MASTER DEVELOPMENT DRAINAGE PLAN AND FINAL DRAINAGE REPORT FOR BARNES AND MEDICAL VIEW APARTMENTS COLORADO SPRINGS, COLORADO

JANUARY 2019

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TABLE OF CONTENTS

REQUIRED MAPS AND DRAWINGS

GENERAL LOCATION MAP

S.C.S. SOILS MAP

FEMA FIRM MAP

HYDROLOGIC CALCULATIONS

HYDRAULIC CALCULATIONS

DETENTION CALCULATIONS

DRAINAGE MAP

MASTER DEVELOPMENT DRAINAGE PLAN AND FINAL DRAINAGE REPORT FOR BARNES AND MEDICAL VIEW APARTMENTS

ENGINEER'S STATEMENT:

This report and plan for the final drainage design of "BARNES AND MEDICAL VIEW APARTMENTS" was prepared by me (or under my direct supervision) and is correct to the best of my knowledge and belief. Said report and plan has been prepared in accordance with the City of Colorado Springs Drainage Criteria Manual and is in conformity with the master plan of the drainage basin. I understand that City of Colorado Springs does not and will not assume liability for drainage facilities designed by others. I accept responsibility for any liability caused by any negligent acts, errors or emissions on my part in preparing this report.

3-15-19

L DUCETT, P.E. 32339 Seal

COLORADO LICENSED 32339 PROFESSIONAL ENGINEER

DEVELOPER'S STATEMENT:

TIROL HOUSING LLC hereby certifies that the drainage facilities for BARNES AND MEDICAL VIEW APARTMENTS shall be constructed according to the design presented in this report. I understand that the City of Colorado Springs does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that are submitted to the City of Colorado Springs pursuant to section 7.7.906 of the City Code; and cannot, on behalf of TIROL HOUSING LLC, guarantee that the final drainage design review will absolve TIROL HOUSING LLC and/or their successors and/or assigns of future liability for improper design. I further understand that the approval of final plat does not imply approval of my engineer's drainage design.

TIROL HOUSING LLC

3/11/19

Authorized Signature Date

Derek Mannelin
Printed Name

Manager, Tirol Housing LLC
Title

16037 SW Lower Boones Ferry Road, Suite 150, Tigard, OR 97224
Address

City of Colorado Springs Statement:

Filed in accordance with Section 7-7-906 of the Code of the City of Colorado Springs, 2001, as amended.

For City Engineer 3/21/19

Conditions: Date

MASTER DEVELOPMENT DRAINAGE PLAN
AND FINAL DRAINAGE REPORT FOR
BARNES AND MEDICAL VIEW APARTMENTS
COLORADO SPRINGS, COLORADO

PURPOSE

The purpose of this Master Development Drainage Plan (MDDP) is to implement the concepts identified in the overall basin plan on the site. The purpose of this Final Drainage Report (FDR) is to identify and analyze the proposed drainage patterns, determine proposed runoff quantities, size storm sewer while reducing runoff to pre-developed rates and treating the water quality capture volume (WQCV).

DBPS

The Barnes and Medical View Apartments site lies within the Sand Creek Drainage Basin and is covered by the Sand Creek Drainage Basin Planning Study, Preliminary Design Report, dated January 1993 and revised March 1996.

GENERAL DESCRIPTION

This MDDP/FDR for "BARNES AND MEDICAL VIEW APARTMENTS (BAMVA)" is an analysis of approximately 11.633 acres located in Section 19, Township 13 South, Range 65 West of the Sixth Principal Meridian, City of Colorado Springs, CO. This MDDP/FDR is to accompany a Development Plan and the Final Plat for a portion that is being platted as BARNES AND MEDICAL VIEW APARTMENTS and will contain the proposed private full spectrum Extended Detention Basins used for reducing and treating runoff for the proposed apartment site and parking lot.

The site is bounded on the west by Barnes Corner Stop Lots 1 and 2, on the east by Medical View, on the north by the public right-of-way for the vacated portion of Comstock Loop, as well as Stetson Hills Subdivision Filing No. 24, and on the south by Barnes Road.

The areas north of this site have been previously studied and these studies were reviewed in the preparation of this report. They include the following drainage studies:

"Final Drainage Study for Stetson Hills Filing No. 17" dated January 1997 by Merrick and Company

"Final Drainage Study for Stetson Hills Filing No. 22" dated May 1997 by Merrick and Company

"Final Drainage Study for Stetson Hills Filing No. 23" dated July 1998 by Merrick and Company

"Stetson Hills Filing No. 24 Comstock Loop Final Drainage Report" dated June 1999 by Merrick and Company

Soils in the study area are shown as mapped by the S.C.S. in the "Soils Survey of El Paso County Area" (see Appendices). Soils for this project are evenly divided between Truckton Sandy Loam 97 (HSG A) and Stapleton-Bernal Sandy Loam 85 (HSG B). The undeveloped land is mainly covered with native grasses with some shrubs and trees. Due to previous overlot grading, HSG B will be used for the entire study area. (See map in appendix)

The site lies within the Sand Creek Drainage Basin and runoff ultimately flows into Fountain Creek.

The study area consists of undeveloped land that has existing vegetation consisting of established trees and native grasses & shrubs. The site drains from the north to south overland and into Barns Road right of way with average slopes of 2% to 33%. There is an existing 60" storm sewer main line that runs from the northwest to the southeast of the site and connects into the existing storm sewer in Barnes Road. This storm pipe does not appear to be in an existing easement. Title work shows no easement, however it is a public storm sewer and will be rerouted into the center of the drive aisle and reconnected to the main in Barnes Road. There will be a dedicated 20' public storm easement over this main dedicated on the final plat. There are no existing drainage studies for this site as it is unplatted and unstudied.

PROJECT CHARACTERISTICS

The site lies on in the west center portion of the Sand Creek Drainage Basin. There is a small amount of offsite flows entering the site from an area adjacent to the site. On the west side of the site existing roads and grading channels runoff and keeps it from entering the site. The northwest side of the site is where offsite runoff flows onto the site. Runoff flows parallel to the north boundary of the site. Medical View and Barnes Road on the east and southeast sides of the site are downstream from the

site.

The site drains from the north to south overland and into the Barnes Road right of way with average slopes of 2% to 33%. A steep sloped section runs across the west side of the site while slopes are shallower on the east side of the site. Detention ponds are proposed along the southeast edge of the site, apartments and their associated parking are proposed on the majority of the site, and a natural/landscaped area is proposed on the southwest corner of the site.

Soils in the study area are shown as mapped by the S.C.S. in the "Soils Survey of El Paso County Area" (see Appendices). Soils for this project are evenly divided between Truckton Sandy Loam 97 (HSG A) and Stapleton-Bernal Sandy Loam 85 (HSG B). The undeveloped land is mainly covered with native grasses with some shrubs and trees. Due to previous overlot grading, HSG B will be used for the entire study area. (See map in appendix)

The site is currently covered with native grasses and some shrubs and trees. No water ways exist on the site.

The site currently consists of 11.633 acres of open space, all of which is proposed for development as apartments.

HYDROLOGIC ANALYSIS FOR MDDP

MAJOR DRAINAGE BASIN

The site lies within the Sand Creek Drainage Basin and a majority of it is developed. Runoff is tributary to Sand Creek, and ultimately flows into Fountain Creek.

METHODOLOGY

The City of Colorado Springs Drainage Criteria, dated May 2014 was the resource used in calculating the runoff. The 5-year and 100-year design storm events were used in determining rainfall and runoff for the proposed drainage system per section 6 of the criteria. Runoff was calculated using the Rational Method for developed conditions. Runoff coefficients were calculated using weighted impervious values for each specific basin.

EXISTING MAJOR SUBBASIN DESCRIPTION (FOR MDDP)

With the existing Medical View private drive to the east, Barnes Road to the south and a private drive to the west keeping offsite flow from entering the site, the only offsite flow is along the northern boundary. Overall the site drains from the north to southeast corner of the site. As mentioned above there is an existing 60" public RCP storm sewer running through the site. This pipe carries flow from the developed areas to the north. The following is a description of the existing Basins, Design Points and the overall existing drainage characteristics for the development of Barnes and Medical View Apartments. (See Existing Drainage Map at the end of report).

Offsite Basin OS-B's 0.59 acres consists of undeveloped open space. Runoff (Q_5 = 3.4 cfs, Q_{100} = 22.6 cfs) sheet flows south onto Basin EXA and then is directed south overland.

Runoff (Q_5 = 3.4 cfs, Q_{100} = 22.6 cfs) from Basin EXA's 10.12 acres sheet flows over undeveloped land from the north to the south and then is directed east in a shallow swale. From here it the runoff ponds in a low area and then overtops and is directed into the north flowline of Barnes Road at the intersection of Medical View (Design Point EX1).

Basin EXB's 0.07 acres consists of a paved private drive along the west boundary of the site. Runoff (Q_5 = 0.3 cfs, Q_{100} = 0.5 cfs) sheet flows south into the north flowline of Barnes Road and then is directed east to Design Point EX1.

Offsite Basin OS-C's 0.04 acres consists of undeveloped open space. Runoff (Q_5 = 0.0 cfs, Q_{100} = 0.1 cfs) sheet flows south onto Basin EXC and then is directed south to Medical View private drive.

Basin EXC's 1.52 acres consists of a paved private drive along the west boundary of the site. Runoff (Q_5 = 1.4 cfs, Q_{100} = 4.5 cfs) sheet flows south into the west flowline of Medical View private drive and then is directed south to Design Point EX1.

Design Point EX-1 is located in the north flowline of Barnes Road at the intersection of Medical View. The combined runoff of the whole site and upstream offsite basins (Q_5 = 5.0 cfs, Q_{100} = 29.0 cfs) is then transported east in the north curb line of Barnes Road.

PROPOSED MAJOR SUBBASIN DESCRIPTION (FOR MDDP)

In the proposed condition offsite and onsite runoff will be directed to one of three Extended Detention Basins (EDB) that provide Water Quality and Full Spectrum Detention. The three ponds are labeled as West, Middle and East. The existing public 60" RCP storm Drain will be re-routed through the site and the outfalls from the three EDBs will tie into this re-routed storm before being transported south offsite. This 60" storm pipe does not appear to be in an existing easement. Title work shows no easement, however it is a public storm sewer and will be rerouted into the center of the drive aisle and reconnected to the main in Barnes Road. There will be a dedicated 20' public storm easement over this main dedicated on the final plat. The following is a description of the Basins, Design Points, storm drain, and the overall drainage characteristics for the development of Barnes and Medical View Apartments.

Basin A1's 2.13 acres is in the northwest corner of the site and will consist of paved parking, landscaping and open space. Runoff (Q_5 = 3.6 cfs, Q_{100} = 8.7 cfs) sheet flows south over the parking lot and is directed to a private 8' D10-R sump inlet (Design Point 2). Pipe Run 1 is a private 18" RCP will carry the flow into the West EDB (Design Point 2).

Basin A2's 0.05 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6" HDPE (Pipe Run 2) directly into the West EDB.

Basin A3's 0.05 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6" HDPE roof drain (Pipe Run 3) directly into the West EDB.

Basin A4's 0.17 acres consists of roof area. Runoff (Q_5 =0.6 cfs, Q_{100} = 1.2 cfs) is directed by a private 8" HDPE roof drain (Pipe Run 4) directly into the West EDB.

Basin A5's 0.11 acres consists of roof area. Runoff (Q_5 =0.4 cfs, Q_{100} = 0.8 cfs) is directed by a private 8" HDPE roof drain (Pipe Run 5) directly into the West EDB.

Basin A6's 0.06 acres consists of roof area. Runoff (Q_5 =0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6" HDPE roof drain (Pipe Run 6) directly into the West EDB.

Basin A7's 0.60 acres consists of landscaping and the West EDB. Runoff (Q_5 = 0.3 cfs, Q_{100} = 0.9 cfs) sheet flows into the West EDB (Design Point 2).

At Design Point 2, a 0.243 ac-ft private full spectrum Extended Detention Basin is proposed. The EDB was calculated using version 3.07 UD-Detention a spreadsheet supplied by Urban Drainage Control Flood District (see appendix). Based upon the 3.17 acres of area tributary from our site (contributing basins A1 through A7) and consisting of 40.10% impervious area. The bottom of the pond is 6571.00 and the top of pond is set at 6576.00. The pond design has a WQCV storage requirement of 0.048ac-ft. The corresponding water surface elevation is 6571.92. The required EURV storage volume of 0.088 ac-ft on top of the WQCV gives an elevation of 6572.65. The required 100-year storage volume of 0.107 ac-ft for a total of 0.243 ac-ft gives a 100-year elevation of 6573.37. The proposed forebay is 45 cu-ft in volume and meets the required 2% of the WQCV (see appendix for calculations). A metal plate over the outlet with one column containing three rows of 3/4" diameter holes spaced 6.6" apart will act as a water quality and EURV outlet. The release of the EURV is 0.01 cfs and will take 68 hours. A 2.0' x 2.0' inlet riser acts as the outlet structure, it is set at a grate elevation of 6572.65 and will route allowable runoff for the 100 year event. The proposed 15" outlet has a restrictor plate 4.25" above the invert giving a release of Q_{100}=2.0 cfs. This is in conformance within 90% of the allowable release rate of 2.2 cfs. A 5' emergency weir set at 6574.00 will also be installed per the city standards with d50 = 12"rip rap and will safely pass the 100-year developed flow downstream. Flow in the emergency overflow situation will flow into the ROW of Barnes Road with a 100 year runoff spillway flow depth of 0.44'.

Basin B1's 1.14 acres consists of paved parking, landscaping and open space. Runoff (Q_5 = 2.7 cfs, Q_{100} = 5.8 cfs) sheet flows south over the parking lot and is directed to a private 8' D10-R sump inlet. Pipe Run 29 a private 30" RCP will carry the flow into the Middle EDB (Design Point 8).

Offsite Basin OS-B1's 0.07 acres consists of undeveloped open space. Runoff (Q_5 =0.0 cfs, Q_{100} = 0.2 cfs) sheet flows south onto Basin B2 and then is directed south to Design Point 3.

Basin B2's 0.46 acres consists of paved parking, landscaping and open space. Runoff (Q_5 = 1.4 cfs,

Q_{100} = 2.8 cfs) sheet flows south over the parking lot and is directed to a private 4' D10-R sump inlet (Design Point 4). Pipe Run 31 a private 15" RCP will carry the combined flow of Design point 4 and Pipe Run 30 to a junction with Pipe Run 29.

Basin B3's 0.13 acres consists of paved parking and landscaping. Runoff (Q_5 = 0.5 cfs, Q_{100} = 1.0 cfs) sheet flows south over the parking lot and is directed to a private 4' D10-R sump inlet (Design Point 5). Pipe Run 30 a private 12" RCP will carry the flow across the driveway entrance to a junction at Design Point 4.

Offsite Basin OS-B2's 0.14 acres consists of undeveloped open space. Runoff (Q_5 =0.2 cfs, Q_{100} = 1.0 cfs) sheet flows south onto Basin B4 and then is directed south to Design Point 6.

Basin B4's 0.78 acres consists of paved parking, landscaping and open space. Runoff (Q_5 = 2.5 cfs, Q_{100} = 4.8 cfs) sheet flows south over the parking lot and is directed to a private 12' D10-R sump inlet (Design Point 6). Pipe Run 28 a private 30" RCP will carry the flow in to a junction at Design Point 3.

Basin B5's 0.47 acres consists of landscaping and the Middle EDB. Runoff (Q_5 = 0.2 cfs, Q_{100} = 1.5 cfs) sheet flows into the Middle EDB (Design Point 8).

Basin B6's 0.06 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6" HDPE (Pipe Run 51) directly into the Middle EDB.

Basin B7's 0.13 acres consists of roof area. Runoff (Q_5 = 0.5 cfs, Q_{100} = 0.9 cfs) is directed by a private 8" HDPE (Pipe Run 52) directly into the Middle EDB.

Basin B8's 0.10 acres consists of roof area. Runoff (Q_5 = 0.4 cfs, Q_{100} = 0.7 cfs) is directed by a private 8" HDPE (Pipe Run 53) directly into the Middle EDB.

Basin B9's 0.07 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6" HDPE (Pipe Run 54) directly into the Middle EDB.

Basin B10's 0.07 acres consists of roof area. Runoff (Q_5 = 0.3 cfs, Q_{100} = 0.5 cfs) is directed by a private 6" HDPE (Pipe Run 55) directly into the Middle EDB.

Basin B20's 0.07 acres consists of roof area. Runoff (Q_5 = 0.3 cfs, Q_{100} = 0.5 cfs) is directed by a private 8" HDPE (Pipe Run 7) to a junction with Pipe Run 8.

Basin B19's 0.07 acres consists of roof area. Runoff (Q_5 = 0.3 cfs, Q_{100} = 0.5 cfs) is directed by a private 8" HDPE (Pipe Run 8) to a junction with Pipe Run 7. Pipe Run 9 a private 12" HDPE routes the combined runoff (Q_5 = 0.5 cfs, Q_{100} = 1.0 cfs) to a junction with Pipe Run 10.

Basin B18's 0.11 acres consists of roof area. Runoff (Q_5 = 0.4 cfs, Q_{100} = 0.8 cfs) is directed by a private 8" HDPE (Pipe Run 10) to a junction with Pipe Run 9. Pipe Run 11 a private 12" HDPE routes the combined runoff (Q_5 = 0.9 cfs, Q_{100} = 1.8cfs) to a junction with Pipe Run 12.

Basin B17's 0.11 acres consists of roof area. Runoff (Q_5 = 0.4 cfs, Q_{100} = 0.8 cfs) is directed by a private 8" HDPE (Pipe Run 12) to a junction with Pipe Run 11. Pipe Run 13 a private 12" HDPE routes the combined runoff (Q_5 = 1.4 cfs, Q_{100} = 2.5 cfs) to a junction with Pipe Run 14.

Basin B16's 0.04 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.3 cfs) is directed by a private 6" HDPE (Pipe Run 14) to a junction with Pipe Run 13. Pipe Run 15 a private 12" HDPE routes the combined runoff (Q_5 = 1.5 cfs, Q_{100} = 2.8 cfs) to a junction with Pipe Run 16.

Basin B15's 0.05 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6" HDPE (Pipe Run 16) to a junction with Pipe Run 15. Pipe Run 17 a private 15" HDPE routes the combined runoff (Q_5 = 1.7 cfs, Q_{100} = 3.2 cfs) to a junction with Pipe Run 18.

Basin B14's 0.12 acres consists of roof area. Runoff (Q_5 = 0.5 cfs, Q_{100} = 0.8 cfs) is directed by a private 8" HDPE (Pipe Run 18) to a junction with Pipe Run 17. Pipe Run 19 a private 15" HDPE routes the combined runoff (Q_5 = 2.2 cfs, Q_{100} = 4.0 cfs) to a junction with Pipe Run 20.

Basin B13's 0.11 acres consists of roof area. Runoff (Q_5 = 0.4 cfs, Q_{100} = 0.8 cfs) is directed by a private 8" HDPE (Pipe Run 20) to a junction with Pipe Run 19. Pipe Run 21 a private 15" HDPE routes the combined runoff (Q_5 = 2.6 cfs, Q_{100} = 4.8 cfs) to a junction with Pipe Run 22.

Basin B12's 0.05 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6" HDPE (Pipe Run 22) to a junction with Pipe Run 21. Pipe Run 23 a private 15" HDPE routes the combined runoff (Q_5 = 2.8 cfs, Q_{100} = 5.1 cfs) to a junction with Pipe Run 24.

Basin B11's 0.05 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6" HDPE (Pipe Run 24) to a junction with Pipe Run 23. Pipe Run 25 a private 15" HDPE routes the combined runoff (Q_5 = 2.9 cfs, Q_{100} = 5.5 cfs) to a junction with Pipe Run 26.

Offsite Basin OS-B3's 0.36 acres consists of undeveloped open space. Runoff (Q_5 =0.2 cfs, Q_{100} = 1.1 cfs) sheet flows south onto Basin B21 and then is directed southwest to Design Point 7.

Basin B21's 0.53 acres consists of landscaping and open space. Runoff (Q_5 = 0.2 cfs, Q_{100} = 1.4 cfs) sheet flows south to a proposed swale along with offsite Basin OS-B3 and is directed to a private Type "C" inlet (Design Point 7). The combined runoff (Q_5 =0.4 cfs, Q_{100} = 2.4 cfs) is routed south via Pipe Run 26 a private 12" HDPE to a junction with Pipe Run 25. Pipe Run 27 a private 18" HDPE routes the combined runoff of (Q_5 = 2.9 cfs, Q_{100} = 7.0 cfs) southwest to a junction at Design Point 6. Pipe Run 28 a private 30" RCP routes the combined flow (Q_5 = 5.0 cfs, Q_{100} = 18.2 cfs) of Design Point 6 and Pipe Run 27 west to a junction at Design Point 3. Pipe Run 29 a private 30" RCP routes the combined flow (Q_5 = 7.4 cfs, Q_{100} = 23.6 cfs) of Design Point 3 and Pipe Run 28 south to a junction at with Pipe Run 31. Pipe Run 32 a private 30" RCP routes the combined flow (Q_5 = 9.2 cfs, Q_{100} = 27.5 cfs) of Pipe Runs 29 & 31 south to the Middle EDB (Design Point 8).

At Design point 8, a 0.529 ac-ft private full spectrum Extended Detention Basin is proposed. The EDB was calculated using version 3.07 UD-Detention a spreadsheet supplied by Urban Drainage Control Flood District (see appendix). Based upon the 5.29 acres of area tributary from our site (contributing basins B1 thru B-21 & OS-B1 thru OS-B3) and consisting of 54.60% impervious area. The bottom of the pond is 6564.00 and the top of pond is set at 6572.00. The pond design has a

WQCV storage requirement of 0.097 ac-ft. The corresponding water surface elevation is 6566.21. The required EURV storage volume of 0.231 ac-ft on top of the WQCV gives an elevation of 6568.24. The required 100-year storage volume of 0.202 ac-ft for a total of 0.529 ac-ft gives a 100-year elevation of 6569.49. The proposed forebay is 135 cu-ft in volume and meets the required 3% of the WQCV (see appendix for calculations). A metal plate over the outlet with one column containing three rows of 7/8" diameter holes spaced 16.9" apart will act as a water quality and EURV outlet. The release of the EURV is 0.1 cfs and will take 73 hours. A 2.0' x 2.0' inlet riser acts as the outlet structure, it is set at a grate elevation of 6568.24 and will route allowable runoff for the 100 year event. The proposed 15" outlet has a restrictor plate 5.50" above the invert giving a release of Q_{100}=4.2 cfs. This is in conformance within 90% of the allowable release rate of 4.7 cfs. A 11' emergency weir set at 6570.00 will also be installed per the city standards with d50 = 12"rip rap and will safely pass the 100-year developed flow downstream. Flow in the emergency overflow situation will flow into the ROW of Barnes Road with a 100 year runoff spillway flow depth of 0.50'.

Basin C1's 1.29 acres consists of paved parking and landscaping. Runoff (Q_5 = 3.2 cfs, Q_{100} = 6.5 cfs) sheet flows south over the parking lot and is directed to a private 8' D10-R sump inlet (Design Point 9). Pipe Run 41 a private 18" RCP will route the flow south to a junction with Pipe Run 42.

Offsite Basin OS-C's 0.06 acres consists of undeveloped open space. Runoff (Q_5 =0.0 cfs, Q_{100} = 0.2 cfs) sheet flows south onto Basin C2 and then is directed south to Design Point 10.

Basin C2's 0.45 acres consists of paved parking, open space and landscaping. Runoff (Q_5 = 1.3 cfs, Q_{100} = 2.8 cfs) sheet flows south over the parking lot and is directed to a private 4' D10-R sump inlet (Design Point 9). Pipe Run 42 a private 15" RCP will route the flow south to a junction with Pipe Run 41. Pipe Run 43 a private 18' RCP will route the combined runoff (Q_5 = 4.3 cfs, Q_{100} = 8.8 cfs) into the East EDB.

Basin C3's 0.07 acres consists of roof area. Runoff (Q_5 = 0.3 cfs, Q_{100} = 0.5 cfs) is directed by a private 8" HDPE (Pipe Run 33) to a junction with Pipe Run 34.

Basin C4's 0.05 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a

private 6” HDPE (Pipe Run 34) to a junction with Pipe Run 33. Pipe Run 35 a private 8’ HDPE routes the combined flow (Q_5 = 0.5 cfs, Q_{100} = 0.8 cfs) directly into the East EDB.

Basin C5’s 0.06 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6” HDPE (Pipe Run 36) directly into the East EDB.

Basin C6’s 0.11 acres consists of roof area. Runoff (Q_5 = 0.4 cfs, Q_{100} = 0.8 cfs) is directed by a private 8” HDPE (Pipe Run 37) directly into the East EDB.

Basin C7’s 0.11 acres consists of roof area. Runoff (Q_5 = 0.4 cfs, Q_{100} = 0.8 cfs) is directed by a private 8” HDPE (Pipe Run 38) directly into the East EDB.

Basin C8’s 0.06 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6” HDPE (Pipe Run 39) directly into the East EDB.

Basin C9’s 0.06 acres consists of roof area. Runoff (Q_5 = 0.2 cfs, Q_{100} = 0.4 cfs) is directed by a private 6” HDPE (Pipe Run 40) directly into the East EDB.

Basin C10’s 0.44 acres consists of landscaping and the East EDB. Runoff (Q_5 = 0.2 cfs, Q_{100} = 1.4 cfs) sheet flows into the East EDB (Design Point 11).

At Design point 11, a 0.301 ac-ft private full spectrum Extended Detention Basin is proposed. The EDB was calculated using version 3.07 UD-Detention a spreadsheet supplied by Urban Drainage Control Flood District (see appendix). Based upon the 2.76 acres of area tributary from our site (contributing basins C1 thru C10) and consisting of 60.10% impervious area. The bottom of the pond is 6572.00 and the top of pond is set at 6578.00. The pond design has a WQCV storage requirement of 0.054 ac-ft. The corresponding water surface elevation is 6573.85 The required EURV storage volume of 0.137 ac-ft on top of the WQCV gives an elevation of 6575.45. The required 100-year storage volume of 0.110 ac-ft for a total of 0.301 ac-ft gives a 100-year elevation of 6576.30. The proposed forebay is 48 cu-ft in volume and meets the required 2% of the WQCV (see appendix for calculations). A metal plate over the outlet with one column containing three rows of 3/4” diameter

holes spaced 15.7" apart will act as a water quality and EURV outlet. The release of the EURV is 0.1 cfs and will take 76 hours. A 2.0' x 2.0' inlet riser acts as the outlet structure, it is set at a grate elevation of 6575.45 and will route allowable runoff for the 100 year event. The proposed 15" outlet has a restrictor plate 3.10" above the invert giving a release of Q_{100}=2.0 cfs. This is in conformance within 90% of the allowable release rate of 2.2 cfs. A 10' emergency weir set at 6576.40 will also be installed per the city standards with d50 = 12"rip rap and will safely pass the 100-year developed flow downstream. Flow in the emergency overflow situation will flow into the ROW of Barnes Road with a 100 year runoff spillway flow depth of 0.35'.

The runoff (Q_5 =0.0 cfs, Q_{100} = 0.2 cfs) from the West EDB outlet is routed east via Pipe Run 44 a private 15" HDPE to a junction with Pipe Run 45. Pipe Run 45 a private 15" HDPE routes the Middle EDB pond runoff of (Q_5 = 0.1 cfs, Q_{100} = 4.4 cfs) to a junction with Pipe Run 44. Pipe Run 46 a private 18" RCP routes the combined flow (Q_5 = 0.1 cfs, Q_{100} = 6.4 cfs) of Pipe Runs 44 & 45 west to a junction at with Pipe Run 47. Pipe Run 47 a public 60" RCP routes the existing flow of (Q_{100} = 347.2 cfs) of the upstream development to a junction at with Pipe Run 46. Pipe Run 48 a public 60" RCP routes the combined flow (Q_{100} = 353.6 cfs) of Pipe Runs 46 & 47 west to a junction at with Pipe Run 49. Pip run 49 (Q_5 = 0.0 cfs, Q_{100} = 2.0 cfs) routes the outlet flow from the East EDB to a junction with Pipe Run 48. Pipe Run 50 an existing public 60" RCP routes the combined flow (Q_{100} = 355.6 cfs) south offsite.

Basin D's 1.06 acres consists of landscaping and sidewalk along the west, south and east boundary that sheet flows into the adjacent streets. Runoff (Q_5 = 3.1 cfs, Q_{100} = 6.6 cfs) is directed by curb and gutter to the north flowline of Barnes Road at the intersection of Medical View. It is then transported east in the north curb line of Barnes Road. The developed flow is less than the historic flow of Q_5 = 5.0 cfs, Q_{100} = 29.0 cfs.

In an effort to protect receiving water and as part of the "four step process to minimize adverse impacts of urbanization" this site was analyzed in the following manner:

1. Reduce Runoff- The new improvements and impervious area to the site will be routed to a proposed private extended detention basins (EDB). In addition to this runoff will be trapped behind the back of walks and curbs and in some of the landscape areas. These above

mentioned items will reduce the volume of runoff using ponding and infiltration.

2. Treat Slowly Release WQCV- The EDBs have been sized and designed to sufficiently capture the required WQCV and slowly release it though the 3 hole outlet, thereby also allowing solids and contaminants to settle out.
3. Stabilize Stream Channel- By paying drainage fees to plat this site, funds will be available to stabilize the Sand Creek Channel. Also, there is no channel adjacent to this property and flows are conveyed to the creek via concrete storm pipes.
4. Source Controls- As this development includes a parking lot, there is a potential for spills and the potential for the introduction of contaminants to the City's MS4. The owner shall keep on hand a spill kit and follow all Federal and State regulations.

HYDROLOGIC CALCULATIONS

Hydrologic calculations were performed using the City of Colorado Springs Drainage Criteria Manual Volumes 1 & 2 May 2014. The Rational Method was used to estimate storm water runoff anticipated from design storms with 5-year and 100-year recurrence intervals.

HYDRAULIC CALCULATIONS

Hydraulic calculations were estimated using the Manning's Formula and the methods described in the City of Colorado Springs Drainage Criteria Manual Volumes 1 & 2 May 2014. The pertinent data sheets are included in the appendix of this report. It is requested that the HGL calculations and plots be provided in an addendum at the time of storm sewer plan submittal. The HGL calculations will be performed using the software UDSEWER (or similar).

WATER QUALITY

In the design of the Extended Detention Basins the City of Colorado Springs Drainage Criteria Volume 2 and the Urban Drainage and Flood Control District Manual Volume 3 were used in the design. The three proposed Extended Detention Basins together collect and treat runoff from nearly the entire site. Calculations can be found in the appendix under EDB Calculations.

FLOODPLAIN STATEMENT

No portion of this site is within a designated F.E.M.A. floodplain, as determined by Flood Insurance Rate Map No. 08041C0539 F dated March 17, 1997 (see appendix).

EROSION CONTROL

It is the policy of the City of Colorado Springs that we submit an erosion control plan with the drainage report. At this time, we respectfully request that the erosion control plan be submitted in conjunction with the grading and erosion control plan. Proposed straw bale check dams, silt fence, vehicle traffic control, and reseeding are proposed as erosion control measures.

CONSTRUCTION COST OPINION

Private Drainage Facilities Improvements (non-Reimbursable)

	Description	Quantity	Unit Price	Cost
1.	6" HDPE	300 LF	$ 20	$ 6,000
2.	8" HDPE	220 LF	$ 25	$ 5,500
3.	12" HDPE	420 LF	$ 30	$ 12,600
4.	15" HDPE	800 LF	$ 35	$ 28,000
5.	18" HDPE	140 LF	$ 45	$ 6,300
6.	30" RCP	385 LF	$ 65	$ 25,025
7.	4' 10-R INLET	3 EA	$ 4,000	$ 12,000
8.	8' 10-R INLET	3 EA	$ 6,000	$ 18,000
9.	12' 10-R INLET	1 EA	$ 8,000	$ 8,000
10.	Type "C" Inlet	1 EA	$ 2,500	$ 2,500
			Total	**$ 123,925**

Private Permanent BMPs (non-Reimbursable)

	Description	Quantity	Unit Price	Cost
1.	Extended Detention Basins (3)			
	- Earthwork	1,731 CY	$ 12	$ 20,772
	- Forebays	3 EA	$ 1,500	$ 4,500
	- Trickle Channel	564 LF	$ 32	$ 18,048

- Outlet Structures (2'x2')	3 EA	$ 3,300	$ 9,900
- Emergency Spillways	3 EA	$ 1,500	$ 4,500
- Access Roads	3 EA	$ 500	$ 1,500
- Stabilization	3 EA	$ 5,000	$ 15,000
		Subtotal	$ 74,220
		10% Contingency	$ 7,422
		Total	**$ 81,642**

Public Drainage Facilities Improvements (non-Reimbursable)

	Description	Quantity	Unit Price	Cost
1.	60" RCP	450 LF	$ 100	$ 45,000
2.	Type 1 MH	4 EA	$ 5,000	$ 20,000
			Total	**$ 65,000**

DRAINAGE FEES

This site is not currently platted, is being platted as part of this development, and is located in the Sand Creek Drainage Fee Basin. Fees for this site will be calculated as follows:

Sand Creek Drainage Fee Basin 2019

Drainage	$12,645/acre	x	11.633 acres	=	$ 147,099
Bridge	$761/acre	x	11.633 acres	=	$ 8,853
Pond Land	$1,070/acre	x	11.633 acres	=	$ 12,447
Pond Facility	$3,676/acre	x	11.633 acres	=	$ 42,763
Surcharge	$1,333/acre	x	11.633 acres	=	$ 15,507
				Total	**$ 226,669**

*Fees are due prior to plat recordation

MAINTENANCE

The three proposed Extended Detention Basins will be privately maintained. The proposed storm sewers include both private and public lines. The private lines will be privately maintained and the public lines will be maintained by the City.

SUMMARY

Development of this site will not adversely affect the surrounding development. Site runoff and storm drain appurtenances from Barnes and Medical View Apartments will not adversely affect the downstream and surrounding developments and will be safely routed to the proposed extended detention basins and runoff reduced to the allowable pre-developed rates while slowly treating the water quality capture volume and in turn helping to stabilize the downstream stream and channel banks. This report is in general conformance with all previously approved reports which included this site.

PREPARED BY:
TERRA NOVA ENGINEERING, INC.

L Ducette, P.E.
President

BIBLIOGRAPHY

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

"Sand Creek Drainage Basin Planning Study, Preliminary Design Report, dated January 1993 and revised March 1996"

SCS Soils Map for El Paso County

FEMA Floodplain Map

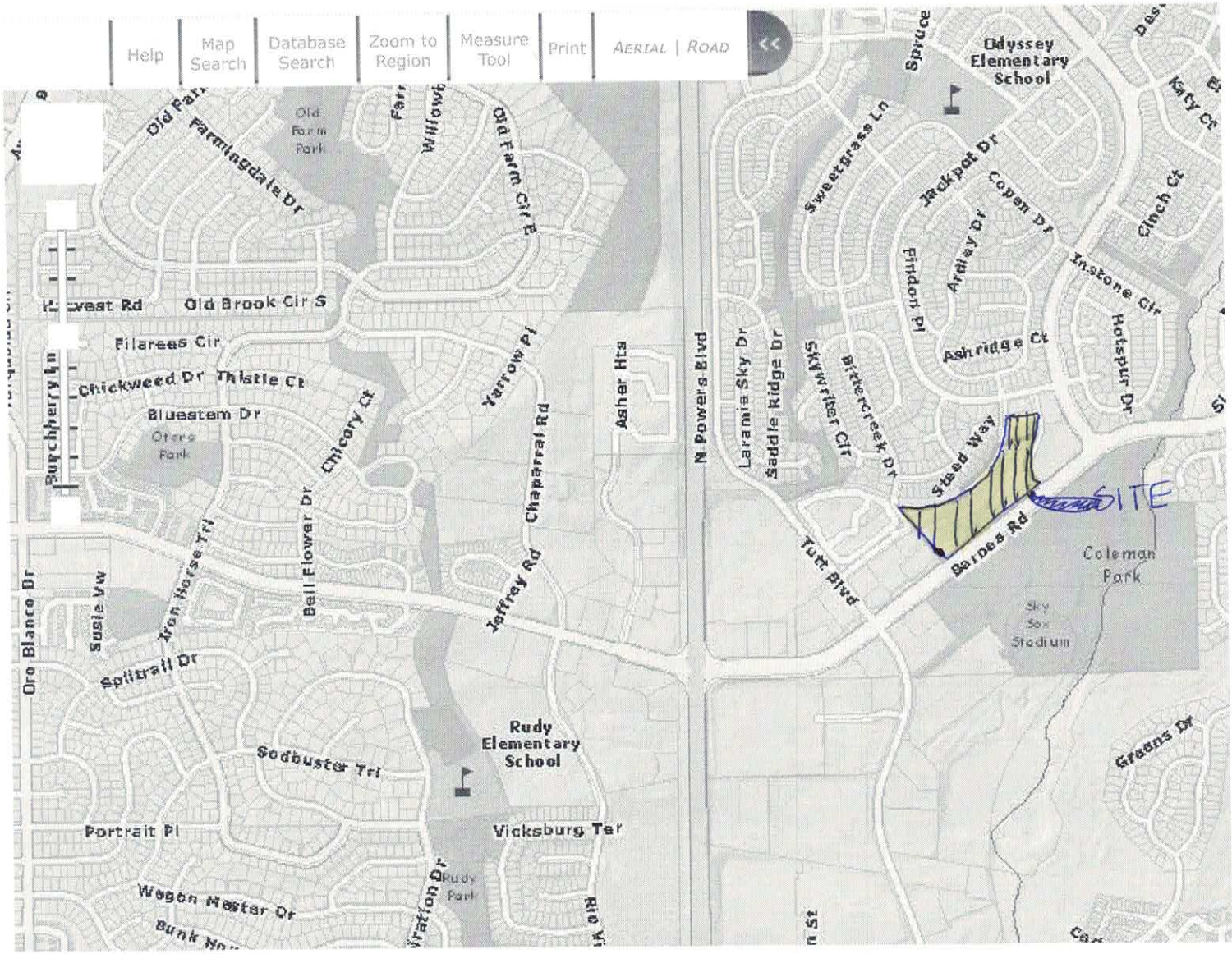
"Final Drainage Study for Stetson Hills Filing No. 17" dated January 1997 by Merrick and Company

"Final Drainage Study for Stetson Hills Filing No. 22" dated May 1997 by Merrick and Company

"Final Drainage Study for Stetson Hills Filing No. 23" dated July 1998 by Merrick and Company

"Stetson Hills Filing No. 24 Comstock Loop Final Drainage Report" dated June 1999 by Merrick and Company

GENERAL LOCATION MAP



A Vicinity Map
N N.T.S.

0 0.15 0.3mi

S.C.S. SOILS MAP

Search

Map Unit Legend

El Paso County Area, Colorado (CO625)

El Paso County Area, Colorado (CO625)

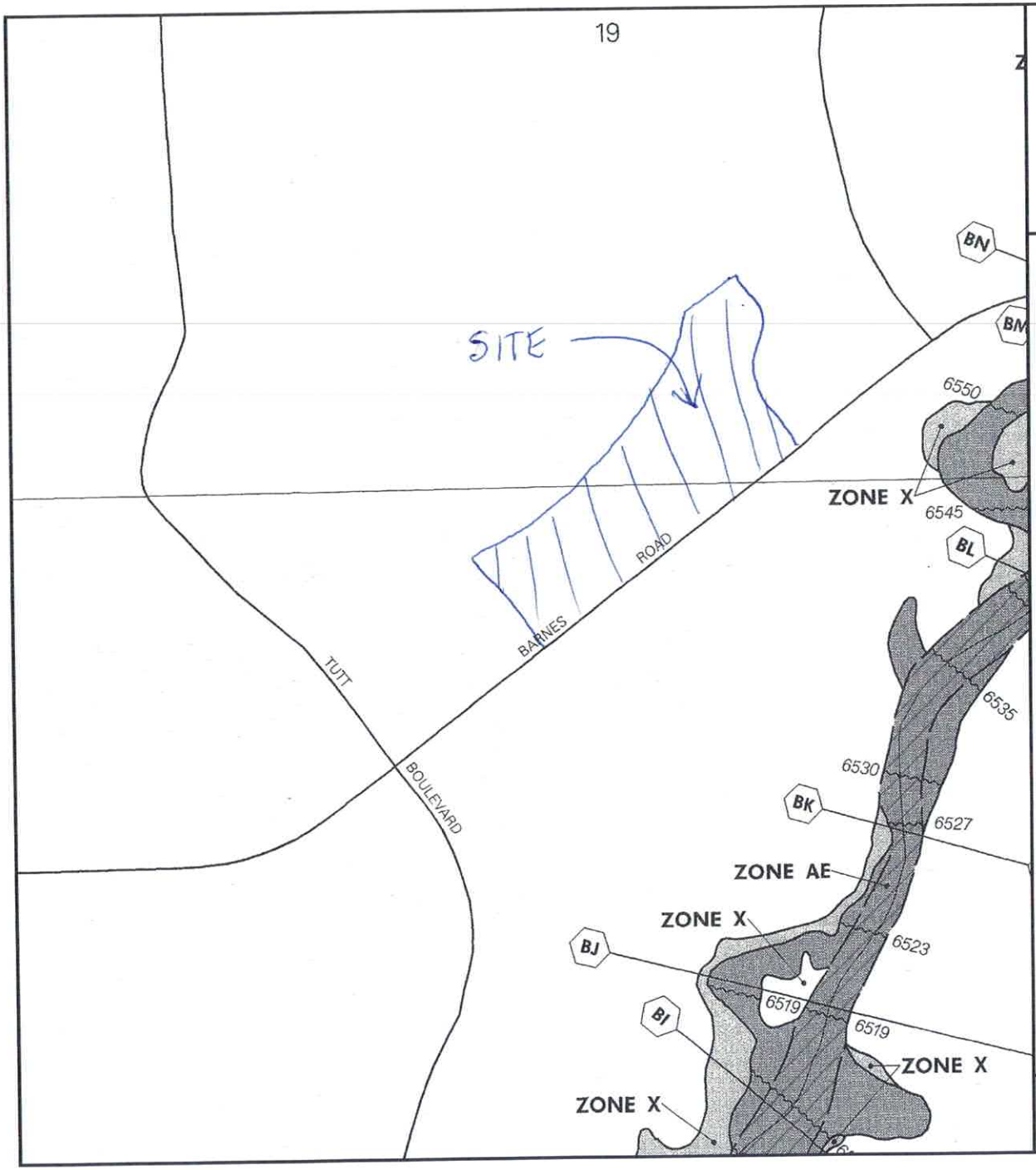
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
85	Stapleton-Bernal sandy loams, 3 to 20 percent slopes	4.9	51.3%
97	Truckton sandy loam, 3 to 9 percent slopes	4.7	48.7%
Totals for Area of Interest		**9.6**	**100.0%**

Legend

Soil Map

Scale (not to scale)

FEMA FIRM MAP



APPROXIMATE SCALE IN FEET

500 0 500

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 539 OF 1300

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS: COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0539	F
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0539	F

MAP NUMBER 08041C0539 F

EFFECTIVE DATE: MARCH 17, 1997

Federal Emergency Management Agency

HYDROLOGIC CALCULATIONS

BARNES AND MEDICAL DRIVE APARTMENTS
(Area Runoff Coefficient Summary)

EXISTING CONDITIONS

		STREETS / IMPERVIOUS			*OVERLAND / NONIMPERVIOUS*			*WEIGHTED*	
BASIN	**TOTAL AREA**	**AREA**	**C_5**	**C_{100}**	**AREA**	**C_5**	**C_{100}**	**C_5**	**C_{100}**
	(Acres)	*(Acres)*			*(Acres)*				
EXA	10.12	0.00	0.90	0.96	10.12	0.09	0.36	0.09	0.36
EXB	0.07	0.06	0.90	0.96	0.01	0.09	0.36	0.79	0.88
EXC	1.52	0.27	0.90	0.96	1.24	0.09	0.36	0.24	0.47
OS-A	0.59	0.00	0.90	0.96	0.59	0.09	0.36	0.09	0.36
OS-C	0.04	0.00	0.90	0.96	0.04	0.09	0.36	0.09	0.36

BARNES AND MEDICAL DRIVE APARTMENTS
(Area Runoff Coefficient Summary)

DEVELOPED CONDITIONS

		STREETS / IMPERVIOUS			*OVERLAND / NONIMPERVIOUS*			*WEIGHTED*	
BASIN	**TOTAL AREA** *(Acres)*	**AREA** *(Acres)*	**C_5**	**C_{100}**	**AREA** *(Acres)*	**C_5**	**C_{100}**	**C_5**	**C_{100}**
A1	2.13	0.89	0.90	0.96	1.24	0.09	0.36	0.43	0.61
A2	0.05	0.05	0.73	0.81	0.00	0.09	0.36	0.73	0.81
A3	0.05	0.05	0.73	0.81	0.00	0.09	0.36	0.73	0.81
A4	0.17	0.17	0.73	0.81	0.00	0.09	0.36	0.73	0.81
A5	0.11	0.11	0.73	0.81	0.00	0.09	0.36	0.73	0.81
A6	0.06	0.06	0.73	0.81	0.00	0.09	0.36	0.73	0.81
A7	0.60	0.00	0.90	0.96	0.60	0.09	0.36	0.09	0.36
OS-B1	0.07	0.00	0.90	0.96	0.07	0.09	0.36	0.09	0.36
OS-B2	0.14	0.00	0.90	0.96	0.14	0.09	0.36	0.09	0.36
OS-B3	0.36	0.00	0.90	0.96	0.36	0.09	0.36	0.09	0.36
B1	1.14	0.66	0.90	0.96	0.48	0.09	0.36	0.56	0.71
B2	0.46	0.30	0.90	0.96	0.16	0.09	0.36	0.62	0.75
B3	0.13	0.11	0.90	0.96	0.02	0.09	0.36	0.78	0.87
B4	0.78	0.59	0.90	0.96	0.19	0.09	0.36	0.64	0.74
B5	0.47	0.00	0.90	0.96	0.47	0.09	0.36	0.09	0.36
B6	0.06	0.06	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B7	0.13	0.13	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B8	0.10	0.10	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B9	0.07	0.07	0.73	0.81	0.00	0.09	0.36	0.64	0.74
B10	0.07	0.07	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B11	0.05	0.05	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B12	0.05	0.05	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B13	0.11	0.11	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B14	0.12	0.12	0.73	0.81	0.00	0.09	0.36	0.73	0.81

BARNES AND MEDICAL DRIVE APARTMENTS
(Area Runoff Coefficient Summary)

		STREETS / IMPERVIOUS			*OVERLAND / NONIMPERVIOUS*			*WEIGHTED*	
BASIN	**TOTAL AREA**	**AREA**	**C_5**	**C_{100}**	**AREA**	**C_5**	**C_{100}**	**C_5**	**C_{100}**
	(Acres)	*(Acres)*			*(Acres)*				
B15	0.05	0.05	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B16	0.04	0.04	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B17	0.11	0.11	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B18	0.11	0.11	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B19	0.07	0.07	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B20	0.07	0.07	0.73	0.81	0.00	0.09	0.36	0.73	0.81
B21	0.53	0.00	0.90	0.96	0.53	0.09	0.36	0.09	0.36
OS-C	0.06	0.00	0.90	0.96	0.06	0.09	0.36	0.09	0.36
C1	1.29	0.90	0.90	0.96	0.39	0.09	0.36	0.66	0.78
C2	0.45	0.28	0.90	0.96	0.17	0.09	0.36	0.59	0.73
C3	0.07	0.07	0.73	0.81	0.00	0.09	0.36	0.73	0.81
C4	0.05	0.05	0.73	0.81	0.00	0.09	0.36	0.73	0.81
C5	0.06	0.06	0.73	0.81	0.00	0.09	0.36	0.73	0.81
C6	0.11	0.11	0.73	0.81	0.00	0.09	0.36	0.73	0.81
C7	0.11	0.11	0.73	0.81	0.00	0.09	0.36	0.73	0.81
C8	0.06	0.06	0.73	0.81	0.00	0.09	0.36	0.73	0.81
C9	0.06	0.06	0.73	0.81	0.00	0.09	0.36	0.73	0.81
C10	0.44	0.00	0.90	0.96	0.44	0.09	0.36	0.09	0.36
D	1.06	0.63	0.90	0.96	0.43	0.09	0.36	0.57	0.72

QNA

Date: 10/26/18

Checked by: _____

BARNES AND MEDICAL DRIVE APARTMENTS
AREA DRAINAGE SUMMARY

EXISTING CONDITIONS

		WEIGHTED		*OVERLAND*				*STREET / CHANNEL FLOW*				T_t	*INTENSITY*		*TOTAL FLOWS*	
BASIN	**AREA TOTAL** *(Acres)*	C_5	C_{100}	C_5	**Length** *(ft)*	**Height** *(ft)*	T_C *(min)*	**Length** *(ft)*	**Slope** *(%)*	**Velocity** *(fps)*	T_t *(min)*	**TOTAL** *(min)*	I_5 *(in/hr)*	I_{100} *(in/hr)*	Q_5 *(c.f.s.)*	Q_{100} *(c.f.s.)*
		** For Calcs See Runoff Summary*														
EXA	10.12	0.09	0.36	0.09	100	7.0	9.6	640	7.3%	2.9	3.7	13.3	3.7	6.2	3.4	22.6
EXB	0.07	0.79	0.88									5.0	5.2	8.7	0.3	0.5
EXC	1.52	0.24	0.47	0.09	100	7.0	9.6	516	7.6%	3.0	2.9	12.5	3.8	6.4	1.4	4.5
OS-A	0.59	0.09	0.36									5.0	5.2	8.7	0.3	1.8
OS-C	0.04	0.09	0.36									5.0	5.2	8.7	0.0	0.1

BARNES AND MEDICAL DRIVE APARTMENTS
AREA DRAINAGE SUMMARY

DEVELOPED CONDITIONS

		WEIGHTED		*OVERLAND*				*STREET / CHANNEL FLOW*				T_t	*INTENSITY*		*TOTAL FLOWS*	
BASIN	**AREA TOTAL** *(Acres)*	C_5	C_{100}	C_5	**Length** *(ft)*	**Height** *(ft)*	T_C *(min)*	**Length** *(ft)*	**Slope** *(%)*	**Velocity** *(fps)*	T_t *(min)*	**TOTAL** *(min)*	I_5 *(in/hr)*	I_{100} *(in/hr)*	Q_5 *(c.f.s.)*	Q_{100} *(c.f.s.)*
		** For Calcs See Runoff Summary*														
A1	2.13	0.43	0.61	0.09	100	7.0	9.6	515	7.6%	5.5	1.6	11.2	4.0	6.7	3.6	8.7
A2	0.05	0.73	0.81									5.0	5.2	8.7	0.2	0.4
A3	0.05	0.73	0.81									5.0	5.2	8.7	0.2	0.4
A4	0.17	0.73	0.81									5.0	5.2	8.7	0.6	1.2
A5	0.11	0.73	0.81									5.0	5.2	8.7	0.4	0.8
A6	0.06	0.73	0.81									5.0	5.2	8.7	0.2	0.4
A7	0.60	0.09	0.36									5.0	5.2	8.7	0.3	1.9
OS-B1	0.07	0.09	0.36									5.0	5.2	8.7	0.0	0.2
OS-B2	0.14	0.09	0.36									5.0	5.2	8.7	0.1	0.4
OS-B3	0.36	0.09	0.36									5.0	5.2	8.7	0.2	1.1
B1	1.14	0.56	0.71	0.09	100	13.0	7.8	352	6.8%	5.2	1.1	9.0	4.3	7.2	2.7	5.8
B2	0.46	0.62	0.75	0.09	84	24.0	5.5	275	4.7%	4.4	1.0	6.6	4.8	8.0	1.4	2.8
B3	0.13	0.78	0.87									5.0	5.2	8.7	0.5	1.0
B4	0.78	0.64	0.74	0.09	37	10.0	3.7	363	2.2%	2.9	2.1	5.8	4.9	8.3	2.5	4.8
B5	0.47	0.09	0.36									5.0	5.2	8.7	0.2	1.5
B6	0.06	0.73	0.81									5.0	5.2	8.7	0.2	0.4
B7	0.13	0.73	0.81									5.0	5.2	8.7	0.5	0.9
B8	0.10	0.73	0.81									5.0	5.2	8.7	0.4	0.7
B9	0.07	0.64	0.74									5.0	5.2	8.7	0.2	0.4
B10	0.07	0.73	0.81									5.0	5.2	8.7	0.3	0.5
B11	0.05	0.73	0.81									5.0	5.2	8.7	0.2	0.4
B12	0.05	0.73	0.81									5.0	5.2	8.7	0.2	0.4
B13	0.11	0.73	0.81									5.0	5.2	8.7	0.4	0.8
B14	0.12	0.73	0.81									5.0	5.2	8.7	0.5	0.8
B15	0.05	0.73	0.81									5.0	5.2	8.7	0.2	0.4
B16	0.04	0.73	0.81									5.0	5.2	8.7	0.2	0.3
B17	0.11	0.73	0.81									5.0	5.2	8.7	0.4	0.8

BARNES AND MEDICAL DRIVE APARTMENTS
AREA DRAINAGE SUMMARY

		WEIGHTED		*OVERLAND*				*STREET / CHANNEL FLOW*				T_t	*INTENSITY*		*TOTAL FLOWS*	
BASIN	**AREA TOTAL** *(Acres)*	C_5	C_{100}	C_5	**Length** *(ft)*	**Height** *(ft)*	T_C *(min)*	**Length** *(ft)*	**Slope** *(%)*	**Velocity** *(fps)*	T_t *(min)*	**TOTAL** *(min)*	I_5 *(in/hr)*	I_{100} *(in/hr)*	Q_5 *(c.f.s.)*	Q_{100} *(c.f.s.)*
		** For Calcs See Runoff Summary*														
B18	0.11	0.73	0.81									5.0	5.2	8.7	0.4	0.8
B19	0.07	0.73	0.81									5.0	5.2	8.7	0.3	0.5
B20	0.07	0.73	0.81									5.0	5.2	8.7	0.3	0.5
B21	0.53	0.09	0.36	0.09	40	4.0	5.4	380	2.1%	2.1	3.0	8.4	4.4	7.4	0.2	1.4
OS-C	0.06	0.09	0.36									5.0	5.2	8.7	0.0	0.2
C1	1.29	0.66	0.78	0.09	95	10.0	8.2	505	1.2%	2.1	4.0	12.2	3.8	6.4	3.2	6.5
C2	0.45	0.59	0.73	0.09	60	10.0	5.6	205	2.0%	2.8	1.2	6.8	4.7	7.9	1.3	2.6
C3	0.07	0.73	0.81									5.0	5.2	8.7	0.3	0.5
C4	0.05	0.73	0.81									5.0	5.2	8.7	0.2	0.4
C5	0.06	0.73	0.81									5.0	5.2	8.7	0.2	0.4
C6	0.11	0.73	0.81									5.0	5.2	8.7	0.4	0.8
C7	0.11	0.73	0.81									5.0	5.2	8.7	0.4	0.8
C8	0.06	0.73	0.81									5.0	5.2	8.7	0.2	0.4
C9	0.06	0.73	0.81									5.0	5.2	8.7	0.2	0.4
C10	0.44	0.09	0.36									5.0	5.2	8.7	0.2	1.4
D	1.06	0.57	0.72									5.0	5.2	8.7	3.1	6.6

Calculated by: QNA

Date: 10/26/2018

Checked by: _____

BARNES AND MEDICAL DRIVE APARTMENTS
SURFACE ROUTING SUMMARY

EXISTING CONDITIONS									
Design Point(s)	*Contributing Basins*	*Area (Acres)*	*Equivalent* CA_5	*Equivalent* CA_{100}	*Maximum* T_C	*Intensity*		*Flow*	
						I_5	I_{100}	Q_5	Q_{100}
EX1	EXA THRU OS-C	12.33	1.38	4.64	13.3	3.6	6.2	5.0	29.0

BARNES AND MEDICAL DRIVE APARTMENTS
SURFACE ROUTING SUMMARY

DEVELOPED CONDITIONS									
Design Point(s)	*Contributing Basins*	*Area (Acres)*	*Equivalent CA_5*	*Equivalent CA_{100}*	*Maximum T_C*	*Intensity*		*Flow*	
						I_5	*I_{100}*	*Q_5*	*Q_{100}*
1	A1	0.22	0.91	1.30	11.2	4.0	6.7	3.6	8.7
2	A1-A7	3.17	1.29	1.87	11.2	4.0	6.7	5.1	12.5
3	B1	1.14	0.58	0.81	9.0	4.3	7.2	2.5	5.8
4	B2 & OS-B1	0.53	0.29	0.37	6.6	4.8	8.0	1.4	3.0
5	B3 & OS-B3	0.27	0.11	0.16	5.0	5.2	8.7	0.6	1.4
6	B4	0.78	0.50	1.52	5.8	4.9	8.3	2.5	12.6
7	B21 & OS-B3	0.89	0.08	0.32	8.4	4.4	7.4	0.4	2.4
8	B1-B21	4.72	2.49	3.18	9.0	4.3	7.2	10.7	22.9
9	C1	1.29	0.85	1.00	12.2	3.8	6.4	3.2	6.5
10	C2 & OS-C	0.51	0.27	0.36	6.8	4.7	7.9	1.3	2.8
11	C1-C10	2.70	1.53	2.02	12.2	3.8	6.4	5.9	13.0

Date: 10/26/18

Checked by: _____

BARNES AND MEDICAL DRIVE APARTMENTS
PIPE ROUTING SUMMARY

DEVELOPED CONDITIONS

Pipe Run(s)	*Contributing Design Points/Basins*	*Area (Acres)*	*Equivalent CA_5*	*Equivalent CA_{100}*	*Maximum T_C*	*Intensity*		*Flow*		*SIZE & TYPE*	*OWNER*
						I_5	*I_{100}*	*Q_5*	*Q_{100}*		
1	A1	0.22	0.91	1.30	11.2	4.0	6.7	3.6	8.7	24" RCP	PRIVATE
2	A2	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
3	A3	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
4	A4	0.17	0.12	0.14	5.0	5.2	8.7	0.6	1.2	8" HDPE	PRIVATE
5	A5	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
6	A6	0.06	0.04	0.05	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
7	B20	0.07	0.05	0.06	5.0	5.2	8.7	0.3	0.5	8" HDPE	PRIVATE
8	B19	0.07	0.05	0.06	5.0	5.2	8.7	0.3	0.5	8" HDPE	PRIVATE
9	PR 7 & 8	0.14	0.10	0.11	5.0	5.2	8.7	0.5	1.0	12" HDPE	PRIVATE
10	B18	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
11	PR 9 & 10	0.25	0.18	0.20	5.0	5.2	8.7	0.9	1.8	12" HDPE	PRIVATE
12	B17	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
13	PR 11 & 12	0.36	0.26	0.29	5.0	5.2	8.7	1.4	2.5	12" HDPE	PRIVATE
14	B16	0.04	0.03	0.03	5.0	5.2	8.7	0.2	0.3	6" HDPE	PRIVATE
15	PR 13 & 14	0.40	0.29	0.32	5.0	5.2	8.7	1.5	2.8	12" HDPE	PRIVATE
16	B15	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
17	PR 15 & 16	0.45	0.33	0.36	5.0	5.2	8.7	1.7	3.2	15" HDPE	PRIVATE
18	B14	0.12	0.09	0.10	5.0	5.2	8.7	0.5	0.8	8" HDPE	PRIVATE
19	PR 17 & 18	0.57	0.42	0.46	5.0	5.2	8.7	2.2	4.0	15" HDPE	PRIVATE
20	B13	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
21	PR 19 & 20	0.68	0.50	0.55	5.0	5.2	8.7	2.6	4.8	15" HDPE	PRIVATE
22	B12	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
23	PR 21 & 22	0.73	0.53	0.59	5.0	5.2	8.7	2.8	5.1	15" HDPE	PRIVATE

BARNES AND MEDICAL DRIVE APARTMENTS
PIPE ROUTING SUMMARY

Pipe Run(s)	*Contributing Design Points/Basins*	*Area (Acres)*	*Equivalent CA_5*	*Equivalent CA_{100}*	*Maximum T_C*	*Intensity*		*Flow*		*SIZE & TYPE*	*OWNER*
						I_5	I_{100}	Q_5	Q_{100}		
24	B11	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
25	PR 23 & 24	0.78	0.57	0.63	5.0	5.2	8.7	2.9	5.5	15" HDPE	PRIVATE
26	DP-7	0.89	0.08	0.32	8.4	4.4	7.4	0.4	2.4	12" HDPE	PRIVATE
27	PR 25 & 26	1.67	0.65	0.95	8.4	4.4	7.4	2.9	7.0	18" HDPE	PRIVATE
28	DP-6 & PR 27	2.45	1.15	2.47	8.4	4.4	7.4	5.0	18.2	30" RCP	PRIVATE
29	DP 3 & PR 28	3.59	1.73	3.28	9.0	4.3	7.2	7.4	23.6	30" RCP	PRIVATE
30	DP 5	0.27	0.11	0.16	5.0	5.2	8.7	0.6	1.4	12" HDPE	PRIVATE
31	DP 4 & 5	0.80	0.40	0.53	6.6	4.8	8.0	1.9	4.3	15" HDPE	PRIVATE
32	PR 29 & 31	4.39	2.13	3.81	9.0	4.3	7.2	9.2	27.5	30" RCP	PRIVATE
33	C3	0.07	0.05	0.06	5.0	5.2	8.7	0.3	0.5	8" HDPE	PRIVATE
34	C4	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
35	PR 33 & 34	0.12	0.09	0.10	5.0	5.2	8.7	0.5	0.8	8" HDPE	PRIVATE
36	C5	0.06	0.04	0.05	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
37	C6	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
38	C7	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
39	C8	0.06	0.04	0.05	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
40	C9	0.06	0.04	0.05	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
41	DP 9	1.29	0.85	1.00	12.2	3.8	6.4	3.2	6.5	18" HDPE	PRIVATE
42	DP 10	0.51	0.27	0.36	6.8	4.7	7.9	1.3	2.8	15" HDPE	PRIVATE
43	PR 41 & 42	1.80	1.12	1.36	12.2	3.8	6.4	4.3	8.8	18" HDPE	PRIVATE
44	POND WEST OUTLET							0.0	2.0	15" HDPE	PRIVATE
45	POND MIDDLE OUTLET							0.1	4.4	15" HDPE	PRIVATE
46	PR 45 & 46							0.1	6.4	18" HDPE	PRIVATE
47	EX 30" STM RE-ROUTED							0.0	347.2	60" RCP	PUBLIC
48	PR 46 & 47							0.1	353.6	60" RCP	PUBLIC
49	POND EAST OUTLET							0.0	2.0	15" HDPE	PRIVATE
50	PR 48 & 49							0.1	355.6	60" RCP	PUBLIC

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

LID Credit by Impervious Reduction Factor (IRF) Method

UD-BMP (Version 3.06, November 2016)

User Input

Calculated cells

***Design Storm: 1-Hour Rain Depth	2-Year Event	1.19	inches	
***Minor Storm: 1-Hour Rain Depth	5-Year Event	1.50	inches	
***Major Storm: 1-Hour Rain Depth	100-Year Event	2.52	inches	
Optional User Defined Storm	CUHP			
(CUHP) NOAA 1 Hour Rainfall Depth and Frequency for User Defined Storm	100-Year Event			
Max Intensity for Optional User Defined Storm	0			

Designer: Dane Frank
Company: Terra Nova Engineering
Date: December 14, 2018
Project: Barnes and Medical View Apartments
Location:

SITE INFORMATION (USER-INPUT)

Sub-basin Identifier	A	B	C	D										
Receiving Pervious Area Soil Type	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam										
Total Area (ac., Sum of DCIA, UIA, RPA, & SPA)	3.170	5.290	2.760	1.060										
Directly Connected Impervious Area (DCIA, acres)	1.270	2.890	1.660	0.340										
Unconnected Impervious Area (UIA, acres)	0.000	0.000	0.000	0.000										
Receiving Pervious Area (RPA, acres)	1.900	0.640	0.910	0.720										
Separate Pervious Area (SPA, acres)	0.000	1.760	0.190	0.000										
RPA Treatment Type: Conveyance (C), Volume (V), or Permeable Pavement (PP)	V	V	V	C										

CALCULATED RESULTS (OUTPUT)

Total Calculated Area (ac, check against input)	3.170	5.290	2.760	1.060										
Directly Connected Impervious Area (DCIA, %)	40.1%	54.6%	60.1%	32.1%										
Unconnected Impervious Area (UIA, %)	0.0%	0.0%	0.0%	0.0%										
Receiving Pervious Area (RPA, %)	59.9%	12.1%	33.0%	67.9%										
Separate Pervious Area (SPA, %)	0.0%	33.3%	6.9%	0.0%										
A_R (RPA / UIA)	0.000	0.000	0.000	0.000										
I_a Check	1.000	1.000	1.000	1.000										
f / I for 2-Year Event:	0.9	0.9	0.9	0.9										
f / I for 5-Year Event:	0.5	0.5	0.5	0.5										
f / I for 100-Year Event:	0.3	0.3	0.3	0.3										
f / I for Optional User Defined Storm CUHP:														
IRF for 2-Year Event:	0.00	0.00	0.00	1.00										
IRF for 5-Year Event:	1.00	1.00	1.00	1.00										
IRF for 100-Year Event:	1.00	1.00	1.00	1.00										
IRF for Optional User Defined Storm CUHP:														
Total Site Imperviousness: I_{total}	40.1%	54.6%	60.1%	32.1%										
Effective Imperviousness for 2-Year Event:	40.1%	54.6%	60.1%	32.1%										
Effective Imperviousness for 5-Year Event:	40.1%	54.6%	60.1%	32.1%										
Effective Imperviousness for 100-Year Event:	40.1%	54.6%	60.1%	32.1%										
Effective Imperviousness for Optional User Defined Storm CUHP:														

LID / EFFECTIVE IMPERVIOUSNESS CREDITS

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

Total Site Imperviousness:	**50.2%**
Total Site Effective Imperviousness for 2-Year Event:	**50.2%**
Total Site Effective Imperviousness for 5-Year Event:	**50.2%**
Total Site Effective Imperviousness for 100-Year Event:	**50.2%**
Total Site Effective Imperviousness for Optional User Defined Storm CUHP:	

Notes:

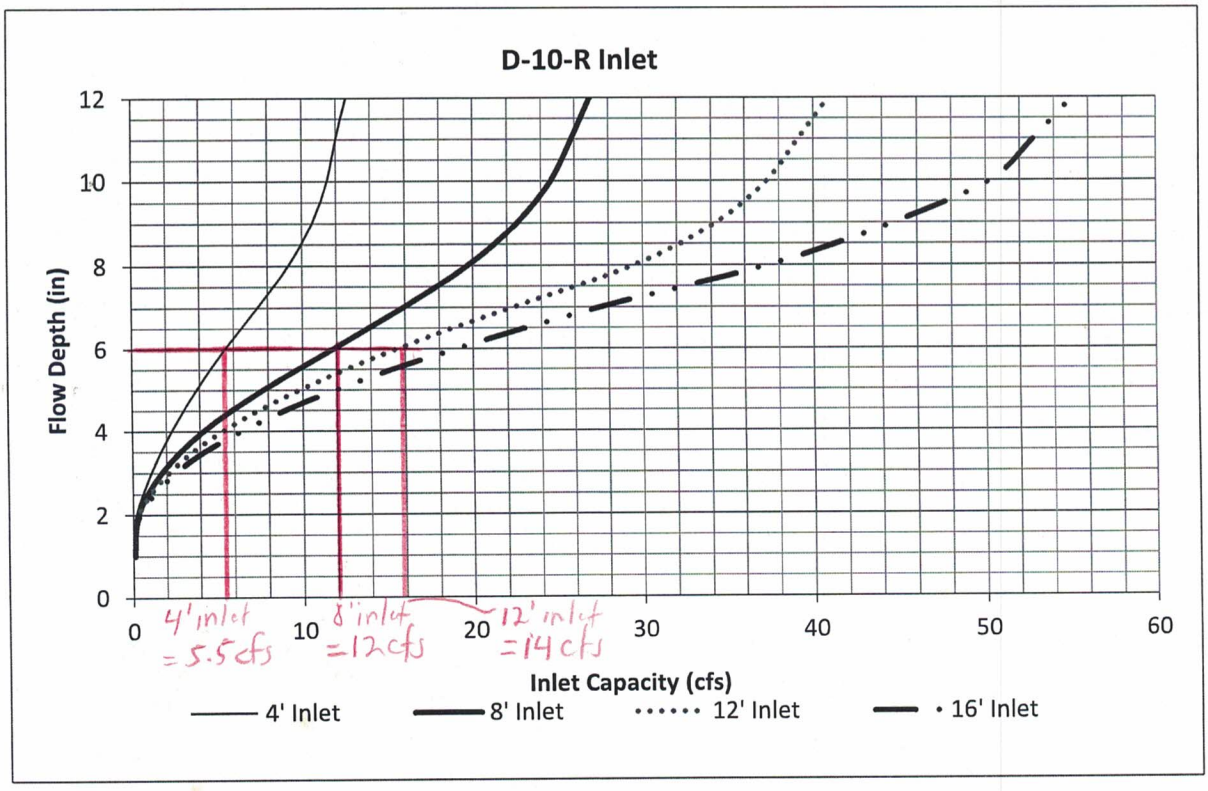
* Use Green-Ampt average infiltration rate values from Table 3-3.

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

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

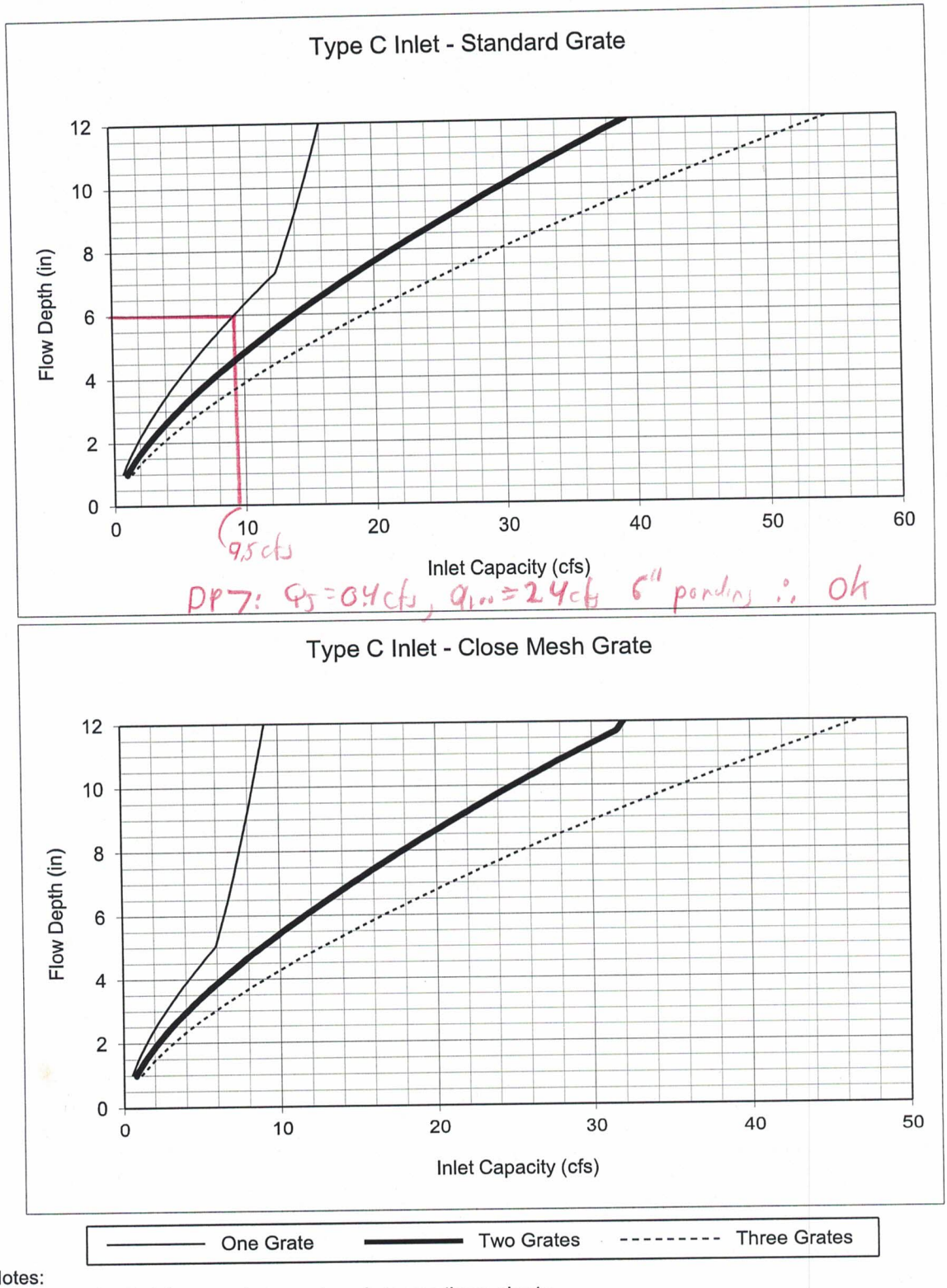
HYDRAULIC CALCULATIONS

Figure 8-12. Inlet Capacity Chart Sump Conditions, Curb Opening (D-10-R) Inlet



DP1: Q_5=3.6 cfs, Q_{100}=8.7 cfs 6" curb head ∴ 8' inlet
DP3: Q_5=2.5 cfs, Q_{100}=5.8 cfs 6" curb head ∴ 8' inlet
DP4: Q_5=1.4 cfs, Q_{100}=3.0 cfs 6" curb head ∴ 4' inlet
DP5: Q_5=0.6 cfs Q_{100}=1.4 cfs 6" curb head ∴ 4' inlet
DP6: Q_5=2.5 cfs, Q_{100}=12.6 cfs 6" curb head ∴ 12' inlet
DP9: Q_5=3.2 cfs, Q_{100}=6.5 cfs 6" curb head ∴ 8' inlet
DP10: Q_5=1.3 cfs, Q_{100}=2.6 cfs 6" curb head ∴ 4' inlet
DP

Figure 8-10. Inlet Capacity Chart Sump Conditions, Area (Type C) Inlet



Notes:
1. The standard inlet parameters must apply to use these charts.

Free Online Manning Pipe Flow Calculator

>> Nationalism not welcome here. <<

Manning Formula Uniform Pipe Flow at Given Slope and Depth

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--CAUTION: If you have downloaded the spreadsheet prior to September 24, you may have received incorrect results!--

Piperun 1

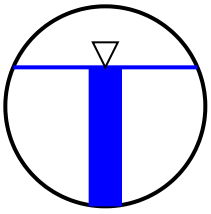
18" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	18 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	69.5 %

Results

Flow, Q	8.7114	cfs
Velocity, v	6.6454	ft/sec
Velocity head, h_v	0.6863	ft
Flow area	1.3109	ft^2
Wetted perimeter	2.9571	ft
Hydraulic radius	0.4433	ft
Top width, T	1.3812	ft
Froude number, F	1.20	
Shear stress (tractive force), tau	0.6509	psf



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Piperun 2, 3, 6, 16, 22, 24, 34, 36, 39, & 40

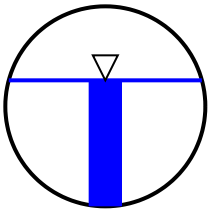
6" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	6 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	63. %

Results

Flow, Q	0.4056	cfs
Velocity, v	3.1127	ft/sec
Velocity head, h_v	0.1506	ft
Flow area	0.1303	ft^2
Wetted perimeter	0.9169	ft
Hydraulic radius	0.1421	ft
Top width, T	0.4828	ft
Froude number, F	1.06	
Shear stress (tractive force), tau	0.1967	psf



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Manning Formula Uniform Pipe Flow at Given Slope and Depth

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--CAUTION: If you have downloaded the spreadsheet prior to September 24, you may have received incorrect results!--

Piperun 4

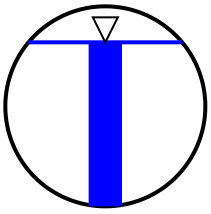
8" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	8 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	82 %

Results

Flow, Q	1.2088	cfs
Velocity, v	3.9460	ft/sec
Velocity head, h_v	0.2420	ft
Flow area	0.3063	ft^2
Wetted perimeter	1.5102	ft
Hydraulic radius	0.2028	ft
Top width, T	0.5122	ft
Froude number, F	0.90	
Shear stress (tractive force), tau	0.3413	psf



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Manning Formula Uniform Pipe Flow at Given Slope and Depth

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Piperun 5, 10, 12, 18, 20, 35, 37, & 38

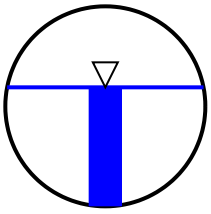
8" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	8 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	59.5 %

Results

Flow, Q	0.8014	cfs
Velocity, v	3.7018	ft/sec
Velocity head, h_v	0.2130	ft
Flow area	0.2165	ft^2
Wetted perimeter	1.1746	ft
Hydraulic radius	0.1843	ft
Top width, T	0.6545	ft
Froude number, F	1.13	
Shear stress (tractive force), tau	0.2477	psf



Free Online Manning Pipe Flow Calculator

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Manning Formula Uniform Pipe Flow at Given Slope and Depth

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--CAUTION: If you have downloaded the spreadsheet prior to September 24, you may have received incorrect results!--

Piperun 7, 8, 33

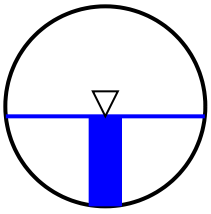
8" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	8 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	45 %

Results

Flow, Q	0.5033	cfs
Velocity, v	3.3037	ft/sec
Velocity head, h_v	0.1696	ft
Flow area	0.1523	ft^2
Wetted perimeter	0.9804	ft
Hydraulic radius	0.1554	ft
Top width, T	0.6633	ft
Froude number, F	1.22	
Shear stress (tractive force), tau	0.1873	psf



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Piperun 9

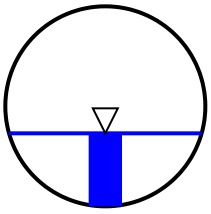
12" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	12 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	36.5 %

Results

Flow, Q	1.0135	cfs
Velocity, v	3.9078	ft/sec
Velocity head, h_v	0.2373	ft
Flow area	0.2594	ft^2
Wetted perimeter	1.2974	ft
Hydraulic radius	0.1999	ft
Top width, T	0.9629	ft
Froude number, F	1.33	
Shear stress (tractive force), tau	0.2279	psf



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Piperun 11

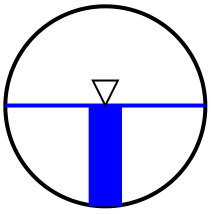
12" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	12 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	50.4 %

Results

Flow, Q	1.8054	cfs
Velocity, v	4.5513	ft/sec
Velocity head, h_v	0.3219	ft
Flow area	0.3967	ft^2
Wetted perimeter	1.5788	ft
Hydraulic radius	0.2513	ft
Top width, T	1.0000	ft
Froude number, F	1.27	
Shear stress (tractive force), tau	0.3147	psf



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Piperun 13 & 26

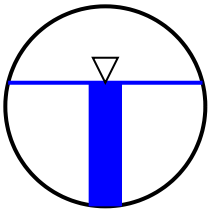
12" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	12 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	61.8 %

Results

Flow, Q	2.5029	cfs
Velocity, v	4.9117	ft/sec
Velocity head, h_v	0.3749	ft
Flow area	0.5096	ft^2
Wetted perimeter	1.8090	ft
Hydraulic radius	0.2817	ft
Top width, T	0.9717	ft
Froude number, F	1.20	
Shear stress (tractive force), tau	0.3859	psf



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Piperun 15

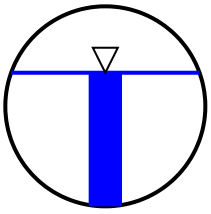
12" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	12 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	66.8 %

Results

Flow, Q	2.8003	cfs
Velocity, v	5.0233	ft/sec
Velocity head, h_v	0.3922	ft
Flow area	0.5575	ft^2
Wetted perimeter	1.9134	ft
Hydraulic radius	0.2913	ft
Top width, T	0.9419	ft
Froude number, F	1.15	
Shear stress (tractive force), tau	0.4171	psf



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Piperun 17

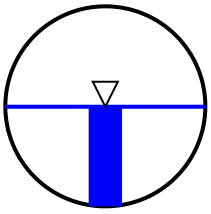
15" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	49.8 %

Results

Flow, Q	3.2077	cfs
Velocity, v	5.2546	ft/sec
Velocity head, h_v	0.4291	ft
Flow area	0.6105	ft^2
Wetted perimeter	1.9585	ft
Hydraulic radius	0.3117	ft
Top width, T	1.2500	ft
Froude number, F	1.33	
Shear stress (tractive force), tau	0.3887	psf



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Piperun 19

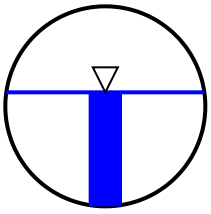
15" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	57 %

Results

Flow, Q	4.0061	cfs
Velocity, v	5.5441	ft/sec
Velocity head, h_v	0.4777	ft
Flow area	0.7226	ft^2
Wetted perimeter	2.1391	ft
Hydraulic radius	0.3378	ft
Top width, T	1.2377	ft
Froude number, F	1.28	
Shear stress (tractive force), tau	0.4449	psf



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Piperun 21

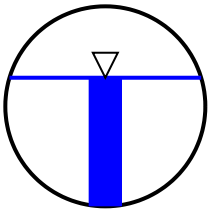
15" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	64.3 %

Results

Flow, Q	4.8104	cfs
Velocity, v	5.7684	ft/sec
Velocity head, h_v	0.5171	ft
Flow area	0.8340	ft^2
Wetted perimeter	2.3260	ft
Hydraulic radius	0.3585	ft
Top width, T	1.1978	ft
Froude number, F	1.22	
Shear stress (tractive force), tau	0.5018	psf



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Piperun 23

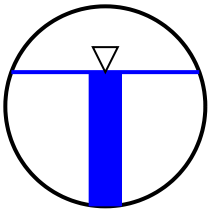
15" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	67.1 %

Results

Flow, Q	5.1089	cfs
Velocity, v	5.8357	ft/sec
Velocity head, h_v	0.5293	ft
Flow area	0.8755	ft^2
Wetted perimeter	2.3998	ft
Hydraulic radius	0.3648	ft
Top width, T	1.1746	ft
Froude number, F	1.19	
Shear stress (tractive force), tau	0.5237	psf



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Piperun 25

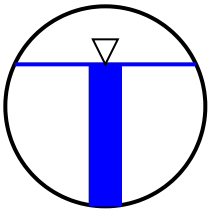
15" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	71. %

Results

Flow, Q	5.5080	cfs
Velocity, v	5.9114	ft/sec
Velocity head, h_v	0.5431	ft
Flow area	0.9318	ft^2
Wetted perimeter	2.5053	ft
Hydraulic radius	0.3719	ft
Top width, T	1.1344	ft
Froude number, F	1.15	
Shear stress (tractive force), tau	0.5541	psf



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Piperun 27

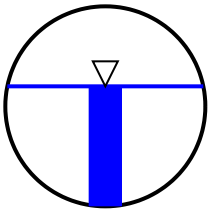
18" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	18 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	60 %

Results

Flow, Q	7.0566	cfs
Velocity, v	6.3743	ft/sec
Velocity head, h_v	0.6315	ft
Flow area	1.1071	ft^2
Wetted perimeter	2.6582	ft
Hydraulic radius	0.4165	ft
Top width, T	1.4697	ft
Froude number, F	1.29	
Shear stress (tractive force), tau	0.5619	psf



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Piperun 28

30" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	30 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	46.7 %

Results

Flow, Q	18.2324	cfs
Velocity, v	8.1098	ft/sec
Velocity head, h_v	1.0222	ft
Flow area	2.2483	ft^2
Wetted perimeter	3.7618	ft
Hydraulic radius	0.5976	ft
Top width, T	2.4945	ft
Froude number, F	1.51	
Shear stress (tractive force), tau	0.7290	psf

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Piperun 29

30" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	30 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	54.5 %

Results

Flow, Q	23.6683	cfs
Velocity, v	8.6534	ft/sec
Velocity head, h_v	1.1638	ft
Flow area	2.7353	ft^2
Wetted perimeter	4.1523	ft
Hydraulic radius	0.6587	ft
Top width, T	2.4898	ft
Froude number, F	1.46	
Shear stress (tractive force), tau	0.8507	psf

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Piperun 30

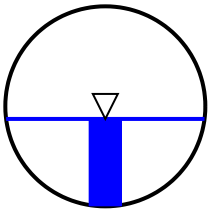
12" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	12 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	43.7 %

Results

Flow, Q	1.4086	cfs
Velocity, v	4.2704	ft/sec
Velocity head, h_v	0.2834	ft
Flow area	0.3299	ft^2
Wetted perimeter	1.4444	ft
Hydraulic radius	0.2284	ft
Top width, T	0.9920	ft
Froude number, F	1.31	
Shear stress (tractive force), tau	0.2729	psf



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Piperun 31

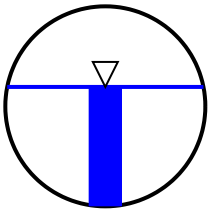
15" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	59.7 %

Results

Flow, Q	4.3063	cfs
Velocity, v	5.6352	ft/sec
Velocity head, h_v	0.4935	ft
Flow area	0.7642	ft^2
Wetted perimeter	2.2075	ft
Hydraulic radius	0.3462	ft
Top width, T	1.2262	ft
Froude number, F	1.26	
Shear stress (tractive force), tau	0.4659	psf



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Piperun 32

30" Min slope 1%

Set units: m mm ft in

Pipe diameter, d_0	30 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	60 %

Results

Flow, Q	27.5543	cfs
Velocity, v	8.9605	ft/sec
Velocity head, h_v	1.2479	ft
Flow area	3.0752	ft^2
Wetted perimeter	4.4303	ft
Hydraulic radius	0.6941	ft
Top width, T	2.4495	ft
Froude number, F	1.41	
Shear stress (tractive force), tau	0.9366	psf

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Piperun 41

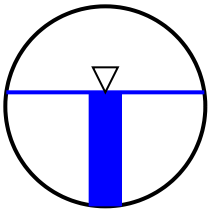
18" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	18 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	57 %

Results

Flow, Q	6.5144	cfs
Velocity, v	6.2607	ft/sec
Velocity head, h_v	0.6092	ft
Flow area	1.0406	ft^2
Wetted perimeter	2.5669	ft
Hydraulic radius	0.4054	ft
Top width, T	1.4852	ft
Froude number, F	1.32	
Shear stress (tractive force), tau	0.5338	psf



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Manning Formula Uniform Pipe Flow at Given Slope and Depth

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Piperun 42

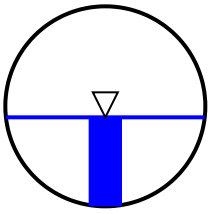
15" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	44.5 %

Results

Flow, Q	2.6377	cfs
Velocity, v	4.9975	ft/sec
Velocity head, h_v	0.3882	ft
Flow area	0.5278	ft^2
Wetted perimeter	1.8257	ft
Hydraulic radius	0.2891	ft
Top width, T	1.2424	ft
Froude number, F	1.35	
Shear stress (tractive force), tau	0.3473	psf



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Piperun 43

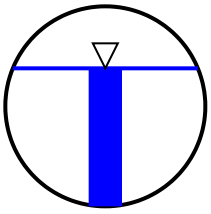
18" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	18 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	69. %

Results

Flow, Q	8.6283	cfs
Velocity, v	6.6346	ft/sec
Velocity head, h_v	0.6841	ft
Flow area	1.3006	ft^2
Wetted perimeter	2.9409	ft
Hydraulic radius	0.4422	ft
Top width, T	1.3875	ft
Froude number, F	1.21	
Shear stress (tractive force), tau	0.6462	psf



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Piperun 44

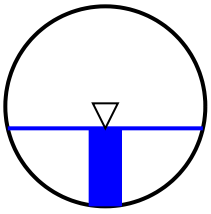
15" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	39 %

Results

Flow, Q	2.0779	cfs
Velocity, v	4.6894	ft/sec
Velocity head, h_v	0.3418	ft
Flow area	0.4431	ft^2
Wetted perimeter	1.6862	ft
Hydraulic radius	0.2628	ft
Top width, T	1.2194	ft
Froude number, F	1.37	
Shear stress (tractive force), tau	0.3044	psf



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Piperun 45

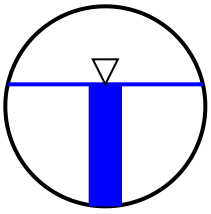
15" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	61 %

Results

Flow, Q	4.4500	cfs
Velocity, v	5.6757	ft/sec
Velocity head, h_v	0.5007	ft
Flow area	0.7841	ft^2
Wetted perimeter	2.2407	ft
Hydraulic radius	0.3499	ft
Top width, T	1.2194	ft
Froude number, F	1.25	
Shear stress (tractive force), tau	0.4761	psf



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Piperun 46

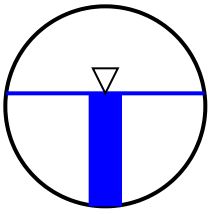
18" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	18 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	56.5 %

Results

Flow, Q	6.4238	cfs
Velocity, v	6.2404	ft/sec
Velocity head, h_v	0.6052	ft
Flow area	1.0294	ft^2
Wetted perimeter	2.5517	ft
Hydraulic radius	0.4034	ft
Top width, T	1.4873	ft
Froude number, F	1.32	
Shear stress (tractive force), tau	0.5292	psf



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Piperun 47

Ex 60" RCP Rerouted Min. 1.78% slope.

Set units: m mm ft in

Pipe diameter, d_0	60 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1.777 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	81.97 %

Results

Flow, Q	347.1741	cfs
Velocity, v	20.1549	ft/sec
Velocity head, h_v	6.3133	ft
Flow area	17.2260	ft^2
Wetted perimeter	11.3225	ft
Hydraulic radius	1.5214	ft
Top width, T	3.8443	ft
Froude number, F	1.68	
Shear stress (tractive force), tau	4.5474	psf

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Piperun 48

Ex 60" RCP Rerouted Min. 1.78% slope.

Set units: m mm ft in

Pipe diameter, d_0	60 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1.777 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	83.75 %

Results

Flow, Q	353.6100	cfs
Velocity, v	20.1365	ft/sec
Velocity head, h_v	6.3018	ft
Flow area	17.5614	ft^2
Wetted perimeter	11.5587	ft
Hydraulic radius	1.5193	ft
Top width, T	3.6891	ft
Froude number, F	1.63	
Shear stress (tractive force), tau	4.6461	psf

Free Online Manning Pipe Flow Calculator

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Manning Formula Uniform Pipe Flow at Given Slope and Depth

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Piperun 49

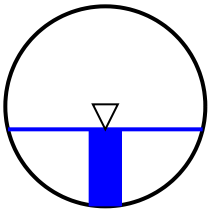
15" Min slope 1%

Set units: m | mm | ft | in

Pipe diameter, d_0	15 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	38.5 %

Results

Flow, Q	2.0290	cfs
Velocity, v	4.6592	ft/sec
Velocity head, h_v	0.3374	ft
Flow area	0.4355	ft^2
Wetted perimeter	1.6734	ft
Hydraulic radius	0.2602	ft
Top width, T	1.2165	ft
Froude number, F	1.37	
Shear stress (tractive force), tau	0.3005	psf



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Piperun 50

Ex 60" RCP Rerouted Min. 1.78% slope.

Set units: m mm ft in

Pipe diameter, d_0	60 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	.013
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	1.777 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	83.75 %

Results

Flow, Q	353.6100	cfs
Velocity, v	20.1365	ft/sec
Velocity head, h_v	6.3018	ft
Flow area	17.5614	ft^2
Wetted perimeter	11.5587	ft
Hydraulic radius	1.5193	ft
Top width, T	3.6891	ft
Froude number, F	1.63	
Shear stress (tractive force), tau	4.6461	psf

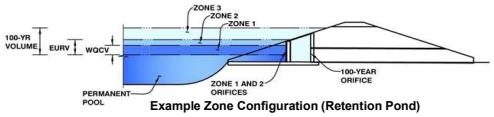
EDB CALCULATIONS

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: Barnes and Powers

Basin ID: East Pond



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	2.76	acres
Watershed Length =	515	ft
Watershed Slope =	0.021	ft/ft
Watershed Imperviousness =	60.10%	percent
Percentage Hydrologic Soil Group A =	54.0%	percent
Percentage Hydrologic Soil Group B =	46.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	
Water Quality Capture Volume (WQCV) =	0.054	acre-feet
Excess Urban Runoff Volume (EURV) =	0.192	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.143	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	0.189	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	0.239	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	0.303	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	0.360	acre-feet
100-yr Runoff Volume (P1 = 2.52 in.) =	0.431	acre-feet
500-yr Runoff Volume (P1 = 3 in.) =	0.560	acre-feet
Approximate 2-yr Detention Volume =	0.134	acre-feet
Approximate 5-yr Detention Volume =	0.178	acre-feet
Approximate 10-yr Detention Volume =	0.222	acre-feet
Approximate 25-yr Detention Volume =	0.255	acre-feet
Approximate 50-yr Detention Volume =	0.274	acre-feet
Approximate 100-yr Detention Volume =	0.301	acre-feet

Optional User Override 1-hr Precipitation

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.52	inches
3.00	inches

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.054	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.137	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.110	acre-feet
Total Detention Basin Volume =	0.301	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

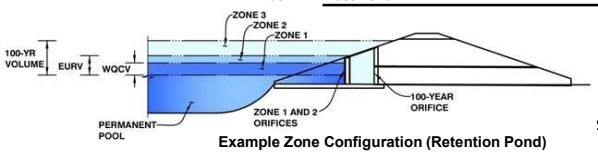
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	74	0.002		
	--	0.25	--	--	--	391	0.009	56	0.001
	--	0.50	--	--	--	708	0.016	195	0.004
	--	0.75	--	--	--	1,025	0.024	416	0.010
	--	1.00	--	--	--	1,343	0.031	720	0.017
	--	1.25	--	--	--	1,660	0.038	1,106	0.025
	--	1.50	--	--	--	1,977	0.045	1,574	0.036
	--	1.75	--	--	--	2,294	0.053	2,125	0.049
	--	2.00	--	--	--	2,611	0.060	2,759	0.063
	--	2.25	--	--	--	3,012	0.069	3,513	0.081
	--	2.50	--	--	--	3,412	0.078	4,336	0.100
	--	2.75	--	--	--	3,813	0.088	5,257	0.121
	--	3.00	--	--	--	4,214	0.097	6,274	0.144
	--	3.25	--	--	--	4,614	0.106	7,389	0.170
	--	3.50	--	--	--	5,015	0.115	8,600	0.197
	--	3.75	--	--	--	5,415	0.124	9,909	0.227
	--	4.00	--	--	--	5,816	0.134	11,314	0.260
	--	4.25	--	--	--	6,395	0.147	12,841	0.295
	--	4.50	--	--	--	6,974	0.160	14,512	0.333
	--	4.75	--	--	--	7,553	0.173	16,327	0.375
	--	5.00	--	--	--	8,131	0.187	18,288	0.420
	--	5.25	--	--	--	8,710	0.200	20,393	0.468
	--	5.50	--	--	--	9,289	0.213	22,643	0.520
	--	5.75	--	--	--	9,868	0.227	25,038	0.575
	--	6.00	--	--	--	10,447	0.240	27,577	0.633

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: Barnes and Powers

Basin ID: East Pond



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.85	0.054	Orifice Plate
Zone 2 (EURV)	3.45	0.137	Orifice Plate
Zone 3 (100-year)	4.30	0.110	Weir&Pipe (Restrict)
		0.301	Total

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

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

Calculated Parameters for Underdrain

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	2.986E-03	ft^2
Depth at top of Zone using Orifice Plate =	3.94	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	15.70	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.43	sq. inches (diameter = 3/4 inch)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.31	2.63					
Orifice Area (sq. inches)	0.43	0.43	0.43					

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

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

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

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.94	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.94	N/A	feet
Overflow Weir Front Edge Length =	2.00	N/A	feet	Over Flow Weir Slope Length =	2.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)	Grate Open Area / 100-yr Orifice Area =	13.80	N/A	should be ≥ 4
Horiz. Length of Weir Sides =	2.00	N/A	feet	Overflow Grate Open Area w/o Debris =	2.80	N/A	ft^2
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	1.40	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.20	N/A	ft^2
Outlet Pipe Diameter =	18.00	N/A	inches	Outlet Orifice Centroid =	0.15	N/A	feet
Restrictor Plate Height Above Pipe Invert =	3.10		inches	Half-Central Angle of Restrictor Plate on Pipe =	0.86	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	4.40	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.35	feet
Spillway Crest Length =	10.00	feet	Stage at Top of Freeboard =	5.75	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.23	acres
Freeboard above Max Water Surface =	1.00	feet			

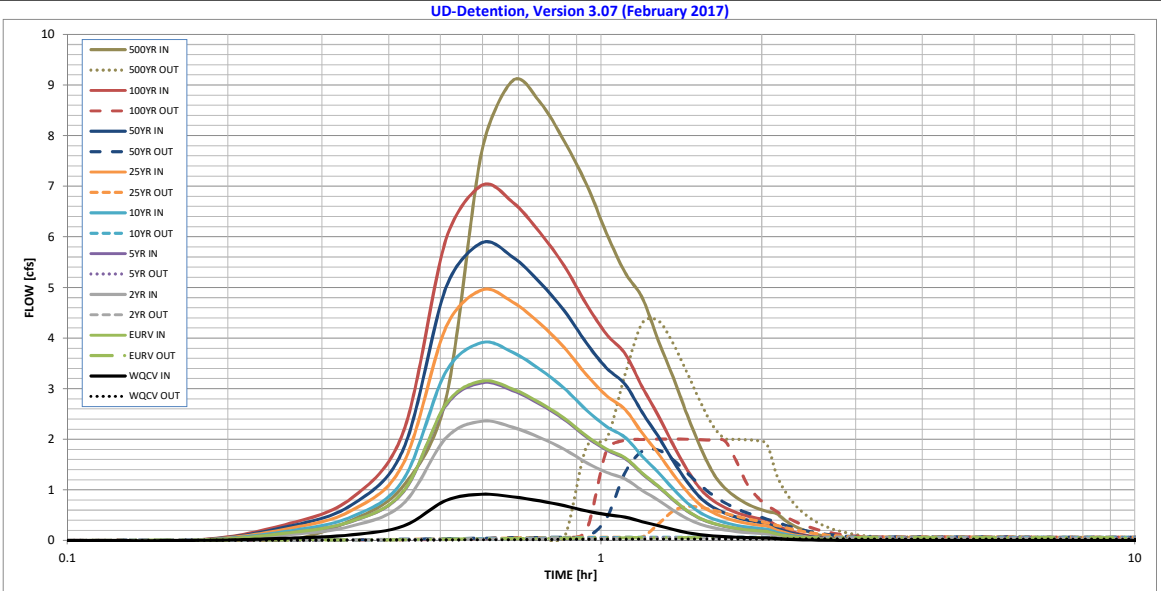
Calculated Parameters for Spillway

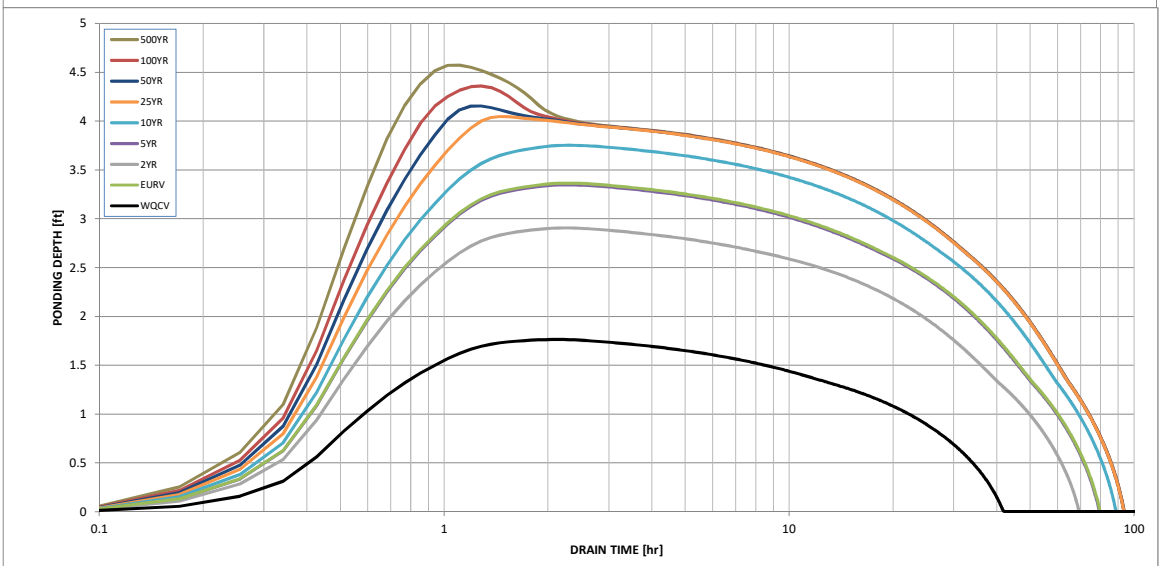
Routed Hydrograph Results

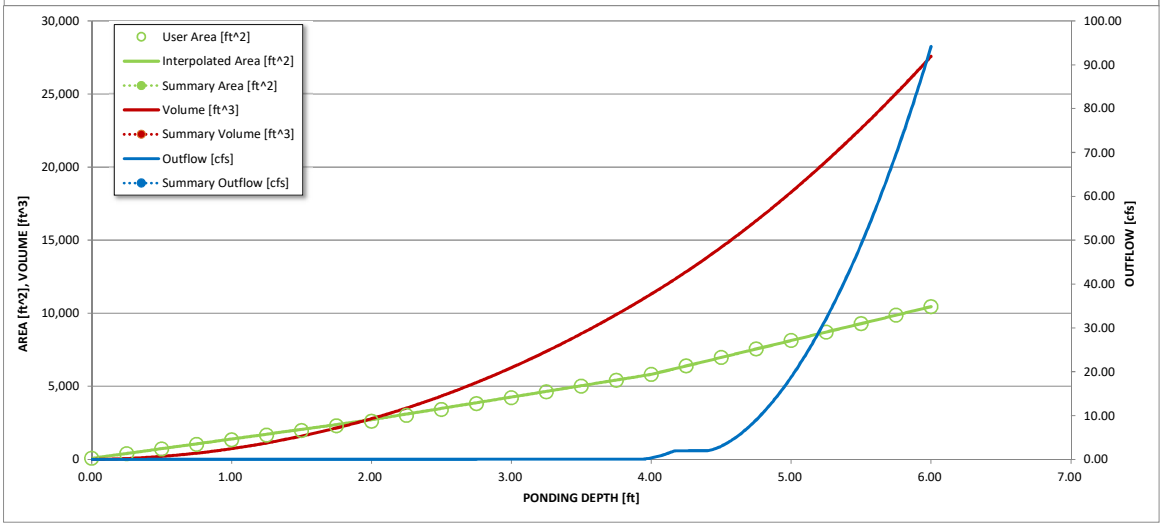
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.00
Calculated Runoff Volume (acre-ft) =	0.054	0.192	0.143	0.189	0.239	0.303	0.360	0.431	0.560
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.054	0.191	0.142	0.189	0.238	0.302	0.360	0.431	0.559
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.01	0.10	0.31	0.51	0.80	1.32
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.0	0.3	0.9	1.4	2.2	3.7
Peak Inflow Q (cfs) =	0.9	3.1	2.4	3.1	3.9	4.9	5.9	7.0	9.1
Peak Outflow Q (cfs) =	0.0	0.1	0.1	0.1	0.1	0.7	1.8	2.0	4.3
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.8	0.2	0.8	1.3	0.9	1.2
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	0.2	0.6	0.7	0.7
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) =	38	71	62	70	78	81	79	77	74
Time to Drain 99% of Inflow Volume (hours) =	40	76	66	75	84	88	87	86	85
Maximum Ponding Depth (ft) =	1.76	3.36	2.91	3.35	3.75	4.05	4.15	4.36	4.57
Area at Maximum Ponding Depth (acres) =	0.05	0.11	0.09	0.11	0.12	0.14	0.14	0.15	0.16
Maximum Volume Stored (acre-ft) =	0.050	0.182	0.134	0.179	0.227	0.265	0.280	0.310	0.344

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







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

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

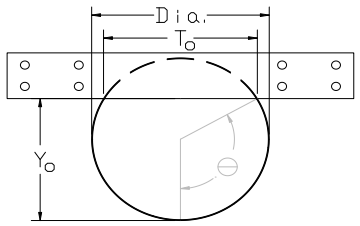
Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

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

	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK
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]
5.12 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrograph Constant	0:10:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:15:22	0.04	0.14	0.11	0.14	0.18	0.22	0.26	0.31	0.40
0.977	0:20:29	0.11	0.38	0.29	0.38	0.47	0.60	0.71	0.84	1.09
	0:25:36	0.29	0.98	0.73	0.97	1.21	1.53	1.82	2.16	2.79
	0:30:43	0.79	2.69	2.02	2.67	3.33	4.21	4.99	5.94	7.67
	0:35:50	0.91	3.15	2.36	3.12	3.91	4.95	5.88	7.02	9.08
	0:40:58	0.86	2.99	2.24	2.96	3.72	4.71	5.60	6.69	8.67
	0:46:05	0.78	2.72	2.03	2.69	3.38	4.29	5.10	6.09	7.89
	0:51:12	0.69	2.41	1.80	2.39	3.00	3.81	4.54	5.42	7.04
	0:56:19	0.58	2.07	1.54	2.05	2.58	3.28	3.90	4.67	6.07
	1:01:26	0.51	1.81	1.35	1.79	2.25	2.86	3.41	4.07	5.29
	1:06:34	0.46	1.63	1.22	1.62	2.04	2.59	3.08	3.69	4.80
	1:11:41	0.37	1.33	0.99	1.32	1.66	2.12	2.53	3.03	3.95
	1:16:48	0.29	1.07	0.79	1.06	1.35	1.72	2.06	2.47	3.22
	1:21:55	0.22	0.81	0.60	0.80	1.02	1.31	1.57	1.89	2.48
	1:27:02	0.15	0.59	0.43	0.58	0.74	0.96	1.16	1.40	1.84
	1:32:10	0.11	0.43	0.32	0.43	0.55	0.70	0.84	1.02	1.33
	1:37:17	0.09	0.34	0.25	0.34	0.43	0.55	0.66	0.79	1.04
	1:42:24	0.08	0.28	0.21	0.28	0.35	0.45	0.54	0.65	0.85
	1:47:31	0.07	0.24	0.18	0.24	0.30	0.38	0.46	0.55	0.72
	1:52:38	0.06	0.21	0.16	0.21	0.26	0.34	0.40	0.49	0.64
	1:57:46	0.05	0.19	0.14	0.19	0.24	0.31	0.37	0.44	0.57
	2:02:53	0.05	0.18	0.13	0.18	0.22	0.28	0.34	0.41	0.53
	2:08:00	0.04	0.13	0.10	0.13	0.16	0.21	0.25	0.30	0.39
	2:13:07	0.03	0.10	0.07	0.09	0.12	0.15	0.18	0.22	0.28
	2:18:14	0.02	0.07	0.05	0.07	0.09	0.11	0.13	0.16	0.21
	2:23:22	0.01	0.05	0.04	0.05	0.06	0.08	0.10	0.12	0.15
	2:28:29	0.01	0.04	0.03	0.04	0.04	0.06	0.07	0.08	0.11
	2:33:36	0.01	0.02	0.02	0.02	0.03	0.04	0.05	0.06	0.08
	2:38:43	0.00	0.02	0.01	0.02	0.02	0.03	0.03	0.04	0.05
	2:43:50	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.04
	2:48:58	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02
	2:54:05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
	2:59:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:04:19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:09:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:14:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:19:41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:24:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:29:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:16:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:21:07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:26:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:31:22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:36:29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:41:36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:46:43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:51:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:56:58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:02:05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:07:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:12:19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:17:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:22:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:27:41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:32:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:37:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:43:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:48:10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:53:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:58:24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:03:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:08:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Reference Figures and Equations

Circular Pipe with Restrictor Plate



WQ Elliptical Slot Weir (Alternative to WQ Orifice Plate for Large Watersheds)

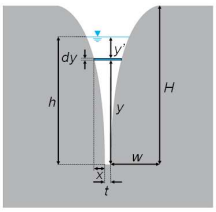
$$f(y)=\sqrt{2g(h-y)}\left[2\frac{H}{R}\left(1-1\sqrt{1-\frac{y^2}{H^2}}\right)+t\right]$$

$$Q_{app}=0.3015h\left[f(0)+f(0.603h)\right]+0.1415h\left[f(0.603h)+f(0.886h)\right]+0.0570h\left[f(0.886h)\right]$$

Orifice Equations

$$Q=C_d A_t\sqrt{2g\left(h-C_y\right)}$$

$$A_t=H(2W+t)-\frac{\pi HW}{2} \qquad C_y=\frac{\frac{H}{2}(2W+t)-\frac{2HW}{3}}{2W+t-\frac{\pi W}{2}}$$



- dy = elementary flow vertical distance [L];
- h = total flow depth [L];
- H = total weir height and semi-major ellipse axis [L];
- t = weir gap thickness [L];
- W = semi-minor ellipse axis [L];
- x = horizontal distance along the ellipse shape [L];
- y = vertical depth measured from the weir crest to the elementary flow strip [L]; and
- y' = vertical distance measured from the water surface to the elementary flow strip [L].

Watershed Runoff Volume Calculations

$$WQCV=\frac{A}{12}*a[0.91I^3-1.19I^2+0.78I]$$

$$EURV=A[0.140I^{1.28}*A\%+0.113I^{1.08}*B\%+0.100I^{1.08}]$$

$$V_{Runoff\_2yr}=P_1A[(0.084I^{1.440})A\%+(0.084I^{1.173})B\%+(0.084I^{1.094})CD\%]$$

$$V_{Runoff\_5yr}=P_1A[(0.084I^{1.350})A\%+(0.077I+0.007)B\%+(0.070I+0.014)CD\%]$$

$$V_{Runoff\_10yr}=P_1A[(0.085I^{1.220})A\%+(0.069I+0.016)B\%+(0.061I+0.024)CD\%]$$

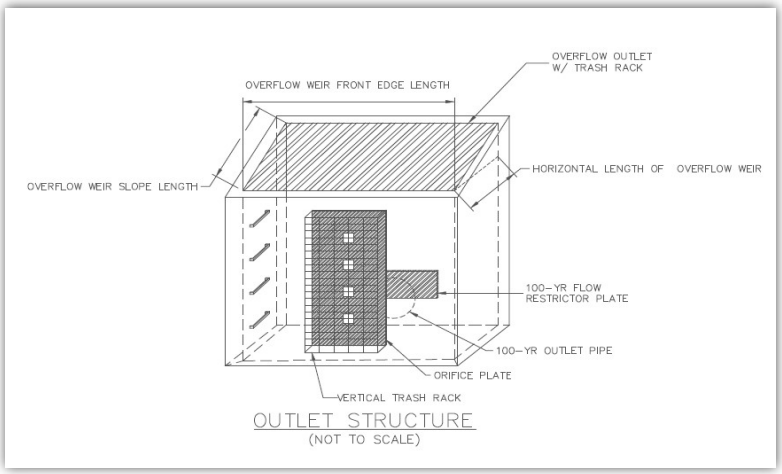
$$V_{Runoff\_25yr}=P_1A[(0.082I+0.004)A\%+(0.055I+0.031)B\%+(0.048I+0.038)CD\%]$$

$$V_{Runoff\_50yr}=P_1A[(0.078I+0.009)A\%+(0.049I+0.038)B\%+(0.044I+0.043)CD\%]$$

$$V_{Runoff\_100yr}=P_1A[(0.073I+0.015)A\%+(0.043I+0.045)B\%+(0.038I+0.050)CD\%]$$

$$V_{Runoff\_500yr}=P_1A[(0.064I+0.025)A\%+(0.036I+0.053)B\%+(0.031I+0.058)CD\%]$$

Where $WQCV$ is the water quality capture volume (acre-ft), EURV is the excess urban runoff volume (acre-ft), V_{fyr} is the volume for the given return period (acre-ft), a is a coefficient corresponding to WQCV drain time (1.0 for 40 hours, 0.9 for 24 hours, and 0.8 for 12 hours), P_1 is the one-hour rainfall depth (in), A is the contributing watershed area (acres), I is the percentage imperviousness (expressed as a decimal), $A\%$, $B\%$, and $CD\%$ are the percent of each hydraulic soil group (expressed as a decimal).



Basin Volume Calculations

Initial Surcharge Volume:

$$ISV=0.003WQCV \qquad L_{ISV}=\sqrt{A_{ISV}}$$

$$A_{ISV}=\frac{ISV}{ISD} \qquad W_{ISV}=\sqrt{A_{ISV}}$$

Where ISV is the initial surcharge volume (ft^3), A_{ISV} is ISV surface area (ft^2), ISD is the initial surcharge depth (ft, typically 0.33 to 0.50), and L_{ISV} and W_{ISV} are the length and width of the ISV (ft).

Basin Floor Volume:

$$L_{floor}=L_{ISV}+\frac{H_{floor}}{S_{TC}}+H_{floor}(S_{main}) \qquad W_{floor}=W_{ISV}+\frac{H_{floor}}{R_{LW}(S_{TC})}$$

$$A_{floor}=L_{floor}(W_{floor})$$

$$V_{floor}=\frac{H_{floor}}{3}\left(A_{ISV}+A_{floor}+\sqrt{A_{ISV}(A_{floor})}\right)$$

Where L_{floor} and W_{floor} (ft) are the length and width of the basin floor section at the point where the top of the basin floor section meets the toe of the basin main section, H_{floor} is the depth of the basin floor section (ft), S_{TC} is the trickle channel slope (ft/ft), S_{main} is the side slope of the basin main section (H:V; e.g., 4 if the horizontal:vertical ratio is 4:1), $R_{L:W}$ is the basin length:width ratio (e.g., 2 if the basin length is twice the basin width), A_{floor} is top area of the basin floor section (ft^2), and V_{floor} is volume of the basin floor section (ft^3).

Main Basin Volume:

$$L_{main}=L_{floor}+2H_{main}(S_{main}) \qquad A_{main}=L_{main}(W_{main})$$

$$W_{main}=W_{floor}+2H_{main}(S_{main})$$

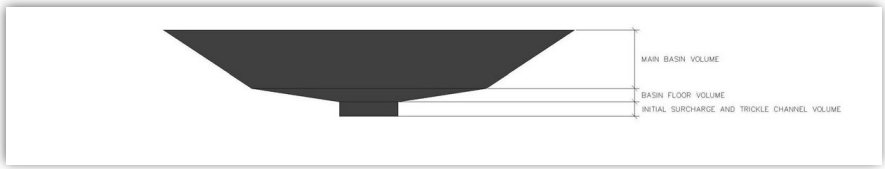
$$V_{main}=\frac{H_{main}}{3}\left(A_{main}+A_{floor}+\sqrt{A_{main}(A_{floor})}\right)$$

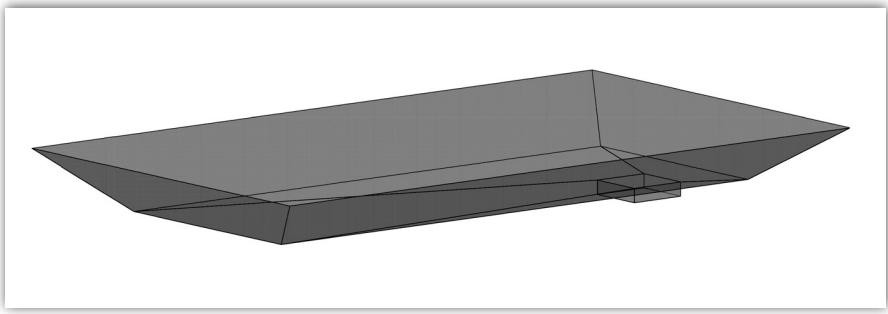
Where L_{main} and W_{main} (ft) are the length and width of the main basin section at the point at the top of the basin, H_{main} is the depth of the main basin section (ft), A_{main} is top area of the main basin section (ft^2), and V_{main} is volume of the main basin section (ft^3).

Total Basin Volume:

$$V_{total}=ISV+A_{ISV}\cdot D_{TC}+V_{floor}+V_{main}$$

Where V_{total} is the volume of the total basin (ft^3) and D_{TC} is the depth of the trickle channel (ft).



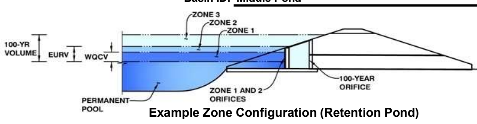


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: Barnes and Powers

Basin ID: Middle Pond



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	**EDB**			
Watershed Area =	5.29	acres		
Watershed Length =	620	ft		
Watershed Slope =	0.020	ft/ft		
Watershed Imperviousness =	54.60%	percent		
Percentage Hydrologic Soil Group A =	54.0%	percent		
Percentage Hydrologic Soil Group B =	46.0%	percent		
Percentage Hydrologic Soil Groups C/D =	0.0%	percent		
Desired WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.097	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.327	acre-feet		
2-yr Runoff Volume (P1 = 1.19 in.) =	0.242	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.323	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.413	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	0.535	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	0.644	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	0.780	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 3 in.) =	1.028	acre-feet	3.00	inches
Approximate 2-yr Detention Volume =	0.228	acre-feet		
Approximate 5-yr Detention Volume =	0.304	acre-feet		
Approximate 10-yr Detention Volume =	0.384	acre-feet		
Approximate 25-yr Detention Volume =	0.442	acre-feet		
Approximate 50-yr Detention Volume =	0.477	acre-feet		
Approximate 100-yr Detention Volume =	0.529	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.097	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.231	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.202	acre-feet
Total Detention Basin Volume =	0.529	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	--	--	--	74	0.002		
	--	0.25	--	--	--	402	0.009	66	0.002
	--	0.50	--	--	--	729	0.017	237	0.005
	--	0.75	--	--	--	1,057	0.024	512	0.012
	--	1.00	--	--	--	1,385	0.032	892	0.020
	--	1.25	--	--	--	1,713	0.039	1,377	0.032
	--	1.50	--	--	--	2,041	0.047	1,966	0.045
	--	1.75	--	--	--	2,368	0.054	2,659	0.061
	--	2.00	--	--	--	2,696	0.062	3,457	0.079
	--	2.25	--	--	--	2,999	0.069	4,385	0.101
	--	2.50	--	--	--	3,303	0.076	5,355	0.123
	--	2.75	--	--	--	3,606	0.083	6,404	0.147
	--	3.00	--	--	--	3,909	0.090	7,529	0.173
	--	3.25	--	--	--	4,212	0.097	8,733	0.200
	--	3.50	--	--	--	4,515	0.104	10,014	0.230
	--	3.75	--	--	--	4,819	0.111	11,372	0.261
	--	4.00	--	--	--	5,122	0.118	12,808	0.294
	--	4.25	--	--	--	5,466	0.125	14,324	0.329
	--	4.50	--	--	--	5,810	0.133	15,921	0.365
	--	4.75	--	--	--	6,155	0.141	17,601	0.404
	--	5.00	--	--	--	6,499	0.149	19,362	0.444
	--	5.25	--	--	--	6,843	0.157	21,205	0.487
	--	5.50	--	--	--	7,187	0.165	23,130	0.531
	--	5.75	--	--	--	7,532	0.173	25,137	0.577
	--	6.00	--	--	--	7,876	0.181	27,225	0.625
	--	6.25	--	--	--	8,255	0.189	29,400	0.675
	--	6.50	--	--	--	8,633	0.198	31,663	0.727
	--	6.75	--	--	--	9,012	0.207	34,015	0.781
	--	7.00	--	--	--	9,390	0.216	36,457	0.837
	--	7.25	--	--	--	9,769	0.224	38,987	0.895
	--	7.50	--	--	--	10,148	0.233	41,607	0.955
	--	7.75	--	--	--	10,526	0.242	44,315	1.017
	--	8.00	--	--	--	10,905	0.250	47,113	1.082
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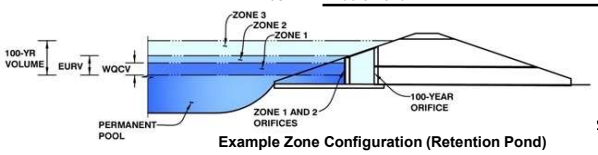
Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: Barnes and Powers

Basin ID: Middle Pond



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.21	0.097	Orifice Plate
Zone 2 (EURV)	4.24	0.231	Orifice Plate
Zone 3 (100-year)	5.49	0.202	Weir&Pipe (Restrict)
		0.529	Total

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

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

Calculated Parameters for Underdrain

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	4.583E-03	ft^2
Depth at top of Zone using Orifice Plate =	4.22	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	16.90	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.66	sq. inches (diameter = 7/8 inch)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.41	2.81					
Orifice Area (sq. inches)	0.66	0.66	0.66					

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

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

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

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	4.22	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	4.22	N/A	feet
Overflow Weir Front Edge Length =	2.00	N/A	feet	Over Flow Weir Slope Length =	2.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)	Grate Open Area / 100-yr Orifice Area =	6.87	N/A	should be ≥ 4
Horiz. Length of Weir Sides =	2.00	N/A	feet	Overflow Grate Open Area w/o Debris =	2.80	N/A	ft^2
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	1.40	N/A	ft^2
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.41	N/A	ft^2
Outlet Pipe Diameter =	15.00	N/A	inches	Outlet Orifice Centroid =	0.27	N/A	feet
Restrictor Plate Height Above Pipe Invert =	5.50		inches	Half-Central Angle of Restrictor Plate on Pipe =	1.30	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	6.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.50	feet
Spillway Crest Length =	11.00	feet	Stage at Top of Freeboard =	8.00	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.26	acres
Freeboard above Max Water Surface =	1.50	feet			

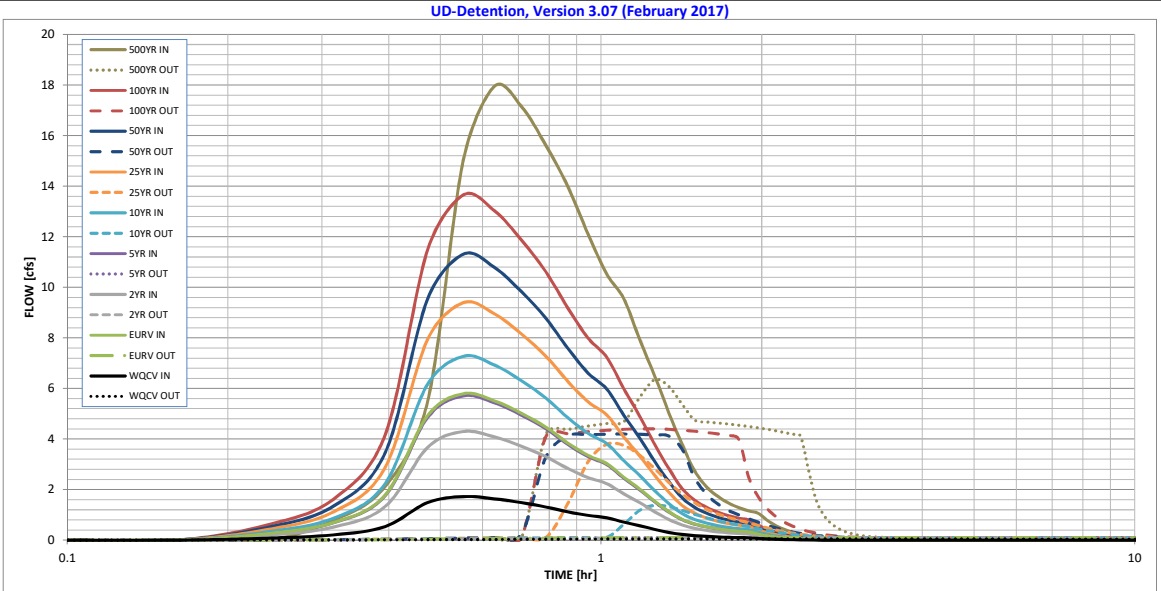
Calculated Parameters for Spillway

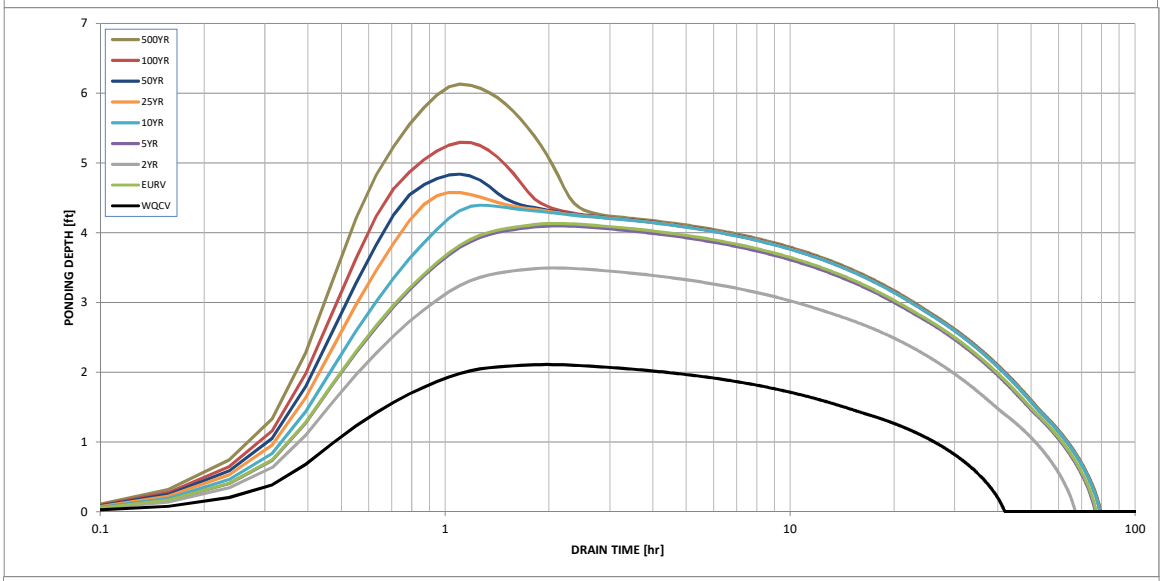
Routed Hydrograph Results

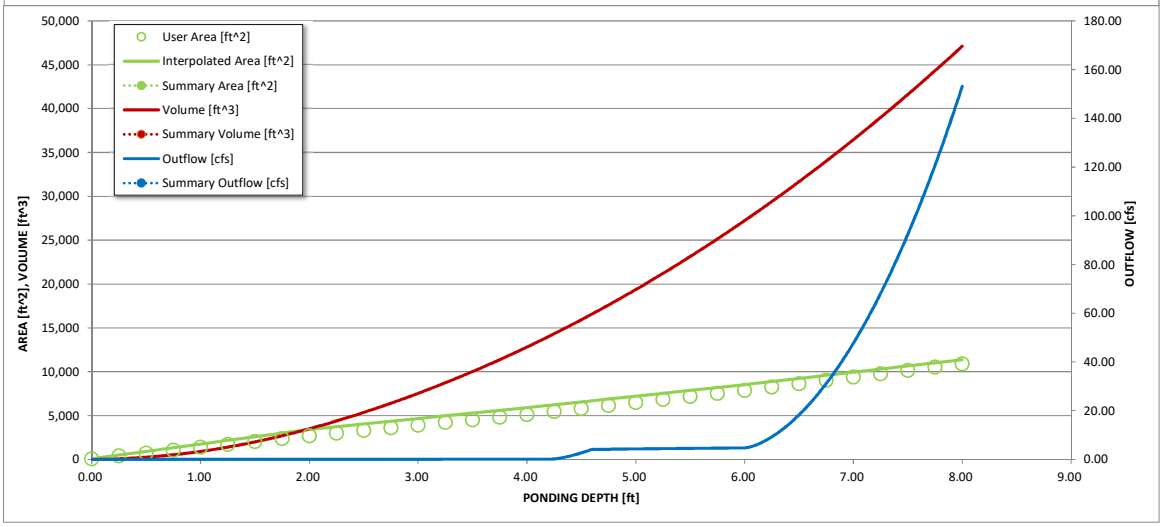
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.00
Calculated Runoff Volume (acre-ft) =	0.097	0.327	0.242	0.323	0.413	0.535	0.644	0.780	1.028
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.096	0.327	0.242	0.322	0.412	0.534	0.644	0.779	1.028
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.01	0.11	0.34	0.57	0.89	1.45
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.1	0.6	1.8	3.0	4.7	7.7
Peak Inflow Q (cfs) =	1.7	5.8	4.3	5.7	7.3	9.4	11.3	13.7	17.9
Peak Outflow Q (cfs) =	0.1	0.1	0.1	0.1	1.4	3.8	4.2	4.4	6.3
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.5	2.4	2.1	1.4	0.9	0.8
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.5	1.3	1.5	1.5	1.6
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) =	38	68	60	68	68	66	64	62	59
Time to Drain 99% of Inflow Volume (hours) =	40	73	64	73	74	73	73	72	70
Maximum Ponding Depth (ft) =	2.11	4.13	3.49	4.10	4.40	4.58	4.84	5.30	6.13
Area at Maximum Ponding Depth (acres) =	0.08	0.14	0.12	0.14	0.15	0.15	0.16	0.17	0.20
Maximum Volume Stored (acre-ft) =	0.088	0.312	0.229	0.306	0.349	0.376	0.417	0.494	0.649

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







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

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

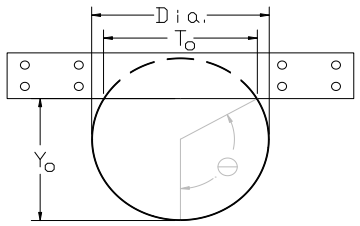
Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

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

Time Interval	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK
	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
4.73 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:04:44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrograph	0:09:28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Constant	0:14:11	0.08	0.26	0.19	0.26	0.33	0.42	0.50	0.60	0.79
1.057	0:18:55	0.21	0.70	0.52	0.69	0.87	1.12	1.35	1.63	2.13
	0:23:39	0.54	1.79	1.33	1.76	2.24	2.89	3.47	4.18	5.47
	0:28:23	1.49	4.92	3.66	4.85	6.16	7.93	9.53	11.47	15.02
	0:33:07	1.72	5.79	4.30	5.71	7.27	9.39	11.31	13.65	17.94
	0:37:50	1.64	5.52	4.09	5.43	6.93	8.96	10.79	13.04	17.14
	0:42:34	1.49	5.02	3.72	4.95	6.31	8.15	9.83	11.87	15.61
	0:47:18	1.31	4.47	3.30	4.40	5.62	7.27	8.78	10.61	13.97
	0:52:02	1.12	3.84	2.83	3.78	4.84	6.27	7.58	9.17	12.10
	0:56:46	0.98	3.35	2.47	3.30	4.22	5.47	6.60	7.99	10.53
	1:01:29	0.88	3.03	2.24	2.99	3.82	4.95	5.98	7.24	9.54
	1:06:13	0.71	2.49	1.83	2.45	3.14	4.08	4.94	5.98	7.91
	1:10:57	0.57	2.02	1.48	1.99	2.55	3.33	4.03	4.89	6.49
	1:15:41	0.43	1.54	1.12	1.51	1.95	2.55	3.10	3.78	5.03
	1:20:25	0.30	1.13	0.82	1.11	1.44	1.90	2.31	2.82	3.78
	1:25:08	0.23	0.82	0.60	0.81	1.05	1.38	1.67	2.04	2.74
	1:29:52	0.18	0.64	0.47	0.63	0.82	1.07	1.30	1.58	2.11
	1:34:36	0.15	0.53	0.39	0.52	0.67	0.88	1.07	1.30	1.73
	1:39:20	0.13	0.45	0.33	0.44	0.57	0.75	0.91	1.10	1.47
	1:44:04	0.11	0.40	0.29	0.39	0.50	0.66	0.80	0.97	1.28
	1:48:47	0.10	0.36	0.26	0.35	0.45	0.59	0.72	0.87	1.16
	1:53:31	0.10	0.33	0.24	0.33	0.42	0.55	0.66	0.80	1.06
	1:58:15	0.07	0.24	0.18	0.24	0.31	0.40	0.48	0.59	0.78
	2:02:59	0.05	0.18	0.13	0.18	0.23	0.29	0.36	0.43	0.57
	2:07:43	0.04	0.13	0.10	0.13	0.17	0.22	0.26	0.32	0.42
	2:12:26	0.03	0.10	0.07	0.09	0.12	0.16	0.19	0.23	0.31
	2:17:10	0.02	0.07	0.05	0.07	0.09	0.11	0.14	0.17	0.22
	2:21:54	0.01	0.05	0.03	0.05	0.06	0.08	0.10	0.12	0.16
	2:26:38	0.01	0.03	0.02	0.03	0.04	0.06	0.07	0.08	0.11
	2:31:22	0.01	0.02	0.02	0.02	0.03	0.04	0.05	0.06	0.08
	2:36:05	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.05
	2:40:49	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02
	2:45:33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	2:50:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:55:01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:59:44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:04:28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:09:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:13:56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:18:40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:23:23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:28:07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:32:51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:37:35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:42:19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:47:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:51:46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:56:30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:01:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:24:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:29:37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:34:20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:39:04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:43:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:48:32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:53:16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:57:59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:02:43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:07:27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:12:11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:16:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:21:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:26:22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:31:06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Reference Figures and Equations

Circular Pipe with Restrictor Plate



WQ Elliptical Slot Weir (Alternative to WQ Orifice Plate for Large Watersheds)

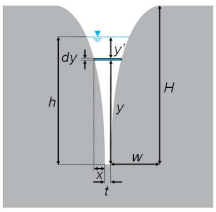
$$f(y) = \sqrt{2g(h-y)}\left[2\frac{H}{R}\left(1-1\sqrt{1-\frac{y^2}{H^2}}\right)+t\right]$$

$$Q_{app} = 0.3015h\left[f(0)+f(0.603h)\right] + 0.1415h\left[f(0.603h)+f(0.886h)\right] + 0.0570h\left[f(0.886h)\right]$$

Orifice Equations

$$Q = C_d A_t \sqrt{2g(h-C_y)}$$

$$A_t = H(2W+t) - \frac{\pi HW}{2} \qquad C_y = \frac{\frac{H}{2}(2W+t) - \frac{2HW}{3}}{2W+t-\frac{\pi W}{2}}$$



- *dy* = elementary flow vertical distance [L];
- *h* = total flow depth [L];
- *H* = total weir height and semi-major ellipse axis [L];
- *t* = weir gap thickness [L];
- *W* = semi-minor ellipse axis [L];
- *x* = horizontal distance along the ellipse shape [L];
- *y* = vertical depth measured from the weir crest to the elementary flow strip [L]; and
- *y'* = vertical distance measured from the water surface to the elementary flow strip [L].

Watershed Runoff Volume Calculations

$$WQCV = \frac{A}{12} * a[0.91I^3 - 1.19I^2 + 0.78I]$$

$$EURV = A[0.140I^{1.28} * A\% + 0.113I^{1.08} * B\% + 0.100I^{1.08}]$$

$$V_{Runoff\_2yr} = P_1 A[(0.084I^{1.440})A\% + (0.084I^{1.173})B\% + (0.084I^{1.094})CD\%]$$

$$V_{Runoff\_5yr} = P_1 A[(0.084I^{1.350})A\% + (0.077I + 0.007)B\% + (0.070I + 0.014)CD\%]$$

$$V_{Runoff\_10yr} = P_1 A[(0.085I^{1.220})A\% + (0.069I + 0.016)B\% + (0.061I + 0.024)CD\%]$$

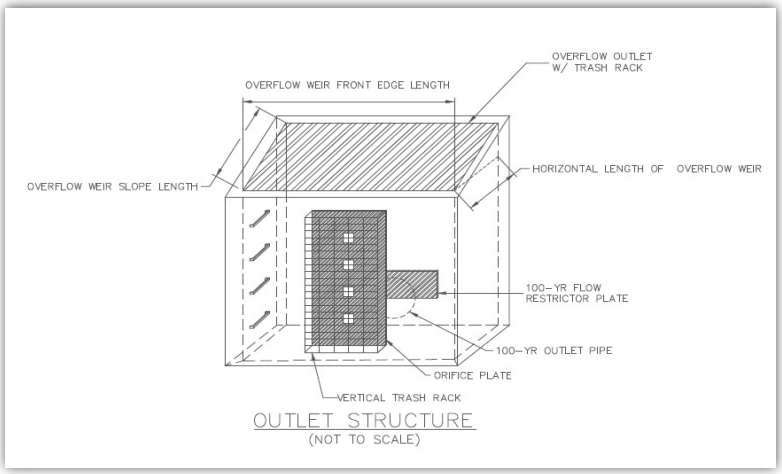
$$V_{Runoff\_25yr} = P_1 A[(0.082I + 0.004)A\% + (0.055I + 0.031)B\% + (0.048I + 0.038)CD\%]$$

$$V_{Runoff\_50yr} = P_1 A[(0.078I + 0.009)A\% + (0.049I + 0.038)B\% + (0.044I + 0.043)CD\%]$$

$$V_{Runoff\_100yr} = P_1 A[(0.073I + 0.015)A\% + (0.043I + 0.045)B\% + (0.038I + 0.050)CD\%]$$

$$V_{Runoff\_500yr} = P_1 A[(0.064I + 0.025)A\% + (0.036I + 0.053)B\% + (0.031I + 0.058)CD\%]$$

Where $WQCV$ is the water quality capture volume (acre-ft), EURV is the excess urban runoff volume (acre-ft), V_{tyr} is the volume for the given return period (acre-ft), a is a coefficient corresponding to WQCV drain time (1.0 for 40 hours, 0.9 for 24 hours, and 0.8 for 12 hours), P_1 is the one-hour rainfall depth (in), A is the contributing watershed area (acres), I is the percentage imperviousness (expressed as a decimal), $A\%$, $B\%$, and $CD\%$ are the percent of each hydraulic soil group (expressed as a decimal).



Basin Volume Calculations

Initial Surcharge Volume:

$$ISV = 0.003WQCV \qquad L_{ISV} = \sqrt{A_{ISV}}$$

$$A_{ISV} = \frac{ISV}{ISD} \qquad W_{ISV} = \sqrt{A_{ISV}}$$

Where ISV is the initial surcharge volume (ft^3), A_{ISV} is ISV surface area (ft^2), ISD is the initial surcharge depth (ft, typically 0.33 to 0.50), and L_{ISV} and W_{ISV} are the length and width of the ISV (ft).

Basin Floor Volume:

$$L_{floor} = L_{ISV} + \frac{H_{floor}}{S_{TC}} + H_{floor}(S_{main}) \qquad W_{floor} = W_{ISV} + \frac{H_{floor}}{R_{LW}(S_{TC})}$$

$$A_{floor} = L_{floor}(W_{floor})$$

$$V_{floor} = \frac{H_{floor}}{3}\left(A_{ISV} + A_{floor} + \sqrt{A_{ISV}(A_{floor})}\right)$$

Where L_{floor} and W_{floor} (ft) are the length and width of the basin floor section at the point where the top of the basin floor section meets the toe of the basin main section, H_{floor} is the depth of the basin floor section (ft), S_{TC} is the trickle channel slope (ft/ft), S_{main} is the side slope of the basin main section (H:V; e.g., 4 if the horizontal:vertical ratio is 4:1), $R_{L:W}$ is the basin length:width ratio (e.g., 2 if the basin length is twice the basin width), A_{floor} is top area of the basin floor section (ft^2), and V_{floor} is volume of the basin floor section (ft^3).

Main Basin Volume:

$$L_{main} = L_{floor} + 2H_{main}(S_{main}) \qquad A_{main} = L_{main}(W_{main})$$

$$W_{main} = W_{floor} + 2H_{main}(S_{main})$$

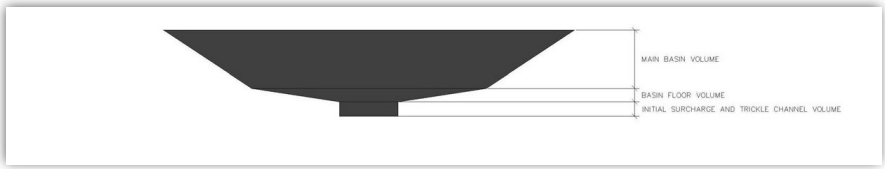
$$V_{main} = \frac{H_{main}}{3}\left(A_{main} + A_{floor} + \sqrt{A_{main}(A_{floor})}\right)$$

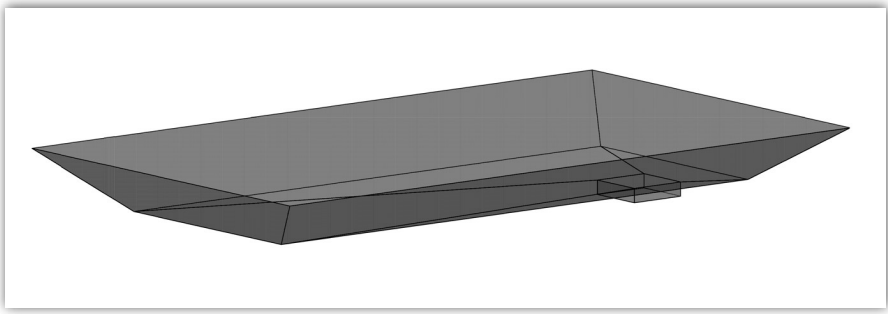
Where L_{main} and W_{main} (ft) are the length and width of the main basin section at the point at the top of the basin, H_{main} is the depth of the main basin section (ft), A_{main} is top area of the main basin section (ft^2), and V_{main} is volume of the main basin section (ft^3).

Total Basin Volume:

$$V_{total} = ISV + A_{ISV} \cdot D_{TC} + V_{floor} + V_{main}$$

Where V_{total} is the volume of the total basin (ft^3) and D_{TC} is the depth of the trickle channel (ft).



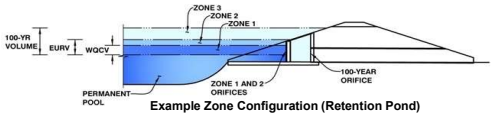


DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: Barnes and Powers

Basin ID: West Pond



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	3.17	acres
Watershed Length =	650	ft
Watershed Slope =	0.022	ft/ft
Watershed Imperviousness =	40.10%	percent
Percentage Hydrologic Soil Group A =	54.0%	percent
Percentage Hydrologic Soil Group B =	46.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	
Water Quality Capture Volume (WQCV) =	0.048	acre-feet
Excess Urban Runoff Volume (EURV) =	0.136	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	0.099	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	0.134	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	0.179	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	0.249	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	0.313	acre-feet
100-yr Runoff Volume (P1 = 2.52 in.) =	0.395	acre-feet
500-yr Runoff Volume (P1 = 3 in.) =	0.546	acre-feet
Approximate 2-yr Detention Volume =	0.093	acre-feet
Approximate 5-yr Detention Volume =	0.126	acre-feet
Approximate 10-yr Detention Volume =	0.164	acre-feet
Approximate 25-yr Detention Volume =	0.193	acre-feet
Approximate 50-yr Detention Volume =	0.211	acre-feet
Approximate 100-yr Detention Volume =	0.243	acre-feet

Optional User Override 1-hr Precipitation

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.52	inches
3.00	inches

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.048	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.088	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.107	acre-feet
Total Detention Basin Volume =	0.243	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

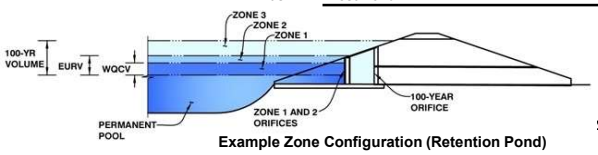
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	74	0.002		
	--	0.25	--	--	--	1,224	0.028	154	0.004
	--	0.50	--	--	--	2,373	0.054	605	0.014
	--	0.75	--	--	--	3,523	0.081	1,353	0.031
	--	1.00	--	--	--	4,673	0.107	2,396	0.055
	--	1.25	--	--	--	5,107	0.117	3,648	0.084
	--	1.50	--	--	--	5,541	0.127	5,006	0.115
	--	1.75	--	--	--	5,976	0.137	6,470	0.149
	--	2.00	--	--	--	6,410	0.147	8,039	0.185
	--	2.25	--	--	--	6,844	0.157	9,783	0.225
	--	2.50	--	--	--	7,279	0.167	11,568	0.266
	--	2.75	--	--	--	7,713	0.177	13,458	0.309
	--	3.00	--	--	--	8,148	0.187	15,454	0.355
	--	3.25	--	--	--	8,644	0.198	17,563	0.403
	--	3.50	--	--	--	9,141	0.210	19,794	0.454
	--	3.75	--	--	--	9,638	0.221	22,145	0.508
	--	4.00	--	--	--	10,135	0.233	24,617	0.565
	--	4.25	--	--	--	10,632	0.244	27,210	0.625
	--	4.50	--	--	--	11,128	0.255	29,924	0.687
	--	4.75	--	--	--	11,625	0.267	32,759	0.752
	--	5.00	--	--	--	12,122	0.278	35,715	0.820

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: Barnes Apartments

Basin ID: West Pond



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.92	0.048	Orifice Plate
Zone 2 (EURV)	1.65	0.088	Orifice Plate
Zone 3 (100-year)	2.37	0.107	Weir&Pipe (Restrict)
		0.243	Total

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

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft²
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

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

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	3.333E-03	ft²
Depth at top of Zone using Orifice Plate =	1.64	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	6.60	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	0.48	sq. inches (diameter = 3/4 inch)	Elliptical Slot Area =	N/A	ft²

Calculated Parameters for Plate

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

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.55	1.09					
Orifice Area (sq. inches)	0.48	0.48	0.48					

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

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft²
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

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

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	1.64	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	1.64	N/A	feet
Overflow Weir Front Edge Length =	2.00	N/A	feet	Over Flow Weir Slope Length =	2.00	N/A	feet
Overflow Weir Slope =	0.00	N/A	H:V (enter zero for flat grate)	Grate Open Area / 100-yr Orifice Area =	9.79	N/A	should be ≥ 4
Horiz. Length of Weir Sides =	2.00	N/A	feet	Overflow Grate Open Area w/o Debris =	2.80	N/A	ft²
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area	Overflow Grate Open Area w/ Debris =	1.40	N/A	ft²
Debris Clogging % =	50%	N/A	%				

Calculated Parameters for Overflow Weir

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

	Zone 3 Restrictor	Not Selected			Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	0.29	N/A	ft²
Outlet Pipe Diameter =	15.00	N/A	inches	Outlet Orifice Centroid =	0.21	N/A	feet
Restrictor Plate Height Above Pipe Invert =	4.25		inches	Half-Central Angle of Restrictor Plate on Pipe =	1.12	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	3.00	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.44	feet
Spillway Crest Length =	5.00	feet	Stage at Top of Freeboard =	5.00	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	0.28	acres
Freeboard above Max Water Surface =	1.56	feet			

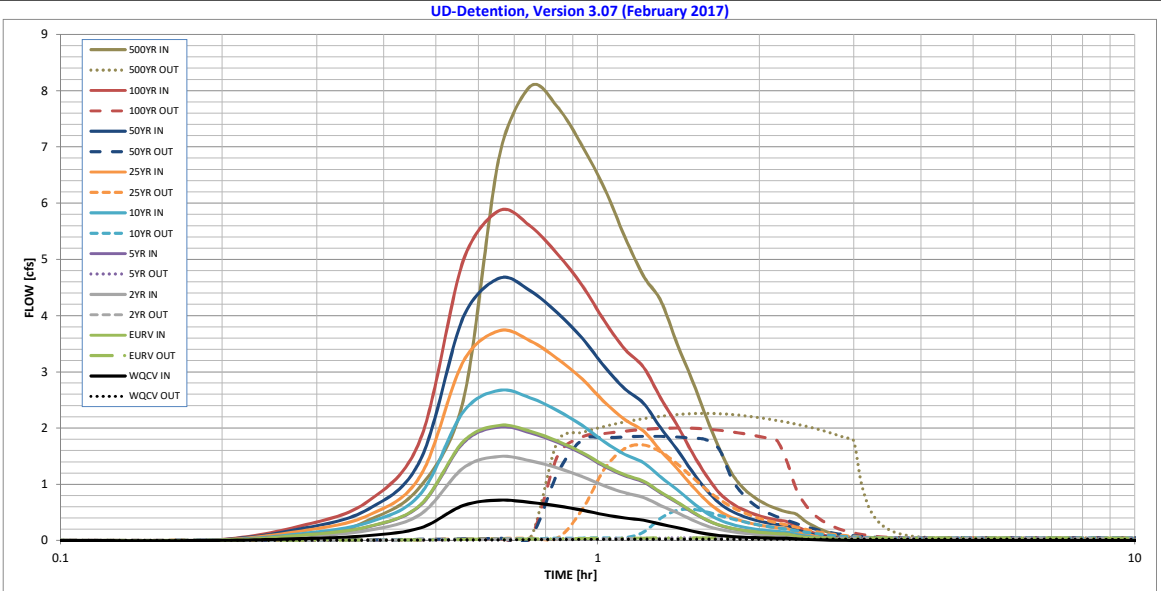
Calculated Parameters for Spillway

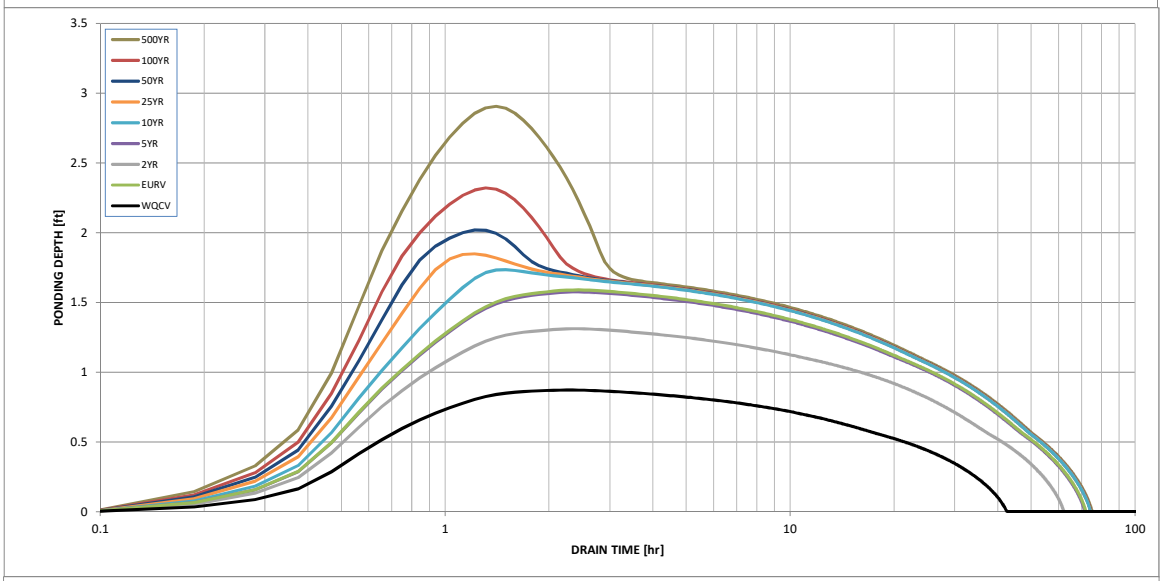
Routed Hydrograph Results

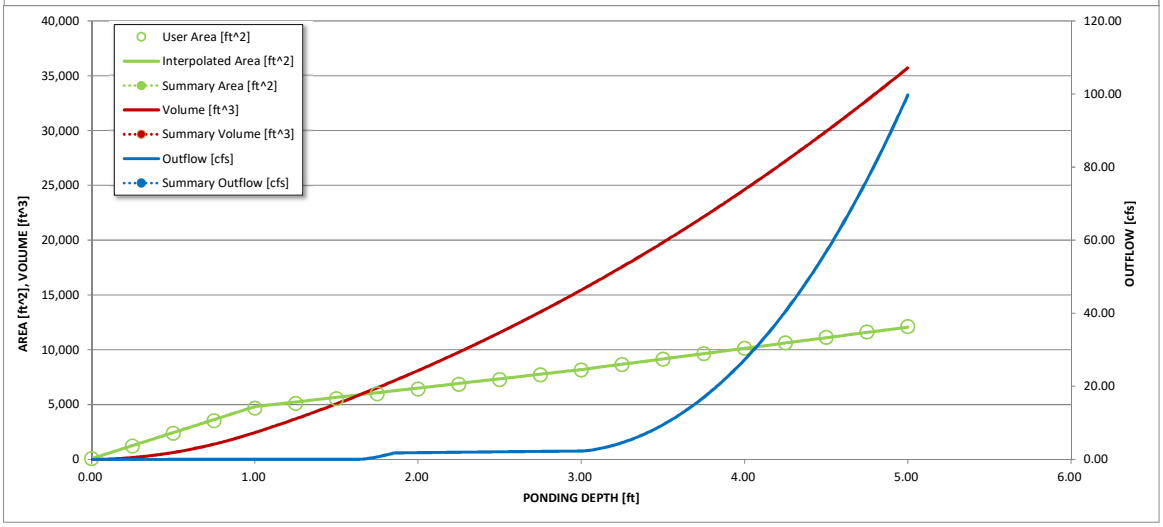
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.00
Calculated Runoff Volume (acre-ft) =	0.048	0.136	0.099	0.134	0.179	0.249	0.313	0.395	0.546
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.047	0.136	0.099	0.134	0.178	0.250	0.313	0.395	0.546
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.01	0.08	0.28	0.46	0.72	1.18
Predevelopment Peak Q (cfs) =	0.0	0.0	0.0	0.0	0.3	0.9	1.4	2.3	3.8
Peak Inflow Q (cfs) =	0.7	2.0	1.5	2.0	2.7	3.7	4.7	5.9	8.1
Peak Outflow Q (cfs) =	0.0	0.0	0.0	0.0	0.6	1.7	1.9	2.0	2.3
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	1.4	2.1	1.9	1.3	0.9	0.6
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Outlet Plate 1	Outlet Plate 1	Outlet Plate 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.1	0.6	0.6	0.7	0.8
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	39	64	56	63	64	61	59	57	52
Time to Drain 99% of Inflow Volume (hours) =	**41**	68	59	68	70	69	68	67	65
Maximum Ponding Depth (ft) =	0.87	1.59	1.31	1.58	1.73	1.85	2.02	2.32	2.91
Area at Maximum Ponding Depth (acres) =	0.10	0.13	0.12	0.13	0.14	0.14	0.15	0.16	0.18
Maximum Volume Stored (acre-ft) =	0.043	0.127	0.092	0.125	0.147	0.163	0.188	0.236	0.336

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







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

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

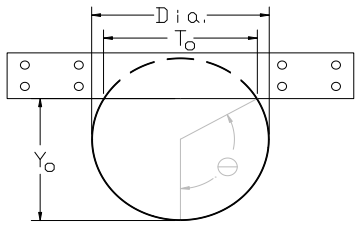
Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

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

	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK
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]
5.62 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrograph	0:11:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Constant	0:16:52	0.03	0.09	0.07	0.09	0.12	0.17	0.21	0.26	0.36
0.890	0:22:29	0.09	0.25	0.18	0.25	0.32	0.45	0.56	0.70	0.97
	0:28:06	0.23	0.64	0.47	0.63	0.83	1.16	1.44	1.81	2.48
	0:33:43	0.62	1.76	1.29	1.73	2.28	3.18	3.97	4.97	6.82
	0:39:20	0.72	2.05	1.49	2.02	2.67	3.73	4.66	5.87	8.08
	0:44:58	0.68	1.94	1.42	1.92	2.54	3.55	4.44	5.59	7.70
	0:50:35	0.61	1.77	1.29	1.74	2.31	3.23	4.04	5.09	7.01
	0:56:12	0.54	1.56	1.14	1.54	2.05	2.87	3.60	4.53	6.26
	1:01:49	0.46	1.34	0.97	1.32	1.75	2.46	3.09	3.90	5.40
	1:07:26	0.40	1.17	0.85	1.15	1.53	2.15	2.70	3.40	4.71
	1:13:04	0.36	1.06	0.77	1.04	1.38	1.95	2.44	3.08	4.26
	1:18:41	0.29	0.86	0.62	0.84	1.13	1.59	2.00	2.53	3.51
	1:24:18	0.23	0.69	0.50	0.68	0.91	1.29	1.62	2.06	2.86
	1:29:55	0.17	0.52	0.37	0.51	0.68	0.97	1.23	1.57	2.20
	1:35:32	0.12	0.37	0.26	0.37	0.50	0.71	0.91	1.16	1.63
	1:41:10	0.09	0.28	0.20	0.27	0.37	0.52	0.66	0.85	1.18
	1:46:47	0.07	0.22	0.16	0.21	0.29	0.41	0.52	0.66	0.92
	1:52:24	0.06	0.18	0.13	0.18	0.24	0.34	0.43	0.54	0.76
	1:58:01	0.05	0.15	0.11	0.15	0.20	0.29	0.36	0.46	0.64
	2:03:38	0.05	0.14	0.10	0.13	0.18	0.25	0.32	0.41	0.56
	2:09:16	0.04	0.12	0.09	0.12	0.16	0.23	0.29	0.37	0.51
	2:14:53	0.04	0.11	0.08	0.11	0.15	0.21	0.27	0.34	0.47
	2:20:30	0.03	0.08	0.06	0.08	0.11	0.16	0.20	0.25	0.34
	2:26:07	0.02	0.06	0.04	0.06	0.08	0.11	0.14	0.18	0.25
	2:31:44	0.01	0.04	0.03	0.04	0.06	0.08	0.10	0.13	0.19
	2:37:22	0.01	0.03	0.02	0.03	0.04	0.06	0.08	0.10	0.14
	2:42:59	0.01	0.02	0.02	0.02	0.03	0.04	0.05	0.07	0.10
	2:48:36	0.01	0.02	0.01	0.02	0.02	0.03	0.04	0.05	0.07
	2:54:13	0.00	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.05
	2:59:50	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.02	0.03
	3:05:28	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02
	3:11:05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	3:16:42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:22:19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:27:56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:33:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:39:11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:44:48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:56:02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:01:40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:07:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:12:54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:18:31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:24:08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:29:46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:41:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:46:37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:52:14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:57:52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:03:29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:09:06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:14:43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:31:35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:37:12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:42:49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:48:26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:54:04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:59:41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:05:18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:10:55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:16:32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:22:10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:27:47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:33:24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:39:01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:44:38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Reference Figures and Equations

Circular Pipe with Restrictor Plate



WQ Elliptical Slot Weir (Alternative to WQ Orifice Plate for Large Watersheds)

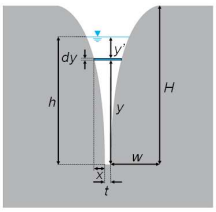
$$f(y) = \sqrt{2g(h-y)}\left[2\frac{H}{R}\left(1-1\sqrt{1-\frac{y^2}{H^2}}\right)+t\right]$$

$$Q_{app} = 0.3015h\left[f(0)+f(0.603h)\right] + 0.1415h\left[f(0.603h)+f(0.886h)\right] + 0.0570h\left[f(0.886h)\right]$$

Orifice Equations

$$Q = C_d A_t \sqrt{2g(h-C_y)}$$

$$A_t = H(2W+t) - \frac{\pi HW}{2} \qquad C_y = \frac{\frac{H}{2}(2W+t) - \frac{2HW}{3}}{2W+t-\frac{\pi W}{2}}$$



- *dy* = elementary flow vertical distance [L];
- *h* = total flow depth [L];
- *H* = total weir height and semi-major ellipse axis [L];
- *t* = weir gap thickness [L];
- *W* = semi-minor ellipse axis [L];
- *x* = horizontal distance along the ellipse shape [L];
- *y* = vertical depth measured from the weir crest to the elementary flow strip [L]; and
- *y'* = vertical distance measured from the water surface to the elementary flow strip [L].

Watershed Runoff Volume Calculations

$$WQCV = \frac{A}{12} * a[0.91I^3 - 1.19I^2 + 0.78I]$$

$$EURV = A[0.140I^{1.28} * A\% + 0.113I^{1.08} * B\% + 0.100I^{1.08}]$$

$$V_{Runoff\_2yr} = P_1 A[(0.084I^{1.440})A\% + (0.084I^{1.173})B\% + (0.084I^{1.094})CD\%]$$

$$V_{Runoff\_5yr} = P_1 A[(0.084I^{1.350})A\% + (0.077I + 0.007)B\% + (0.070I + 0.014)CD\%]$$

$$V_{Runoff\_10yr} = P_1 A[(0.085I^{1.220})A\% + (0.069I + 0.016)B\% + (0.061I + 0.024)CD\%]$$

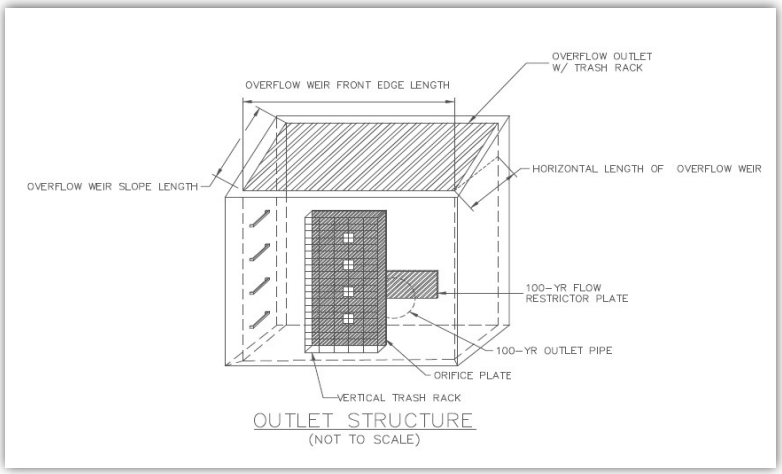
$$V_{Runoff\_25yr} = P_1 A[(0.082I + 0.004)A\% + (0.055I + 0.031)B\% + (0.048I + 0.038)CD\%]$$

$$V_{Runoff\_50yr} = P_1 A[(0.078I + 0.009)A\% + (0.049I + 0.038)B\% + (0.044I + 0.043)CD\%]$$

$$V_{Runoff\_100yr} = P_1 A[(0.073I + 0.015)A\% + (0.043I + 0.045)B\% + (0.038I + 0.050)CD\%]$$

$$V_{Runoff\_500yr} = P_1 A[(0.064I + 0.025)A\% + (0.036I + 0.053)B\% + (0.031I + 0.058)CD\%]$$

Where $WQCV$ is the water quality capture volume (acre-ft), EURV is the excess urban runoff volume (acre-ft), V_{tyr} is the volume for the given return period (acre-ft), a is a coefficient corresponding to WQCV drain time (1.0 for 40 hours, 0.9 for 24 hours, and 0.8 for 12 hours), P_1 is the one-hour rainfall depth (in), A is the contributing watershed area (acres), I is the percentage imperviousness (expressed as a decimal), $A\%$, $B\%$, and $CD\%$ are the percent of each hydraulic soil group (expressed as a decimal).



Basin Volume Calculations

Initial Surcharge Volume:

$$ISV = 0.003WQCV \qquad L_{ISV} = \sqrt{A_{ISV}}$$

$$A_{ISV} = \frac{ISV}{ISD} \qquad W_{ISV} = \sqrt{A_{ISV}}$$

Where ISV is the initial surcharge volume (ft^3), A_{ISV} is ISV surface area (ft^2), ISD is the initial surcharge depth (ft, typically 0.33 to 0.50), and L_{ISV} and W_{ISV} are the length and width of the ISV (ft).

Basin Floor Volume:

$$L_{floor} = L_{ISV} + \frac{H_{floor}}{S_{TC}} + H_{floor}(S_{main}) \qquad W_{floor} = W_{ISV} + \frac{H_{floor}}{R_{LW}(S_{TC})}$$

$$A_{floor} = L_{floor}(W_{floor})$$

$$V_{floor} = \frac{H_{floor}}{3}\left(A_{ISV} + A_{floor} + \sqrt{A_{ISV}(A_{floor})}\right)$$

Where L_{floor} and W_{floor} (ft) are the length and width of the basin floor section at the point where the top of the basin floor section meets the toe of the basin main section, H_{floor} is the depth of the basin floor section (ft), S_{TC} is the trickle channel slope (ft/ft), S_{main} is the side slope of the basin main section (H:V; e.g., 4 if the horizontal:vertical ratio is 4:1), $R_{L:W}$ is the basin length:width ratio (e.g., 2 if the basin length is twice the basin width), A_{floor} is top area of the basin floor section (ft^2), and V_{floor} is volume of the basin floor section (ft^3).

Main Basin Volume:

$$L_{main} = L_{floor} + 2H_{main}(S_{main}) \qquad A_{main} = L_{main}(W_{main})$$

$$W_{main} = W_{floor} + 2H_{main}(S_{main})$$

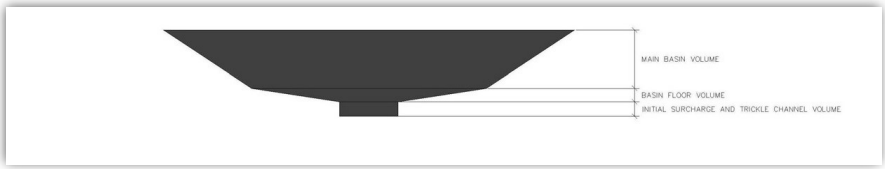
$$V_{main} = \frac{H_{main}}{3}\left(A_{main} + A_{floor} + \sqrt{A_{main}(A_{floor})}\right)$$

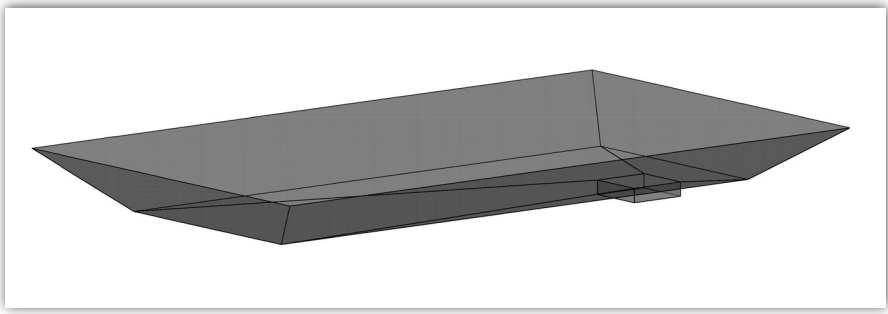
Where L_{main} and W_{main} (ft) are the length and width of the main basin section at the point at the top of the basin, H_{main} is the depth of the main basin section (ft), A_{main} is top area of the main basin section (ft^2), and V_{main} is volume of the main basin section (ft^3).

Total Basin Volume:

$$V_{total} = ISV + A_{ISV} \cdot D_{TC} + V_{floor} + V_{main}$$

Where V_{total} is the volume of the total basin (ft^3) and D_{TC} is the depth of the trickle channel (ft).





FORBAY VOLUMES

WEST FORBAY VOLUME

ELEV	*AREA*	*AREA AVG.*	*DELTA ELEV.*	*VOLUME*	*VOLUME TOTAL*
71.00	30				
		30	1.5	45	
72.50	30				45

End Area Method: 45 C.F.
0.001 A.F.

Total East Forebay Volume= 45 C.F.
0.001 A.F.

Required Forbay Volume = 2% of WQCV
WQCV = 0.05 ac-ft
WQCV = 2,072 cu-ft
2% of WQCV = 41.45 cu-ft

MIDDLE FORBAY VOLUME

ELEV	*AREA*	*AREA AVG.*	*DELTA ELEV.*	*VOLUME*	*VOLUME TOTAL*
65.00	90				
		90	1.5	135	
66.50	90				135

End Area Method: 135 C.F.
0.003 A.F.

Total East Forebay Volume= 135 C.F.
0.003 A.F.

Required Forbay Volume = 3% of WQCV
WQCV = 0.10 ac-ft
WQCV = 4,210 cu-ft
3% of WQCV = 126.30 cu-ft

EAST FORBAY VOLUME

ELEV	*AREA*	*AREA AVG.*	*DELTA ELEV.*	*VOLUME*	*VOLUME TOTAL*
77.00	32				
		32	1.5	48	
78.50	32				48

End Area Method: 48 C.F.
0.001 A.F.

Total East Forebay Volume= 48 C.F.
0.001 A.F.

Required Forbay Volume = 2% of WQCV
WQCV = 0.05 ac-ft
WQCV = 2,369 cu-ft
2% of WQCV = 47.39 cu-ft

DRAINAGE MAPS

BARNES AND MEDICAL VIEW APARTMENTS

COLORADO SPRINGS, CO

EXISTING DRAINAGE MAP

DECEMBER 2018

LEGEND

10' EX CONTOUR — 6810

2' EX CONTOUR — 6802

PROPOSED FLOW DIRECTION

BASIN BOUNDARY

TIME OF CONCENTRATION

BASIN ID — A

ACREAGE — 0.37

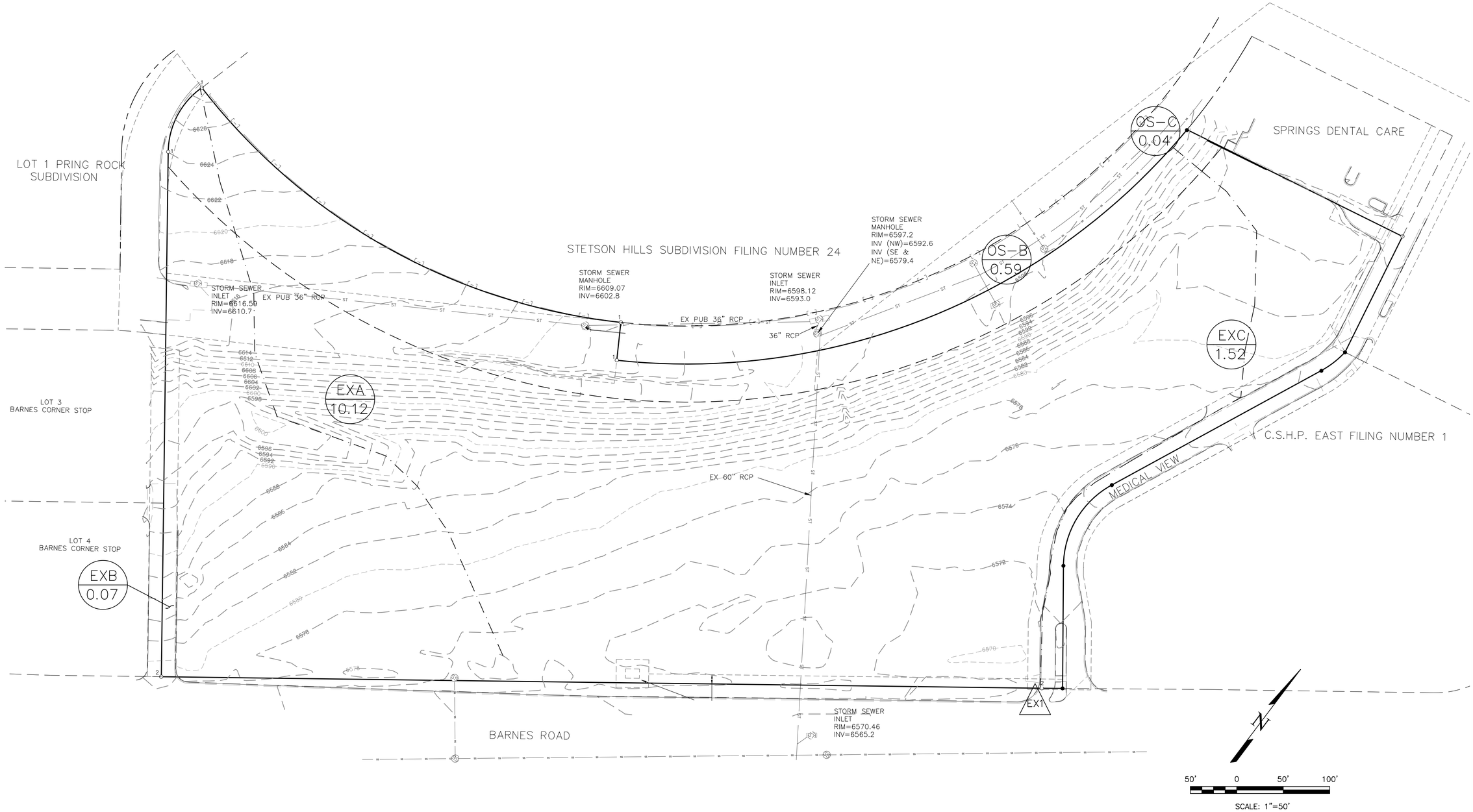
DESIGN POINT — 3

EXISTING CONDITIONS

BASIN	ACRES	Q5 CFS	Q100 CFS
EXA	10.12	3.4	22.6
EXB	0.07	0.3	0.5
EXC	1.52	1.4	4.5
OS-B	0.59	0.3	1.8
OS-C	0.04	0.0	0.1

DESIGN POINT SUMMARY

DP	CONTRIBUTING BASINS	AREA AC.	Q5 CFS	Q100 CFS
EX1	EXA, EXB, EXC, OS-B & OS-C	12.33	5.0	29.0



REVISIONS

NO.	DESCRIPTION	DATE

UNTIL SUCH TIME AS THESE DRAWINGS ARE APPROVED BY THE APPROPRIATE REVIEWING AGENCIES, TERRA NOVA ENGINEERING, INC. APPROVES THEIR USE ONLY FOR THE PURPOSES DESIGNATED BY WRITTEN AUTHORIZATION.

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Transforming Civil Engineering
721 S. 23RD STREET
COLORADO SPRINGS, CO 80904
OFFICE: 719-635-6422
FAX: 719-635-6426
www.tneinc.com

BARNES AND MEDICAL VIEW APARTMENTS

EXISTING DRAINAGE MAP

DESIGNED BY	LD
DRAWN BY	JF
CHECKED BY	LD
H-SCALE	AS NOTED
V-SCALE	N/A
JOB NO.	1859.00
DATE ISSUED	12/18/18
SHEET NO.	1 OF 4

N:\jobs\1859.00\drawings\dp\185900 FDM.dwg, EX DRAINAGE MAP, 12/19/2018 10:47:53 AM

BARNES & MEDICAL VIEW APARTMENTS

COLORADO SPRINGS, CO

PROPOSED DRAINAGE MAP

DECEMBER 2018

PROPOSED CONDITIONS

BASIN	ACRES	Q5 CFS	Q100 CFS
A1	2.13	3.6	8.7
A2	0.05	0.2	0.4
A3	0.05	0.4	0.4
A4	0.17	0.6	1.2
A5	0.11	0.4	0.8
A6	0.06	0.2	0.4
A7	0.60	0.3	1.9
OS–B1	0.07	0.0	0.2
OS–B2	0.14	0.1	0.4
OS–B3	0.36	0.2	1.1
B1	1.14	2.7	5.8
B2	0.46	1.4	2.8
B3	0.13	0.5	1.0
B4	0.78	2.5	4.8
B5	0.47	0.2	1.5
B6	0.06	0.2	0.4
B7	0.13	0.5	0.9

PROPOSED CONDITIONS

BASIN	ACRES	Q5 CFS	Q100 CFS
B8	0.10	0.4	0.7
B9	0.07	0.2	0.4
B10	0.07	0.5	0.9
B11	0.05	0.2	0.4
B12	0.05	0.2	0.4
B13	0.11	0.4	0.8
B14	0.12	0.5	0.8
B15	0.05	0.2	0.4
B16	0.04	0.2	0.3
B17	0.11	0.4	0.8
B18	0.11	0.4	0.8
B19	0.07	0.3	0.5
B20	0.07	0.3	0.5
B21	0.53	0.2	1.4
OS–C	0.06	0.0	0.2
C1	1.29	3.2	6.5
C2	0.45	1.3	2.6

PROPOSED CONDITIONS

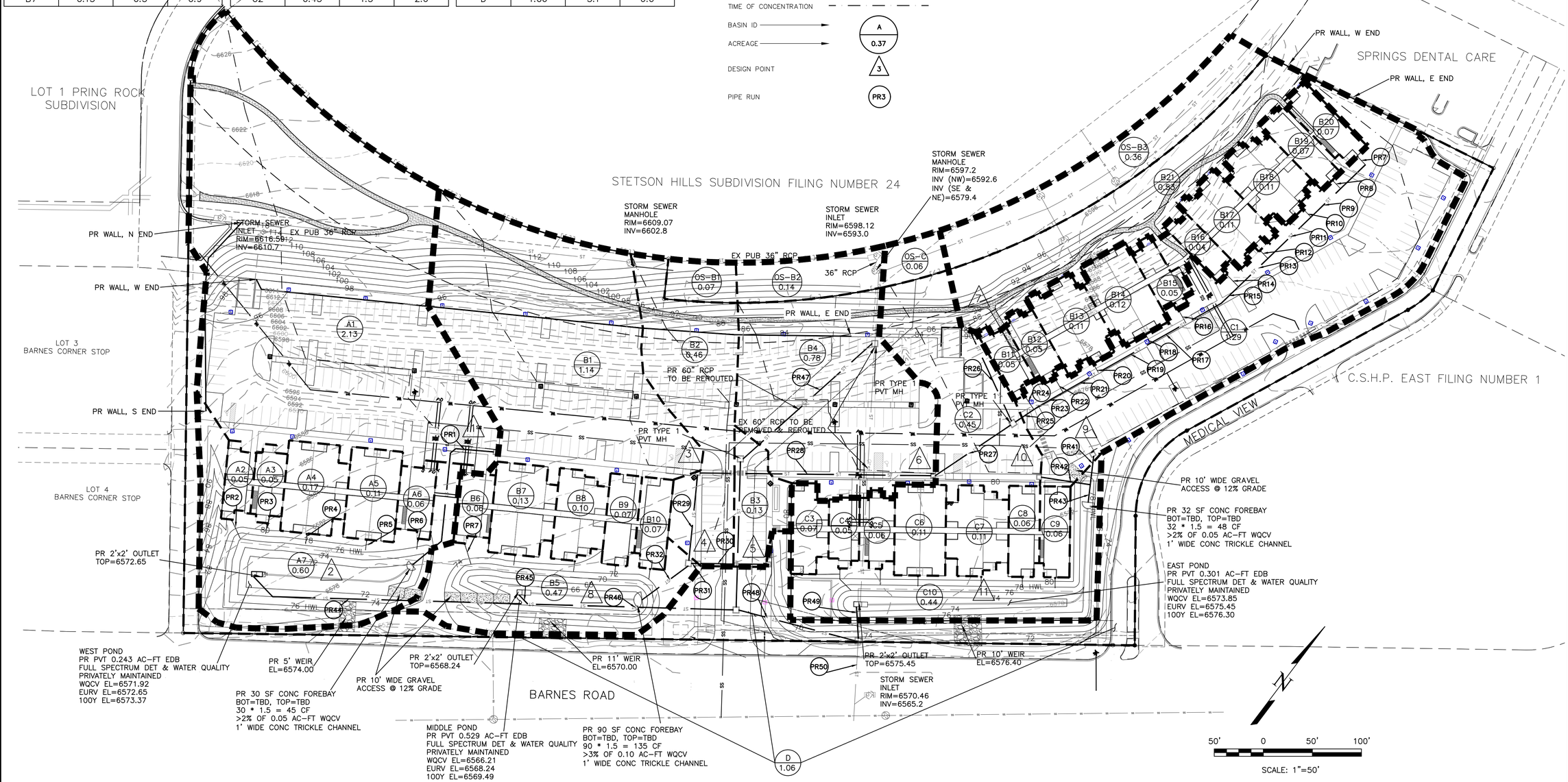
BASIN	ACRES	Q5 CFS	Q100 CFS
C3	0.07	0.3	0.5
C4	0.05	0.2	0.4
C5	0.06	0.2	0.4
C6	0.11	0.4	0.8
C7	0.11	0.4	0.8
C8	0.06	0.2	0.4
C9	0.06	0.2	0.4
C10	0.44	0.2	1.4
D	1.06	3.1	6.6

LEGEND

- 10' EX CONTOUR — 6810
- 2' EX CONTOUR — 6802
- 10' PROP. CONTOUR — 6810
- 2' PROP. CONTOUR — 6802
- PROPOSED FLOW DIRECTION
- BASIN BOUNDARY
- TIME OF CONCENTRATION
- BASIN ID — A
- ACREAGE — 0.37
- DESIGN POINT — 3
- PIPE RUN — PR3

DESIGN POINT SUMMARY

DP	CONTRIBUTING BASINS	AREA AC.	Q5 CFS	Q100 CFS	INLET SIZE/TYPE	OWNER
1	A1	0.22	3.6	8.7	8' D10–R SUMP	PRIVATE
2	A1–A7	3.17	5.1	12.5	WEST POND	PRIVATE
3	B1	1.14	2.5	5.8	8' D10–R SUMP	PRIVATE
4	B2 & OS–B1	0.53	1.4	3.0	4' D10–R SUMP	PRIVATE
5	B3 & OS–B3	0.27	0.6	1.4	4' D10–R SUMP	PRIVATE
6	B4	0.78	2.5	12.6	12' D10–R SUMP	PRIVATE
7	B21 & OS–B3	0.89	0.4	2.4	TYPE "C" INLET	PRIVATE
8	B1–B21	4.72	10.7	22.9	MIDDLE POND	PRIVATE
9	C1	1.29	3.2	6.5	8' D10–R SUMP	PRIVATE
10	C2 & OS–C	0.45	1.3	2.8	4' D10–R SUMP	PRIVATE
11	C1–C10	2.70	5.9	13.0	EAST POND	PRIVATE



REVISIONS

NO.	DESCRIPTION	DATE

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BARNES & MEDICAL VIEW APARTMENTS

PROPOSED DRAINAGE MAP

DESIGNED BY QNA
DRAWN BY QNA
CHECKED BY
H–SCALE AS NOTED
V–SCALE N/A
JOB NO. 1859.00
DATE ISSUED 12/18/18
SHEET NO. 2 OF 4

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BARNES & MEDICAL VIEW APARTMENTS

COLORADO SPRINGS, CO

PROPOSED DRAINAGE MAP

DECEMBER 2018

PROPOSED CONDITIONS

BASIN	ACRES	Q5 CFS	Q100 CFS
A1	2.13	3.6	8.7
A2	0.05	0.2	0.4
A3	0.05	0.4	0.4
A4	0.17	0.6	1.2
A5	0.11	0.4	0.8
A6	0.06	0.2	0.4
A7	0.60	0.3	1.9
OS–B1	0.07	0.0	0.2
OS–B2	0.14	0.1	0.4
OS–B3	0.36	0.2	1.1
B1	1.14	2.7	5.8
B2	0.46	1.4	2.8
B3	0.13	0.5	1.0
B4	0.78	2.5	4.8
B5	0.47	0.2	1.5
B6	0.06	0.2	0.4
B7	0.13	0.5	0.9

PROPOSED CONDITIONS

BASIN	ACRES	Q5 CFS	Q100 CFS
B8	0.10	0.4	0.7
B9	0.07	0.2	0.4
B10	0.07	0.5	0.9
B11	0.05	0.2	0.4
B12	0.05	0.2	0.4
B13	0.11	0.4	0.8
B14	0.12	0.5	0.8
B15	0.05	0.2	0.4
B16	0.04	0.2	0.3
B17	0.11	0.4	0.8
B18	0.11	0.4	0.8
B19	0.07	0.3	0.5
B20	0.07	0.3	0.5
B21	0.53	0.2	1.4
OS–C	0.06	0.0	0.2
C1	1.29	3.2	6.5
C2	0.45	1.3	2.6

PROPOSED CONDITIONS

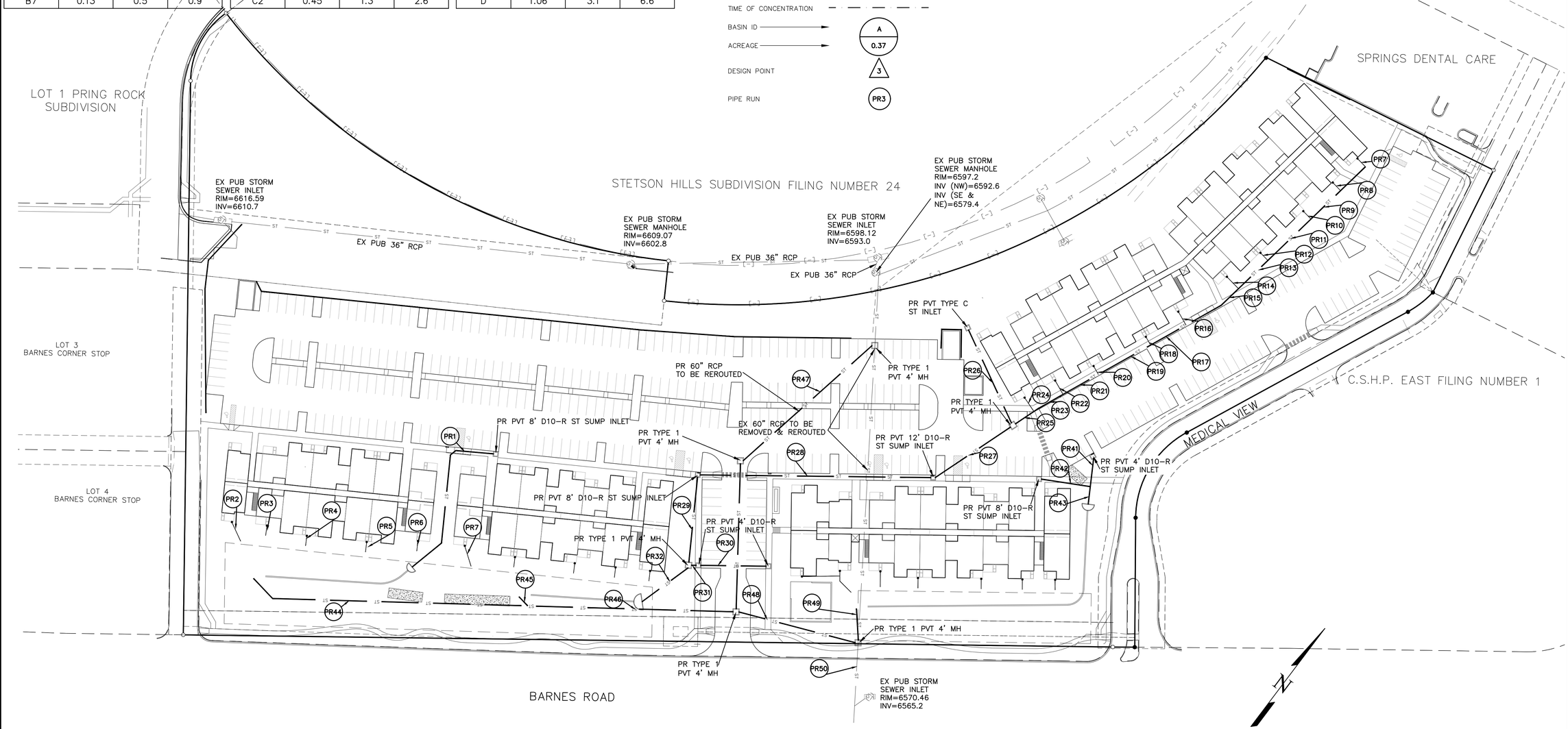
BASIN	ACRES	Q5 CFS	Q100 CFS
C3	0.07	0.3	0.5
C4	0.05	0.2	0.4
C5	0.06	0.2	0.4
C6	0.11	0.4	0.8
C7	0.11	0.4	0.8
C8	0.06	0.2	0.4
C9	0.06	0.2	0.4
C10	0.44	0.2	1.4
D	1.06	3.1	6.6

LEGEND

- 10' EX CONTOUR — 6810
- 2' EX CONTOUR — 6802
- 10' PROP. CONTOUR — 6810
- 2' PROP. CONTOUR — 6802
- PROPOSED FLOW DIRECTION
- BASIN BOUNDARY
- TIME OF CONCENTRATION
- BASIN ID — A
- ACREAGE — 0.37
- DESIGN POINT — 3
- PIPE RUN — PR3

DESIGN POINT SUMMARY

DP	CONTRIBUTING BASINS	AREA AC.	Q5 CFS	Q100 CFS	INLET SIZE/TYPE	OWNER
1	A1	0.22	3.6	8.7	8' D10–R SUMP	PRIVATE
2	A1–A7	3.17	5.1	12.5	WEST POND	PRIVATE
3	B1	1.14	2.5	5.8	8' D10–R SUMP	PRIVATE
4	B2 & OS–B1	0.53	1.4	3.0	4' D10–R SUMP	PRIVATE
5	B3 & OS–B3	0.27	0.6	1.4	4' D10–R SUMP	PRIVATE
6	B4	0.78	2.5	12.6	12' D10–R SUMP	PRIVATE
7	B21 & OS–B3	0.89	0.4	2.4	TYPE "C" INLET	PRIVATE
8	B1–B21	4.72	10.7	22.9	MIDDLE POND	PRIVATE
9	C1	1.29	3.2	6.5	8' D10–R SUMP	PRIVATE
10	C2 & OS–C	0.45	1.3	2.8	4' D10–R SUMP	PRIVATE
11	C1–C10	2.70	5.9	13.0	EAST POND	PRIVATE



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BARNES & MEDICAL VIEW APARTMENTS

STORM SEWER LAYOUT

DESIGNED BY QNA
DRAWN BY QNA
CHECKED BY
H–SCALE AS NOTED
V–SCALE N/A
JOB NO. 1859.00
DATE ISSUED 12/18/18
SHEET NO. 3 OF 4

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BARNES & MEDICAL VIEW APARTMENTS

COLORADO SPRINGS, CO

PIPERUN SUMMARY

DECEMBER 2018

BARNES AND MEDICAL DRIVE APARTMENTS
PIPE ROUTING SUMMARY

DEVELOPED CONDITIONS

Pipe Run(s)	*Contributing Design Points/Basins*	*Area (Acres)*	*Equivalent CA_5*	*Equivalent CA_{100}*	*Maximum T_C*	*Intensity*		*Flow*		*SIZE & TYPE*	*OWNER*
						I_5	*I_{100}*	*Q_5*	*Q_{100}*		
1	A1	0.22	0.91	1.30	11.2	4.0	6.7	3.6	8.7	24" RCP	PRIVATE
2	A2	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
3	A3	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
4	A4	0.17	0.12	0.14	5.0	5.2	8.7	0.6	1.2	8" HDPE	PRIVATE
5	A5	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
6	A6	0.06	0.04	0.05	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
7	B20	0.07	0.05	0.06	5.0	5.2	8.7	0.3	0.5	8" HDPE	PRIVATE
8	B19	0.07	0.05	0.06	5.0	5.2	8.7	0.3	0.5	8" HDPE	PRIVATE
9	PR 7 & 8	0.14	0.10	0.11	5.0	5.2	8.7	0.5	1.0	12" HDPE	PRIVATE
10	B18	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
11	PR 9 & 10	0.25	0.18	0.20	5.0	5.2	8.7	0.9	1.8	12" HDPE	PRIVATE
12	B17	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
13	PR 11 & 12	0.36	0.26	0.29	5.0	5.2	8.7	1.4	2.5	12" HDPE	PRIVATE
14	B16	0.04	0.03	0.03	5.0	5.2	8.7	0.2	0.3	6" HDPE	PRIVATE
15	PR 13 & 14	0.40	0.29	0.32	5.0	5.2	8.7	1.5	2.8	12" HDPE	PRIVATE
16	B15	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
17	PR 15 & 16	0.45	0.33	0.36	5.0	5.2	8.7	1.7	3.2	15" HDPE	PRIVATE
18	B14	0.12	0.09	0.10	5.0	5.2	8.7	0.5	0.8	8" HDPE	PRIVATE
19	PR 17 & 18	0.57	0.42	0.46	5.0	5.2	8.7	2.2	4.0	15" HDPE	PRIVATE
20	B13	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
21	PR 19 & 20	0.68	0.50	0.55	5.0	5.2	8.7	2.6	4.8	15" HDPE	PRIVATE
22	B12	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
23	PR 21 & 22	0.73	0.53	0.59	5.0	5.2	8.7	2.8	5.1	15" HDPE	PRIVATE

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BARNES AND MEDICAL DRIVE APARTMENTS
PIPE ROUTING SUMMARY

Pipe Run(s)	*Contributing Design Points/Basins*	*Area (Acres)*	*Equivalent CA_5*	*Equivalent CA_{100}*	*Maximum T_C*	*Intensity*		*Flow*		*SIZE & TYPE*	*OWNER*
						I_5	*I_{100}*	*Q_5*	*Q_{100}*		
24	B11	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
25	PR 23 & 24	0.78	0.57	0.63	5.0	5.2	8.7	2.9	5.5	15" HDPE	PRIVATE
26	DP-7	0.89	0.08	0.32	8.4	4.4	7.4	0.4	2.4	12" HDPE	PRIVATE
27	PR 25 & 26	1.67	0.65	0.95	8.4	4.4	7.4	2.9	7.0	18" HDPE	PRIVATE
28	DP-6 & PR 27	2.45	1.15	2.47	8.4	4.4	7.4	5.0	18.2	30" RCP	PRIVATE
29	DP 3 & PR 28	3.59	1.73	3.28	9.0	4.3	7.2	7.4	23.6	30" RCP	PRIVATE
30	DP 5	0.27	0.11	0.16	5.0	5.2	8.7	0.6	1.4	12" HDPE	PRIVATE
31	DP 4 & 5	0.80	0.40	0.53	6.6	4.8	8.0	1.9	4.3	15" HDPE	PRIVATE
32	PR 29 & 31	4.39	2.13	3.81	9.0	4.3	7.2	9.2	27.5	30" RCP	PRIVATE
33	C3	0.07	0.05	0.06	5.0	5.2	8.7	0.3	0.5	8" HDPE	PRIVATE
34	C4	0.05	0.04	0.04	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
35	PR 33 & 34	0.12	0.09	0.10	5.0	5.2	8.7	0.5	0.8	8" HDPE	PRIVATE
36	C5	0.06	0.04	0.05	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
37	C6	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
38	C7	0.11	0.08	0.09	5.0	5.2	8.7	0.4	0.8	8" HDPE	PRIVATE
39	C8	0.06	0.04	0.05	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
40	C9	0.06	0.04	0.05	5.0	5.2	8.7	0.2	0.4	6" HDPE	PRIVATE
41	DP 9	1.29	0.85	1.00	12.2	3.8	6.4	3.2	6.5	18" HDPE	PRIVATE
42	DP 10	0.51	0.27	0.36	6.8	4.7	7.9	1.3	2.8	15" HDPE	PRIVATE
43	PR 41 & 42	1.80	1.12	1.36	12.2	3.8	6.4	4.3	8.8	18" HDPE	PRIVATE
44	POND WEST OUTLET							0.0	2.0	15" HDPE	PRIVATE
45	POND MIDDLE OUTLET							0.1	4.4	15" HDPE	PRIVATE
46	PR 45 & 46							0.1	6.4	18" HDPE	PRIVATE
47	EX 30" STM RE-ROUTED							0.0	347.2	60" RCP	PUBLIC
48	PR 46 & 47							0.1	353.6	60" RCP	PUBLIC
49	POND EAST OUTLET							0.0	2.0	15" HDPE	PRIVATE
50	PR 48 & 49							0.1	355.6	60" RCP	PUBLIC

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DRAWN BY QNA
CHECKED BY

H-SCALE AS NOTED
V-SCALE N/A

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SHEET NO. 4 OF 4