-f t
K) User Input of Excess Urban Runoff Volume (EURV) Design Volume (Only if a different EURV Design Volume is desired)	$EURV_{DESIGN\ USER}$= ac-f t
2. Basin Shape: Length to Width Ratio (A basin length to width ratio of at least 2:1 will improve TSS reduction.)	L : W = 2.0 : 1
3. Basin Side Slopes	
A) Basin Maximum Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred)	Z = 4.00 ft / ft
4. Inlet	
A) Describe means of providing energy dissipation at concentrated inflow locations:	
5. Forebay	
A) Minimum Forebay Volume (V_{FMIN} = 2% of the WQCV)	V_{FMIN} = 0.004 ac-ft
B) Actual Forebay Volume	V_F = 0.004 ac-ft
C) Forebay Depth (D_F = 18 inch maximum)	D_F = 18.0 in
D) Forebay Discharge	
i) Undetained 100-year Peak Discharge	Q_{100} = 75.00 cfs
ii) Forebay Discharge Design Flow ($Q_F = 0.02 * Q_{100}$)	Q_F = 1.50 cfs
E) Forebay Discharge Design	Choose One ○ Berm With Pipe ◉ Wall with Rect. Notch ○ Wall with V-Notch Weir **Flow too small for berm w/ pipe**
F) Discharge Pipe Size (minimum 8-inches)	Calculated D_P = in
G) Rectangular Notch Width	Calculated W_N = 6.5 in

Design Procedure Form: Extended Detention Basin (EDB)

Designer:	**MARC A. WHORTON, P.E.**
Company:	**CLASSIC CONSULTING**
Date:	**May 17, 2024**
Project:	**RETREAT AT TIMBERRIDGE FILING NO. 4**
Location:	**POND 4**

6. Trickle Channel

A) Type of Trickle Channel

Choose One
- (●) Concrete
- ( ) Soft Bottom

F) Slope of Trickle Channel — S = 0.0100 ft / ft

7. Micropool and Outlet Structure

A) Depth of Micropool (2.5-feet minimum) — D_M = 2.5 ft

B) Surface Area of Micropool (10 ft^2 minimum) — A_M = 107 sq ft

C) Outlet Type

Choose One
- (●) Orifice Plate
- ( ) Other (Describe):

D) Smallest Dimension of Orifice Opening Based on Hydrograph Routing (Use UD-Detention) — $D_{orifice}$ = 0.97 inches

E) Total Outlet Area — A_{ot} = 2.49 square inches

8. Initial Surcharge Volume

A) Depth of Initial Surcharge Volume (Minimum recommended depth is 4 inches) — D_{IS} = 6 in

B) Minimum Initial Surcharge Volume (Minimum volume of 0.3% of the WQCV) — V_{IS} = cu ft

C) Initial Surcharge Provided Above Micropool — V_s= 53.5 cu ft

9. Trash Rack

A) Water Quality Screen Open Area: $A_t = A_{ot} * 38.5*(e^{-0.095D})$ — A_t = 87 square inches

B) Type of Screen (If specifying an alternative to the materials recommended in the USDCM, indicate "other" and enter the ratio of the total open are to the total screen are for the material specified.) — *S.S. Well Screen with 60% Open Area*

Other (Y/N): N

C) Ratio of Total Open Area to Total Area (only for type 'Other') — User Ratio =

D) Total Water Quality Screen Area (based on screen type) — A_{total} = 146 sq. in.

E) Depth of Design Volume (EURV or WQCV) (Based on design concept chosen under 1E) — H= 3.5 feet

F) Height of Water Quality Screen (H_{TR}) — H_{TR}= 70 inches

G) Width of Water Quality Screen Opening ($W_{opening}$) (Minimum of 12 inches is recommended) — $W_{opening}$ = 12.0 inches **VALUE LESS THAN RECOMMENDED MIN. WIDTH. WIDTH HAS BEEN SET TO 12 INCHES.**

Design Procedure Form: Extended Detention Basin (EDB)

Designer:	**MARC A. WHORTON, P.E.**
Company:	**CLASSIC CONSULTING**
Date:	**May 17, 2024**
Project:	**RETREAT AT TIMBERRIDGE FILING NO. 4**
Location:	**POND 4**

10. Overflow Embankment A) Describe embankment protection for 100-year and greater overtopping:	
B) Slope of Overflow Embankment (Horizontal distance per unit vertical, 4:1 or flatter preferred)	Ze = 4.00 ft / ft
11. Vegetation	Choose One ○ Irrigated ◉ Not Irrigated
12. Access A) Describe Sediment Removal Procedures	

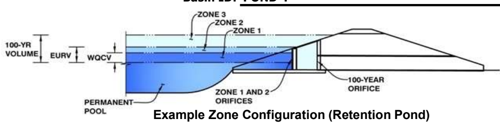
Notes:

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

Project: **RETREAT AT TIMBERRIDGE FILING NO. 4**

Basin ID: **POND 4**



Example Zone Configuration (Retention Pond)

Stormwater Facility Name: **RETREAT AT TIMBERRIDGE FILING NO. 4 - POND 4**

Facility Location & Jurisdiction: **Approx. 1400' east of int. of Vollmer Road and Arroya Lane, El Paso County**

Watershed Information

Selected BMP Type =	**EDB**			
Watershed Area =	48.50	acres		
Watershed Length =	2,200	ft		
Watershed Length to Centroid =	1,000	ft		
Watershed Slope =	0.050	ft/ft		
Watershed Imperviousness =	7.10%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	100.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Target WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			

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

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.201	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.315	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.541	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	1.291	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	2.054	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	3.459	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	4.396	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	5.766	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.85 in.) =	11.146	acre-feet	3.85	inches
Approximate 2-yr Detention Volume =	0.194	acre-feet		
Approximate 5-yr Detention Volume =	0.313	acre-feet		
Approximate 10-yr Detention Volume =	0.766	acre-feet		
Approximate 25-yr Detention Volume =	1.125	acre-feet		
Approximate 50-yr Detention Volume =	1.163	acre-feet		
Approximate 100-yr Detention Volume =	1.531	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.201	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.114	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	1.216	acre-feet
Total Detention Basin Volume =	1.531	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	--	--	--	106	0.002		
7250	--	2.00	--	--	--	2,988	0.069	3,094	0.071
7252	--	4.00	--	--	--	17,546	0.403	23,628	0.542
7254	--	6.00	--	--	--	21,886	0.502	63,060	1.448
7256	--	8.00	--	--	--	26,651	0.612	111,597	2.562
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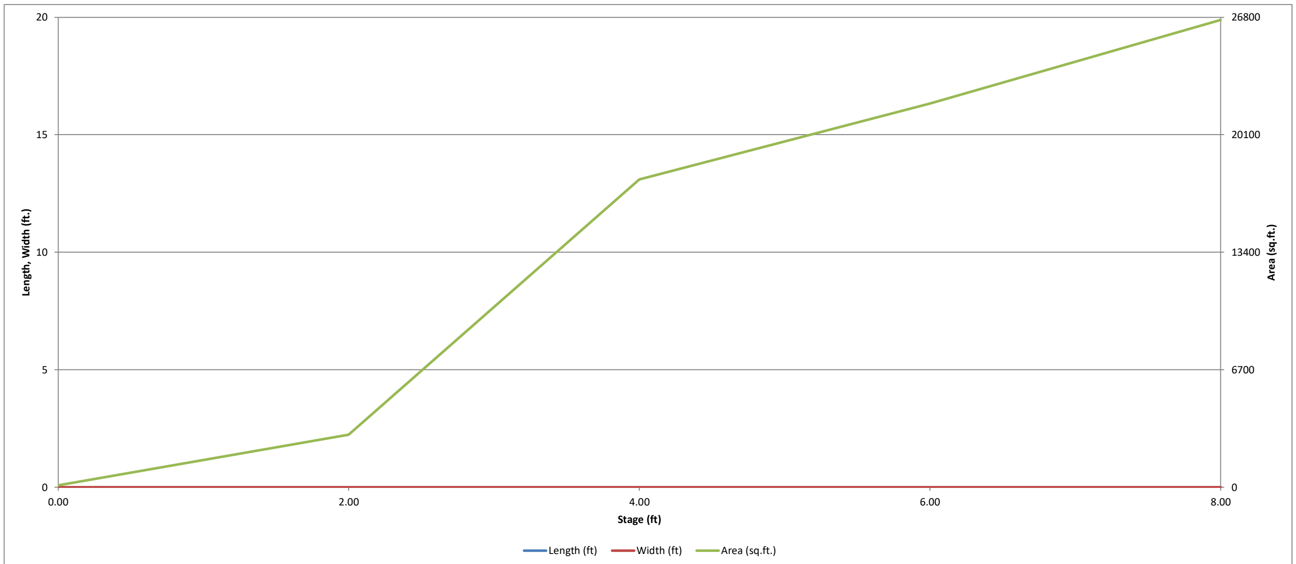
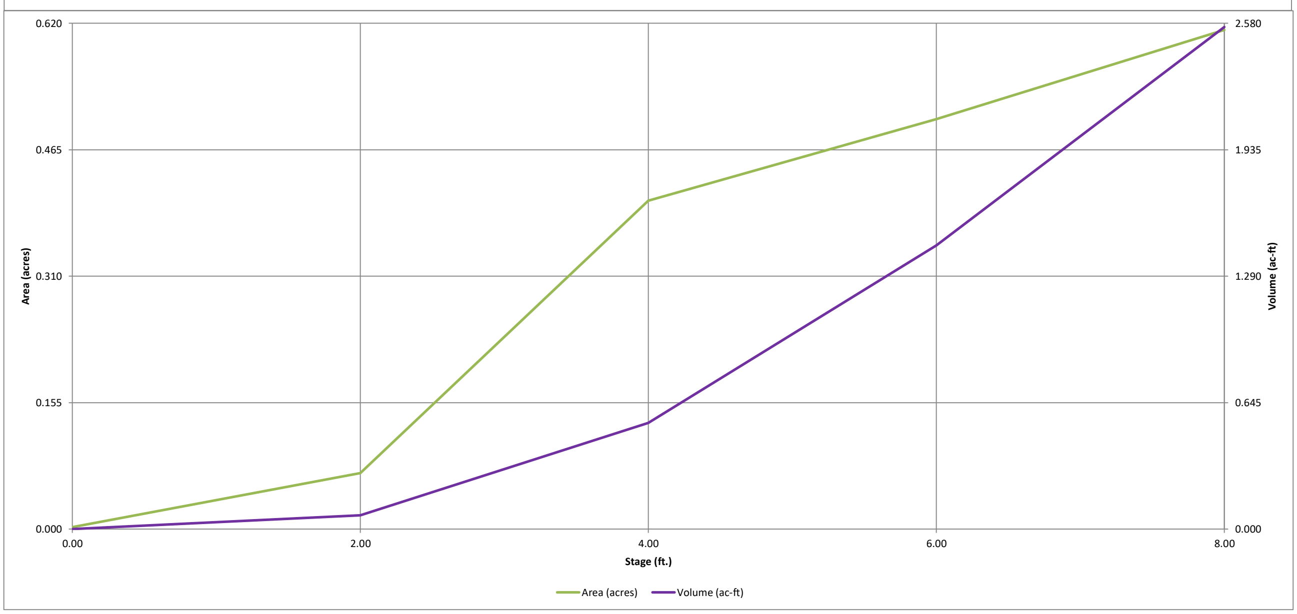
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

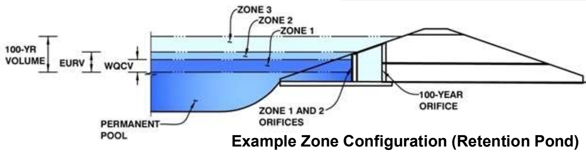




DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: **RETREAT AT TIMBERRIDGE FILING NO. 4**
Basin ID: **POND 4**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.91	0.201	Orifice Plate
Zone 2 (EURV)	3.35	0.114	Orifice Plate
Zone 3 (100-year)	6.17	1.216	Weir&Pipe (Restrict)
	Total (all zones)	1.531	

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)

Centroid of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	3.50	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	14.00	inches
Orifice Plate: Orifice Area per Row =	N/A	sq. 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	1.20	2.40					
Orifice Area (sq. inches)	0.79	0.89	0.89					

	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 with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.50	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	9.00	N/A	feet
Overflow Weir Grate Slope =	4.00	N/A	H:V
Horiz. Length of Weir Sides =	4.00	N/A	feet
Overflow Grate Type =	Close Mesh Grate	N/A	
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	4.50	N/A	feet
Overflow Weir Slope Length =	4.12	N/A	feet
Grate Open Area / 100-yr Orifice Area =	6.86	N/A	
Overflow Grate Open Area w/o Debris =	29.35	N/A	ft^2
Overflow Grate Open Area w/ Debris =	14.68	N/A	ft^2

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 =	3.00	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	36.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	21.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	4.28	N/A	ft^2
Outlet Orifice Centroid =	1.00	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	1.74	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	6.00	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	25.00	feet
Spillway End Slopes =	3.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.93	feet
Stage at Top of Freeboard =	7.93	feet
Basin Area at Top of Freeboard =	0.61	acres
Basin Volume at Top of Freeboard =	2.52	acre-ft

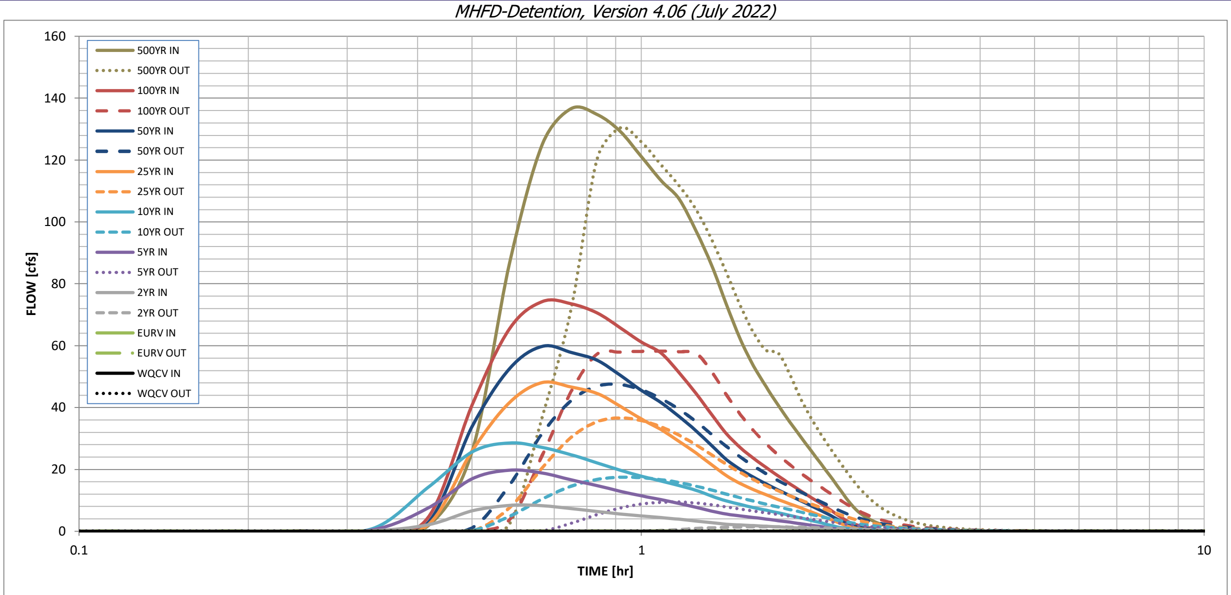
Routed Hydrograph Results

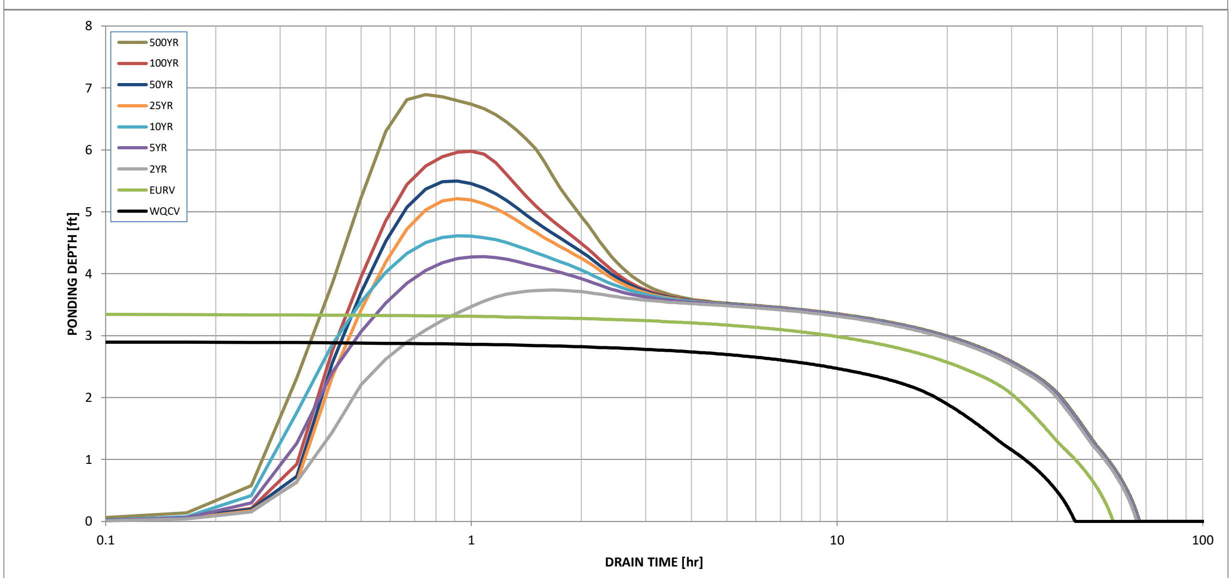
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

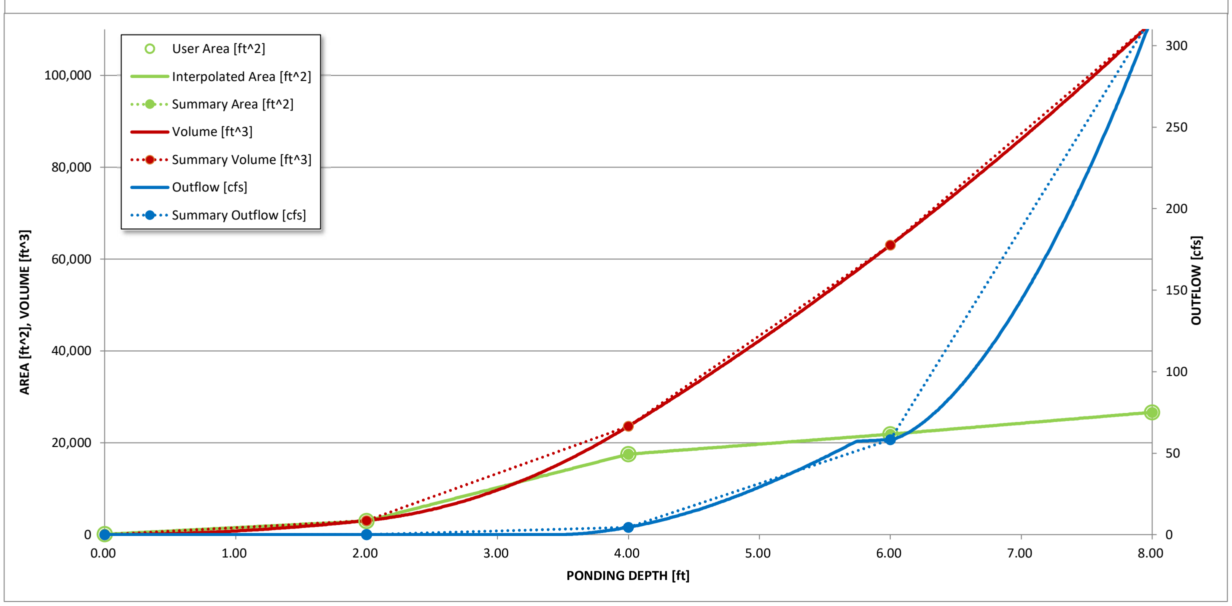
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.85
CUHP Runoff Volume (acre-ft) =	0.201	0.315	0.541	1.291	2.054	3.459	4.396	5.766	11.146
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.541	1.291	2.054	3.459	4.396	5.766	11.146
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	6.1	17.2	26.0	45.5	57.2	71.6	133.9
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A		11.0				69.0	
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.13	0.23	0.54	0.94	1.18	1.42	2.76
Peak Inflow Q (cfs) =	N/A	N/A	8.4	19.7	28.6	48.0	59.8	74.3	136.6
Peak Outflow Q (cfs) =	0.1	0.1	1.5	9.5	17.5	36.7	47.4	58.2	130.4
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.9	0.7	0.8	0.8	0.8	1.0
Structure Controlling Flow =	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	0.05	0.3	0.6	1.2	1.6	2.0	2.1
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	50	55	47	43	35	31	26	8
Time to Drain 99% of Inflow Volume (hours) =	**42**	54	61	57	54	49	47	44	34
Maximum Ponding Depth (ft) =	2.91	3.35	3.74	4.28	4.61	5.21	5.50	5.98	6.89
Area at Maximum Ponding Depth (acres) =	0.22	0.29	0.36	0.42	0.43	0.46	0.48	0.50	0.55
Maximum Volume Stored (acre-ft) =	0.203	0.316	0.440	0.653	0.797	1.066	1.198	1.433	1.916

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)







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

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

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

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
	0:15:00	0.00	0.00	0.04	0.07	0.09	0.06	0.07	0.07	0.15
	0:20:00	0.00	0.00	0.17	0.53	0.98	0.17	0.20	0.24	1.71
	0:25:00	0.00	0.00	2.06	7.44	14.04	1.94	2.56	4.22	25.79
	0:30:00	0.00	0.00	6.58	16.97	25.62	25.93	33.77	40.74	86.94
	0:35:00	0.00	0.00	8.37	19.75	28.59	41.71	52.67	65.59	125.12
	0:40:00	0.00	0.00	8.29	18.84	27.07	48.05	59.82	74.25	136.60
	0:45:00	0.00	0.00	7.31	16.64	24.77	46.61	57.77	73.56	134.74
	0:50:00	0.00	0.00	6.42	14.79	22.16	44.63	55.37	70.63	129.26
	0:55:00	0.00	0.00	5.61	12.95	19.72	40.44	50.43	65.81	121.03
	1:00:00	0.00	0.00	4.96	11.45	17.83	36.26	45.54	61.13	113.40
	1:05:00	0.00	0.00	4.45	10.21	16.28	32.85	41.60	57.59	107.42
	1:10:00	0.00	0.00	3.90	9.03	14.78	29.09	37.10	51.34	97.17
	1:15:00	0.00	0.00	3.34	7.81	13.29	25.30	32.53	44.54	85.98
	1:20:00	0.00	0.00	2.79	6.56	11.38	21.53	27.76	37.75	73.33
	1:25:00	0.00	0.00	2.32	5.59	9.83	17.98	23.21	31.53	61.97
	1:30:00	0.00	0.00	2.04	4.99	8.67	15.42	19.99	27.03	53.40
	1:35:00	0.00	0.00	1.82	4.49	7.68	13.43	17.44	23.54	46.62
	1:40:00	0.00	0.00	1.63	3.97	6.79	11.77	15.30	20.57	40.76
	1:45:00	0.00	0.00	1.43	3.46	5.96	10.27	13.37	17.91	35.51
	1:50:00	0.00	0.00	1.24	2.96	5.17	8.91	11.62	15.46	30.69
	1:55:00	0.00	0.00	1.05	2.48	4.37	7.61	9.94	13.16	26.16
	2:00:00	0.00	0.00	0.85	2.00	3.56	6.35	8.32	11.01	21.92
	2:05:00	0.00	0.00	0.66	1.52	2.75	5.11	6.72	8.96	17.78
	2:10:00	0.00	0.00	0.46	1.05	1.97	3.88	5.13	6.91	13.69
	2:15:00	0.00	0.00	0.28	0.62	1.29	2.66	3.56	4.90	9.83
	2:20:00	0.00	0.00	0.14	0.35	0.89	1.58	2.19	3.11	6.70
	2:25:00	0.00	0.00	0.09	0.25	0.68	0.98	1.43	2.05	4.71
	2:30:00	0.00	0.00	0.07	0.19	0.53	0.62	0.96	1.37	3.34
	2:35:00	0.00	0.00	0.05	0.15	0.41	0.40	0.64	0.89	2.32
	2:40:00	0.00	0.00	0.04	0.11	0.31	0.25	0.42	0.55	1.56
	2:45:00	0.00	0.00	0.03	0.09	0.23	0.16	0.28	0.32	1.00
	2:50:00	0.00	0.00	0.02	0.06	0.17	0.10	0.18	0.16	0.60
	2:55:00	0.00	0.00	0.02	0.05	0.12	0.06	0.12	0.08	0.35
	3:00:00	0.00	0.00	0.01	0.03	0.08	0.04	0.08	0.06	0.24
	3:05:00	0.00	0.00	0.01	0.02	0.05	0.03	0.06	0.04	0.17
	3:10:00	0.00	0.00	0.01	0.02	0.04	0.02	0.05	0.04	0.14
	3:15:00	0.00	0.00	0.01	0.01	0.03	0.02	0.03	0.03	0.11
	3:20:00	0.00	0.00	0.00	0.01	0.02	0.01	0.03	0.02	0.08
	3:25:00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.06
	3:30:00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.04
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

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]
7248	0.00	106	0.002	0	0.000	0.00
7250	2.00	2,988	0.069	3,094	0.071	0.06
7252	4.00	17,546	0.403	23,628	0.542	4.58
7254	6.00	21,886	0.502	63,060	1.448	58.31
7256	8.00	26,651	0.612	111,597	2.562	318.05

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).

REFERENCE DOCUMENTS

(RAIN GARDEN 1 CONSTRUCTED W/FILING 3)

Description

A BMP that utilizes bioretention is an engineered, depressed landscape area designed to capture and filter or infiltrate the water quality capture volume (WQCV). BMPs that utilize bioretention are frequently referred to as rain gardens or porous landscape detention areas (PLDs). The term PLD is common in the UDFCD region as this manual first published the BMP by this name in 1999. In an effort to be consistent with terms most prevalent in the stormwater industry, this document generally refers to the treatment process as *bioretention* and to the BMP as a *rain garden*.

Photograph B-1. This recently constructed rain garden provides bioretention of pollutants, as well as an attractive amenity for a residential building. Treatment should improve as vegetation matures.

The design of a rain garden may provide detention for events exceeding that of the WQCV. There are generally two ways to achieve this. The design can provide the flood control volume above the WQCV or the design can provide and slowly release the flood control volume in an area downstream of one or more rain gardens. See the *Storage* chapter in Volume 2 of the USDCM for more information.

This infiltrating BMP requires consultation with a geotechnical engineer when proposed adjacent to a structure. A geotechnical engineer can assist with evaluating the suitability of soils, identifying potential impacts, and establishing minimum distances between the BMP and structures.

Bioretention (Rain Garden)	
Functions	
LID/Volume Red.	Yes
WQCV Capture	Yes
WQCV+Flood Control	Yes
Fact Sheet Includes EURV Guidance	No
Typical Effectiveness for Targeted Pollutants[3]	
Sediment/Solids	Very Good[1]
Nutrients	Moderate
Total Metals	Good
Bacteria	Moderate
Other Considerations	
Life-cycle Costs[4]	Moderate

[1] Not recommended for watersheds with high sediment yields (unless pretreatment is provided).

[3] Based primarily on data from the International Stormwater BMP Database (www.bmpdatabase.org).

[4] Based primarily on BMP-REALCOST available at www.udfcd.org. Analysis based on a single installation (not based on the maximum recommended watershed tributary to each BMP).

Terminology

The term *bioretention* refers to the treatment process although it is also frequently used to describe a BMP that provides biological uptake and retention of the pollutants found in stormwater runoff. This BMP is sometimes referred to as a *porous landscape detention (PLD) area* or *rain garden*.

Benefits

- Bioretention uses multiple treatment processes to remove pollutants, including sedimentation, filtering, adsorption, evapotranspiration, and biological uptake of constituents.
- Stormwater treatment occurs within attractive landscaped areas.
- There is a potential reduction of irrigation requirements by taking advantage of site runoff.

Limitations

- Additional design and construction steps are required for placement of any ponding or infiltration area near or upgradient from a building foundation and/or when expansive (low to high swell) soils exist. This is discussed in the design procedure section.
- In developing or otherwise erosive watersheds, high sediment loads can clog the facility.

Site Selection

This BMP allows WQCV treatment within one or more areas designated for landscape (see design step 7 for suggusted vegetation). In this way, it is an excellent alternative to extended detention basins for small sites. A typical rain garden serves a tributary area of one impervious acre or less, although they can be designed for larger tributary areas. Multiple installations can be used within larger sites. Rain gardens should not be used when a baseflow is anticipated. They are typically small and installed in locations such as:

- Parking lot islands
- Street medians
- Landscape areas between the road and a detached walk
- Planter boxes that collect roof drains

Bioretention requires a stable watershed. Retrofit applications are typically successful for this reason. When the watershed includes phased construction, sparsely vegetated areas, or steep slopes in sandy soils, consider another BMP or provide pretreatment before runoff from these areas reaches the rain garden.

The surface of the rain garden should be flat. For this reason, rain gardens can be more difficult to incorporate into steeply sloping terrain; however, terraced applications of these facilities have been successful in other parts of the country.

When bioretention (and other BMPs used for infiltration) are located adjacent to buildings or pavement areas, protective measures should be implemented to avoid adverse impacts to these structures. Oversaturated subgrade soil underlying a structure can cause the structure to settle or result in moisture-related problems. Wetting of expansive soils or bedrock can cause swelling, resulting in structural movements. A geotechnical engineer should evaluate the potential impact of the BMP on adjacent structures based on an evaluation of the subgrade soil, groundwater, and bedrock conditions at the site. Additional minimum requirements include:

- In locations where subgrade soils do not allow infiltration and/or where infiltration could adversely impact adjacent structures, include a drainage layer (with underdrain) under the growing medium.
- In locations where potentially expansive soils or bedrock exist, placement of a rain garden adjacent to structures and pavement should only be considered if the BMP includes a drainage layer (with underdrain) and an impermeable geomembrane liner designed to restrict seepage.

Designing for Maintenance

Recommended maintenance practices for all BMPs are in Chapter 6 of this manual. During design, consider the following to ensure ease of maintenance over the long-term:

- Do not put a filter sock on the underdrain. This is not necessary and can cause the underdrain to clog.

- The best surface cover for a rain garden is full vegetation. Use rock mulch sparingly within the rain garden because rock mulch limits infiltration and is more difficult to maintain. Wood mulch handles sediment build-up better than rock mulch; however, wood mulch floats and may clog the overflow depending on the configuration of the outlet or settle unevenly. Some municipalities may not allow wood mulch for this reason.

- Consider all potential maintenance requirements such as mowing (if applicable) and replacement of the growing medium. Consider the method and equipment for each task required. For example, in a large rain garden where the use of hand tools is not feasible, does the shape and configuration of the rain garden allow for removal of the growing medium using a backhoe?

- Provide pre-treatment when it will reduce the extent and frequency of maintenance necessary to maintain function over the life of the BMP. For example, if the tributary is larger than one acre, prone to debris or the use of sand for ice control, consider a small forebay.

- Make the rain garden as shallow as possible. Increasing the depth unnecessarily can create erosive side slopes and complicate maintenance. Shallow rain gardens are also more attractive.

- Design and adjust the irrigation system (temporary or permanent) to provide appropriate water for the establishment and maintenance of selected vegetation.

Is Pretreatment Needed?

Designing the inflow gutter to the rain garden at a minimal slope of 0.5% can facilitate sediment and debris deposition prior to flows entering the BMP. Be aware, this will reduce maintenance of the BMP, but may require more frequent sweeping of the gutter to ensure that the sediment does not impede flow into the rain garden.

Design Procedure and Criteria

1. **Subsurface Exploration and Determination of a No-Infiltration, Partial Infiltration, or Full Infiltration Section**: Infiltration BMPs can have three basic types of sections. The appropriate section will depend on land use and activities, proximity to adjacent structures and soil characteristics. Sections of each installation type are shown in Figure B-1.
   - **No-Infiltration Section**: This section includes an underdrain and an impermeable liner that prevents infiltration of stormwater into the subgrade soils. Consider using this section when any of the following conditions exist:
     - The site is a stormwater hotspot and infiltration could result in contamination of groundwater.
     - The site is located over contaminated soils and infiltration could mobilize these contaminants.
     - The facility is located over potentially expansive soils or bedrock that could swell due to infiltration and potentially damage adjacent structures (e.g., building foundation or pavement).
   - **Partial Infiltration Section**: This section does not include an impermeable liner, and allows some infiltration. Stormwater that does not infiltrate is collected and removed by an underdrain

system.

- **Full Infiltration Section**: This section is designed to infiltrate the water stored in the basin into the subgrade below. UDFCD recommends a minimum infiltration rate of 2 times the rate needed to drain the WQCV over 12 hours. A conservative design could utilize the partial infiltration section with the addition of a valve at the underdrain outlet. In the event that infiltration does not remain adequate following construction, the valve could be opened and allow this section to operate as a partial infiltration section.

A geotechnical engineer should scope and perform a subsurface study. Typical geotechnical investigation needed to select and design the section includes:

- Prior to exploration review geologic and geotechnical information to assess near-surface soil, bedrock and groundwater conditions that may be encountered and anticipated ranges of infiltration rate for those materials. For example, if the facility is located adjacent to a structure and the site is located in a general area of known shallow, potentially expansive bedrock, a no-infiltration section will likely be required. It is also possible that this BMP may be infeasible, even with a liner, if there is a significant potential for damage to the adjacent structures (e.g., areas of dipping bedrock).
- Drill exploratory borings or exploratory pits to characterize subsurface conditions beneath the subgrade and develop requirements for subgrade preparation. Drill at least one boring or pit for every 40,000 ft^2, and at least two borings or pits for sites between 10,000 ft^2 and 40,000 ft^2. The boring or pit should extend at least 5 feet below the bottom of the base, and at least 20 feet in areas where there is a potential of encountering potentially expansive soils or bedrock. More borings or pits at various depths may be required by the geotechnical engineer in areas where soil types may change, in low-lying areas where subsurface drainage may collect, or where the water table is likely within 8 feet below the planned bottom of the base or top of subgrade. Installation of temporary monitoring wells in selected borings or pits for monitoring groundwater levels over time should be considered where shallow groundwater is encountered.
- Perform laboratory tests on samples obtained from the borings or pits to initially characterize the subgrade, evaluate the possible section type, and to assess subgrade conditions for supporting traffic loads. Consider the following tests: moisture content (ASTM D 2216); dry density (ASTM D 2936); Atterberg limits (ASTM D 4318); gradation (ASTM D 6913); swell-consolidation (ASTM D 4546); subgrade support testing (R-value, CBR or unconfined compressive strength); and hydraulic conductivity. A geotechnical engineer should determine the appropriate test method based on the soil type.
- For sites where a full infiltration section may be feasible, perform on-site infiltration tests using a double-ring infiltrometer (ASTM D 3385). Perform at least one test for every 160,000 ft^2 and at least two tests for sites between 40,000 ft^2 and 160,000 ft^2. The tests should be located near completed borings or pits so the test results and subsurface conditions encountered in the borings can be compared, and at least one test should be located near the boring or pit showing the most unfavorable infiltration condition. The test should be performed at the planned top of subgrade underlying the growing media.
- Be aware that actual infiltration rates are highly variable dependent on soil type, density and moisture content and degree of compaction as well as other environmental and construction influences. Actual rates can differ an order of magnitude or more from those indicated by infiltration or permeability testing. Select the type of section based on careful assessment of the subsurface exploration and testing data.

The following steps outline the design procedure and criteria, with Figure B-1 providing a corresponding cross-section.

2. **Basin Storage Volume**: Provide a storage volume based on a 12-hour drain time.

   Find the required WQCV (watershed inches of runoff). Using the imperviousness of the tributary area (or effective imperviousness where LID elements are used upstream), use Figure 3-2 located in Chapter 3 of this manual to determine the WQCV based on a 12-hour drain time.

   Calculate the design volume as follows:

$$V = \left[\frac{\mathrm{WQCV}}{12}\right]A$$ Equation B-1

   Where:

   V= design volume (ft^3)

   A = area of watershed tributary to the rain garden (ft^2)

3. **Basin Geometry:** UDFCD recommends a maximum WQCV ponding depth of 12 inches to maintain vegetation properly. Provide an inlet or other means of overflow at this elevation. Depending on the type of vegetation planted, a greater depth may be utilized to detain larger (more infrequent) events. The bottom surface of the rain garden, also referred to here as the filter area, should be flat. Sediment will reside on the filter area of the rain garden; therefore, if the filter area is too small, it may clog prematurely. If the filter area is not flat, the lowest area of the filter is more likely to clog as it will have a higher sediment loading. Increasing the filter area will reduce clogging and decrease the frequency of maintenance. Equation B-2 provides a minimum filter area allowing for some of the volume to be stored beyond the area of the filter (i.e., above the sideslopes of the rain garden).

Note that the total surcharge volume provided by the design must also equal or exceed the design volume. Where needed to meet the the required volume, also consider the porosity of the media at 14 percent. Use vertical walls or slope the sides of the basin to achieve the required volume. Sideslopes should be no steeper than 4:1 (horizontal:vertical).

$$A_F = 0.02AI$$

Equation B-2

Where:

A_F= minimum (flat) filter area (ft^2)

A = area tributary to the rain garden (ft^2)

I = imperviousness of area tributary to the rain garden (percent expressed as a decimal)

4. **Growing Medium:** Provide a minimum of 18 inches of growing medium to enable establishment of the roots of the vegetation (see Figure B-1). A previous version of this manual specified a mixture consisting of 85% coarse sand and a 15% compost/shredded paper mixture (by volume). Based on field monitoring of this medium, compost was removed to reduce export of nutrients and fines and silts were added to both benefit the vegetation and increase capture of metals in stormwater.

Table B-1 specifies the growing media as well as other materials discussed in this Fact Sheet**.** Growing media is engineered media that requires a high level of quality control and must almost always be imported. Obtaining a particle size distribution and nutrient analysis is the only way to ensure that the media is acceptable. UDFCD has identified placement of media not meeting the specification as the most frequent cause of failure. Sample the media after delivery and prior to placement or obtain a sample from the supplier in advance of delivery and placement and have this analyzed prior to delivery.

Other Rain Garden Growing Medium Amendments

The specified growing medium was designed for filtration ability, clogging characteristics, and vegetative health. It is important to preserve the function provided by the rain garden growing medium when considering additional materials for incorporation into the growing medium or into the standard section shown in Figure B-1. When desired, amendments may be included to improve water quality or to benefit vegetative health as long as they do not add nutrients, pollutants, or modify the infiltration rate. For example, a number of products, including steel wool, capture and retain dissolved phosphorus (Erickson 2009). When phosphorus is a target pollutant, proprietary materials with similar characteristics may be considered. Do not include amendments such as top soil, sandy loam, and compost.

Table B-1. Material specification for bioretention/rain garden facilities

Material		Specification			Submittals	Testing	Notes
Bioretention Growing Media (soil + organics)	Bioretention soil	Particle size distribution: 80-90% sand (0.05 - 2.0 mm diameter) 3-17% silt (0.002-0.5 mm diameter) 3-17% clay (<0.002 diameter) Chemical attribute and nutrient analysis: pH 6.8 - 7.5 organic matter < 1.5% nitrogen <15 ppm phosphorus < 15 ppm salinity < 6 mmhos/cm			Particle size distribution and nutrient analysis required.		Percentages are in weight.
	Bioretention organics	3 to 5% shredded mulch (by weight of growing media)					bioretention soil required. Aged 6 months (minimum).
Landscape mulch		Shredded hardwood					Aged 6 months (minimum). No weed fabric allowed.
Underdrain aggregate	CDOT filter material (Class B or C as specified)		Mass Percent Passing Square Mesh Siev				
		Sieve Size	Class B	Class C	Particle size distribution required.		
		37.5 mm (1.5")	100				
		19.0 mm (0.75")		100			
		4.75 mm (No.4)	20-60	60-100			
		1.18 um (No. 16)	10-30				
		300 um (No. 50)	0-10	10-30			
		150 um (No. 100)		0-10			
		75 um (No. 200)	0-3	0-3			
Underdrain Pipe		Pipe diameter and type	Maximum slot width (inches)	Minimum open area (per foot)	Required	Pipe must conform to requirements of ASTM designation F949. There shall be no evidence of splitting, cracking, or breaking when the pipe is tested per ASTM test method D2412 in accordance with F949 section 7.5 and ASTM F794 section 8.5.	Contech A-2000 slotted pipe (or equal)
		4-inch slotted PVC	0.032	1.90 in.²			
		6-inch slotted PVC	0.032	1.98 in.²			
Impermeable liner			Thickness 0.76 mm (30 mil)	Test method	Required	Thermal welding required for fully lined facilities (not a cutain). Leak testing in the field required.	
		Thickness, % Tolerance	+/-5	ASTM D 1593			
		Tensile strength, kN/m (lb/in)	12.25 (70)	ASTM D8 82, method B			
		Modulus at 100% elongation, kN/m	5.25 (30)	ASTM D8 82, method B			
		Ultimate elongation, %	350	ASTM D8 82, method A			
		Tear resistance, N(lbs)	38 (8.5)	ASTM D 1004			
		Low temperature impact, ° C (° F)	-29 (-20)	ASTM D 1790			
		Volatile loss, % maximum	0.7	ASTM D8 82, method A			
		Pinholes, no. per 8 m² (no. per 10 yd.²)	1 (max)	N/A			
		Bonded seam strength, % of tensile	80	N/A			

5. **Underdrain System**: When using an underdrain system, provide a control orifice sized to drain the design volume in 12 hours or more (see Equation B-3). Use a minimum orifice size of 3/8 inch to avoid clogging. This will provide detention and slow release of the WQCV, providing water quality benefits and reducing impacts to downstream channels. Space underdrain pipes a maximum of 20 feet on center. Provide cleanouts to enable maintenance of the underdrain. Cleanouts can also be used to conduct an inspection (by camera) of the underdrain system to ensure that the pipe was not crushed or disconnected during construction.

Calculate the diameter of the orifice for a 12-hour drain time using Equation B-3 (Use a minimum orifice size of 3/8 inch to avoid clogging.):

$$D_{\text{12 hour drain time}} = \sqrt{\frac{V}{1414\, y^{0.41}}} \qquad \text{Equation B-3}$$

Where:

D = orifice diameter (in)

y = distance from the lowest elevation of the storage volume (i.e., surface of the filter) to the center of the orifice (ft)

V = volume (WQCV or the portion of the WQCV in the rain garden) to drain in 12 hours (ft^3)

In previous versions of this manual, UDFCD recommended that the underdrain be placed in an aggregate layer and that a geotextile (separator fabric) be placed between this aggregate and the growing medium. This version of the manual replaces that section with materials that, when used together, eliminate the need for a separator fabric.

The underdrain system should be placed within an 6-inch-thick section of CDOT Class B or Class C filter material meeting the gradation in Table B-1. Use slotted pipe that meets the slot dimensions provided in Table B-3.

6. **Impermeable Geomembrane Liner and Geotextile Separator Fabric:** For no-infiltration sections, install a 30 mil (minimum) PVC geomembrane liner, per Table B-1, on the bottom and sides of the basin, extending up at least to the top of the underdrain layer. Provide at least 9 inches (12 inches if possible) of cover over the membrane where it is attached to the wall to protect the membrane from UV deterioration. The geomembrane should be field-seamed using a dual track welder, which allows for non-destructive testing of almost all field seams. A small amount of single track is allowed in limited areas to seam around pipe perforations, to patch seams removed for destructive seam testing, and for limited repairs. The liner should be installed with slack to prevent tearing due to backfill, compaction, and settling. Place CDOT Class B geotextile separator fabric above the geomembrane to protect it from being punctured during the placement of the filter material above the liner. If the subgrade contains angular rocks or other material that could puncture the geomembrane, smooth-roll the surface to create a suitable surface. If smooth-rolling the surface does not provide a suitable surface, also place the separator fabric between the geomembrane and the underlying subgrade. This should only be done when necessary because fabric placed under the geomembrane can increase seepage losses through pinholes or other geomembrane defects. Connect the geomembrane to perimeter concrete walls around the basin perimeter, creating a watertight seal between the geomembrane and the walls using a continuous batten bar and anchor connection (see Figure B-3). Where the need for the impermeable membrane is not as critical, the membrane can be attached with a nitrile-based vinyl adhesive. Use watertight PVC boots for underdrain pipe penetrations through the liner (see Figure B-2) or the technique shown in photo B-3.

Photograph B-2. The impermeable membrane in this photo has ripped from the bolts due to placement of the media without enough slack in the membrane.

Photograph B-3. Ensure a water-tight connection where the underdrain penetrated the liner. The heat-welded “boot” shown here is an alternative to the clamped detail shown in Figure B-2.

Table B-2. Physical requirements for separator fabric[1]

Property	Class B		Test Method
	Elongation < 50%[2]	Elongation > 50%[2]	
Grab Strength, N (lbs.)	800 (180)	510 (115)	ASTM D 4632
Puncture Resistance, N (lbs.)	310 (70)	180 (40)	ASTM D 4833
Trapezoidal Tear Strength, N (lbs.)	310 (70)	180 (40)	ASTM D 4533
Apparent Opening Size, mm (US Sieve Size)	AOS < 0.3mm (US Sieve Size No. 50)		ASTM D 4751
Permittivity, sec^{-1}	0.02 default value, must also be greater than that of soil		ASTM D 4491
Permeability, cm/sec	k fabric > k soil for all classes		ASTM D 4491
Ultraviolet Degradation at 500 hours	50% strength retained for all classes		ASTM D 4355

[1] Strength values are in the weaker principle direction

[2] As measured in accordance with ASTM D 4632

7. **Inlet and Outlet Control:** In order to provide the proper drain time, the bioretention area can be restricted at the underdrain outlet with an orifice plate or can be designed without an underdrain (provided the subgrade meets the requirements above). Equation B-3 is a simplified equation for sizing an orifice plate for a 12-hour drain time. UD-BMP or UD-Detention, available at www.udfcd.org, also perform this calculation.

   How flow enters and exits the BMP is a function of the overall drainage concept for the site. Curb cuts can be designed to both allow stormwater into the rain garden as well as to provide release of stormwater in excess of the WQCV. Roadside rain gardens located on a steep site might pool and overflow into downstream cells with a single curb cut, level spreader, or outlet structure located at the most downstream cell. When selecting the

Photograph B-4. The curb cut shown allows flows to enter this rain garden while excess flows bypass the facility.

type and location of the outlet structure, ensure runoff will not short-circuit the rain garden. This is a frequent problem when using a curb inlet located outside the rain garden for overflow.

For rain gardens with concentrated points of inflow, provide a forebay and energy dissipation. A depressed concrete slab works best for a forebay. It helps maintain a vertical drop at the inlet and allows for easily removal of sediment using a square shovel. Where rock is used for energy dissipation, provide separator fabric between the rock and growing medium to minimize subsidence.

8. **Vegetation:** UDFCD recommends that the filter area be vegetated with drought tolerant species that thrive in sandy soils. Table B-3 provides a suggested seed mix for sites that will not need to be irrigated after the grass has been established.

   Mix seed well and broadcast, followed by hand raking to cover seed and then mulched. Hydromulching can be effective for large areas. Do not place seed when standing water or snow is present or if the ground is frozen. Weed control is critical in the first two to three years, especially when starting with seed.

   When using sod, specify sand–grown sod. Do not use conventional sod. Conventional sod is grown in clay soil that will seal the filter area, greatly reducing overall function of the BMP.

   When using an impermeable liner, select plants with diffuse (or fibrous) root systems, not taproots. Taproots can damage the liner and/or underdrain pipe. Avoid trees and large shrubs that may interfere with restorative maintenance. Plant these outside of the area of growing medium. Use a cutoff wall to ensure that roots do not grow into the underdrain or place trees and shrubs a conservative distance from the underdrain.

9. **Irrigation:** Provide spray irrigation at or above the WQCV elevation or place temporary irrigation on top of the rain garden surface. Do not place sprinkler heads on the flat surface. Remove temporary irrigation when vegetation is established. If left in place this will become buried over time and will be damaged during maintenance operations.

   Adjust irrigation schedules during the growing season to provide the minimum water necessary to maintain plant health and to maintain the available pore space for infiltration.

Designing for Flood Protection

Provide the WQCV in rain gardens that direct excess flow into to a landscaped basin designed for flood control or design a single basin to provide water quality and flood control. See the *Storage* chapter in Volume 2 of the USDCM for more information. UD-Detention, available at www.udfcd.org, will facilitate design either alternative.

Table B-3. Native seed mix for rain gardens

Common Name	Scientific Name	Variety	PLS[2] lbs per Acre	Ounces per Acre
Sand bluestem	Andropogon hallii	Garden	3.5	
Sideoats grama	Bouteloua curtipendula	Butte	3	
Prairie sandreed	Calamovilfa longifolia	Goshen	3	
Indian ricegrass	Oryzopsis hymenoides	Paloma	3	
Switchgrass	Panicum virgatum	Blackwell	4	
Western wheatgrass	Pascopyrum smithii	Ariba	3	
Little bluestem	Schizachyrium scoparium	Patura	3	
Alkali sacaton	Sporobolus airoides		3	
Sand dropseed	Sporobolus cryptandrus		3	
Pasture sage[1]	Artemisia frigida			2
Blue aster[1]	Aster laevis			4
Blanket flower[1]	Gaillardia aristata			8
Prairie coneflower[1]	Ratibida columnifera			4
Purple prairieclover[1]	Dalea (Petalostemum) purpurea			4
Sub-Totals:			27.5	22
Total lbs per acre:			**28.9**	

[1] Wildflower seed (optional) for a more diverse and natural look.
[2] PLS = Pure Live Seed.

Aesthetic Design

In addition to effective stormwater quality treatment, rain gardens can be attractively incorporated into a site within one or several landscape areas. Aesthetically designed rain gardens will typically either reflect the character of their surroundings or become distinct features within their surroundings. Guidelines for each approach are provided below.

Reflecting the Surrounding

- Determine design characteristics of the surrounding. This becomes the context for the drainage improvement. Use these characteristics in the structure.
- Create a shape or shapes that "fix" the forms surrounding the improvement. Make the improvement part of the existing surrounding.
- The use of material is essential in making any new improvement an integral part of the whole. Select materials that are as similar as possible to the surrounding architectural/engineering materials. Select materials from the same source if possible. Apply materials in the same quantity, manner, and method as original material.
- Size is an important feature in seamlessly blending the addition into its context. If possible, the overall size of the improvement should look very similar to the overall sizes of other similar objects in the improvement area.
- The use of the word texture in terms of the structure applies predominantly to the selection of plant material. The materials used should as closely as possible, blend with the size and texture of other plant material used in the surrounding. The plants may or may not be the same, but should create a similar feel, either individually or as a mass.

Reflective Design

A reflective design borrows the characteristics, shapes, colors, materials, sizes and textures of the built surroundings. The result is a design that fits seamlessly and unobtrusively in its environment.

Creating a Distinct Feature

Designing the rain garden as a distinct feature is limited only by budget, functionality, and client preference. There is far more latitude in designing a rain garden that serves as a distinct feature. If this is the intent, the main consideration beyond functionality is that the improvement create an attractive addition to its surroundings. The use of form, materials, color, and so forth focuses on the improvement itself and does not necessarily reflect the surroundings, depending on the choice of the client or designer.

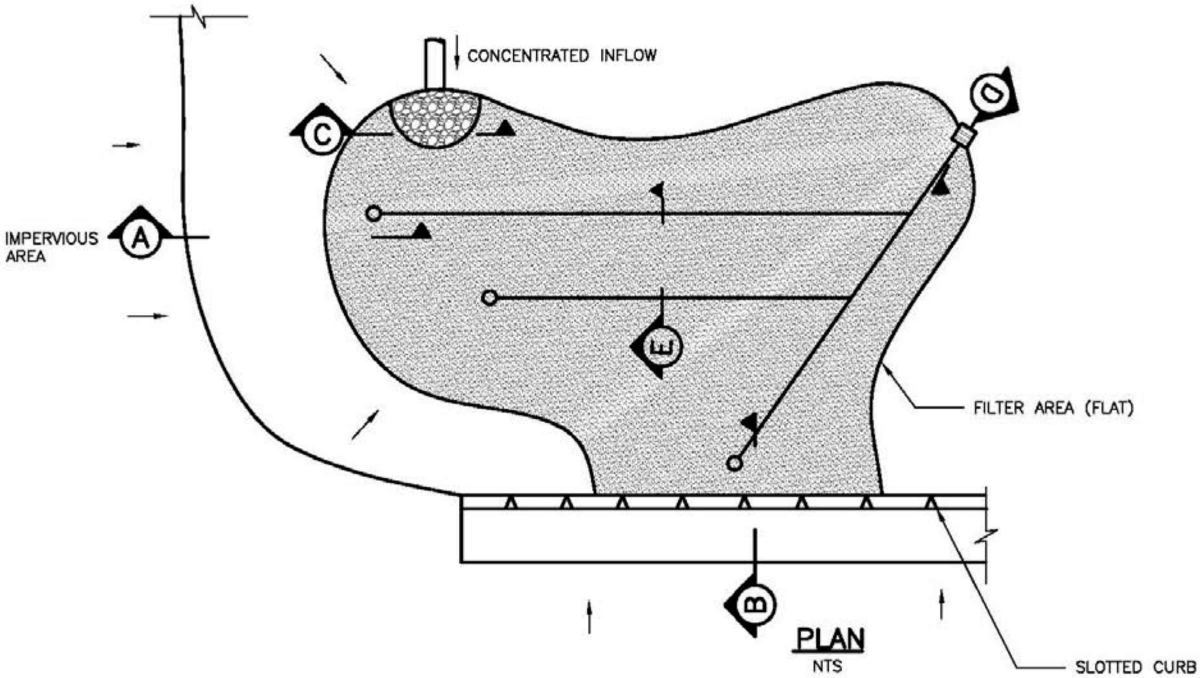
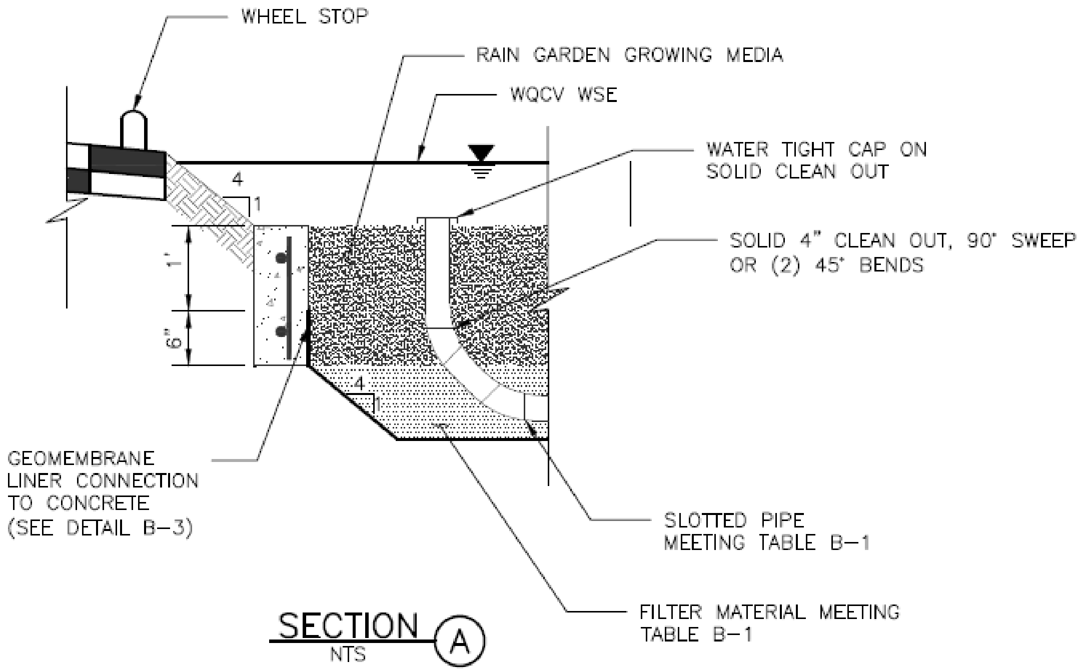
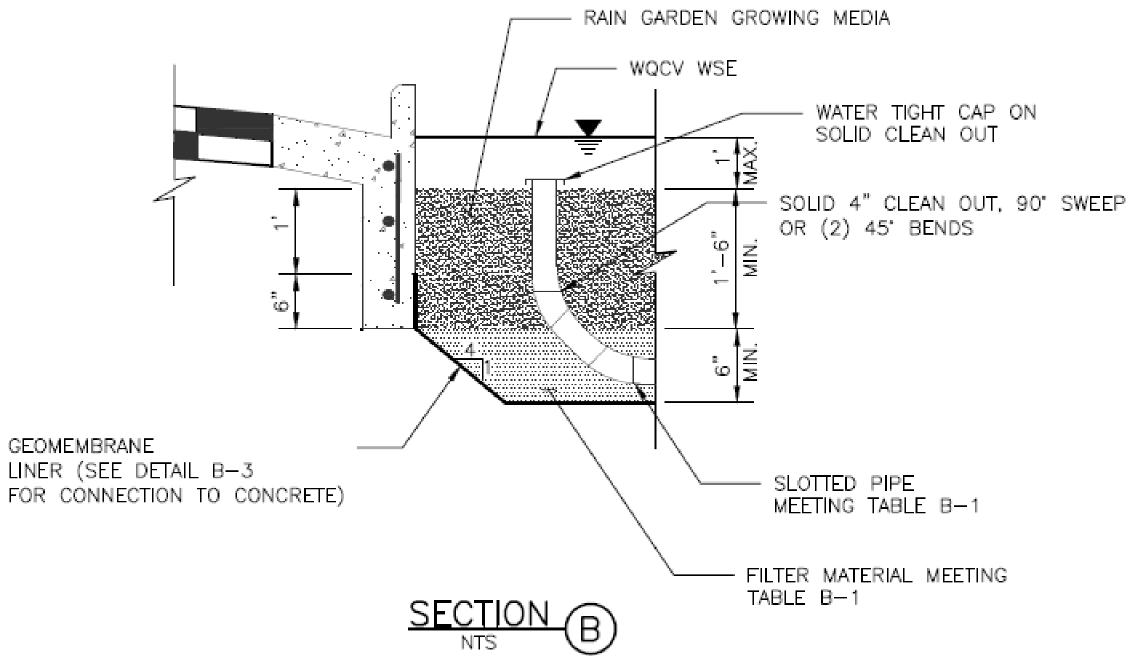
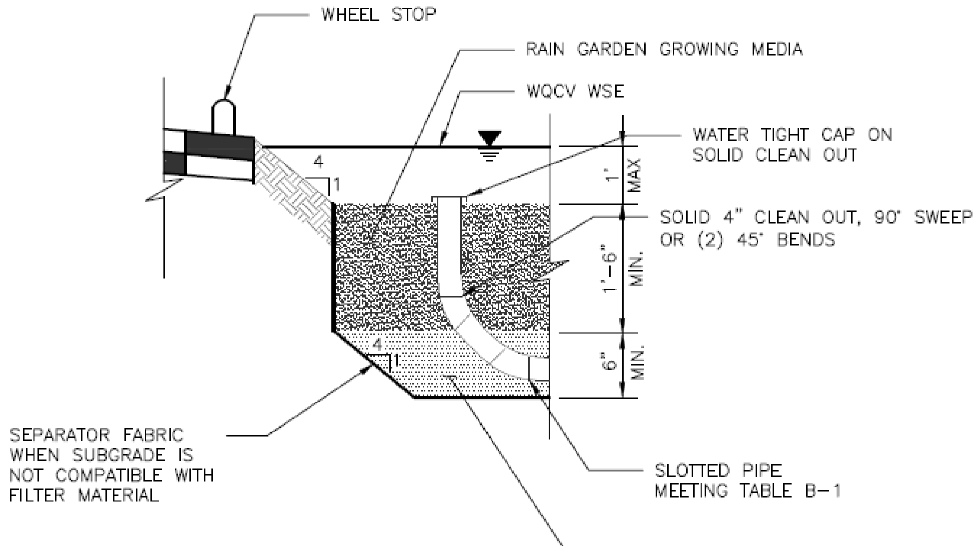


Figure B-1 – Typical rain garden plan and sections

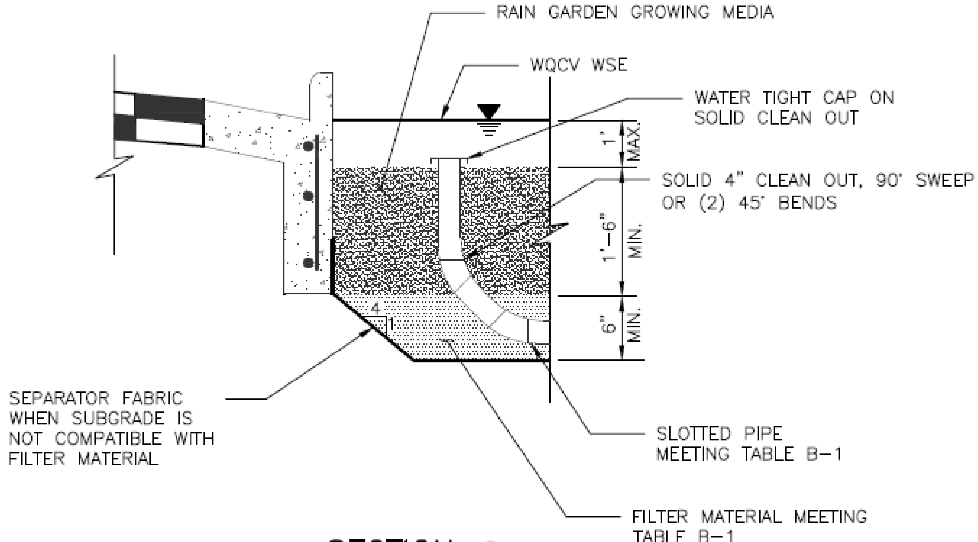




NO-INFILTRATION SECTIONS



SECTION (A)
NTS



SECTION (B)
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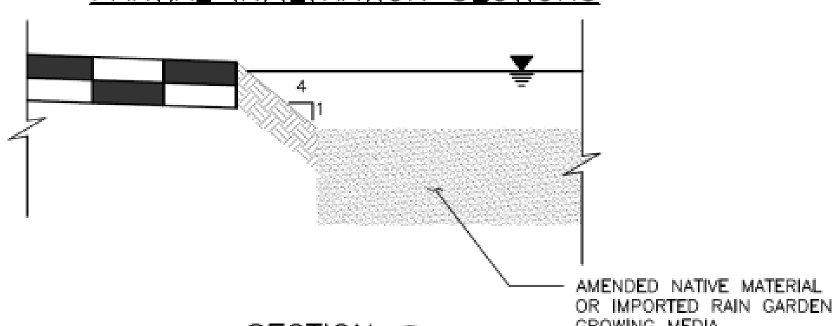
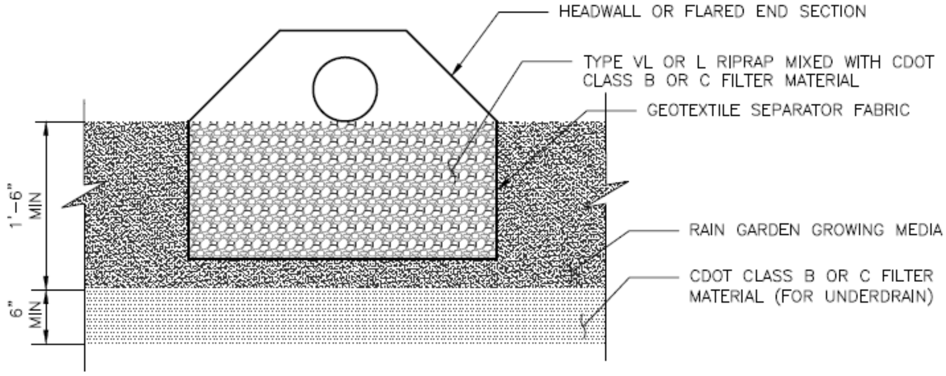
PARTIAL INFILTRATION SECTIONS



SECTION (A)
NTS

FULL INFILTRATION SECTION



SECTION C
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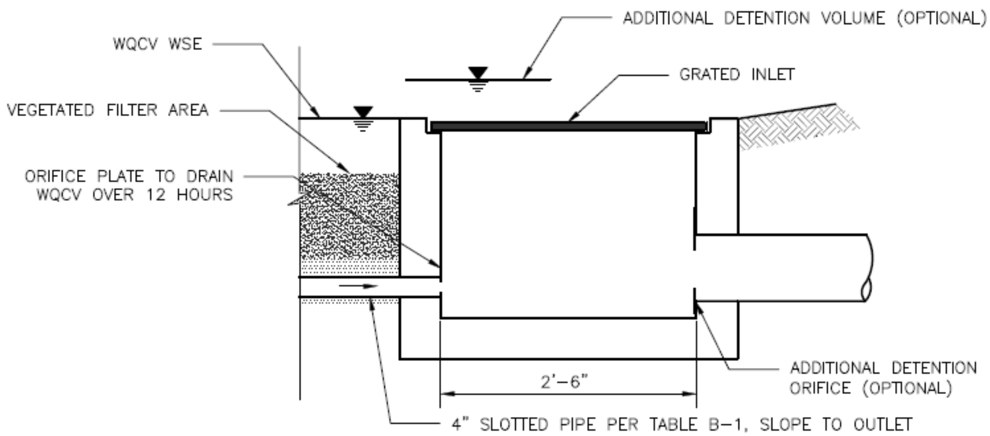
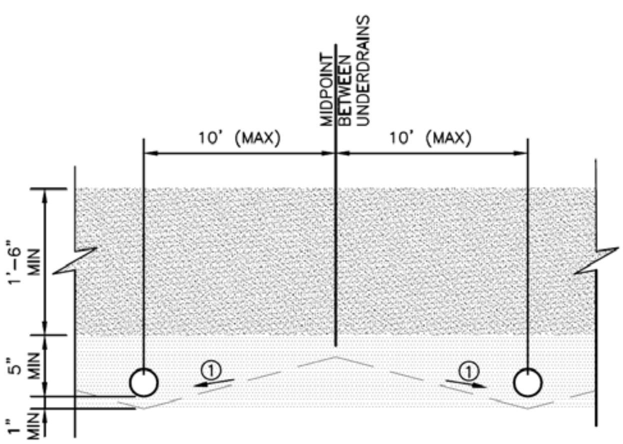


SECTION D
NTS



① SLOPE (STRAIGHT GRADE) SUBGRADE (2–10%) TO UNDERDRAIN TO REDUCE SATURATED SOIL CONDITIONS BETWEEN STORM EVENTS (OPTIONAL)

SECTION E
NTS

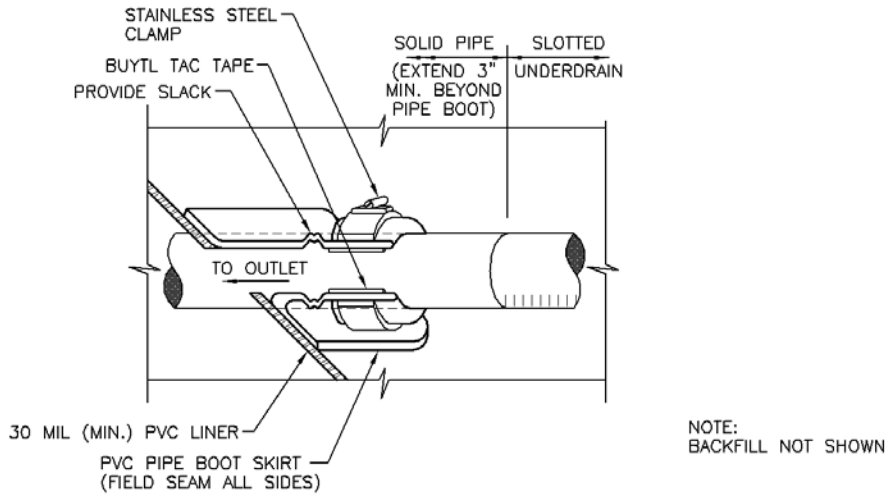


Figure B-2. Geomembrane Liner/Underdrain Penetration Detail

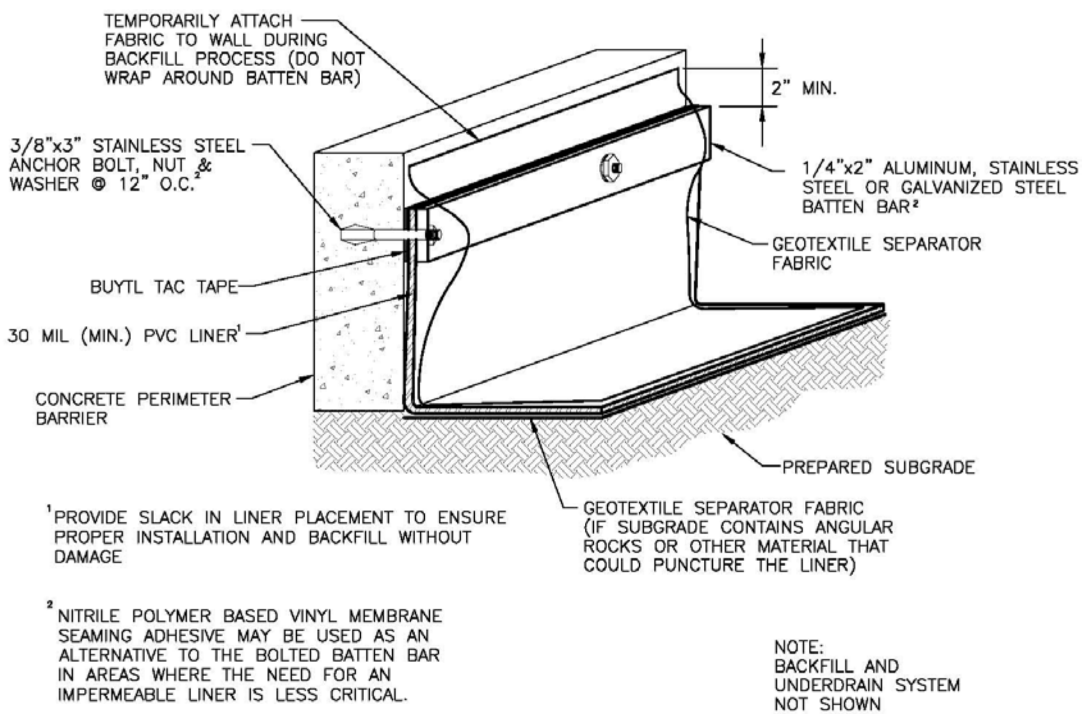


Figure B-3. Geomembrane Liner/Concrete Connection Detail

Construction Considerations

Proper construction of rain gardens involves careful attention to material specifications, final grades, and construction details. For a successful project, implement the following practices:

- Protect area from excessive sediment loading during construction. This is the most common cause of clogging of rain gardens. The portion of the site draining to the rain garden must be stabilized before allowing flow into the rain garden. This includes completion of paving operations.

- Avoid over compaction of the area to preserve infiltration rates (for partial and full infiltration sections).

- Provide construction observation to ensure compliance with design specifications. Improper installation, particularly related to facility dimensions and elevations and underdrain elevations, is a common problem with rain gardens.

Photograph B-3. Inadequate construction staking may have contributed to flows bypassing this rain garden.

- When using an impermeable liner, ensure enough slack in the liner to allow for backfill, compaction, and settling without tearing the liner.

- Provide necessary quality assurance and quality control (QA/QC) when constructing an impermeable geomembrane liner system, including but not limited to fabrication testing, destructive and non-destructive testing of field seams, observation of geomembrane material for tears or other defects, and air lace testing for leaks in all field seams and penetrations. QA/QC should be overseen by a professional engineer. Consider requiring field reports or other documentation from the engineer.

Photograph B-4. Runoff passed the upradient rain garden, shown in Photo B-3, and flooded this downstream rain garden.

- Provide adequate construction staking to ensure that the site properly drains into the facility, particularly with respect to surface drainage away from adjacent buildings. Photo B-3 and Photo B-4 illustrate a construction error for an otherwise correctly designed series of rain gardens.

References

Erickson, Andy. 2009. Field Applications of Enhanced Sand Filtration. University of Minnesota *Stormwater Management Practice Assessment Project Update*. http://wrc.umn.edu.

Hunt, William F., Davis, Allen P., Traver, Robert. G. 2012. "Meeting Hydrologic and Water Quality Goals through Targeted Bioretention Design" *Journal of Environmental Engineering*. (2012) 138:698-707. Print.

FINAL DRAINAGE REPORT ~ BASIN RUNOFF SUMMARY

BASIN	WEIGHTED CA(2)	WEIGHTED CA(5)	WEIGHTED CA(100)	OVERLAND C(5)	OVERLAND Length (ft)	OVERLAND Height (ft)	OVERLAND Tc (min)	STREET / CHANNEL FLOW Length (ft)	STREET / CHANNEL FLOW Slope (%)	STREET / CHANNEL FLOW Velocity (fps)	STREET / CHANNEL FLOW Tc (min)	Tc TOTAL (min)	INTENSITY I(2) (in/hr)	INTENSITY I(5) (in/hr)	INTENSITY I(100) (in/hr)	TOTAL FLOWS Q(2) (cfs)	TOTAL FLOWS Q(5) (cfs)	TOTAL FLOWS Q(100) (cfs)
OS-1	0.72	2.17	8.68	0.09	300	16	18.2	1300	3.5%	1.9	11.6	29.8	2.00	2.49	4.18	1	**5**	**35**
OS-2	0.07	0.10	0.22	0.22	220	11	13.9					13.9	2.91	3.64	6.11	0.2	**0.4**	**1.3**
OS-3	0.76	1.05	1.97	0.25	100	2	12.2	550	2.8%	1.7	5.5	17.7	2.62	3.27	5.50	2	**3**	**11**
OS-4	0.38	0.59	1.43	0.12	300	10	20.6	700	5.0%	2.2	5.2	25.8	2.17	2.71	4.54	1	**2**	**6**
OS-5	1.67	4.92	18.20	0.10	300	20	16.7	1900	3.0%	1.7	18.3	35.0	1.80	2.25	3.78	3	**11**	**69**
OS-6	0.61	0.94	2.42	0.09	300	10	21.2	300	2.0%	1.4	3.5	24.8	2.22	2.77	4.65	1	**3**	**11**
OS-7	0.58	0.65	0.90	0.14	100	2	13.8	250	2.0%	1.4	2.9	16.7	2.68	3.36	5.63	2	**2**	**5**
A	1.13	2.09	5.82	0.12	300	13	18.9	100	2.0%	1.4	1.2	20.1	2.47	3.08	5.18	3	**6**	**30**
B	1.06	1.76	3.87	0.20	230	3	22.6	700	2.0%	1.4	8.2	30.8	1.96	2.44	4.10	2	**4**	**16**
C	0.39	0.48	0.76	0.25	50	1	8.6	700	2.0%	1.4	8.2	16.9	2.67	3.34	5.61	1	**2**	**4**
D	0.05	0.06	0.10	0.30	50	1	8.1					8.1	3.54	4.44	7.46	0.2	**0.3**	**0.7**
E	0.35	0.51	1.06	0.22	100	5	9.3	200	5.5%	4.7	0.7	10.1	3.29	4.12	6.92	1	**2**	**7**
F	0.29	0.33	0.47	0.25	60	2	8.0	200	5.5%	4.7	0.7	8.7	3.46	4.34	7.28	1.0	**1.4**	**3**
G	0.40	0.55	1.03	0.25	300	9	18.5	600	1.5%	1.2	8.2	26.7	2.13	2.66	4.46	1	**1**	**5**
H1	0.29	0.46	1.09	0.12	100	8	8.9					8.9	3.43	4.30	7.22	1	**2**	**8**
H2	0.46	0.72	1.44	0.16	100	12	7.5					7.5	3.64	4.57	7.67	2	**3**	**11**
I	0.13	0.31	1.01	0.12	300	4	27.9					27.9	2.08	2.59	4.35	0.3	**0.8**	**4**
J1	0.34	0.49	1.08	0.12	300	12	19.4					19.4	2.51	3.14	5.26	1	**2**	**6**
J2	0.02	0.05	0.16	0.12	160	4	16.5					16.5	2.70	3.37	5.66	0.1	**0.2**	**0.9**
K	0.63	0.83	1.60	0.12	300	8	22.2					22.2	2.35	2.93	4.93	1	**2**	**8**
L	0.40	0.70	1.67	0.14	300	12	19.0					19.0	2.53	3.17	5.32	1	**2**	**9**
M	0.34	0.36	0.43	0.12	15	0.3	5.5	350	1.5%	2.4	2.4	7.8	3.59	4.50	7.55	1	**2**	**3**
N	0.28	0.30	0.39	0.12	15	0.3	5.5	350	1.5%	2.4	2.4	7.8	3.59	4.50	7.55	1	**1**	**3**
O	0.03	0.07	0.24	0.12	100	6	9.8					9.8	3.32	4.16	6.98	0.1	**0.3**	**2**

FINAL DRAINAGE REPORT ~ BASIN RUNOFF COEFFICIENT SUMMARY

BASIN	TOTAL AREA (AC)	IMPERVIOUS AREA / STREETS AREA (AC)	IMPERVIOUS AREA / STREETS C(2)	IMPERVIOUS AREA / STREETS C(5)	IMPERVIOUS AREA / STREETS C(100)	LANDSCAPE/DEVELOPED AREAS AREA (AC)	LANDSCAPE/DEVELOPED AREAS C(2)	LANDSCAPE/DEVELOPED AREAS C(5)	LANDSCAPE/DEVELOPED AREAS C(100)	WEIGHTED C(2)	WEIGHTED C(5)	WEIGHTED C(100)	WEIGHTED CA CA(2)	WEIGHTED CA CA(5)	WEIGHTED CA CA(100)	EFFECTIVE IMPERVIOUS (%)
OS-1	24.1	0.00	0.89	0.90	0.96	24.1	0.03	0.09	0.36	0.03	0.09	0.36	**0.72**	**2.17**	**8.68**	2.0%
OS-2	0.47	0.00	0.89	0.90	0.96	0.47	0.15	0.22	0.46	0.15	0.22	0.46	**0.07**	**0.10**	**0.22**	25.0%
OS-3	4.2	0.00	0.89	0.90	0.96	4.2	0.18	0.25	0.47	0.18	0.25	0.47	**0.76**	**1.05**	**1.97**	30.0%
OS-4	3.3	0.25	0.89	0.90	0.96	3.1	0.05	0.12	0.39	0.11	0.18	0.43	**0.38**	**0.59**	**1.43**	13.3%
OS-5	49.2	0.00	0.89	0.90	0.96	49.2	0.03	0.10	0.37	0.03	0.10	0.37	**1.67**	**4.92**	**18.20**	3.0%
OS-6	5.9	0.50	0.89	0.90	0.96	5.4	0.03	0.09	0.36	0.10	0.16	0.41	**0.61**	**0.94**	**2.42**	14.0%
OS-7	1.4	0.60	0.89	0.90	0.96	0.8	0.06	0.14	0.40	0.42	0.47	0.64	**0.58**	**0.65**	**0.90**	55.7%
A	14.2	0.50	0.89	0.90	0.96	13.70	0.05	0.12	0.39	0.08	0.15	0.41	**1.13**	**2.09**	**5.82**	10.1%
B	8.8	0.00	0.89	0.90	0.96	8.80	0.12	0.20	0.44	0.12	0.20	0.44	**1.06**	**1.76**	**3.87**	20.0%
C	1.4	0.20	0.89	0.90	0.96	1.20	0.18	0.25	0.47	0.28	0.34	0.54	**0.39**	**0.48**	**0.76**	38.6%
D	0.2	0.00	0.89	0.90	0.96	0.20	0.23	0.30	0.50	0.23	0.30	0.50	**0.05**	**0.06**	**0.10**	40.0%
E	2.3	0.00	0.89	0.90	0.96	2.30	0.15	0.22	0.46	0.15	0.22	0.46	**0.35**	**0.51**	**1.06**	25.0%
F	0.8	0.20	0.89	0.90	0.96	0.60	0.18	0.25	0.47	0.36	0.41	0.59	**0.29**	**0.33**	**0.47**	45.0%
G	2.2	0.00	0.89	0.90	0.96	2.20	0.18	0.25	0.47	0.18	0.25	0.47	**0.40**	**0.55**	**1.03**	30.0%
H1	2.5	0.20	0.89	0.90	0.96	2.30	0.05	0.12	0.39	0.12	0.18	0.44	**0.29**	**0.46**	**1.09**	14.0%
H2	3.1	0.30	0.89	0.90	0.96	2.80	0.07	0.16	0.41	0.15	0.23	0.46	**0.46**	**0.72**	**1.44**	15.5%
I	2.6	0.00	0.89	0.90	0.96	2.60	0.05	0.12	0.39	0.05	0.12	0.39	**0.13**	**0.31**	**1.01**	7.0%
J1	2.4	0.26	0.89	0.90	0.96	2.14	0.05	0.12	0.39	0.14	0.20	0.45	**0.34**	**0.49**	**1.08**	16.5%
J2	0.4	0.00	0.89	0.90	0.96	0.40	0.05	0.12	0.39	0.05	0.12	0.39	**0.02**	**0.05**	**0.16**	7.0%
K	3.30	0.55	0.89	0.90	0.96	2.75	0.05	0.12	0.39	0.19	0.25	0.49	**0.63**	**0.83**	**1.60**	24.2%
L	3.90	0.20	0.89	0.90	0.96	3.70	0.06	0.14	0.40	0.10	0.18	0.43	**0.40**	**0.70**	**1.67**	15.1%
M	0.54	0.38	0.89	0.90	0.96	0.16	0.05	0.12	0.39	0.64	0.67	0.79	**0.34**	**0.36**	**0.43**	65.1%
N	0.55	0.30	0.89	0.90	0.96	0.25	0.05	0.12	0.39	0.51	0.55	0.70	**0.28**	**0.30**	**0.39**	52.7%
O	0.61	0.00	0.89	0.90	0.96	0.61	0.05	0.12	0.39	0.05	0.12	0.39	**0.03**	**0.07**	**0.24**	7.0%

FINAL DRAINAGE REPORT ~ SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	Intensity I(100)	Flow Q(5)	Flow Q(100)	Inlet Size
1	Basin A (14.2 AC.)	2.09	5.82	20.1	3.08	5.18	6	30	EX. 30" RCP CULVERT
2	Basin C (1.4 AC.)	0.48	0.76	16.9	3.34	5.61	2	4	5' TYPE R SUMP INLET
3	Basins B, OS-2 and D (9.47 AC.)	1.92	4.19	30.8	2.44	4.10	5	21	15' TYPE R SUMP INLET
4	Basins F and OS-7 (2.2 AC.)	0.98	1.37	16.7	3.36	5.63	2	8	EX. 10' TYPE R AT-GRADE INLET
5	Basins E and OS-3 (6.5 AC.)	1.56	3.03	17.7	3.27	5.50	5	17	EX. 15' TYPE R AT-GRADE INLET
6	Basin OS-1 (24.1 AC.)	2.17	8.68	29.8	2.49	4.18	5	35	PROP. TEMP. SEDIMENT BASIN
7	Basin OS-4 (3.3 AC.)	0.59	1.43	25.8	2.71	4.54	2	6	PROP. TYPE C CDOT INLET
8	Basin N (0.55 AC.)	0.30	0.39	7.8	4.50	7.55	1	3	5' TYPE R SUMP INLET
9	Basin M (0.54 AC.)	0.36	0.43	7.8	4.50	7.55	2	3	5' TYPE R SUMP INLET
10	Basins OS-4, N, M, O (5.0 AC.)	1.33	2.48	26.1	2.69	4.51	4	11	PROP. RAIN GARDEN 1
11	Basin OS-6 (5.9 AC.)	0.94	2.42	24.8	2.77	4.65	3	11	PROP. RIP-RAP RUNDOWN
12	Basins EX-7, K, L and EX-9 (40.8 AC.)	6.13	16.77	40.4	2.03	3.41	12	57	EX. DUAL 30" RCP CULVERTS

FINAL DRAINAGE REPORT ~ PIPE ROUTING SUMMARY

Pipe Run	Contributing Basins	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	Intensity I(100)	Flow Q(5)	Flow Q(100)	Pipe Size*
1	DP-1	2.09	5.82	20.1	3.08	5.18	6	30	30" RCP
2	DP-2	0.48	0.76	16.9	3.34	5.61	2	4	18" RCP
3	DP-3	1.92	4.19	30.8	2.44	4.10	5	21	30" RCP
4	PR-1, PR-2 and PR-3	4.50	10.77	20.9	3.03	5.08	14	55	36" RCP
5	DP-7	0.59	1.43	25.8	2.71	4.54	2	6	18" RCP
6	DP-8	0.30	0.39	7.8	4.50	7.55	1	3	18" RCP
7	DP-9	0.36	0.43	7.8	4.50	7.55	2	3	18" RCP
8	PR-6 and PR-7	0.66	0.81	7.8	4.50	7.55	3	6	24" RCP
9	PR-5, PR-8	1.25	2.24	26.0	2.69	4.52	3	10	24" RCP

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RETREAT AT TIMBERRIDGE FILING NO. 3
FINAL DRAINAGE REPORT
DEVELOPED DRAINAGE MAP

DESIGNED BY	MAW	SCALE	DATE 1/30/24
DRAWN BY	MAW	(H) 1"= 100'	SHEET 2 OF 2
CHECKED BY		(V) 1"= N/A	JOB NO. 1185.30

Design Procedure Form: Rain Garden (RG)

UD-BMP (Version 3.07, March 2018)

Designer: **Marc A. Whorton, P.E.**
Company: **Classic Consulting**
Date: **September 20, 2023**
Project: **Retreat at TimberRidge Filing No. 3**
Location: **Arroya Lane (Rain Garden 1)**

1. Basin Storage Volume	
A) Effective Imperviousness of Tributary Area, I_a (100% if all paved and roofed areas upstream of rain garden)	I_a = 22.4 %
B) Tributary Area's Imperviousness Ratio ($i = I_a/100$)	i = 0.224
C) Water Quality Capture Volume (WQCV) for a 12-hour Drain Time (WQCV= 0.8 * (0.91* i^3 - 1.19 * i^2 + 0.78 * i)	WQCV = 0.10 watershed inches
D) Contributing Watershed Area (including rain garden area)	Area = 217,800 sq ft
E) Water Quality Capture Volume (WQCV) Design Volume Vol = (WQCV / 12) * Area	V_{WQCV} = cu ft
F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm	d_6 = 0.42 in
G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume	$V_{WQCV\ OTHER}$ = 1,776 cu ft
H) User Input of Water Quality Capture Volume (WQCV) Design Volume (Only if a different WQCV Design Volume is desired)	$V_{WQCV\ USER}$ = cu ft
2. Basin Geometry	
A) WQCV Depth (12-inch maximum)	D_{WQCV} = 12 in
B) Rain Garden Side Slopes (Z = 4 min., horiz. dist per unit vertical) (Use "0" if rain garden has vertical walls)	Z = 4.00 ft / ft
C) Mimimum Flat Surface Area	A_{Min} = 976 sq ft
D) Actual Flat Surface Area	A_{Actual} = 1935 sq ft
E) Area at Design Depth (Top Surface Area)	A_{Top} = 2718 sq ft
F) Rain Garden Total Volume (V_T= ((A_{Top} + A_{Actual}) / 2) * Depth)	V_T= 2,327 cu ft
3. Growing Media	Choose One ◉ 18" Rain Garden Growing Media ○ Other (Explain):
4. Underdrain System	
A) Are underdrains provided?	Choose One ◉ YES ○ NO
B) Underdrain system orifice diameter for 12 hour drain time	
i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice	y = 1.5 ft
ii) Volume to Drain in 12 Hours	Vol_{12} = 1,776 cu ft
iii) Orifice Diameter, 3/8" Minimum	D_O = 1 1/16 in

Design Procedure Form: Rain Garden (RG)

Designer:	**Marc A. Whorton, P.E.**
Company:	**Classic Consulting**
Date:	**September 20, 2023**
Project:	**Retreat at TimberRidge Filing No. 3**
Location:	**Arroya Lane (Rain Garden 1)**

5. Impermeable Geomembrane Liner and Geotextile Separator Fabric A) Is an impermeable liner provided due to proximity of structures or groundwater contamination?	Choose One ○ YES ◉ NO
6. Inlet / Outlet Control A) Inlet Control	Choose One ○ Sheet Flow- No Energy Dissipation Required ◉ Concentrated Flow- Energy Dissipation Provided
7. Vegetation	Choose One ◉ Seed (Plan for frequent weed control) ○ Plantings ○ Sand Grown or Other High Infiltration Sod
8. Irrigation A) Will the rain garden be irrigated?	Choose One ○ YES ○ NO

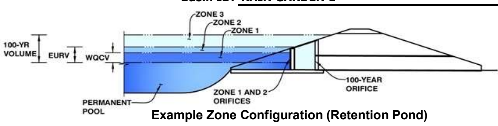
Notes:

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

Project: **RETREAT AT TIMBERRIDGE FILING NO. 3**

Basin ID: **RAIN GARDEN 1**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	**RG**			
Watershed Area =	5.00	acres		
Watershed Length =	1,000	ft		
Watershed Length to Centroid =	300	ft		
Watershed Slope =	0.044	ft/ft		
Watershed Imperviousness =	22.40%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	100.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Target WQCV Drain Time =	12.0	hours		
Location for 1-hr Rainfall Depths =	User Input			

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

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.042	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.112	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.118	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.209	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.294	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	0.430	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	0.529	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.664	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3.85 in.) =	1.221	acre-feet	3.85	inches
Approximate 2-yr Detention Volume =	0.078	acre-feet		
Approximate 5-yr Detention Volume =	0.114	acre-feet		
Approximate 10-yr Detention Volume =	0.179	acre-feet		
Approximate 25-yr Detention Volume =	0.217	acre-feet		
Approximate 50-yr Detention Volume =	0.230	acre-feet		
Approximate 100-yr Detention Volume =	0.279	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.042	acre-feet
Zone 2 Volume (100-year - Zone 1) =	0.238	acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =	0.279	acre-feet
Initial Surcharge Volume (ISV) =	N/A	ft^3
Initial Surcharge Depth (ISD) =	N/A	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	N/A	ft
Slope of Trickle Channel (S_{TC}) =	N/A	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 = 1.00 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)
Media Surface	--	0.00	--	--	--	1,922	0.044		
7234	--	1.50	--	--	--	3,119	0.072	3,781	0.087
7235	--	2.50	--	--	--	4,065	0.093	7,373	0.169
7236.5	--	4.00	--	--	--	5,688	0.131	14,687	0.337
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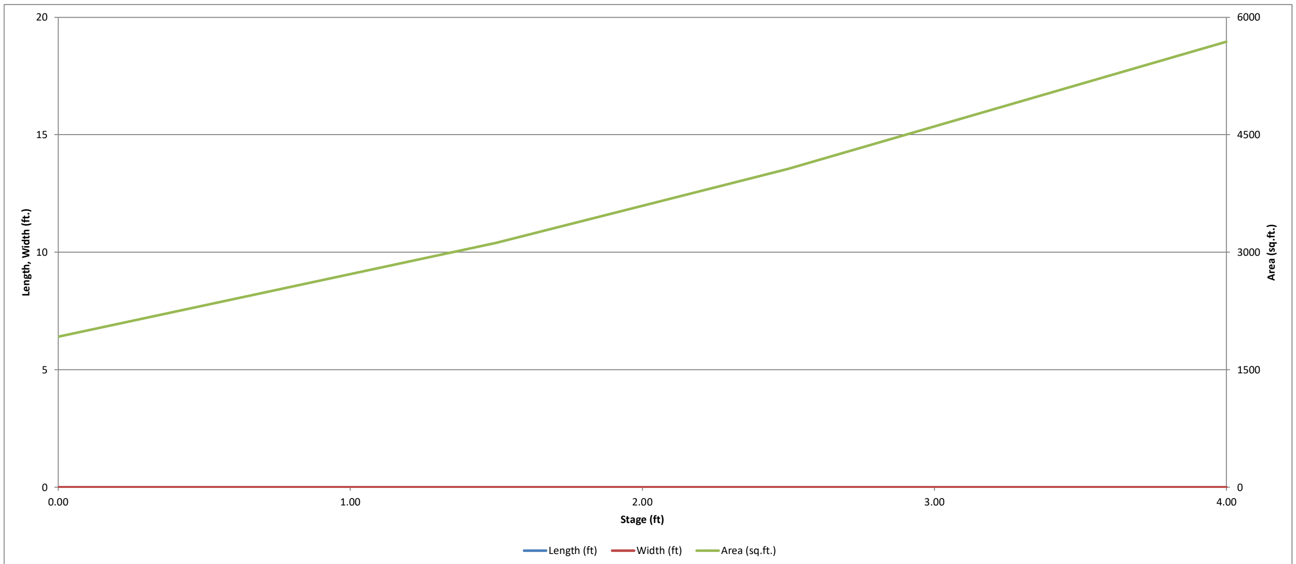
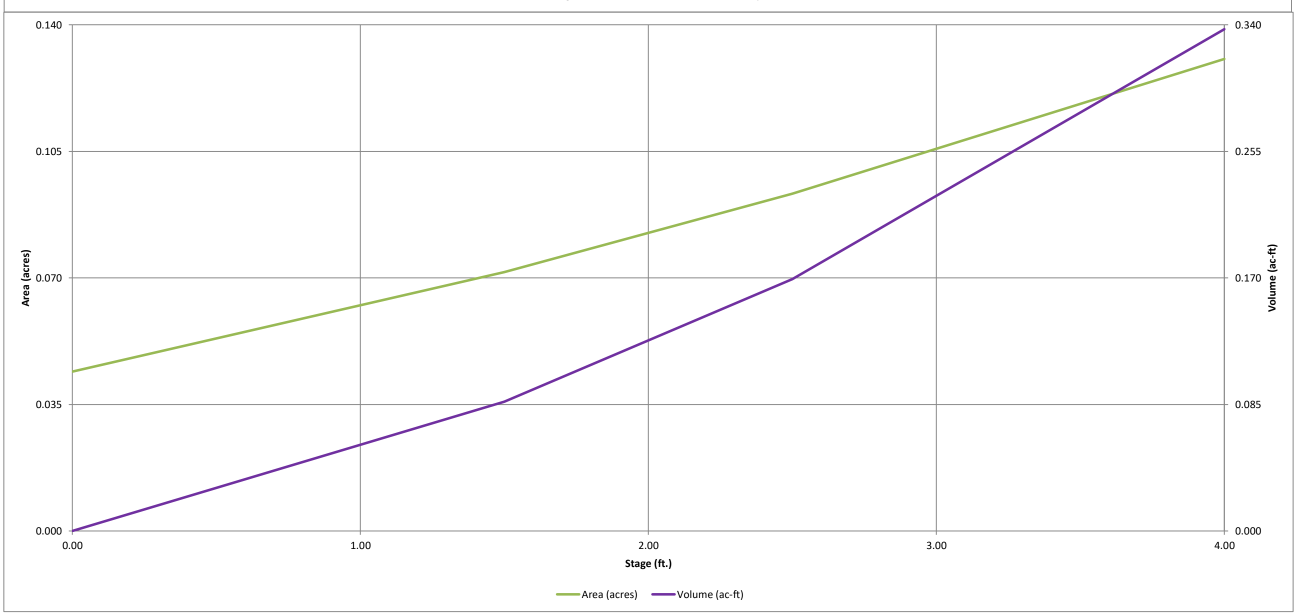
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

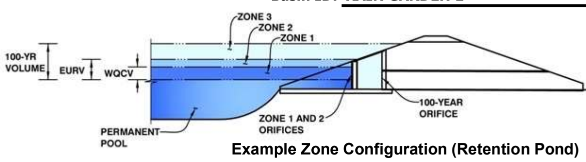




DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: **RETREAT AT TIMBERRIDGE FILING NO. 3**
Basin ID: **RAIN GARDEN 1**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.81	0.042	Filtration Media
Zone 2 (100-year)	3.54	0.238	Weir&Pipe (Restrict)
Zone 3			
Total (all zones)		0.279	

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

Underdrain Orifice Invert Depth =	1.50	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	1.08	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	0.0	ft^2
Underdrain Orifice Centroid =	0.05	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)

Centroid of Lowest Orifice =	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	N/A	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	N/A	inches
Orifice Plate: Orifice Area per Row =	N/A	sq. 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 (optional)	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)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Orifice Area (sq. inches)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	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)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Orifice Area (sq. inches)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

User Input: Vertical Orifice (Circular or Rectangular)

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

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =			ft^2
Vertical Orifice Centroid =			feet

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

	Zone 2 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	1.00	1.95	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	3.00		feet
Overflow Weir Grate Slope =	4.00		H:V
Horiz. Length of Weir Sides =	3.00		feet
Overflow Grate Type =	Close Mesh Grate		
Debris Clogging % =	50%		%

Calculated Parameters for Overflow Weir

	Zone 2 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	1.75		feet
Overflow Weir Slope Length =	3.09		feet
Grate Open Area / 100-yr Orifice Area =	9.67		
Overflow Grate Open Area w/o Debris =	7.34		ft^2
Overflow Grate Open Area w/ Debris =	3.67		ft^2

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

	Zone 2 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.00		ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	18.00		inches
Restrictor Plate Height Above Pipe Invert =	8.00		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 2 Restrictor	Not Selected	
Outlet Orifice Area =	0.76		ft^2
Outlet Orifice Centroid =	0.39		feet
Half-Central Angle of Restrictor Plate on Pipe =	1.46	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	2.50	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	10.00	feet
Spillway End Slopes =	3.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.39	feet
Stage at Top of Freeboard =	3.89	feet
Basin Area at Top of Freeboard =	0.13	acres
Basin Volume at Top of Freeboard =	0.32	acre-ft

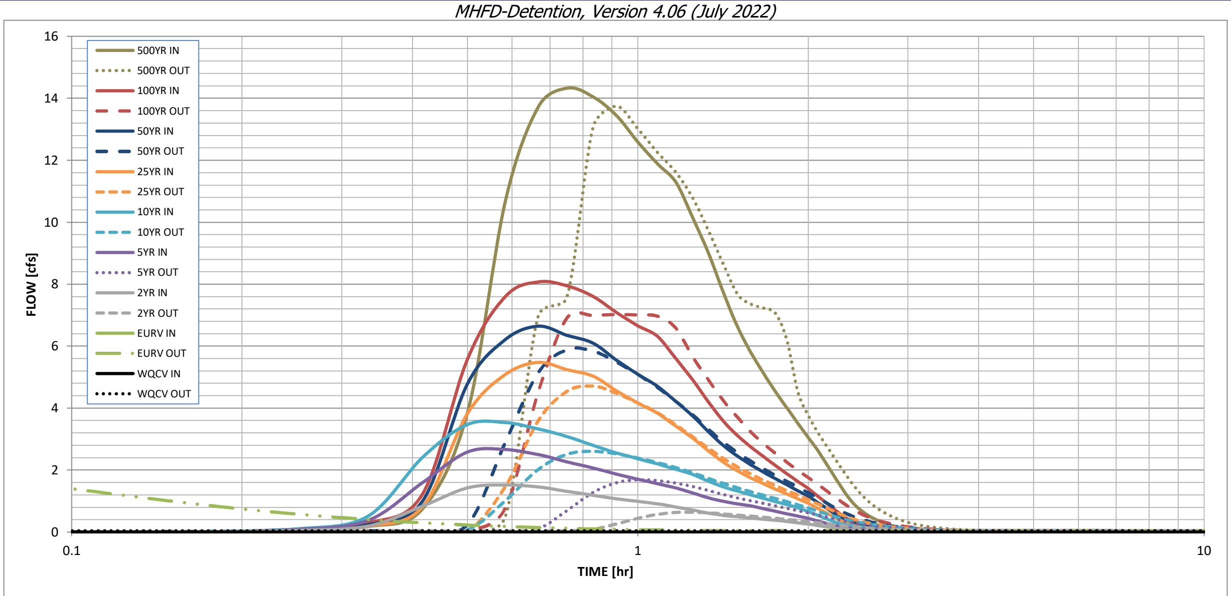
Routed Hydrograph Results

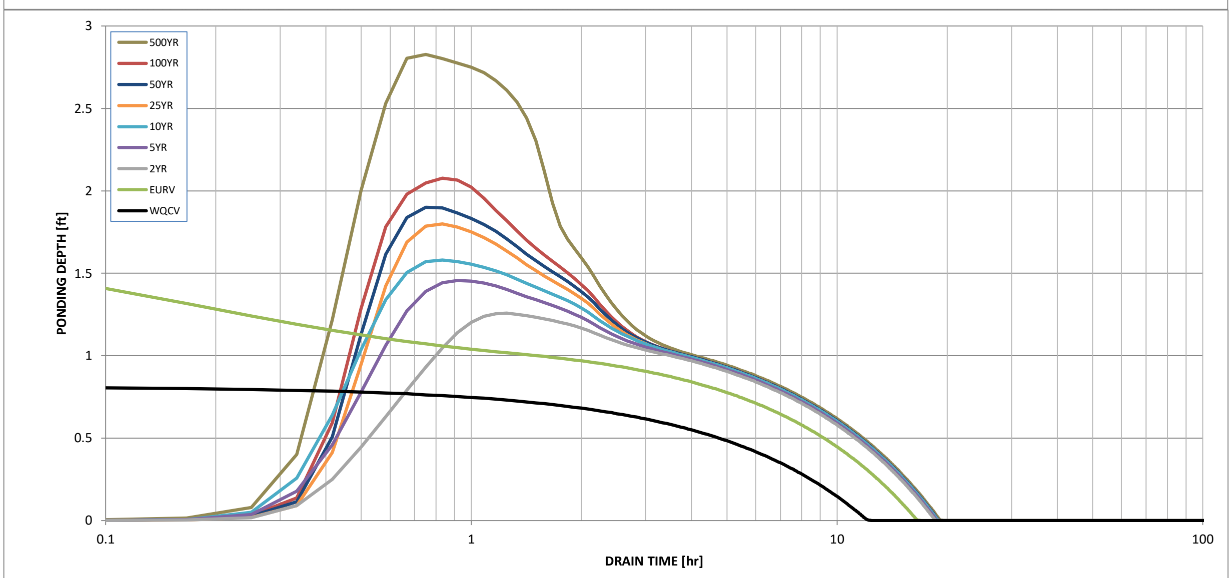
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

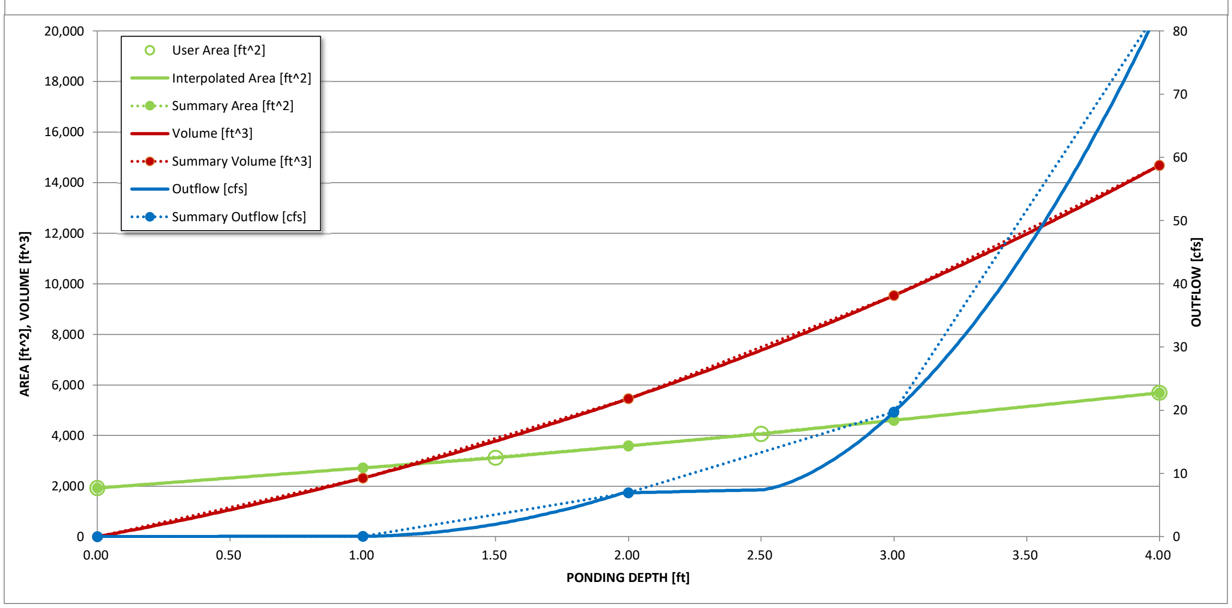
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.85
CUHP Runoff Volume (acre-ft) =	0.042	0.112	0.118	0.209	0.294	0.430	0.529	0.664	1.221
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.118	0.209	0.294	0.430	0.529	0.664	1.221
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.6	1.6	2.4	4.3	5.4	6.7	12.6
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.11	0.32	0.48	0.86	1.08	1.35	2.51
Peak Inflow Q (cfs) =	N/A	N/A	1.5	2.7	3.5	5.5	6.6	8.1	14.3
Peak Outflow Q (cfs) =	0.0	3.5	0.6	1.7	2.6	4.7	5.9	7.0	13.7
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.0	1.1	1.1	1.1	1.0	1.1
Structure Controlling Flow =	Filtration Media	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	0.70	0.08	0.2	0.3	0.6	0.8	0.9	1.0
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) =	12	16	18	17	16	15	14	13	9
Time to Drain 99% of Inflow Volume (hours) =	**12**	16	18	18	18	18	17	17	15
Maximum Ponding Depth (ft) =	0.82	1.84	1.26	1.46	1.58	1.80	1.90	2.08	2.83
Area at Maximum Ponding Depth (acres) =	0.06	0.08	0.07	0.07	0.07	0.08	0.08	0.08	0.10
Maximum Volume Stored (acre-ft) =	0.042	0.112	0.069	0.083	0.093	0.109	0.116	0.131	0.200

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)







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

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

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

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04
	0:15:00	0.00	0.00	0.05	0.09	0.11	0.07	0.09	0.09	0.17
	0:20:00	0.00	0.00	0.19	0.37	0.51	0.19	0.24	0.29	0.75
	0:25:00	0.00	0.00	0.83	1.59	2.41	0.81	1.00	1.21	3.85
	0:30:00	0.00	0.00	1.43	2.58	3.47	3.83	4.78	5.58	10.67
	0:35:00	0.00	0.00	1.52	2.66	3.54	5.08	6.21	7.60	13.72
	0:40:00	0.00	0.00	1.46	2.50	3.33	5.47	6.64	8.08	14.33
	0:45:00	0.00	0.00	1.31	2.27	3.08	5.24	6.35	7.94	14.05
	0:50:00	0.00	0.00	1.19	2.07	2.80	5.03	6.10	7.61	13.44
	0:55:00	0.00	0.00	1.08	1.87	2.56	4.56	5.55	7.09	12.59
	1:00:00	0.00	0.00	0.99	1.71	2.37	4.16	5.09	6.66	11.88
	1:05:00	0.00	0.00	0.91	1.56	2.20	3.83	4.70	6.31	11.29
	1:10:00	0.00	0.00	0.81	1.42	2.03	3.42	4.22	5.60	10.14
	1:15:00	0.00	0.00	0.71	1.26	1.86	3.02	3.74	4.91	9.00
	1:20:00	0.00	0.00	0.61	1.10	1.64	2.62	3.24	4.20	7.72
	1:25:00	0.00	0.00	0.54	0.99	1.46	2.25	2.79	3.58	6.63
	1:30:00	0.00	0.00	0.49	0.91	1.32	1.97	2.45	3.12	5.80
	1:35:00	0.00	0.00	0.45	0.84	1.20	1.75	2.17	2.75	5.13
	1:40:00	0.00	0.00	0.42	0.76	1.09	1.56	1.94	2.44	4.54
	1:45:00	0.00	0.00	0.38	0.67	0.99	1.39	1.72	2.15	4.01
	1:50:00	0.00	0.00	0.34	0.59	0.89	1.23	1.53	1.89	3.52
	1:55:00	0.00	0.00	0.30	0.52	0.78	1.08	1.34	1.64	3.05
	2:00:00	0.00	0.00	0.26	0.44	0.66	0.93	1.16	1.40	2.61
	2:05:00	0.00	0.00	0.21	0.35	0.53	0.76	0.95	1.15	2.13
	2:10:00	0.00	0.00	0.16	0.27	0.41	0.59	0.74	0.90	1.66
	2:15:00	0.00	0.00	0.12	0.19	0.30	0.43	0.54	0.66	1.22
	2:20:00	0.00	0.00	0.09	0.14	0.23	0.29	0.37	0.45	0.88
	2:25:00	0.00	0.00	0.07	0.11	0.19	0.21	0.27	0.32	0.65
	2:30:00	0.00	0.00	0.05	0.09	0.15	0.16	0.20	0.24	0.48
	2:35:00	0.00	0.00	0.04	0.07	0.12	0.12	0.15	0.17	0.36
	2:40:00	0.00	0.00	0.03	0.06	0.10	0.09	0.11	0.12	0.26
	2:45:00	0.00	0.00	0.03	0.05	0.08	0.07	0.09	0.08	0.19
	2:50:00	0.00	0.00	0.02	0.04	0.06	0.05	0.07	0.06	0.13
	2:55:00	0.00	0.00	0.02	0.03	0.05	0.04	0.05	0.04	0.09
	3:00:00	0.00	0.00	0.01	0.02	0.04	0.03	0.04	0.03	0.07
	3:05:00	0.00	0.00	0.01	0.02	0.03	0.02	0.03	0.03	0.06
	3:10:00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.05
	3:15:00	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.02	0.04
	3:20:00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.03
	3:25:00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02
	3:30:00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

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]
Media Surface	0.00	1,922	0.044	0	0.000	0.00
7235	1.00	2,720	0.062	2,321	0.053	0.05
7236	2.00	3,592	0.082	5,458	0.125	6.95
7237	3.00	4,606	0.106	9,540	0.219	19.73
7238	4.00	5,688	0.131	14,687	0.337	83.61

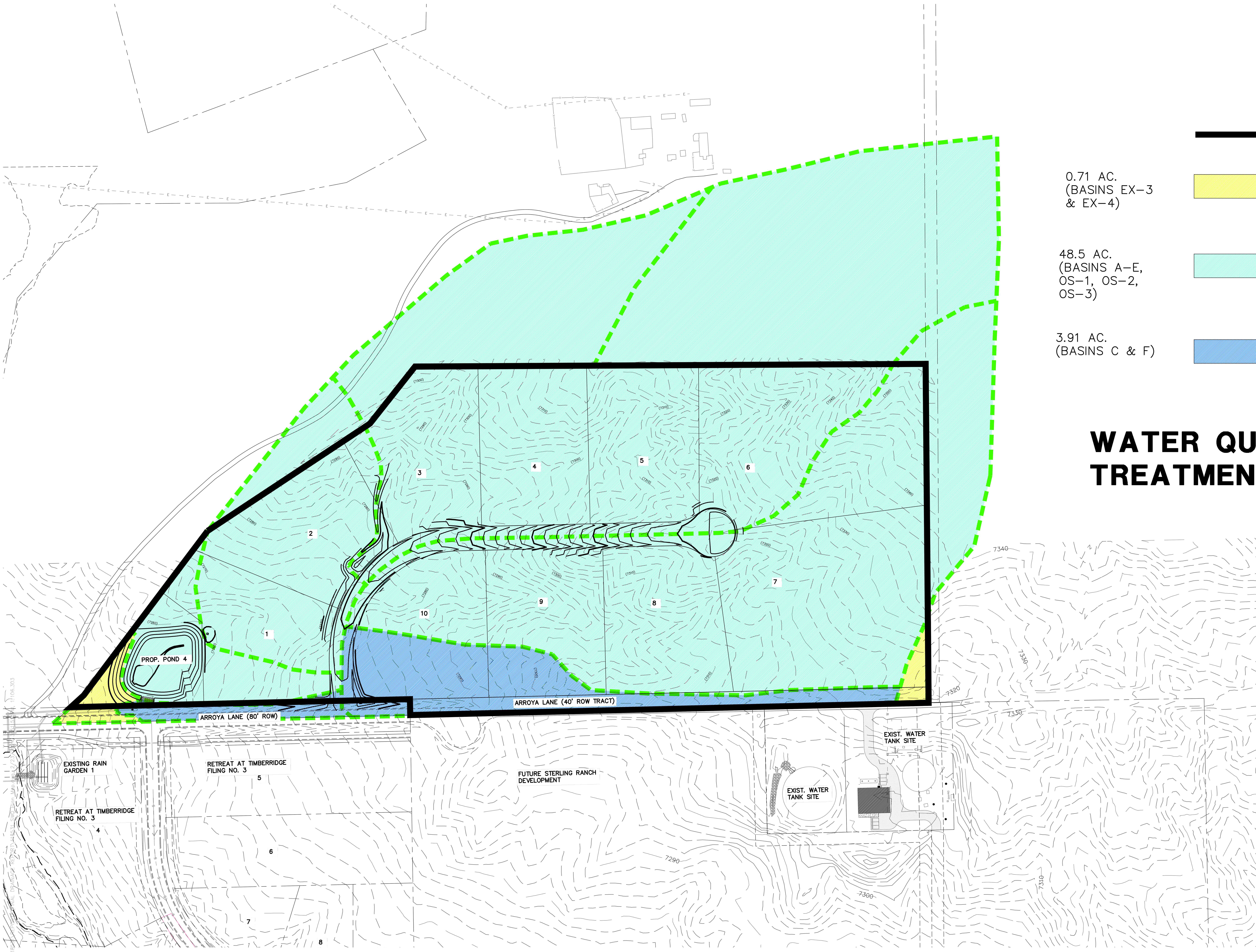
For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

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

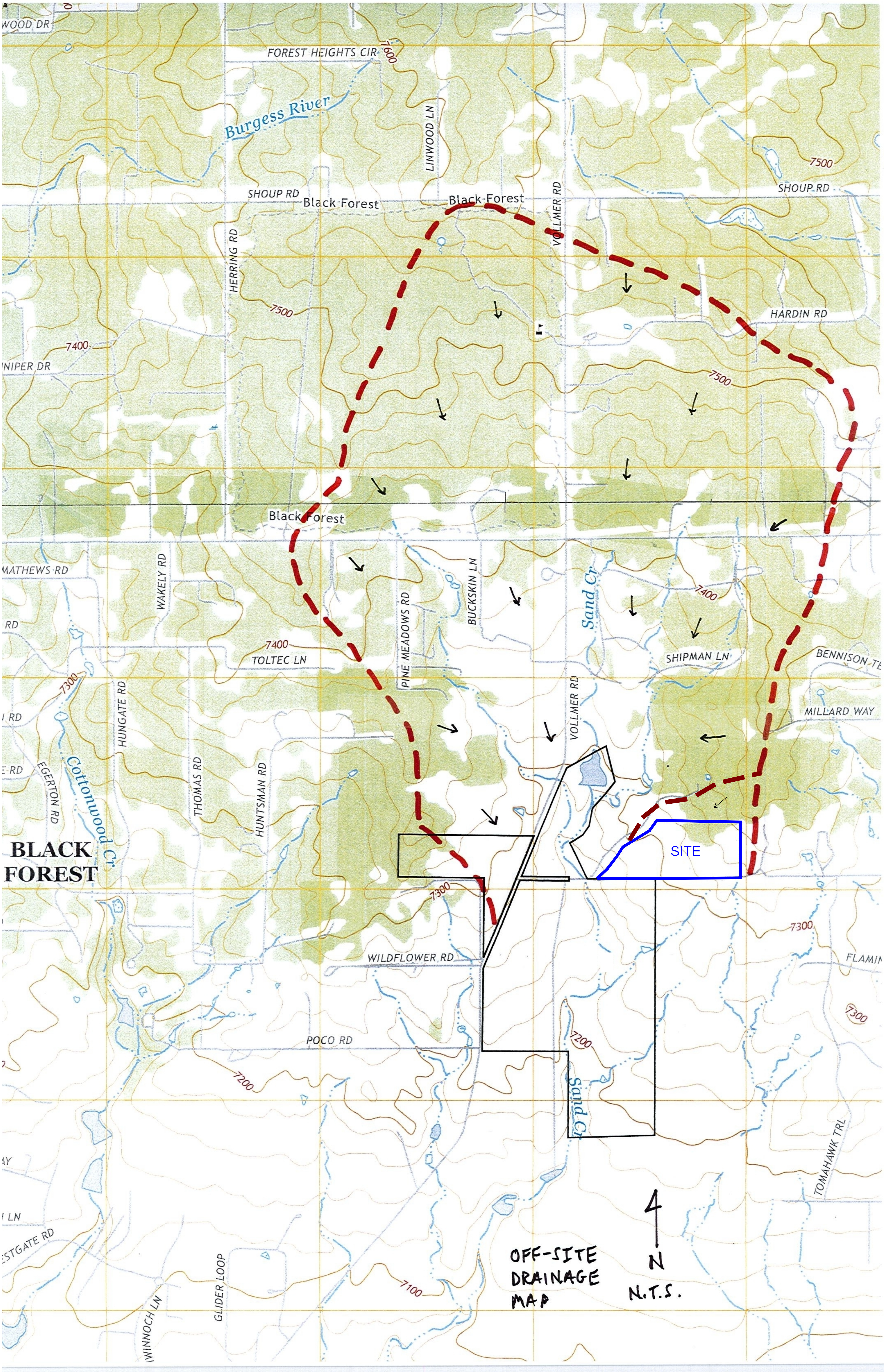
DRAINAGE MAPS

CLASSIC
CONSULTING
ENGINEERS & SURVEYORS

WATER QUALITY TREATMENT PLAN MAP



	(black line)	FILING 4 BOUNDARY LINE
0.71 AC. (BASINS EX-3 & EX-4)	(yellow)	AREA QUALIFIES FOR EXCLUSION I.7.1.C.1 (ECM) ALLOWS 20% NOT TO EXCEED 1.0 AC.
48.5 AC. (BASINS A-E, OS-1, OS-2, OS-3)	(light green)	AREA TREATED IN PROPOSED PERMANENT POND 4 FACILITY
3.91 AC. (BASINS C & F)	(blue)	AREAS TREATED IN EXISTING RAIN GARDEN 1 FACILITY



FOREST HEIGHTS CIR
Burgess River
LINWOOD LN
SHOUP RD
Black Forest
Black Forest
VOLLMER RD
SHOUP RD
HERRING RD
7500
HARDIN RD
7400
7500
Black Forest
MATHEWS RD
WAKELY RD
BUCKSKIN LN
Sand Cr
7400
PINE MEADOWS RD
7400
TOLTEC LN
SHIPMAN LN
BENNISON TE
7300
HUNGATE RD
VOLLMER RD
MILLARD WAY
EGERTON RD
Cottonwood Cr
THOMAS RD
HUNTSMAN RD
BLACK FOREST
SITE
7300
7300
WILDFLOWER RD
FLAMIN
7300
POCO RD
7200
7200
Sand Cr
TOMAHAWK TRL
ESTGATE RD
GLIDER LOOP
WINNOCH LN
7100
OFF-SITE DRAINAGE MAP
N
N.T.S.

BASIN RUNOFF COEFFICIENT SUMMARY

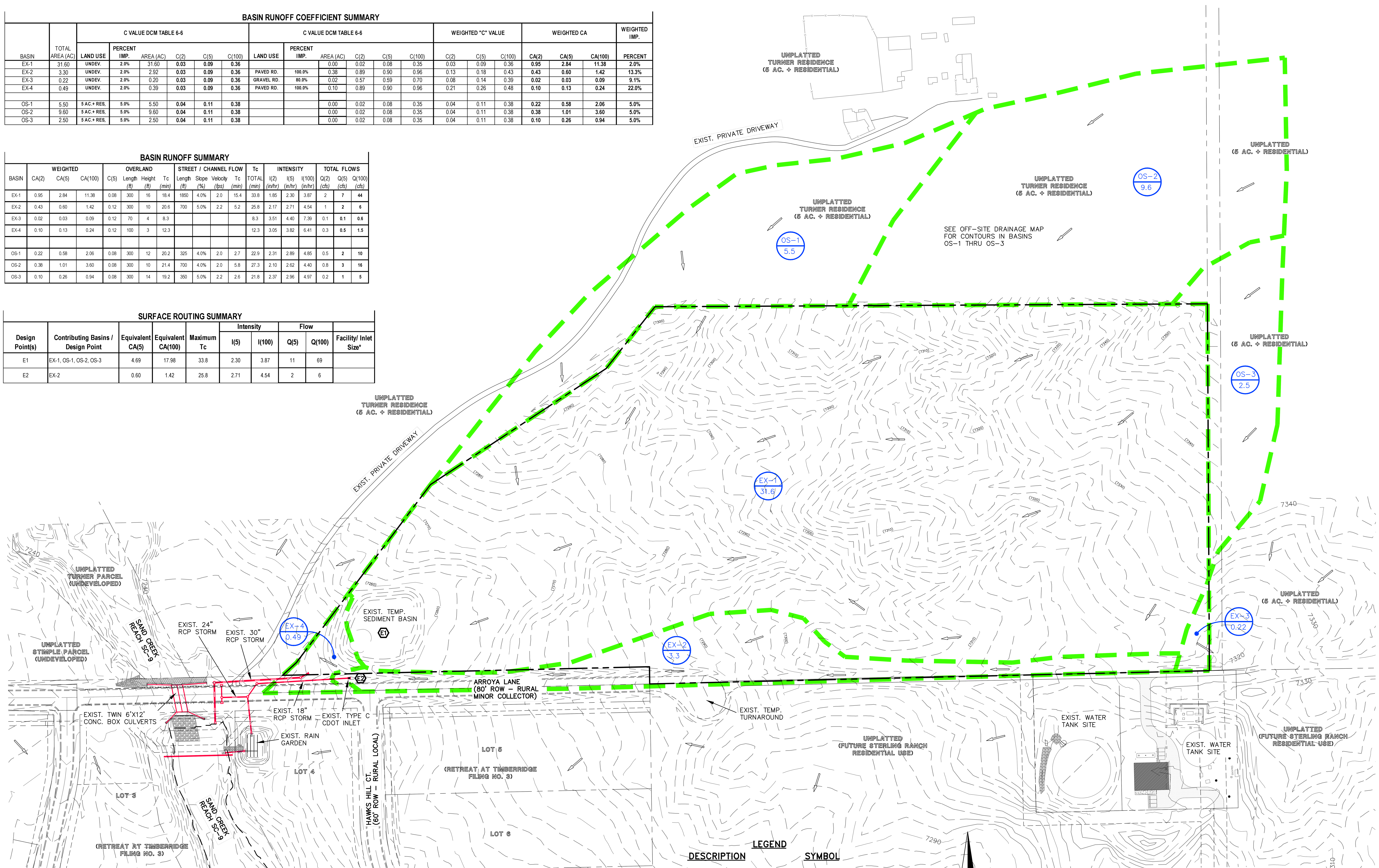
BASIN	TOTAL AREA (AC)	C VALUE DCM TABLE 6-6						C VALUE DCM TABLE 6-6						WEIGHTED "C" VALUE			WEIGHTED CA			WEIGHTED IMP.
		LAND USE	PERCENT IMP.	AREA (AC)	C(2)	C(5)	C(100)	LAND USE	PERCENT IMP.	AREA (AC)	C(2)	C(5)	C(100)	C(2)	C(5)	C(100)	CA(2)	CA(5)	CA(100)	PERCENT
EX-1	31.60	UNDEV.	2.0%	31.60	0.03	0.09	0.36			0.00	0.02	0.08	0.35	0.03	0.09	0.36	0.95	2.84	11.38	2.0%
EX-2	3.30	UNDEV.	2.0%	2.92	0.03	0.09	0.36	PAVED RD.	100.0%	0.38	0.89	0.90	0.96	0.13	0.18	0.43	0.43	0.60	1.42	13.3%
EX-3	0.22	UNDEV.	2.0%	0.20	0.03	0.09	0.36	GRAVEL RD.	80.0%	0.02	0.57	0.59	0.70	0.08	0.14	0.39	0.02	0.03	0.09	9.1%
EX-4	0.49	UNDEV.	2.0%	0.39	0.03	0.09	0.36	PAVED RD.	100.0%	0.10	0.89	0.90	0.96	0.21	0.26	0.48	0.10	0.13	0.24	22.0%
OS-1	5.50	5 AC.+ RES,	5.0%	5.50	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.22	0.58	2.06	5.0%
OS-2	9.60	5 AC.+ RES,	5.0%	9.60	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.38	1.01	3.60	5.0%
OS-3	2.50	5 AC.+ RES,	5.0%	2.50	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.10	0.26	0.94	5.0%

BASIN RUNOFF SUMMARY

BASIN	WEIGHTED			OVERLAND				STREET / CHANNEL FLOW				Tc	INTENSITY			TOTAL FLOWS		
	CA(2)	CA(5)	CA(100)	C(5)	Length (ft)	Height (ft)	Tc (min)	Length (ft)	Slope (%)	Velocity (fps)	Tc (min)	TOTAL (min)	I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)
EX-1	0.95	2.84	11.38	0.08	300	16	18.4	1850	4.0%	2.0	15.4	33.8	1.85	2.30	3.87	2	7	44
EX-2	0.43	0.60	1.42	0.12	300	10	20.6	700	5.0%	2.2	5.2	25.8	2.17	2.71	4.54	1	2	6
EX-3	0.02	0.03	0.09	0.12	70	4	8.3					8.3	3.51	4.40	7.39	0.1	0.1	0.6
EX-4	0.10	0.13	0.24	0.12	100	3	12.3					12.3	3.05	3.82	6.41	0.3	0.5	1.5
OS-1	0.22	0.58	2.06	0.08	300	12	20.2	325	4.0%	2.0	2.7	22.9	2.31	2.89	4.85	0.5	2	10
OS-2	0.38	1.01	3.60	0.08	300	10	21.4	700	4.0%	2.0	5.8	27.3	2.10	2.62	4.40	0.8	3	16
OS-3	0.10	0.26	0.94	0.08	300	14	19.2	350	5.0%	2.2	2.6	21.8	2.37	2.96	4.97	0.2	1	5

SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins / Design Point	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity		Flow		Facility/ Inlet Size*
					I(5)	I(100)	Q(5)	Q(100)	
E1	EX-1, OS-1, OS-2, OS-3	4.69	17.98	33.8	2.30	3.87	11	69	
E2	EX-2	0.60	1.42	25.8	2.71	4.54	2	6	



LEGEND

DESCRIPTION	SYMBOL
EXISTING GROUND CONTOUR	6910
BASIN BOUNDARY	
BASIN IDENTIFIER / AREA IN ACRES	BB 10.0
EXISTING DIRECTION OF FLOW	
EXISTING STORM SEWER	
DESIGN POINT	1

100 50 0 100 200

SCALE: 1" = 100'

N

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RETREAT AT TIMBERRIDGE FILING NO. 4
FINAL DRAINAGE REPORT
PRE-DEVELOPMENT DRAINAGE MAP

DESIGNED BY	MAW	SCALE	DATE 1/10/24
DRAWN BY	MAW	(H) 1"= 100'	SHEET 1 OF 2
CHECKED BY		(V) 1"= N/A	JOB NO. 1185.31

BASIN RUNOFF COEFFICIENT SUMMARY

BASIN	TOTAL AREA (AC)	C VALUE DCM TABLE 6-6 LAND USE	PERCENT IMP.	AREA (AC)	C(2)	C(5)	C(100)	C VALUE DCM TABLE 6-6 LAND USE	PERCENT IMP.	AREA (AC)	C(2)	C(5)	C(100)	WEIGHTED "C" VALUE C(2)	C(5)	C(100)	WEIGHTED CA CA(2)	CA(5)	CA(100)	WEIGHTED IMP. PERCENT
OS-1A	4.70	5 AC.+ RES,	5.0%	4.70	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.19	0.49	1.76	5.0%
OS-1B	0.80	5 AC.+ RES,	5.0%	0.80	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.03	0.08	0.30	5.0%
OS-2	9.60	5 AC.+ RES,	5.0%	9.60	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.38	1.01	3.60	5.0%
OS-3	2.50	5 AC.+ RES,	5.0%	2.50	0.04	0.11	0.38			0.00	0.02	0.08	0.35	0.04	0.11	0.38	0.10	0.26	0.94	5.0%
A	11.20	RES. 2.5 AC.	10.0%	8.10	0.06	0.13	0.40	RES. 5 AC.	5.0%	3.10	0.04	0.11	0.38	0.05	0.12	0.39	0.61	1.38	4.40	8.6%
B	13.40	RES. 2.5 AC.	10.0%	6.50	0.06	0.13	0.40	RES. 5 AC.	5.0%	6.90	0.04	0.11	0.38	0.05	0.12	0.39	0.67	1.57	5.19	7.4%
C	2.80	RES. 2.5 AC.	10.0%	2.45	0.06	0.13	0.40	PAVED ROAD	100.0%	0.35	0.89	0.90	0.96	0.16	0.23	0.47	0.46	0.63	1.32	21.3%
D	4.30	RES. 2.5 AC.	10.0%	4.30	0.06	0.13	0.40			0.00	0.05	0.12	0.39	0.06	0.13	0.40	0.26	0.56	1.72	10.0%
E	2.00	RES. 2.5 AC.	10.0%	0.85	0.06	0.13	0.40	POND TRACT	7.0%	1.15	0.05	0.12	0.39	0.05	0.12	0.39	0.11	0.25	0.79	8.3%
F	0.50	RURAL ROW	13.0%	0.40	0.07	0.16	0.41	PAVED ROAD	100.0%	0.10	0.05	0.12	0.39	0.07	0.15	0.41	0.03	0.08	0.20	30.4%

TOTAL AREA TRIBUTARY TO PROP. ON-SITE POND 48.50 7.1%

Basins tributaty to proposed on-site Pond
Basin tributary to exist. Rain Garden within RTR Fil. 3

BASIN RUNOFF SUMMARY

BASIN	WEIGHTED CA(2)	CA(5)	CA(100)	OVERLAND C(5)	Length (ft)	Height (ft)	Tc (min)	STREET / CHANNEL FLOW Length (ft)	Slope (%)	Velocity (fps)	Tc (min)	Tc TOTAL (min)	INTENSITY I(2) (in/hr)	I(5) (in/hr)	I(100) (in/hr)	TOTAL FLOWS Q(2) (cfs)	Q(5) (cfs)	Q(100) (cfs)
OS-1A	0.19	0.49	1.76	0.08	300	12	20.2	325	4.0%	2.0	2.7	22.9	2.31	2.89	4.85	0.4	1	9
OS-1B	0.03	0.08	0.30	0.08	200	8	16.5					16.5	2.70	3.38	5.67	0.1	0.3	1.7
OS-2	0.38	1.01	3.60	0.08	300	10	21.4	700	4.0%	2.0	5.8	27.3	2.10	2.62	4.40	0.8	3	16
OS-3	0.10	0.26	0.94	0.08	300	14	19.2	350	5.0%	2.2	2.6	21.8	2.37	2.96	4.97	0.2	1	5
A	0.61	1.38	4.40	0.08	300	14	19.2	1200	3.0%	1.7	11.5	30.7	1.96	2.44	4.10	1.2	3	18
B	0.67	1.57	5.19	0.08	300	16	18.4	1400	4.0%	2.0	11.7	30.0	1.99	2.48	4.16	1.3	4	22
C	0.46	0.63	1.32	0.08	300	13	19.7	200	1.5%	1.2	2.7	22.4	2.34	2.92	4.90	1	2	6
D	0.26	0.56	1.72	0.08	300	12	20.2	140	1.0%	2.0	1.2	21.4	2.39	2.99	5.02	1	2	9
E	0.11	0.25	0.79	0.08	300	16	18.4	140	1.0%	2.0	1.2	19.5	2.50	3.13	5.25	0.3	0.8	4
F	0.03	0.08	0.20	0.08	20	0.8	5.2	470	5.0%	2.2	3.5	8.7	3.46	4.34	7.28	0.1	0.3	1

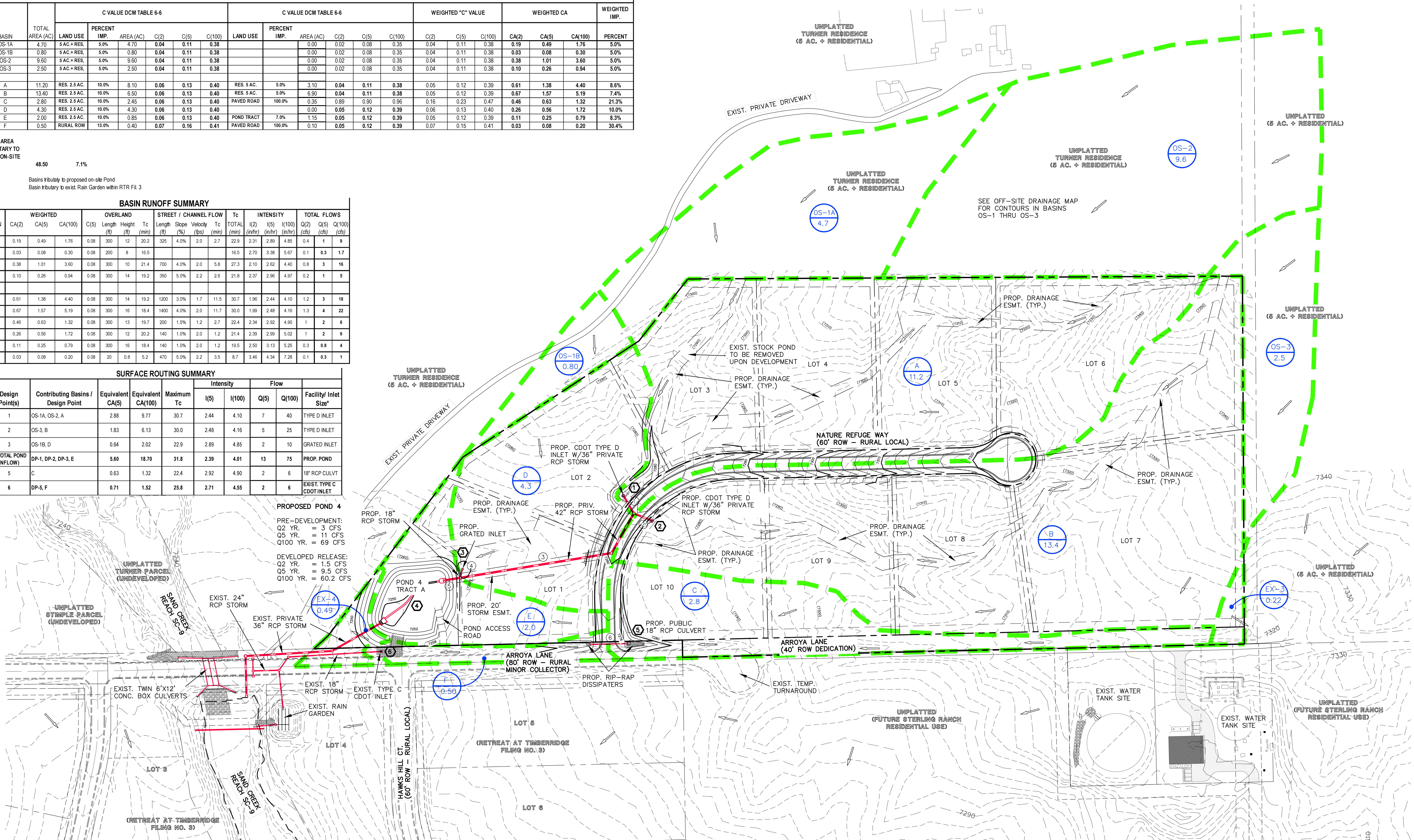
SURFACE ROUTING SUMMARY

Design Point(s)	Contributing Basins / Design Point	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	I(100)	Flow Q(5)	Q(100)	Facility/ Inlet Size*
1	OS-1A, OS-2, A	2.88	9.77	30.7	2.44	4.10	7	40	TYPE D INLET
2	OS-3, B	1.83	6.13	30.0	2.48	4.16	5	25	TYPE D INLET
3	OS-1B, D	0.64	2.02	22.9	2.89	4.85	2	10	GRATED INLET
4 (TOTAL POND INFLOW)	DP-1, DP-2, DP-3, E	5.60	18.70	31.8	2.39	4.01	13	75	PROP. POND
5	C	0.63	1.32	22.4	2.92	4.90	2	6	18" RCP CULVT
6	DP-5, F	0.71	1.52	25.8	2.71	4.55	2	6	EXIST. TYPE C CDOT INLET

PROPOSED POND 4

PRE-DEVELOPMENT:
Q2 YR. = 3 CFS
Q5 YR. = 11 CFS
Q100 YR. = 69 CFS

DEVELOPED RELEASE:
Q2 YR. = 1.5 CFS
Q5 YR. = 9.5 CFS
Q100 YR. = 60.2 CFS



PIPE ROUTING SUMMARY

Pipe Run	Contributing Basin / Design Point / Pipe Run	Equivalent CA(5)	Equivalent CA(100)	Maximum Tc	Intensity I(5)	I(100)	Flow Q(5)	Q(100)	Pipe Size*
1	DP-1	2.88	9.76	30.7	2.44	4.10	7	40	PROP. 36" RCP
2	DP-2	1.83	6.13	30.0	2.48	4.16	5	25	PROP. 36" RCP
3	PR-1, PR-2	4.71	15.88	31.3	2.42	4.05	11	64	PROP. 42" RCP
4	DP-3	0.65	2.03	22.9	2.89	4.85	2	10	PROP. 18" RCP
5	PR-3, PR-4 (42" RCP OUTFALL)	5.36	17.91	31.3	2.42	4.05	13	73	PROP. 42" RCP

LEGEND

DESCRIPTION	SYMBOL
EXISTING GROUND CONTOUR	6910
PROPOSED FINISHED CONTOUR	6910
BASIN BOUNDARY	
DESIGN POINT	1
PIPE RUN	8
BASIN IDENTIFIER	BB
AREA IN ACRES	10.0
EXISTING DIRECTION OF FLOW	
EXISTING/PROP. STORM SEWER	

100 50 0 100 200

SCALE: 1" = 100'

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RETREAT AT TIMBERRIDGE FILING NO. 4
FINAL DRAINAGE REPORT
DEVELOPED DRAINAGE MAP

DESIGNED BY	MAW	SCALE	DATE 1/10/24
DRAWN BY	MAW	(H) 1"= 100'	SHEET 2 OF 2
CHECKED BY		(V) 1"= N/A	JOB NO. 1185.31